# INTERNATIONAL CONFERENCE ON SUSTAINABLE DEVELOPMENT IN CIVIL ENGINEERING

23rd - 25th November 2017

ICSDC 2017

# CONFERENCE

## PROCEEDINGS VOLUME I

Organized by
Department of Civil Engineering
Mehran University of Engineering and Technology, Jamshoro

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# Preface

Mehran University of Engineering and Technology (MUET) is an ISO-9001 certified institute that has been active in various disciplines of engineering, constituting 31 departments, institutes and directorates offering undergraduate and postgraduate programs since 1963. It is emerging as one of the leading universities of the country, ranked by Higher Education Commission and Pakistan Engineering Council. The university has academic alliance with leading universities and industrial collaboration with various establishments around the globe.

In order to provide a platform to all the collaborators and policy makers from academic organizations, public and private institutes for discussing their technical and general issues, Mehran UET organizes international and national conferences, workshops and seminars regularly. In this framework, Department of Civil Engineering is hosting an "International Conference on Sustainable Development in Civil Engineering" (ICSDC 2017), November 23-25, 2017.

The Department of Civil Engineering is one of the oldest and largest departments of the University, which has produced tens of thousands of engineers working diligently in various academia and industrial sectors. It aims to produce top-level engineers who maintain the integrity and glory of their profession.
ICSDC 2017 aims to provide discussion on the present-day research on sustainable development in various disciplines of civil engineering namely, Structural Engineering, Geotechnical Engineering, Transportation Engineering, Irrigation and Drainage Engineering, Construction Management, Environmental Engineering, etc. The convention encourages collaborators from academia arena as well as industry professionals to present their original research of top-notch quality. The forum assembles keynote speakers, authors and participants from educational and industrial sectors to present and debate on various challenges faced by the stakeholders in the domain of Sustainable Civil Engineering.
ICSDC 2017 has been triumphant in attracting National and International participants and speakers from public and private organizations.

# Acknowledgment

The organizing committee of ICSDC 2017 acknowledges the collaboration and support of Higher Education Commission (HEC), Pakistan Engineering Council (PEC), Omni Power (Pvt.) Ltd., Osmani & Company (Pvt.) Ltd., Niaz Khan Brothers Engineers and Contractors (NKB), M/S. Technology Links (Pvt.) Ltd. Karachi and Ideal Autonetics (Pvt.) Ltd. to make the event successful.

The active participation of the National and International Keynote speakers, authors and participants is highly appreciable who made the event eminent.

High gratitude for the rigorous efforts of conference organizing committees.

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# Keynote Speakers

**Prof. Dr. Marat Ubaydulla Akhmet**

Prof. Marat is a Professor of Mathematics at Middle East Technical University, Ankara, Turkey. He is known for his research on the chaos and bifurcation theory in differential equations and hybrid systems with applications in physics, neural networks, biology, medicine and economics. He has been awarded a Science Prize of TUBITAK (Turkey, 2015), for best achievements in scientific research. He is also author of four books on covering range of topics. Prof. Marat has introduced and developed the theory of differential equations with piece wise constant argument of generalized type and many aspects of discontinuous dynamical systems.

**Chattering, Grazing and Singularity in Impact Mechanisms**

**Abstract:** Two of the most difficult and interesting phenomena of nonlinear dynamics of impact mechanisms are Chattering and Grazing. In last several years we have performed research on these problems. The results of our studies published in our papers will be presented on this platform. The method of regular perturbation is utilized for analysis of grazing collision of solids. Chattering, which is considered as infinitely many impacts in finite time, is considered as a singular problem for the first time. Sufficient conditions for chattering have been formulated for the first time in literature. The Pyragas control is applied to stabilize chattering. We will demonstrate the results by simulation modelling of colliding bodies, Van der Pol and Duffing oscillators with impacts.

**Prof. Dr. Othman Bin Che Puan**

Prof. Dr. Othman is a faculty member of Civil Engineering Universiti Teknologi Malaysia (UTM). He started his teaching career from Kuala Lumpur Technical School. Dr. Othman has expertise in Highway & Traffic Engineering. He did his doctor of Philosophy from University of Wales, Cardiff, United Kingdom. He has held various high profile posts including Deputy Dean (Engineering) and Head of Postgraduate Studies at UTM. His fields of interest include Transportation Engineering & Planning and Traffic Engineering & Safety. He has produced more than 100 technical papers and supervised more than 30 post graduate students.

## Driver's Car Following Headway On Single Carriageway Roads

**Abstract:** One of many aspects that are considered to influence road crashes and road traffic handling capacity is the driver's "Car Following Behavior." This study examines the distance separation between impeded vehicles on single carriageway roads. Data defining headway and speed for more than 8000 vehicles were collected using video cameras to record traffic movement at four sites in Malaysia. The distance headways and associated vehicle speeds were separated into vehicle following category by vehicle type and then into speed classes for vehicle following vehicle: car following car, car following heavy goods vehicle (HGV), HGV following HGV and HGV following car categories. In most cases the lognormal distribution was found to be an appropriate representation of the variation in distance headways for vehicles within a particular speed class. Linear regression models were developed to represent the relationships between distance headway and speed and the predicted variation in population mean distance headway with vehicle speed. In general, Malaysian drivers tend to follow another vehicle closely and platoons appeared to develop rapidly.

Dr. Ahmed is a Full Professor at E-JUST, and Chairperson of Environmental Engineering Department. He has received several national and international awards. Moreover, he has published 79 papers in peer reviewed international ISI journals with h-index Google Scholar of 21. Dr. Ahmed has a significant contribution for creating novel and innovative technologies for wastewater treatment including industrial, domestic and drainage. Which have been disseminated not only in Egypt but also in Africa to mitigate the severe water pollution problems. He has supervised 38 PhDs and MSc- students since 2001.

**Prof. Dr. Ahmed Taufik**

**Sustainable Technologies for Safe Conversion of Wastes (Liquid &Solids) into Renewable Resources for Further Use**

**Abstract:** Building of a sustainable society will require reduction of dependency on fossil fuels and lowering of the amount of pollution that is generated. Wastewater treatment and valorization of solid waste is an area in which these two goals can be addressed simultaneously. As a result, there has been a paradigm shift recently, from disposing of waste to using it. Utilization of wastewater and solid waste is an attractive approach for biofuels production. However, the major problems in biofuels production from wastes (wastewater) are the low rates and yields. Developing more efficient processing schemes, optimizing the environmental conditions, improving the reactors' efficiency and developing more efficient bioreactors would overcome such problems. The holistic approach of energy from wastewater (liquid & solids) via wet/dry anaerobic digestion process will make the major bio-waste-producing sectors less dependent on natural energy resources and strongly reduce the impact of wastewater discharges and solid waste dumping into the environment avoiding health risks. This will help to generate employment, social well-being and economic benefits for developing countries.

Dr. Fayyaz Ali Memon is associate professor in Water Engineering at University of Exeter, UK. He has worked at Imperial College London for about 10 years on Sustainable Urban Water Management Systems. In this domain of, he heads a research group with focus on developing countries. He has, to his credit, over 130 publications in peer reviewed journals and refereed international conferences, along with 11 book chapters and 9 co-edited books. He is an associate editor for the British Journal of Environment and Climate Change, member of CIWEM, Chartered Environmentalist, fellow of the UK Higher Education Academy and also a member of the Institution of Civil Engineers.

**Prof. Dr. Fayyaz Ali Memon**

**Modelling Water Energy Food Nexus**

**Abstract:** The presentation describes the development of two domestic and city scale models that capture interactions and implications of water, energy and food consumption and strategies to enhance resilience. The models were tested using consumption behaviors extracted from a survey of over 400 households. These models were integrated and then investigated for established four global scenarios. The results will be discussed within the context of resilience and risk due to seasonal variability.

Dr. Naveed Anwar holds an experience of over 30 years in structural modeling, analysis and design of buildings, bridges and other structures. He is proficient in the development of software for structural engineering applications, including earthquake resistant design, structural detailing etc. Dr. Anwar is teaching academic courses to Masters and PhD students in Tall Buildings, Bridge Design and Advanced Concrete Design at Asian Institute of Technology (AIT). He is the Executive Director of AIT Solutions (AITS), formerly AIT Consulting, established by the Asian Institute of Technology.

**Dr. Naveed Anwar**

**Trends and Advancements for Structural Performance – Lessons learnt from the Performance-based Design (PBD) of 100 Tall Buildings**

**Abstract:** The explicit consideration of performance in recently developed performance-based design (PBD) philosophy has brought a major paradigm shift in the field of structural design and evaluation. It provides a systematic and flexible methodology for assessing the structural performance of a building, system or any component, as opposed to the cookbook type design methods prescribed in building codes. This methodology explicitly evaluates the response of the buildings under the potential seismic hazard while considering different probable site-specific seismic demand levels (Service Level Earthquake (SLE) and Maximum Considered Earthquake (MCE)). For this purpose, various state-of-the-art nonlinear analysis procedures and latest computer modeling tools are used to accurately determine the seismic demands of whole structure and its individual components. This study discusses latest seismic design philosophies and provides an account of recent developments and trends in the modeling, analysis and performance evaluation of high-rise buildings. Based on practical experience obtained from a detailed PBD of 100 buildings, this study also shares some important insights into the nonlinear and dynamic behavior of buildings and provide useful recommendations for their effective design and enhanced structural performance against wind and earthquake loads.

Douglas Barreto is a senior lecturer in the Department of Civil Engineering, University of Sao Carlos, Brazil. He has wide experience in civil engineering construction especially in "Building Systems", "Sustainable Built Environment" with a focus on rational use of water in buildings and alternative energy. He has conducted numerous studies on pathology solutions in building systems in addition to technical work of restoration of historic sites. He has authored several national and international articles on building systems and is also a member of Regional Council of Engineers.

**Dr. Douglas Barreto**

**Urbanization and Environmental Degradation**

**Abstract:** By 2025, more than 85% of total world population will live in cities, i.e. urban areas. This is an important matter to consider now and in the near future, since these cities can be considered as part of built environment. These cities are built from natural resources and consist of buildings, roads, streets, amenities and so on. From this point of view, all incomes used to make cities come from nature. So this huge amount of urban population would utilize natural raw materials for their settlement in urban area. Since the natural resources are limited, and their depletion can cause irreversible consequences on local and as well as global environment. According to ancient philosophy the nature is composed of the four fundamental elements, i.e. "earth", "air", "fire" and "water". This rapid urban growth in terms of civil construction would consume some of these fundamental elements. The construction materials like bricks, sand, cement, iron and so on are derived from "Earth", and are utilized for construction of buildings and ultimately whole cities. The construction activities release pollutants into the air which adversely affects the atmosphere. "Fire" is a source of energy. Since every construction activity require energy, the consumption of energy affects the environment negatively. "Water" is a fundamental need for life, and in the civil construction, it is used during execution, and even afterwards by the end users. So we should take more conscious efforts in building projects and other construction processes. For each kind of these elements, there is a huge list of examples to demonstrate the effect on environment depletion caused by civil construction.

# Date Palm Fiber as Geo Reinforcement Material for Shale

Shabana Ghanghro[1], Aneel Kumar[2], Zaheer Almani[2]

*Post Graduate Student Department of Civil Engineering, Mehran University of Engineering & Technology Jamshoro, Sindh.[1]*
*Department of Civil Engineering, Mehran University of Engineering & Technology Jamshoro, Sindh[2]*

***Abstract*: Construction of structures on weak soil is risky because such soil has low bearing capacity, high compressibility, swelling and differential settlement. For these, type of soil we provide expensive pile foundation, most of time it is not good for economy of project. It is better to go soil reinforcement to improve the strength, bearing capacity and swelling potential of soil. Shale have low bearing capacity. We need to stabilize the soil by additive means or use soil reinforcement by synthetic and natural fiber. Date palm is one of the most cultivated trees on the earth with an overall distribution of around 100 million palms in 30 countries. Date palm fiber, mostly produced in Asian nations, for example, Saudi Arabia, Iraq, Iran, Pakistan, Indonesia and so on. In this research Date Palm fiber is added and mixed by 1%, 2%, 4% and 6% by weight of air-dry shale to investigate fiber reinforcement effect on water density relationship, shear strength parameters and California Bearing Ratio (CBR) of Shale. It could be concluded that Date Palm fiber can be utilized to enhance the unconfined compressive strength of Shale.**

***Keywords*: Date Palm Fiber, Geo reinforcement, Soil improvement, Unconfined Compressive Strength.**

## I. INTRODUCTION

The geo reinforcement materials used to improve the strength and properties of soil. The palm fibers in date creation have filament surfaces with properties, for example, low costs, plenitude in the area, durability, lightweight, tension capacity and relative quality against deterioration [1]. The main advantage of fiber materials as that they are locally accessible and low cost. They are not biodegradable in short term. These fiber materiels especially Date Palm fiber can be improved the rural economy. Date Palm fiber utilized in different application for slopes, embankments, erosion control and bearing capacity of soil [2].
With respect to this concept, this study aims to add date palm fiber in shale to enhance its strength to be utilized as a geo reinforcement material. Precisely, soil is reinforced with date palm fiber at 1%, 2%, 4% and 6% by weight. Quartering method is used to mix date palm fiber and shale. In this study geotechnical properties intend to modify the moisture density relationship, unconfined compressive strength and CBR value and swelling potential. In this study the size of date palm fiber approximately 1 inch used. The sole purpose of selecting shale, it has low bearing capacity, high swelling potential and low compressibility etc. foundation on such soil build on expansive pile foundation to overcome this we can use a date palm fiber to improve the properties of soil.

## II. LITERATURE REVIEW

The fundamental focus on issue is by utilizing different types of natural and synthetic fiber [3]. The soil reinforcement by fibers is one of technique to check the properties of soil. Direct shear test, modified proctor test and California bearing ratio (CBR) test performed on soil by adding four percentages of fiber content (5%, 10%, 15% and 20%). Date palm considered as one of the effective reinforcement materials [4]. The significance of date palm fiber in various industries will be potential other options to synthetic fiber [5]. Use of date palm fibers as alternative has less cost. They use a soil with date palm fiber in the construction of village road. CBR strength of fine sand increases with addition of date palm fiber [6]. They demonstrated that unconfined compression strength of sandy soils can be increased with fiber reinforcement [7]. Natural fiber is biodegradable and hence does not create disposal problems in environment [8]. The study made on silty-sand soil to examine the strength and ductility behavior. Date Palm fiber treatment provided and observed the maximum improvement in the Geotechnical Properties of soil. [9]. Construction of structure on expansive soils are cause problems on foundation of structure. These soils having swelled and shrinkage properties. The effect of fiber analyzed at four different fiber contents of (0.25%, 0.5%, 1% and 1.25%). The Maximum Dry Density (MDD) of fiber balanced out soils continues decreasing and Optimum Moisture Content (OMC) continues increasing with addition of fiber in soil. The outcome demonstrated that expansion of palm fiber increases the ductility and strength of soil. [10]. This study aimed an investigation to examine the fiber reinforcement on Unconfined Compressive Strength of composite soil (i.e. sand composite). Natural fiber has been selected for soil improvement [11].

## III. MATERIALS & METHODS

### *A. Shale*

Jamshoro Shale has low strength, high compressibility and high swelling potential. Most of existing structure in Jamshoro constructed on expansive pile foundation still cracks appear in the structure. So, we need to stabilize a soil by additive means is one of the option or use geo reinforcement materials. In this research, we used a date palm fiber with shale to increase its engineering properties.

### B. *Date Palm fiber*

Date Palm fibers have physical properties such as tensile strength, light weight and cheap rate will make it more efficient to use as soil reinforcement. The date palm fibers are chosen as geo reinforcement material that is commercially available in Hyderabad market. Date palm fiber used 1 inch by length.

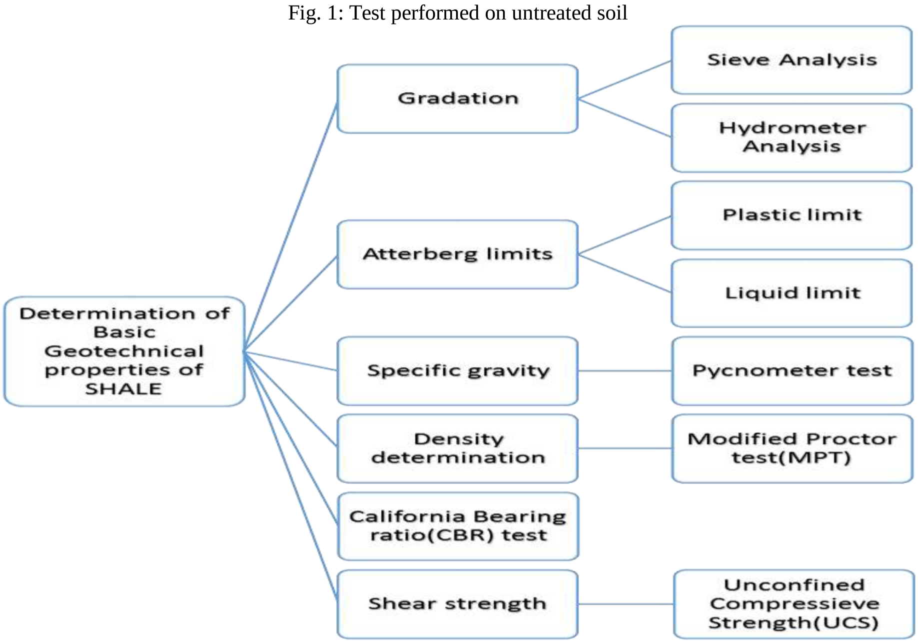
### C. *Methodology*

In total, twelve reinforcement combinations and one untreated sample investigated to evaluate the effect of date palm fiber on water-density relationship, unconfined compressive strength, CBR value and swelling potential. Fig 1 shows the flow chart used to determine the basic Geotechnical properties of shale soil. Fig 2 used to determine the properties of shale soil with addition of Date Palm fiber percentages. Table 1 shows the various codes and standard followed in this research to perform the laboratory testing.

Table 1: Various codes & standards followed in laboratory testing

| PROPERTY | •CODES/STANDARD |
|---|---|
| Natural Moisture Content | •AASHTO T 265, ASTM D 2216. |
| Classification | •AASHTO T87,88.ASTM D 421,422, 2217 |
| Liquid Limit | •AASHTO T89.90.ASTM D-4318. |
| Plastic Limit | •AASHTO T89.90.ASTM D-4318. |
| Plasticity Index (P.I) | •AASHTO T89.90.ASTM D-4318. |
| Dry Density (maximum) | •AASHTO T 180,ASTM D-1557 |
| OMC | •AASHTO-T 265, ASTM D 2216. |
| CBR | •AASHTO T 193,ASTM D 1883 |
| Unconfined Compressive Strength(UCS) | •ASTM D2166 , AASHTO T 208 |

Fig. 1: Test performed on untreated soil



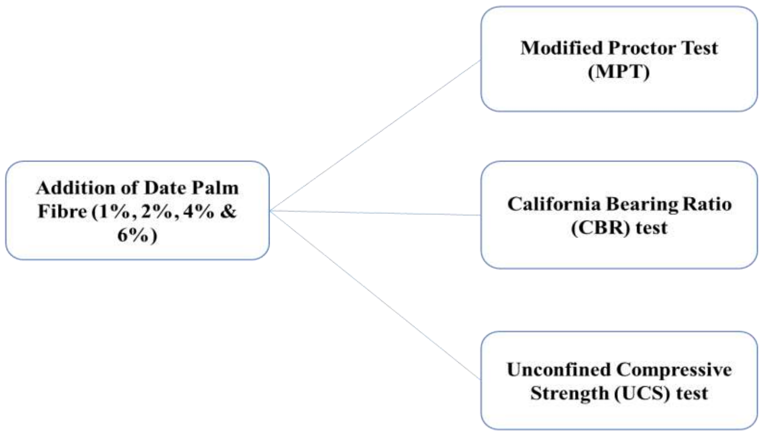



Fig. 2: Test performed with addition of Date Palm fiber

## IV. RESULTS

### *A. Soil Classification*

Soil classification two test performed to know the type of soil. Gradation, consistency limit of untreated soil can be computed by sieve analysis, hydrometer analysis, liquid limit and plastic limit. The index properties of untreated Shale were shown in Table 2. The color of soil sample is yellowish. It has been observed that the soil is A-7-5 group according to American Association of State Highway and Transportation Officials (AASHTO).

Table 2: Basic Geotechnical Properties of Shale

| Characteristics | Value |
|---|---|
| Colour | Yellowish |
| Gravel | 10% |
| Clay | 38% |
| Slit | 52% |
| Specific Gravity | 2.47 |
| Plastic Limit | 43 |
| Liquid Limit | 75 |
| Plasticity Index | 32 |
| Group | A-7-5 |
| Dry Density | $1.64 g/cm^3$ |
| UCS | $5.3 kg/cm^2$ |
| CBR(Un-soaked) | 36.96% |
| CBR(soaked) | 1.43% |

### *B. Modified Proctor Test*

Modified proctor test (MPT) performed to evaluate the effect of Date Palm fibre on Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of “SHALE”. The Dry Density of “SHALE” decreases with addition of Date Palm Fibre whereas OMC does have significant effect with increase of Date Palm fibre content.

### *C. California Bearing Ratio Test*

California Bearing Ratio (CBR) test performed to determine the strength and swelling potential of “SHALE”. A series of soaked and un-soaked CBR test evaluate the effect of Date Palm Fibre on bearing value and swelling potential. From the test result of CBR was observed decrease with addition of Date Palm Fibre in un-soaked and soaked condition

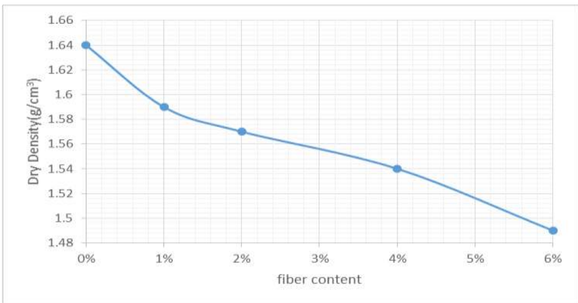



Fig. 3: Addition of date palm fibers decrease the dry density of "shale"

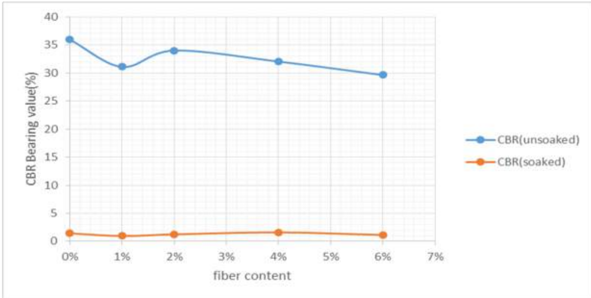



Fig. 4: CBR of shale decreases with addition of Date Palm fibre content

### *D. Unconfined Compressive Strength Test*

For shear strength parameters, Unconfined Compressive Strength (UCS) test performed to know the strength of "SHALE". It was observed that Unconfined Compressive Strength of "SHALE" increases with addition of Date Palm Fibre.

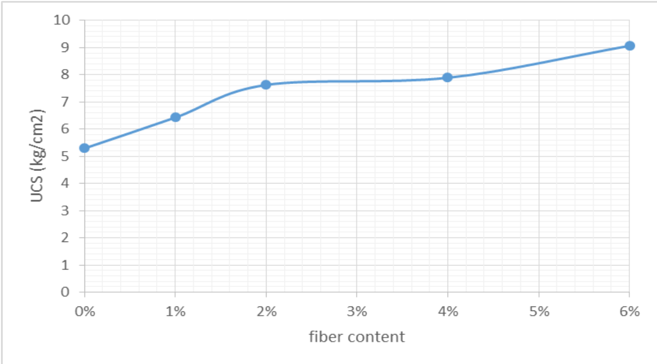



Fig. 5: Unconfined compressive strength of shale increase with addition of date palm

## V. CONCLUSION

The influence of date palm fibers for geotechnical properties of shale were present in this research are as follows.

- The modified proctor test was observed with addition of date palm fibers content maximum dry density of shale decrease because of light weight.
- It was concluded that the bearing value of CBR was decrease with addition of date palm.
- The unconfined compressive strength of shale increases with addition of date palm fibers.
- The date palm fibers effectively utilized to improve UCS of the Shale.

## VI. RECOMMENDATIONS

- The study demonstrates the effect of date palm fiber on geotechnical properties of jamshoro soil (Shale).
- It is recommended that similar research shall be conducted on other type of soil.
- The research shall also be conducted to know the influence of date palm fiber on other parameters of soil, like consolidation, drained and un-drained shear strength.

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# Enhancing the Concrete Tensile Strength by Using Soft Drink Tins

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***Abstract*— Concrete plays an important role in construction world. It has more compressive strength and is not enough to withstand the tensile force. This research study is to examine the tensile strength performance of concrete with addition of some percentage of fiber by weight of cement. Usually, the fibers are added to increase the crack resistance and tensile strength. In this research study thirty (30) cylinders were cast using concrete DoE mix design method at 1: 1.69: 3.15 at 0.54 w/c ratio. The cylinders were cast by utilizing a different amount of fiber i.e. 1% 2% and 3% by weight of cement using 12.7mm, 25.4mm and 38.1mm long strips of soft drinks tins respectively. The results showed that with increase the percentage and size of fiber in concrete, the concrete workability was reduced and tensile strength of fiber reinforced concrete (FRC) significantly increased. The maximum value of tensile strength, i.e. 27.3 % more than the controlled specimen was achieved at 38.1 mm long strip and 3% of fiber sample.**

***Keywords*— Concrete, Fiber, Tensile Strength and Workability**

## I. Introduction

Concrete is an artificial stone, used for various structural purposes. It is made by mixing cement and various aggregates, such as sand, pebbles, gravel, shale, etc., with water and allowing the mixture to harden by hydration [1].

Concrete has a wide range of application from small main holes to roads, sidewalks, houses, bridges, skyscrapers, pipes, dams, canals, missile silos, and nuclear waste containment. It is strong and durable material. Concrete is friendly to the environment. It's recyclable. Due to its numerous advantages, its production is around a ton per person per year on earth [2]. By weight, one-half to two-thirds of our infrastructures are made of concrete such as: roads, bridges, buildings, airports, sewers, canals, dams, and subways [2].

Use of admixtures to concrete has long been practiced since 1900 [3]. In the early 1900s, asbestos fibers were used in concrete, and in the 1950s the concept of composite materials came into being and fiber reinforced concrete was one of the topics of interest [4]. By 1960s, steel, glass (GFRC) and synthetic fibers such as polypropylene fibers were used in concrete, this research of adding materials in concrete to enhance its properties is continue today [4].

Concrete in general is weak in tensile strength and strong in compressive strength. The main aim of researchers of concrete technology is to improve the tensile strength of concrete. To overcome this serious defect, partial incorporation of fibers is practiced. Great quantities of steel waste fibers are generated from industries related to lathes, empty beverage metal cans and soft drink bottle caps. This is an environmental issue as steel waste fibers are difficult to biodegrade and involves processes either to recycle or reuse [4]. Fiber reinforced concrete is an interesting topic discussed by numerous researchers [5,6]in the last two decades. The aim of research is to utilize the small pieces of soft drink tins in concrete to enhance the tensile strength of concrete. The purpose of this work is to recycle or reuse a waste product in to concrete to enhance its mechanical properties.

## II. Literature Review

R. Kandasamy and R. Murugesan [1] studied the influence of addition of polythene fibers (domestic waste plastics) at a dosage of 0.5% by weight of cement on compressive and flexural strength. The studies were conducted on a M20 mix. It was concluded that, compressive strength at 7 days was increased to 0.68%, at 28 days, 5.12% and 1.63% increment of splitting tensile strength at 28 days. Also, various other properties were increased.

Many studies had been conducted on enhancing the mechanical properties like compressive strength, splitting tensile strength and toughness index improved with utilization of tin fibers composition. A study found that the splitting tensile strengths increased by 98 % at 2 % steel fiber volume fraction while the modulus of rupture increased by 126 % [7]. It has been noted in a research that, the ductility of steel fiber reinforced concrete (SFRC) increase when the fibre content and its length is increased. It is also concluded that due to the bridging effect of fibres, the cubes during testing did not crush but held up their integrity until the end of the test [8,9].

Amit Rai and P Joshi [10] reported that fiber reinforced concrete (FRC) is an effective to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar. Steel fibers can improve the structural strength and cause reduction of compression steel in concrete. Moreover, freeze thaw resistance of the concrete is improved. Polypropylene and Nylon fibers are used to improve impact resistance.

A.M. Shende et. al. [11] introduced steel fibres of 50, 60 and 67 aspect ratios (l/d). Obtained results were analyzed and compared with a control specimen (0% fibre). A relationship between aspect ratio vs. Compressive strength, flexural strength and split tensile strength were found & represented graphically. It is observed that compressive strength, split tensile strength and flexural strength are on higher side at 3% fibres. All the strength properties are observed to be on higher side for aspect ratio of 50 as compared to 60 and 67. It is observed that compressive strength increases from 11 to 24% with addition of steel fibres. In this research the soft drink tins are utilized as reinforcement in concrete. The recycling and bio degrading of steel waste material is difficult. Preservation of environment and conservation of rapidly diminishing natural resources should be essence of sustainable development. Soft drink tins are the substitute for fibers and added to enhance the mechanical properties of concrete, including tensile strength and density. Soft drink tin fibers are used in different percentages and sizes as 1%, 2%, 3% and 12.7 mm, 25.4 mm and 38.1 mm respectively, to make fiber reinforced concrete.

## III. MATERIAL PROPERTIES

### *A. Cement*

Ordinary Portland cement (commercially available as falcon cement) was used in this research. The standard consistency is approximately laying between the ranges of 27% to 28%. While the initial setting and final setting time is 40 minutes and 144 minutes respectively. The specific gravity of cement is found to be 3.14. The Fineness value of OPC cement was 320 $m^2$/kg.

### *B. Aggregates*

The coarse and fine aggregate was obtained from the Bolhari pit near Karachi, Sindh, Pakistan. Coarse aggregate pebbles of maximum 10 mm size were used for concrete. The Specific gravity, Fineness modulus, Water absorption and Unit weight (Bulk Density) was found as 2.66, 6.94, 1.38% and 1562 Kg/$m^3$espectively.
Fine aggregates were conforming to zone-III. The fineness modulus, specific gravity, bulk density and water absorption was found during material testing as 2.49, 2.61, 1641 Kg/$m^3$ and 1.38% respective.

### *C. Soft Drink Tins*

The metallic waste of soft drink tins obtained from various sources was utilized as fiber. The top and bottom cover of the tin was removed before using. After removal of covers, tins were thoroughly washed with clean water and dried properly. In order to increase the friction, tins were scratched with the wire brush. The tins finally cut in different sizes i.e. 12.7 mm x 12.7 mm, 12.7 mm x 25.4 mm and 12.7 mm x 38.1mm. These fibers are added into the concrete with 1%, 2%, and 3% by weight of cement.

## IV. RESEARCH METHODOLOGY

Concrete mix design was aimed for 30N/$mm^2$ at 28 days as per British DoE mix design method. To obtain the required strength, the mix design ratio was determined as 1:1.69:3.15 at 0.54 w/c ratio. The workability test by the slump cone method was conducted on freshly prepared concrete. In this research 30 cylinders of size 101.6 mm x 203.2 mm were prepared using the standard moulds to compute the tensile strength of concrete. Among 30 cylinders, 3 cylinders were made with control concrete and remaining 27 were made of fiber reinforced concrete. Moreover, among 27 cylinders, 9 cylinders were made using 1%, 2% and 3% of fiber. In each category of 9 cylinders, three different sizes of fibers adopted as 12.7 mm x 12.7 mm, 12.7 mm x 25.4 mm and 12.7 mm x 38.1 mm. Furthermore, the description of specimens is given in Table 1.

After casting the cylinders were kept in water tank for 28 days curing. After the curing specimens were tested for splitting tensile strength in Universal Testing Machine (UTM).

Fig.1. Soft drink tins fiber added to concrete

## V. TEST RESULTS AND DISCUSSION

The experimental results are determined by taking the average of three cylinders. The results of various tests are explained below.

### *A. Workability*

As Per BS EN 12350-2 [12] this test is useful to measure the consistency of concrete and change the concrete ingredients into uniform mix [12,13]. The workability of control and fiber made mixes was computed by the slump cone test method. The workability test results of all concrete mixes are summarized in Table 2. The results showed that the slump of fiber made mixes is decreasing than control mix with the increase in size and percentage of fiber used. The workability of fiber made mixes might be decreased due to non-uniformly distributed fibers, fibers inter locking and entangle around aggregate particles.

TABLE.1. DETAILS OF SPECIMEN

| NO. | Type of mix( size and percentage of fiber | Number of cylinders cast | Total number of cylinders cast |
|---|---|---|---|
| 1. | Controll mix | 3 | 3 |
| 2. | 12.7 mm size and 1% fiber | 3 | 9 |
| | 12.7 mm size and 2% fiber | 3 | |
| | 12.7 mm size and 3% fiber | 3 | |
| 3. | 25.4 mm size and 1% fiber | 3 | 9 |
| | 25.4 mm size and 2% fiber | 3 | |
| | 25.4 mm size and 3% fiber | 3 | |
| 4. | 38.1 mm size and 1% fiber | 3 | 9 |
| | 38.1 mm size and 2% fiber | 3 | |
| | 38.1 mm size and 3% fiber | 3 | |

TABLE 2. TEST RESULTS OF SLUMP

| NO. | Mix design ratio | W/C Ratio | Type of mix( size and percentage of fiber | Slump value (mm) |
|---|---|---|---|---|
| 1. | 1:1.6:3.15 | 0.54 | Controll mix | 18 |
| 2. | 1:1.6:3.15 | | 12.7 mm size and 1% fiber | 17 |
| | | | 12.7 mm size and 2% fiber | 15 |
| | | | 12.7 mm size and 3% fiber | 6 |
| 3. | 1:1.6:3.15 | | 25.4 mm size and 1% fiber | 16 |
| | | | 25.4 mm size and 2% fiber | 13 |
| | | | 25.4 mm size and 3% fiber | 5 |
| 4. | 1:1.6:3.15 | | 38.1 mm size and 1% fiber | 12 |

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | 38.1 mm size and 2% fiber | 7 |
| | | | 38.1 mm size and 3% fiber | 5 |

*B. Tensile Strength*

Tensile strength is a major property of concrete. This was measured by casting small scale cylinders and tested in UTM. The tensile strength test results of all the concrete cylinders are summarized in Table 3. The result shows that, cylinders with fibers have shown significant enhancement in their tensile strength.

TABLE 3. TEST RESULTS OF CYLINDERS FOR TENSILE STRENGTH

| NO. | Type of mix( size and percentage of fiber | Tensile strength (MPa) | Density (Kg/m$^3$) |
|---|---|---|---|
| 1. | Controll mix | 3.26 | 2429 |
| | 12.7 mm size and 1% fiber | 3.27 | 2364 |
| 2. | 12.7 mm size and 2% fiber | 3.27 | 2384 |
| | 12.7 mm size and 3% fiber | 3.42 | 2366 |
| | 25.4 mm size and 1% fiber | 3.65 | 2382 |
| 3. | 25.4 mm size and 2% fiber | 3.75 | 2358 |
| | 25.4 mm size and 3% fiber | 3.87 | 2384 |
| | 38.1 mm size and 1% fiber | 3.90 | 2386 |
| 4. | 38.1 mm size and 2% fiber | 3.99 | 2423 |
| | 38.1 mm size and 3% fiber | 4.15 | 2372 |

It was observed that by increasing the size and percentage of fiber by weight of cement, the tensile strength significantly increases. This may be the reason that the failure of plain concrete is caused by mortar (sand + cement) failure. The bond between mortars with fiber in fiber reinforced concrete is stronger than that of plain concrete.

Also, Table: 3, summarized the average values of unit weight or density (Kg/m$^3$) of all the mixes determined at the time of the testing of the specimens for tensile strength. The unit weight of fiber made mixes was found lesser than controlled concrete mixes. Hence, the unit weight of FRC which was made with soft drink tins strips was not considered as main factor.

## VI. CONCLUSION

In this research, soft drink tins are utilized in concrete as fiber to make FRC. Based on the experimental study conducted, following conclusion are drawn.

- Workability of FRC mixes was decreased gradually with increase in the percentage and size of the fiber over control concrete mix.

- FRC mixes gives better tensile strength than that of control concrete mix at 28 days. With the increase in the percentage and sizes of fiber the tensile strength increases of fiber made concrete mixes over control concrete mix. At higher percentage and size of fiber the tensile strength was increased approximately 27.3% more than control mix concrete.

- Finally, the experimental study showed that with the increase in size and percentage of the fiber the workability of FRC mixes decreases and the tensile strength increased than control concrete mix.

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# Stabilization of Jamshoro Soil with Lime

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***Abstract*: The geology of Jamshoro soil (being expansive soil which expands when wet and contracts on drying) posing serious problem of deformation and rutting on superhighway which is running through the vicinity of Jamshoro. This paper describes the influence of lime content on geotechnical properties of Jamshoro soil. The soil was collected from Jamshoro and then mixed to obtain the homogeneous characteristics and then mixed with lime content of different proportions that was 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12% by dry weight of soil. For every lime-soil mixture optimum moisture content were obtained by utilizing the particular OMC. The effect of lime content on unconfined compressive strength, California bearing ratio, and swelling potential were then observed. The results show that mixing of lime content in the soil increased the unconfined compressive strength, improved the CBR value in un-soaked and soaked conditions, and decreased the swelling potential. It is also observed that the lime content of 8% is sufficient to achieve desirable unconfined compressive strength, California bearing ratio (CBR) value, and lowest swelling for a sub grade material.***

***Keywords*: California Bearing Ratio, Jamshoro soil, Lime content, Unconfined Compressive Strength.**

## I. INTRODUCTION

Jamshoro city is known as Educational hub because three major universities lie in this region. Superhighway is a main highway which connects Karachi with north of Pakistan. This highway is busy highway in Pakistan. Superhighway nearly to be turned into Motorway (M-9), it means this motorway is under construction has length of about 136 km with 6 lanes. The soil in the vicinity of Jamshoro causing rutting problems and excessive deformation in Superhighway. Therefore, it is unsafe to use directly local soil of Jamshoro as a subgrade. Now it becomes necessary for Jamshoro soil to be improved before construction of any structure specially highway, because highway is under repetitive loading [14].

The soil of Jamshoro is expansive soil which expands when moisture content increases and contracts when it becomes dry. This change in volume is responsible for loss in CBR value and increase in swelling potential. Subgrade of this type of soil should not be used directly but should be stabilized so that California bearing ratio for subgrade should be more than 10 in both conditions and swelling potential should be less than 10% [15].

The improving of geotechnical properties of soil by applying various methods is known as soil stabilization. The soil can be stabilized by compaction and drainage and other is by using certain admixtures. Many researchers used different chemicals like cement, lime, fly ash, lime and cement etc. to alter the geotechnical properties of soil. This research aimed to use hydrated lime as a stabilizer. Stabilizer is selected on the basis percent passing the No.200 and the plasticity index of soil. Soil with at least 25% passing the No.200 sieve and having a plasticity index greater than 10 can be stabilized using this method [8]-[15]. The result of sieve analysis of this soil of percent passing the No.200 was 61.12% and PI determined was 31. In this regard percent passing No.200 was greater than 25% and PI was also greater than 10. Therefore, hydrated lime can be used as a stabilizer in this research. Amount of lime may be used by keeping in view unconfined compressive strength or CBR criteria. Normally 2 or 8% of lime may be required for coarse grained soils and 5 to 10% for plastic soils. Percent passing of No.200 sieve of this soil is more than 50% therefore it is categorized as fine-grained soil. It means optimum lime content should be fewer than 10% [10,11].

The proportions of lime used in this research were 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12% by dry weight of soil. Laboratory tests conducted were modified proctor test, consistency limits, CBR in both conditions, swelling potential, and unconfined compressive strength test. Optimum lime content was mainly decided by studying the results of CBR in both conditions, swelling potential, and unconfined compressive strength by maintaining the optimum moisture content and maximum dry density from modified proctor test.

## II. MATERIALS & METHODS

### A. Soil used in the research

The soil used in this research was expansive soil. Expansive soil means the soil which expands when comes in contact with moisture and contracts when it becomes dry. Due to this expansion and contraction volume changes which poses the problems of uneven settlements, rutting in the highways, and damages to the structures etc. The soil was collected by excavating the pit of 3ft in depth having 3.5ft rock above. The soil was collected from the distance of 55ft from the check post which is situated near the Civil engineering department of Mehran University of Engineering and Technology, Jamshoro, Sindh, Pakistan. Index properties of Jamshoro soil were determined which are given in Table.2
Jamshoro soil used in the study is shown in Fig.1

### B. Hydrated Lime

The lime used in this research was purchased from the local shop in Hyderabad city, Sindh, Pakistan. In this study hydrated lime was used for the stabilization of Jamshoro soil. Different quantities of lime used in the study shown in Table.1
Fig.2 shows lime used in the study.

### C. Water

Water used in this research was free from every type of contaminations. Because literature suggested for using the water which should be free from alkalis, salts, organic materials, acids, and oils etc.

Table 1: Different quantities of lime used in research

| Mix No. | Hydrated Lime (%) by dry weight of soil |
|---|---|
| 1 | 0 |
| 2 | 1 |
| 3 | 2 |
| 4 | 4 |
| 5 | 6 |
| 6 | 8 |
| 7 | 10 |
| 8 | 12 |

Table 2: Index properties of Jamshoro soil

| Parameter | Value | Parameter | Value |
|---|---|---|---|
| Natural moisture content | 8% | AASHTO Classification | A-7-6 |
| Liquid limit | 70% | Free swell in water | 35.49% |
| Plastic limit | 39 | Free swell in kerosene | 10% |
| Plasticity index | 31 | Fine grained (-#200) | 61.12% |

Fig 1: Jamshoro soil used in study

Fig 2: Hydrated lime

### D. Methodology

All the specimens required for the different tests were prepared and being tested according to the codes and standards. The preparation and testing of specimens were made in the Geotechnical Engineering Laboratory, Mehran university of Engineering and Technology, Jamshoro, Sindh, Pakistan. Soon after the mixing of soil and lime, modified proctor test was performed for each mix and optimum moisture content was obtained for each mix. Then all the required tests were performed for each mix by keeping in view the modified proctor results. Following tests were conducted.

*E. Atterberg limits tests*

The PL, LL and PI were obtained by following the method given in ASTM D 4318-00. The change occurred in untreated and treated soils were then studied. The PL tests were performed on material prepared for the LL test. Both LL and PL tests were performed at room temperature [1].

*F. Compaction tests*

Compaction tests were performed for each mix according to the Modified Proctor test (ASTM D 1557-91) to determine the maximum dry density and optimum moisture contents. Amount of lime content used were 1%, 2%, 4%, 6%, 8%, 10%, and 12%.

*G. California Bearing Ratio and CBR Swelling tests*

CBR value is extensively used in the pavement courses. It is very important test to compute the strength of soils. CBR tests were conducted according to the (ASTM D1883) by utilizing the optimum moisture content. CBR was calculated in both conditions (un-soaked and soaked). For un-soaked condition test was performed soon after compaction. For soaked CBR samples have been tested after being soaked in water for 96 hours. The soaked condition is performed to assume the behavior of subgrade under heavy rainfall or flooded situations. In this research samples were compacted to a maximum dry density at the OMC determined by modified proctor tests. CBR swellings were also determined for all mixes. Because swelling relates to the change in volume of subgrade, therefore it is important to study swelling behavior of soil used for subgrade of road [3]-[6].

*H. Unconfined Compressive Strength tests*

Soon after compaction, the specimens were tested at the OMC. All specimens were subjected to the unconfined compressive strength test in accordance with the ASTM D2166 [2].

## III. RESULTS

*A. Effect of lime on Atterberg limits of Jamshoro soil*

Fig.3. shows the effect of lime content on liquid limit and plastic limit. With the replacement of lime content, the liquid limit is increasing then fluctuates. By the replacement of lime content 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12%, the liquid limit obtained was 70%, 80%, 83%, 82%, 81%, 82%, 80%, and 83% respectively.

With the replacement of lime content, the plastic limit increases then fluctuates. By the replacement of lime content 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12%, the plastic limit obtained was 39%, 48%, 53%, 54%, 67%, 72%, 69%, and 67% respectively.

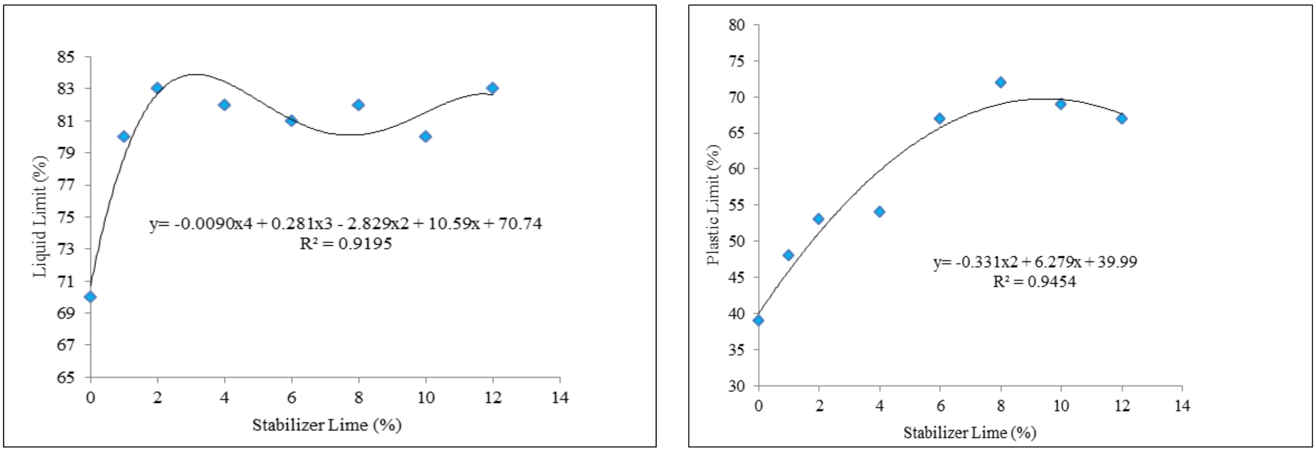



Fig 3: Effect of lime on liquid limit and plastic limit of Jamshoro

Fig.4shows the effect of lime content on plasticity index (%). With the replacement of lime content, the plasticity index decreases up to 10% then fluctuates. By the replacement of lime content 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12%, the plasticity index obtained was 31%, 32%, 30%, 28%, 14%, 10%, 11%, and 16% respectively.

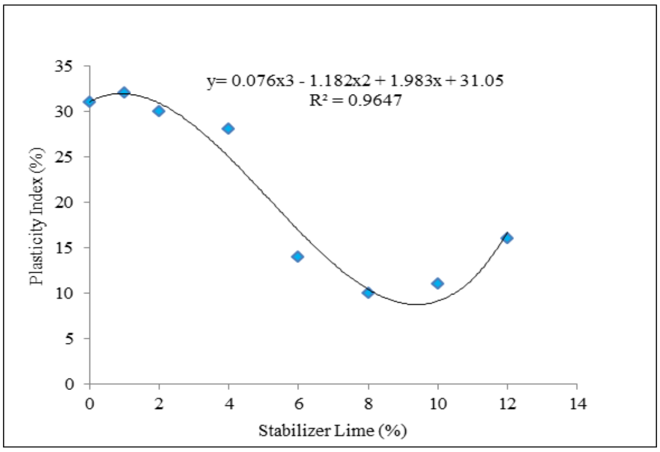
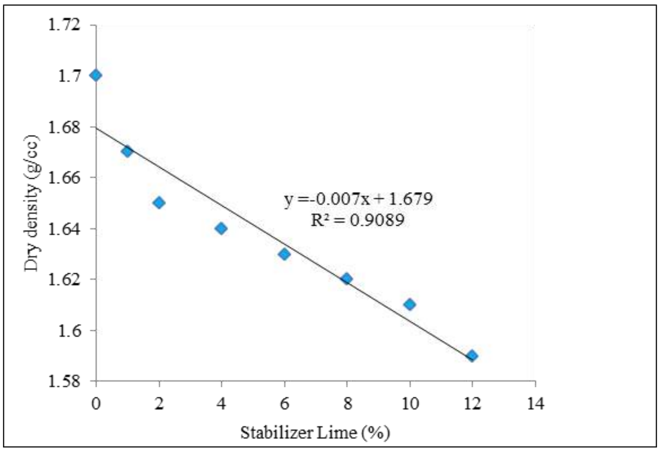



Fig 4: Effect of lime on plasticity index of Jamshoro soil

### B. *Effect of lime on compaction tests*

Fig.5 shows the effect of lime on maximum dry density and optimum moisture content. With the replacement of lime content, the γdmax was decreasing. By the replacement of lime content 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12%, the γdmax obtained was 1.70 g/cc, 1.67 g/cc, 1.65 g/cc, 1.64 g/cc, 1.63 g/cc, 1.62 g/cc, 1.61 g/cc, and 1.59 g/cc respectively.

With the replacement of lime content, the OMC was increasing. By the replacement of lime content 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12%, the OMC obtained was 18.22%, 18.55%, 18.77%, 18.95%, 19.31%, 20.93%, 21.36%, and 22.24% respectively.



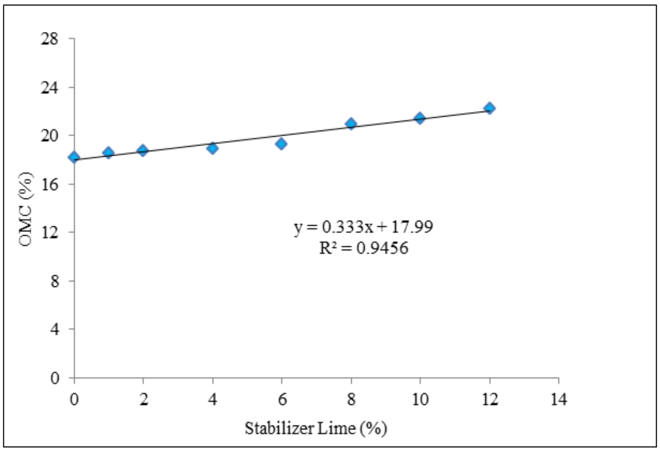
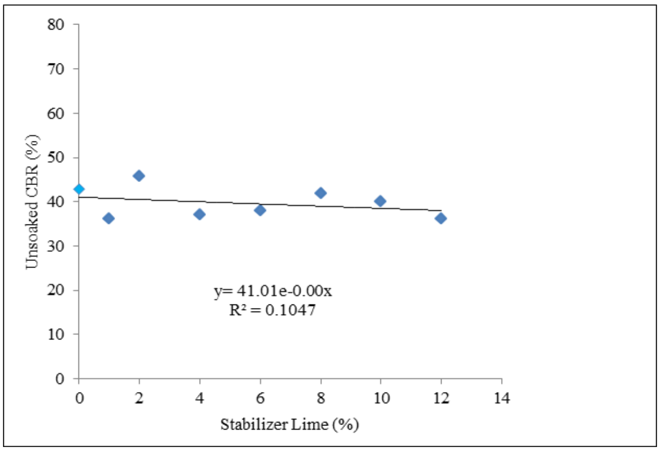




Fig 5: Effect of lime on maximum dry density and optimum moisture content of Jamshoro soil

### C. *Effect of lime on California Bearing Ratio and CBR Swelling tests*

Fig.6 shows the effect of lime content on un-soaked and soaked CBR. With the replacement of lime content, the un-soaked CBR shows almost constant behavior. By the replacement of lime content 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12%, the un soaked CBR obtained is 42.86 %, 36.19%, 45.71%, 37.14%, 38.10%, 41.90%, 40.00%, and 36.19% respectively.

With the replacement of lime content, the soaked CBR increases up to 10% and then decreases. By the replacement of lime content 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12%, the soaked CBR obtained is 1.43%, 3.93%, 4.29%, 15.24%, 28.57%, 40.00%, 45.71%, and 40.00% respectively.



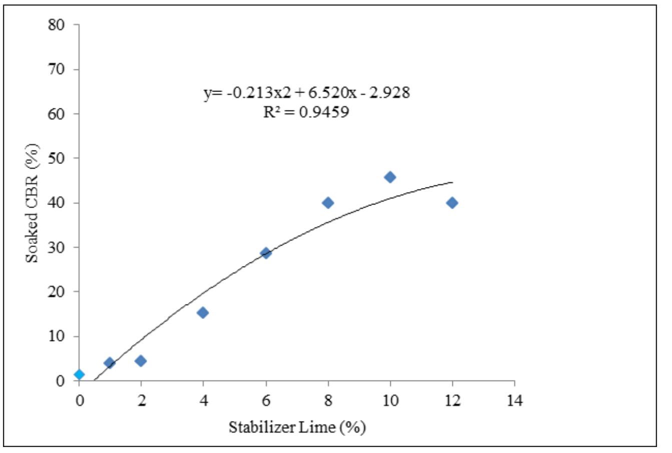



Fig 6: Effect of lime on un-soaked and soaked CBR of Jamshoro soil

Fig.7 shows the effect of lime content swelling characteristic. With the replacement of lime content, the swelling increases and then fluctuates (10.9 for 0% lime and minimum was observed 8.83 for 8% lime). By the replacement of lime content 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12%, the swelling obtained is 10.90 %, 11.78%, 12.48%, 14.11%, 11.83%, 8.83%, 11.72%, and 12.30% respectively.

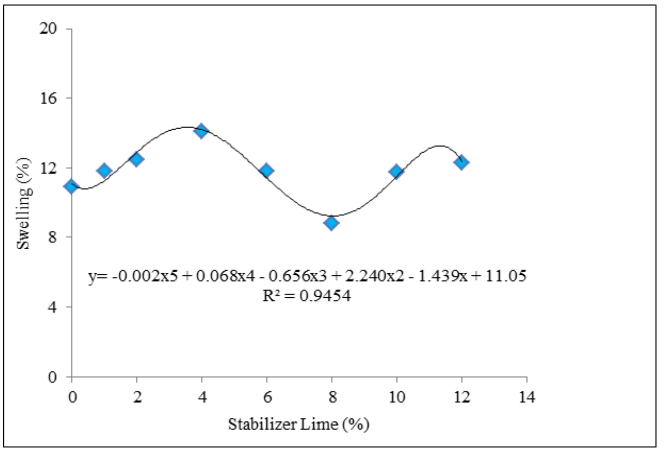



Fig 7: Effect of lime on swelling % of Jamshoro soil

## D. *Effect of lime on Unconfined Compressive Strength tests*

Fig.8 shows the effect of lime content on UCS (Kg/cm$^2$).With the replacement of lime content, the UCS is decreasing. By the replacement of lime content 0%, 1%, 2%, 4%, 6%, 8%, 10%, and 12%, the UCS obtained is 5.84 Kg/cm$^2$, 6.81 Kg/cm$^2$, 5.65 Kg/cm$^2$, 5.38 Kg/cm$^2$, 5.10 Kg/cm$^2$, 5.40 Kg/cm$^2$, 4.57 Kg/cm$^2$, and 4.30 Kg/cm$^2$ respectively.

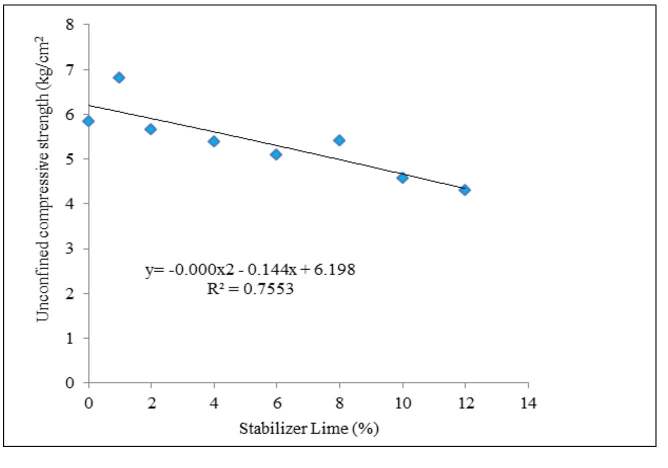



Fig 8: Effect of lime on unconfined compressive strength of Jamshoro soil

Sub grade is an important part of the pavement to carry the loads which transfers from the series of layers. Sub grade must be strong enough to support the heavy loads transmitted from the pavement structure. Sub grade performance depends upon the two characteristics; load bearing capacity which relates to CBR (≥10) and volume change of the sub grade which relates to swelling potential [15]. Minimum CBR of 10 is required to support the heavy loads and repetitive loading without excessive

deformation. In this study this value of required CBR in both un-soaked and soaked conditions was achieved at 4% lime content but desired value for swelling potential was obtained at 8% lime content.
By observing the above-mentioned facts:
8% lime content may be considered as the optimum for the stabilization of Jamshoro soil as a sub grade material for lime stabilization.

## IV. CONCLUSION

The experimental study was conducted to examine the effect of hydrated on water density relationship, Atterberg limits, unconfined compressive strength, California bearing ratio (CBR), and swelling potential of Jamshoro soil. Following are the conclusion made from this study.

- Up to 12% lime content optimum moisture content increased from 18.22% for 0% lime content to 22.24% for 12%LC. While maximum dry density was decreased from 1.70 g/cc for 0% lime content to 1.59 g/cc for 12% lime content, which suggests that if lime is mixed in the soil more compaction efforts may be needed to achieve a required degree of compaction.
- The plasticity index was decreasing with the mixing of lime content to the soil from 31% for 0% lime content to 10% for 8% lime content then fluctuates.
- By mixing lime content in the soil there is slight increase in unconfined compressive strength (at 2%LCC=6.81 kg/cm), then decreased.
- Mixing of lime content in the soil improved CBR in both un-soaked and soaked conditions. The maximum value in un-soaked condition was obtained (with 2% lime content=45.71%). The maximum result in soaked condition was achieved (at 10% lime content=45.71%).Un-soaked CBR remained higher than soaked CBR up to 8% lime content. While with higher lime content (more than 8%), the soaked CBR remained higher than un-soaked CBR.
- Mixing of lime in the soil affects the swelling potential which initially increased then decreased. The least swelling potential was found (at 8% lime content=8.83%).

In the end it was concluded that 8% lime is sufficient to achieve the desirable material for subgrade.

## ACKNOWLEDGMENT

Author is thankful to the Mehran University of Engineering and Technology, Jamshoro, Sindh, Pakistan for their technical support.

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# Urban Metabolism Approach Incorporating Renewable Energy Resources in the City of Gwadar: The Context of CPEC

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***Abstract*: Pakistan being rich in solar irradiations is reported as one of the most appropriate regions to manage its energy requirements. Utilization of fossil fuel as an energy resource has the major contribution in the electrical system of Pakistan, with an energy deficit of 4000-6000 MW so far and this figure may accelerate in the coming decades due to substantial increase in demographic statistics and international investment focusing China Pakistan Economic Corridor (CPEC) surrounding regions. The eye catching Gwadar port in the Balochistan province will consequently may face inevitable growth, with high projected energy demands and urbanization. Urban metabolism approach can be incorporated in the development plan of Gwadar city by using the methods of ecological network analysis and energy flow analysis. After a comprehensive review of literature about the successful implementation of Urban Metabolism in the major cities of Asia, Europe and United States, it is concluded that these methods aim to forecast and manage the energy requirements of the residential, industrial, transportation, ICT and commercial sectors by utilizing the available resources in the pursuit of satisfying predicted energy demands for the port city Gwadar. This approach can not only incentivize the foreign investment but it can also influence environmental sustainability in the region.**

***Keywords*: Sustainable city planning, Urban metabolism, Sustainable energy, CPEC.**

## I. INTRODUCTION

Availability of appropriate amount of energy has a vital role in the development of urbanization to satisfy the energy requirements for technological systems, infrastructure development, transportation, buildings and industries. Pakistani electrical system is already facing an energy shortage of 4000-6000 MW and the significant increase in population demands for more energy production. It is forecasted and assumed that the inauguration of CPEC can bring a tremendous growth in the fluctuating Pakistani economy. The main objective of this study is to plan and manage the resources availability necessary towards the sustainable development of Gwadar city. This can be achieved by realizing the significance and implementing the comprehensive Urban Metabolism model. The proposed model can be adopted by the city planners, engineers, architects, environmentalists, energy experts, in order to design and optimize the availability of required energy, carbon reduction and waste management by utilizing Gwadar's own natural resources to manage the CPEC project development in a sustainable way. The CPEC has attracted the attention of global investors to launch residential, commercial, industrial and technological projects in the regions surrounding the Gwadar Port but the availability of energy has raised certain concerns required for the execution of these projects. According to energy year book 2015-16 published by Hydrocarbon Development Institute of Pakistan, share of natural resources in energy production are 31% Oil, 47% Natural Gas, 11% Hydro, 1 % Nuclear, 1 % LPG and 9% Coal [1]. It is estimated that a system based on fossil fuel releases twenty one billion metric tons of carbon dioxide in the atmosphere globally [2]. In order to overcome the hazards and risks associated with the sustainability of energy resources and carbon emissions, the alternate solutions should be incorporated in managing the energy requirements of Pakistani cities. To promote rapid development in the community based on urbanization, the phenomenon of autonomous management of resources has been adopted by the contemporary societies. When there is specifically the discussion of energy, communities look into their geographical location and the available resources to satisfy the needs of the community [3]. Based on these facts, it is necessary for the communities to figure out the potential resources that can be utilized to satisfy the needs and requirements, therefore, in depth analysis of available resources is required in determining the possible constraints in their utilization[4]. In order to perform such analyses for the proper utilization of available energy resources in a community, the phenomenon of UM is adopted.

The paper further progresses with the comprehensive information about the urban metabolism in the section II. Section III of this paper is about the potential of renewable energy resources with in an urban system. The case of the Gwadar city under CPEC is discussed in section IV and section V concludes the overall study with limitations, implications and future research possibilities.

## II. URBAN METABOLISM

The term UM can be defined as, "The sum of all socioeconomic and technical processes that take place with in cities leading to energy production, growth and removal of waste" [5]. Over the time, the term is often referred to develop an energy and material flow of cities but the scope of its implementation is limited for the renewable energy resources so far, therefore, neglecting the sustainable nature of renewable energy resources, the overall circular metabolic process of a community may not maps the real essence of UM. The incorporation of renewable energy resources in the energy systems may not be restricted to national and provisional renewable energy based power projects but it should also be included in the planning and development of individual cities [6]. Hence, the incorporation of renewable energy resources in the UM of cities may not only reduce the energy imports but it may help in lowering the carbon emissions of cities. Just like living organisms, a city also need energy and other resources to make it productive by the process of energy transformation, conversion and waste elimination but the metabolism of a city should be considered as an ecosystem rather as a single organism. Based on this principle, recently inaugurated cities and communities rely on the energy and materials across their boundaries to manage their processes such as construction, living, communication, transportation and waste management [7].

*A)Evaluation Methods:*

Generally, there are two methods to evaluate the urban metabolism of a city, such as

*i. Accounting and Assessment Methods*

Urban Metabolism is a framework of information regarding infrastructure of cities, about its energy, materials and waste disposal [5]. It is also used to measure the scale and potential of food, energy, materials, water and waste with in a city [8][9], therefore, following methods are used to account and evaluate the urban metabolism:

*a) Analyzing Material Flows:* In this analysis material flows are classified, monitored and balanced based on the statistical data of a specific city or community. It is an effective way to manage the resources and environment of a city by measuring the material's inflows and outflows [10].

b) *Analyzing Energy Flows:* Keeping in view the significance of energy, the phenomenon of energy metabolism is proposed by the Haberl because in metabolic analysis energy flows cannot be neglected [11]. The analysis is performed to measure the amount of energy utilized in the material's development and flow. It also determines the quality difference in the materials and energy.

c) *Analyzing Ecological Footprints:* The materials and energy flow analysis are not accountable to measure the degree of sustainability of a city or an urban system, therefore, in order to overcome the sustainability challenge, it necessary to measure ecological sustainability of an urban system, therefore, to manage the ecological sustainability challenges such as unused materials or deficit materials, socioeconomic demands and capacity of environmental supply should be combined in terms of urban development [12].

*ii. Simulation Models*

Simulations models are different from the accounting and assessment methods as these models are identified to quantitatively measure and simulate the different aspects of metabolism such producing consuming and circulating the components of an urban system. Simulation models comprise of the following:

*a) Ecological Dynamics:* The ecological dynamic model is a useful tool to simulate the energy and material flow of an urban ecosystem to influence urban metabolic system. The system also tends to simulate the trend evolution including all the elements of an urban metabolic system such as societal, economical and natural elements of an urban system [12].

*b) Ecological Network Analysis:* In this analysis, the structural and the complex functional components of an urban system is simulated to analyze the path, flow and utility quantitatively, required for a metabolic system [13].

c) *Input-output Analysis:* In order to distribute the metabolic actors into other compartments of the society such as economic sector, the input-output analysis is performed to estimate the economic aspects of material and energy flows with in an urban system [12].

d) *Process Analysis:* Such type of analysis is used to account for the recycling process of resources and environmental hazards associated with the refinement of materials and their waste management [14].

*B)Applications*

The concept of urban metabolism is conceived by Wolman which has been restricted to the air pollution concerns of an urban system but in order to implement the urban metabolism approach, it is required to scientifically analyze its application in an urban system [15][16]. The concept of urban metabolism can be applied to the urban system using the following applications:

*i. Indicators of Sustainability:* The process of urban metabolism also looks into the sustainability aspects of the cities, the sustainability indicators with in an urban metabolism are representative, understandable, responsive, comparable over time, relevant and unambiguous, as reported by Maclaren based on state of the environment [17].

*ii. Inputs to Carbon Accounting:* One of the other significant aspects of urban metabolism is its ability in reducing carbon emissions within the communities and societies. Inputs to carbon accounting is a process to quantify the emissions produced with in the cities. The major contribution in the greenhouse gases (GHG) emissions are the methane and carbon dioxide gases, as a result of energy production based upon fossil fuels and waste elimination from the transportation, industries and other sectors. This process evaluates the amount of GHG emissions produced with in the boundaries of the city during the material flows, energy production and consumption and during the waste removal [16]. In order to measure the carbon emissions with in the city, the following formula is applied according to IPCC guideline:

*Activity level x Emissions Factor*

Activity level is the product of energy consumption and the intensity of GHG emissions with in a community. For the purpose of calculation of emissions factor, an inventory of fossil fuels is established at the national/provincial/regional/community level based on the combustion process of fossil fuels [5].

*iii. Mathematical Modeling and Policy Analysis:* The concept of urban metabolism is basically the accounting process of the material flows, energy flows and waste management but a number of other researchers have worked on the mathematical models for the analysis of nutrients, substances and metals of a city beyond to quantification of resources only. These models are effective in managing the alterations in the urban metabolism after the technological innovations and to determine the costs and benefits analysis of these innovations in the sustainability of the environment [16].

## IV. Renewable Energies in the Urban System

In urban metabolism, energy has a vital impact because energy is used to process materials with in the urban system, which is dissipated rather being stored [18]. There are certain types of energies in the urban system such as direct energy, external energy and indirect energy. Direct energy is obtained from the energy source like solar or biomass in a socioeconomic environment, on the other hand, indirect energy can be obtained from systems and products of various productive sectors and the external energy is carried by the materials with in an urban system [19]. The energy in a community or with in a city is an embedded form of such types of energies in which the contribution of indirect energies is higher than the direct energies, therefore, this study aims to maximize the utilization of renewable energy resources that are the direct forms of energy to meet energy requirements of the growing urban areas. Over the years, the conventional urban energy models are based on fossil fuels such as coal and oil, for the urban and industrial development but the environmental and sustainability issues related to fossil fuels result into the decline of oil consumption in the urban system and switching to sustainable and green renewable energies [7][20]. Following the process of closed energy cycle, the self-efficient nature of renewable forms of energy can be the best alternate over fossil fuel based resources for an urban system [5], therefore, keeping in view the availability and potential of energy resources and geographical location of a certain city, an appropriate energy model can be developed [3]. The energy model incorporating renewable energy sources can be developed after the identification of spatial and temporal significance, methodology and supply & demand of the urban system categories including technology and building design, its climate, energy system design, policy assessment and transportation [21]. Based on the sustainability and potential of renewable energy resources, their utilization should be motivated over fossil fuels with the help of policies and regulations at national, provincial and community levels. This utilization can not only reserve the national energy resources with in ground for the future generations, but it can also promote the employment, growth and energy endogenous process with in a city.

## V. THE CASE OF GWADAR AND CPEC

The port city of Gwadar is blessed with the scarce natural resources from unique minerals to exotic beaches surrounding turquoise water [22]. The natural richness blended with the execution of significant projects such as Gwadar port and the CPEC has attracted the global attention to invest in the region. It is reported that the opening of CPEC can bring a tremendous economic growth in the country and infrastructure development in the city of Gwadar. The pipelined transportation and logistics projects under CPEC can transform the overlooked region into a trade hub between Pakistan and its surrounding countries such as Afghanistan, Iran and Central Asia. The shipping and transportation activities are aimed to generate a substantial amount of revenue for the Pakistan and the China, which will result into more strategic and bilateral relationship between both countries [23].

Demographically the city constitutes a population of around 85000 people and it is estimated by the Gwadar Development Authority (GDA) that it may exceed from eighty five thousand to one million by 2030; consequently it leads to massive construction and resources allocation in the city [24]. This infrastructure development requires extensive resources in the priority areas of city master plan as shown in the Table I.

TABLE I: Port City Sustainable Master Plan Priority Areas and Methods for Execution (Source:[25])

| Priority Areas | Method |
|---|---|
| Urban Design | Sustainable land used of residential commercial Buildings, Industries, Public Sector, Horticulture, Sports and Parks |
| Energy | Energy Policy (National, Provincial), Regulations for Sustainable Building Design, Implementation of Sustainable Energy Systems, Energy Resources and Production |
| Trunk System | Sewerage & Drainage System, Supply, Filtration and Desalination of Water, Waste Collection and Disposal, Rain Water Management |

| | |
|---|---|
| Environment | Ecosystem and Climate Change, Case Studies and Surveys, Environmental Policy and Regulations, Social Awareness towards Green Concept, Environmental Impact Assessment |
| Technology | Implementation of Innovative and Sustainable technologies in Health, Electricity, Connectivity, Energy Efficiency, Automotive Systems |
| Economics | Economic Policy, Infrastructure Development for Industries, Transportation, Public and Private Sector, Improving Socioeconomic Conditions of People thorough employment and entrepreneurship, Business Plans and Proposals |
| Disaster Risk Management | Vulnerability and Risk Assessment, Framework and Contingency Plans, Security Systems Plans |

This master plan can be implemented in Gwadar by the incorporation of renewable energy resources in its urban metabolism. For this purpose, an urban metabolism framework is proposed for the port city Gwadar as shown in the Figure 1.

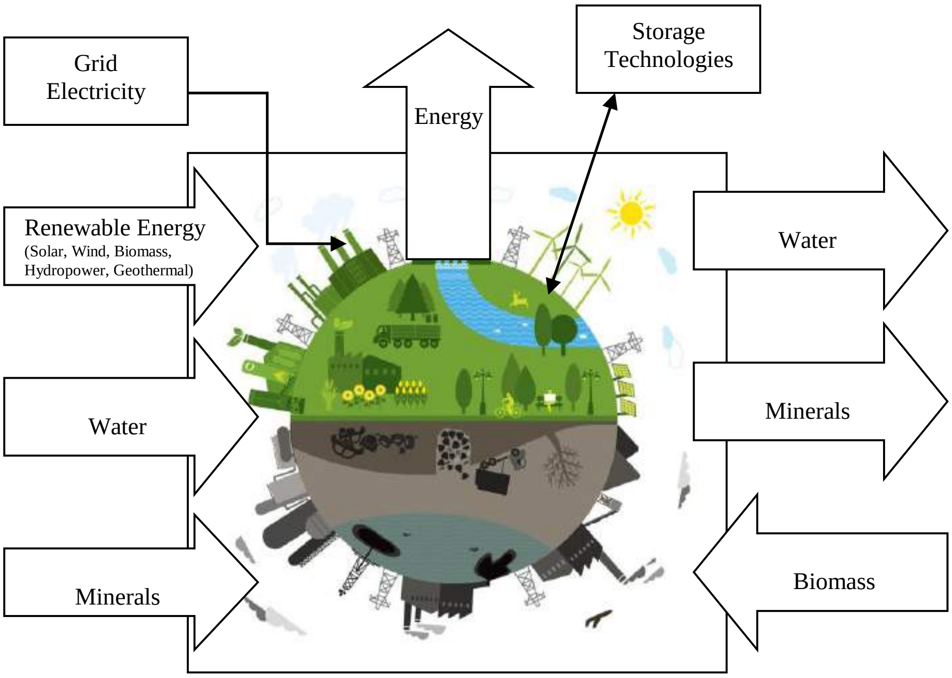


FIG. 1: PROPOSE URBAN METABOLISM FRAMEWORK FOR THE PORT CITY GWADAR, SOURCE [26]

The above framework can be implemented in Gwadar by determining the availability and potential of the renewable energy resources in Gwadar and the optimization of energy technologies in satisfying energy requirements. After a thorough literature review, it is not evident which energy technology is the best focusing its economical, technological, environmental and social aspects, therefore, The Institute of Energy Saving and Diversification (IESD) of Spain has highlighted renewable energy systems classified into different sectors as shown in the Table II:

TABLE II: RENEWABLE ENERGY SYSTEMS IN DIFFERENT CITIES OF THE WORLD IDENTIFIED BY IESD SPAIN, SOURCE [27]

| City | Sectors | System | Use |
|---|---|---|---|
| Kerkrade (Netherlands) | Solar PV | Photovoltaic | Electric |
| Mexico City (Mexico) | Solar Thermal, Solar Thermoelectric | Solar Thermal, Central receiver, Linear Fresnal reflector, Parabolic Dish Stirling | Thermal |
| Wageningen (Netherlands) | Wind | Onshore, Offshore | Electric |
| Mar del Plata (Argentina) | Biomass | Direct Combustion | Electric |
| Chinese Cities | Biofuels | Bioethanol, Biodiesel | Thermal |

| | | | |
|---|---|---|---|
| US Cities | Biogas | Biogas | Electric |
| Switzerland village | Hydroelectric | Small Hydro | Electric |

The research performed on these cities is based upon the availability and potential of the renewable energy resources with in these cities rather the energies from outside maintaining the circular urban metabolism. Like other metropolitan global cities, a layout design to utilize the city's own available resources following the concept of UM is shown in the Figure 2.

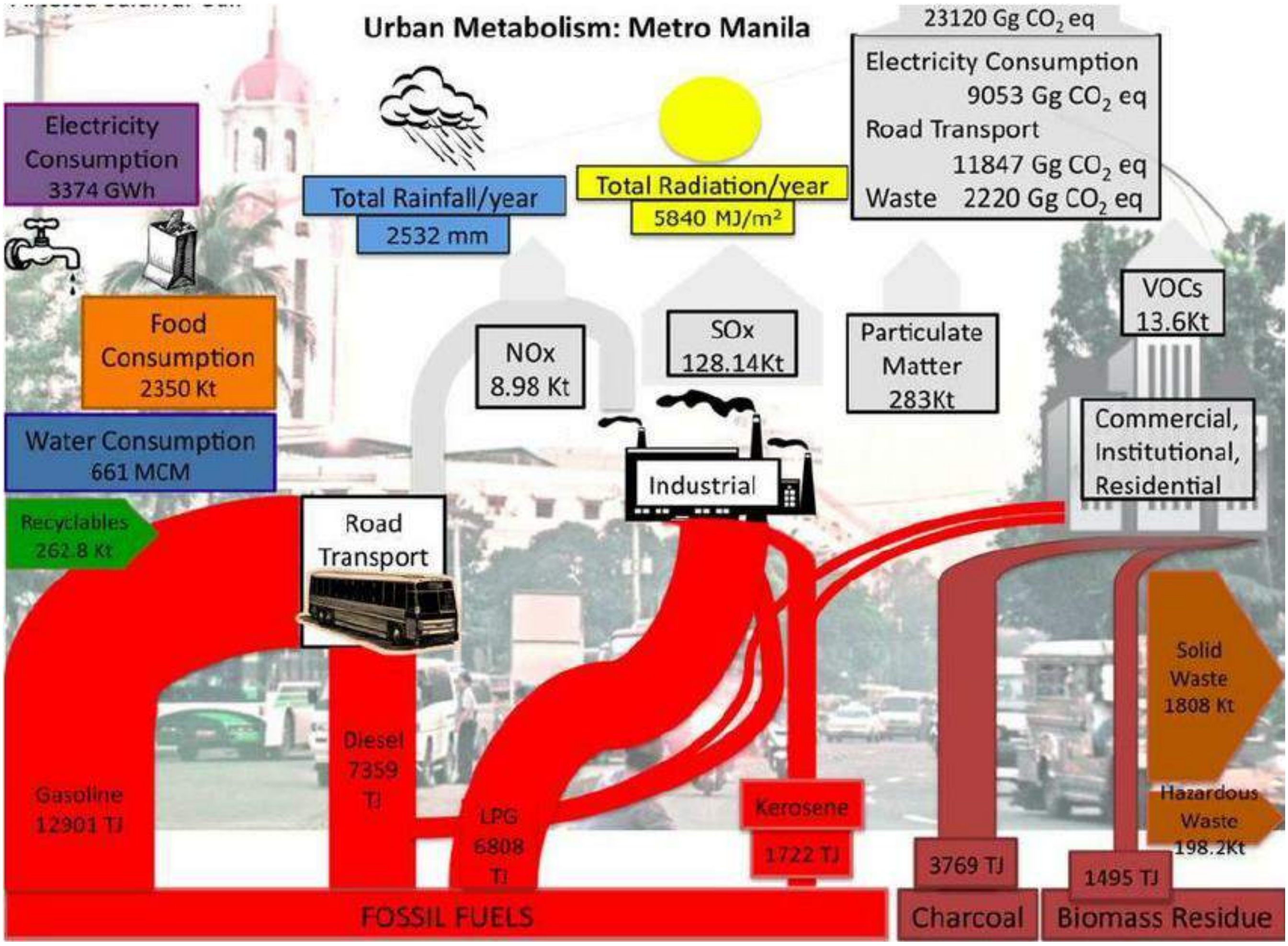


FIG. 2: URBAN METABOLISM LAYOUT DESIGNED BY USING AVAILABLE NATURAL RESURCES FOR THE MANILA CITY, PHILIPPINES: SOURCE [26]

Another study reveals that UM particularly urban energy metabolism can serve as a scientific baseline for the industrial infrastructure development and to optimize the future energy utilization in the city f Jing-Jin-Ji, China. UM is also adopted in a study to compare the world's megacities such as Tokyo, London, Shinghai and Paris in terms of their energy sustainability performance using multi scale integrated analysis of societal and ecosystem metabolism (MuSIASEM). When considering the case of Gwadar, the renewable energy systems available are solar, wind and small hydro. The available data about the renewable energy resources in Gwadar is mentioned in the Table III. These resources can be combined with the national/provincial grid electricity and the pipelined renewable energy projects under CPEC such as Quaid-e-Azam solar park of capacity around 1000MW. Hence, the proposed urban metabolism framework for the Gwadar can manage its energy requirements using a hybrid energy model. Keeping in view, the intermittent nature of renewable energy resources, it is mandatory to install storage devices such as batteries and hydro-pump systems for the solar, wind and hydroelectric energy systems respectively. These storage systems can be utilized during the unavailability of sun irradiations, low wind speed or water for the hydroelectric energy. With the passage of time, the expansion and development of Gwadar's residential, agriculture, infrastructure and industrial growth may reveal the availability and utilization of biomass, biofuel and waste energy resources in the future. Although Gwadar is one of the richest regions conserving the underground precious coal and oil resources but the environmental and sustainability constraints discourage their consumption in the urban metabolism approach. Based on all these facts and figures, it is proposed that the port city of Gwadar can be designed as a sustainable and green city conditioned by the renewable energy resources under its circular urban metabolism, therefore, it is required to devise appropriate policies, regulations and improving governance under the sustainable development mechanism of CPEC.

TABLE III: AVAILABLE RENEWABLE ENERGY POTENTIAL OF GWADAR (SOURCE: [28]

| Month | Daily solar radiation - horizontal kWh/m2/d | Wind speed m/s |
|---|---|---|
| Annual | 5.19 | 4.1 |

## IV. CONCLUSIONS

The proposed urban metabolism using ecological network analysis and energy flow analysis incorporating renewable energy resources can bring sustainability in the port city of Gwadar keeping in view the predicted urban growth due to CPEC. Pakistani electrical system is traditional and mostly dependent upon fossil fuel leading to the depletion of underground resources, substantial fuel imports and high carbon emissions. It is a matter of concern that the adaption to climate changes and avoiding electricity shortfalls provoke to utilize renewable energy resources not only in the national electrical system but also cities/communities can utilize the available renewable energy resources independently within their proximity. However, the limitation of resources availability depending about the cities geographical location is a stumbling block. Following the urban metabolism approach, material and energy flows determine the possible utilization of renewable energy resources to establish the process of sustainable development with in an urban system. Urban metabolism approach recommends adapting the conventional energy models by incorporating renewable energy resources consequently it cannot only reduce the carbon emissions associated with fossil fuel consumption but it can also reduce fuel imports and grid load as well. The port city of Gwadar is an under developed city so far but launching of CPEC project has diverted the focus of national and international investors as Asia's future trade hub in the region, therefore, the significance of CPEC demands the establishment of technological infrastructure, industrial zones and residential societies. Just like the other major metropolitan cities of the developed countries, the prosed urban metabolism framework can be implemented in the port city to manage its material and energy requirements self-sufficiently while maintaining the sustainability of the region. The study can be enhanced by including the renewable energy scenarios in connection to the urban metabolism framework. The implementation of renewable energy technologies requires the Government attention by encouraging the use of renewable energy technologies through policies reforms. Financial subsides and feed in tariff incentives can motivate the investors and manufacturers of renewable energy systems but it requires good governance, modified regulatory framework and green policies.

The major limitation of the study is the unavailability of data that has restricted to accomplish and justify the implication of UM in the Gwadar city. The data sources about the future projects are under process and not yet finalized. After the confirmation of residential, industrial and other projects with their estimated energy requirements, this study can be served as a baseline with a great scope of future research under CPEC perspective.

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# The Development of Strategy for the Green Spaces in the Hyderabad City

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***Abstract*: Urbanization without considering the urban green spaces can cause numerous social and physical effects on its occupants. A study was conducted in the Qasimabad, Hyderabad, Pakistan to determine the available green spaces and also to measure the demands of citizen for urban green spaces. The both of the qualitative and quantitative methods of data collection were used. In this research paper, the data was collected with help of GIS techniques analysis with the provided standards. A questionnaire was generated and administered to know the demands of residences for the urban green spaces. The questionnaire was distributed among 50 households. The analysis shows that residents are highly in demand for the well-maintained green spaces in their vicinity. According to GIS report and questionnaire survey the availability of green spaces was about 213682 m$^2$ (52.8 acres) which is very less as compared to SBCA & HDA byelaws, and those which are existing were not properly maintained. It is concluded that the policy makers, municipality, private entrepreneurs, planners and investors should strictly follow a stringent strategy worked out in this research work so as to meet the minimum requirement of the urban open/green spaces in residential areas of Qasimabad, Hyderabad.**

*Keywords:* **Planning strategies, Social sciences, Urban green spaces.**

## I. INTRODUCTION

The world's population, more than half, living in the urban areas [1]. However, an extensive extent of the total populace presently lives in urban territories, where they are frequently denied of contact with nature. One specific issue of city living is that occupants may encounter more worries than country side inhabitants [2]. Green space renders great benefits to urban sustainable development from ecological, economical, and social point of view [3].

The community-oriented GIS gives advantages, for example, continuous co-operations, comprehensiveness, social learning, and mindfulness about the mutual difficulties that need basic arrangements [4]. Yet, center gathering workshops and meetings connected independently can uncover diverse valuation data [5]. The mix makes chances to enhance content legitimacy by making every one of the issues related with urban green spaces attitude clearer.

Measuring residents' states of mind towards urban green spaces has been accomplished to a great extent through organized questionnaire surveys. The predominant utilization of questionnaire surveys to describe ecological states of mind is depicted in a few investigations that investigate for instance, dispositions toward urban development [6], personal satisfaction [7], group protection [8], ranger service [9], provincial woodlots [10], and vitality utilize [11].

Where the proposed city Qasimabad, Hyderabad are facing one of major issue is that lacking green spaces and its due to major growth of population, for that such, these studies are important as they act at a neighborhood level and address fine scale social complexities and disposition flow.

To cope with the tasks of the supply and demand of public goods and services, and administrative requirements of pubic providers, standards and norms are widely hired by urban governments. The concerned(s) of UAE are expecting to build the territory of green space per capita, by multiplying the present evaluated figure of 13.18m$^2$ to 25 m$^2$ by 2020 [12]. In the arranging open spaces, there have been many methodologies that go past simply determining green space per capita, normally characterizing various leveled and utilitarian typologies.

## II. MATERIALS & METHODS

### *I. Goal:*

The particular goals of this are to:

a. Consider how GIS methodologies and these outcomes might be associated with green space arrangements.
b. Review census report of population of Qasimabad, Hyderabad.
c. Study the standards of SBCA (Sindh Building Control Authority) and HDA (Hyderabad Development Authority) for the open/green spaces in urban areas.
d. Overview of inhabitants' values for green spaces in an urbanizing area.
e. Discuss the findings and strategies for urban green spaces planning.
(*Excluding private gardens and street trees).*

*II. Methods*:

The study consists of a literature review and by two empirical studies. The first empirical study deals with the quantity of green space in Qasimabad, Hyderabad using satellite and administrative data. The second study uses a questionnaire survey to analyze green space specified in Qasimabad, Hyderabad, and residences' requirements for the green spaces.

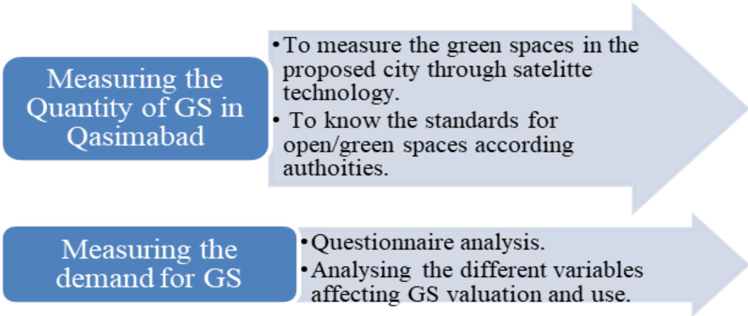


Fig.1: Flow chart outlining the two empirical studies.

*III. Materials:*

*A. Study Area*

Hyderabad is the 8th largest city in the Pakistan and the 2nd largest city in the Sindh on the east bank of the Indus River. It is located in south-east of the country. The estimated population recorded is 2,201,079 population recorded in 2017census report, by the iMMAP, Alhasan Systems, or USAID, concerning the legal status of any country, territory, city or area or of its authorities. For this research, the study area has been chosen Qasimabad is the town of Hyderabad City, Sindh, Pakistan. It has total zonal area 9.22km$^2$.It is populated around 304,899 *(census reports, 2017).* Hyderabad city is the region of hot desert climate. In May, the hottest climate ever recorded. During this time, the degree mostly recorded as 41.4 °C (106.5 °F), the blowing wind usually bring dust during daytime, whereas the wind that at night is more pleasing. Winters are mostly warm in day with highs around 25°C (77 °F), whereas it lows can frequently drop to the below 10 °C (50 °F) at night. The highest temperature was documented in on 7 June 1991was as 48.5 °C (119 °F), and the lowest temperature of 1 °C (34 °F) was noted on 8 February 2012.

Like many other mega cities Hyderabad struggles from prominent level of pollution, traffic difficulties, over population and deficiency of services and infrastructure. For that and other relatively reasons this research paper describes about the benefits of green space on urban cities. It starts from the observation that amount of green spaces in Qasimabad, Hyderabad relatively low and even diminishing in many areas of the city. In this background, urban planning becomes the essential part of development, to plan the sustenance of a livable city with more green space.

*B. Data collection & Analysis*

*i. Quantitively study of G.S (Green Space):*

As Hyderabad city of Pakistan were of mostly agricultural land but the uncontrollably growth of population make the matters inferior, the main agricultural land in the valley and greenery is endangered. The much of land is valued for urban uses, specifically for residential purposes, besides working and recreating the land, whereas these uses are dominating over fields, plantations, trees or open spaces. Though, considering the result of this calculus, the diminishing of naturally or historically irrigated green land may occur. The SBCA and HDA standard for the green spaces is per 1000 persons is 0.32 acres, and even its mentioned in book *"National Reference Manual on Planning and Infrastructure standards"* that according to zonal planning of area 5-7.5% reserved area for open spaces/ green spaces. According to population the recreational spaces should be 2-5% area as per 5, 00, 000+ persons *(source H&PP Dept., Lahore).* But according to recent survey from satellite GIS technology the green spaces are less than 5% that are very far below the approved standards in Qasimabad, Hyderabad, it needs to be improved, as shows in Fig.1. Thus, the study is essentially focused on green spaces within the urban areas, rather than the green spaces that are vanished through urban expansion.

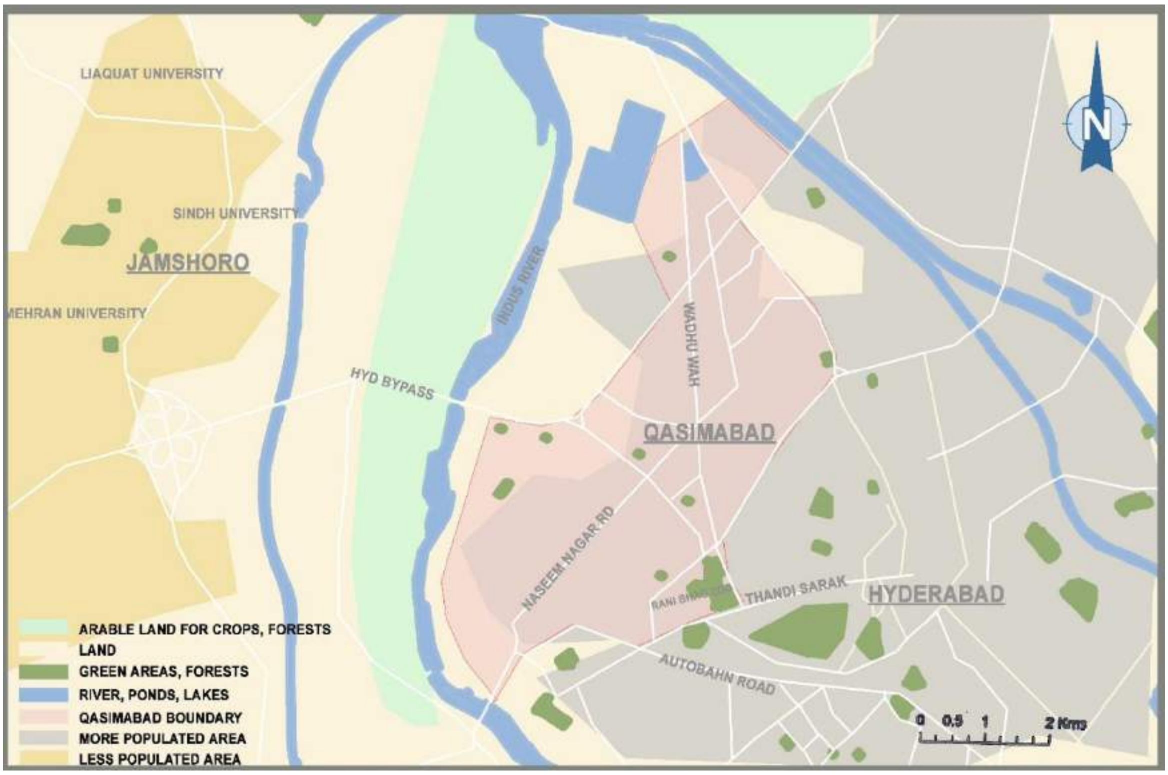


Fig. 2: shows Green Spaces in Qasimabad are relatively low according standards.

*ii. Qualitative study of G.S; Questionnaire survey:*

Most inquiries in survey are gotten from existing and approved questionnaire. Some of which are tailored to particular target of open requests. Natural environments were characterized as all open and private green spaces, for example, city parks, little and huge pocket parks and so on. The qualitative phase using the semi-structured interview and the combined GIS procedure produced an extensive list of concepts and topics that citizens associated with urban green spaces conservation system delivered a broad rundown of ideas and themes that citizens related with urban green spaces protection. The demographic profile demonstrates that respondents were equally disseminated over the levels of the deliberate free factors (Table.1). This recommends the questionnaire survey prevailing with regards to speaking to all classes of the statistic factors.

**Table 1: Demographic profile of respondents**

| Demographic Information | Number n = 50 | (%) |
|---|---|---|
| **Gender** | | |
| Male | 27 | 54% |
| Female | 23 | 46% |
| **Age** | | |
| <20 | | |
| 20-35 | 33 | 66% |
| 35-50 | 7 | 14% |
| 50-65 | 7 | 14% |
| >65 | 3 | 6% |
| **Education** | | |
| Not studied | | |
| Primary Education | 3 | 6% |
| Secondary education | 3 | 6% |
| Graduated | 18 | 36% |
| Ms/Phd..etc | 26 | 52% |
| **Employed** | 47 | 94% |
| **un-employed** | 3 | 6% |
| **Monthly Income in Rupees** | | |
| <15000 | 3 | 6% |
| 15000-25000 | 8 | 16% |
| 25000-35000 | 3 | 6% |
| 35000-45000 | 8 | 16% |
| 45000-60000 | 3 | 6% |
| >60000 | 25 | 50% |

| | | |
|---|---|---|
| **Married** | 23 | 46% |

In the survey process, the participants expressed concern about the rapid residential developments occurring around green spaces, the loss of neighborhood arranging control because of the inescapable district mergers, the absence of directions particularly along zoning arrangements that are withdrawn from environmental standards.

The semi-organized meetings uncovered a general want to enhance the management and design of urban green spaces in the study area and proposed that demeanor may be critical in clarifying expressed conduct.

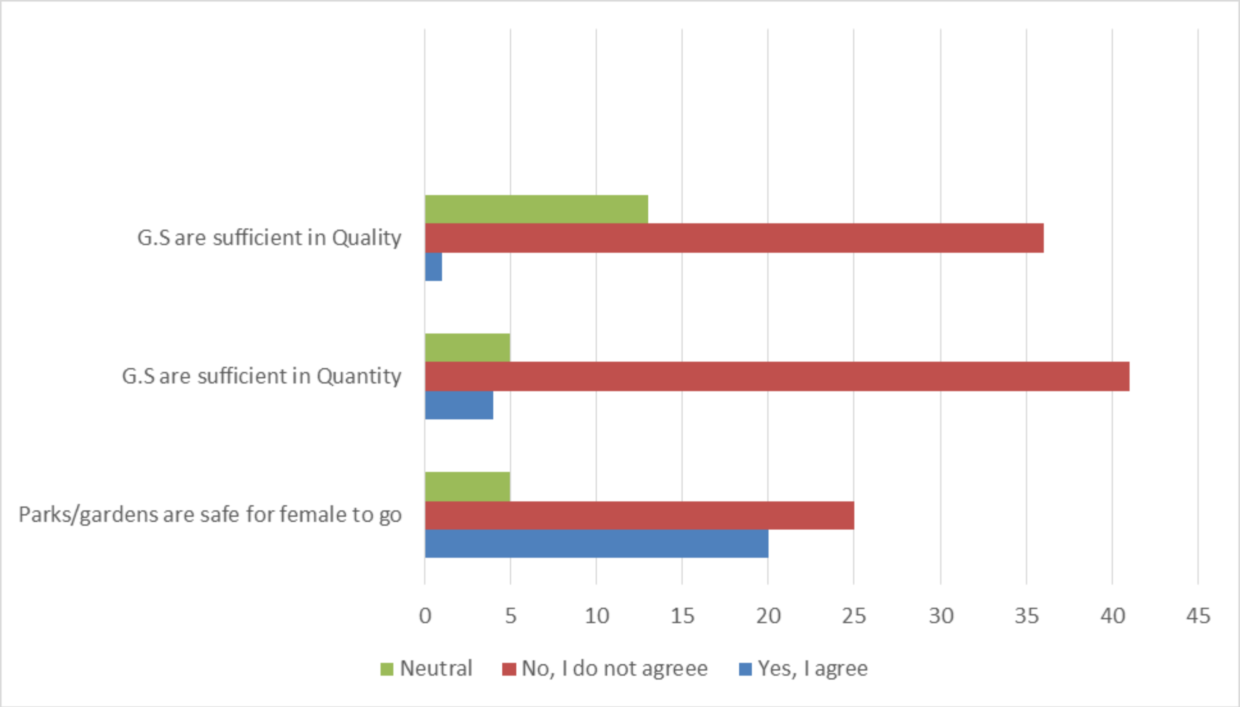


Fig.3: Cross tabulation of urban green spaces' quantity, quality and female safety respondents**.**

The frequencies distribution of respondents' fulfillment with amount of urban green spaces among entire specimen demonstrates in fig:3 that 8% are satisfy with quantity, while 82% are not agreed whereas 10% were neutral in their perspectives. Residents expressed that urban green spaces are not adequate in quantity. They require more open spaces for their wellbeing, social life and to improve kids exercises also. They require more open spaces for their wellbeing, social life and to improve kids exercises also. The disappointment with the nature of accessible green spaces in Qasimabad, around 72% questioner contradicting the adequate quality in their general vicinity. Though the general winning recognition in Qasimabad that open spaces are “not ok” for females, around half of the respondents are not concurring with the wellbeing for females in green spaces, consequently female security is a vital factor of green space request in Qasimabad.

Another issue perceived by the occupants in their encompassing green spaces are measured in the fig.4. In that figure demonstrates the one of real issue is "absence of greenery like bushes and trees" around 26% perceived this issue, while the "Maintenance" issue perceived by 20% respondents and 18% people have security issues. These issues ought to be informed by the organizer of open and private business people in arranging the parks and gardens for the better enhancements of accessible green spaces/open spaces.

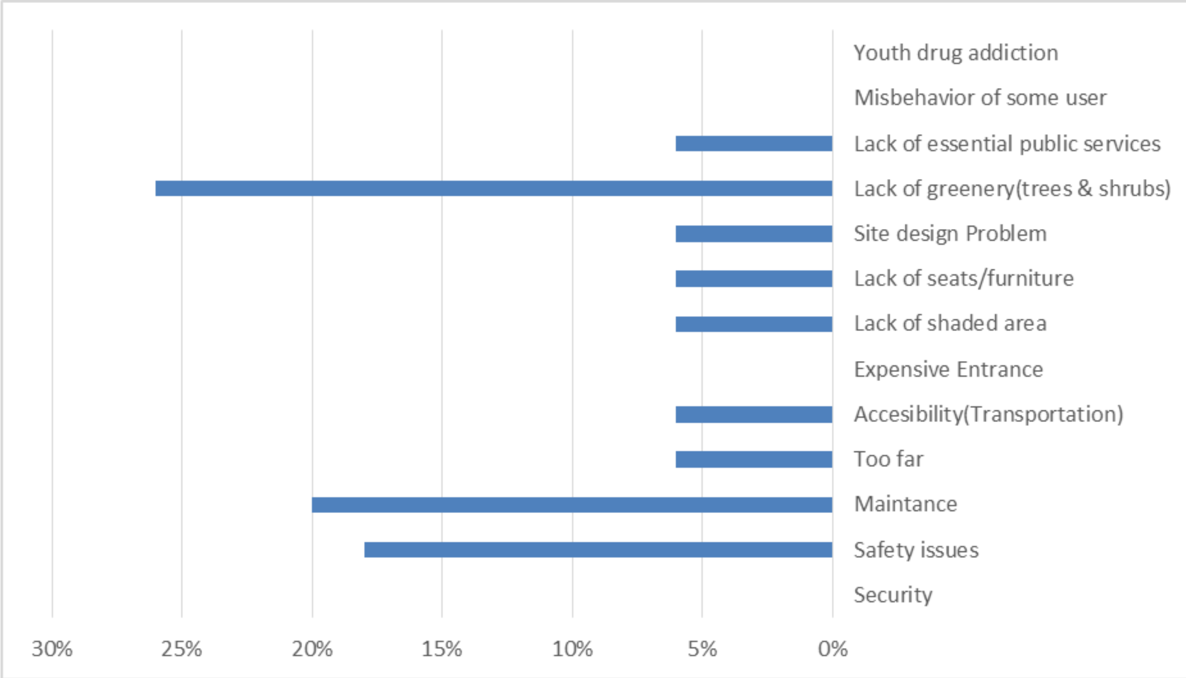


Fig.4: Problem Perceived by people in surrounding/available green spaces.

The interviewees were additionally made a request to organize their inclinations if the administration had stores for building up the urban green spaces, the best decision among five sorts of green spaces were "Pay to enter fenced gardens" Fig.5

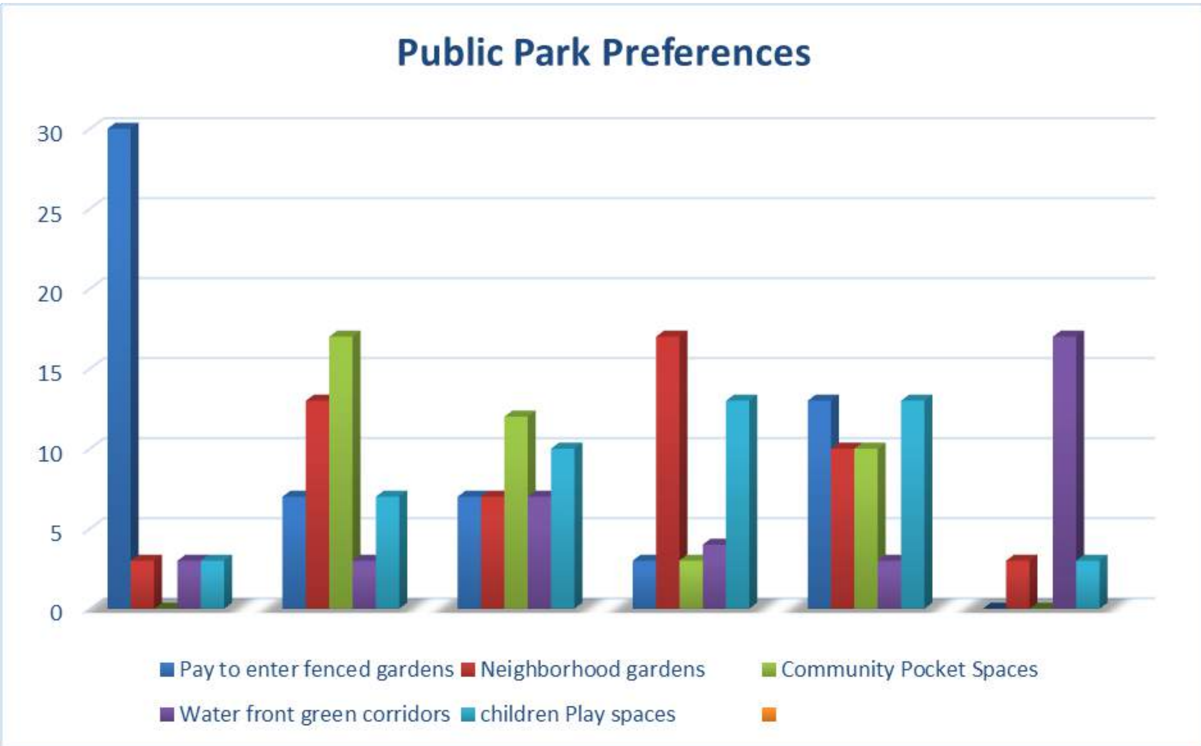


Fig.5: distribution of priority choices over different type of Green spaces.

This might be incompletely identifying with the greater part of Qasimabad, Hyderabad Large parks are not very much made do with environmental quality, that has been accomplished through fencing and charging.

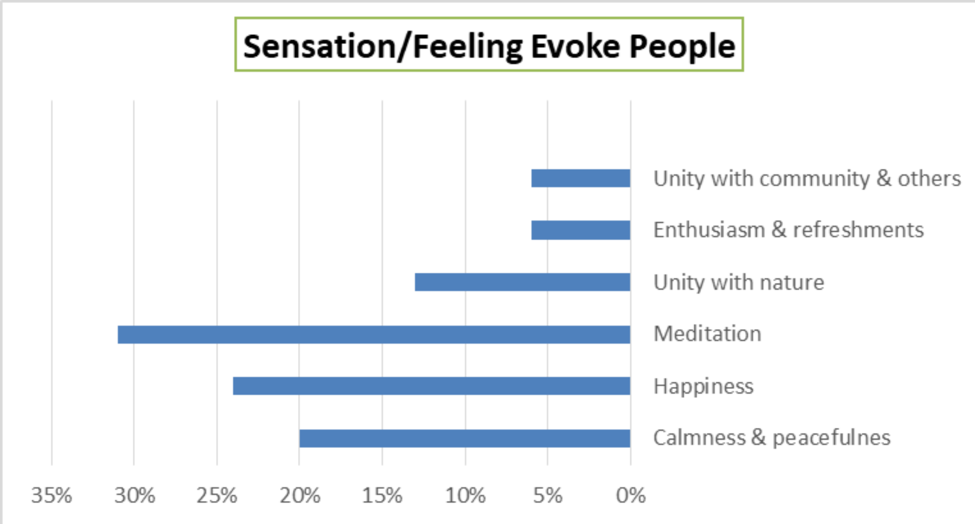


Fig.6: Sensation/feeling observed by the residents in green spaces.

For the most part individuals may feel meditation while going to in green spaces. Concurring fig.6 the inhabitants depicts their inclination subsequent to going to some private and open spaces that are "Meditation" 31%, "Happiness" 24% and "calmness & peacefulness" 20%. Generally, Meditation and calmness & peacefulness are identifying with some extent degree. It is conceivable these sensations related with the inhabitants have higher level of education, these being more complex unique idea. In any case, all that can be reasoned that green spaces bring out rich scope of sentiments.

The residents were approached about their commitment or devotion for improving the neighborhood green spaces would be; pay money, donate plants & site furniture, give effort and time, provide advice and consultancy, donate a plot of land or do not participate. Among 50 respondents just 6(12%) would prefer not to take an interest however staying 44(88%) needs to partake as appeared in fig.6. The most successive reaction was for the Give time and effort (14 or 28%), provide advice and consultancy was picked by (12 or 24%). Incredibly, 1 respondent expressed an eagerness to give a plot of land to be changed over into green spaces to improve green foundation in their nearby group. This is truly a noteworthy arrangement of finding, recommends that issue of green space shortage in the city isn't because of absence of interest yet an issue in sorting out that request in a way empowers more prominent supply.


Fig.7: Percentages of the willingness to contribute in variables.

## III. RESULTS

The provision of open/green spaces prescribed in HDA byelaws is 0.32 acres of land for every 1000 persons, the measure of GS comes about 208 acres of land for 304,899 populace that implies G.S per capita 1.29m$^2$. In Qasimabad the aggregate green space adds up to 213,682 m$^2$ or 52.8acres (3.25% of the total land). Out of 52.8 acres, 46 acres consists of Rani Bagh and this city park is only the park which serves whole Hyderabad city but exist in the boundary line of Qasimabad, while remaining 6.8acres exists in small patches in Qasimabad, which is far below the byelaws. This research is a pushed to bring out special attention for developing urban communities like Qasimabad, Hyderabad to reserve adequate land for nature friendly green spaces.

The review comes about demonstrated that for each inquiry thing the mean score was littler than the neutral rating value recommending that residents have a general inspirational state of mind towards urban green spaces (Fig.7). But, organizers and decision makers may need to refine procedures to be more participatory, so citizens' worries can be tended to right time in the development procedure.

To meet the for the advancement of urban green spaces to give a quality domain to better and solid living, to meet social and mental needs of tenants, it is basic to investigations requests of citizens and the dispersion of green cover in the city. Such investigation additionally should concentrate on per capita green cover accessible for each national.

## IV. CONCLUSIONS

The essential target accomplished in this paper is to devise a logical strategy that can control the allotment of green spaces inside urban areas of residents and to know the demands for the green spaces. The strategies followed in this paper precludes biases and had solid explanations behind relative green cover dispersion which could principally administer the future designation of parks. In order to bring a systematic improvement for green spaces in Qasimabad Hyderabad following strategy should be adopted.

- Improvement of allotted parks ought to be the prime objective of the nearby metropolitan regulatory specialists, and key dissemination of new spaces ought to involve top motivation in the city's all-inclusive strategy arrangements.
- There must be broad open awareness programs on the helpfulness of such green spaces and to stick to "just green in Green space".
- The unfilled land plots of Qasimabad, Hyderabad city represent an impressive extent in its property utilize. They frequently fall prey to strong waste littering and turns into the rearing ground for mosquitoes, stray creatures and venomous creepy crawlies. Rather, these terrains can be kept in authority with nearby districts, who can develop little removable green parks for different employments of the occupants.
- On the other hand, the civil experts should spatially remunerate openness to urban green space all through the city by making little green spaces in the empty plots.

And the public and private entrepreneurs also focus for the development of green spaces according to standards and public need. Instead of focusing their profit for the residential commercial they must put efforts to strictly follow rule for open/green spaces as devised by the Hyderabad Development Authority and Sindh Building Control Authority.

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# Investigation of Hyperbolic Heat Flux for the Flow of Three Dimensional Third Grade Fluid

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***Abstract:*** **In this article, we have studied the effects of hyperbolic heat transfer of three-dimensional steady incompressible flow of third grade fluid flow. The flow phenomena is produced due to the linear stretching sheet. For the main flow problem the partial differential equations of momentum and temperature are converted into ordinary differential equations by using suitable similarity transformations. These dimensionless equations solved using well known numerical technique homotopy analysis method (HAM). The results of different physical parameters used in dimensionless momentum and temperature equations are discussed graphically.**

***Keywords:*** **Three dimensional flow, Cattaneo-christove heat flux model, Series solution.**

## I. INTRODUCTION

In present eras the mathematicians, scientists and engineers are fascinated to learning the flow fashioned by linear stretching sheets since of their extensive applications in applied sciences e.g mechanical engineering, bio sciences, space technology, civil engineering, chemical engineering,biomedical engineering, geophysics, astrophysics, and biology etc.Numerous of fluids used in our averagerepetitivedisplays the landscapes of non-Newtonian fluids. Illustrations of such fluids include, soaps ,shampoos, muds, apple sauce, condensed milk, sugar solution, tomato ketchup, etc. All non-Newtonian ingredients cannot be calculated by a solitary relation. Unlike fluid representations have been articulated for changed non-Newtonian ingredients giving to their nature. The model of third-grade fluids is between such non-Newtonian constituents that discover the shear thinning and shear thickening properties. [1] discussed the flow of third grade fluid with homogeneous-heterogeneous feedbacks. [2] studied MHD third grade fluid flow with heat transference owed to parallel plates. Third grade fluid flow in the incidence of magnetic field is examined by [3]. [4] established incompressible flow of third grade fluid past a extending sheet with viscous degeneracy. [5] discussed impact of heat and mass transfer in third grade fluid flow due to stretching sheet. [6] presented third grade fluid flow by revolving plates. [7] deliberated the influence of third grade fluid flow over an extending surface.

The investigations on machinery of heat transmission have reformed emphasis of the investigators because of immediate progress of engineering technology. Heat transfer incomes place as of alteration of temperature among comparable material or two ingredients. The character of heat transfer has been stated approximately by means of the Fourier's theory of heat conduction [8]. The submission of Fourier's theory of heat transmission approves to parabolic energy countenance and that is the limit of Fourier's law. This inadequancy has been disconnected by [9] through the calculation of thermal relaxation time. The presence of thermal relaxation time principals to heat transfer through thermal wave propagation with immovablehaste. [10] made a modification in [11] by keen-sighted the Oldroyd's upper convective differentiation. The individuality of Cattaneo-Christov heat dispersion law has been described by [12]. [13] numerically exposed the character of Cattaneo-Christov heat flux theory for stable flow of viscoelastic liquids by an exponentially extending sheet. Some current works by sighted Cattaneo-Christov heat theory have been done by [14-17].

The goal of existing learning is to examine three dimensional, steady, incompressible flow of third grade fluid with Cttaneo-Christov heat flux model. The flow is engendered by linear stretchable surface. The follow on nonlinear delinquent is preserved for series solution by homotopy analysis method $(\mathrm{HAM})$.

## II. MATHEMATICAL ANALYSIS

We deliberate a stable, three dimensional, incompressible flow of third grade fluid over a linear stretchable exterior. We choice the cartesian coordinate system in such a technique that sheet is corresponding with $xy-$plane and fluid flow inhabits the region $z \geq 0.$ Heat transmissionmachinery is demonstrated by with the comprehensivetypes of Fourier law through Cattaneo-Christov double diffusion. The foremost boundary layer equations that designates the flow condition are articulated as:

$$\frac{\partial u_1}{\partial x}+\frac{\partial v_1}{\partial y}+\frac{\partial w_1}{\partial z}=0, \tag{1}$$

$$\begin{aligned}
& u_1\frac{\partial u_1}{\partial x}+v_1\frac{\partial u_1}{\partial y}+w_1\frac{\partial u_1}{\partial z}=\frac{\alpha_1}{\rho}\left\{w_1\frac{\partial^3 u_1}{\partial z^3}+u_1\frac{\partial^3 u_1}{\partial x\partial z^2}+v_1\frac{\partial^3 u_1}{\partial y\partial z^2}+4\frac{\partial u_1}{\partial z}\frac{\partial^2 u_1}{\partial x\partial z}+2\frac{\partial v_1}{\partial z}\frac{\partial^2 u_1}{\partial y\partial z}+3\frac{\partial u_1}{\partial x}\frac{\partial^2 u_1}{\partial z^2}\right.\\
& \left.+\frac{\partial u_1}{\partial y}\frac{\partial^2 v_1}{\partial z^2}+\frac{\partial u_1}{\partial y}\frac{\partial^2 v_1}{\partial z^2}+2\frac{\partial v_1}{\partial x}\frac{\partial^2 v_1}{\partial z^2}+2\frac{\partial v_1}{\partial z}\frac{\partial^2 v_1}{\partial x\partial z}+\frac{\partial u_1}{\partial z}\frac{\partial^2 w_1}{\partial z^2}+\frac{\partial w_1}{\partial z}\frac{\partial^2 u_1}{\partial z^2}\right\}+\\
& \frac{\alpha_2}{\rho}\left\{4\frac{\partial u_1}{\partial z}\frac{\partial^2 u_1}{\partial x\partial z}+\frac{\partial u_1}{\partial z}\frac{\partial^2 v_1}{\partial y\partial z}+\frac{\partial v_1}{\partial z}\frac{\partial^2 u_1}{\partial y\partial z}+2\frac{\partial u_1}{\partial x}\frac{\partial^2 u_1}{\partial z^2}+2\frac{\partial u_1}{\partial z}\frac{\partial^2 u_1}{\partial x\partial z}\right.\\
& \left.+\frac{\partial u_1}{\partial y}\frac{\partial^2 v_1}{\partial z^2}+\frac{\partial v_1}{\partial z}\frac{\partial^2 v_1}{\partial x\partial z}+\frac{\partial v_1}{\partial x}\frac{\partial^2 v_1}{\partial z^2}+2\frac{\partial w_1}{\partial z}\frac{\partial^2 u_1}{\partial z^2}\right\}+\frac{\beta_3}{\rho}\left\{6\left(\frac{\partial u_1}{\partial z}\right)^2\frac{\partial^2 u_1}{\partial z^2}\right.\\
& \left.+2\left(\frac{\partial v_1}{\partial z}\right)^2\frac{\partial^2 u_1}{\partial z^2}+4\frac{\partial u_1}{\partial z}\frac{\partial v_1}{\partial z}\frac{\partial^2 v_1}{\partial z^2}\right\}+\nu\frac{\partial^2 u_1}{\partial z^2},
\end{aligned} \tag{2}$$

$$\begin{aligned}
& u_1\frac{\partial v_1}{\partial x}+v_1\frac{\partial v_1}{\partial y}+w_1\frac{\partial v_1}{\partial z}=\frac{\alpha_1}{\rho}\left\{w_1\frac{\partial^3 v_1}{\partial z^3}+u_1\frac{\partial^3 v_1}{\partial x\partial z^2}+v_1\frac{\partial^3 v_1}{\partial y\partial z^2}+2\frac{\partial u_1}{\partial z}\frac{\partial^2 v}{\partial x\partial z}+2\frac{\partial u_1}{\partial z}\frac{\partial^2 u_1}{\partial y\partial z}\right.\\
& \left.+4\frac{\partial v_1}{\partial z}\frac{\partial^2 v}{\partial y\partial z}+2\frac{\partial w_1}{\partial z}\frac{\partial^2 v_1}{\partial z^2}+2\frac{\partial u_1}{\partial y}\frac{\partial^2 u_1}{\partial z^2}+\frac{\partial v_1}{\partial x}\frac{\partial^2 u_1}{\partial z^2}+3\frac{\partial v_1}{\partial y}\frac{\partial^2 v_1}{\partial z^2}+\frac{\partial v_1}{\partial z}\frac{\partial^2 w_1}{\partial z^2}\right\}\\
& +\frac{\alpha_2}{\rho}\left\{4\frac{\partial v_1}{\partial z}\frac{\partial^2 v_1}{\partial y\partial z}+\frac{\partial v_1}{\partial z}\frac{\partial^2 u_1}{\partial x\partial z}+\frac{\partial u_1}{\partial z}\frac{\partial^2 u_1}{\partial y\partial z}+\frac{\partial u_1}{\partial y}\frac{\partial^2 u_1}{\partial z^2}+\frac{\partial u_1}{\partial z}\frac{\partial^2 v_1}{\partial x\partial z}\right.\\
& \left.+\frac{\partial v_1}{\partial x}\frac{\partial^2 u_1}{\partial z^2}+2\frac{\partial v_1}{\partial y}\frac{\partial^2 v_1}{\partial z^2}+2\frac{\partial w_1}{\partial z}\frac{\partial^2 v_1}{\partial z^2}+2\frac{\partial w_1}{\partial z}\frac{\partial^2 v_1}{\partial z^2}\right\}+\frac{\beta_3}{\rho}\left\{6\left(\frac{\partial v_1}{\partial z}\right)^2\frac{\partial^2 v_1}{\partial z^2}+2\left(\frac{\partial u_1}{\partial z}\right)^2\frac{\partial^2 v_1}{\partial z^2}\right.\\
& \left.+8\frac{\partial v_1}{\partial z}\frac{\partial w_1}{\partial z}\frac{\partial^2 w_1}{\partial z^2}+4\frac{\partial u_1}{\partial z}\frac{\partial v_1}{\partial z}\frac{\partial^2 u_1}{\partial z^2}\right\}+\nu\frac{\partial^2 v_1}{\partial z^2},
\end{aligned} \tag{3}$$

$$\rho c_p\left[u_1\frac{\partial T}{\partial x}+v_1\frac{\partial T}{\partial y}+w_1\frac{\partial T}{\partial z}\right]=-\nabla.\mathbf{q}, \tag{4}$$

Now $u_1(x,y,z)$ , $v_1(x,y,z)$ and $w_1(x,y,z)$ are the components of velocity in the $x-$, $y-$ and $z-$orders, $T$ the temperature , $\rho$ the density, $c_p$ the specific heat, $\mathbf{q}$ the heat flux, $\alpha_1$, $\alpha_2$ are the second grade fluid parameters and $\beta_3$ the third grade fluid parameter. Heat flux $\mathbf{q}$ is given as:

$$\mathbf{q}+\lambda\left[\frac{\partial \mathbf{q}}{\partial t}+V.\nabla\mathbf{q}-\mathbf{q}.\nabla V+(\nabla.V)\mathbf{q}\right]=-K^*\nabla.T, \tag{5}$$

in which $\boldsymbol{\lambda}$ is the thermal relaxation time for heat flux, $K^*$ being the thermal conductivity of fluid. By means of the incompressibility and firm state condition Eq. (5) takes the form:

$$\mathbf{q}+\lambda\left[V.\nabla\mathbf{q}-\mathbf{q}.\nabla V\right]=-K^*\nabla.T, \tag{6}$$

for $\boldsymbol{\lambda}=0,$ Eq. (5) cuts to traditional Fourier's law. Refusing heat flux $\mathbf{q}$ between Eq. (4) and Eq. (5), we obtain following leading equation for heat transfer:

$$u_1\frac{\partial T}{\partial x}+v_1\frac{\partial T}{\partial y}+w_1\frac{\partial T}{\partial z}+\boldsymbol{\lambda\lambda}_E=\frac{K^*}{\rho c_p}\frac{\partial^2 T}{\partial y^2}, \tag{7}$$

where

$$\lambda_E = u_1^2 \frac{\partial^2 T}{\partial x^2} + v_1^2 \frac{\partial^2 T}{\partial y^2} + w_1^2 \frac{\partial^2 T}{\partial z^2} + u_1 \frac{\partial u_1}{\partial x}\frac{\partial T}{\partial x} + v_1 \frac{\partial u_1}{\partial y}\frac{\partial T}{\partial x} + w_1 \frac{\partial u_1}{\partial z}\frac{\partial T}{\partial x} + u_1 \frac{\partial v_1}{\partial x}\frac{\partial T}{\partial y} + v_1 \frac{\partial v_1}{\partial y}\frac{\partial T}{\partial y} + w_1 \frac{\partial v_1}{\partial y}\frac{\partial T}{\partial y} + u_1 \frac{\partial w_1}{\partial x}\frac{\partial T}{\partial z} + v_1 \frac{\partial w_1}{\partial y}\frac{\partial T}{\partial z} + w_1 \frac{\partial w_1}{\partial z}\frac{\partial T}{\partial z} + 2u_1 v_1 \frac{\partial^2 T}{\partial x \partial y} + 2v_1 w_1 \frac{\partial^2 T}{\partial z \partial y} + 2u_1 w_1 \frac{\partial^2 T}{\partial x \partial z}, \tag{8}$$

The agreed boundary conditions for velocity and temperature are assumed below

$$u_1 = U_w(x) = cx, v_1 = V_w(y) = dy, w_1 = 0, T = T_w, \text{ at } z = 0, \quad u_1 \to 0, v_1 \to 0, T \to T_\infty \text{ as } z \to \infty. \tag{9}$$

Presenting the following similarity alterations

$$u_1 = cxf'(\eta), v_1 = cyg'(\eta), w_1 = -\sqrt{c\nu}\,(f(\eta) + g(\eta)), \quad \eta = \sqrt{\frac{c}{\nu}}z, \theta(\eta) = \frac{T - T_\infty}{T_{w1} - T_\infty}, \tag{10}$$

applying the above mentioned changes we get the resulting equations:

$$f''' - (f')^2 + (f+g)f'' + \chi_1\left\{4(f'')^2 + 4ff''' - (f''+g'')f'' - (f+g)f^{(iv)} - (f'+g')f'''\right\} + \chi_2\left[4(f'')^2 + f''g'' - 2g'f'''\right] + \chi_3\left[6(f'')^2 f''' + 2(g'')^2 f''' + 4f''g''g'''\right] = 0, \tag{11}$$

$$g''' - (g')^2 + (f+g)g'' + \chi_1\left\{4(g'')^2 + 4g'g''' - (f''+g'')g'' - (f+g)g^{(iv)} - (f'+g')g'''\right\} + \chi_2\left[4(g'')^2 + f''g'' - 2f'g'''\right] + \chi_3\left[6(g'')^2 g''' + 2(f'')^2 g''' + 4f''g''f'''\right] = 0, \tag{12}$$

$$\theta'' + \Pr(f+g)\theta' - \lambda \Pr\left\{(f+g)(f'+g')\theta' + (f+g)^2\theta''\right\} = 0, \tag{13}$$

changed boundary conditions are

$$f = 0,\ f' = 1,\ g = 0,\ g' = \beta_1,\ \theta = 1, \text{ at } \eta = 0, \quad f' \to 0,\ g' \to 0,\ \theta \to 0, \text{ as } \eta \to \infty. \tag{14}$$

In upstairs equations $\chi_1 = \frac{\alpha_1 c}{\rho\nu}$, $\chi_2 = \frac{\alpha_2 c}{\rho\nu}$ are non-dimensional second grade fluid parameters, $\chi_3 = \frac{\beta_3 c^3 x^2}{\rho\nu^2}$ the third grade fluid parameter, $\Pr = \frac{\mu c_p}{k}$ the Prandtl number, $\beta_1$ the ratio parameter and $\lambda$ being the non-dimensional relaxation time parameter for temperature. Third grade fluid reduced to Newtonian fluid when $\chi_1 = \chi_2 = \chi_3 = 0$.

## III. SOLUTIONS BY HAM

Initial guesses for dimensionless velocities and temperture corresponding to linear operators are

$$f_0(\eta) = 1 - e^{-\eta},\ g_0(\eta) = \beta_1(1 - e^{-\eta}),\ \theta_0(\eta) = e^{-\eta}, \tag{15}$$

$$£_f = \frac{d^3 f}{d\eta^3} - \frac{df}{d\eta},\ £_g = \frac{d^3 g}{d\eta^3} - \frac{dg}{d\eta},\ £_\theta = \frac{d^2\theta}{d\eta^2} - \theta, \tag{16}$$

The consistent linear operators are

$$\pounds_f\left[C_1+C_2e^{\eta}+C_3e^{-\eta}\right]=0,\ \pounds_g=\left[C_4+C_5e^{\eta}+C_6e^{-\eta}\right]=0, \tag{17}$$
$$\pounds_\theta\left[C_7e^{\eta}+C_8e^{-\eta}\right]=0,$$

Where $C_i\ (i=1-8)$ are the random constants.

## IV. GRAPHICAL RESULTS

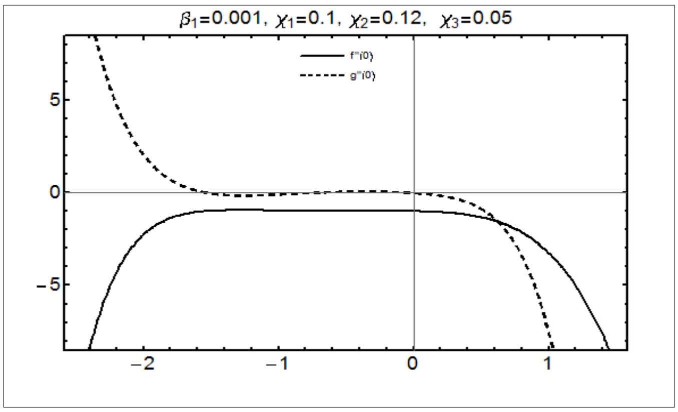


Fig: 1 $\hbar$-curves for $f''(0)$ and $g''(0)$

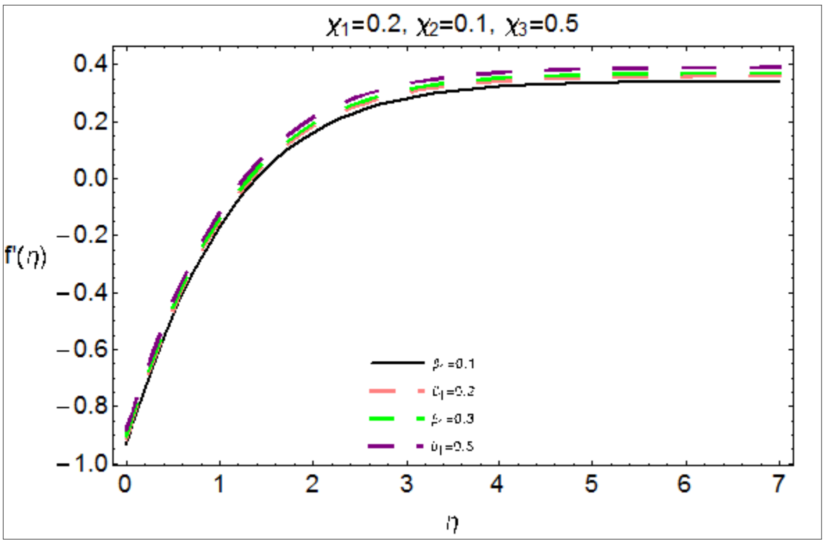


Fig: 2 Velocity profile for different values of ratio parameter $\beta_1$.

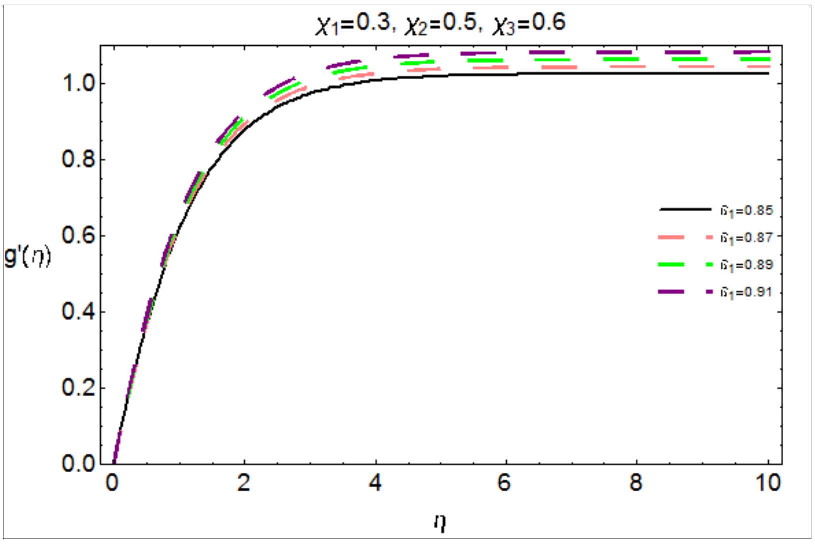


Fig: 3 Velocity profile for different values of ratio parameter $\beta_1$.

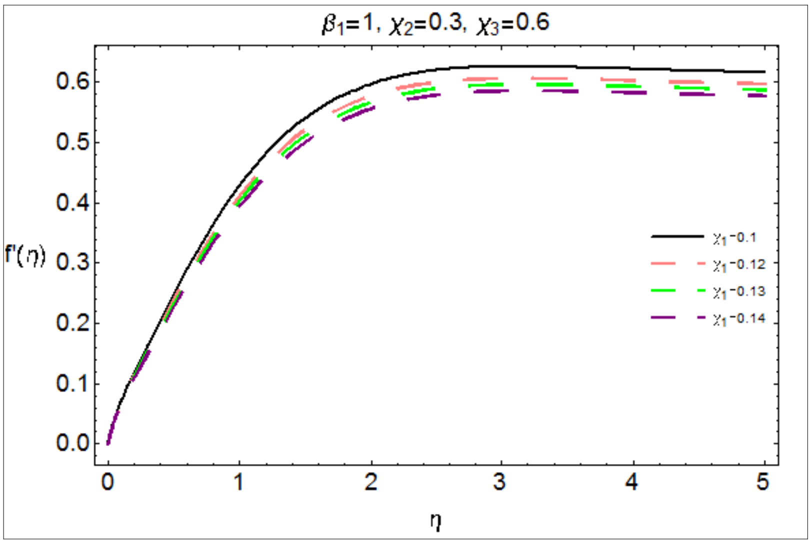


Fig: 4 Velocity profile for different values of Second grade fluid parameter $\chi_1$.

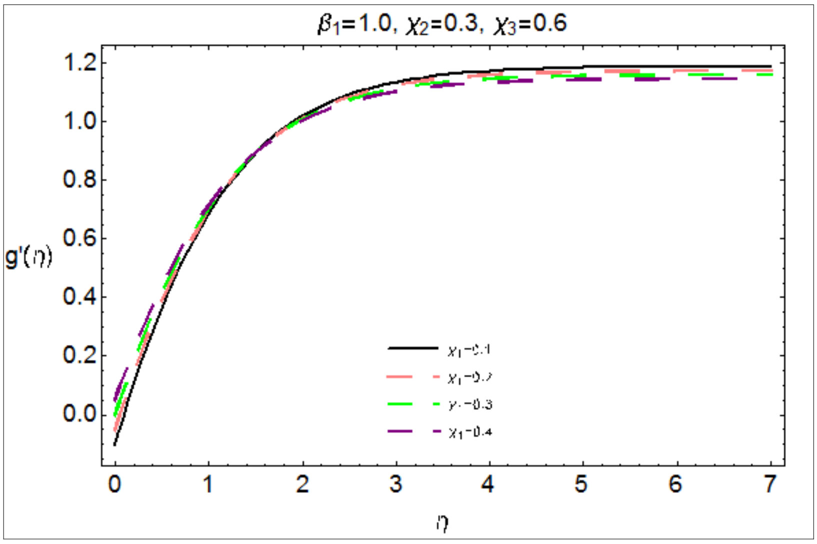


Fig: 5 Velocity profile for different values of Second grade fluid parameter $\chi_1$.

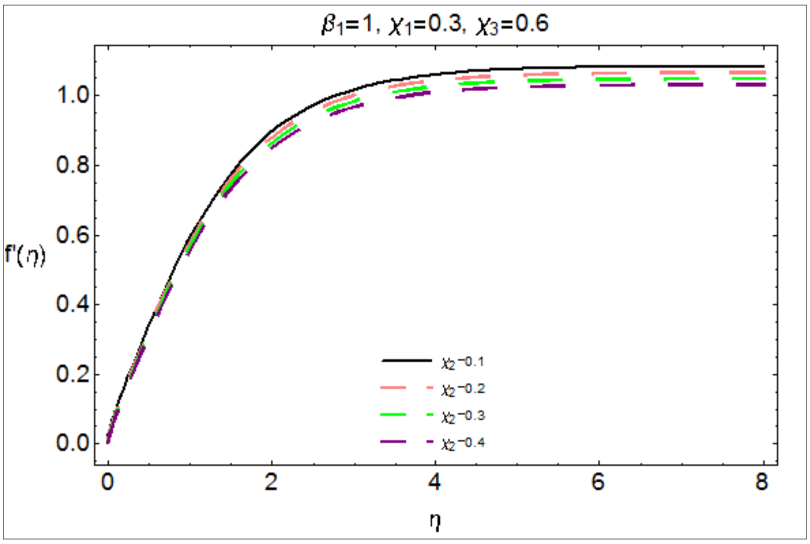


Fig: 6 Velocity profile for different values of Second grade fluid parameter $\chi_2$,

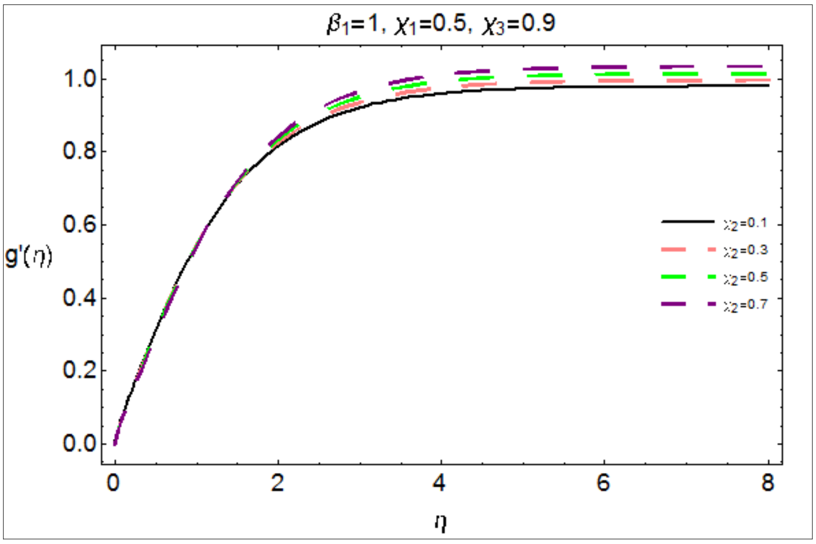


Fig: 7 Velocity profile for different values of Second grade fluid parameter $\chi_2$,

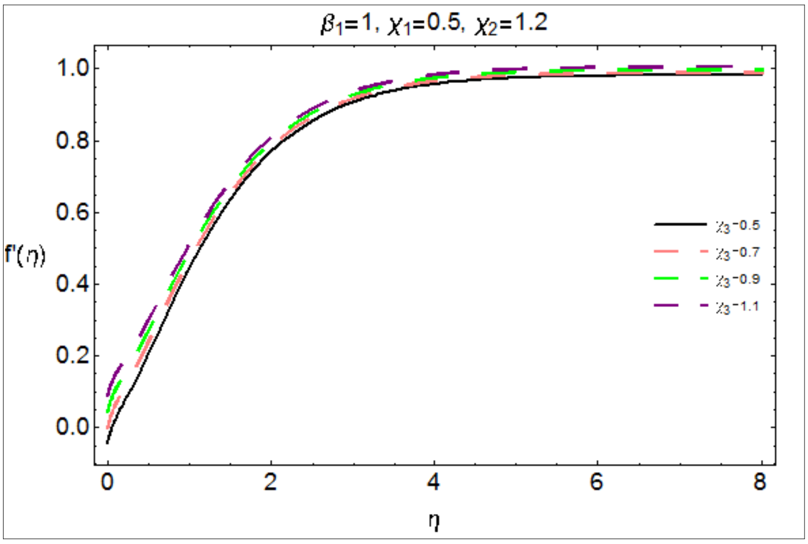


Fig: 8 Velocity profile for different values of Third grade fluid parameter $\chi_3$.

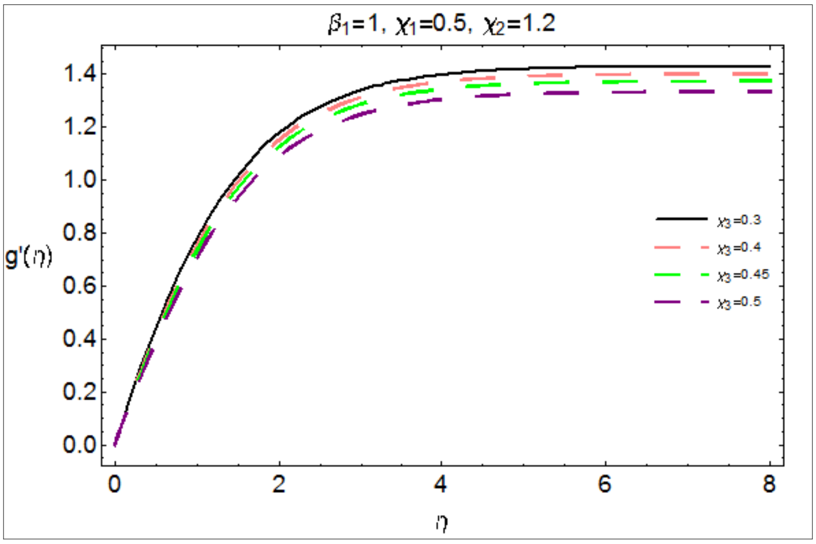


Fig: 9 Velocity profile for different values of Third grade fluid parameter $\chi_3$.

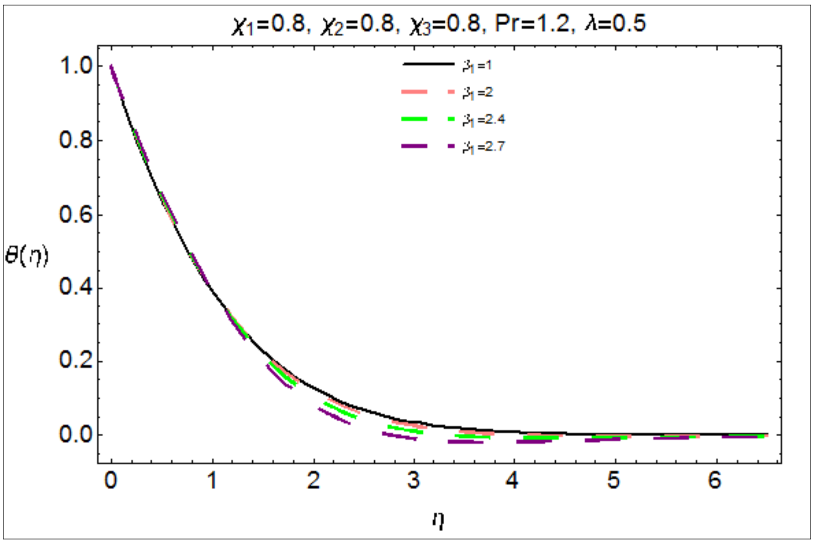


Fig: 10 Temperature profile for different values of ratio parameter $\beta_1$.

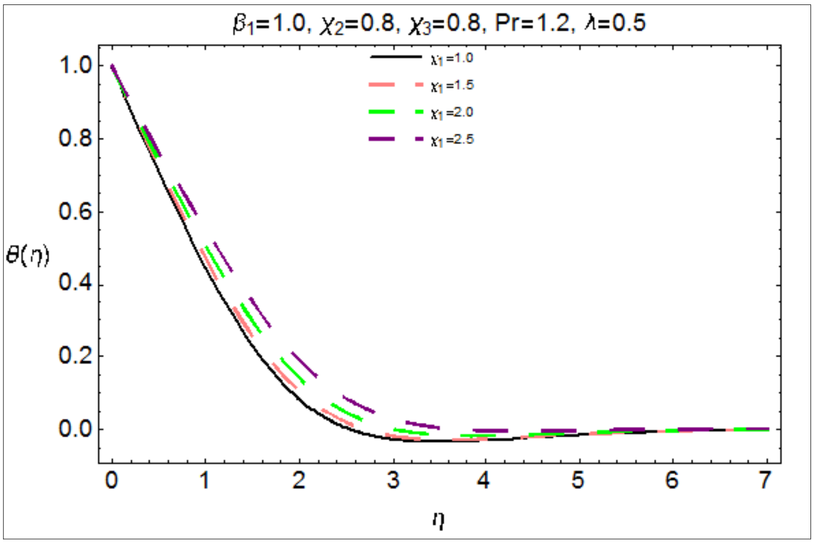


Fig: 11 Temperature profile for different values of Second grade fluid parameter $\chi_1$.

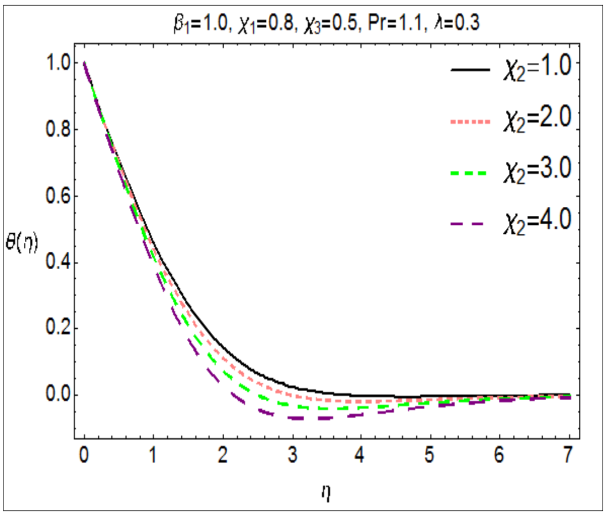


Fig: 12 Temperature profile for different values of Second grade fluid parameter $\chi_2$.

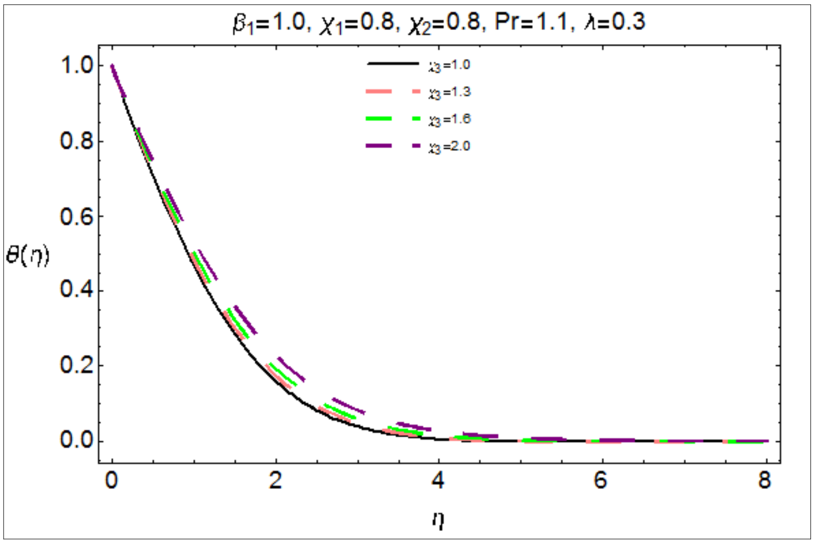


Fig: 13 Temperature profile for different values of Third grade fluid parameter $\chi_3$.

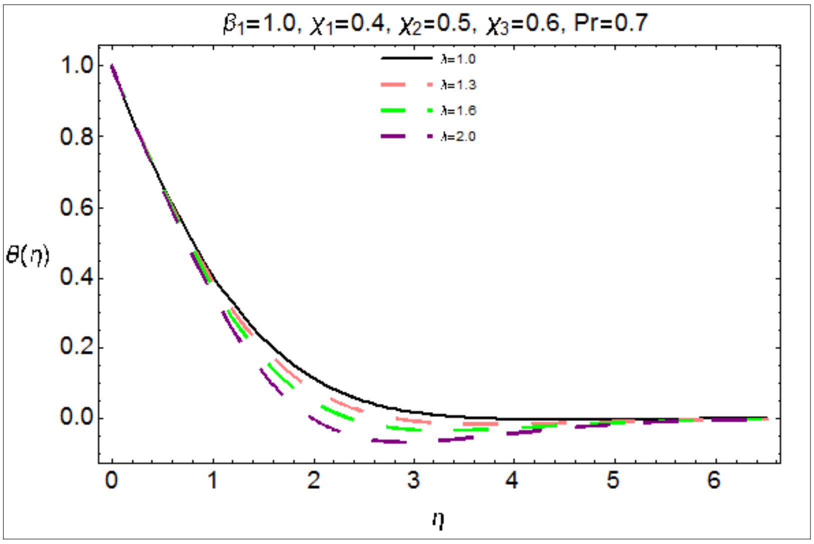


Fig: 14 Temperature profile for different values of Thermal relaxtion parameter $\lambda$.

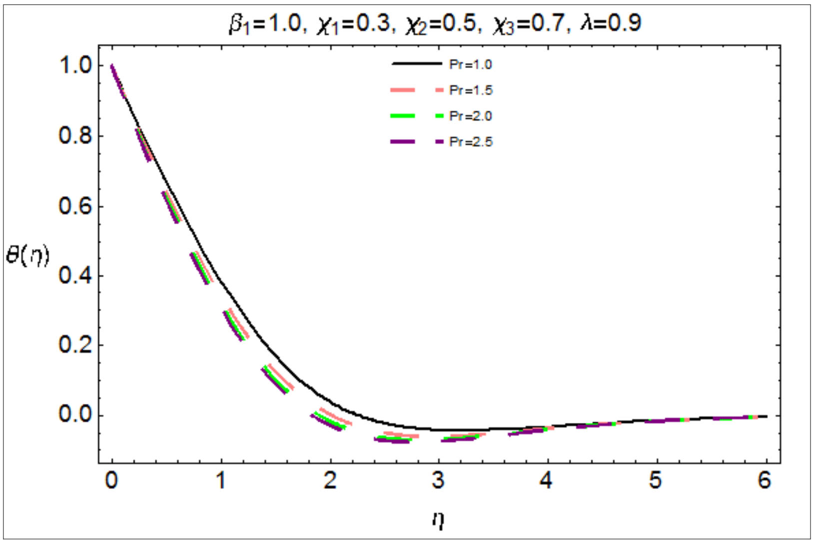


Fig: 15 Temperature profile for different values of Prandtl number $P_r$.

## V. DISCUSSION

This unit displays arithmetical consequences that illustration the effect of each fluid parameter on flow like Second grade fluid parameters $\chi_1$ and $\chi_2$, third grade fluid parameter $\chi_3$, thermal relaxation parameter $\lambda$, Prandtl number Pr, and ratio parameter $\beta_1$, on the non-dimensional velocities $f'(\eta)$, $g'(\eta)$ and temperature $\theta(\eta)$ fields. For this determination Figs. $2-15$ have been offered.

The inspiration of ratio parameter $\beta_1$ on velocity profiles $f'(\eta)$, $g'(\eta)$ are exposed in Figs. 2 and 3. It can be noticed that an improvement in the velocity profiles when there is an growth in the ratio parameter. This can occuroutstanding to the statistic that the intensification in the ratio parameter increases the boundary layer of the momentum. The stimulus of the second-class fluid parameter on the velocity profiles are revealed in Figs. 4 and 5. After these Figs. it can be realized that increasing the worth of the second-grade fluid parameter $\chi_1$ decreases the momentum boundary layer.

Figs. 6 and 7 portray the outcome of the second grade fluid parameter on velocity profiles $f'(\eta)$ and $g'(\eta)$ correspondingly. These statisticspropose that increasing the second grade fluid parameter $\chi_2$ willdecline the velocity profile $f'(\eta)$, while the increasing values of the second grade fluid parameter $\chi_2$ velocity profile $g'(\eta)$ will be increased. In Figs. 8 and 9 show the consequence of the third grade fluid parameter on velocity profiles $f'(\eta)$ and $g'(\eta)$ individually.

These datarecommend that cumulative the third grade fluid parameter $\chi_3$, will increased the velocity profile $f'(\eta)$, while the increasing values of the third grade fluid parameter $\chi_3$, velocity profile $g'(\eta)$ will be decreased.

Fig. 10 demonstrations the consequence of ratio parameter on temperature profiles of the flow. It is experimental that an increase in the ratio parameter $\beta_1$ decreases the temperature profiles of the flow. It is predictable that an rise in ratio parameter will statement the heat energy to the flow, which origins the temperature profiles to intensification. Fig. 11 represent the inspiration of the second-grade fluid parameter $\chi_1$ on temperature profile.It is obvious from the character that rise in second-grade fluid parameter $\chi_1$ enhance the temperature boundary layers. Fig. 12 labels the effect of the second grade fluid parameter $\chi_2$ on temperature profile. It is apparent from the figure that increase in parameter decays the temperature boundary layers. Fig. 13 pronounce the stimulus of the third grade fluid parameter $\chi_3$ on temperature profile. It is obvious from the figure that upsurge in third grade fluid parameter $\chi_3$ improve the temperature boundary layers.

In Figs. 14 and 15 the result of the Prandtl number $\Pr$ on the temperature profile has been portrayed in Fig. 15. The temperature and the thermal boundary layer thickness decrease with the increase of $\Pr$. Actually it specifies that intensification in the Prandtl number resources an increase of fluid viscosity, which bases a decay in the temperature distribution.

## VI. CONCLUSIONS

The basic overriding equations are rehabilitated into coupled nonlinear ordinary differential equations. Homotopy analysis process is used to accomplish the numerical computations. The possessions of diverse parameters like, second grade fluid parameters, third grade fluid parameter thermal slackening parameter Prandtl number $\Pr$ and ratio parameter $\beta_1$ are scrutinized with the help of graphs. Fleetingly the overhead ponderings can be summarized as follows:

**1**. The upsurge of momentum border layer chunkiness with the increase in $\beta_1$ noted and the thermal boundary layer thickness decreases with the increase in $\beta_1$.

2. Growing the second-grade fluid parameter decreases the velocity $g'(\eta)$ and growing the $\chi_1$ and $\chi_2$ enhance velocity $f'(\eta)$.

3. Increasing the third-grade fluid parameter decreases the velocity $g'(\eta)$ and increasing the $\chi_3$ enhance velocity $f'(\eta)$, also by increasing $\chi_3$ thermal boundry layer increased.

4. An increment in the thermal relaxation parameter decreases the temperature distribution.

5. An increment in the Prandtl number $\Pr$ decreases the temperature distribution. Due to which thermal boundry layer thickness increases.

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# Laboratory Electrical Resistivity and Moisture Content Correlation for Compacted Laterite Soil in Malaysia

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***Abstract*: Laterite soil is generally believed to be a good natural material for foundation and building purposes. The occurrence of laterite soil is found in abundance in the tropical regions of the world including Malaysia. The properties of laterite soil are normally determined by borehole sampling method. This method renders actual determination of the soil material, but on the contrast it is very expensive and requires too much time and effort. Being an alternative method, electrical resistivity technique can be used to deliver a quick assessment of the subsurface soil and thus save expenditure, time and energy. This research paper focuses on the preliminary analysis of compacted laterite soil on laboratory basis by correlating electrical resistivity with moisture content. Correlations obtained from electrical resistivity and moisture content highlights good relationship with higher regression values ranging from 0.6859 to 0.9974. It is found that an increase in moisture content decreases the electrical resistivity of the soil.**

***Keywords*: C*ompacted* laterite soil, Electrical resistivity, Moisture content, Correlations.**

## I. INTRODUCTION

Laterite soil is red in color and rich in clay, found in tropical and sub-tropical regions. High temperatures and abundant rainfalls of the tropics are needed for laterite soil to be formed. The water works as a weathering agent and removes all the bases and silicic acid, thus enhancing the soil with aluminum silicates, aluminum hydro silicates, iron oxides and iron hydroxides. Red color of the laterite soil is mainly due to the presence of iron oxides [1].

In tropical regions, variation in geotechnical properties of soil are caused by different formation factors and these differences in the results obtained from the investigation are common to find even within short lengths and depth [2]. Therefore, prior to their application in civil engineering work, the preliminary investigations of engineering properties of laterite soil is needed. Moreover, it does not only depend upon the abundance of the laterite soil but also its usefulness as a construction material or foundation for structures. It has been reported from the literature that lateritic soils can be used as fill materials in construction works in most of the tropical countries [3].

It has been observed that the laterite soil is generally believed to be a good natural material for foundation and building purposes. Although there are some unfavorable properties for instance shrinkage, cracks, water sensitivity and uneven distribution. These properties are usually evaluated by borehole sampling which is the absolute determination of the physical properties of the soil but on contrary it is very time consuming and expensive [4].

Therefore, electrical resistivity (E.R) technique offers a quick assessment of the subsurface properties without making any soil disturbance and save much time and energy.

Eko Andi Suryo [5] conducted study of the influence of deep cracks on soil stability using electrical resistivity measurements in unsaturated residual soil slopes and concluded that soil electrical resistivity can be affected by moisture content, density and clay content of the soil. The research suggests that the electrical resistivity survey could be used to detect the deep cracks.

The study on the electrical resistivity is also carried out by Siddiqui [6] on correlation of electrical resistivity with water content and found good relationship between E.R values and water content.
W. Bai et. al. [4] investigated the electrical properties in lateritic soil by performing electrical conductivity measurements and found increment in conductivity values with the increase in water content. Findings from previous research present encouraging results and therefore suggests to determine the relationship between electrical resistivity and moisture content for compacted laterite soil which would enable electrical resistivity to eliminate the physical parameters in calculations and designing for the foundation and construction purposes.

## II. MATERIALS & METHODS

The research methodology is based on laboratory investigations of laterite soil to analyze the behavior of laterite soil under the influence of resistivity and water content. Laboratory work is carried out based on the following steps:

### *A. Soil Sample Collection*

This research project involves the testing of 20 number of disturbed laterite soil samples obtained from different field positions near Perak state and are investigated at laboratory conditions by methods proposed in British Standards (BS).

*B. Soil Mixing and Compaction*

Samples obtained from field site were brought to laboratory and placed into oven for 24 hours in order to dry the soil. After the soil has been dried, breaking was performed to reduce the soil lumps into smaller sizes for further experimental stages. Initially considered water for mixing process was 10, 15, 20, and 25 percent for different soil samples due to their distinct nature. An increment of about 5 percent was made once the soil was thoroughly mixed and compressed based on the initial addition of water. Compaction mechanism was performed after every increment of water till the bulk unit weight decreased twice.

Before performing the compaction test, internal sides of the mold were lined by thick plastic bag so that it should prevent the mold steel to affect the resistivity values.The laterite soil was then compacted in three equal layers using automatic compactor machine that delivered 27 blows per layer. The automatic compactor exhibits effective and effortless performance as compared to conventional proctor hammer which requires too much effort and time. Figure 1 and 2 shows experimental procedure for soil mixing and compaction.


Figure 1. Soil Mixer

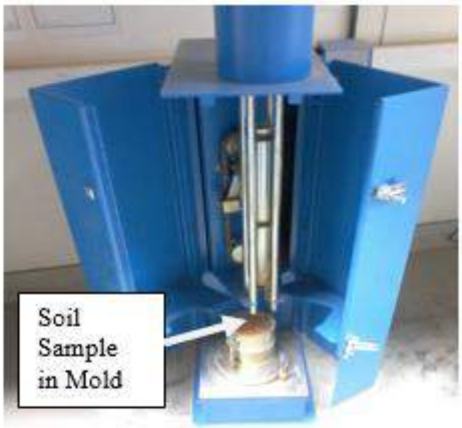


Figure 2. Automatic Compactor

*C. Laboratory Electrical Resistivity (LER) Test*

Electrical resistivity measurements were conducted by simple multimeter alongwith DC power source. In order to record the resulting current for each soil sample, a potential difference of 60V was applied. E.R values were calculated using equation (1) as discussed below. Figure 3 presents laboratory resistivity testing procedure.

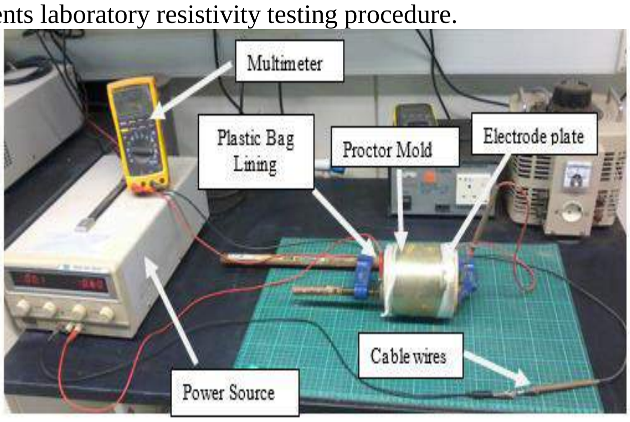


Figure 3. Experimental setup for Laboratory electrical resistivity measurements

E.R calculations were then performed on the mold by connecting the disc electrodes on either sides of the cylindrical soil sample in the mold using equation (1) and (2).Where V is for voltage in volts, I is for current in amperes, R is for the resistance in ohms, A is for the cross-sectional area of soil sample in mold in $m^2$, L is for the length of the soil sample in mold in meters and ρ is for the resistivity in ohms meter.

$$R = V/I \quad (1)$$

$$\rho = (A/L)R \quad (2)$$

*D. Determination of Moisutre Content (MC)*

Current research is based on experiments conducted for the determination of electrical resistivity and moisture content relationship of compacted laterite soil. Once the resistivity was performed, the sample for moisture content determination was taken out from mold and then placed into oven for 24 hours. The amount of water content in soil sample was evaluated by equation (3).

$$\text{Moisture content, } w = \frac{m_2 - m_3}{m_3 - m_1} \times 100(\%) \quad (3)$$

Where,

$m_1$ represents the mass of container, $m_2$ represents the mass of container alongwith wet soil and $m_3$ represents the mass of container and dry soil

## III. Results and discussions

*A. Correlations between Moisture Content and Electrical Resistivity*

For results and analysis, regression analysis is performed using Microsoft Excel 2013 which is simple and easily operated tool. The correlations of electrical resistivity with moisture content of tested soil samples have been analyzed by applying exponential, logarithmic, polynomial and power regression method and highest correlation coefficient is selected. Correlations between Moisture Content and Electrical Resistivity

The relationship between moisture content and laboratory electrical resistivity indicates curvilinear trend with $R^2$ 0.9883, 0.9902, 0.9922, 0.8786, 0.0322, 0.9156, 0.6859, 0.9769, 0.9538, 0.9929, 0.9974, 0.9921, 0.9416, 0.9131, 0.9904, 0.9502, 0.9883, 0.9601, 0.9622 and 0.932 from sample number 1 to sample number 20 respectively. Table 1 illustrates the regression analysis results.

Table 1: Summary of regression analysis results

| Soil Properties | Sample ID | Soil Type | Equations | Determination Coefficient ($R^2$) |
|---|---|---|---|---|
| Water content | 1 | Laterite Soil | $y = 2E{+}07x^{-3.184}$ | 0.9883 |
| | 2 | | $y = 82008e^{-0.182x}$ | 0.9903 |
| | 3 | | $y = 26881e^{-0.098x}$ | 0.9922 |
| | 4 | | $y = 2E{+}07x^{-3.031}$ | 0.8786 |
| | 5 | | $y = 2739.3e^{0.0014x}$ | 0.0322 |
| | 6 | | $y = 4682e^{-0.103x}$ | 0.9156 |
| | 7 | | $y = -1076\ln(x) + 4093.3$ | 0.6859 |
| | 8 | | $y = 17030e^{-0.102x}$ | 0.9769 |
| | 9 | | $y = 2E{+}07x^{-2.876}$ | 0.9538 |
| | 10 | | $y = 2E{+}06x^{-2.732}$ | 0.9929 |
| | 11 | | $y = 3E{+}06x^{-2.692}$ | 0.9974 |
| | 12 | | $y = 455322x^{-2.004}$ | 0.9921 |
| | 13 | | $y = 8E{+}06x^{-2.773}$ | 0.9416 |
| | 14 | | $y = 7653.2e^{-0.068x}$ | 0.9131 |
| | 15 | | $y = 1E{+}06x^{-2.403}$ | 0.9904 |
| | 16 | | $y = 2E{+}06x^{-2.411}$ | 0.9502 |
| | 17 | | $y = 6956.3e^{-0.085x}$ | 0.9883 |
| | 18 | | $y = 2E{+}07x^{-3.212}$ | 0.9601 |
| | 19 | | $y = 6E{+}06x^{-2.902}$ | 0.9622 |
| | 20 | | $y = 3E{+}06x^{-2.502}$ | 0.932 |

Where y = Electrical Resistivity and x = Moisture content

The regression values delivered very strong relationship between electrical resistivity and moisture content for 19 samples and found that decrement in moisture content increases the electrical resistivity of laterite soil. This is due to the fact that electrical current flows smoothly through water and therefore increasing in moisture content allows the electric current to pass freely without causing any hindrance and therefore causing decrement in resistivity. Whereas, there was one sample which did not render understandable relationship with regression value 0.0322. This result might be due to some error while performing experiment and could be verified by carrying out further tests. The results obtained are consistent with the results obtained from [7, 8, and 9] for correlating the moisture content and electrical resistivity. Figure 4, 5, 6 and 7 shows relationship of electrical resistivity with water content.

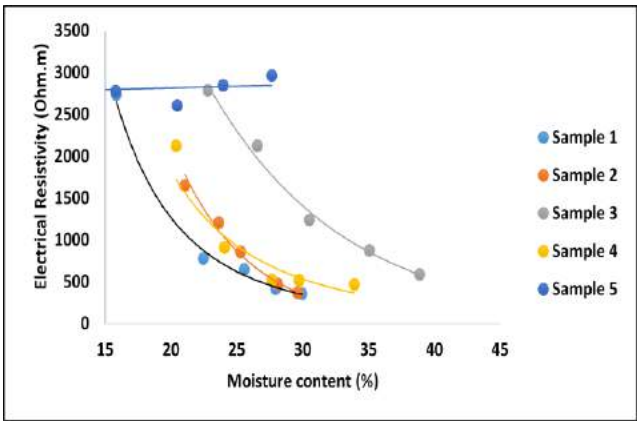


Figure 4 .Correlation between MC and LER for first five samples

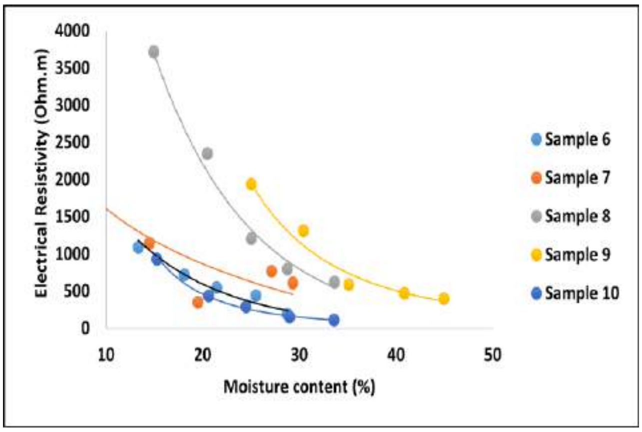


Figure 5. Correlation between MC and LER from sample 6 to 10

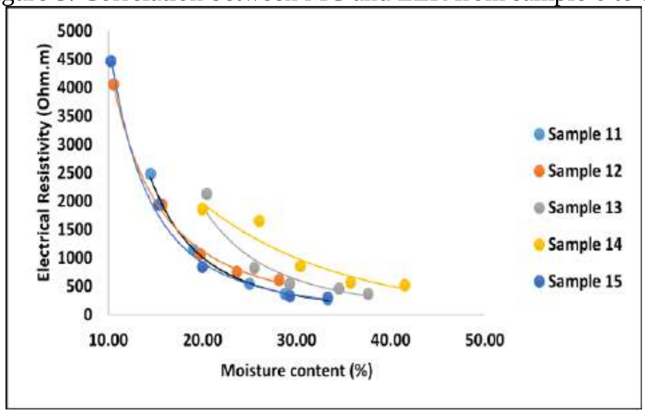


Figure 6. Correlation between MC and LER from sample 11 to 15

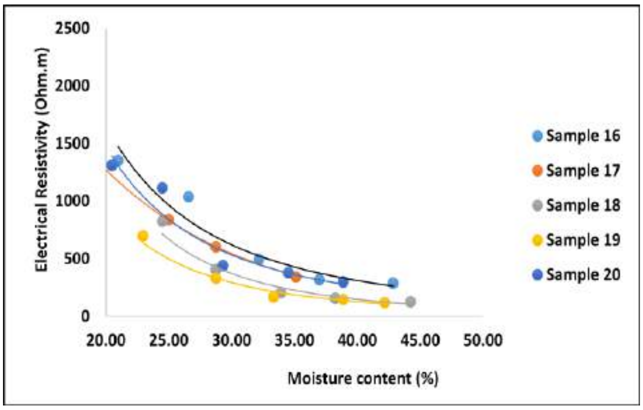


Figure 7. Correlation between MC and LER from sample 16 to 20

## IV. CONCLUSION

In this study, it was concluded that the obtained relationship between electrical resistivity and moisture content for compacted laterite soil was quite strong with higher regression values except one sample which delivered weak relationship possibly due to the human error while performing experiment and could be verified by conducting further tests. The good correlations obtained from this study enhance the importance of electrical resistivity technique to be applied for time, cost and effort saving soil investigation purpose in the field of geotechnical engineering.

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# Measuring Safety Management System of Oil and Gas Industry in Sindh

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***Abstract:*** **Oil and Natural Gas industry is very sensitive due to its vulnerability towards accidents. A small mishap may cause huge disaster in the field. These accidents cause loss of both, the time and valuable assets. Eventually, loss of time and assets causes financial losses that also damage the credibility of the Oil & Gas (O&G) company which is worth more than the loss of money. There are variety of reasons that may cause on-field accidents. These accidents can be categorized as i) explosion, ii) Falling out, iii) being struck, iv) being caught, v) electrocution, vi) chemical exposure, vii) electrocution, and viii) rig collapsing. Pakistan, especially the land of its province Sindh is rich in Oil & Gas minerals and lot of international and national companies have started their operations already. This paper focuses the trend of Health & Safety (H&S) in relevant companies / industries operating within the region. The data collected through surveys helps us to analyze the adoption rate of quality standard regarding (H&S) during the production processes within O&G companies. The analytical reviews are carried out using SPSS™ V23.0. Various interesting results are observed after running different algorithms / filters that can guide any stakeholder of the Oil & Gas industry to know more precisely about the culture of H&S in existing oil exploring companies. The findings can also be helpful for new entrants in the O&G industry to evaluate their H&S parameters. In this research, safety management is measured for Sindh. Through literature survey 34 attributes are selected and a questionnaire was distributed. The authors received 41 responses, which helped in measuring safety management of Oil and Natural Gas Industry of Sindh. Results indicate that the important factors are commitment, safey documentation, stakeholder's cooperation, communication, risk assessment, supportive environment safety awareness, housekeeping, accountability and workers' relationships. The research concluded that Leadership has prime importance for creating safety management.**

***Keywords;*** **Leadership, Process, EFQM, Goals and resources. Health & safety management.**

## I. INTRODUCTION

Chernobyl, the city of Ukraine, nuclear reactor devastation g mishap happened in 1986 which occasioned various expiries in the vicinity. The International Atomic Energy (IAEA) stayed the site to discover the purpose of the tragedy. At latter, the team familiarized a term as Safety Management System to prevent such mishap, which was weak at the nuclear reactor (Gadd and Collins). Various studies to analyze Safety Management System are carried out (little 2002).
How to define safety management system? Scientists do not agree on a single definition yet, however, the definitions revolve around that safety management system is common beliefs, behaviors, attitudes rules and values (Potter, 2003). A widely accepted definition is presented by Advisory Committee on the Safety of Nuclear Installations, which is given below.
Safety Management System is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's Health and safety management. Organization with a positive safety Management System are characterized by communications found on mutual trust, shared perception of the importance of safety, and confidences in the efficacy of preventive measures (ACSNI, 1993).

## II. METHODOLGY

A Questionnaire is based on EFQM European Foundation for Quality Management feedback was obtained from Oil and N. Gas industry, fifty-three professionals were requested out of which 41 responded completed it. The responses were entered in the SPSS 23.0v (Statistical Program for Social Sciences) and identify the issues of Oil and N. Gas industry. The weighted average method is applied to arrange the importance of various variables. The correlation among the variables were found to identify the managerial supportive handlers.

## III. SAFETY MANAGEMENT SYSTEM

In what way to define Safety Management System? Scientists do not agree on a single definition yet, though, the definition revolve near around the scope in the Safety Management System is common beliefs, behaviors, attitudes rules and values (Potter, 2003). A generally acknowledged definition is vacant by Advisory Committee on the Safety of Nuclear Mechanisms which is specified, below.
Safety Management System is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's Health and safety management. Organization with a positive safety Management System are characterized by communications found on mutual trust, shared perception of the importance of safety, and confidences in the efficacy of preventive measures (ACSNI, 1993).

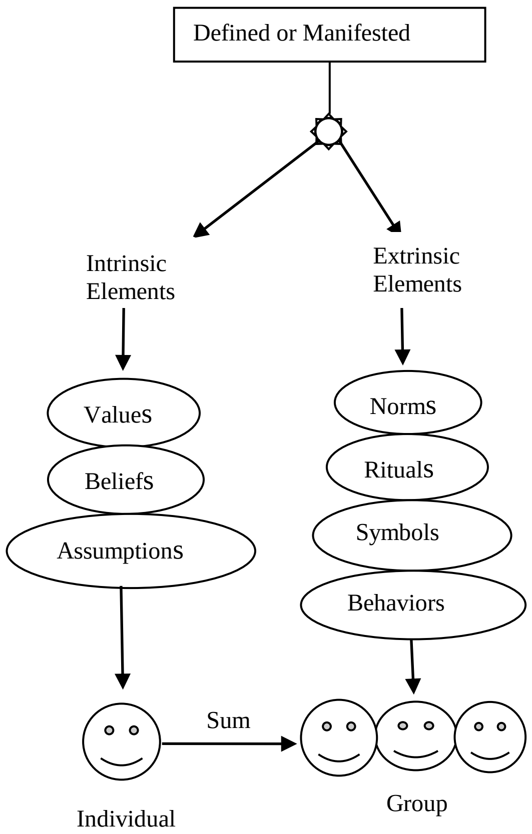


Figure 1. Safety Management System

### *A. Questionnaire design on lime survey*

A Questionnaire was enclosed on lime survey created on literature to Measuring safety in management system of oil and gas industry Sindh. In-depth analysis of prevailing studies led to growth of Questionnaire made up to 43 attributes. Six-point likert Scale was expended to assessed discriminations of professional on the safety management system of oil and gas industry queries are included in the groups.

**Leadership**

| **Factor** | **Variables** |
|---|---|
| In our organization, management takes safety seriously | Commitment |
| Management encourages workers to give opinions and/or suggestions on safety issues | Communication |
| In our organization, management makes sure that workers hold responsibilities for their own safety | Accountability |
| Management acts quickly to correct safety problems when brought to his/her notice | Prompt decision |

**Policy & Strategy**

| **Factor** | **Variables** |
|---|---|
| It is our organization's policy to recognize workers with good safe Behaviors | Safety awareness |
| It is our organization's policy to give safety the same priority as Production | Safety and productivity alignment |
| Our organization has a safety policy that | Safety standards |

| | |
|---|---|
| gets reviewed and upgraded Regularly | |
| In our organization, safety initiatives are proactively planned in order to continually improve our safety standards | Safety initiatives |
| In our organization, safety is an integral part in formulating our business decisions and goals | Safety integration in business goals |

**People**

| Factor | Variables |
|---|---|
| Our project staff (including workers) believe that our organization is deeply concerned about workplace safety | Shared perceptions |
| Our project staff (including workers) fully understand their safety Responsibilities | Safety responsibilities |
| In our organization, workers can seek advice without hesitation on safety matters from their immediate boss, such as project manager, safety manager, supervisor etc. | Supportive environment |
| In our organization, project staff (including workers) are involved, formally and/or informally, in safety related issues | Workers' involvement |
| In our organization, workmates are encouraged to give suggestions to each other on how to work safely | Workers' relationships |
| In our organization, workload is reasonably balanced among workers so that they can get the job done safely | Workload |
| Our organization ensures that workers live stress free to avoid unsafe Behaviors | Work pressure |

**Partnerships & Resources**

| Factor | Variables |
|---|---|
| Project participants, such as subcontractors, cooperate with us in following our safety standards | Stakeholders' cooperation |
| In our organization, financial resources are adequately provided to support the implementation of our safety policy | Financial resources |
| Our organization has sufficient necessary safety resources available so that workers can carry out their jobs safely | Safety resources |
| Our organization endeavors to have adequate human resources to get the job done safely | Human resources |

**Processes**

| Factor | Variables |
|---|---|
| In our organization, we provide adequate training for those performing new tasks safely | Training |
| In our organization, risk and hazard assessment is a part of our routine safety planned activities | Risk assessment |
| Feedback on safety implementation is encouraged within the organization in order to improve safety performance | Feedback |
| Our organization adopts a no-blame approach so that workers always report near misses and accidents they experience or witness | No-blame approach |
| In our organization, site housekeeping is maintained at a high level | Housekeeping |
| Our organization keeps accidents records to investigate their causes | Safety documentation |
| Our organization has a good safety benchmarking system to compare with other similar organizations | Benchmarking system |

**Goals**

| Factor | Variables |
|---|---|
| Workers are generally satisfied with the way we currently manage safety in our organization | Job satisfaction |
| The way we currently manage safety in our organization promotes safe work behavior | Safe work behavior |
| The way we currently manage safety in our organization helps us reduce the number of severe accidents and safety related incidents | Reduction in accidents |
| The way we currently manage safety in our organization helps us meet our clients' expectations | Customers' expectations |
| Public perceive our organization with a good safety image | Industrial image |
| The way we currently manage safety in our organization has a positive influence on workers' morale | Workforce morale |
| Our expenditure due to accidents are gradually decreasing per annum | Cost of accidents |

Following likert scale is adopted for minimum and maximum statistics: 0=Irrelevant, 1= strongly disagree, 2= disagree, 3= not sure, 4= Agree and 5= Strongly Agree.

**Table 1. Maximum to Minimum Descriptive Statistics.**

| | Attributes | Total responders | Min: | Max: |
|---|---|---|---|---|
| 1 | Commitment | 41 | 4 | 5 |
| 2 | Safety documentation | 41 | 4 | 5 |
| 3 | Stakeholders' cooperation | 41 | 4 | 5 |
| 4 | Communication | 41 | 4 | 5 |
| 5 | Risk assessment | 41 | 4 | 5 |
| 6 | Supportive environment | 41 | 4 | 5 |
| 7 | Safety awareness | 41 | 4 | 5 |
| 8 | Housekeeping | 41 | 2 | 5 |
| 9 | Accountability | 41 | 3 | 5 |
| 10 | Workers' relationships | 41 | 4 | 5 |
| 11 | Shared perceptions | 41 | 3 | 5 |
| 12 | Prompt decision | 41 | 4 | 5 |
| 13 | Safety standards | 41 | 3 | 5 |
| 14 | Workers' involvement | 41 | 4 | 5 |
| 15 | Feedback | 41 | 3 | 5 |
| 16 | Safety integration in business goals | 41 | 3 | 5 |
| 17 | Customers' expectations | 41 | 2 | 5 |
| 18 | Reduction in accidents | 41 | 2 | 5 |
| 19 | Safety responsibilities | 41 | 3 | 5 |
| 20 | Safety initiatives | 41 | 3 | 5 |
| 21 | No-blame approach | 41 | 3 | 5 |
| 22 | Safety and productivity alignment | 41 | 2 | 5 |
| 23 | Industrial image | 41 | 2 | 5 |
| 24 | Safety resources | 41 | 3 | 5 |
| 25 | Safe work behavior | 41 | 2 | 5 |
| 26 | Training | 41 | 3 | 5 |
| 27 | Bench marking system | 41 | 2 | 5 |

| | | | | |
|---|---|---|---|---|
| 28 | Workforce morale | 41 | 3 | 5 |
| 29 | Job satisfaction | 41 | 3 | 5 |
| 30 | Human resources | 41 | 3 | 5 |
| 31 | Financial resources | 41 | 3 | 5 |
| 32 | Workpressure | 41 | 2 | 5 |
| 33 | Cost of accidents | 41 | 1 | 5 |
| 34 | Workload | 41 | 2 | 5 |

## IV. RESULTS

Following factor are identified from most important to least important; (1)Commitment, (2)Safety documentation, (3)Stakeholders' cooperation, (4)Communication, (5)Risk assessment, (6)Supportive environment, (7)Safety awareness, (8)Housekeeping, (9)Accountability and (10)Workers' relationships.

## V. CONCLUSION

It shows that commitment (leadership), Safety documentation (Processes), Stakeholders' cooperation (Partnerships & Resources), Communication (Leadership), Risk assessment (Processes), Supportive environment (People), Safety awareness (Policy & Strategy), Housekeeping (Processes), Accountability (Leadership), Workers' relationships (People), Shared perceptions (People), Prompt decision (Leadership), Safety standards (Policy & Strategy), Workers' involvement (People), Feedback (Processes), Safety integration in business goals (Policy & Strategy), Customers' expectations (Goals), Reduction in accidents (Goals), Safety responsibilities (People), Safety initiatives (Policy & Strategy), No-blame approach (Processes), Safety and productivity alignment (Policy & Strategy), Industrial image (Goals), Safety resources (Partnerships & Resources), Safe work behavior (Goals), Training (Processes), Bench marking system (Processes), Workforce morale (Goals), Job satisfaction (Goals), Human resources (Partnerships & Resources), Financial resources (Partnerships & Resources), Work pressure (People), Cost of accidents (Goals) and Workload (People) has the sequence of the importance to manage safety of Oil and N. Gas industry in Sindh.

## VI. ACKNOWLEDGMENTS

The authors are thankful to Mehran Universityof E & T, Jamshoroto provide the research facilities and funding for the above project to add something in the body of knowledge. The timely help provided by Assistant Professor Dr. Adnan Ashraf Arain Department of Computer System Engineering made the project to enhance in lot of ways.

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# An Investigation of Present Situations of Burn Care Units in Vicinity of Hyderabad

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*Abstract:* **Burn care is one of the most neglected health care issues in Pakistan. The rate of mortality for victims with 40 to 50 % body burns is almost 86% in Pakistan. While the mortality rate is less than 10% in the developed countries for victims having 50 per cent burns. According to an estimate 195,000 deaths are reported every year due to burns in which majority of cases belong to low socio-economic class of our country. None of the burn units in Pakistan is giving satisfactory treatment to the patients. The situation is even worst in Hyderabad. The lack of awareness is clearly reflected by the civil hospital of city. This study is aimed to highlight the present situation of burn care units in Hyderabad initially. Also, it aims to investigate the causes of burns in interior Sindh patients. The research work includes unstructured interviews with the concerned doctors and Head of Departments of burn units. The causes of burns were determined through a questionnaire survey from relevant medical practitioners and by physical visits of hospital units in the vicinity of Hyderabad. This study proposed a new specialized bun care center with required capacity on the basis of frequency of patients and necessary facilities for patients. This investigation of present condition & suggestions is a road map for top management of Hyderabad and Jamshoro Civil Hospital.**

*Keywords*: **Burn care units, Causes of burns, Health care, Hyderabad.**

## I. INTRODUCTION

The modern technologies were invented by men for their comfort, but this comfort also added miseries by increasing risk of burn injuries. Since ages, we have paid the price of this comfort in terms of various burn injuries. For all these burn injuries carelessness is believed to be the major cause that leads to accidental injuries, however because of strong Eastern background even the cases of homicidal nature are referred as suicidal or accidental [1].

Burns are considered as the fourth most common type of trauma worldwide, following traffic incidents, falls and inter personnel violence [2]. Annually about 2 million people suffer from various types of burn injuries world wide of whom more than 0.1 million people die [3]. Each year across England and Wales, around 3000-4000 adults are admitted to specialized burn centers where they have to face with numerous physical, social and psychological problems in and beyond hospitalization [4]. Despite intensive care and treatment, most of the burn patients suffer from severe pain during the acute phase [5]. Severe acute burn pain also seems to have an impact on the development of psychological problems such as post-traumatic stress disorder, PTSD) [6] and the high co morbidity between pain and depression in different populations is well documented [7]. Though the mortality has shown a declining trend in developed countries, it is still considerable [8]. Mortality rate due to burn injuries is higher in developing countries of world as compared to developed countries because of unawareness among people and lack of availability of burn care services [9]. In India annually about 60,000 people suffer from burn injuries, from which more than 50,000 are treated in hospitals and about 10,000 succumb to thermal injury [9]. Like other developing countries the Pakistan is also facing lot of burn cases on daily bases and it is one of the major public health problems, yet not addressed properly. None of the burn units in Pakistan is treating patients on similar lines. Most of burn units are under the control of the armed forces where civilians are charged with very high fee. Since the treatment of burns is said to be much expensive and high-risk, the patients have no option but to visit the government hospitals, where they have to face very unhygienic conditions.

In Pakistan there are only eight burn centers for the population of 201,663,382 people [10]. Among the country's renowned burn centers are "Nescom Burn Centre" in Islamabad that is meant for patients with chemical burns and is reserved for officials of sensitive installations, "Kharian burn center" at the Combined Military Hospital Kharian and the "Pakistan Ordnance Factories" (PAF) burn unit at Wah Cantonment. Most of the burn patients in Pakistan die due to infection and those, fortunately are survived, don't get proper treatment.

The conditions of burn care facilities at Sindh province is even worse and in all over the province including the city of Hyderabad, there is a serious lack of burns treatment facilities. According to World Health Organization (WHO's) standard, there should have one burn center for one million people at least. The population of Hyderabad is more than three (03) million but there is no proper functioning burn care center here.

The burns unit of civil hospital Hyderabad is the only facility for the victims of burns which also caters patients from different areas of interior Sindh. But unfortunately, it also lacks many facilities including an intensive care unit, emergency department and plastic/reconstructive surgery.

Treatment of burns is not always straightforward. Moreover, national and international guidelines of one region is different to another. On one hand, it is necessary to understand pathophysiology, surgical treatments, classification of burns, and the latest updates in burn science while on the other hand, the clinical situation for treating these burn cases needs clear guidelines to cover every single aspect during the treatment procedure.In order to fully understand what patients go through during their healing process, first of all it is necessary to know the types of burn injuries.

Keeping in view the problem this research is therefore intended to highlight the current situation of facilities of burns treatment at Hyderabad. The research involves in-depth interviews with hospital consultants and doctors experienced in burns treatment. It also includes; Survey research, Interview research and case studies. This research proposed a specialized burn care center with all basic facilities for the patients in Hyderabad city.

## II. METHODOLOGY

In research methodology different methods are used to assume a richer and complete result. Case study, interviews, observations reviewing literature, and photography were the main tools throughout the process. The first step was to start with studying previous researches in order to strengthen conceptual linkage between what has been found before and what will be found. In depth questionnaire survey was conducted to determine causes of burns in Hyderabad vicinity, frequency of patients, area from where mostly people come and level of satisfaction of people about present situation of hospital. Study also involves personal visit of various sites in Hyderabad for proposing burn care unit in the city. Google map was used additionally for this purpose.

### a) DATA COLLECTION AND ANALYSIS

Initially the cause of burn was investigated through a comprehensive questionnaire survey & in-depth interviews among medical practitioners. The questionnaire was floated among filed experts like Physician, having rich experience in burn treatment. Table 1 shows the statistics of questionnaire for this research work.

Table: 1 Questionnaire survey statistics

| | |
|---|---|
| No. of questionnaire distributed | 40 |
| No. of questionnaire received | 35 |
| Valid Questionnaire | 33 |

A detailed questionnaire survey is conducted with well experienced Doctor of Civil hospital Hyderabad to know about the causes of burns. According to survey results the highest percentage is of hot liquids i.e. 76% and lowest is of electrical burns i.e. 3%. As shown in table 2.

Table: 2 Questionnaire survey results for burn causes

| S. No | Causes of burns | % |
|---|---|---|
| 1 | Hot liquids | 76 |
| 2 | Flame | 9 |
| 3 | Chemical | 12 |
| 4 | electricity | 3 |

Other questions that have been asked in survey area as follows;

*From which areas do most patients come?*

According to survey, 93& of patients come from interior Sindh only. Remaining 7% is from vicinity of Hyderabad.

*Which age group is on highest risk?*

The survey yields that, maximum percentage of patients are under 10 years. Table 3 illustrates the patients age wise.

Table 3: Age wise patients in Hyderabad Hospital

| S. No | Age group | Percentage % |
|---|---|---|
| 1 | 0-10 years | 70 % |
| 2 | 10-20 years | 27% |
| 3 | 20-40 years | 3 |
| 4 | More than 40 years | 0 |

*Are the present conditions of burn care facilities are satisfactory or not?*

The patients used to visit the hospitals were asked about their level of satisfaction from the present facilities and condition of hospital. About 63% patients were of the opinion that, they are not satisfied from the present facilities of hospital. Further, the results are shown in fig. 1

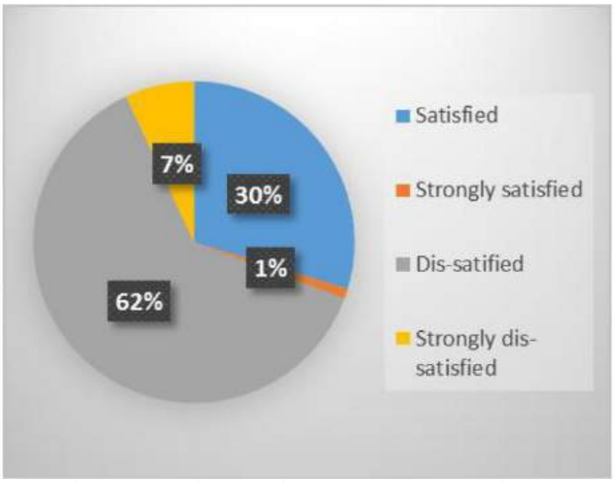


Fig. 1: Satisfaction level of patients from present conditions of burn care units.

## IV. CASE STUDY

In order to better accomplish the research work 2 case studies were done ("The Burn Care Unit of Civil Hospital Hyderabad" and "The Plastic Surgery Unit of LUMHS Jamshoro"). The main research objective of these case studies was to know about the conditions of burn care facilities provided to the burn victims and the problems faced by the patients during treatment and the doctors while treating. All the necessary data is collected through observation, photography and interviews with doctors and patients.

### *A. Case Study of Burns Unit of Civil Hospital Hyderabad*

Burn care unit of civil hospital Hyderabad, the only facility for the people of Hyderabad managed approximately 10,000 burn patients per year, with an average of around 500-600 in-patients with severe burns, annually. On daily basis it has to face 20 to 25 patients in summer season while in winter this number increase to more than 40. It provides all the diagnostic and treatment facilities completely free and that is the reason why majority of poor and needy patients who cannot afford the extremely high treatment costs prefer to come there.

The building of burns unit was not designed for such purpose but latter on converted into it, because of which it is not functioning properly, and spaces were very congested. The front area of the hospital is crowed with patients and their relatives Moreover, it has been observed while visit that due to inadequate security, the patients and their relatives were facing many problems to get avail of the services of the hospital.

### *B. Facilities*

Many important facilities which are necessary for burned patients are missing there like, Intensive care unit, emergency ward, hydrotherapy unit etc. The planning of burns unit of civil hospital is linear. On ground floor 4 patient rooms, first aid room, administration and outpatient department are present. On first floor 4 patient rooms, 2, operating rooms and 1 sterilization room is provided. No proper orientation and ventilation is there and patients were facing many problems. The ward's building had 8 rooms and can admit 8 patients at a time but contrary to protocols, three patients each along with their attendants were admitted to a room, exposing them to greater risk of infection. As shown in plate 1. The operation theatre was provided at first floor consisting of 2 operating rooms, scrub-up area, and clean-up area. As shown in plate 2.

Plate 1: Patient room of Hyderabad civil hospital

Plate 2: operation theater of Hyderabad civil hospital

### *C. Case Study of Plastic Surgery Unit LUMHS Jamshoro*

The plastic surgery unit of LUMHS Jamshoro provide the facility of plastic surgery and out-patient services to the burn patients. Like civil hospital Hyderabad it also caters patients from Hyderabad, Jamshoro and different areas of interior Sindh and provide treatment completely free of cost. The descriptions of facilities that are available there are as follows;

The out-patient department consisting of waiting areas and consultants' office. The operation theatre consists of operation room, scrub up area, clean up room, storage. 6 bedded general ward and 3 private rooms. Duty room for doctor is attached with consultant room in which two doctors are always present. Pharmacy is also provided which is common for all the departments of hospital and poor people can easily get medicines free of cost. Plate 3 and 4 shows the general ward & operation theater of LUMHS Jamshoro.

Plate 3: General ward Lumhs Jamshoro

Plate 4: Operation theater of Lumhs jamshoro

## IV. RESEARCH FINDINGS

During visit to burns unit of civil hospital, Hyderabad and plastic surgery unit of LUMHS Jamshoro observations are made about the problems faced by the patients and doctors while treatment. It has been found that due to lack of facilities, improper spaces and functions of the hospital patients were facing many problems. Both local hospitals lack many important facilities which are necessary for any burn care hospital. And because of this patient are facing many problems like, in civil hospital Hyderabad, there is no ICU ward and critically injured are also kept at private rooms. The provision of healing environment like green spaces, water bodies and interior design elements which provide comfort to the psychology of the patient and increase the healing rate were also missing there.

While interviewing, it has been informed by the doctors that majority of the burn cases are found in the age group between 0-5 years. Females are on high risk as compared to males. Patients belonging to rural areas outnumbered patients of urban areas but not statistically significant. Majority of these patients belongs to different regions of interior Sindh.

Most of the acid-throwing accidents are related to problems involving dowry demands and rejection of proposal for marriage. Among unemployed patients' majority of patients are housewives. Most of the incidents occur during winter season (November to march). And a smaller number of incidents occur during rainy season (June to August). Maximum number of injuries occurred between 5 pm and 11 pm while minimum number of injuries occurred between 11 pm and 5 am when most of the people are sleeping. Majority of burns took place at work place or home. More than 80% of burns are accidental, remaining 20% are homicidal and suicidal. Because of strong Eastern background even the cases of homicidal nature are referred as suicidal or accidental. The majority of deaths (82%) due to burns occurred within a week of the incidence. During this period the maximum number of deaths occurred within 2-6 days (65.1%).

Thus, there is intense need of proper facilities for the patents as well as for the staff of hospitals. Most of the staff and patients are not satisfied from the present facilities available there. This study initially investigates the problems faced there and then will proposed the basic facilities that should be available there.

## VI. PROPOSED FACILITIES OF BURN CARE AT HYDERABAD

Burn centers required highly trained health care professionals of various disciplines who work together to ensure the best therapeutic, surgical, functional, and psycho social recovery for burn victims, as well as for patients with severe skin disorders. The proposed burn care center addresses all aspects of burn injuries (chemical, electrical flame, scalds from hot liquids and inhalation injury) from complex wounds to the treatment for burn scars and deformities. It will be consisting of all the necessary requirements of burn center. All the spaces will have proper linkage between each other as shown in plate 3

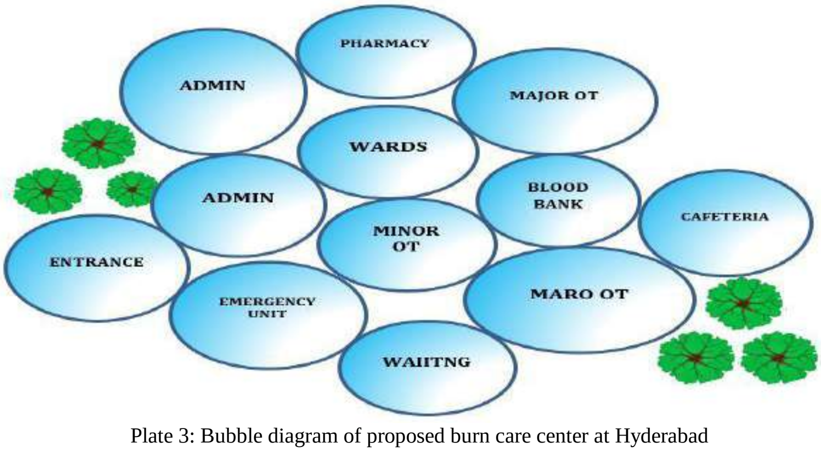


Plate 3: Bubble diagram of proposed burn care center at Hyderabad

On entrance patients will be transferred to emergency unit. Near to emergency unit there will be operation theater and diagnostic areas while pharmacy is located centrally. As shown in plate 3.

Patients will be cared by a team of doctors, nurses and staff from the Section of Plastic/Reconstructive Surgery and the Department of Anesthesia and Critical Care. Patients with minor injuries, not requiring hospitalization, will be provided outpatient wound care and rehabilitation throughout patient burn clinic. The facility of plastic surgery and rehabilitation are available for patients in the post-acute phases of their treatment regardless of where they received treatment for them sever burns.

The site selected for the proposed burn center is located at Hyderabad By-pass Road. The total area of site is 301,435.2 sq. ft. (6.92 acres). Which is enough to accommodate all the requirements of the proposed project. The site has a road network and it is therefore well connected to different regions of Sindh (shown in plate 4).

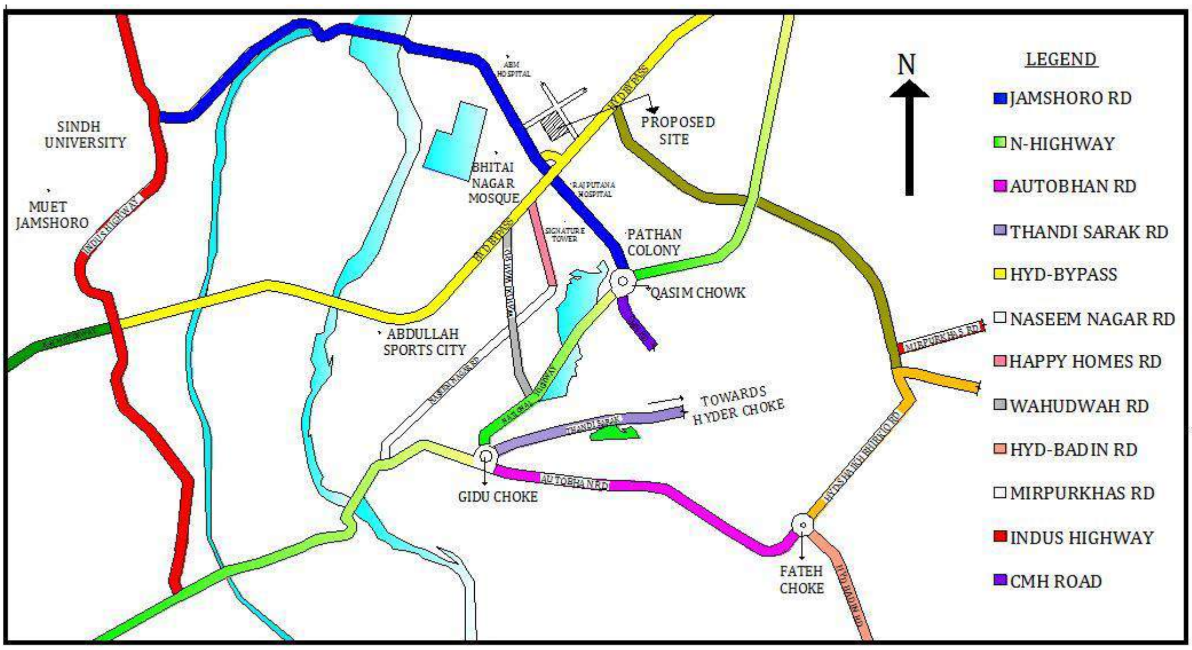


Plate 4: location plan of proposed site

## VII. CONCLUSION AND FUTURE RECOMMENDATIONS

From the findings of present study, it can be concluded that lot of people are affected in Hyderabad and in various regions of interior Sindh due to different types of burns. The most common types of burn injuries are Hot liquids (76%), second most common type of burn injury is chemical burns (i.e. 12%), after that flames are about 9 % and electrical burns are around 3 %. Because of lack of facilities most of these burn victims do not get proper treatment. Majority of such patients die while being shifted from Hyderabad to Karachi and those who survived will live a very uncomfortable life due to post-burn complications. Despite being a major cause of death and disability, the issue of burns remains a chronically underfunded and often unrecognized issue at the national and international level. The study suggests that with improved burn care facilities, the mortality rate due to burn injuries will come down. To overcome this neglected health problem there is a very strong need of constructing a specialized burn care center where patients could receive holistic treatment including surgical, nursing, physiotherapy, occupational therapy, dietary, psychological and medico-legal support. This research proposed a specialized burn center at Hyderabad by-pass road near Rajputana Hospital for the people of Hyderabad and interior Sindh with all the necessary facilities and requirements.

## VIII. ACKNOWLEDGMENT

It is a genuine pleasure to express our deep sense of thanks and gratitude to Dr. Muhammad Ali, senior surgeon at Burn Unit of Hyderabad Civil Hospital. We would also like to show our gratitude to Dr. Rizwana for sharing their pearls of wisdom with us during the course of this research.

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# Effect of Human Hair as Fibers in Cement Concrete

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***Abstract*: In present era, to recycle the waste and to reduce the environmental pollution are the main objectives of sustainable development. Many researchers are working on new techniques and thinking for innovation in the field of concrete technology by utilizing the waste material in concrete. This research aims, to evaluate the effect of human hair (waste material) as fiber on plain concrete with various percentage of human hair fiber i-e 0.25%, 0.50%, 0.75% and 1.0% by weight of cement. In this regard behaviour of concrete was in terms of machanical properties (compressive strength and spiliting tensile strength) and workability (slump test). Therefore, for each proportion of hair three cylinders and three cubes were cast at 1:2:4 mix ratio with 0.5 water-cement ratio and tested at 28 days curing period. The experimental results show that the workabality of fresh concrecte reinforced with human hair is less than the plain concrete. And it is also observed that human hair as fiber reinforcement increases the compressive strength and tensile strength of concrete by 10.71% and 3.65% at 0.25% addition of human hair in plain concrete respectively.**

***Keywords*: Humain hair fibers, Mechanical properties of concrete, Sustainable developement.**

## I. INTRODUCTION

Artificial fibers are manmade fibers in which basic chemical units are manufactured by chemical synthesis [1]. Natural fibers are classified as hair like material which is obtained from cutting animal hair and plants [2]. Synthetic fibers can be produced at very low cast and in huge quantity as compared to natural fibers. Natural fibers can give some benefits for clothing, i.e. comfort and over their synthetic counterparts and also used for structural applications, but the usually with synthetic thermoset matrix material that gives some environmental benefits [3], [4]. The study about human hair waste and its utilization was evaluated by Gupta [5]. Gupta observed that the uses of human hair in the large number of areas which including agricultural, medicine and industrial [5]. Fibers which are are commonly used in construction industry are steel fibers, glass fibers, synthetic fibers and natural fibers [6]. Fibers having short length are mixed in plain concrete for improving its brittle behavior and imparting the ductility [7]. This new type of concrete having short discrete fibers spread in all direction is referred as fiber reinforced concrete (FRC) [7]. Fibers can be reduced permeability of concrete as well as Bleeding of water [8]. Fibers interlink and entrap around the aggregate particles and mixing of these are more cohesive so that reduce the workability [9]. Sometimes fibers act as a reinforcement in non-structural interior [10]. Fibers in concrete control the cracks due to plastic shrinkage and to drying shrinkage [11]. Human hair is strong in tension so that it used as fiber reinforced material [12]. As plain concrete is weak in tension, therefore, number of techniques are being developed to overcome this dificincey. Furthermore, these techniques includes using modified materials like natural fiber e.g. animal hair, human hair etc which can increase ductile behaviour and imparts in flexural behaviour of concrete [13]. Sustainbale concrete involves use of such materials which fulfill both requirments i.e. improve strength and material should be available in local market at affordable amount. This is the reason hair are used in this research as fiber. Hair are considered as waste and byproduct in most of the socities and are dumped in open air. Some where these dumps are left openly for its degration, at other places hair burnet openely which creats environmental pollution by creating toxic gases [13]. To save the environment from its degradation by utilizaing the waste stuff (human hair) and to improve the tensile behvaiour of concrete are the main objectives of this research.

## II. MATERIALS & METHODOLOGY

Methodology is adopted to check the workability in terms of slump loss and mechanical properties in terms of compressive strength and splitting tensile strength of concrete. In this regards total 60 concrete specimens were caste which include 20 cubes and 40 cylinders. All concrete specimens were cast at well-known mix ratio of 1:2:4 at 0.50 water-cement ratio. After casting, all specimens kept in curing tank for curing and then tested at 28 days curing period in universal testing machine (UTM). Standard cylinders (4inch diameter and 8inch height) and cube (4” x 4” x 4”) were used for casting of specimens under the guidance of American Society of Testing Materials (ASTM) code. Human hair used in this research are by weight of the cement. Total five proportions i.e. 0%, 0.25%, 0.50%, 0.75% and 1.0% are used and then result are compared with the speciman having no any hair. At each proportion of hair four specimans were cast, tested and then average of three is taken as final result at specified proportion of hair.

Materials used in this research were obtained from local market of Larkana, Pakistan. Fine aggregates were sieved from 4.75mm sieve for removing the unwanted materials. Coarse aggregates used in this work having size of 12mm size. And drinking water available in laboratory was used for mixing purpose. All the materials were batched by weight and mixed in concrete mixer for preparing the fresh concrete. Workability of fresh concrete was measured first and then concrete was poured in to the molds for other tests as shown in Figure 1.

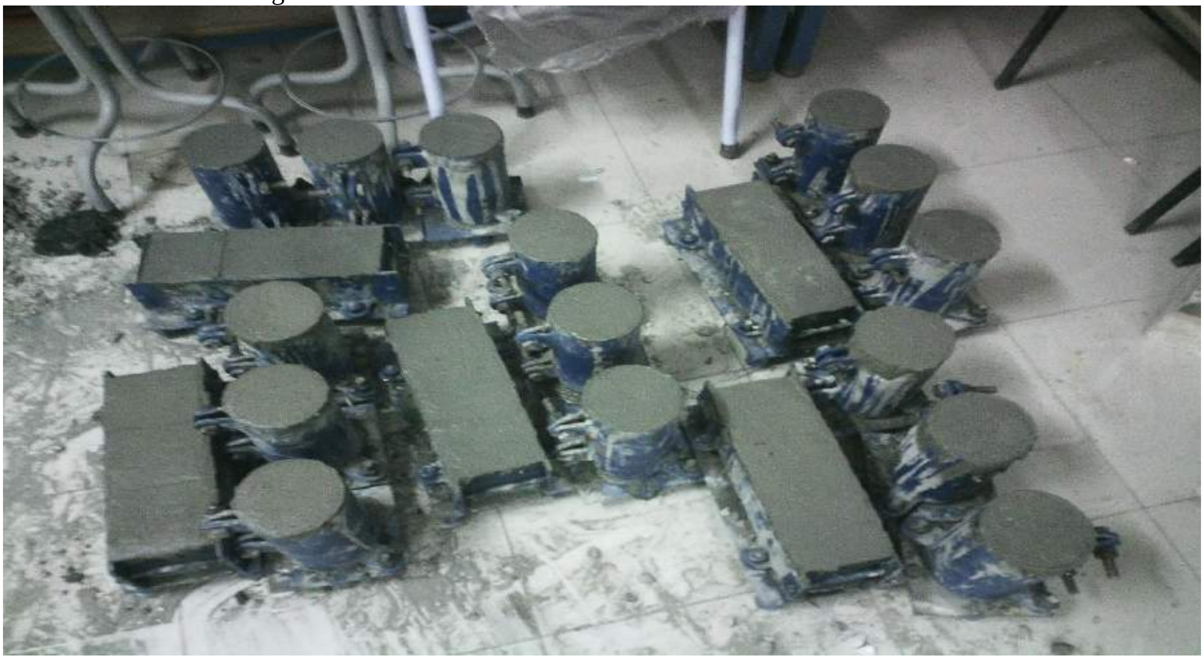

Figure 1. Casting of concrete cylinders and cubes

## III. RESULTS AND DISCUSSIONS

### *A. Workability of Fresh Concrete*

Workability of fresh concrete is measured in terms of slump loss. Standard slump cone used for measuring the workability. High workability was recorded in concrete having no any percentage of human hair. As proportion of hair increases then workability gradually decreases. Lower value of workability is recorded at 1% of addition of hair. This decrease in workability may be due to the less water available, as hair required some water to coat its surface. Ultimately, lowers down due to lack of free available water which can impart workability. Experimental results are presented in graphical as shown in Figure 2.

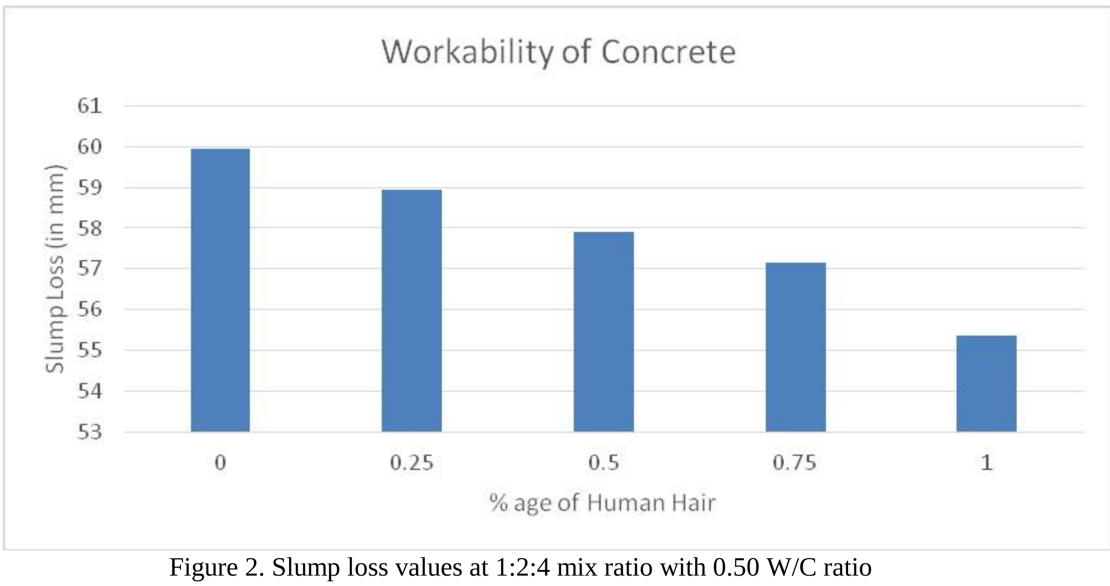


Figure 2. Slump loss values at 1:2:4 mix ratio with 0.50 W/C ratio

### *B. Compressive Strength of Concrete*

The compressive strength of concrete is evaluated by two methods i.e. cubical and cylindrical testing methods. At each proportion of hair four cubes and four cylinders were cast and tested for compressive strength and finally average of four is taken as final result. From experimental results presented in Table 1, Table 2 and Figure 3, Figure 4 it is observed that as percentage of hair increases then both cubical and cylindrical compressive strength decreases. Increase in cubical strength observed at 0.25% and 0.50% is 10.71% and 1.77% respectively. Reduction in cubical compressive strength is 8.87% and 10.87%at 0.75% and 1% addition of hair respectively. Similarly, increase in cylindrical strength observed at 0.25% and 0.50% is 10.74% and 1.32% respectively. And reduction in cylindrical compressive strength is 8.75% and 10.22% at 0.75% and 1% addition of hair respectively. Maximum and minimum strength were recorded at 0.25% and 1% of hair. This reduction in strength is may be due to decrease in density of concrete with increasing percentage of hair.

**Table 1:** Cubical Compressive strength of concrete at 28 days curing period

| S. No | Cube Number | Human Hair % | Cubical Strength (psi) | Avg. Cubical Strength (psi) |
|---|---|---|---|---|
| 1 | I | 0 | 3935 | |
| 2 | ii | 0 | 4285 | |
| 3 | ii | 0 | 4055 | 4086 |
| 4 | iv | 0 | 4069 | |
| 5 | i | 0.25 | 4798 | |
| 6 | ii | 0.25 | 4461 | |
| 7 | iii | 0.25 | 4318 | 4524 |
| 8 | iv | 0.25 | 4519 | |
| 9 | i | 0.5 | 4461 | |
| 10 | ii | 0.5 | 4318 | |
| 11 | iii | 0.5 | 3925 | 4159 |
| 12 | iv | 0.5 | 3932 | |
| 13 | i | 0.75 | 4028 | |
| 14 | Ii | 0.75 | 3725 | |
| 15 | iii | 0.75 | 3548 | 3719 |
| 16 | iv | 0.75 | 3576 | |
| 17 | i | 1 | 3828 | |
| 18 | ii | 1 | 3567 | |
| 19 | iii | 1 | 3643 | 3641 |
| 20 | iv | 1 | 3527 | |

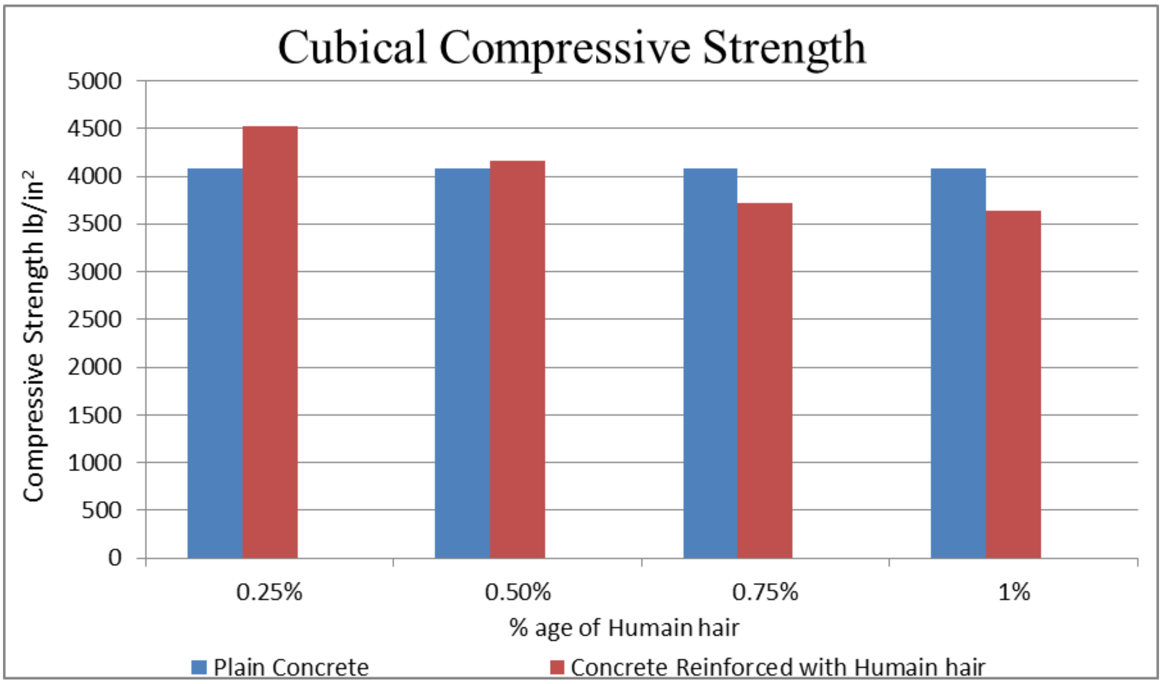

Figure 3: Cubical compressive strength of concrete at 1:2:4 mix ratio with 0.50 W/C ratio

**Table 2:** Cylindrical Compressive strength of concrete at 28 days curing period

| S. No | Cylinder Number | Human Hair % | Compressive Strength (psi) | Avg. Compressive Strength (psi) |
|---|---|---|---|---|
| 1 | i | 0 | 2506 | |
| 2 | ii | 0 | 2506 | |
| 3 | ii | 0 | 2505 | 2504 |
| | iv | 0 | 2500 | |
| 4 | i | 0.25 | 2766 | |
| 5 | ii | 0.25 | 2751 | |
| 6 | iii | 0.25 | 2807 | 2773 |
| 7 | iv | 0.25 | 2769 | |
| 8 | i | 0.5 | 2542 | |
| 9 | ii | 0.5 | 2528 | |
| 10 | iii | 0.5 | 2535 | 2537 |
| 11 | iv | 0.5 | 2543 | |
| 12 | i | 0.75 | 2286 | |
| 14 | ii | 0.75 | 2281 | |
| 15 | iii | 0.75 | 2285 | 2285 |
| 16 | iv | 0.75 | 2288 | |
| 17 | i | 1 | 2257 | |
| 18 | ii | 1 | 2245 | |
| 19 | iii | 1 | 2240 | 2248 |
| 20 | iv | 1 | 2250 | |

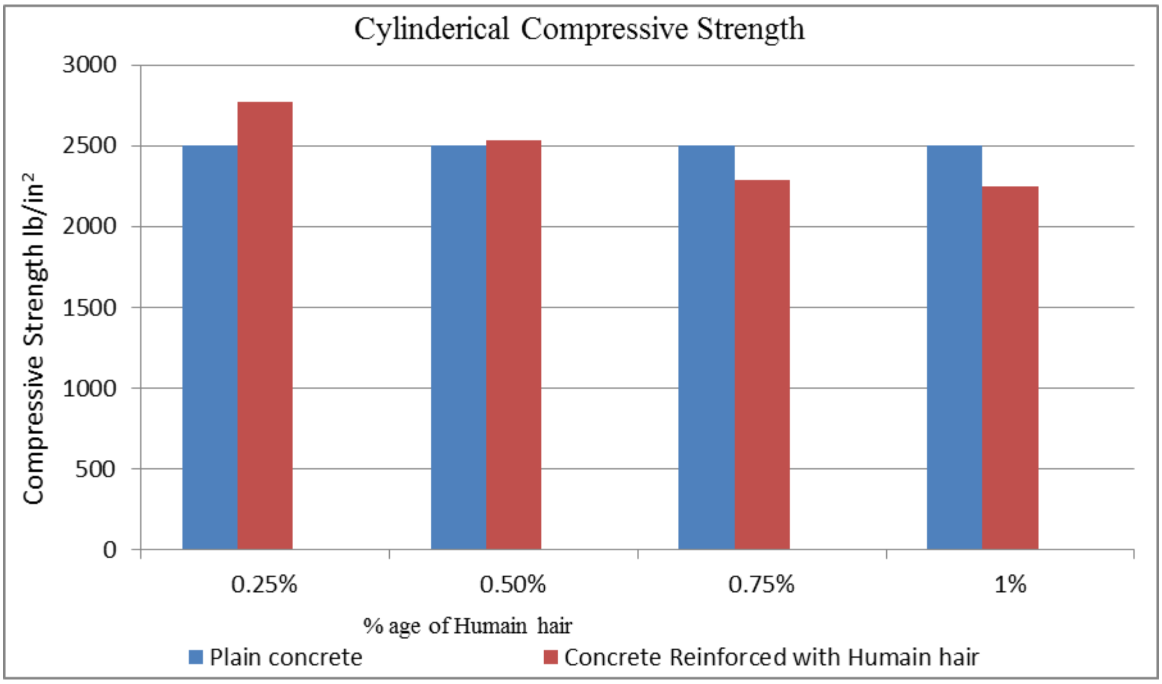


Figure 4: Cylindrical compressive strength of concrete at 1:2:4 mix ratio with 0.50 W/C ratio

### C. *Splitting Tensile Strength of Concrete*

Tensile strength of concrete is evaluated indirectly by using splitting cylinder method. Total 20 concrete cylinders were cast for splitting tensile strength. At each proportion of hair four cylinder were cast and then average of four is given as final result. Similar trend in splitting tensile strength has been observed as that of compressive strength. Maximum and minimum tensile strength were recorded at 0.25% and 1% respectively. At other percentages of hair, splitting tensile tends to reduce as given in Table 3 and Figure 5. This reduction in splitting tensile may be due to presence of reduction of density of concrete. As percentage of hair increases then there may be in reduction in density of concrete which ultimately reduces the tensile strength of concrete.

**Table 3:** Splitting Tensile strength of concrete at 28 days curing period

| S. No | Cylinder Number | Human Hair % | Spilt Tensile Strength (psi) | Avg. Split Tensile Strength (psi) |
|---|---|---|---|---|
| 1 | i | 0 | 334 | |
| 2 | ii | 0 | 330 | |
| 3 | ii | 0 | 332 | 331 |
| 4 | iv | 0 | 329 | |
| 5 | i | 0.25 | 339 | |
| 6 | ii | 0.25 | 346 | |
| 7 | iii | 0.25 | 353 | 342 |
| 8 | iv | 0.25 | 332 | |
| 9 | i | 0.5 | 311 | |
| 10 | ii | 0.5 | 307 | |
| 11 | iii | 0.5 | 301 | 305 |
| 12 | iv | 0.5 | 302 | |
| 13 | i | 0.75 | 309 | |
| 14 | ii | 0.75 | 317 | |
| 15 | iii | 0.75 | 315 | 312 |
| 16 | iv | 0.75 | 308 | |
| 17 | i | 1 | 309 | |
| 18 | ii | 1 | 317 | |
| 19 | iii | 1 | 323 | 319 |
| 20 | iv | 1 | 328 | |

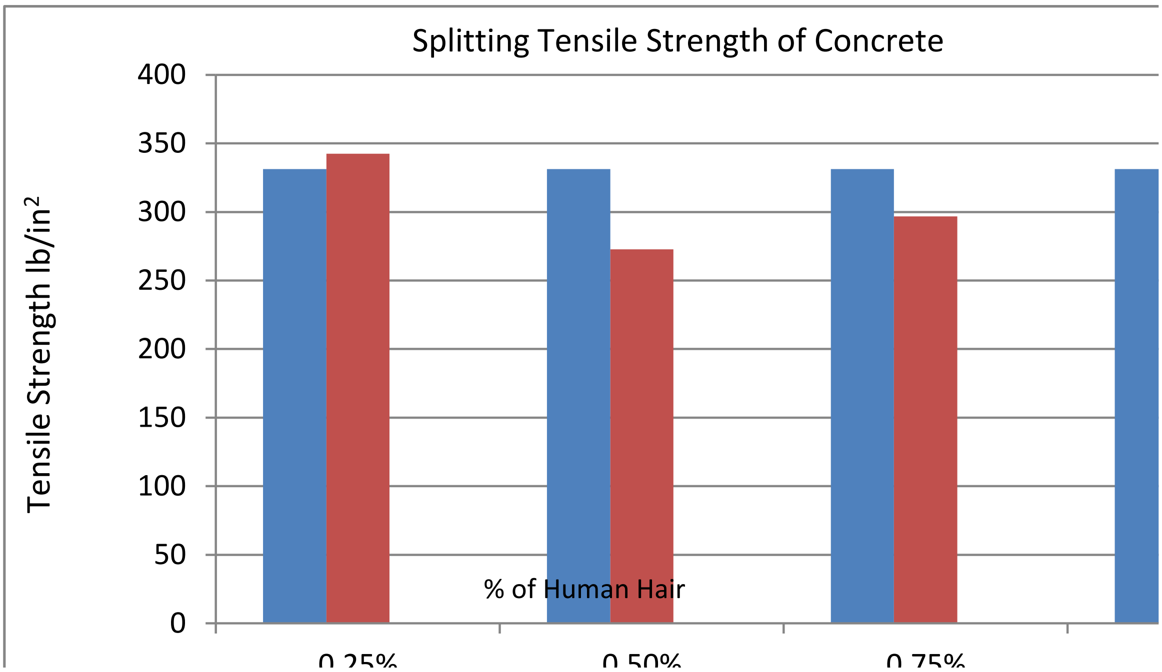


Figure 5: Splitting Tensile strength of concrete at 1:2:4 mix ratio with 0.50 W/C ratio

## IV. CONCLUSIONS

On the basis of the experimental results obtained in laboratory, it is concluded that:

- At 0.25% human hair when used in concrete then there is an increment of 10.71% and 3.65% in cubical compressive and splitting tensile strength respectively at 1:2:4 mix ratio with 0.50 water-cement ratio.
- At 0.50% human hair when used in concrete then there is an increment of 1.77% in cubical compressive strength and 7.84% decrement in splitting tensile strength at 1:2:4 mix ratio with 0.50 water-cement ratio.
- At 0.75% human hair when used in concrete then there is decrement of 8.97% in cubical compressive and 5.67% in splitting tensile strength at 1:2:4 mix ratio with 0.50 water-cement ratio.
- At 1% human hair when used in concrete then there is decrement of 10.89% in cubical compressive and 3.65% in splitting tensile strength at 1:2:4 mix ratio with 0.50 water-cement ratio.

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# Identification of Causes Leading to Heat Stress and their Negative Effects on Construction Labor in Extreme Hot Weather: A Case Study of Sindh

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***Abstract:*** **Global warming is a serious threat worldwide because of its negative effects on industries either indoor or outdoor. Several measures are taken for indoor industries to maintain labor performance but outdoor industries like construction industry still needs attention. Construction labor encounters multiple activities that can cause heat stress. Heat exhaustion and heat stroke directly affects labor health and indirectly affects their performance. Extreme hot weather is a major hazard in construction industry which has an increasing effect. Hence, this paper focuses on identification of causes leading to heat stress along with the negative effects on labor health. An extensive literature review has been carried out followed by unstructured interviews and finally the factors are identified with the collaboration of Sindh province construction industry stakeholders and medical field experts. This research paper will help the project stakeholders to design their work plans and activities accordingly in hot weather to achieve higher performance and to provide better health protection to construction labor.**

***Keywords:*** **Extreme hot weather, Causes of heat stress, Negative effects, Construction labor health & safety, Construction industry.**

## I. INTRODUCTION

Construction labor encounters daily activities that can cause heat stress and do not even know it! There are many causes of heat stress at construction site for labor in extreme hot weather. Such as, high air temperature, high humidity, wind speed/ air stagnant, sun radiations [1]. Also heat acclimation, being older than 60 [2], previous heat-related illness, use of certain medications, presence of certain concurrent diseases, severe obesity [3]. In other view, unavailability of rest tent at site, utilizing labor continuously without rest, unavailability of potable water, shades/hats/caps not provide to labor for preventing direct sunlight during working, prohibition of job rotation [4]. Furthermore, lack of safety supervision, unavailability of emergency treatment services, untrained/ unaware worker's regarding heat stress [5], wearing of PPEs can also cause of heat stress at a construction site [6,7].

Heat stress always influence negative effects on labor health and their performance. Such as, heat exhaustion, heat edema, heat syncope, heat cramps [8], slips of sweaty palms, diarrhea [9]. Also, dizziness, increasing Nausea, heat rashes [10], high rate of sweating, headache, increasing irritability [11]. Whereas, heat strain, **f**eeling faint, heat Fatigue, dehydration, heat stroke, impair mental performance/ judgments, reduce physical working ability, vomiting, skin burn and also death can occur [12]. All negative effects mostly occurred in hot summer season and due to these effects labor performance affects at construction site [13].

Human internal body temperature transfers to the surrounding environment through radiation, convection, and conduction. When the ambient temperature of the surrounding air raised to 32°C or higher, then the process of radiation, convection, and conduction stop working and sweating takes place to cool down the internal body temperature [14].

The comfort temperature for labor working in which optimal productivity can be achieved i.e. 10°C to 21°C [15]. However, labor can work easily during summer season if the temperature is lying between 21°C to 31°C, when relative humidity less than 30% [1,17]. When, temperature and relative humidity or one of them crossed the limit, then it converts into a silent hazard [18]. Hence, in this scenario proper utilization of labor becomes very difficult.

The maximum sustainable upper temperature limit of human internal body becomes 37°C, whereas if it is raised upto or above 38°C, it may cause short-term illness, long-term illness or death can occur [19]. In this situation, if labor continuously doing work without rest then the chances of accidents are increased [20,21] (Dawson, 1993, M and JSR, 1983).

In addition, personal protective equipment (PPE) also play an important role to increase the chances of heat stress accidents [6,7]. During 1985 to 1990 in America, when labor death toll increased due to heat exhaustion or heat stroke, then American conference of governmental industrial hygienists declare the law that labor should not be allowed to work when their internal body temperature reaches 38°C [22].

Heat exhaustion and heat stroke directly affect labor health and indirectly affects their performance at site. Therefore, labor performance and productivity losses happened which is verified by mathematical models through the relationship between extreme hot weather and labor productivity at a construction site [23]. Forecasting the losses in labor productivity, It is clear evidence that extreme hot weather negatively effects the labor performance [24].

Construction Workers Productivity (CWP) losses also calculated through thermal comfort index i.e. Predict Mean Vote (PMV) [25]. As noticed over the past decades, incidents of injuries and deaths occurred due to heat exhaustion and heat strokes during project execution activities in extreme hot weather at different regions of the world, which results shows the losses in labor productivity, performance, and firm profit [26,23]. According to Pakistan Metrological Department (PMD), the air temperature of Sindh province become very hot in every summer season [27,28,29].

Majority of incidents were noticed in peak hot hours of the day i.e. 13:00 to 15:00, we can say that hazardous period of the day. In this situation, UAE, Saudi Arabia & Gulf Countries, Hong Kong, America, UK, and many other developed countries were introducing the efficient and effective rules, procedures, methods, laws, and techniques [30]. These all efforts were made, specially for the outdoor working industries including construction industry to minimize the causes of negative effects and utilize the labor without heat stress in healthy and safe environment, to achieve optimal productivity with good quality performance and productivity [31]

The outdoor temperature of summer season becomes very hot. It was recorded in Gulf countries, African contries, and also in Asian countries that temperature raised up to 50°C +, it was also recorded in Pakistan by Metrological Department. In this scenario Pakistan still follow the previous working practices, methods, procedures, hence accidents were happened. This is an alarming situation for the outdoor industries including construction industry to save the labor resource and utilizes efficiently without heat stress hazard at construction site by minimizing the causes of negative effects.

Labor is a vulnerable resource in extreme hot weather because, when surrounding temperature raised at 32°C ± 1°C, then at that stage human internal body temperature becomes 37°C ± 1°C, due to physical activities the metabolic heat generates inside the human body. The sustainable limits of Human internal body temperature is 37°C [13]. When labor uses 100% of chemical energy, it converts into 20% mechanical power for doing any work whereas, 80% metabolic heat is generated inside the body [13,25]. If construction labor continuously doing work without any rest, heat stress hazard becomes active and chances of accidents at site going to increase. Many other factors are identified through this research from the relative literature review and unstructured interviews.

Construction labor counted as a leading resource for the construction industry and important asset to generate the country's GDP. Therefore, we have to take some steps to save them from all kind of hazards at workplace including heat stress hazard. There are many other hazards which makes physical obstacle during the execution of projects whereas, heat stress hazard creates silent profile obstacle at construction site. Therefore, it is more dangerous as compared to other hazards [19].

Many accidents of morbidity and mortality of outdoor laborers were reported in every summer season. This research paper aims to identify the causes of heat stress and their negative effects on labor health and performance at a construction site in extreme hot weather during the summer season at Sindh province of Pakistan.

## II. LITERATURE REVIEW

Heat stress is a big problem for outdoor labor because it affects labor health and safety, especially it is active in extreme hot weather during summer season [13]. Surrounding temperature play an important role to increase the internal body temperature which leads heat stres [32].

According to the second law of thermodynamics, heat travels from hot region to cold region, when surrounding temperature becomes less than that of body temperature, then internal body temperature transferred to surrounding. Whereas, if surrounding temperature becomes higher than body temperature, then surrounding temperature transferred to inside the body [33]. Therefore, heat stress continuously raised due to physical activity and surrounding temperature [31]. However, there are many other reasons which also increase the heat stress of construction labor while physical working in extreme hot weather [12].

Physical movement of human generates metabolic heat inside the body whereas outer environment temperature also plays an important role to increase or decrease human internal temperature [34]. Human muscles convert chemical energy into mechanical power during this process metabolic heat produced. Metabolic heat continuously increases due to human physical movement and with the impact of outer hot environment [35]. It can reduce or stop the human physiological activity task as well as diminished the psychological performance and increase the accidents risk at a construction site [13, 18].

Hence, it is clear that extreme hot weather is a hazard for construction industry which is growing day by day because the temperature of the globe increases continuously since past few decades, due to this global warming construction industry of the world faces difficulties [26,11]. Global warming is a very serious issue which is discussed on the world level forum because global warming negatively affects all the industries either indoor or outdoor.

However, some measures are taken for indoor industries to maintain labor performance but outdoor industries like construction industry still needs attention [36]. Extreme precipitation, extreme snow, and extreme winds create physical obstacles for the construction industry, whereas extreme hot weather makes a slightly different hazard profile, known as a silent hazard [37]. During the 20th century, the average rise in temperature is 0.76°C, whereas the 1st decade of the 21st century the average rise in temperature is 0.60°C [38].

In UAE and other Gulf countries, laborers are not permitted to work at site during the peak hot hours of the day i.e. from 12:30 to 15:30 in the hottest months of the summer season i.e. May, June, and July [39,30,40]. Summer temperature of UAE reach its extremes and raised up to 50°C or above but the construction industry of UAE one of the successful industry of the world due to efficient rules and laws for construction industry regarding labor utilization in extreme hot weather [41], also developed countries like Hong Kong introduced work pattern/ work schedule for construction industry operations in summer season [4].

If the surrounding temperature raised above 32°C then internal temperature of the human body is also raised above 37 °C, which is known as basic effective temperature. Whereas, at 38°C significant drop occurred in human mental and physical performance [42,1], and at 39°C or above heat stroke can happen which can be fatal/ death [20,43]. Hence, the temperature becomes major cause of negative effects [44].

The inside body temperature must be maintained below the limit, if temperature of the body raised from specified limit then there are increasing the chances of mental disorder or physical disorder [31]. There are six principle causes of negative effects which generates heat stress for the labor at construction site i.e. air temperature, sun radiations, air stagnant, humidity, clothing, nature of work [45].

According to BBC News, June 2015 in Karachi (Pakistan) more than 1300 people were dead due to heat stroke among them 40 % of mortality is from construction industry while working in extreme hot weather [46,47]. There are so many other accidents which are reported from all over the world related to the heat stress hazard, to avoiding these type of accidents [48,49] recommended the limit of human internal body temperature i:e 38°C, this limit also recommended by [50].

Pakistan construction industry faces the heat threads, in Pakistan heat wave occasion begins from the month of May up to the month of September and temperature reaches up to 50°C or above [46]. As per 47 years recorded temperature of the summer season at different regions of the country since 1960 to 2007 during the months of May to September, there is 3°C rise in temperature [51]. Pakistan climate projection (PCP) indicates that there will be 5°C rise in temperature by the end of 21st century [27]. Hence, global warming is a major source to increase the causes of negative effects to create heat stress at construction site [29].

Extreme hot weather creating problems and losses for Construction industry of developed countries like United Arab Emirate (UAE) and construction industry of developing countries like Pakistan. However, developed countries discovered some remedial measures to overcome this issue, whereas developing countries like Pakistan are left behind to resolve it.

## III. METHODOLOGY

Many factors are identified through the relative literature review. These factors are further refined and clarified through unstructured interviews, which have been conducted with the construction industry stakeholders and medical practitioners in hot cities of the Sindh province i.e. Dadu, Larkana, Sukkur, Jacobabad, and Nawabshah/ Shaheed Benazirabad.

According to Pakistan Metrological Department (PMD), these cities become very hot in every summer season and many accidents of morbidity and mortality of outdoor laborers were reported in every season. In these cities, there are many small, medium, and big size of projects of buildings and highways are under construction nowadays, therefore we focused on these projects and conducted unstructured interviews with them.

There are two main aims of unstructured interviews: i.e.

1) To refine and confirmation of the factors (Shown in Table-1) which are identified through extensive literature review
2) To explore the causes of heat stress and their negative effects on construction industry labor in extreme hot weather during the summer season in Sindh province.

After unstructured interviews,

It has been confirmed that the majority of factors (which are identified through literature review) are really happening at the construction sites and few of them are not identified in the construction industry of Sindh province.

Few new factors are investigated through unstructured interviews (shown in Table-2), which are the causes of heat stress and their negative effects on construction labor while working in extreme hot weather during the summer season in Sindh province.

**RESULTS**

**Table-1:** Shows the Mutual factors of literature review and unstructured interviews. The factors which are mentioned in high lighted boxes are the new factors which discovered in unstructured interviews.

| S. # | Respondent Introduction/ Demographics | S. # | Causes of Heat Stress | S. # | Negative Effects |
|---|---|---|---|---|---|
| 1 | Owner of M/s Zubair Ali & Brother (Sukkur).<br>15 years’ experience in highways projects<br>Currently working on Sukkur-Multan Motorway | 1 | High Air Temperature | 1 | Heat Exhaustion |
| | | 2 | High Humidity | 2 | Heat Stroke |
| | | 3 | Air Stagnant | | |
| 2 | Owner of M/s Gulzar Ahmed Shaikh (Dadu)<br>25 years’ experience in buildings & roads projects<br>Currently working on District Government Projects | 4 | No Usage of Rest Tents / Unavailability of Rest Area | 3 | Diarrhea/ Stools discharge frequently in a liquid form |
| 3 | Owner of M/s Mehran Builders (Larkana)<br>22 years’ experience in buildings & roads projects<br>Currently working on District Government Projects | 5 | Sun Radiations | 4 | Heat Rashes/ Spots raised on skin |
| | | 6 | No Usage of Hats, Caps, Shades while working | 5 | Skin Burn/ Skin changed in Black color |
| 4 | P.M in M/s Wahid Bux Pahwar (NawabShah-Dadu)<br>20 years’ experience in buildings & highways Projects<br>Currently working on Private & Public Projects | 7 | Presence of Certain Diseases/ Existing illness | 6 | Dizziness/ Whirling Sensation in the Head |
| | | 8 | Low Wind Speed | | |
| 5 | P.M in Meesam Construction Company (Dadu)<br>13 years’ experience in buildings & roads projects<br>Currently working on District Government Projects | 9 | Usage of Safety Helmet | 7 | Increasing Irritability |
| | | 10 | Usage of Safety Coverall | | |
| 6 | R.E in NESPAK (Karachi)<br>17 years’ experience in buildings & highways projects<br>Currently working in Karachi-Hyderabad Motorway | 11 | Usage of Safety Shoes/ Boots | 8 | Dehydration/ Water Removed from Body |
| 7 | R.E in TECHNO CONSULTANT (Karachi)<br>19 years’ experience in buildings & highways projects<br>Currently working on Karachi-Hyderabad Motorway | 12 | Eating Hot Efficacy Foods & Spicy Foods | 9 | Impair Mental Judgment Ability |
| 8 | A.R.E in NESPAK (Karachi)<br>10 years’ experience in buildings & highways projects<br>Currently working in Building Projects | 13 | Smoking | 10 | Asthma |
| 9 | Sub-Contractor, M/s Aslam Saryou (Dadu)<br>15 years’ experience in buildings projects<br>Currently working in Dadu Cadet College Project | 14 | No Supply of Potable Water | 11 | Injuries/ Morbidity |
| 10 | Mason (Skilled Labor) Dadu<br>10 years’ experience in buildings projects<br>Currently working in Dadu Cadet College Project | 15 | No Rest Schedule/ Work Without Rest | 12 | Deaths/ Mortality |
| | | 16 | Job Experience | 13 | Vomiting |
| 11 | Labor (Unskilled Labor) Dadu<br>15 years’ experience in buildings projects<br>Currently working in Dadu Cadet College Project | 17 | No Rule of Job Rotation / Restriction in Job Rotation | 14 | Heat Syncope/ Fall in Blood Pressure |
| 12 | Labor (Unskilled Labor) Jacobabad<br>25 years’ experience in buildings & highways projects<br>Currently working in PAF Base Jacobabad | 18 | Taking Unhealthy Foods / Unhygienic Meal | 15 | Feeling Faint/ Sudden Loss of Consciousness |
| 13 | M.O in LUMS Jamshoro Hospital<br>23 years’ experience in general medical field<br>Currently working in OPD Section, LUMS Jamshoro | 19 | Labor Being Older Than 60 | 16 | Reduce Physical Working Ability |
| | | 20 | Bald Head | | |
| 14 | M.O in Dadu Civil Hospital<br>19 years’ experience in general medical field<br>Currently working in Emergency Ward | 21 | Previous Heat-Related illness | 17 | Excessive Sweating/ Wastage of body water |
| | | 22 | Nature of Job/ Type of Work | | |
| 15 | R.M.O in Nawabshah Civil Hospital | 23 | Use of Certain | 18 | Headache/ Pain in the |

| | | | | | |
|---|---|---|---|---|---|
| | 20 years’ experience in general medical field Currently working in Emergency Ward | | Medication | | Head |
| | | 24 | Severer Obesity | 19 | Increasing Blood Pressure |

For further clarification, Table-1 converted into Figure-1 in which, Causes of heat stress divided into four categories.

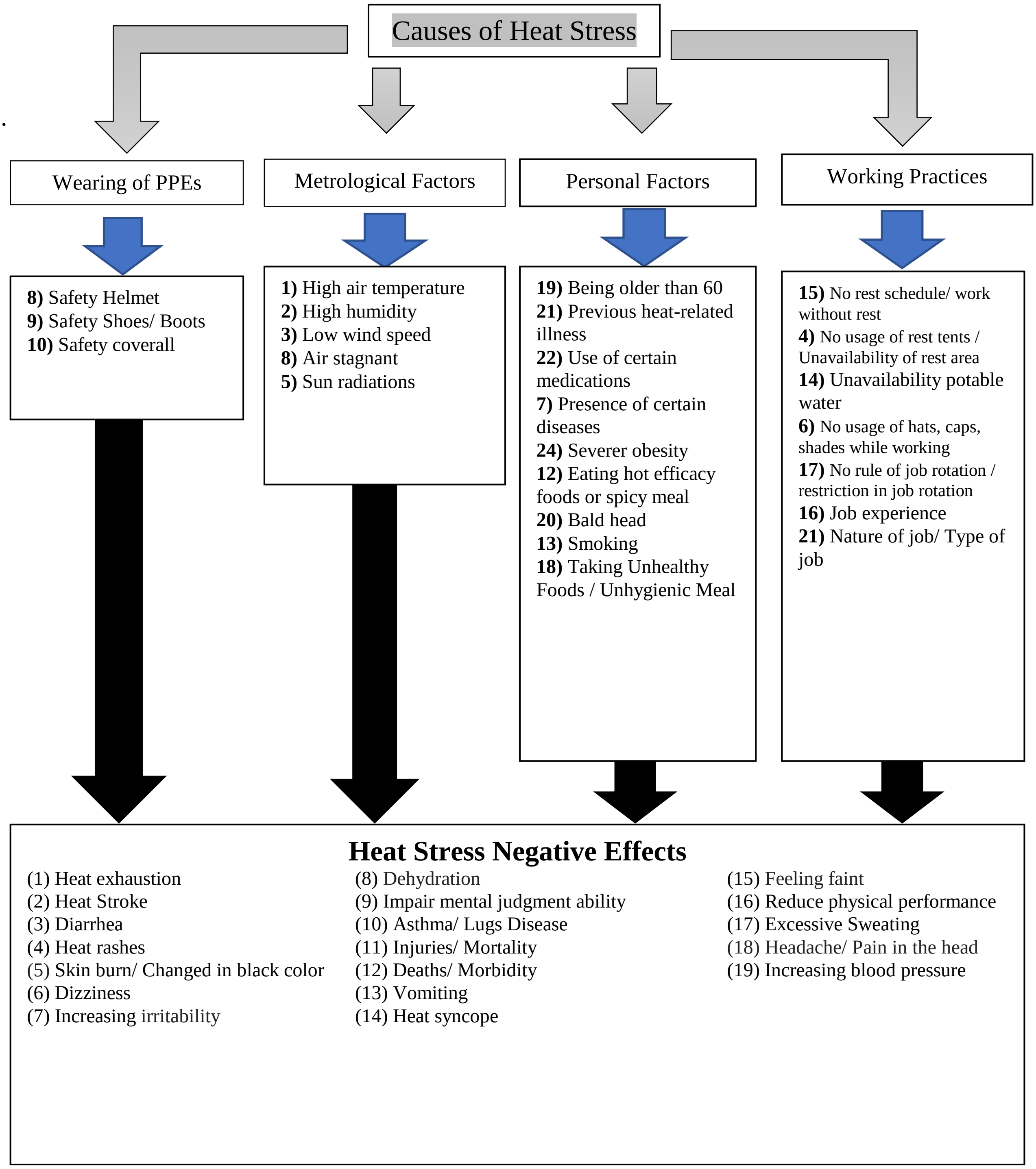


**Figure-1:** Four Divisions of heat stress causes leads negative effects on labor health & safety

Figure-1 shows the causes of heat stress and their negative effects on labor at construction site. It has been identified and cleared that heat stress is a harmful hazard for the construction industry labor which leads negative effects on labor health and safety. Hence, it is observed that heat stress directly affects labor health and indirectly affects their performance at site. Therefore, attention is required to make improvement in working practices, methods, procedures, policies, rules, and laws while working in hot weather during summer season within the construction industry of Sindh province.

## IV. CONCLUSION

During the course of research, it has been successfully pointed out the wide-ranging catastrophic causes and negative effects of heat stress on construction laborers. This negative effect of heat stress damaging their health and creating a serious threat to their lives afterwards, it also effects negatively on the projects being carried out. The health issues mostly posed by working in hot weather areas, which are pointed out in detail and the ways to minimize and eliminate them.
The methodology adopted to ascertain the issue, which has been thoroughly studied by extensive literature review, and the results point out the similar problems associated with extreme hot weather, and so are the ways to mitigate them.
By adopting the preventive and corrective measures the hazard to the life can be minimized or altogether eliminated and can vastly improve the performance of the project.

## V. RECOMMENDATIONS

According to Figure-1, heat stress is a thread for the construction labor which is increased day by day due to global warming. Therefore, to avoid this type of thread at the construction site to, we have to minimize the laborer's exposure to the high temperature and follow a safe way to utilize the labor resource effectively and efficiently in extreme hot weather during summer season at construction sites.
The Construction Industry of Sindh province needs attention in this matter and it is very important in this time and for future to develop the remedial measures to overcome this issue and save the construction labor and construction industry of Sindh province, Pakistan.

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# Design of Pilot Scale Equipment for Arsenic Removal Using Nanomaterial

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*Abstract:* **Arsenic is a recognized threat to human health all over the world. Chronic exposure to arsenic could lead to skin lesions and skin cancer. WHO recommends the accepted level of arsenic to be 10µg/l. Arsenic has been seen all around as the most destructive inorganic contaminant of drinking water. Nanofiltration, among other techniques has been gaining more attraction recently. However, no automatic equipment has been designed and tested using nanofiber for purification of Arsenic from water. In this study, an attempt has been made to design an equipment for convenient purification of Arsenic from water. The equipment consists of a compartment in which contaminated water is guided automatically by control panel. Chitosan/$Fe^{3+}$ nanofibers were fabricated using electrospinning process to be used in the machine. These can be placed inside filters attached on the ends of the shafts. The water is guided through pipes using automatic valves. The results were optimized for time, dosage and RPM. The research found that the equipment purifies best when water is treated for 45 minutes (83.1% removal rate). The optimal dosage was found to be 200mg of nanofibre and 200 RPM gives the best removal percentage of 83.3%.**

*Keywords:* **Adsorption, Arsenic, Chitosan, Electrospinning.**

## I. Introduction

Arsenic contamination in water is a serious health risk. Exposure to arsenic can occur through irrigation of crops, drinking contaminated water or using contaminated water in cooking. Chronic exposure to arsenic could lead to skin lesions and skin cancer. In countries such as China, India and Bangladesh arsenic contamination are a problem of increasing urgency [1]. In Pakistan too, arsenic contamination poses a serious risk of health due to widespread use of groundwater which is also polluted with inorganic arsenic (about 1 in 10 wells are contaminated) [2]. Different methods are used for arsenic removal. These include precipitation, membrane processes, ion exchange, and adsorption. Adsorption is considered the most important as owing to it is cheaper and simple in operation [3]. Activated carbon, chitosan, alumina, carbon char, titanium dioxide has also been used for arsenic removal, but they have low efficiency and contaminate the water by their particles mixing in water [4-8]. For adsorption, surface area is the most important characteristic in any adsorbent. In this context, as amorphous or Nano particles have high surface area they tend to be more efficient. Iron oxide Nano crystals (Fe2O3, Fe3O4) are found to be potential adsorbents because of additional adsorption mechanisms [9]. Chitosan is derived from chitin. Chitin is among the most commonly available natural polysaccharides. It binds toxic metal ions, a property which is advantageous air and water filtration processes [10]. Chitosan based adsorbents have been made with considerable interest for removal of metal ions from water because of its special physical and chemical properties. Moreover, Chitosan is made in many different physical forms such as nanoparticles, gel beads, membranes and fibers easily. It is a fact that larger the specific surface area higher the adsorption capacity for a particular adsorbent. When Chitosan is fabricated into a porous or fibrous structure, its specific surface area increases. Fabricating the Nano fiber is done by various ways, but electrospinning is the most popular one which produces ultrafine fibers efficiently. Chitosan's rigid D-glucosamine repeat units with regularly arranged hydroxyl and amino groups make it a poor choice for electrospinning ability however incorporating metal-based material in Chitosan increases its electrospinning ability with strong functional properties. Iron-based materials can be one such material and has been used frequently with Chitosan as adsorbent for arsenic removal from water under neutral pH

JJ. Chitosan/$Fe^{3+}$nanofibres have been produced by electrospinning with success and good properties. An electrospinning solution was made including Triflouro acetic acid (TFA) and Ferric Oxide. The solution was electrospun following which dried matts were cross linked using glutaraldehyde. In this research also Chitosan/Fe nanofibers were prepared. They were also characterized using FTIR and SEM. In this project I have designed purification equipment for water treatment. The idea is to test the efficiency of the nanofiber filtration in an automatic method and convenient way.

## II. EXPERIMENTAL METHODOLOGY

*Design and Fabrication of Pilot Scale Equipment*

*Components and their Function*

a). Container: Container holds contaminated water to be released in to the equipment. It is made oand has a capacity to hold about 4 liters of water.

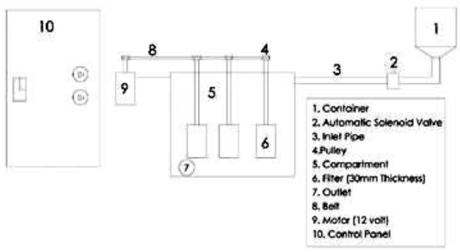



**Figure 1. Schematic diagram of pilot scale equipment.z**

- b) *Compartment: Compartment is a major part of the pilot project. It houses the rotating rods. It is made of acrylic sheets of 8mmthickness.*
- c) *Rods: The rods are fitted on inside the compartment. 3 rods are provided of 4mm diameter. Each rod has a detachable filter at the end.*
- d) *Filters: These are 30mm in diameter and are detachable by a nut. They are made of iron. Filters are used to house the nanofiber material.*
- e) *Pulleys: Pulleys are attached with rods and are rotated by motor through belts. They have a diameter of 12.5mm.*
- f) *Bearings: They support the rods and keep them in position to run smoothly. They have a diameter of 13mm.*
- g) *Motor: Motor rotates the all three rods. Its specification is 12 volts and its rotation can be controlled by Control Panel.*
- h) *Belts: They connect the pulleys with motor.*
- i) *Pipes: They are used to transport the contaminated and treated water. Made of plastic the flow controlled by automatic valves.*
- j) *Automatic Valves: Two automatic solenoid valves are fitted on pipes to regulate the flow of water through the equipment. They are controlled by control panel.*
- k) *Control Panel: Control panel automatizes the whole system. It controls the motor and two solenoid valves. Settings can be inserted through timers installed inside the panel while the equipment can be turned on through switch provided outside the panel.*
- l) *Paper Filter: This is fitted just before the exit valve so that treated water is filter of the nanofiber matt particles.*
- m) *Wooden Board: Wooden board supports the whole structure of the equipment. All parts of the pilot equipment are installed on the board.*

### *2) Fabrication of the Equipment*

The equipment consists of a compartment in which three rods (4 mm diameter) are arranged by pulley and belt system. Filters of 30mm diameter are fitted at the end of the rods (removable by nuts) in which nanofiber is placed. The rods are rotated by motor (220 volts, controllable RPM) through belt assembly. 13 mm diameter bearings attached on the rods to reduce friction and smooth operation. The compartment is attached with the container through which water is supplied via plastic pipes. Water is dispensed by automatic valves of 220volts. Automatic system opens the valves to transport the water from the bottle into the compartment. Settings have been pre-installed in the system as to when the water will enter the equipment, the treatment time and removal time and valves open and close accordingly automatically. The optimized flow rate of the equipment (sample entry, exit and treatment) is about 11 ml/min. When filtration is complete an automatic tap facilitates the removal of water for testing.

### *B. Synthesis of Nanofiber*

#### *1) Electrospinning*

Chitosan solution was made in 3.5% w/w in TFA. Ferric Oxide and β-cyclo dextrin were added and stirred of 36 hours. The prepared solution was taken for electrospinning and a copper wire was inserted for positive charge. The voltage supplied during spinning was25 kV. The needle tip was set at an angle of 10 degrees to the collector surface. The collector is made negative so that emerging webs are drawn to the collector which is covered with aluminum foil. Nanofibers were collected for 5-6 hours following which they were dried and then cross linked in glutaraldehyde vapor.

### *C. Application of the Equipment*

Equipment is used for removal of arsenic from contaminated water through adsorption method using synthesized nanofiber.

Experiment start with the entry of water in the compartment automatically through the pipe with solenoid automatic valve. Once there the contaminated water is treated by rotating the nanofiber laced filters by motor. Water is agitated by the rotating shafts. The agitation will continue for different times after which the water will be transferred through pipe and automatic valve. After treatment the water flows out of the tap, this is collected for testing. The same process will be repeated for different tests.

### *D. Figures*

Arsenic stock solution of 1000ppm is prepared by dissolving 1.3203g of arsenic oxide (As2O3) in a minimum volume of 20% (w/v) KOH. Neutralization to 1L with 1% (v/v) HNO3 gives 1000ppm arsenic solution.

All the experiments use 500ml Arsenic solution for filtration in the pilot equipment. 200mg of chitosan nanofiber in 500ml contaminated solution. The parameters affecting adsorption were optimized by varying one factor at a time keeping others same. Influence of time was determined by shaking the arsenic contaminated solution and nanofiber mixture at 200rpm. The different time intervals used were 5, 10, 15, 20, 25, 45, 65 and 85 minutes. The optimum dosage of nanofiber mass was tested from 100-300mg. RPM was varied through 50 to 250 rpm by keeping another parameters constant. The treated water was analyzed for arsenic removal percentage using Aurora AAS system.

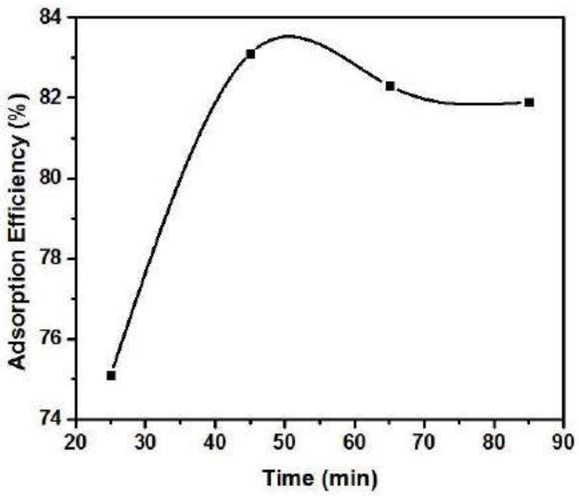
The percentage adsorption was calculated by using the following equation;

$C_i$ = initial concentration (mg/L)
$C_f$ = final concentration
V= volume of solution
m = mass of nanofiber (g)

## III. RESULTS AND DISCUSSIONS

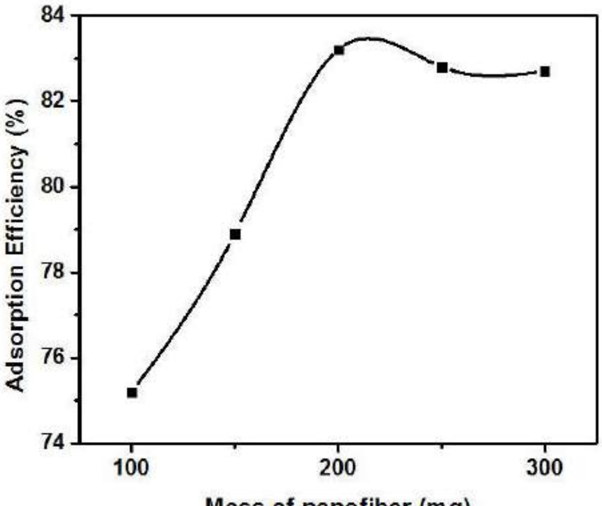
### *A. Effect of Time*

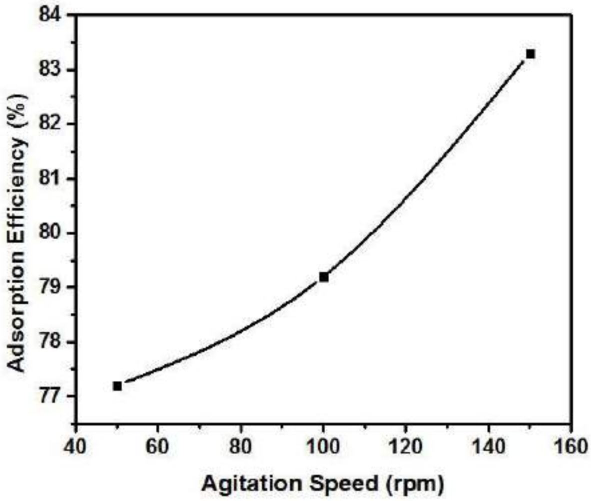
The equipment was tested for optimal time. Water was treated for 5,10,15,20,25,45,65 and 85 minutes. The maximum removal was found at 45 minutes. Treating for more than 45 minutes was found to decrease to removal efficiency.




### *B. Effect of Mass of Nanofiber*

Dosage i.e. the amount of nanofiber material was also tested for optimization. Increasing the amount of nanofiber increased the removal percentage, however the optimum quantity was reached at 200mg after which the removal decreased or remained stagnant.






## IV. CHARACTERIZATION

### *A. SEM Analysis*

Scanning electron microscope was used to measure the surface characteristics of the nanofiber both before and after crosslinking. Fig.2 and Fig. 3 shows the SEM images of nanofiber before crosslinking and after crosslinking respectively.

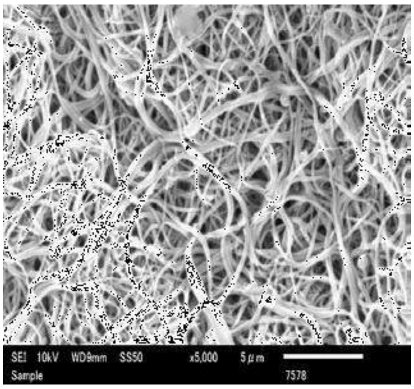



**Figure 2. SEM image of nanofibers before crosslinking.**

The average surface roughness could be calculated from the roughness profile determined from the SEM image. In fig. 2 the chitosan nanofiber without cross linking show an average surface roughness of 110nm while in fig. 3 a higher roughness can be seen besides the average roughness of cross linked nanofibers to be 170nm.

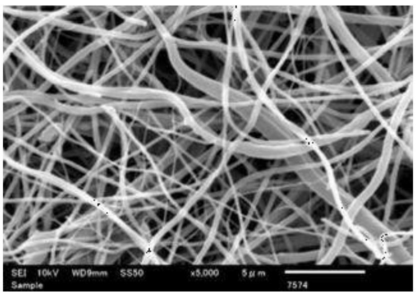



**Figure 3. SEM image of nanofibers after crosslinking**

*C.* Effect of RPM

Agitation of water has a significant effect on the adsorption of Arsenic of nanofiber. The maximum removal percentage was found to be 83.3% at 150 RPM. Increasing the rotation of the shafts more than that decreases the removal which is attributed to the disintegration of nanofiber matts.

This is important as higher surface roughness increases the adhesion. It has a significant influence on the formation of metal ion complexes. It is therefore concluded that cross linking with glutaraldehyde increases the surface roughness of and the consequent sorption capacity of the Chitosan nanofiber.

## V. CONCLUSION

Arsenic contamination in water is a recurring and serious issue especially in developing countries like Pakistan. Researchers are trying to find ways to combat this problem and devise ways to purify the water using different materials. I have also attempted to put some effort in and devised a lab scale equipment to purify the water automatically and conveniently. The results are promising, and further research is welcome. In the study it was found that the equipment purifies best when water is treated for 45 minutes. The flow rate of the equipment is 500ml in 45 minutes (approximately 11ml/min). The optimum dosage of nanofiber is 200 mg and the speed at which the water is treated was optimized at 150 RPM.

## ACKNOWLEDGMENT

This work was supported by Mehran University of Engineering and Technology Jamshoro Pakistan and Shinshu University, Japan.

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# Application of GIS and Remote Sensing for Flood Management: A Case Study of Larkana Division

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***Abstract*: Floods are among the most devastating events in nature; they cause a huge amount of damage to infrastructure; crops and they destroy many lives. Pakistan has faced several cycles of destructive floods in its history. It is difficult to control a flood. However, if the excess water is managed properly then the extent of the flood and its damages can be reduced. Integration of a Geo Information System (GIS) with remote sensing data gives sufficient knowledge for many hydrological studies including, flood prediction, generating drainage lines, highlighting flood risk zones and more effective flood management. The information extracted from digital elevation models with the help of ArcGIS software is the most helpful approach for making flood risk maps. In this paper, an attempt is made to generate flood risk maps and to generate feasible flow path for the Larkana Division by using digital elevation models employing the GIS approach. Depending on the elevation of the entire area, three risk zones are categorized: low, medium and high. The analysis shows that the most vulnerable site in Larkana Division is Qamber-Shahdadkot. The results also indicate that some of the western locations in Jacobabad and the southern part of Larkana Districts are also at high risk to the flood damages.**

***Keywords*: Digital Elevation Models, Feasable flow path, Flood risk mapping, GIS, Remote Sensing.**

## I. INTRODUCTION

Water is one of the most valuable resources on earth's surface, without which life would not be possible on the planet - all living things depend on the availability of the water. But sometimes water causes major devastation in different forms like heavy rainfall, floods, and drought. Floods are considered as the most overwhelming natural disaster throughout the globe contributing significant economic, environmental and social losses [1]. Asia is the home for more than half of the world's population and its geographical area is approximately one-fifth of the earth's land. Asian region suffers quite frequently losses in infrastructure, life and economic progress due to flood-related losses. Looking at the history from 1994 to 2004 alone, Asia has faced about one-third of 1562 floods worldwide and approximately 60,000 people lost lives in those floods [2]

In Pakistan, 90% of the natural hazards are flooding related [3]. In the flood-prone countries, almost every year floods results massive damages to properties and causing loss of lives. Indus River with its tributaries has caused extensive floods in the history of Pakistan. Thus, Pakistan has suffered almost 67 times from devastating floods since 1928, some of them are 1929 1955, 1959, 1973, 1976, 1988, 1992, 1996, 2005 and 2010 [4]-[5]-[6]. It is reported that since 1947 to 2008, due to floods in the Indus River Basin, more than 7,000 people are killed, and massive infrastructure and crop loss occurred [7]. The devastating flood of 1992 surpassed all previous record causing damages worth Rupees 50 billion [8]

During July 2010, above average monsoon rainfall events occurred in the Khyber Pakhtunkhwa, Gilgit-Baltistan, Kashmir, and Punjab which up shots devastating floods in the Punjab, Sindh and Khyber Pakhtunkhwa, provinces of Pakistan. It inundated an area of about 60,000 km$^2$, displaced 15–20 million people (11 % of total population) and caused the death of about 2000 people [9]. Flows in River Indus further intensified when an unexpected cloudburst occurred in Koh Suleman Range, as a result, Indus flow in Sindh at Guddu Barrage (1st barrage on Indus in Sindh province) touched flow of 1.14 million cusecs. Due to vast flow in the river, a breach in protective bunds on the right side of the river at Tori, district Kashmore occurred on August 07, 2010 which inundated vast areas of Jacobabad, Kambar-Shahdadkot, Shikarpur, Kashmore, and Dadu. The flood runoff started from Kashmore and advanced as per natural slope and after flooding Jacobabad, Shikarpur, Kambar-Shahdadkot, and Dadu districts, it eventually disposed of in Manchar Lake.

The heavy rainfall generates a huge amount of runoff water, which flows from upstream to downstream and causes flood. The floods rank top in natural disasters, therefore, the occurrence of floods is a top priority in natural hazards and hydrological studies. [10] From the previous trend of floods, it can be forecasted that due to climate change, severe weather conditions and heavy river discharges, the frequency, and intensity of floods will be increased in many regions of the world [11]. Therefore, the problems experienced from floods need to be addressed, and it is highly required that an accurate flood risk maps, using the integrated approach of GIS and remote sensing data, should be made in order to reduce the quick response of floods.

The advancement in satellite technology and GIS provides enormous facilities for assessing and mapping the flood risks. It is clear that the natural disaster in terms of globally affected people and their individual fatalities can be managed properly by using GIS techniques based on remote sensing data [12]. The use of GIS for flood management serves two main purposes; it generates a visualization of flooding and also creates potential to further analyze this product to estimate probable damage due to flood [13]-[14].

A number of studies are conducted to map the flood risk areas using digital elevation models (DEM) data and GIS techniques. Reference [8], presented a simple and competent procedure for describing area under flood, flood hazard area and suitable area for flood shelters to reduce the impact of floods. With the help of ArcGIS Model Builder, they modeled the probable limit of flooding and they mapped for Sindh province. Reference [15], used remote sensing and GIS to develop flood risk maps for the middle course of the river Kaduna, Nigeria. Based on DEM data, they developed a flow accumulation model which showed low risk, moderate risk and high-risk zones, using an equal interval for separation, based on the elevation of the area. Reference [16], reviews the application of remote sensing for determining river discharge, inundation, and stage. Since then, the focus in this direction is shifting from flood boundary delineation to risk and damage assessment.

The similar approach of GIS and remote sensing is used in this study for flood management. The main objective of this study was to develop flood risk map for Larkana division and also to generate feasible flow paths for safe disposal of future flood runoff. Besides this, the secondary objective of the study was, to assess the impact of flood 2010 on Normalized difference vegetation index (NDVI) and to determine the change in vegetation area.

## II. MATERIALS & METHODS

### *A. Study area*

The Larkana Division is a secondary administrative unit in Pakistan, while it is a primary administrative unit of Sindh Province, Pakistan. It is situated in the Northwest part of Sindh Province at longitude 67° 11' 6" E and 69° 48' 40" E, and Latitude 27° 7' 56" N and 28° 29' 12" N. It comprises of five districts (secondary administrative units of Sindh province). They are Larkana, Jacobabad, Kashmore, Shikarpur, and Qamber-Shahdadkot, as shown in Figure 1. The total area of the division is about 15,491 $km^2$. The Indus River flows along the eastern border of the division. The climate of Larkana Division is hot, during summer, and in winter it is dry and cold. Larkana Division is an arid region with mean annual precipitation of about 160 mm. The major Kharif crop grown in Larkana is rice, while wheat is a major Rabi crop. Agricultural lands of the division are irrigated from the network of canals that receive water from Guddu and Sukkur Barrages.

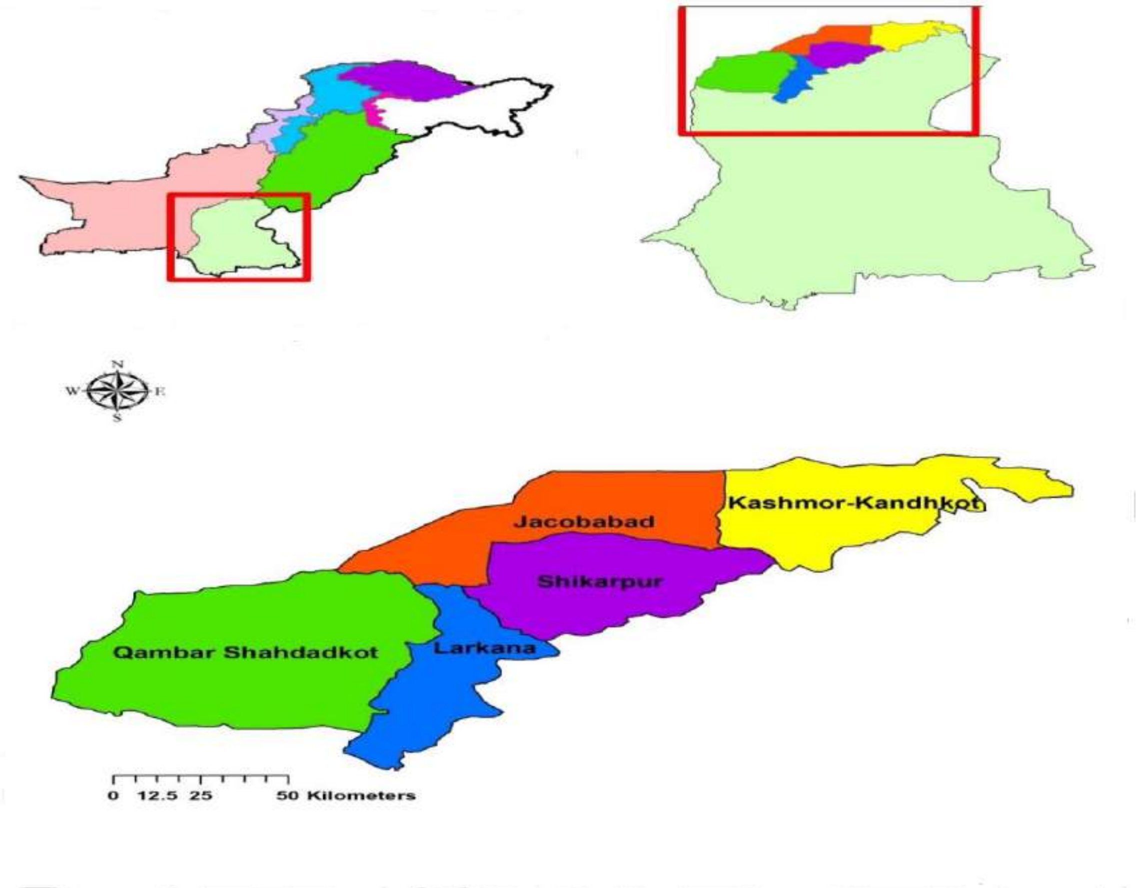


**Fig.1: Location map of Larkana division**

*B. Materials and data*

The data used in this study was: ASTER global digital elevation model (ASTER DEM) of 30-meter resolution, acquired from earth explorer. The Landsat7 imagery of September 2009 and 2011, acquired from golvis.usgs.gov using path 152 and row 40, 41. The ERDAS imagine and ArcGIS tool were used to preprocess and analyze the remote sensing data respectively.

*C. Flood risk map*

The Digital Elevation Model (DEM), also known as a 3-D representation of terrain surface, can be used for several purposes, including water-flow modeling, soil-wetness modeling, and development of relief maps, satellite navigation, base mapping, and flight simulation. In this study, A DEM of 30 m resolution was used to map flood risk zones. The study area lies within different DEM tiles; therefore, to develop a single image, all DEMs were mosaicked. Moreover, the shapefile for Larkana division was used to extract the area of interest. The extracted image was then analyzed in ArcGIS to create flood-risk maps. The study area has varying elevations; therefore, depending on the elevation of the surface, the entire division was categorized as high, medium and low-risk zones through the GIS risk map.

*D. Feasible flow paths*

The same DEM was used here for creating feasible flow paths, as discussed under the heading of flood risk map. The DEMs may have some pits, therefore, to fill those pits, the “Fill” command was used, which is embedded in the Arc Hydro tools. We would obtain 8 different values for flow while using the flow direction command. Running the “flow accumulation and streamline” commands, the software will highlight the various streams within the study area. Streams were highlighted, whether they were dry or whether there is some water in them. After running the “catchment” command, the number of catchments was created around the streams. These catchments can be used for various purposes, such as watershed delineation, calculating runoff and many other purposes. The catchment can be converted into a polygon for different uses. If it is required to calculate the catchment area, the catchment polygon process can be used to create a polygon. These polygons are now in vector formats. After completing all the steps, the longest flow path was created, by running the “drainage line” command. The generated longest-flow path meets the objective of creating a feasible flow path for the flood runoff waters in Larkana Division.

*E. Normalized difference vegetation index*

The Landsat images of WRS-2 path 152, row 40 and 41, processing level 1T was acquired from United States Geological Survey (USGS) portal before and after the flood, for the years 2009 and 2011. The Landsat images of September were only taken for analysis. The Landsat data needs to be pre-processed before analyzing for change detection, in order to develop the clear relationship between biophysical and available data [17]. For that purpose, the Landsat data was pre-processed in ERDAS imagine for gap fill, the black strips of missing data in Landsat 7 image, and also it was used for geo-referencing the data. Besides this, the GIS tool was used for mosaicking and also for extracting the area of interest, however, it can also be done by using ERDAS imagine. After pre-processing the data, the ArcGIS was used for making NDVI maps. For NDVI maps, only red and near-infrared bands (band 3 and band 4) of Landsat7 images were composited together, while other bands were not considered in this study. The composited bands of two imageries for path 152, row 40 and 41, were then mosaicked. After mosaicking, it covers the larger area; the shapefile for Larkana Division was used to extract the area of the study from the mosaic image. The images were further processed in ArcGIS for more analysis. To determine the NDVI, a simple method, image analysis window that is embedded in ArcGIS, was used. In image analysis, a new window opens. By selecting red band as 3 and near-infrared band as 4, the NDVI maps are generated. The Normalized Difference Vegetation Index (NDVI) derived from the Landsat7 imagery is considered an efficient way to monitor crop condition and forecast yield. The generated NDVI maps are now in raster format, therefore, to calculate the area of vegetation, theses maps were converted into vector format as shown in the flowchart.

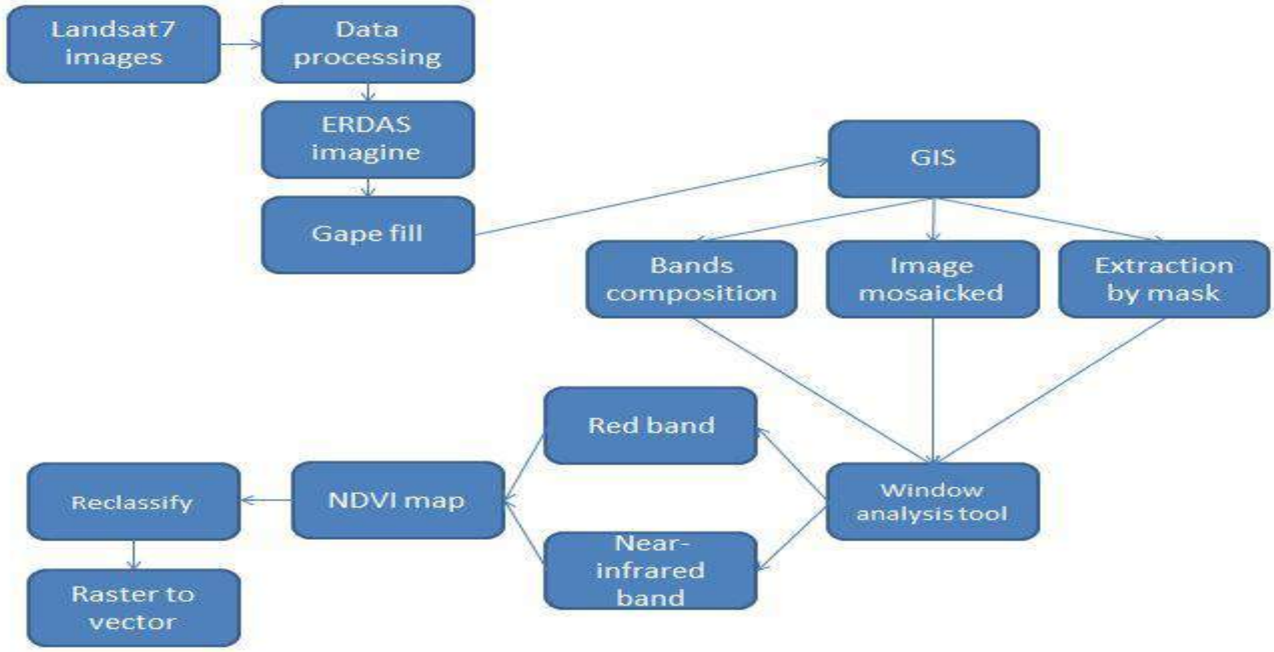


**Fig.2: Flow Chart for determining NDVI**

## III. RESULTS

### *A. Flood risk map*

A number of studies are conducted to map the flood risk areas using DEM data and GIS techniques. In this study, a simple method is used to prepare flood risk map. After analyzing the DEM data, the resulted flood risk map shows three different zones in terms of elevation of the study area. The risk of floods is classified as low risk 23-53 meters, medium risk 53- 68 meters and high risk 68-255 meters. The distance of the study area from the river was not taken during the analysis; however, the analysis was entirely based on the elevations, as the elevation is the main factor compared to distance regarding flood risks. For instance, it is not always necessary that the areas which are near to the river are always at high risk, however, the areas which are far away from the river may have a high risk, if the elevation of the land is low compared to the elevation of the river. Reference [18], used the same approach to study the risk of flood from river Kaduna, they considered the elevation only as a major factor for developing the flood risk map. The similar technique was used to map flood risk for Larkana division, and the results showed that most parts of the Qamber-Shahdadkot and Larkana are at high risk to floods as they have a low elevation, while Jacobabad and most parts of Shikarpure are at medium risk to floods. Besides this, the hilly area of Qamber and Kashmore-Kandkot are at low risk to floods.

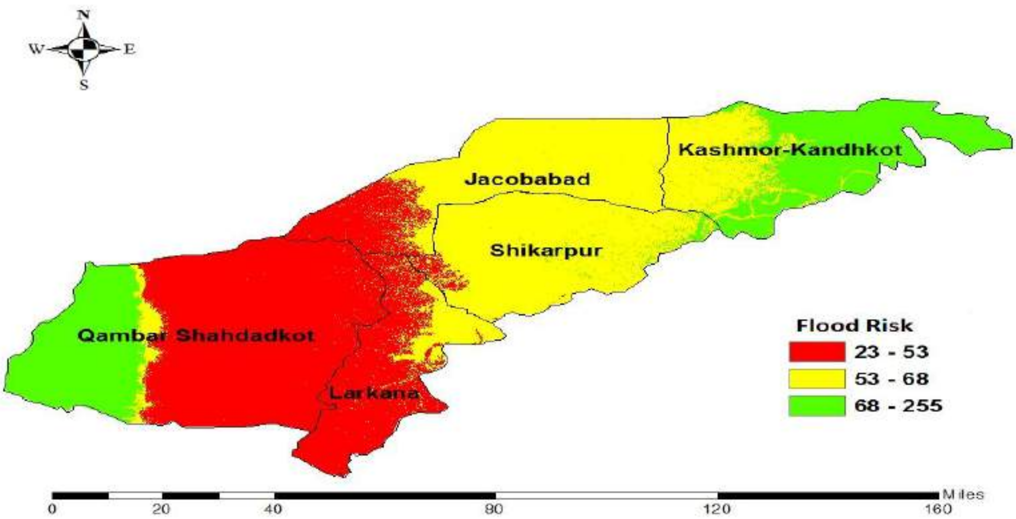


**Fig.3: Flood risk map**

*A. Flow paths*

The application of remote sensing and GIS facilitates users for management of floods, in order to reduce its impacts. During the floods, the flow path generated from DEM data can be used for streamlining the flood water. The delineation of the flow path is based on the eight-direction (D8) flow model. However, [19] presented a new model, which is multiple flow direction model (D∞ ), in his model, he represented flow within a DEM instead of representing flow in eight possible directions.

In this study, the GIS and remote sensing data are used to generate longest flow path based on eight-direction (D8) flow model, for that purpose, the SRTM DEM of 30 m resolution was taken. The analysis of DEM data showed the various flow lines for different catchment areas. The results of the analysis showed that the longest flow path starts from Kashmore-Kandhkot and crosses through Shikarpur, Jacobabad and then disposed into Hamal Lake in Qamber-Shahdadkot. The generated longest flow path is shown in Fig.4.19.

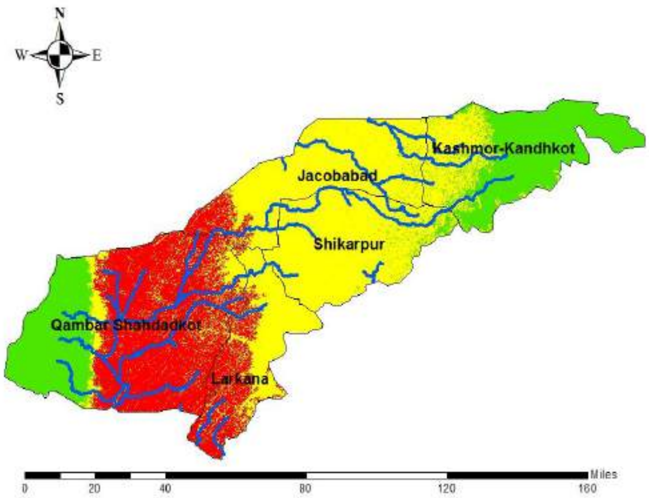


**Fig.4: Flow path**

*A. Normalized difference vegetation index (NDVI)*

The remote sensing data are commonly used for different purposes, and one of the main purposes is to determine vegetation bearing areas with the help of different indices but the most common indices are NDVI [20]. The NDVI is a difference of ratios between near-infrared and red bands in terms of canopy reflectance values [21]. In this study, the NDVI is used as to determine the impact of floods on crop condition. Therefore, two Landsat7 images of September were selected for analysis. After analysis, the resulted maps are shown in Fig. 5 and 6.

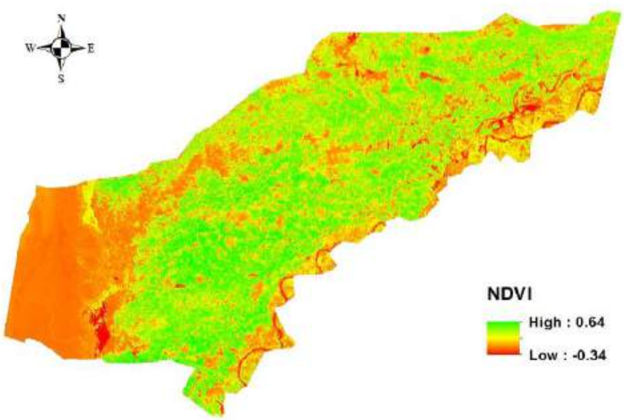


**Fig.5: NDVI map of September 2009**

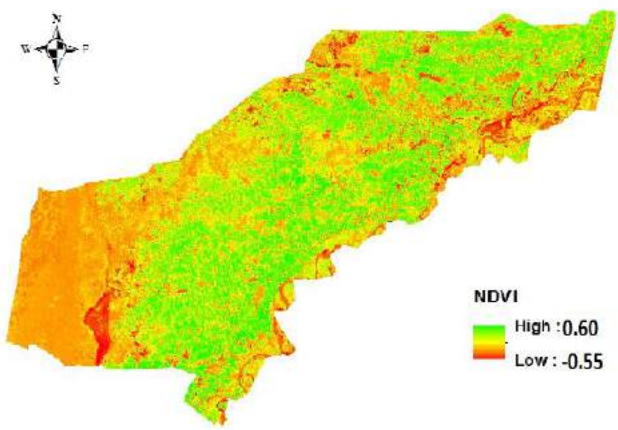


**Fig.6: NDVI map of September 2011**

The analysis of Landsat images shows the decrease of NDVI value during 2009 to 2011 and this change in NDVI can be caused due to flood 2010. Reference [22], tells that due to floods and Tsunami, the NDVI values decreases, on the other hand, normalized difference water index (NDWI) values increased. The NDVI value of September 2009 was 0.64 and then it decreases to 0.60 in September 2011. Reference [23], shows that the NDVI value is related to the photosynthetic activities, and its range is from 0.2 to 1, and those plants, which are in good condition, have NDVI value about 0.6. Therefore, based on the results of the analysis, it is concluded that the crops were in good condition before the flood, but after the quick response of flood, the crops were damaged in September 2011. After reclassifying the NDVI maps, the new vegetation mask is shown in the

Fig. 7 and 8. While converting these raster images into vector format, the calculation of area shows that in September 2009, the total area of vegetation were 706344.347 Hectors, but in September 2011, the area reduced to 627020.851 hectors. Therefore, the total reduction in the area was observed about 11.230 percent.

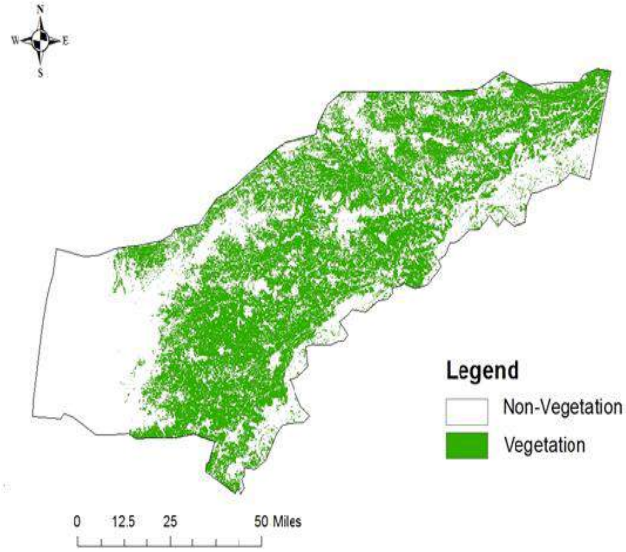


Fig.7: Vegetation mask of September 2009

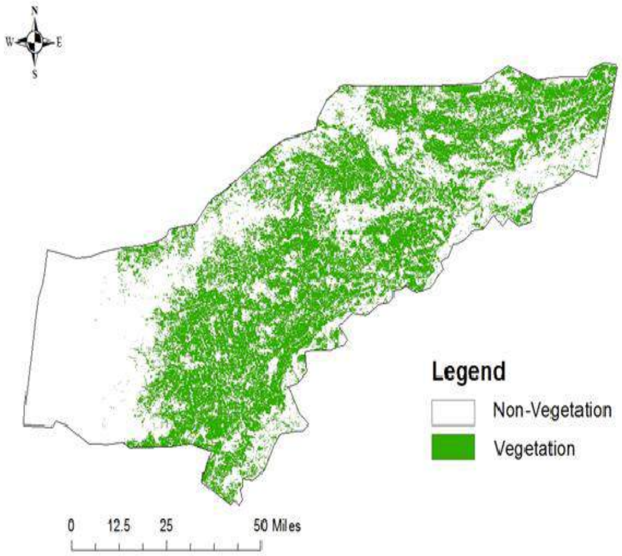


Fig.8: Vegetation mask of September 2011

## IV. CONCLUSIONS

To assess the flood damages and to mitigate its effects is a crucial task for natural disaster management authorities. The accurate analysis of flood risk areas requires comprehensive information about the conditions of the field. In this study, the simple technique of GIS and remote sensing data were used to develop the flood risk map, based on the elevation of the area, and to streamline the flood runoff water for a future flood event. The results of the study show the three different risk zones for whole Larkana division. These zones were categorized as low, medium and high-risk zones. Based on the resulted risk map, most parts of the Larkana and Qamber-Shahdadkot are at the high-risk zone to flood. The GIS and remote sensing technique were also used to determine the change in the area of vegetation in Larkana division and the result shows a decrease of 79323.496 hectors.

## V. RECOMMENDATIONS

The application of GIS and remote sensing provides a satisfactory result; therefore, the approach should be applied in Pakistan for devising water resource planning and management, in order to develop flood protection strategies. The flood risk maps and flow paths developed in this study should be adopted in flood protection strategies in order to reduce the damages of the flood. For further studies, the Analytical hierarchy process (AHP) and Hydrological engineering center and river analysis system (HEC-RAS) techniques integrated with GIS should be used to make more accurate flood risk maps by considering various factors such as: type of soil, slope and elevation, distribution of annual rainfall, information of land use land cover changes, and drainage density.

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# Numerical Evaluation of Pile Axial Capacity

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***Abstract:*** **Single axially loaded pile has been numerically simulated to evaluate axial bearing capacity in layered soil. Geotechnical finite element software, PLAXIS 2D is capable to simulate soil-pile interaction, changes in state of stress in pile installation and its effect on skin friction and end bearing. Soil response is simulated by 15-noded triangular element with elastic perfectly plastic Mohr Coulomb constitutive model and pile response is assumed to be with linear-elastic. Soil-pile interaction has been simulated using interface element. Load displacement curve of full scale pile load test is used in calibration of numerical model to select appropriate mesh size. Load displacement curve from PLAXIS 2D shows reasonable agreement with pile load test. The calculated axial capacity from numerical modeling is compared with published empirical and theoretical methods.**

***Keywords*****: Pile axial capacity, Soil-Pile interaction, Pile load test, Finite element method**

## I. INTRODUCTION

With the increase in Infrastructure development in Pakistan, pile foundation is widely adopted. Cast in-situ piles are widely used because of its advantages like adjacent soil is not disturbed, less disturbance to adjacent structures due to absence of vibration, less environmental noise, strong adaptation for formation and high bearing capacity. Engineers are still struggling to estimate precisely the load bearing capacity of cast in-situ piles, though for this purpose several methods are available. These methods incorporate some basic assumptions / empirical approaches regarding soil stratigraphy, interaction between soil-pile and soil resistance distribution along the pile. Therefore, the values of these methods cannot be directly useful in pile capacities evaluation. [1].

Piles load carrying capacity can be evaluated by using five approaches: static analysis, dynamic analysis, dynamic testing, pile load test and in-situ testing. Results evaluated by static approach are usually very rough and these cannot be relied on for the evaluation of pile capacities. The basis for dynamic approaches is wave mechanics of the hammer-pile-soil system. The load carrying capacity of pile evaluated by this method may leads to approximate results because of, uncertainty involved in the impact of hammer, also the changes in strength of the soil at the time of pile driving, as well as at the loading time. Dynamic testing approached needs experienced engineers and also pile capacities cannot be evaluated till driving of the pile is completed [2].The most suitable approach for evaluation of pile load bearing capacities is pile load test, however these tests are time consuming and costly. Therefore, for the prediction of pile capacities it is necessary to depend on direct application of in situ tests being carried out along with the geotechnical investigation results.

In this study, axial bearing capacity of in-situ bored pile is calculated based on axisymmetric finite element analysis using PLAXIS 2D. Numerical model is validated using load-settlement curve obtained from pile load test. Numerically estimated Axial bearing capacity is compared with calculated capacity from empirical and theoretical methods.

## II. METHODS TO EVALUATE AXIAL BEARING CAPACITY

In Pakistan, theoretical (NAVFAC DM 7.2) [3] and empirical method based on SPT (Reese and Wright [4], Touma and Reese [5], Decourt [6] and Meyerhof [7]) are commonly used to estimate axial pile capacity of in-situ piles. Theoretical and empirical methods used in this study are listed in Table 1.

Depending upon the nature of project Pile Load tests are also performed to measure pile load carrying capacity. Slope and Tangent method [8], Limit value method [9], 90% Hansen method [10] and AASHTO 6mm methods are typically used for the interpretation of pile load test in Pakistan.

## III. CASE STUDY

Orange Line Metro Train is an under-construction rapid transit line being built as part of Lahore Metro, Pakistan. The line spans 27.1 km (16.8 mi). 25.4 km (15.8 mi) of the line is to be elevated, while 1.72 km (1.1 mi) km will be underground, and 0.7 km (0.4 mi) of track will be laid in the transition zone between elevated and underground sections. Most of the site area comprises on existing roads surrounded by residential and commercial buildings. The soil deposits in the project region are made up of river transported alluvial deposits which are typical of Punjab plains. The location plan of the area under study is given in Fig. 1.

To account for the spatial variation of subsurface soil parameters, the route is divided into five zones and geotechnical investigations are performed. Fig. 2 shows the variation in subsurface strata encountered along alignment of the five zones of orange line. A total of 109 SPT and 49 CPT sounding were conducted along the project route. The SPT was performed at one-meter interval ranging up to a maximum depth of 50 m and CPT soundings were recorded at each 10 cm up to 20 m depth below NSL. Energy and overburden corrections were carried out for SPT numbers [11]. After collection of soil samples and subsoil data at site a detailed laboratory tests were performed on the representative soil samples. Based on site subsurface investigations and laboratory testing, soil stratigraphy and soil strength parameters were finalized as shown in fig. 3.a-f.

Table 1: Theoretical and Empirical methods for axial bearing capacity estimation of In-situ bored piles

| Method Type | Method Name | Functional form | Remarks |
|---|---|---|---|
| Theoretical | NAVFAC DM 7.2 | $Q_{ult} = P_t N_q A_t + \sum_{H=0}^{H=D} (K_{HC}) P_o \tan\delta (s)$ | Non-cohesive soils |
| | | $Q_{ult} = CN_cA_t + \alpha Cs$ | Cohesive soils |
| Empirical | Reese and Wright (1977) | $Q_u = 2.8N_sA_s + 64N_tA_p$ | |
| | Touma and Reese (1974) | $Q_u = K\sigma_s'\tan\varphi_f A_s + 1500(A_p/100)$ | Medium dense sand |
| | | $Q_u = K\sigma_s'\tan\varphi_f A_s + 3800(A_p/k)$ | Dense Sand |
| | Decourt (1995) | $Q_u = \alpha\ (2.8N_{60}+10) + K_bN_bA_p$ | |
| | Meyerhof (1976) | $Q_u = X_mN_{55} + A_p\ (40N_{55})\ L_b/D \leq Ap\ (380N_{55})$ | |

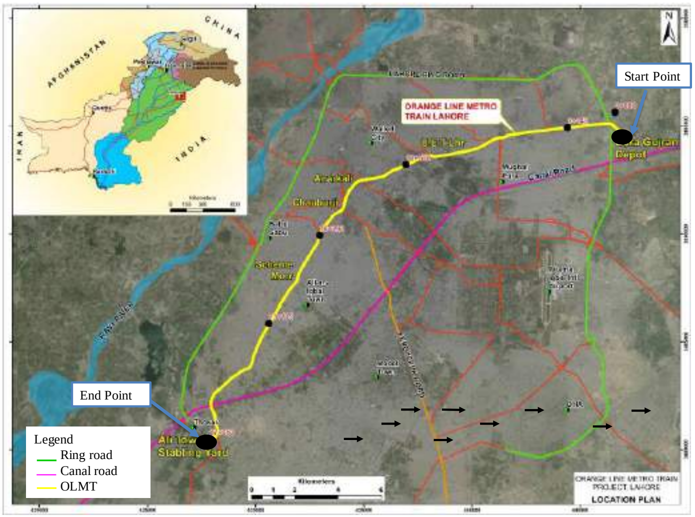



Fig. 1: Location Plan of Orange Line Metro Train Project, Lahore, Pakistan

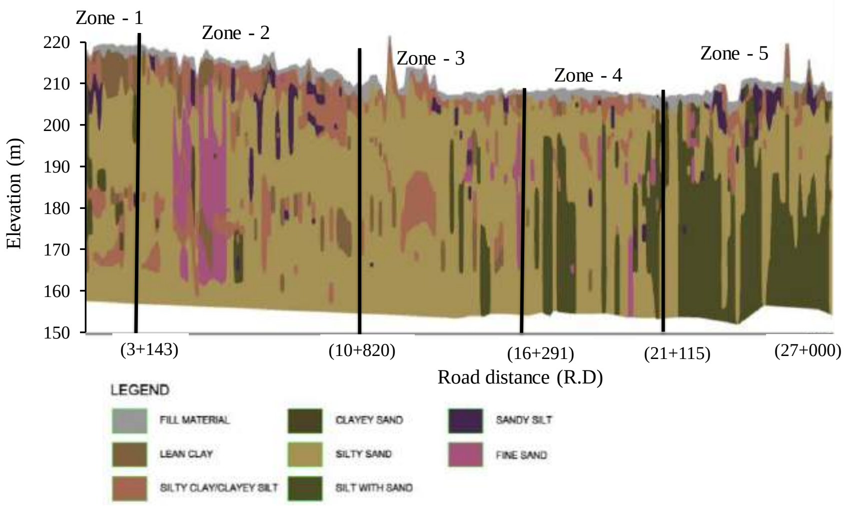



Fig. 2: Idealized Subsurface Profile for Orange Metro Train Project, Lahore

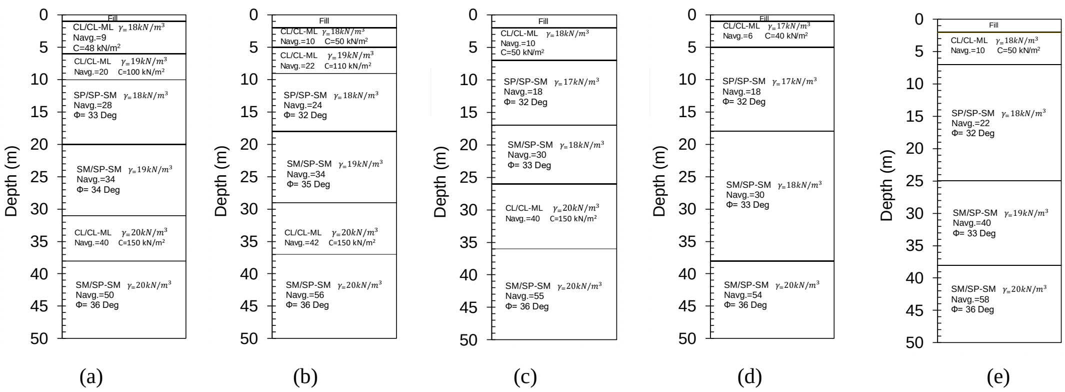



Fig. 3: Soil Profiles along five zones showing Soil classifications, SPT $N_{avg}$ blow counts and shear strength parameters (a) Zone-1 (b) Zone-2 (c) Zone- 3 (d) Zone-4 (e) Zone-5

Fourteen full scale Pile load tests were also performed at the project site in accordance with ASTM D-1143 [12]. The test load varied from 800 to 1200 tons for 760, 1000 and 1200mm diameter piles with length ranging from 22 to 40 m. In performing pile load test, four settlement gauges were used to record the settlement of the piles. These gauges were connected on two reference I beams. Each load increment was applied up to 25% of the design load. Shaft as well as tip were fully mobilized for some of the piles while other shows small displacement at test load. The arrangement of reaction load was made using a system of jack bearing against dead load which is resting on a platform. The dead load was supplied by using concrete blocks at the platform as shown in Fig. 4. The averages of the four gauges give settlement after each load interval. Summary of the pile load tests is given in Table 2 and load vs settlement curves for all the tests are shown in Fig. 5.

Fig.4 Concrete Blocks Platform at Orange Line Metro Train Project, Lahore

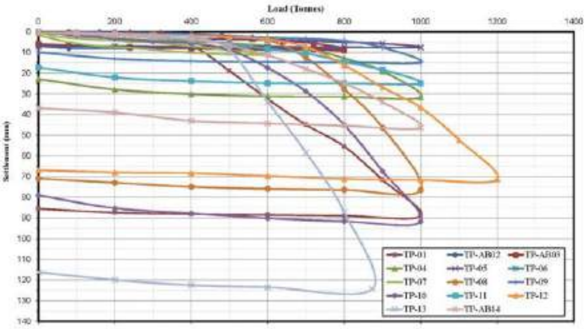



Fig. 5. Load-Displacement curves of Pile Load Tests

Table 2: Summary of field Pile Load Tests

| Zone # | Pile I.D. | R. D | Test Load | Pile Length | Pile Dia |
|---|---|---|---|---|---|
| - | - | - | (Tones) | (m) | (mm) |
| Zone-1 | TP-01 | 1+220 | 1000 | 30 | 1200 |
| | TP-AB02 | 2+196 | 800 | 22 | 1200 |
| Zone-2 | TP-AB03 | 5+000 | 800 | 22.6 | 1200 |
| | TP-04 | 8+694 | 1000 | 40 | 1000 |
| | TP-05 | 9+612 | 1000 | 30 | 1200 |
| Zone-3 | TP-06 | 12+348 | 1000 | 30 | 1200 |
| | TP-07 | 12+936 | 600 | 33 | 760 |
| | TP-08 | 15+400 | 1000 | 30 | 1200 |
| | TP-09 | 15+716 | 1000 | 30 | 1200 |
| Zone-4 | TP-10 | 49+436 | 1000 | 40 | 1000 |
| | TP-AB11 | 20+142 | 1000 | 24 | 1200 |
| Zone-5 | TP-12 | 12+348 | 1200 | 35 | 1200 |
| | TP-13 | 23+144 | 873 | 30 | 1200 |
| | TP-AB14 | 25+760 | 800 | 22 | 1200 |

## IV. Numerical Model

Axisymmetric two-dimensional (2D) finite element models (FEM) using PLAXIS 2D [13] were developed to simulate load-settlement response of axially loaded pile for five zones of Orange Metro Train Project, Lahore. FEM computation domain is shown in fig. 6 (a). Horizontal fixities and total fixities are applied at vertical and bottom sides respectively to simulate boundary conditions. With these boundary conditions vertical settlement behavior of pile and soil due to vertical load can be simulated.

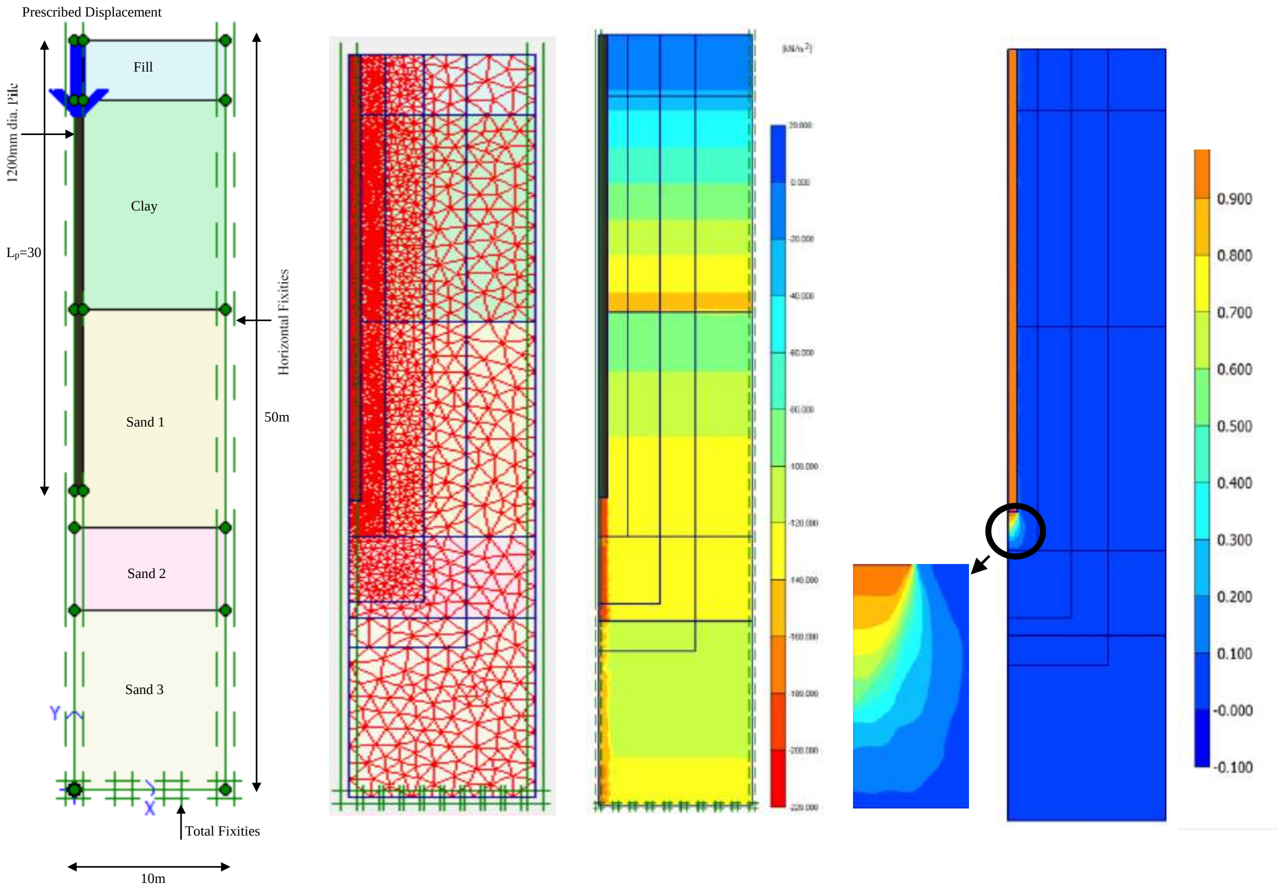
Both soil and pile were modeled using 15-noded triangular solid element, which allows fourth order interpolation for displacements. Relative movement between soil and pile is simulated by the 5-noded line interface elements. Interface geometry is extended below pile toe to avoid nonphysical stress state. Sensitivity analysis was performed to select the appropriate mesh size of domain, such that mesh size has no significant effect on ultimate capacity of pile, fig. 6 (b) shows the optimum generated mesh. There are 27881 nodes, 3432 elements and 41184 stress points in computational model as shown in fig. 6 (b).

Pile and soil behaviors were modeled with linear elastic and elastic perfectly plastic constitutive models respectively. PLAXIS 2D, defines elastic perfectly plastic behavior of soil using Mohr-Coulomb (MC) failure criterion. Five parameters, three cohesions, friction angle and dilatancy for shear strength and two moduli of elasticity and poisson's ratio for stiffness are required to define MC failure criterion. Interface behavior is also modeled using MC, with additional reduced strength parameter [14].

Table 2: Mohr coulomb parameters for Zone-5 used in PLAXIS

| Depth below NSL (m) | | Soil Type | Young's Modulus | Poisson Ratio | Angle of Internal friction | Dilatancy Angle* | Undrained Cohesion |
|---|---|---|---|---|---|---|---|
| From | To | - | (MPa) | | degree | degree | KPa |
| 0 | 2 | Fill Material | 5 | 0.4 | 25 | - | 0.01** |
| 2 | 7 | Lean Clay /Silty Clay | 7 | 0.4 | 25 | - | 50 |
| 7 | 25 | Silty Sand/Sandy Silt/Poorly Graded Sand with Silt | 20 | 0.3 | 32 | 2 | 0.01 |
| 25 | 38 | Silty Sand/Sandy Silt/Poorly Graded Sand with Silt | 30 | 0.3 | 33 | 3 | 0.01 |
| 38 | 50 | Silty Sand/Sandy Silt/Poorly Graded Sand with Silt | 40 | 0.3 | 36 | 4 | 0.01 |

* Dilatancy angles are calculated following [15]
** Very small value of cohesion to avoid numerical instabilities.[13]
*** Elastic modulus is calculated following [16-18]




(a) (b) (c) (d)

Fig. 6 Finite element simulation of Zone-5 Pile (a) Axisymmetric computational model (b) Generated mesh (c) Initial mean horizontal stress contour (d) Final stage Displacement contours at pile toe

## V. RESULTS AND DISCUSSIONS

Pile axial load capacities are calculated from Theoretical, Empirical and Numerical methods for single pile in each zone for Orange Line Metro, Lahore. Numerical model for each zone is calibrated using the measured pile load tests. Comparison of measured and estimated load-settlement curve is presented in Fig. 7, which is reliable estimate. Estimated difference of each method average axial load carrying capacity is calculated relative to the average of measured pile capacity for each zone, as shown in Fig. 8.

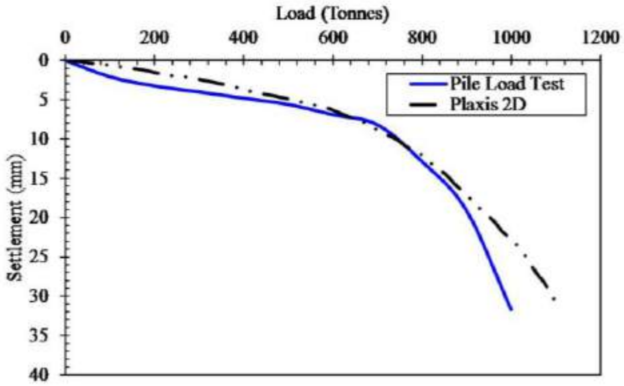



Fig. 7 Comparison of measured (Pile load test) and estimated (FEM) load-settlement curve for Zone-5

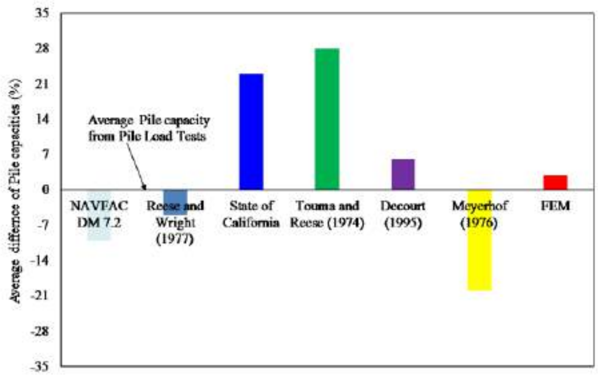



Fig. 8 Trend of variation of estimated Pile Capacity from Measured Pile Load tests

## VI. CONCLUSION

In this research, the comparison of axial load carrying capacity of piles evaluated from Numerical analysis (FEM), Theoretical (NAVFAC) and Empirical methods (SPT N, based) with measured pile load tests data for soil conditions of Lahore are presented. Among these methods, which predict axial capacity close to measured are recommended as suitable for local soils.

Calibrated numerical model gives a reliable prediction of Axial load capacity of single pile in a layered soil deposit. FEM model along with Decourt's and Reese & Wright and NAVFAC DM 7.2 method gives close results to those measured from pile load test data, therefore it is recommended to use these methods for local soil conditions. In absence of pile load test data, it is recommended to compare numerical axial load carrying capacity with upper bound of Decourt and lower bound of Reese and Wright. Further studies are currently underway to address three-dimensional modeling of axial pile response along with nonlinear soil constitutive models.

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# Comparative Study of the Compressive Strength of Concrete using River Indus Sand as Fine aggregate

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***Abstract*: In construction industry, the use of hill sand in concrete as fine aggregate has increased enormously. This paper presents the comparative study of the compressive strength of concrete using river Indus sand as fine aggregate. For this study, compressive strength tests were performed at the ages of 7, 14, 21, 28 days respectively using mix ratios of 1:2:4, 1:1.5:3 and 1:1:2 at 0.5 water cement ratio. Slump test was also conducted for each type of concrete mix. The results showed that the slump of concrete was reduced with the use of river Indus sand as fine aggregate. Furthermore, 20%-30% reduction in strength was observed in concrete samples with river Indus sand as fine aggregates than those of hill sand.**

***Keywords*: Compressive strength, Slump, River Indus sand, Hill sand.**

## I. INTRODUCTION

Concrete is a versatile, durable, sustainable, and economical construction material widely used in construction industry. About four tons of concrete are produced per capita per annum worldwide. [1]. Concrete is the mixture of aggregates (i.e. sand, and either gravel or crushed stone), which is bonded with cementing paste. The paste is normally made up of Portland cement and water. [2]. Aggregates are used as inert filler in a concrete mix. [3]. Aggregate plays a vital role in fresh and hardened properties concrete. [3]. Changes in gradation, maximum size, unit weight, and moisture content change the behavior of concrete mix. [3]. Economy is an important factor while aggregate selection. [4]. The selection of aggregate has directly influence on cost of concrete [5]. The utilization of hill sand made the concrete uneconomical where the construction site in near to sea or river [6]. River sand is obtained by natural weathering of rocks over a period of millions of years. [7]. It is obtained by scouring from the river beds. [7]. The composition of river sand is highly variable, depending on the Local rock sources and conditions, but the most common constituent of sand is silica (silicon dioxide, $SiO_2$), usually in the form of quartz. River sand contains different types of minerals including clayey minerals. [7]. River sand is widely used as fine aggregate in back filling, Building Blocks, under tiles, road paving, plastering, mortar, reinforced Ready mix concrete, filling under foundations, fabricating masonry blocks. [8]. River sand is used in the construction industry mainly for concrete production and cement-sand mortar. [8]. River sand is superior for construction purpose than other because it is easily available and made the construction economical. [9].

The aim of this research is to save the natural resources of hill sand and make the concrete economical by utilizing river Indus sand when the site location is far away from the hill sand resources. In this research the hill sand was fully replaced by the river Indus sand. The workability and compressive strength were investigated and compared to the conventional concrete at 7, 14, 21 and 28days water curing.

## II. LITERATURE REVIEW

Deepak [10] investigated the compressive strength of the concrete in which sea sand was partially utilized as fine aggregate. In this research the M20 grade concrete were designed. The fine aggregate proportion from the design mix was replaced partially in percentages of 20%, 40%, 60%, 80% and 100% by sea sand. The compressive strengths of concrete specimens for respective mix proportions were tested at 7, 14 and 28 days of water curing. The behavior of concrete by partial replacement of fine aggregate with sea sand were showed that the increase in the percentage of sea sand replacement in concrete, the compressive strength of the concrete significantly reduced. A researcher concluded that the compressive strength of concrete by using Washed Obimo sand is 6.5% more than that of the compressive strength of concrete by using river sand. Raval [11] performed the experimental work on concrete by replacing the sand with foundry sand partially with different percentages 10%, 20%, 30%, 40 % and 50 % by weight of fine aggregate at different curing ages (7 days, 14 days and 28 days). The conclusion demonstrated that 30% replacement was optimum where the compressive increases beyond that it decreases. Amrutha [12] examined the slump flow and strength (compressive, tensile and flexural strength) performance of concrete at 10%, 20%, 30%, 40%, and 50% partially replacement of foundry sand to natural sand. The outcomes demonstrated that the slump flow of 30 % replacement of natural sand to foundary sand was adequate and the strength behavior was enhanced than all proportion.

## III. MATERIALS & METHODS

### *A.Materials*

Ordinary Portland cement CEM I 42.5 N that complies with ASTM C150-04, branded name as Falcon cement was used for this research work. Hill sand was taken from Bolari having Fineness modulus of 3.01 and water absorption of 1.2% was used as fine aggregates. Coarse aggregates were taken from Petaro quarry for the study with fineness modulus and water absorption of 3.16and 1.9%, respectively. River sand was taken from the River Indus Sindh for replacement of hill sand having fineness modulus and water absorption of 2.04 and 3.8%. River sand was dark grey in color.

*B.Test Parameters and Mixture Proportions*

There were three concrete mixtures 1:2:4, 1:1.5:3 and 1:1:2 produced for the study. Two types of concrete were made, one is conventional concrete using hill sand as fine aggregates and other concrete using river Indus sand as fine aggregates. Hill sand was 100% replaced by river Indus sand. A total of 48 cylinders were tested for the compressive strength of concrete at the curing ages of 7, 14, 21, 28 days. Mixing was carried out using in a rotary mixer.

Workability of the concrete was checked by standard slump test using standard slump cone and procedure followed according to ASTM C 143. All the cylinders were extracted from molds after 24 hours and cured for the required age of testing.

Compressive strength of the concrete was carried out in universal testing machine available at Civil engineering department, MUET jamshoro followed the overall procedure described in ASTM C39.

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## IV. RESULTS AND DISCUSSIONS

*a.. Fresh Properties*

The results of fresh properties of concrete were tabulated in table:1. The results showed that there is a decrease in workability of River Indus sand concrete because of the improper interlocking of aggregates.

**Table 1: Workability Values of Concrete mixes**

| ***Mixture*** | ***Slump Value (mm)*** |
|---|---|
| Conventional concrete (1:2:4) | 32 |
| River sand concrete (1:2:4) | 25 |
| Conventional concrete (1:1.5:3) | 51 |
| River sand concrete (1:1.5:3) | 43 |
| Conventional concrete (1:1:2) | 64 |
| River sand concrete (1:1:2) | 51 |

*b.. Hardened properties*

The results of hardened properties of concrete were showed in table 2 and figures 1,2, and 3. The comparison showed that there was decline in the compressive strength of river Indus sand concrete.

**Table 2: Compressive Strength of Concrete Mixtures at Different Curing Ages**

| **Mixture** | **Compressive Strength at 7 Days (MPa)** | **Compressive Strength at 14 Days (MPa)** | **Compressive Strength at 21 Days (MPa)** | **Compressive Strength at 28 Days (MPa)** |
|---|---|---|---|---|
| **Conventional Concrete(1:2:4)** | 13.99 | 17.6 | 19.355 | 20.45 |
| **River sand concrete (1:2:4)** | 10.3 | 13.45 | 15.315 | 16.3 |
| **Conventional Concrete(1:1.5:3)** | 15.535 | 18.135 | 21.09 | 23.735 |
| **River sand concrete (1:1.5:3)** | 11.36 | 13.95 | 16.975 | 19.545 |
| **Conventional Concrete(1:1:2)** | 16.25 | 22.0 | 24.79 | 27.315 |
| **River sand concrete (1:1:2)** | 12.075 | 17.85 | 20.61 | 23.3 |

At 7 days the compressive strength decreases by 35.8%, 26.87% and 34.5% for 1:2:4, 1:1.5:3 and 1:1:2 respectively. At 14 days compressive strength decreases by 30.85%, 30% and 23.25% for 1:2:4, 1:1.5:3 and 1:1:2 respectively. At 21 days the compressive strength decreases by 26.23%, 24.24% and 20.28% for 1:2:4, 1:1.5:3 and 1:1:2 respectively. Similarly, at 28 days compressive strength decreases by 25.46%, 21.43% and 17.23 % for 1:2:4, 1:1.5:3 and 1:1:2 respectively. The decrease in the compressive strength is because of the improper interlocking of the aggregate particles.

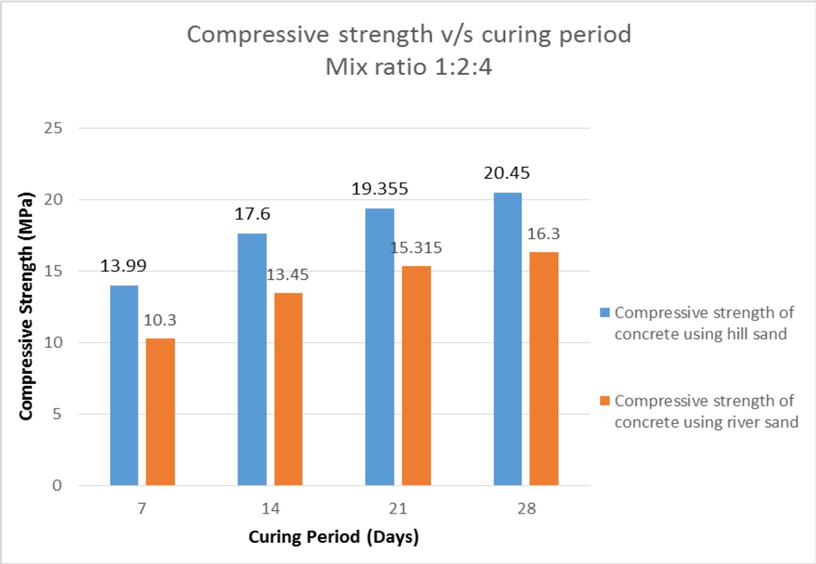


Figure 1: Compressive strength (MPa) comparison of 1:2:4 mix at different curing ages

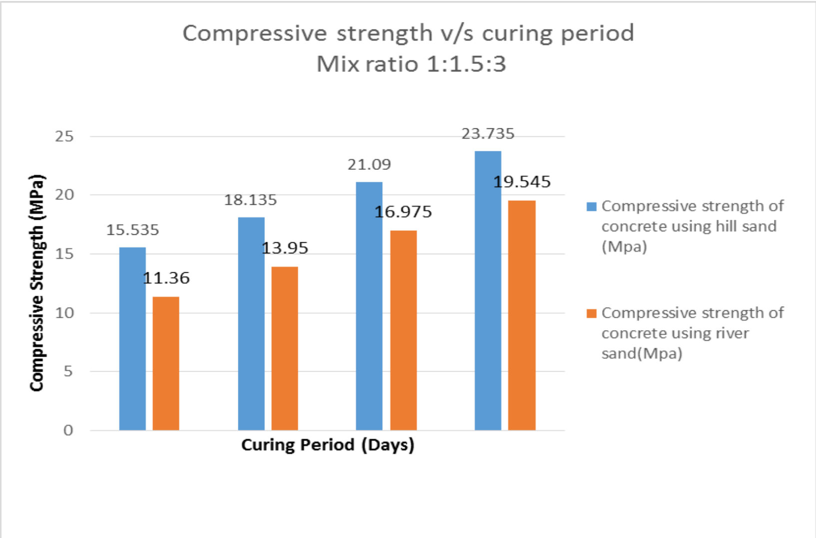


Figure 2: Compressive strength (MPa) comparison of 1:1.5:3 mix at different curing ages

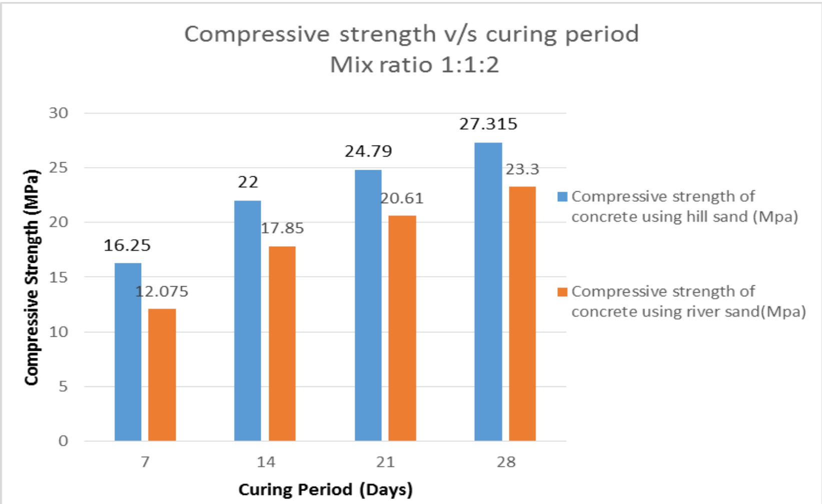

Figure 3: Compressive strength (MPa) comparison of 1:1:2 mix at different curing ages

## V. CONCLUSIONS

From the research it is concluded that the workability of the concrete was decreased 10% to 15% by using river Indus sand as fine aggregates. For that some admixtures are required. The compressive strength also decreased by 15% to 35% compared to the conventional concrete.

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# Evaluation of Mechanical Properties of Dry-Stack Block Masonry

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***Abstract:*** **The expanding interest in earth development as a practical building arrangement prompted the advancement of current earth development systems, specifically of Brick/Blocks masonry made of compacted cement stabilized soil known as Dry-Interlocking Masonry Construction. Dry-Stack masonry because of the absence of mortar joints have few advantages over the conventional masonry, its simplicity of development, easy construction technique, less requirement of skilled labor and higher compressive quality make it different from conventional masonry construction. From the experimental results, it was concluded that compacted Hydraform Dry Interlocking blocks have higher compressive strength along with the higher prism compressive strength compared to the conventional brick masonry. The reason for the higher prism strength was due to the elimination of weak interface element. The unevenness in the dry contracting surfaces results in the initial deformation only at interface and the localized stress concentration at the interface results in the lowering the prism strength. It was also observed that water absorption of Hydraform blocks is very less compared to brick masonry units. Thermal performance has been assessed theoretically by calculating U-value of Dry-Stack masonry for which the thermal conductivity of masonry units (blocks) was measured experimentally.**

***Keywords:*** **Hydraform blocks, Dry-Stack masonry, U-value.**

## I. INTRODUCTION

Masonry is generally known for the lying of standard dimension units on one another to make buildings, wall and other structures. Masonry constructions have had an important role in the history. It is used worldwide because of its economical and easy construction [1]. The important characteristic of masonry construction is its simplicity of laying. Bricks/Blocks laid on one another with or without mortar between there bedding joint [2]. Compared to steel structure or concrete frame structures, masonry structures required less technical labors (Mason). Also, masonry material required less energy to produce, which results in the reduction of overall construction cost [3].

It is a well-known fact that earthquakes not only cause damages to buildings, infrastructure and human loss but also results in economic and social losses. In October 08, 2005 earthquake, around 455,000 houses were affected [4]. The affected houses were either fully collapsed or partially damaged. These damages in buildings/infrastructures was due to inappropriate construction techniques and a lack of proper design. Buildings which was designed properly and detailed on the basis of modern seismic building codes were less affected because these buildings dissipate energy through inelastic behavior [4]. To minimize these damages, there must be proper construction standards and practices available, so that the design of the structure will be appropriate and having resistance to the applied earthquake forces.

Considering the growing rate of world population, the demand for the accurate design and low-cost structures is of interest. Technically and economically, it seems very unlikely that the demand will be only met with industrialized building materials such as steel and concrete. For this reason, there are simply neither sufficient production capabilities nor resources [5]. The demand in regard to masonry structure is also of interest for the construction industry. Because the construction industry needs to speed up the masonry construction process, as the old method of construction is slower and labour intensive, due to the presence of a large number of mortar joints [6]. The large number of mortar joints increases the overall time and subsequently increases the cost of the structure. In order to reduce the time and cost of the construction process, the number of mortar joints either be minimized or by increasing the masonry unit size (using block masonry instead of brick masonry), after this, the idea was introduced that by eliminating the mortar in the bedding joints in the block masonry will cause reduction of mortar. This mortar-less block masonry construction is called as Dry-Stack block masonry.

Dry-Stack block masonry structure refers to the technique of building construction in which majority of the units are held together without mortar joints. In Dry-Stack block masonry, mortar is eliminated fully or can be used by some percentage or used only for top and bottom courses. The behavior and properties of these blocks must be satisfied with international standards. The mechanism of masonry units is that they are held in place by gravity using lock-and-key type. The shape of mould or the units usually provides the predefined alignment when laid in a specified fashion. Dry-Interlocking blocks mainly relies on the mechanical interlocking features of the units, which helps in providing alignment and stability during construction. The skilled labour is also reduced by Dry-stacking mechanism. Moreover, the load of the roof can directly be applied on the walls which ultimately results in reducing the construction time. The reduction in the mortar and overall construction time results in the saving of building costs up to 27% compared to conventional masonry [6]. The mechanical behaviour i.e. compressive strength, prism strength, modulus of elasticity, behavior of blocks in panel were investigated by [1], [6], [7], [8], [9], [10]. The behaviour of blocks as a single unit and the units in masonry panels is different from each other because of the reason that ratio, geometry and the interlocking mechanism were different from each other. Due to the lack in knowledge about the mechanical behaviour of specially design Hydraform blocks, University of Engineering and Technology Peshawar with the financial support of Eco-Enterprises, Islamabad is currently investigating the mechanical behavior of a Hydraform Dry-Stack Block Masonry manufactured by Eco-Enterprises. This paper presents the mechanical behaviour of Hydraform Dry-Stacking blocks. The dimension of the Hydraform block was 8.7"*9.5"*4.5". The typical shape of Hydraform block is shown in Figure 1

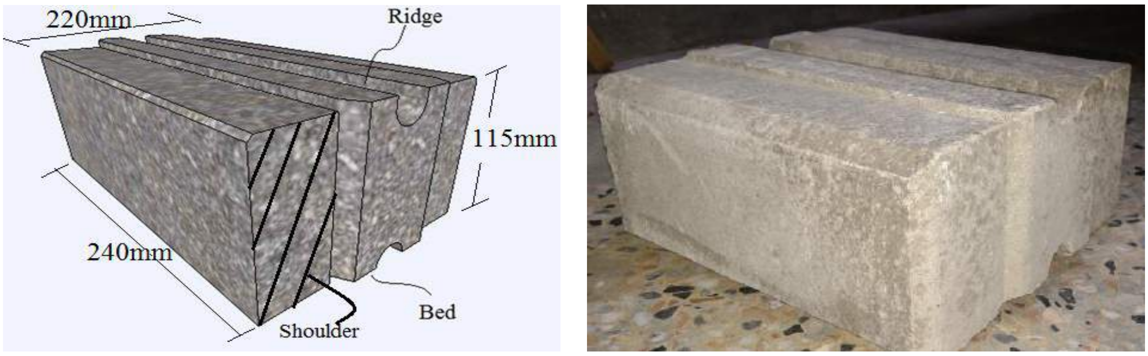


Figure 8 Schematic diagram of Hydraform block (left) Typical Hydraform Dry-Interlocking Masonry Unit (right)

## II. Mechanical Behaviour

The mechanical behaviour includes the compressive strength, prism strength, water absorption and thermal conductance of Hydraform Dry-Interlocking blocks. As it is discussed earlier that the geometry of the interlocking masonry units is very different from the conventional masonry units, therefore the behaviour as a single unit and the behaviour as combine unit need to be investigated.

### A. *Compressive Strength*

Compressive strength of material or any type of assembly referred to as the breaking/cracking under compression load. As masonry is brittle material, therefore its breaking point or failure will be considered when first crack appears after the application of load applied perpendicular to the surface. Compressive strength of masonry is very important because it determines that how much resistance it will provide to the load of the structure. Therefore, it is also called as the key value for the design of any structure. Compressive strength of an assembly, taking an example of wall/panel will be different from the compressive strength of single unit. Because an assembly is not made from homogeneous material, but it is made from the combination of different material (masonry unit, mortar etc.) while in case of single unit it is made from homogenous material. In case of Dry-Stack masonry compressive strength of single unit and assembly unit will not be same. Although of assembly is not heterogeneous material it is only made from the same material, but the difference is contact surface because two layer of masonry units. Lower surface of upper course is not fully attached with the upper part of the lower course, therefore there is localized stress concentration due to which the stress taken by assembly will be less than stress taken by single unit.

### B. *Water Absorption*

Water absorption of any material mainly refers to as the capacity of material to absorb water. It is the ratio of total weight of water absorbed divided by the dry weight of the specimen/material. Water absorption test indicates that how much porous the material is. If the water absorption is more its mean that the porosity of material/specimen is more and vice versa.

### C. *Thermal Conductivity*

Thermal conductivity refers to the conductance of heat energy from one side of material to another with the principle of temperature difference i.e. from hot side to the cold side. It mainly depends on the material properties. For the case of blocks, it mainly depends on the material used, porosity of material, compaction of material etc. As compressive strength of a single unit and the assembly is different from each other, there is also the difference in the conductance of heat from a single block and from the whole assembly. The coefficient of thermal conductance of single unit is denoted by K, while the assembly thermal conductance is denoted by U-value. In case of Dry-Stack block masonry, a phenomenon of thermal bridging creates in which air is replaced by mortar. Thermal bridging, in general, highly effects the thermal performance of masonry building. This replacement of materials by air play a major role in affecting thermal performance of dry masonry. The bridge at the dry interface causes the flow of air which greatly effects the temperature at the other side.

## III. Experimental Investigation

### A. *Compression Test*

Compression Strength of single unit was tested in Universal Testing Machine (UTM) in accordance with the block specification provided by ASTM C90-16a and testing in accordance with ASTM C140/C140M–17. For uniform load on the surface, the Hydraform block was first capped with the capping material i.e. gypsum according to ASTM C1552–16. After the capping, the specimen was tested in UTM. The failure of the block after the application of compressive load is shown in Figure 2 (right) and the capped block is shown in Figure 2 (left).



Figure 9 Hydraform Block Capped with Gypsum (left), Hydraform Block after Uni-axial Compression Failure (right)

As shown in Figure 2 (right) the diagonal crack appears after the application of uni-axial compression load. Total three specimens of single masonry units were tested. The following values of ultimate compression stress were calculated as shown in Table 1

Table 2 Uni-axil Compression Load on Single Masonry Unit

| S.No | Max Compressive Stress (Psi) |
|---|---|
| 1 | 2010 |
| 2 | 1860 |
| 3 | 1960 |

From the experimental results, the max compressive stress was found out by dividing the max compressive load in kilo pound (kips) on total resisting surface area to obtain results in pound/inch$^2$ (psi). It is therefore concluded that the average compressive strength of the single Hydraform masonry unit is 1940 psi. The results also reflect that max compressive stress taken by Hydraform block is almost equal a good quality brick.

B. *Prism Test*

The test was performed on prism made from three blocks. Prism test is also performed in Universal Testing Machine (UTM) According to ASTM C1314–16, Minimum criteria for the units in the prism was adopted i.e. three masonry units. The dimension of the prism was 9.5"*8.7"*13.5". Dial gauge on front face (male face) of the top block was attached and the gauge length was measured as 9.6". The interlocking blocks along with the dial gauge attached on the top block is shown in Figure 3. The purpose of the dial gauge was to measure the axial deformation in three blocks at each increment of loading and calculation of elastic modulus of blocks under uni-axial compression. Two steel plates having dimension greater than shoulder of the block and thickness 0.5", were placed on the-top of the shoulder of the blocks in order to replicate the same load transfer mechanism as actually in wall/panel. The behaviour of strain against the applied stress, ultimate stress and elastic modulus were investigated by keeping the same geometry all the blocks, same condition of loading with the same location of dial gauge. Total three specimens were tested. The dial gauge and UTM were connected with the advanced data acquisition system (structural load analysis and solenoid automation system). The test specimen in UTM before the application of load is shown in Figure 3.


Figure 10 Deformation Dial Gauge and UTM connected with Data Acquisition System (left), Magnified picture of prism (right)

Stress strain relationship is developed from the experimental results as shown in Figure 4.

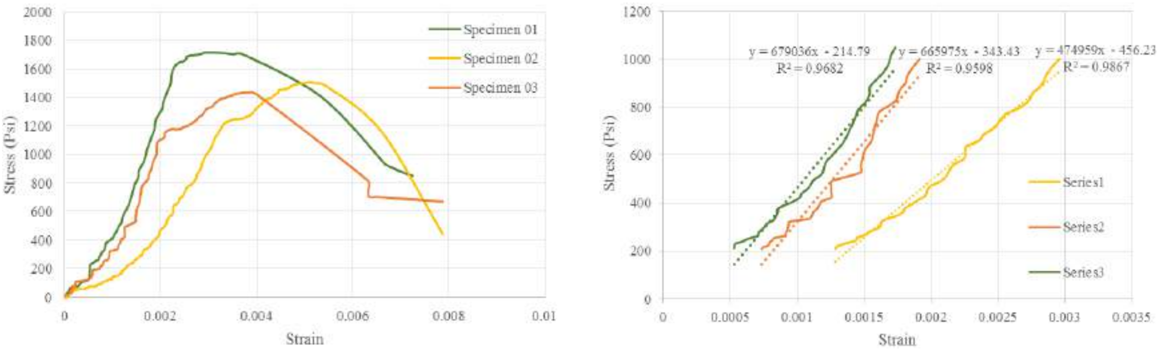


Figure 11 Stress Strain curve of masonry prism (left), Linear straight portion of stress strain curve (right)

As shown in Figure 4 (left) it was observed that initially, the graph is upward concave which shows the greater deformation at the initial stage. This behaviour was concluded as the seating of blocks because of the unevenness and rough surface between the dry interfaces. Conventional method of calculating elastic modulus was not applicable to the prism used in this research work i.e. ratio of stress over strain is in between 5% and 33% of the peak stress. The modulus of elasticity was calculated as the straight portion of the stress-strain curve after removing the seating of the blocks. The separate linear portion of stress-strain curve in shown in Figure 4 (right). The masonry prism results (peak stress and elastic modulus) was calculated and the results are shown in Table 2.

Table 3 Summary of Max Prism Stress values and Modulus of Elasticity

| S.No | Net Area Stress (Psi) | Modulus of Elasticity (Psi) |
|---|---|---|
| TS 01 | 1720 | 679,040 |
| TS 02 | 1510 | 474,960 |
| TS 03 | 1440 | 665,980 |

The average compressive stress of the masonry prism was calculated as the total load divided by the Net area i.e. resisting area or the shoulders of the blocks. Load transfer in case of dry interlocking will only transfer through the shoulders of the block and will not transfer through the bed and ridge portion of the block. The reason behind this is that there is 3mm distance between the ridge of one block and the bed of another block as shown in Figure 5.

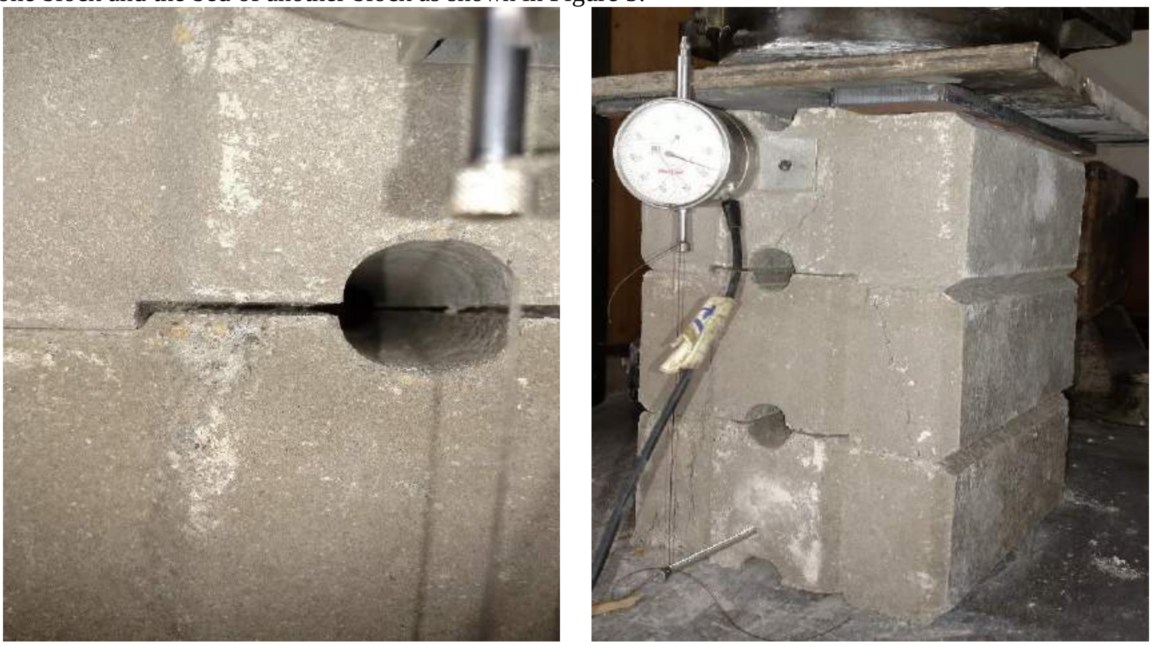

Figure 12 Magnified picture of Ridge of one block and the Bed of another block (left), Typical failure of masonry prisms after the ultimate load (right)

Figure 8 shows the failure of specimen after the application of loading. It was observed that the failure of the all the prisms were due to the formation of vertical splitting cracks along their height. The stress concentration at the cracked location is high due to the elevated portion of the ridge. The location of the cracks was observed same in all the specimen. The stress transfer will only be effective in mortared masonry.

C. *Water Absorption Test*

Water absorption test was conducted in accordance with ASTMC140/C140M–17. The specimen was placed in oven for the period of 24 hours. After 24 hours, when the surface was fully dry, the Hydraform block was free from water content, the block was weighted. After that, the block was then immersed in water tank for a period of 24 hours. Figure 6 (left) shows the Hydraform block in electric oven and Figure 6 (right) shows the weighing of the specimen after fully saturated in water.

Figure 13 Hydraform blocks in Electric Oven (left), Hydraform block on Electric Balance after fully saturated in water (right)

Water absorption of the specimen was calculated from the difference in saturated weight and dry weight divided by dry weight of the block. The results are shown in Table 3.

Table 4Summary of results of water absorption before and after immersed in water

| S.No | Dry Weight of Single Block (kg) | Saturated Weight of Blocks (kg) | Difference in weight (kg) | Water absorption (%) |
|---|---|---|---|---|
| 1 | 11.67 | 12.66 | 0.99 | 8.48 |
| 2 | 11.88 | 12.79 | 0.91 | 7.65 |
| 3 | 12.03 | 12.98 | 0.95 | 7.89 |

Above table shows that the average water absorption of the Hydraform blocks is 8.01%. It was already discussed that water absorption mainly depend on the pores in specimen. The results also reflect that the Hydraform blocks used in the research work was well compacted and having less/acceptable range of water absorption.

D. *Thermal Conductivity Test*

Thermal conductivity test was performed on Helton Heat conduction apparatus. The thermal conductivity apparatus consists of Linear Module and Electrical console. Electrical console was used for the recording of the temperature on different sensors with the capability of variation in temperature. The test specimens were taken with the help of core cutter from the different blocks having dimension 25mm*30mm and then placed in Linear Module for period of minimum 30 minutes to make the heat flow constant. The temperature on the different sensor was recorded and the thermal heat coefficient was calculated for a single block. Thermal conductivity apparatus is shown in Figure 7.

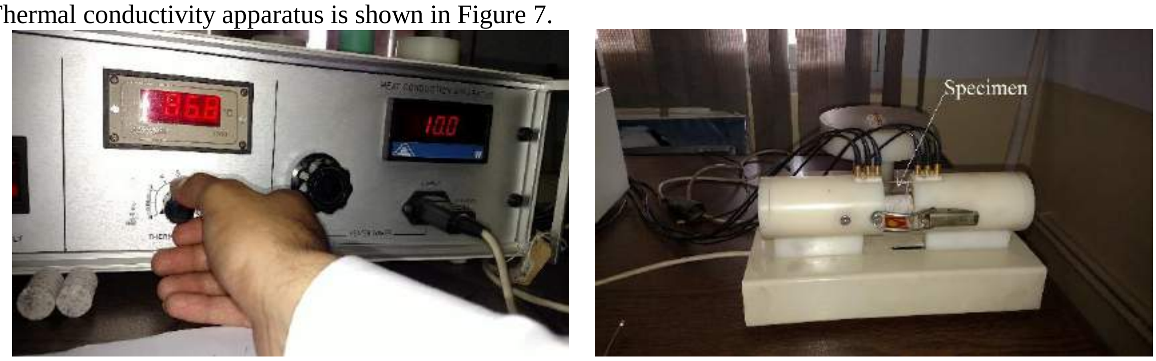

Figure 14 Electrical console of Helton Heat Conduction Apparatus (left), Linear Module Helton Heat Conduction Apparatus (right)

The results of thermal conductivity of the specimen were calculated at the constant power of 10W from the graph of temperature vs sensor location using Fourier's law. After the graph, the thermal conductance of the specimen was found out. The results of thermal conductivity of single masonry unit (Hydraform block) are shown in Table 4.

Table 5 values of thermal conductivity of single Hydraform block

| S. No. | Thermal conductance (K) |
|---|---|
| 1 | 0.96 W/m/k |
| 2 | 0.96 W/m/k |
| 3 | 0.95 W/m/k |

The values which were obtained from the thermal conductivity of single block were then used for the theoretical calculation of thermal conductance of assembly which is also known as U-value. U-value mainly refers to as the measure of the rate of heat flow through the assembly or a surface made from composite material. From the experimental results of thermal conductivity of single block, U-values for-the wall/panel was calculated and the results are shown in Table 5.

Table 6 Theoretical U-values of wall/panel made from Hydraform blocks

| S. No | U-Value ($W/m^2.k$) |
|---|---|
| 1 | 2.26 |
| 2 | 2.26 |
| 3 | 2.25 |

The average U-value of the wall made from the Hydraform blocks was calculated as 2.256 W/$m^2$.k. The U-values calculated will only be valid before any seismic activity or any type of shaking of the building caused by blast or any other source.

## IV. CONCLUSIONS

Average Uni-Axial compressive stress of Hydraform single full block loading is 1940 psi which confirms the minimum requirement of building code of Pakistan-SP-2007 (compressive strength of masonry units shall not be less 11.75 MPa (1700 psi) for solid/hollow concrete blocks).

Prism strength of the blocks is 1560 psi which is also quite greater than actual stress of two-story building on pier made from Hydraform blocks (25 psi stress on gross cross-sectional area)

Water absorption of blocks was found to be 8.55%, which is less than the maximum allowable range as per ASTM C90-11b.

U-values of the wall made from Hydraform block (2.256 W/$m^2$.k) correlates to 9" brick masonry wall (2.2 to 2.7 W/$m^2$.k).

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# Semi-permanent Structures (Sandwich Panels)

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***Abstract:*** **Polyurethanes are some of the utmost versatile plastic materials. Polyurethane insulated panel is made from firm core squash in amongst two metal sheets. The firm core is manufactured from polyurethane, which is also known for its outstanding heat insulation possessions. The standard building material Polyurethane sandwich panels are recognized for cold rooms and controlled atmosphere application throughout the globe. The top insulation characteristics of panels can be used to lower the temperature applications in cold rooms. The Polyurethane sandwich panels can stand temperatures from -45° Celsius to +80° Celsius. These panels are factory-made in a continuous progression of linking the insulating core with external lining, most often metal plates. The universal feasting of polyurethane for the use of insulation is nearly 665 million kilograms annually. The final product is a sandwich panel consisting of numerous layers. Metallic lining secures against weather environments, such as rain or snow. The firm core, made of Polyurethane foam, which guarantees thermal and auditory insulation. When linked with the lining, it becomes a fence protecting against fire, snow load, wind, temperature and other factors. Polyurethane is a very good composite prefabricated building material, it helps in saving the energy, it increases protection, add to everyday comfort – and thus subsidize meaningfully to the quality of up-to-date life.**

***Keywords*: Semi-permanent, Polyurethane, Sandwich panels.**

## I. INTRODUCTION

Polyurethane is an excellent compound prefabricated building material, it helps in saving the energy, upsurge safety, add to regular luxury – and thus subsidize significantly to the quality of modern life. It is one of the most versatile plastic materials. These insulated panels are manufactured from the firm core, which is sandwiched between two metal sheets. The firm core, which is polyurethane is known for its outstanding heat insulation characteristics. The polyurethane material is often considered as the most extensively used lining substantial for cold-rooms and energy efficient buildings. It is likewise well known for its insulation properties. The universal consumption of polyurethane for the use of insulation is nearly 662 Million Kilograms annually. The standard material for cold rooms is Polyurethane Sandwich Panels, which is also used for the applications of throughout the globe. The excellent insulation characteristics of panels can be used to lower the temperature applications in cold rooms. Polyurethane sandwich panels can resist temperatures from -45 degree Celsius to + 80 degree Celsius. These panels can endure various air densities and moisture.

## II. CONSTRUCTION

The Polyurethane sandwich Panels are constructed in different sizes in comparison with the required land and area. The panels are then assembled on applicable place. These panels have very fast and simple assembling process. The process of dissembling and relocation or extension is very easy of these panels. These Panels are made up of two metal sheets which are formed to rise the strength to resist the loads. Using the high-pressure injection machine, the sheets of steel are placed in molds and injected with liquid polyurethane. Heat is preserved in the molds of panels to form a stiff sandwich panels, these have high strength and outstanding insulation properties. The material is galvanized steel for the sheet metal that is pre-tinted and consists a layer of polythene on upper surface. This provides the panel great insulation and is rust impervious entirely. These panels are constructed in a continuous long procedure of joining the insulating core with external facing, most often metal plates. The final product is a sandwich panel consisting of numerous layers. Metallic lining protects it, against weather conditions, such as rain or snow. The core is made up of polyurethane foam, which guarantees thermal and audio insulation. When combined with the lining, it becomes a barrier, which may protect against fire, snow load, wind, temperature and other factors.

## III. SCOPE OF POLYURETHANE SANDWICH PANELS

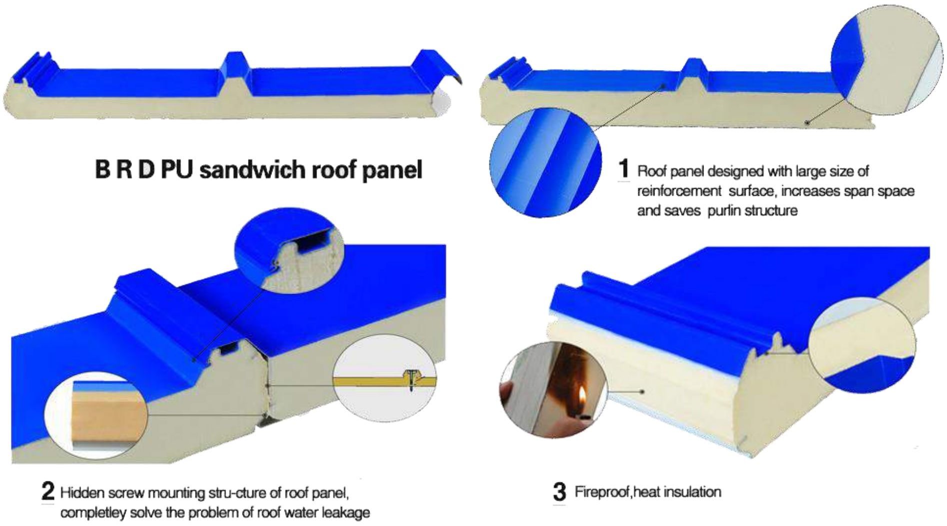
The usage and scope of sandwich panels is very extensive: in storage halls, production halls, small and large commercial facilities, public utility buildings such as gymnasiums and swimming pools, farm buildings like cow houses, poultry houses, mushroom-growing cellars. They are suitable for food storages, cold stores and freezers. Sandwich panels may also be utilized in food processing plants. The locations where hygienic conditions are required, with no effect on food in contact with panels and resistance to chemicals used in food processing and cleaning. Polyurethane sandwich panels may be used as walls of buildings, both external and internal, roofs and suspended ceilings in halls with additional protection. With proper coating, they can be very sturdy in areas with salty conditions (such as seaside regions) or high levels of industrial pollution.

## IV. USAGE OF SANDWICH PANELS

Sandwich panels are used for constructing the walls and roofs of the houses, and also for making enclosures of industrial apparatus, cold rooms, sports halls, warehouses and power plants. The panels are also appropriate for food industry construction. Walls of large industries and refrigerated buildings, cold storages, exhibition, warehouses and halls of sports, educational institutions and other large buildings can be best erected from the components which provide thermal insulation, while also meet other technical requirements such as firmness, low-cost assembling, maintenance free and easy disassembling and rebuilding.

## V.SPECIFICATIONS

The sandwich panel specification B, S2, D0 and upper metal thickness 0.50mm / under metal thickness 0.40mm / density of 40/43 kg/m³ on the list below,




| S. No. | Roof Panel | Wall Panel | Cold Storage |
|---|---|---|---|
| 1 | 5 Ribs Roof Panel 40mm | 40mm | 40mm |
| 2. | 5 Ribs Roof Panel 50mm | 50mm | 50mm |
| 3. | 5 Ribs Roof Panel 60mm | 60mm | 60mm |
| 4. | 5 Ribs Roof Panel 80mm | 80mm | 80mm |
| 5. | 3 Ribs Roof Panel 40mm | 100mm | 100mm |
| 6. | 3 Ribs Roof Panel 50mm | 120mm | 120mm |
| 7. | 3 Ribs Roof Panel 60mm | 150mm | 150mm |
| 8. | 3 Ribs Roof Panel 80mm | | |

## VI. ADVANTAGES

- These panels are Light weight
- Thin walls are made from these polyurethane panels.
- These panels provide great Resistance to the corrosion.
- These panels have exceptional capacity to bear the heavy loads.
- Freedom from the maintenance, no chance of the bacteria, easy to clean surfaces.
- These panels have simple and fast jointing methods.
- The components of these Polyurethane panels can be demolished and recycled.
- These panels are economical and have reliable quality.
- These panels are creative and supple.
- These panels have outstanding hygienic conditions.
- Polyurethane panels satisfy the all hazard analysis and critical control points and global standards for the processing of food and storage.
- These are perfect option to store the meat, vegetables, vaccines and medicines.
- These panels have clean and smooth finish of the surfaces, which provides resistance from the bacterial existence.
- The panels are totally resistant to water and air, which averts any of the air escapes completely.
- Physically these panels give a clean and neat appearance and variates its premium choice for cold-room construction.
- The panels can withstand the extreme weather circumstances, plus in height breezes, hefty snow, extreme rain, heavy snow and life-threatening to the temperature variations.

- The properties of Insulation prevent the heat out of the closure in warm climate, and keeps the structure serener than outside temperature.
- The clean surface finishes provide it a lower friction rating which allows the water or snow to slide off without any trouble.
- This material is flexible to very elastic to engross stresses in the long term.
- The panels are Noise resistant, as well as fire resistant.
- These panels have quick and simply relaxed installation, these have low costs of construction, operating costs in comparison with other structures.

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# Groundwater Modeling of Coastal Aquifers near Karachi Pakistan

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***Abstract*: The coastal aquifers of Karachi are predominantly recharged due to seawater intrusion, resulting in groundwater contamination. The objective of the study is modelling groundwater solute transport and flow of coastal aquifers for 12 km of Karachi coastline using Visual MODFLOW. The 10 groundwater samples were collected and tested in commercial laboratory for TDS. The maximum and minimum TDS values from the observed data for the study area were 96180 mg/L and 2020 mg/L respectively. The maximum and minimum observed heads were 7.7 m and 2.4 m below the ground surface, respectively. The sensitivity analysis for different parameters was performed before calibration and validation of the model. The correlation coefficients (R) for calibration and validation of the groundwater flow model were 0.60 and 0.55, respectively. The calibration and validation of solute transport model resulted in R as 0.33 and 0.97, respectively. Overall, model proves to be very accurate to be utilized for coastal areas of Karachi.**

***Keywords*: Coastal aquifers, groundwater quality, MODFLOW, Water resources management.**

## I. INTRODUCTION

In many parts of the world, groundwater is used as primary source of water. The mega city Karachi, which lies near the coast of Arabian Sea is also facing water scarcity issue. In coastal regions, the reasons for groundwater depletion are increase in urbanization, industrialization, agriculture and lack of precipitation [1]. The areas near the coastal belt of the city such as Defense Housing Authority (DHA) are very much affected by water scarcity issues due to improper water supply system. Consequently, residents have to pay huge amount of money to private water suppliers in order to fulfill their daily consumption. As an alternative, well pumps are installed to utilize groundwater which is easily accessible at shallow depth. Thus, there was a need to study groundwater quality and accessibility conditions in the region.

The similar study was the assessment of quality for the groundwater in the coastal aquifer of Wadi Ham of northeastern UAE. The results showed that the intrusion from sea has become the main factor of the saline water in the aquifer recently [2]. Also, it was established that temporal and spatial characteristics of groundwater and groundwater quality in different aquifers help to solve the groundwater management issues [3], [4]. Ghoraba and Zyedan studied the aquifer quality management of Middle Delta, Egypt using MODFLOW by carrying simulations for 5, 10 ,15 and 20 years [5]. Hence, to generate and study the mathematical model of a region is one of the effective ways to understand the spatiotemporal groundwater conditions.

The main objective of the study is to investigate the groundwater quality near coastal region of Karachi by conducting laboratory tests and generate a model using Visual MODFLOW. The specific objectives are: (1) Investigate accessibility to groundwater table depth for the study area. (2) Investigate groundwater quality of the study area in terms of usage and processes. (3) To relate quality of water due to seawater intrusion.

### *A. Study Area and Hydrogeology*

Karachi is the capital of Sindh province of Pakistan, located on the coast of Arabian Sea at 24.8600° N latitude and 67.0100° E longitude with the elevation of 8 meters from the Mean Sea Level (MSL). The study area comprised of the coastal belt of Karachi running from the industrial area of Korangi to the residential and commercial area of Clifton Beach, measuring the length of 12 km approximately. This area is not used for agricultural purposes. The recharge source for groundwater is only the seawater since this is an arid coastal region and much of it is carpeted. Fig.1 represents study area utilized for generating model, along with the position of 10 wells scattered randomly around the area and are marked with numbers from 1 to 10.
The model domain was 100m deep from the MSL and covered the area as shown in Fig.1. The 100m depth constituted three different types of soil obtained from borehole data of Well No 7. The three types of soils encountered were silty sand, silty clay and clayey silt at different depths and of different heights.


Fig.1. Study Area comprising of residential, commercial and industrial zones.

## II. MATERIALS & METHODS

The study was carried out in two phases. The first phase involved field data collection and testing which were utilized as input for the succeeding phase of model creation. The second phase was the formation of groundwater and solute transport model using MODFLOW. The Fig. 2 represents step by step approach for methods employed during the study. The sources of data collection were field observations, laboratory testing of water samples and available literature. The sensitivity analysis was performed to identify sensitive parameters which were later used for model calibration.

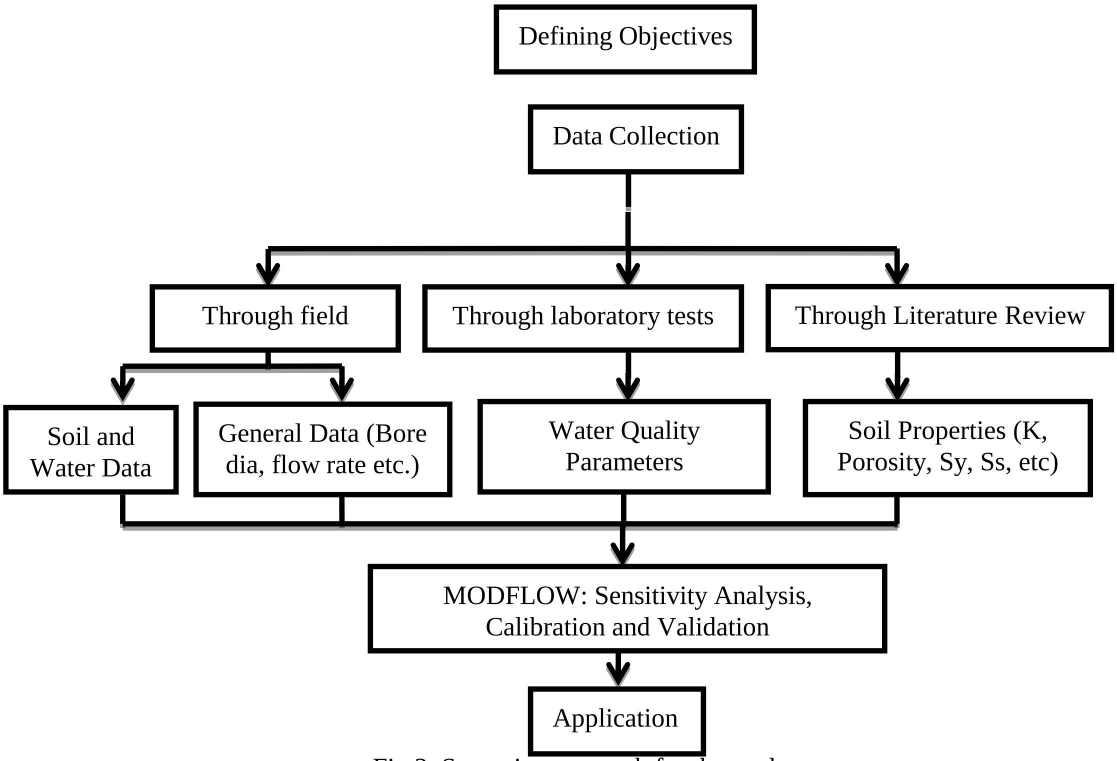


Fig 2. Step wise approach for the study.

### A. Data Collection and Testing

The required data were collected from three different sources. The data collected at field comprised of pumping rates, water table depth in meters, borehole data and water samples. Water samples were collected from hand-pumps, dug wells and boreholes. The pumping wells were installed at depths ranging from 45 m to 105m. The water samples collected in leak-tight or lined cap transparent plastic bottles were stored at temperature less than 4 ºC. The collected water samples were tested in commercial laboratory to examine concentration of Total Dissolved Solids (TDS). The concentration of TDS in mg/L was utilized for simulating solute transport model. The values pertaining to characteristics of encountered soil types such as hydraulic conductivities ($K_x$ and $K_y$), porosity, effective porosity, specific yield and bulk density were obtained from the available literature [6]-[10]. Precipitation taken as mean annual rainfall was obtained from Pakistan Meteorological Department. Evapotranspiration (ET) was reported to be 60% of the groundwater discharge in arid area of Ordos Plateau in northern China [11]. ET for arid coastal areas accounts for 35% of the precipitation [12]. For Karachi which is an arid coastal region, ET is taken as 35% of the precipitation in this study. The Digital Elevation Model (DEM) required for input in MODFLOW and coordinates of 10 observation wells were obtained using Global Mapper. Table I shows Northing and Easting of the observation well, respective water table depths from the ground surface in meters and concentration of TDS in mg/L.

Table I: Location, water table depths and TDS concentration of observation wells

| Observation Well No. | Northing | Easting | Groundwater Head (m) | TDS Concentration (mg/L) |
|---|---|---|---|---|
| 1 | 24º48′38″ | 67º3′44″ | 3.50 | 2020 |
| 2 | 24º48′29″ | 67º2′55″ | 2.70 | 55240 |
| 3 | 28º52′21″ | 67º3′16″ | 5.30 | 27316 |
| 4 | 24º50′19″ | 67º6′34″ | 7.70 | 11670 |
| 5 | 24º48′22″ | 67º3′55″ | 3.08 | 17716 |
| 6 | 24º47′13″ | 67º3′43″ | 4.00 | 96810 |
| 7 | 24º47′18″ | 67º4′10″ | 3.40 | 5630 |
| 8 | 24º38′21″ | 67º3′58″ | 2.40 | 32029 |
| 9 | 24º46′44″ | 67º3′31″ | 3.08 | 8464 |
| 10 | 24º48′34″ | 67º3′50″ | 3.08 | 6234 |

### B. Boundary Conditions

Boundary conditions are the existing conditions of the model domain at its four sides. These are considered due to the fact that area under study has been cut from its original position for modeling purpose. There are two types of boundary conditions in MODFLOW, one for groundwater flow model and other for solute transport model. Boundary conditions utilized for the given study area are Constant Head, General Head, Recharge, Evapotranspiration, Constant Concentration and Point Source boundary conditions.

### C. Groundwater Flow and Solute Transport Model

The Visual MODFLOW was utilized for simulating groundwater flow and solute transport model [13]. Groundwater flow model estimates water table head below the ground surface and solute transport model simulates concentration of contaminants [14], [15]. The process involved sensitivity analysis of parameters which could be adjusted by varying values from -75% to +100% of the actual value. The sensitive parameters were varied for calibration of the model. The calibration of the model was based on 5 set of observation wells. The calibrated model was utilized to validate it by using another set of 5 wells. Table II, III and IV show the sensitive parameters along with the ranges within which they were varied and a specific value which has been used for model calibration for three different types of soil encountered that are Silty Sand, Silty Clay and Clayey Silt respectively.

Table II: Sensitive parameters for soil type – Silty Sand

| S.No. | Parameters | Variable ranges | Value Used for Calibration |
|---|---|---|---|
| 1 | Horizontal Hydraulic Conductivity | 2.5E-6 to 2E-5 m/s | 1E-5 m/s |
| 2 | Longitudinal Hydraulic Conductivity | 2.5E-6 to 2E-5 m/s | 1E-5 m/s |
| 3 | Vertical Hydraulic Conductivity | 2.5E-7 to 2E-6 m/s | 1E-6 m/s |
| 4 | Specific Yield | 0.02 to 0.16 5 % | 0.08 % |
| 5 | Specific Storage | 5.75E-5 to 4.6E-4 1/m | 2.3E-4 1/m |
| 6 | Total Porosity | 0.0875 to 0.7 % | 0.35 % |
| 7 | Effective Porosity | 0.05 to 0.4 % | 0.2 % |
| 8 | Bulk Density | 320 to 2560 Kg/m$^3$ | 1280 Kg/m$^3$ |

Table III: Sensitive parameters for soil type – Silty Clay

| S.No. | Parameters | Variable ranges | Value Used for Calibration |
|---|---|---|---|
| 1 | Horizontal Hydraulic Conductivity | 1.25E-5 to 1E-4 m/s | 5E-5 m/s |
| 2 | Longitudinal Hydraulic Conductivity | 1.25E-5 to 1E-4 m/s | 5E-5 m/s |
| 3 | Vertical Hydraulic Conductivity | 1.25E-6 to 1E-5 m/s | 5E-6 m/s |
| 4 | Specific Yield | 0.0575 to 0.46 % | 0.23 % |
| 5 | Specific Storage | 2.46E-5 to 1.968E-4 1/m | 9.84E-5 1/m |
| 6 | Total Porosity | 0.1 to 0.8 % | 0.4 % |
| 7 | Effective Porosity | 0.0825 to 0.66 % | 0.33 % |
| 8 | Bulk Density | 372.5 to 2980 Kg/m3 | 1490 Kg/m3 |

Table IV: Sensitive parameters for soil type – Clayey Silt

| S.No. | Parameters | Variable ranges | Value Used for Calibration |
|---|---|---|---|
| 1 | Horizontal Hydraulic Conductivity | 2.5E-6 to 2E-5 m/s | 1E-5 m/s |
| 2 | Longitudinal Hydraulic Conductivity | 2.5E-6 to 2E-5 m/s | 1E-5 m/s |
| 3 | Vertical Hydraulic Conductivity | 2.5E-7 to 2E-6 m/s | 1E-6 m/s |
| 4 | Specific Yield | 0.02 to 0.16 5 % | 0.08 % |
| 5 | Specific Storage | 5.75E-5 to 4.6E-4 1/m | 2.3E-4 1/m |
| 6 | Total Porosity | 0.0875 to 0.7 % | 0.35 % |
| 7 | Effective Porosity | 0.05 to 0.4 % | 0.2 % |
| 8 | Bulk Density | 320 to 2560 Kg/m3 | 1280 Kg/m3 |

## III. RESULTS

### A. *Variation of TDS Concentration with Distance from Coastline*

The graph is plotted between concentrations of TDS in mg/L against the increasing distance from the coastline to understand the behavior of contamination as shown in Fig. 3. It is observed that the maximum TDS concentration is 96180 mg/L at the distance of 1.27 km from the coastline. The minimum TDS concentration is 2020 mg/L at the distance of 1.98 km from the coastline. It is identified that as the distance from the coastline increases, the concentrations of contaminants also increase. However, the least value of concentration obtained at the distance of 1.98 km and the surrounding area is anomalous. This is due to the fact that source of freshwater recharge is available in this area, the Moin Khan Cricket Academy water the grass everyday in the morning, resulting in decreased salinity. Thus, the water in coastal aquifers is found to be saline due to seawater intrusion and inadequate for daily consumption. It is recommended by Pakistan Environmental Protection Agency in National Standards for Drinking Water Quality (NSDWQ) that TDS concentration should be less than 1000 mg/L for drinking water [16].

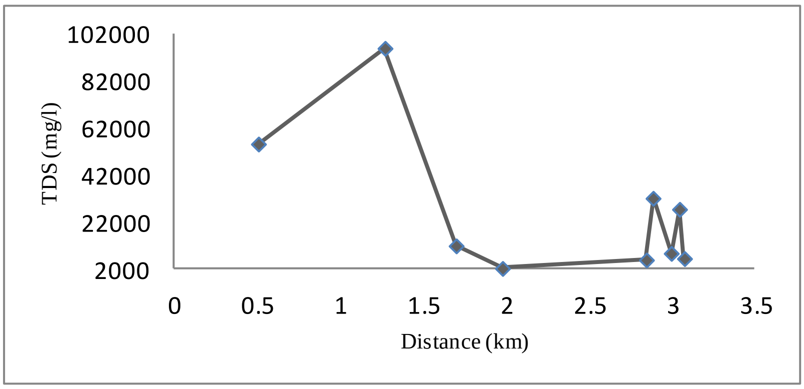


Fig. 3. Variation of TDS Concentration with distance from coastline

### B. *Sensitivity Analysis*

The change in output when one of the input parameters is changed by some percentage of its observed value, keeping other input parameters constant is called Sensitivity Analysis. This process helps determine which of the input parameter is so responsive to the change such that it influences the model results. When such input parameters are known, model can be calibrated by changing them. For Visual MODFLOW model, sensitivity analysis for groundwater flow model was performed in transient flow state. It was found that 5 parameters which include recharge, ET, specific yield, specific storage and hydraulic conductivity ($K_x$,

$K_y$and $K_z$) were sensitive. Both the $K_x$ and $K_y$ were observed to be the most sensitive parameters among all. However effective and total porosity did not show any sensitivity.

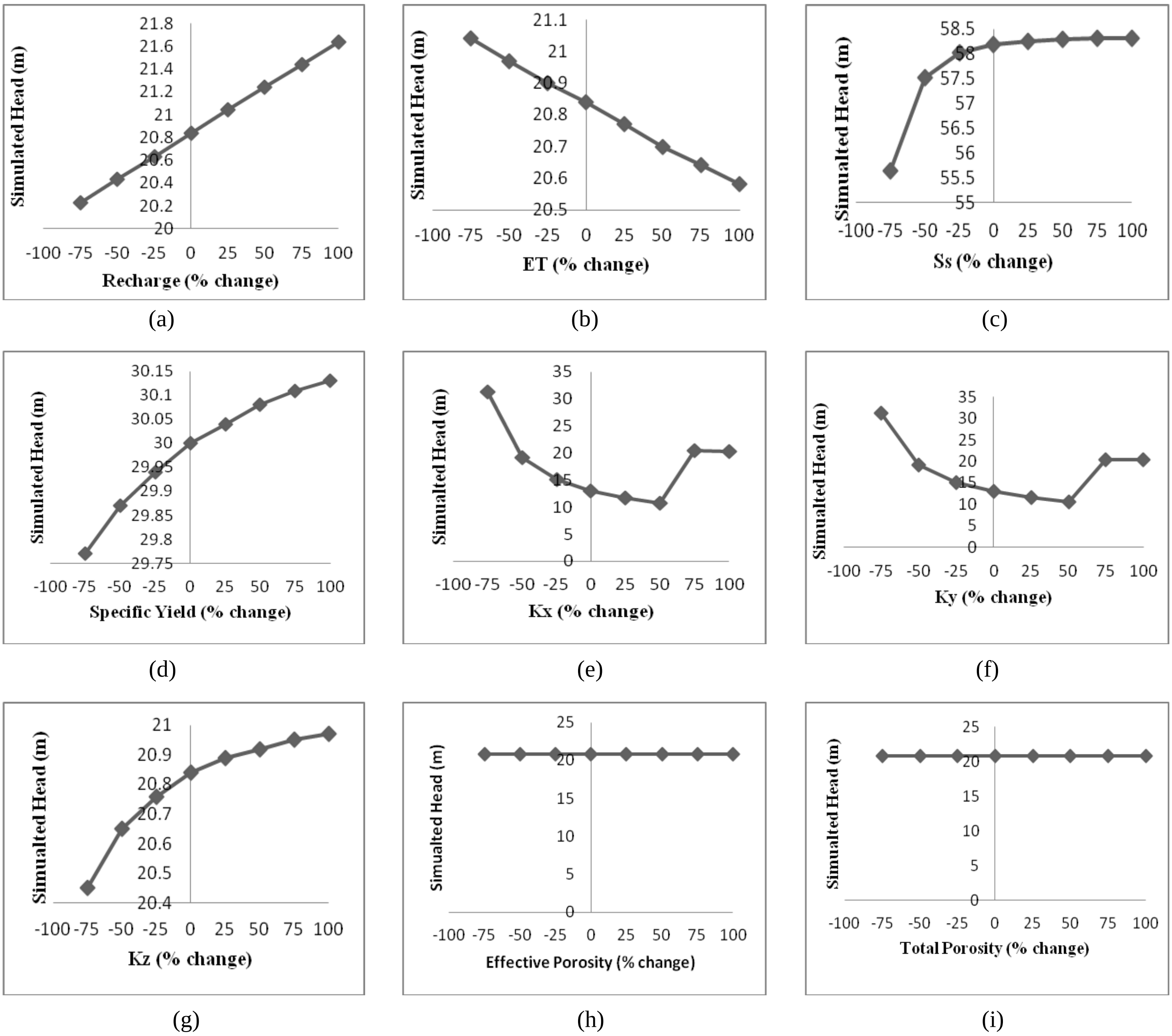


Fig. 4. Sensitivity analysis for several parameters of groundwater flow model

Fig. 4(a) represents direct relationship between simulated head and recharge and Fig.4 (b) represents inverse relationship of ET and simulated head. Fig.4(c) shows specific storage ($S_s$) is very sensitive when smaller values are used. As percent change in this parameter gets positive, the parameter turns out to be insensitive. Therefore, any change beyond 100% will give no change in simulated head. Fig. 4(d) shows specific yield is very sensitive parameter. As value of specific yield increases, the simulated head also increases. There is an exponential drop in head as specific yield of particular soil type decreases. This is due to the fact that any soil type with greater specific yield releases more water and takes less into the storage. Fig. 4 (e), (f) and (g) establish that Kx, Ky and Kz are the most sensitive parameters in the groundwater flow model. This is in accordance with the model equation or the general form of Darcy's law i.e. q= Ki, where q is the flux velocity, K is the hydraulic conductivity and i is the change in elevations of two points divided by the distance between them. For Kx and Ky, graphs represent exponential drop in simulated head with increase in hydraulic conductivity values and further increment after 75% will render these parameters insensitive. Smaller Kx and Ky values imply that water moves slowly down the gradient in horizontal directions of an aquifer over time and results in higher head at that interval of time and vice versa. Whereas for Kz, higher values would result in greater simulated head due to ease of percolation through that particular soil type. The changes in effective porosity and total porosity showed no change in output since they do not play any role in transient state of groundwater flow model equation as shown in Fig 4 (h) and (i) respectively.

*C. Calibration of the model*

The technique to bring simulated results of the model, as close as possible to the observed values from the field by adjusting sensitive parameters is called calibration [17]. The target of calibration is to minimize the difference between simulated results and observed values. This difference of simulated results and observed values is called calibration residual (CR). Smaller the CR, better will be the model calibration. The values of observation head, simulated head and the calibration residual in meters for the model are tabulated in Table V. The Fig.5. represents calibration results of groundwater flow model. The observed results are presented with squared marks and calculated values are plotted with line. The correlation coefficient (R) of 0.60 was achieved. The correlation coefficient is suitable factor for measuring the relation between the two data as utilized by Lathashri and Mahesha for studying the model of coastal aquifers in Karnataka, India [18]. Mean Absolute Error (MAE) was calculated to be 1.532m, Square Mean Error (SME) is 2.75 sq.m and Root Mean Square Error (RSME) is 1.658m. These values suggest that model has less variation between observed and simulated results.

Table V. Calibration results of groundwater flow model

| Well.No | Observed Head (m) | Simulated Head (m) | CR (m) |
|---|---|---|---|
| 1 | 3.5 | 1.96 | 1.54 |
| 2 | 2.7 | 2.18 | 0.52 |
| 3 | 5.3 | 4.02 | 1.28 |
| 4 | 7.7 | 5.81 | 1.89 |
| 5 | 3.08 | 5.51 | -2.43 |

Table VI. Calibration results of solute transport model

| Well.No. | Observed TDS Concentration (mg/L) | Simulated TDS Concentration (mg/L) | CR (mg/L) |
|---|---|---|---|
| 1 | 2020 | 31811 | -29791 |
| 2 | 55240 | 33810 | 21430 |
| 3 | 27316 | 26540 | 776 |
| 4 | 11670 | 16558 | -4888 |
| 5 | 17716 | 10.48 | 17705.52 |

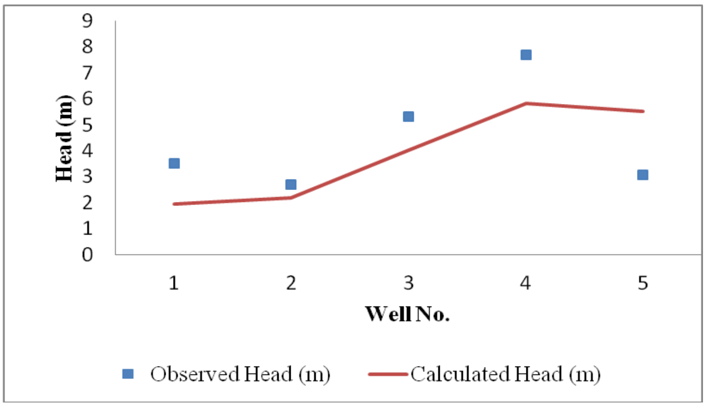


Fig. 5. Simulated and observed heads for calibration of groundwater flow model

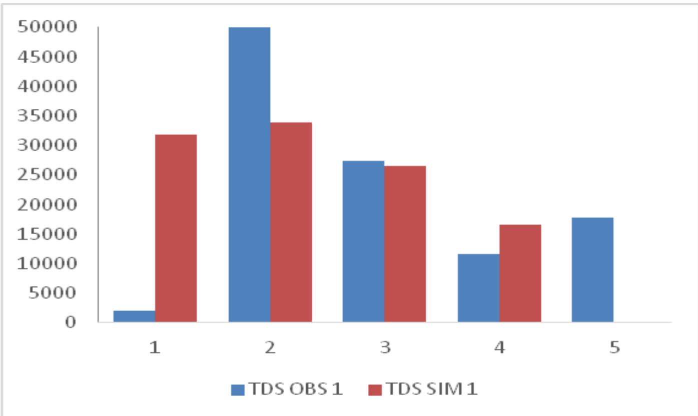


Fig. 6. Simulated and observed TDS concentrations of solute transport model

Table VI shows observed and simulated values of TDS. These simulated values are for the period of 1800 days or 5 years and are represented in bar chart in Fig 6. This time period is considered as warm up period when model first started simulating the concentration results. The correlation coefficient R of 0.33 has been obtained. The MAE is 14318 mg/L and RMSE is 18356 mg/L. These values are greater in error which means model requires efforts and further data to be calibrated properly. This is chiefly due to the fact that recharge from Moin Khan Cricket Academy is not considered for the Well No. 1 where observed TDS values are not in agreement with the values simulated by the model.

### *D. Validation of the model*

Groundwater model was validated for another set of 5 monitoring wells. Table VII shows observed values with simulated values obtained from the model. Validation curve was plotted as shown in Fig. 7. The correlation coefficient R of 0.55 was achieved for the given data. MAE is 1.496m, SME is 2.33 square meters and RSME is 1.53m. In this case, the correlation coefficient is less than that of the calibration site, but MAE and RSME are also lesser than that of calibration site which signifies that the error between the two results is lesser and good validation of the groundwater model has been achieved.

Table VII. Validation results of groundwater flow model

| Well.No | Observed Head (m) | Simulated Head (m) |
|---|---|---|
| 1 | 3.5 | 1.96 |
| 2 | 2.7 | 2.18 |
| 3 | 5.3 | 4.02 |
| 4 | 7.7 | 5.81 |
| 5 | 3.08 | 5.51 |

Table VIII. Validation results of solute transport model

| Well.No. | Observed TDS Concentration (mg/L) | Simulated TDS Concentration (mg/L) |
|---|---|---|
| 1 | 61000 | 34585 |
| 2 | 5630 | 7000 |
| 3 | 32029 | 27000 |
| 4 | 8464 | 13000 |
| 5 | 6234 | 7790.2 |

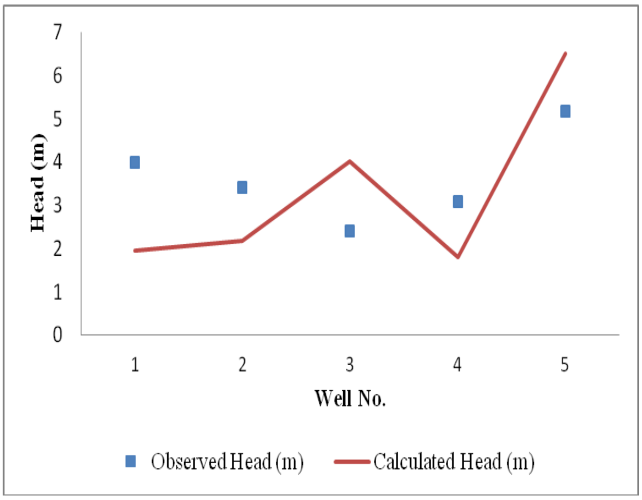

Fig. 7. Validation results of groundwater flow model

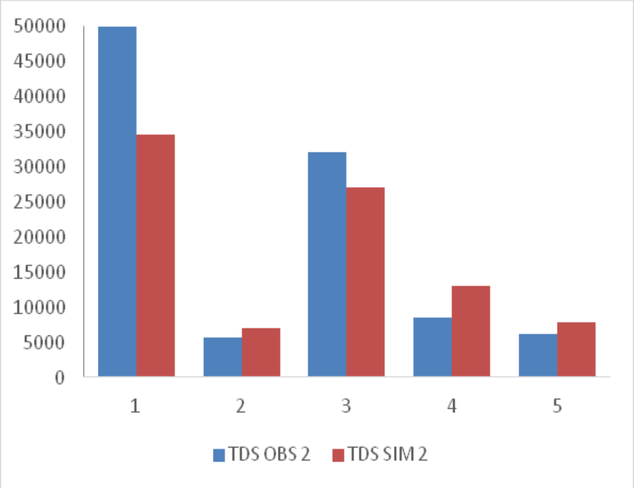

Fig. 8. Validation results of solute transport model

The validation of solute transport model for TDS was carried out for the observed and simulated values for the period of 3600 days or 10 years. Table VIII shows observed and simulated TDS in mg/L. The correlation coefficient R of 0.9667 was achieved which means there is strong relation between observed and simulated results as shown in Fig. 8. The MAE is 7781.2 mg/L and RSME is 12230 mg/L which means the model is very well validated.

*E. Application of the Model*

The model was run for the simulation period of 5400 days (15 years) and 7200 days (20 years) in order to predict the TDS for the first set of 5 observation wells. These simulation results are shown in Fig 9. It predicts that concentration of TDS will increase over time at all monitoring wells.

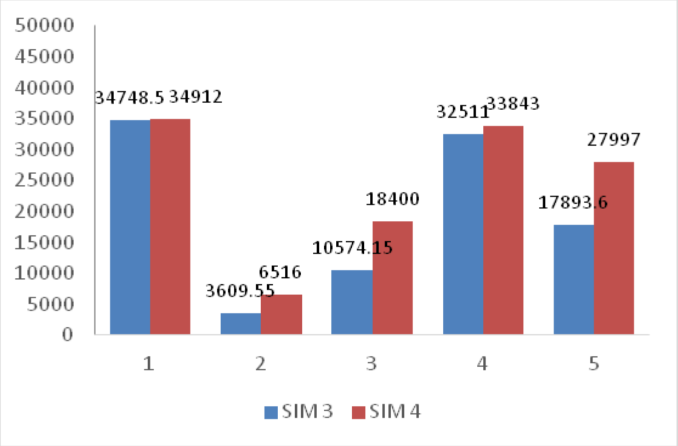

Fig. 9. Simulated results in order to predict TDS values for 15 and 20 years

## IV. CONCLUSIONS

The calibration of groundwater model was achieved with the correlation coefficient of 0.60 with MAE of 1.22m. The validation of model resulted in correlation coefficient of 0.55 with MAE of 1.45m for the interval of 3 days. Groundwater table is high near the coastline as compare to areas away from the coastline; this is because of seawater intrusion. The correlation coefficient of 0.33 was achieved for calibration with MAE of 14918 mg/L for concentration of TDS. The validation of model yielded correlation coefficient of 0.9667 with MAE of 7781.2 mg/L for the same. This means that the model has yielded results much suitable for validation site than the calibration site. The concentration of contaminants in groundwater is low near the coastline while moving away from the coastline, concentration of contaminants increases. A freshwater recharging source available in the study area affected the concentration of the contaminants, having TDS value of 2020 mg/L as observed by the field data. Furthermore, the model can be made more accurate by including more water data from monitoring wells over a greater time period, for almost 5 to 10 years. The model can then be utilized for effective management of groundwater and suggest treatment processes.

It is also concluded that the recharge source of groundwater in coastal regions is seawater since there is less precipitation throughout the year for significant recharge. Hence, seawater intrusion is the dominant source for recharging and contaminating the available groundwater along the coastal belt of the city.

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# Analysis and Design of Flexible Pavement Using Empirical-Mechanistic Based Software (KENPAVE)

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***Abstract*: Premature failures like Rutting and fatigue in the flexible pavements of Pakistan are considered to be the most severe violent distresses because of their high severity and densities and their huge effect on pavement performance. Instant increases of heavy vehicles and truck axle loads, improper pavement design procedures to meet local environmental conditions and errors occurring during manual design are major factors responsible for premature failures now days in Pakistan. Thus, it is bare need to minimize these premature failures for economical design. Aim of this research is to reduce these failures by using Empirical-Mechanistic based real software like KENPAVE. This software is used to calculate stresses and strain in flexible and rigid pavement. The object of this research work is to validate and compare KENPAVE design software with existing empirical design approaches and to investigate the effect of variation in thicknesses of wearing course and base course on pavement performance and on design life with respect to fatigue and rutting damage. For this purpose, NHA (N-55) (JAMSHORO TO SEHWAN) section of road taken as a test section. Various probable cross-sections that may be used in Pakistan for wearing course and base course are considered by varying their thickness +25% and -25%. By doing that there are total 10 cross-sections to be analyzed. These 10 cross-sections are analyzed for allowable number of load repetitions in terms of rutting (Nr) and fatigue (Nf) depending upon maximum allowable ESAL on N-55 road. Result shows that most failure resisting pavement cross-section in terms of allowable number of load repetitions to prevent rutting (Nr) and fatigue (Nf) failure are crossection-5 and crossection-10 and cost of construction of designed crossection-5 and crossection-10 are nearly equal. However, crossection-10 is economical in terms of design life and failure resisting properties.**

***Keywords*: Premature failures, Rutting, Fatigue, KENPAVE, Design life, Empirical-Mechanistic design.**

## I. INTRODUCTION

Highways are important in the growth of any nation's economy [1]. Most countries use asphalt pavements for construction of roads and also Pakistan uses asphalt pavements for construction of roads. In Pakistan highways are designed on traditional methods which give slightly uneconomical road construction. Empirical-Mechanistic design method which uses different number of distress models for design is the most effective technology now days for flexible pavement design [2]. In design and analysis of flexible roads, heavy axle loads on the pavements turn out two types of critical strains, that are horizontal tensile strain (fatigue) at the bottom of the bituminous layer ($\varepsilon t$) and vertical compressive strain (rutting) at the top of sub grade ($\varepsilon c$) [3,4]. Instant increases of heavy vehicles and truck axle loads, improper pavement design procedures to meet local environmental conditions and errors occurring during manual design are the major factors responsible for premature failures in Pakistan now days [5]. For a flexible pavement it is necessary that it should have durable surface and failure resistant life and it very much important to minimize cracking and rutting within pavement layers [6]. Thus, it is bare need to minimize these premature failures for economical design. Aim of this research is to reduce these failures by using Empirical-Mechanistic based real software like KENPAVE.

## II. PROBLEM STATEMENT

Premature failures like Rutting and fatigue in the flexible pavements of Pakistan are considered to be the most severe violent distresses because of their high severity and densities and their huge effect on pavement performance. In Pakistan Present pavement design procedure are based on empirical methods, in which design is result of experimental results or experiences that are limiting the premature failures bellow the critical level. Moreover, these approaches are only accurate for the exact conditions for which they were developed and may be invalid outside the range of variables used in their development. Now a day's Empirical-Mechanistic design method are considered to be the most popular design method, which evaluates accurately stresses and strains in flexible pavements at different stages of the design. This may also help in predicting the design life accurately from the pavement response. For a flexible pavement it is necessary that it should have durable surface and failure resistant life and it very much important to minimize cracking and rutting within pavement layers. Thus it is bare need to minimize these premature failures for economical design by using Empirical-Mechanistic based real software like KENPAVE.

## III. AIMS AND OBJECTIVES OF RESEARCH

This research study is aimed to design and analyze the flexible pavements using KENPAVE pavement design software. With this study we will be able to introduce the latest and more efficient, economical, mechanistic based flexible pavement design methods including KENPAVE software. Main objectives of the research are to validate and compare existing design approaches with KENPAVE design software and to examine the effect of variation in AC wearing course and AC base course thicknesses on the pavement performance.

## IV. INTRODUCTION OF KENPAVE SOFTWARE

KENPAVE software was developed at University of Kentucky by Haung, 2004. KENPAVE is Microsoft-Windows base software. KENLAYER and KENSLAB are the main two parts of KENPAVE software. However, KENLAYER part is used for the analysis of flexible pavements and KENSLAB for the analysis of rigid pavements. The KENPAVE software can analyze linear, non-linear and visco-elastic material properties for each layer. KENPAV software can performs damage analysis and can handle up to 19 layers either bounded or unbounded. KENLAYER can be applied to layer systems under various axle conditions (dual, tandem, tridem or their combination). Each year is divided into maximum 12 periods for damage analysis, and each period must have 12 load groups. Finally design life is estimated by summing the damages caused by fatigue, rutting and overall deformation of each load group. Input parameters in KENLAYER software are mainly load groups, loading condition, material properties and layer thicknesses. Main advantage of KENLAYER over other programs is that it can solve either linear-elastic, nonlinear-elastic and visco-elastic material properties and it evaluates design life of pavement by performing damage analysis, damage caused by fatigue and rutting distresses.


Fig.1 Main screen of KENPAVE software

## V. RESEARCH METHODOLOGY

Flexible pavements are designed to have a durable and failure resistant life. In Pakistan represent design methods followed are the Empirical design methods such as AASHTO design method, CBR method, GI (Group Index) method, ROAD NOTE methods etc. These methods are only correct for the scenario for which they were designed and developed and may not give satisfactory results outside the range of their development and in case of variation in conditions and variables [7]. However now a days most popular design method is mechanistic design method that evaluates accurately stresses and strains in flexible pavement. The theme of this research is to introduce Empirical-Mechanistic based software in the field of pavement design in Pakistan. The software to be used in this study is KENPAVE. This software can accurately estimate stresses and strains in flexible pavement using different distress models. Thus, to investigative the effect of AC wearing course and AC base coarse thickness on the design life and pavement performance with respect to rutting and fatigue damage, NHA (N-55) (Jamshoro to Sehwan) section of road has been taken as a test section. The test section has five layers and it is a two-lane road; including AC Wearing coarse (5cm) or (2.0”), AC Base course (16.5cm) or (6.6”), Aggregate Base course (30cm) or (12”), Fill material (30cm) or (12”) and a Sub grade as shown in Figure.

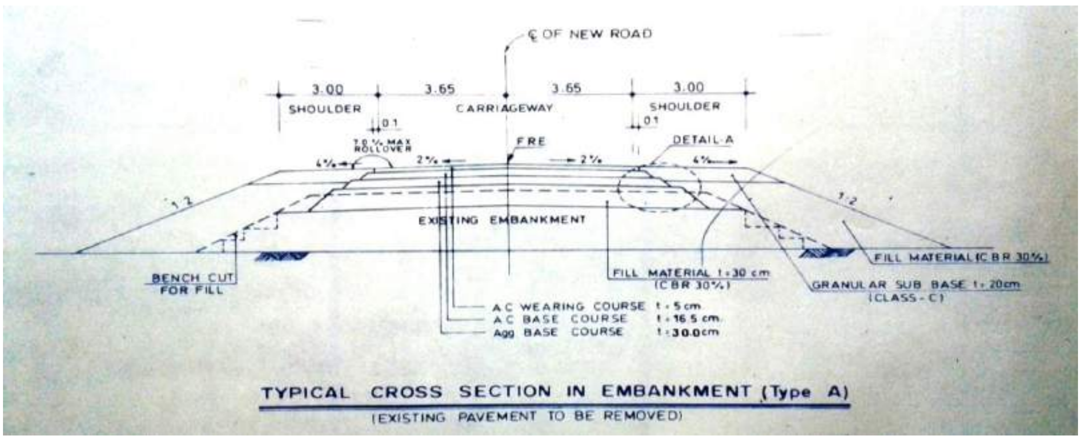



Fig. 2 NHA N-55 Road Cross-section

Various probable cross-sections that may be used in Pakistan for AC wearing course and AC base course are considered by varying their thickness +25% and -25% that is (0.98”, 1.48”, 2.0”, 2.46”, 2.95”) for AC wearing coarse and (3.25”, 4.87”, 6.6”, 8.12”, 9.74”) for AC base course. By varying these thicknesses with each other we have total Twelve 12 cross-sections including original cross-section. Every cross-section is checked for Max: Horizontal tensile strain at the bottom of bituminous layer (εt) and Max: vertical compressive strain at the top of sub-grade layer (εv). This actually helps in manually calculating Max: Allowance for Number of load repetitions to prevent Rutting failure (Nr) and Maximum Allowance for Number of load repetitions to prevent Fatigue failure (Nf). The cross-section which gives Maximum Allowance for Number of load repetitions to prevent Rutting failure (Nr) and Fatigue failure (Nf), that will be considered as optimum cross-section in terms of design life of pavement and failure resisting properties.

## VI. RESULTS AND DISCUSSIONS

### *A. General Disscussion*

The facts and figures used in this research study are taken from NHA (National highway authority). Various layer thicknesses, poison’s ratios and elastic modulus values were taken from NHA guidelines. According to NHA Specifications for Asphalt concrete wearing course is taken of Class-A which has the elastic modulus of 400000 psi and poisons ratio of 0.25. Asphalt concrete base course is taken as Class-A which has the elastic modulus of 350000 psi and poisons ratio as 0.2. The Aggregate base course has the elastic modulus of 200000 psi and poisons ratio as 0.3. The Sub-grade (Fill material) has the elastic modulus of 10000 psi and poisons ratio as 0.4 and the Sub-grade (natural) has the elastic modulus of 5000 psi and poisons ratio as 0.45. The analysis of pavement is done on the upper two layers i.e. Asphalt concrete (AC) wearing course and Asphalt concrete (AC) base course. In this analysis the properties of wearing course and base course are kept constant but thickness is varied ±25%. Due to all this we have total twenty one 12 sections which are to be analyzed by pavement design software KENPAVE and are given below.

Table 1: Thicknesses of each designed Cross-section

| Designed Cross Section # | AC wearing coarse thickness | AC base coarse thickness | Granular base coarse thickness | Fill Material (Sub-grade) thickness | Natural Sub-grade thickness |
|---|---|---|---|---|---|
| Existing Pavement | 2.0” | *6.6”* | *12”* | *12”* | ∞ |
| x-section1 | 0.98” | 6.6” | *12”* | *12”* | ∞ |
| x-section2 | 0.98” | 3.25” | *12”* | *12”* | ∞ |
| x-section3 | 0.98” | 4.87” | *12”* | *12”* | ∞ |
| x-section4 | 0.98” | 8.12” | *12”* | *12”* | ∞ |
| x-section5 | 0.98” | 9.47” | *12”* | *12”* | ∞ |
| x-section6 | 1.48” | 6.6” | *12”* | *12”* | ∞ |
| x-section7 | 1.48” | 3.25” | *12”* | *12”* | ∞ |
| x-section8 | 1.48” | 4.87” | *12”* | *12”* | ∞ |
| x-section9 | 1.48” | 8.12” | *12”* | *12”* | ∞ |
| x-section10 | 1.48” | 9.47” | *12”* | *12”* | ∞ |

The output obtained from KENPAVE as a text is discussed in previous chapter. In this chapter KENPAVE results and graphs after analyzing KENPAVE output as a text are discussed. Analyzed parameters from KENPAVE output as a text are Vertical deflection **($\Delta_z$)**, Vertical stress **($\sigma_z$)**, Vertical Strain ($\varepsilon_z$) and Horizontal P. Strain **($\varepsilon_t$).**
The results of KENPAVE output as text for each cross-section gives the idea of variation of maximum deflection, maximum vertical stress, maximum tensile strain and maximum compressive strain at each depth. But for rutting analysis Maximum vertical compressive strain ($\varepsilon_z$) at the top of sub-grade layer and for Fatigue analysis Maximum horizontal tensile strain ($\varepsilon_t$) at the bottom of bituminous layer is taken into account. Then those ($\varepsilon_z$) and ($\varepsilon_t$) will help in calculating maximum allowable number of load repetitions to prevent rutting failure (Nr) and Fatigue failure (Nf) simultaneously for particular section.

### *B. Analysis of KENPAVE Results*

The results of maximum Fattigue and maximum Rutting can be obtained from graphs of each cross-section. The results of the Maximum tensile strain and the maximum vertical strain are than used as inputs for the models used to predict the number of allowable repetition to prevent Fatigue and Rutting failure in the flexible pavement given by the Asphalt Institute (AI 1982), which are given bellow

**Model for fatigue failure**

Model to predict the Number of allowable repetitions to cause the fatigue cracking is given below.

$$Nf = 0.0796 * (et)^{\wedge} - 3.291 * E1^{\wedge} - 0.854 \quad (1)$$

Where, Nf = Number of Repetitions required to prevent Fatigue cracking

**Model for rutting failure**

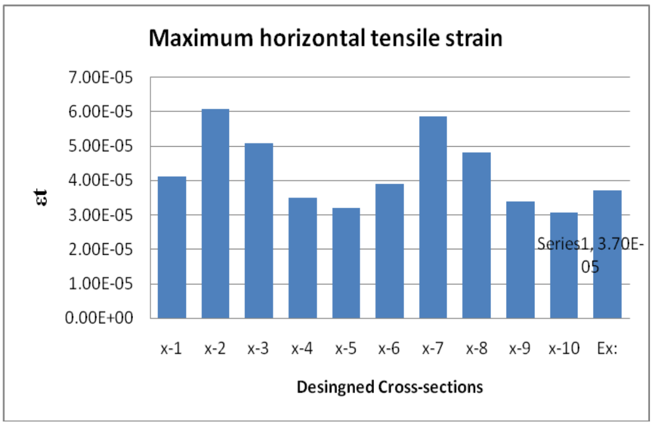
Model to predict the Number of allowable repetitions to cause the rutting in the pavement is given below.

$$Nr = 1.36 * 10^{-9} * (er)^{-4.477} \quad (2)$$

Where, Nr = Number of Repetitions required to prevent Rutting

Total number of allowable road repetitions to prevent rutting (Nr) and fatigue (Nf) failure for each cross-section can be obtained by using graphs discussed bellow and with the help of above formulas.

The detailed discussion of obtaining maximum Nr and Nf from maximum $\varepsilon_z$ and $\varepsilon_t$ is given in the graphs shown bellow.



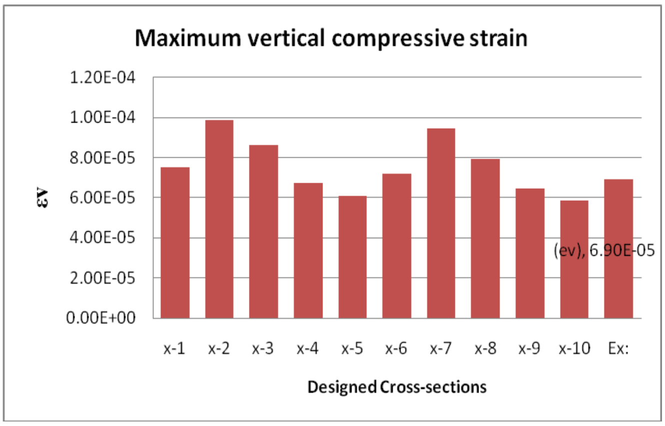
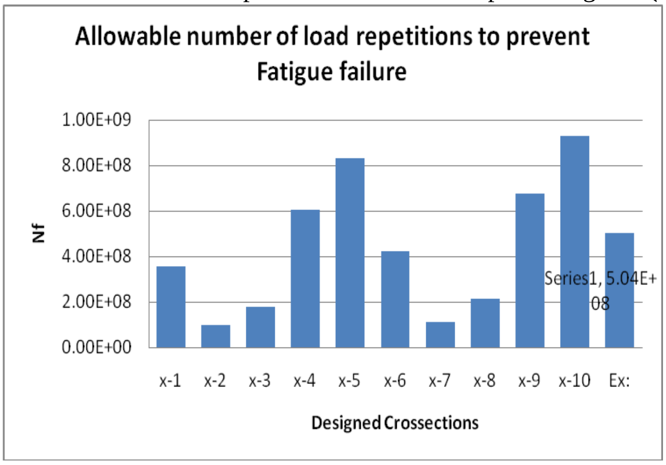




Fig. 3(a) Bar Chart for Maximum horizontal tensile strain at the bottom of bituminous layer **($\varepsilon_t$)** and Fig. 3(b) Bar Chart for Maximum vertical compressive strain at the top of sub-grade **($\varepsilon_v$)**



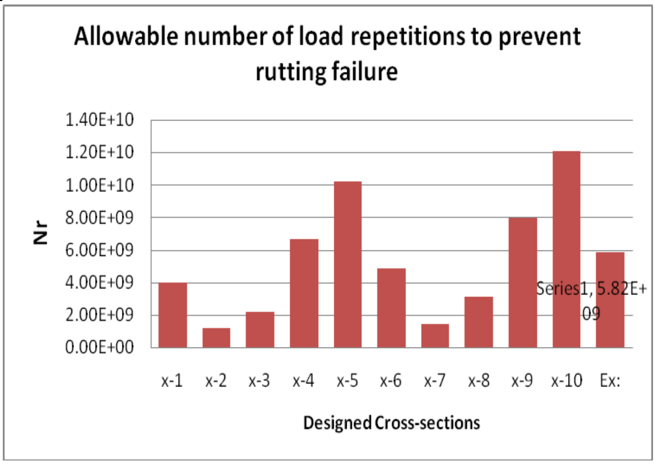




Fig. 4(a) Bar Chart for Allowable number of load repetitions to prevent Fatigue failure (Nf) and Fig. 4(b) Bar Chart for Allowable number of load repetitions to prevent Rutting failure.

It can be concluded from Fig. 3(a) that cross-section number 10 is giving maximum allowance for number of load repetitions in terms of fatigue failure (Nf), that is *9.30E+08 cycles of tandem axle load*. Also, it can be observed from Fig.3(b) that cross-section number 10 is giving maximum allowance for number of load repetitions in terms of rutting failure (Nr), that is *1.21E+10 cycles of tandem axle load*

Since optimum cross-section satisfying failure resisting conditions is cross-section number 10, thus the allowable cross-section to be constructed on NHA road is cross-section number 10. Particulars of cross-section number 10 are given bellow

- ✓ AC Wearing coarse (3.75cm) (1.48”).
- ✓ AC Base course (24.05cm) (9.47”).
- ✓ Aggregate Base course (30cm) (12”).
- ✓ Fill material (30cm) (12”) and a
- ✓ Sub grade

✓


Fig. 5 Designed Cross-section of road.

## VII. CONCLUSION

This research work is carried out to investigative the effect of AC wearing course and AC base coarse thickness on the design life and pavement performance with respect to rutting and fatigue damage analysis with the following conclusions.

1. KENPAVE (KENLAYER computer program) can be used to predict the performance of flexible pavement more easily and efficiently and it is users friendly.
2. The design obtained from manual and KENPAVE analysis is almost same. KENPAVE software is equally reliable and applicable for analysis and design of the pavements with much less complications and in a very short time with almost same accuracy of the results. An additional advantage of using this software is that it can be used for multiple layers while on the other hand manual calculation for multiple layers is very complicated and time taking venture. Therefore, the given calculations and results clearly validate the software results and gives a rational understanding of why it is better to use software than manual work for the on-site works of pavement analysis.
3. In Rutting analysis, increase in the thickness of AC wearing coarse increases the allowance for load repetitions to prevent rutting damage and decreasing the thickness of AC wearing coarse decreases the allowance for load repetitions to prevent rutting damage. Similarly increase in the thickness of AC base course increases the allowance for load repetitions to prevent rutting damage and decreasing the thickness of AC base course decreases the allowance for load repetitions to prevent rutting damage.
4. In Fatigue analysis, increase in the thickness of AC wearing coarse increases the allowance for repetitions to prevent rutting damage and decreasing the thickness of AC wearing coarse decreases the allowance for load repetitions to prevent rutting damage. Similarly increase in the thickness of AC base course increases the allowance for load repetitions to prevent rutting damage and decreasing the thickness of AC base course decreases the allowance for load repetitions to prevent rutting damage.
5. The economical cross-section in terms of Rutting and Fatigue life and cost analysis achieved is cross-section number 10, which gave maximum allowance for number of load repetitions in terms of rutting failure (Nr) equals to *1.21E+10 cycles of tandem axle load and* maximum allowance for number of load repetitions in terms of fatigue failure (Nf) equals to *9.30E+08 cycles of tandem axle load.*

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# Comparison of Control and Crumb Rubber Modified Asphalt for Rutting Potential (M.9 Construction)

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***Abstract*: Pakistan has a street system of around 263775 km, In which Motorway plays an important role in development, total length of motorway is 1010 km, and around 3690 km of motorway are under construction, which conveys a huge extent of traveller and in addition of heavy cargo activity. Practically the entire length of this system is comprised of flexible asphalt pavement. These pavements are subjected to many sorts of distress, amongst which rutting is considered as a critical issue. Rutting causes surface, sub surface and sub grade deformation due to heavy axle loading and also influences the frictional properties of surface due to gathering of water in the wheel ways. In this way, protected and practical operation of asphalt pavement can be determined by limiting such distress through effective mix design and developments in asphalt material. The presented study investigated and compared the performance of Control mix and Crumb Rubber Modified Asphalt (CRM) on their rutting behaviour. It was investigated that the CRM Asphalt execute better than Control mix. Moreover, the CRM Asphalt is way to recycle the waste material in an appropriated way**

***Keywords*: Crumb rubber, Control mix, Crumb rubber modified asphalt, Rut.**

## I. INTRODUCTION

Pakistan has a street system of 25830 km with an expected estimation cost of Rs250 billion for infrastructure sector including energy and transport in budget 2015-16 [1]. This system serves its 90% of its traveller and cargo traffic [2]. Motorways plays vital role in development total length of motorway is 1010 km are constructed, and around 3690 km of motorway are under construction. Which convey a huge extent of traveller and in addition of heavy cargo activity. Traffic densities & Volume varying, high loads and Low execution of bituminous blend under fluctuating loads and different environmental conditions have concluded in premature pavement failures [3]. Further that, increasing in vehicular on carriage ways also produce tons of wasted tyres, each year enhancing the issues of landfill or environmental problems. An example of enormous increase in traffic density and resultant generation of waste tyres [4]. Additionally, modified binder are being developed and, within the previous couple of years, it has been validated that to minimize the reaction of enhanced axle loading through improved pavement system and performance [5]. The main object to modify the bitumen is to utilize the waste materials, containing thermoplastic polymers, sulphur, and rubber to produce a modified mix of bitumen, such as reclaimed scrap tyres with extra environmental edges. From the past it has also been affirmed that, the performance of virgin mixture and binder resistance was upgraded against premature failure of pavement [6]. On other hand condition of road networks have degraded as Rutting and fatigue cracking [7]. Therefore, it has more necessary to research modified binders or material that integrated in asphalt pavement to make them more durable against distress with low maintenance cost. In this investigation a detailed examination has been done by comparing Control and Crumb rubber Modified mix as per M-9 Specification.

## II. LITERATURE REVIEW

The examination paper gives a diagram of CRM black-top with specific reference to the dry procedure blends, which is gainful for other analyst to utilize piece elastic by dry process for change of Asphalt blend. The dry procedure can possibly reuse more Crumb rubber rather than to wet process. The paper high light the few basic issues in regard to its alteration idea, the design outline and noteworthy part in enhancing the blend properties for future investigations [5].
The dry procedure of Crumb rubber Modified Asphalt blend is described by basic development process that outcome in more more beneficial natural advantages than the wet procedure does. This research investigates the compaction methodology of dry process CRM Modified blend utilizing air void substance and the extension proportion as the guideline shows. Assessing the key factor influencing compaction, a sequence of CRM modified blends were arranged and compacted at various substance by add up to total volume 3.0%, 5.5%, 8.0% and 10%. The outcome shows that increase in crumb rubber content also increase the expansion ratio substance. Moreover, found that with addition of 5.5% of Crumb rubber significantly improved the bulk stability and bulk volume of mixture [6].

The wealth and increment of waste tire is a difficult issue and it prompt the natural contamination, elastic acquired from destroyed from scrap tires, has been demonstrated from past examinations can improve the property of plain bitumen since

1840s. The near examination is made among the changed bitumen tests utilizing the different size of piece elastic and the best size for adjustment of bitumen is proposed in view of the basic research center tests on plain bitumen and morsel elastic altered bitumen, the infiltration and the softening purpose of plain bitumen can be enhanced by changing with expansion of scrap elastic, which is major ecological contamination, the size fluctuating from (0.3-0.15mm) give the most astounding dependability esteem 0f 1597.64 kg , least stream, greatest unit weight, greatest air voids, least VMA and VFA % values [7].

During the disintegration of these hazardous substance can filter down over the sites and into the surrounding, which polluted the watercourses and disturb the living organisms. The site surface of landfills raised by waste tyres, which oppose the future construction of land [8].

The Crumb elastic is a gainful material utilized as a part of virgin bitumen rather than a waste material. The examination was completed to explore the communication of two material constituent at phase of creation and capacity, broke down the adjustment in densities of essential segment amid generation. Before mixing over all densities of CRMB mix pattern to be expanded, changes angle was because of the nearness of segment in Crumb elastic like dampness, extender oils and carbon dark and their disintegration into bitumen in mixing process. And in addition, the thickness of bitumen buildup was expanded, because of dissemination, volatilization and disintegration of couple of segments with CR at high temperature. Focus at various sizes and rates of CR, came about huge variety in general densities amid collaboration process. Morsel elastic of lower estimate with gentler fastener upgraded the similarity by permitting most extreme diminishment in densities in the mix [10].

In general, industrialized and developing countries generate approximately one old tyre per capita per annum. Recent report reveals the increase in vehicular traffic between 1970 and 1996 more than doubled in Britain, from 200 billion to 440 billion vehicles kilometres a year. With this increase in traffic density, 37 million used tyres are generated in the United Kingdom every year and this could increase by up to 60% by 2021. This increase in traffic density could lead to problems such as storage or dumping of used tyres, which is a real threat to the environment. [12].

In today's society, the solid waste is being a part. Generally, the used tyres have been scraped in landfill or stored in stockpiles. However, such accumulation of millions of worn tyres may also lead to a considerable environmental problem. Tyres are designed to last for a long time and thus tough to separate and break down into their constituent component. That problem is coupled with potentially noxious compounds, such as poly-aromatic hydrocarbons (PAHs) benzene and phenol, which when released into the environment by their disposal, have suspected carcinogenic properties [12].

Typically, waste tyres burning has been taken as a measure to get rid of this waste in some parts of the world but was observed to admit a severe environmental effect. Burning waste tyres turn out immense quantities of deleterious emission that may polluted the atmosphere. Tyres can burn for long periods of time due to their high energy content. In Powys, the 10 million tyre get fired in 1986 in covered tip and was continuously burning for more than nine years [12].

## II. MATERIALS & METHODS

### *A. Bitumen*

The bitumen used in study was grade of 60/70 according to the M-9 specification. The basic standard test is conducted to find the properties of bitumen, like as Penetration, Specific gravity, Softening point, Ductility, Flash point, & Solubility on Highway lab MUET Jamshoro. Results are summarized in Table 1.

### *B. Coarse Aggregate*

Coarse aggregates (CA) was taken from Nooriabad Quarries. The sizes vary from 38mm to 9.5 mm. Basic aggregate test were conducted to find the properties of coarse aggregates i.e. Bulk specific gravity, Bulk S.S.D Gravity, Apparent Specific gravity and water absorption as per AASHTO T 85 and ASTM C 127. Shown in Table 2.

### *C. Fine Aggregate*

The fine aggregate was also taken from Nooriabad Quarries. The specific gravity and water absorption of FA as per AASHTO T 84 and ASTM C 128, are shown in Table 2. The particle size distribution of an aggregate or gradation determine the asphalt design execution as material in HMA.
Type B aggregate gradation of NHA was employed and shown in Fig 1.

### D. Crumb Rubber

Used tyres, which complete their life cycle on roads by automotive and trucks. These waste tyres through expelling steel and tire string (fluff) used as recycled waste material in granular form term as Crumb rubber (CR), the necessary product used to produce Crumb rubber Asphalt. Determine by methods and techniques CR is accessible in an extensive range of sizes and surface consistency. The truck product higher quantity of reused tire rubber than other automotive. In this research the crumb rubber was brought with appropriate size from one of the factories of Korangi No.4 industrial area, Sindh Pakistan. The replica sieve size of crumb rubber was passes from 2.36mm and retain on 1.86mm was taken as shown in Fig 2 and 3. The different characteristics of CR was shown in Table 3.

Table 1: Test Result of Bitumen (60/70)

| Name of Test | Properties |
|---|---|
| Penetration @ 25°C 100 Grams | 69 |
| Softening Point °C | 49 |
| Specific Gravity | 1.015 |
| Ductility @ 5cm/mint | >100 |
| Flash Point °C | 312 |
| Solubility in CCL/wt. | 99.8 |

Table 2: Specific Gravity and water absorption of coarse aggregate

| Aggregate | Bulk Specific Gravity | Bulk SSD Gravity | Apparent Specific Gravity | Water Absorption % |
|---|---|---|---|---|
| CA (38mm to 22mm) | 2.642 | 2.656 | 2.680 | 0.54 |
| CA (22mm to 13mm) | 2.648 | 2.633 | 2.688 | 0.56 |
| CA (13mm to 5mm) | 2.638 | 2.652 | 2.680 | 0.65 |
| Fine Aggregates | 2.613 | 2.646 | 2.703 | 1.27 |

Table 3: Physical Properties of CR

| Characteristics | Value |
|---|---|
| Color | Black |
| Shore Hardness | 55-62 |
| Flakiness Index | ≤10 |
| Mental Content % | 0.07 |
| Specific Gravity (g.m$^3$) | 1.05~1.15 |
| Moisture Content (%) | 0.3 |
| Salt resistance | High |
| Acid resistance | High |
| Alkali resistance (%) | 100 |

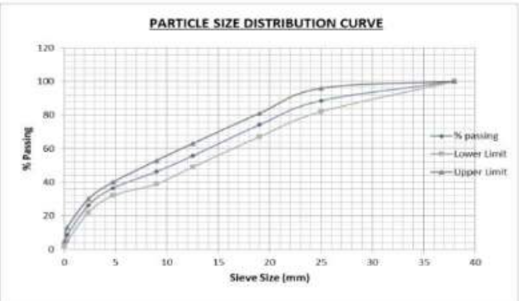


Fig. 1: Partical size distribution Curve of M-9 JMF blend

Fig. 2: Sieve size of CR

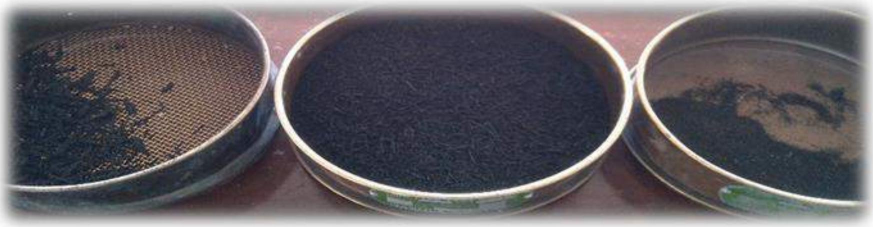

Fig. 3: CR with different size

*Methodology*

On the basis of OBCs of control mix and modified mix the rutting susceptibility was determine using dry process with addition of crumb rubber as replica. The OBCs of both control and modified mix was found through Marshall Mix design. Using five level of bitumen content for preparation of modified samples i.e. 5.0%, 5.5%, 6.0%, 6.5%, 7.0% with addition of crumb rubber (1-3%) by weight on size passes from 2.36 and retain on 1.86mm was found to match with control mix specification of M-9 construction. Depend on optimum bitumen content of control mix and modified mix the eighteen (18) samples were prepared for rut potential. These eighteen samples were distributed respectively, nine (9) for control and nine for modified mix and further more distributed on the basis of three varying temperature i.e. 60°C, 55°C and 50°C three samples for each temperature for both mixes. Prepared samples were tested in wheel tracker device for rutting susceptibility.

## III. RESULTS

A. *Ruth Sample Sizes*

The performance of both mix (Control and modified) of M-9 construction, the rut mold sample size was selected is 300*300*50 mm.

B. *Ruth Depth*

The test was regulating on 80kN axle load by passing of wheel at 10,000 repetition the distance was covered 300*300mm. Test was done at three varying temperature levels of of 50°C, 55°C and 60°C respectively for proportionally divided specimens of both mix. On the basis of total samples, the average value of Ruth depth was computed as shown in Fig 4.

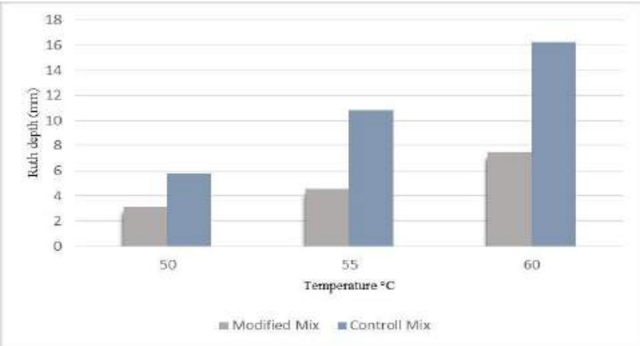


Fig. 4: Ruth depth comparison of control and modified

## IV. CONCLUSIONS

The aim of this study was to figure out the performance of both mix design of M-9 construction. Shows the inappropriate selection of binder, poor mix design, fully unawareness of axle load and elevated climatic condition on entire route sections, Because of extreme and severe type of road failures appears. The research not only determining the gaps but also exploring the utilization of waste material in a suitable way.

1. Due to modification of control mix with crumb rubber as an additive has improved its physical properties.
2. The design durability and stiffness were improved, also increasing the Marshall stability with minimum flow rate.
3. Giving better performance and also enhancing the resistance to rut failure, with increase service life of road.
4. By increasing little bit bitumen content has decrease the maintenance cost increase in Rut resistance.

## V. RECOMMENDATIONS

1. The study demonstrates the modification of control mix design with crumb rubber on the rutting failure.
2. Due to hot climatic, the binder with high softening point must be used in control mix rather than soft binder.
3. Heavy axle load on entire route, therefore it is recommended that control mix design needs little higher binder content.
4. Modified mix design not only solving the waste material problems but also increasing the service life of road efficiently.

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# Determination of Aquifer Parameters using AQTESOLV Software: A Case Study of Matiari Distributary Command Area

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***Abstract*: An important application of groundwater models is to estimate parameters, such as hydraulic properties and flow dynamics, of groundwater systems by assessing and analyzing the field data. For instance, the pumping and the hydrochemistry and environmental tracer tests are two effective ways to obtain such data. The pumping tests over unconfined aquifer were conducted in shallow alluvium in the command of Matiari distributary which is taking off from main Rohri Canal of Indus River. Two pumping tests were conducted at the head and the tail reaches of the distributary's command. The time drawdown data was recorded from monitoring wells during pumping tests and analyzed on AQTESOLV software. The pumping tests were carried out for the periods of six hours on each tube well. The selection of analysis method depends on the parameter to be determined like the Storage coefficient (S) and Transmissivity (T) have been determined using Theis and Cooper Jacob methods. The average value of transmissivity and storativity was calculated to be 1868.95 $m^2$/day and 0.00089935 respectively. Furthermore, the software results revealed that S and T values are higher at the head reach than the tail reach by 25% and 32% respectively which points out that soil at the tail reach is less permeable (i.e. flow of water under the ground is slower) and having less storage. Therefore, it is suggested to keep the tube wells in the vicinity of the tail reach shut off for longer period of time compared to those running at the head reach after continuous pumping of same period of time.***

***Keywords*: Aquifer parameters, AQTESOLV, Groundwater, Pumping test.**

## I. INTRODUCTION

The quantitative determination of hydro-geologic aquifer parameters is essential for management of groundwater resources in effective scientific and technical planning. Many methods of analysis are generally employed for estimating the spatial scattering of aquifer parameters i.e. hydraulic conductivity and transmissivity [1]. The knowledge of hydraulic conductivity and transmissivity is crucial for the determination of natural water flow through an aquifer [2]. Thus, hydraulic characteristics of aquifers play key role in the assessment of groundwater and contaminated lands and also the safe construction of structures [3]. As groundwater is main source of uncontaminated fresh water therefore the value-added hydrogeological knowledge, advanced groundwater investigation technologies and data processing methods must be well efficient to facilitate investigations and evaluation of groundwater resources [4].

Now a day's number of computer software like AQTESOLV, Aquifer Test, ADEPT, Excel and etc. have been developed for determination of aquifer parameters and flow dynamics of groundwater systems by assessing and analyzing the field data. For instance, the pumping and the hydrochemistry, environmental tracer and pumping tests are among the effective ways to obtain such field data. A pumping test is a field experiment in which an aquifer is discharged in a pumped well at a controlled rate and water-level response (i.e. drawdown) is measured with respect to time in surrounding observation wells or even the pumped well itself. Type-curve matching approaches are typically functional techniques which are normally adopted based on various mathematical models for transient groundwater flows induced by the pumping [5].

Moreover, on the other side drawdown derivative plots are advantageous means for analytical and numerical analysis of the pumping test and essential flow segments are easily identified as different curve patterns in the drawdown derivative plots [6]. Furthermore, the drawdown derivative plots can also be employed to approximate the hydraulic properties of the pumped aquifer based on accurate identification of each flow segment. As we know that the advancement in computer technology has brought an ease while solving the complex differential equations involved in groundwater mechanics. For instance, AQTESOLV is one among such computer software which develops the above-mentioned derivative plots and matching curves by just importing the time-drawdown data obtained through pumping test. Therefore, in this connection the pumping tests over unconfined aquifer were conducted in shallow alluvium in the command of Matiari distributary which is taking off from main Rohri Canal of Indus River in order to analyze the mechanics of groundwater flow by determining the aquifer parameters using mentioned computer software.

Amah, E. A and Anam, G. S. (2016) determined the aquifer hydraulic parameters by analyzing the pumping test data for Akpabuyo coastal plain aquifers, Cross river state, S-E Nigeria using Cooper Jacob (1946) method of analysis [7]. They obtained data from number of pumping tests subjected to constant discharge, step drawdown and recovery tests aimed to get some primary approximation of hydraulic parameters for the study area. The results showed that transmissivity (T), hydraulic

conductivity (k), and specific capacity (SC), ranging from 485.0 $m^2/d$ to 1346.0 $m^2/d$, 9.7 m/d to 27.9 m/d, 0.02 $m^3/d/m$ to 346.$m^3/d/m$ respectively. While the mean static water level (SWL), saturated thickness of the aquifer (b) and borehole drilled depths (BDD) were 30.29 m, 48.0 m and 64.8 m, respectively. The lithology-logs of the boreholes confirm that the estimated hydraulic parameters were obtained from unconfined gravelly sandy aquifers underlain by mostly sandy clay (aquitard).
Kori et al. (2013) developed the optimum strategies of groundwater pumping regime under scavenger tube wells in lower Indus basin, Sindh, Pakistan. They coupled already calibrated groundwater flow model with solute transport model (MT3D) [8]. The model was run for various saltines to fresh water pumping rates and daily operational hours for optimization. The study revealed that optimum strategy to control fresh and saline water interface was achieved at operational factor of 0.55 and 0.5 for two tube wells under study with recovery ratio of 0.5:0.5.

## II. MATERIALS & METHODS

### *A. Study Area*

Matiari distributary command area has been selected as a study area to achieve the objectives of the targeted research; which is located in the Sekhat town of Matiari district situated on National Highway N-5. The distributary is off-taking from right side of Rohri main canal at RD- 889. The study area has a gross command area (GCA) of 13000 acres (52.6 sq.km) out of which 11000 acres (50 sq.km) are culturalable commanded area (CCA). The head regulator of distributary is located at coordinates of 25° 18' 56.44" N and 68° 33' 40.86" E while the tail at 25° 36’ 54.37” N 68° 26’ 35.53” E. Location of the study area prepared on ArcGIS is shown in Fig.1.

### *B. Experimental setup for pumping test*

For the determination of aquifer parameters i.e. storativity (S) and transmissivity (T), the pumping tests were carried out at two tube well sites within the study area. One of the site is located at the head reach of distributary’s command while other at the tail reach providing a range of values for the entire study area. The location coordinates of selected sites have been collected through GPS device for preparing a map using ArcGIS as shown in Fig. 2.

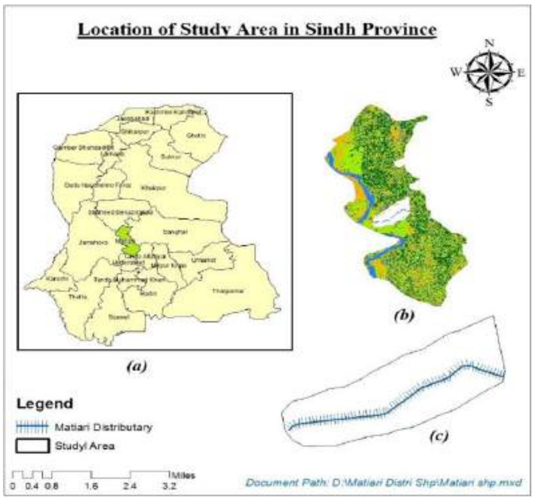


Fig.1: Location of study area

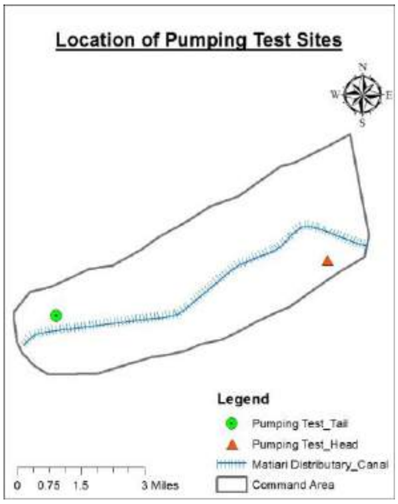


Fig. 2: Location of Pumping test site

The pumping test requires piezometers for observing time-drawdown data therefore literature was reviewed for deciding the number of piezometers to be installed for each pumping test and it was found that one piezometer is sufficient for determining the aquifer parameters i.e. T and S (Howle et al. 2009). Also, the British standards under ISO 14686: (2003) suggest one piezometer for satisfactory determination of aquifer parameters. In this connection one piezometer was installed near each selected pumping site. Secondly the distance of piezometer away from tube well depends on many factors like soil lithology, tube well performance and discharge. The above mentioned standard suggested average spacing of 82ft (25m) for silt and clayey soils, as the exploration of soil for installation of piezometers revealed that aquifer contains silt and clayey soil. Finally, for depth of installation, the same British standard (2003) suggests that the satisfactory values of aquifer parameters can be achieved by installing the piezometer at mid of the screen of pumping well. In this connection the piezometers at both the sites have been installed following above mentioned guidelines.

### *C. Data collection*

Time-drawdown was observed since the instant of operation of pumping wells till the pumping stopped. The drawdown data was collected at different consecutive intervals of time lasted till continuous operation of tube wells for six hours, where the drawdown stopped completely, and water table became static. The time-drawdown data collected during pumping tests at the tail and head reaches is presented in Tables 1 and 2 respectively.

Table 1: Time-drawdown data for pumping test at the head reach

| Drawdown data for Pumping Test at Head | | | |
|---|---|---|---|
| Time (min) | Draw down (ft.) | Time (min) | Draw down (ft.) |
| 0 | 0 | 25 | 2.21125 |
| 0.25 | 0.254167 | 30 | 2.300208 |
| 0.5 | 0.470208 | 35 | 2.370104 |
| 0.75 | 0.635417 | 40 | 2.414583 |
| 1 | 0.737083 | 50 | 2.541667 |
| 2 | 0.965833 | 60 | 2.5925 |
| 3 | 1.14375 | 70 | 2.636979 |
| 4 | 1.308958 | 80 | 2.681458 |
| 5 | 1.423333 | 90 | 2.706875 |
| 6 | 1.518646 | 120 | 2.859375 |
| 7 | 1.613958 | 150 | 2.922917 |
| 8 | 1.709271 | 180 | 3.037292 |
| 9 | 1.747396 | 210 | 3.138958 |
| 10 | 1.791875 | 240 | 3.227917 |
| 12 | 1.893542 | 270 | 3.291458 |
| 14 | 1.9825 | 300 | 3.323229 |
| 16 | 2.065104 | 330 | 3.329583 |
| 18 | 2.084167 | 360 | 3.335938 |

Table 2: Time-drawdown data for test at the tail reach

| Time (min) | Draw down (ft.) | Time (min) | Draw down (ft.) | Time (min) | Draw down (ft.) |
|---|---|---|---|---|---|
| **0** | 0 | **10** | 1.46875 | **80** | 2.197917 |
| **0.25** | 0.208333 | **12** | 1.552083 | **90** | 2.21875 |
| **0.5** | 0.385417 | **14** | 1.625 | **120** | 2.34375 |
| **0.75** | 0.520833 | **16** | 1.692708 | **150** | 2.395833 |
| **1** | 0.604167 | **18** | 1.708333 | **180** | 2.489583 |
| **2** | 0.791667 | **20** | 1.75 | **210** | 2.572917 |
| **3** | 0.9375 | **25** | 1.8125 | **240** | 2.645833 |
| **4** | 1.072917 | **30** | 1.885417 | **270** | 2.697917 |
| **5** | 1.166667 | **35** | 1.942708 | **300** | 2.723958 |
| **6** | 1.244792 | **40** | 1.979167 | **330** | 2.729167 |
| **7** | 1.322917 | **50** | 2.083333 | **360** | 2.734375 |
| **8** | 1.401042 | **60** | 2.125 | | |
| **9** | 1.432292 | **70** | 2.161458 | | |

The discharge of pumping wells was determined by volumetric method. The rectangular basin constructed at well was used to observe the volume of pumping water collected for a particular time. Finally, the division of collected volume by time of operation gives the discharge. The calculation of discharge of wells is shown in Table 3.

Table 3: Discharge of tube wells for pumping tests

| S. No | Test Site | Basin Dimensions (ft.) | | | Volume ($ft^3$) | Time (sec) | Discharge | |
|---|---|---|---|---|---|---|---|---|
| | | L | B | D | | | cusecs | lit/sec |
| 1 | Head reach | 4.33 | 3.89 | 0.7 | 11.7906 | 9 | 1.3101 | 37.09149 |
| 2 | Tail reach | 4.5 | 3.25 | 0.56 | 8.19 | 10 | 0.819 | 23.1881 |

*D. Analysis tools and techniques*

The obtained time-drawdown data as mentioned above was simulated using AQTESOLV version 4.5 software for the determination of aquifer parameters. It is world's leading aquifer test analysis software since 1989 and widely used in academics and the research due to its high reliability of results and attractive graphical interface. The time-drawdown data is tabulate in Excel sheet which is then imported to the software for simulation. The AQTESOLV software is incorporated with thirty-five methods of analysis for all types of aquifers like confined, unconfined, fractured and leaky. Out of these thirty-five methods, only five methods pertain to unconfined aquifers. In this regard storativity and transmissivity were determined by Theis (1935) and Cooper Jacob (1946) methods.

## III. RESULTS

### *A. Results of aquifer parameters*

Storativity and transmissivity have been determined using Theis (1935) and cooper Jacob (1946) methods of analysis using AQTESOLV software, thus in this regard Theis method estimated the Storativity to be 0.0007656 while the Transmissivity to be 1395.9 $m^2$/day for the tail reach. However, the Cooper Jacob method estimated the Transmissivity as 1434.7 $m^2$/day and storativity as 0.0006696. Both the methods predicted values of parameters having a small difference, therefore the average of both values is taken as representative value. Hence, the average of transmissivity and storativity came out to be 1415.3 $m^2$/day and 0.0007176 respectively. Similarly, the transmissivity and storativity for the pumping test at the head reach computed by Theis method was found to be 1843.5 $m^2$/day and 0.0009592 respectively. On the other hand, Cooper Jacob method estimated values of both the parameters as 1894.4 $m^2$/day and 0.0008395 respectively. The average value of transmissivity and storativity came out to be 1868.95 $m^2$/day and 0.00089935 respectively. The software results obtained through Cooper Jacob (1946) are shown in Fig. 3 and Fig. 4 for the pumping test at tail and head reaches respectively. While the software results obtained through Theis (1935) are shown in Fig. 5 and Fig. 6 for the pumping test at tail and head reaches respectively

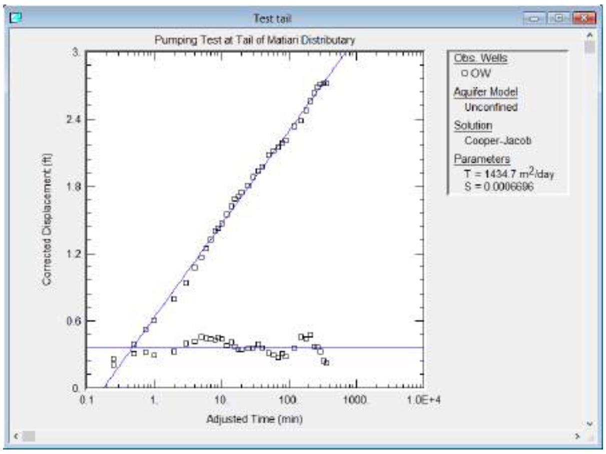


Fig. 3: Results of S and T for the tail reach

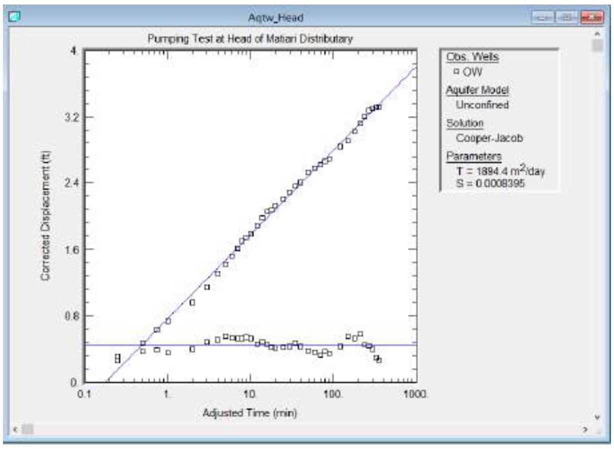


Fig. 4: Results of S and T for the head reach

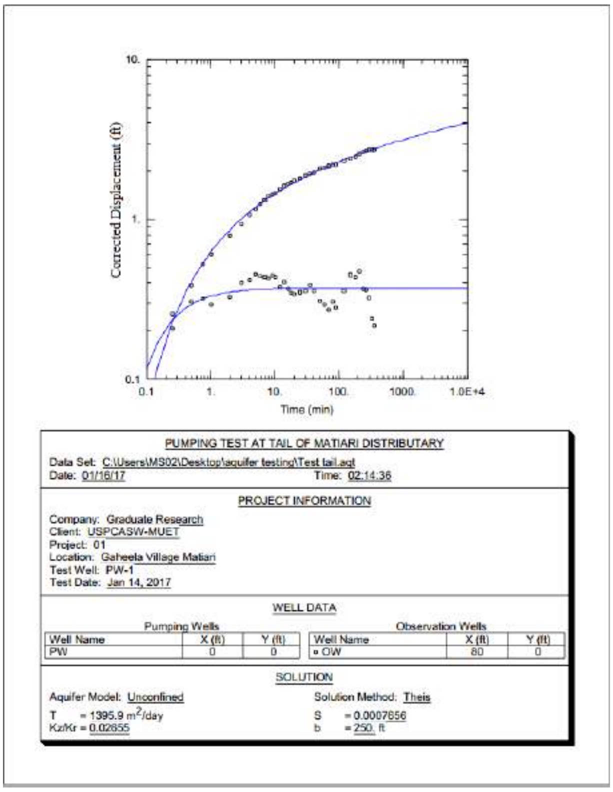


Fig. 5: Results of S and T for the tail reach

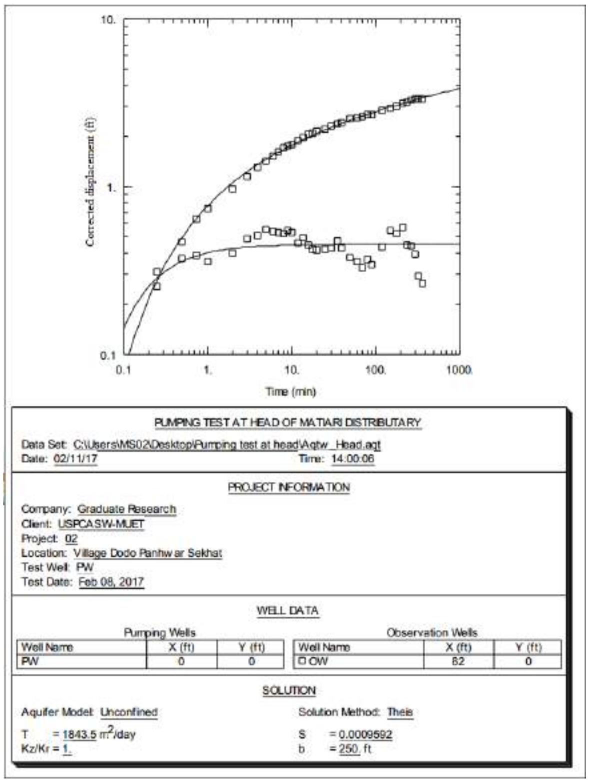


Fig. 6: Results of S and T for the head reach

### *B. Summary of Results*

The values of both the parameters obtained through Theis and Cooper Jacob methods of analyses are summarized in Table 4 as shown below.

Table 4: Summary of S and T values

| Reaches | Parameters | Theis | Jacob | Average | % |
|---|---|---|---|---|---|
| Head | T | 1843.5 | 1894.4 | 1868.95 | 100 |
| | S | 0.00096 | 0.00084 | 0.0009 | 100 |
| Tail | T | 1395.9 | 1434.7 | 1415.3 | 75.7 |
| | S | 0.00077 | 0.00067 | 0.00072 | 80 |

It is inferred from above table that Cooper Jacob method has estimated the value of transmissivity a bit higher than Theis method for both the pumping tests and vice versa for storativity. Also, the average transmissivity at tail reach is 75.7% and 80% of the head reach respectively.

## IV. CONCLUSIONS

Based on the analyses of the present work obtained from simulation of the software, it is concluded that the values of aquifer parameters such as, Storativity and Transmissivity were found higher for the head reach as compared to that for the tail reach. Hence the slow movement of water table recovery was pointed out at the tail reach which is indicating that the soil at the tail reach is less permeable than that of head reach and also the storage at tail is less as realized from results of storativity as shown in Table 5.

## V. RECOMMENDATIONS

It is recommended based on the obtained values of aquifer parameters that the tube wells in vicinity of the tail reach of study area should be shut off for more time as compared to that of head reach after continuous pumping of certain time period because the soil at that reach is less permeable and aquifer has lesser storage. This sort of management strategy will not lead the depletion of water table at either of the reaches of study area.

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# Performance Evaluation of Tertiary Canals of Jamrao West Branch under Participatory Irrigation Management

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***Abstract*: This study has been conducted to evaluate the performance of Area Water Board and Farmers Organization regarding the water delivered to tertiary canals (distributaries) and its reliable supply at their tail ends. The performance of canal irrigation system was examined by using performance indicators such as delivery performance ratio (DPR), equity, reliability, and Tail-end supply ratio (TSR). In this connection Jamrao West branch of NCAWB has been selected and its three off-taking Bellaro, Mir and Potho minors. Data regarding gauge height of water supplied to these canals was collected. The discharges were measured, and Rating Curves were developed. This study reveals the reliability of water delivered to off-taking minors and performance of Mir Minor is "Good" in both seasons. Farmers Organizations are performing well as they are distributing the water among all stakeholders, especially to supply water at tail ends. Tail-end Supply Ratio has been computed for all three minors, which is mostly about 80%, and reaches to 92% for Potho minor. However, during walk thru survey, considerable outlets were observed as tempered, which needs improvement in governing the system.**

*Keywords:* **Delivery performance ratio, Tail-end supply ratio, Water availability.**

## I. INTRODUCTION

The irrigation system of Pakistan is one of the world's largest systems which were established in the middle of the nineteenth century under the British rule. The system was constructed on Indus river for diverting irrigation water to the country by the means of rivers, lakes and streams which dispersed into the barrages, dam's main canals, secondary canals, and from these canals to distributaries/ minors and lastly into the farmer fields. This massive irrigation network makes in-equitability in the distribution of water and this unfair distribution makes conflicts between provinces.

To make improvement in 1997, the government have established a self-sustaining participatory irrigation system in the country. These systems are committed to promote sustainable development and provide food security to the country. Aims and objective of establishment is to (i) delivery required quantity of water safe to the end users and (ii) organize the local community to take their due shares.

Efficient management of irrigation water is more important, as the new sources of irrigation supplies are scarce and new irrigation development work requires huge investments. Thus, optimum utilization of limited water resources is very important to attain the maximum beneficial use. The time may soon come, when additional irrigation supplies will only be possible through saving of water being lost in the present system [1].

The performance of an irrigation system refers to the efficient supply and distribution of irrigation water spatial and temporal scales where water is delivered to a sufficient location. The performance of the system is measured according to the setting criteria determined by some indicators. Many researchers [2], [3], [4] and [5] propose a delivery performance ratio (DPR). Information on discharge measurements can be used to calculate various performance indicators, such as efficiency; this term can be evaluated in different irrigation systems. The performance evaluation of the irrigation system must address the operational assessment of the information required by the system manager and enable it to manage and operate the system [6]. The performance of the integrated irrigation system can be judged by several indicators, such as water productivity, reliable water supply and fairness of water distribution at the canal level. In this paper, an attempt has been made to evaluate the performance of some selected distributaries of Jamrao West branch through developed rating curves, computing the delivery performance ratio and survey observation availability of water at from head to tail and computing tail end supply ratio.

## II. MATERIALS & METHODS

The study area is located at the Nara canal command under participatory irrigation management. The canal is located at tail end of Jamrao west branch. Jamrao West branch canal directly off-takes from Nara canal at the RD of 143, having five units such as Khadro, Jhole, Mirpurkhas, Kot Ghulam Muhammad and Digri subdivisions. Three distributaries of Digri subdivision were selected for this study. The FOs of these distributaries responsible for distribution of water among all stakeholders. Three minor distributaries are randomly selected, namely Mir minor, Bellaro minor, and Potho minor. The salient feature of these selected distributaries are as under:

*A. Discharge measurement*

Discharge was measured at the head of selected distributaries/minors by velocity area method. The flow probes a velocity measuring instrument was used in this regard to measure the discharge in the distributaries. After knowing the velocity of each section, the rating curves were developed to generate a discharge equation for each distributary.

Performance indicators such as delivery performance ratio (DPR), tail-end supply ratio and recovery cost ratios are used to measure the present condition of supply of irrigation water

**Table. 1 Salient Features of Distributaries.**

| S. No. | Name of Distributary | Parent Channel | Off-taking RD | No. of Water-courses | Design Discharge (cusecs) | CCA (acres) |
|---|---|---|---|---|---|---|
| 1 | Belharo Minor | Jamrao West Branch | 143.0 | 21 | 57.2 | 11344 |
| 2 | Mir Minor | Jamrao West Branch | 146.5 | 15 | 31.00 | 8062 |
| 3 | Potho Minor | Jamrao West Branch | 215.0 | 19 | 33.00 | 8392 |

*B. Delivery Performance Ratio (DPR)*

The DPR values for two seasons of Rabi and Kharif of 2016-2017 has been calculated. DPR of selected distributaries were calculated at their head to check the performance of the system. The availability of water and this DPR ratio at head of distributaries will provide the level of performance of Area Water Board at main or branch canal level. These values will display their performance regarding water delivered from the main or branch canal to its off-taking distributaries/minors.

$$DPR = \frac{Q_a}{Q_d} \qquad (1)$$

Where,

$Q_a$ = actual discharge in cusec

$Q_d$ = designed discharge in cusec

*C. Co-Efficient of variance*

The temporal co-efficient of variation is an indicator used to determine the variation in discharge at the secondary canals (i.e. distributaries/minors). It indicates the degree of variation of actual discharge from design discharge with respect to time. This indicator has been used by different researchers [7, 8]. In this paper, the co-efficient of variation (CV) has been determined for two seasons, viz. summer (Kharif 2016) and winter (Rabi 2016-17). The CV can be calculated using the following formula. Its performance level is described in Table 2.

$$CV = \frac{\text{Standard Deviation of Discharge}}{\text{Design Discharge}} \qquad (2)$$

**Table 2: Level of performance indicator**

| S. No. | Performance | Value |
|---|---|---|
| 1 | Good | 0.90 < CV < 1.1 |
| 2 | Fair | 0.70 < CV < 0.90 or 1.1 < CV < 1.3 |
| 3 | Poor | CV < = 0.70 or CV > =1.3 |

Source : Chris (1996) [9]

*D. Tail-end supply ratio*

Tail end Supply ratio is the ratio of availability of water supply at the tail in number of days to the total no. of days of water supply at the head of that distributary, has been computed. TSR is expressed as follows:

$$TSR = \frac{No.of\ Days\ sufficient\ Water\ Supply\ at\ Tail}{Total\ No.of\ Days} \qquad (3)$$

III. RESULTS

*A. Development of Rating Curves from Measured Discharge*

The discharge was measured for three-gauge heights. These discharge gauge relation (Q-H) reading were used to develop the rating curves equations for selected distributaries/minors of west Branch Jamrao Canal of Nara Canal Area Water Board. The developed equation are shown as follow (Fig. 1)

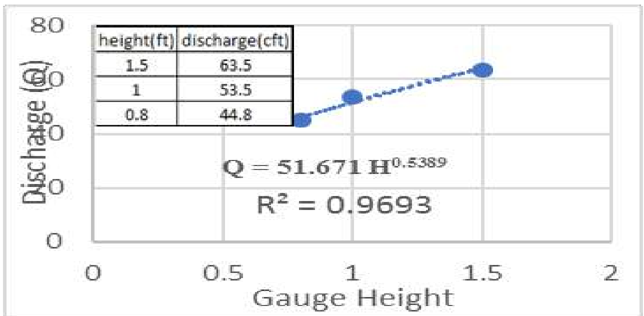


Fig. 1 Developed Rating Curve for the Bellaro Minor

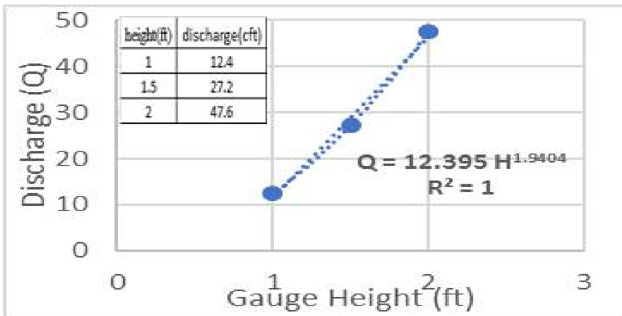


Fig. 2 Developed Rating Curve for the Mir Minor

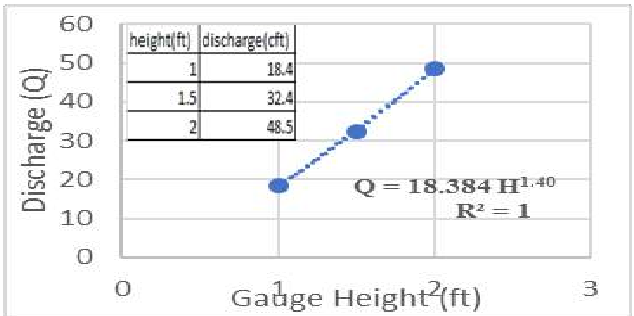


Fig. 3 Developed Rating Curve for the Potho Minor

## 1. *RELIABILITY AND EQUITY ANALYSES*

Reliability and equity has been analyzed for the available supply with reference to design discharge in all selected secondary canals. In this regard, the gauge heights at head of secondary canals (distributaries/minors) have been collected from participatory managed system (Jamrao West Branch of Nara Canal Area Water Board). In this section, initially water availability at head of distributaries were described from the observed/collected gauge height readings and computed discharges using developed rating curves. Then, average actual discharges were computed, delivery performance ratio (DPR) and coefficient of variation (CV) were also determined.

### 2. *Water Availability: Gauge Height Readings and Discharges*

Water availability in the selected distributaries has also been observed physically during field visits. The gauge heights at head of selected distributaries were collected from participatory managed canal system (Jamrao West Branch of NCAWB) from XEN offices of Mirpurkhas and Digri sub-division at Mirpurkhas. These gauge readings were collected for April 2016 to March 2017.

Using the developed rating curve equations of the selected distributaries, the discharges were computed for above mentioned gauge readings. Availability of water in number of days has been depicted and given in following Table 3. This show the actual discharge availability for the study period i.e. from 1st April 2016 to 31st March 2017.

**Table 3. Water Availability at Head reach of the selected distributaries/minors**

| S# | Water availability | Bellaro Distry | Mir Minor | Potho Minor |
|---|---|---|---|---|
| 1 | Water Availability (No. of days) | 233 | 261 | 196 |
| 2 | Water Availability (% of total 365 days) | 63.8 | 71.5 | 53.7 Minimum |

Table 4 shows the water availability at the head of the minors; observed maximum number of days was observed in Bellaro and Mir minor, these are getting 64 and 72% respectively whereas, Potho minor is supplying water for (196 days) out of 365 days i.e. only about 54%. It should be noted that for annual maintenance of barrages in Sindh, delivery of water at Sukkur barrage remain closed in the month of January for about 21 days (i.e. about 5.8%).

### *B. Delivery Performance Ratio*

Delivery performance ratio (DPR), ratio of actual discharge to the design discharge, is used to check the performance in terms of reliability of water calculated at the head of each selected distributary. These ratios were computed to evaluate the degree of performance of distributaries of canal of Sindh for Kharif 2016 and Rabi 2016-17. These values used to know the performance indicator which the average actual discharge is calculated using rating curve to the design discharge at the head of the distributary. The DPR values are noted in Table 4. Nara Canal receive more discharge 80-85% at the head of minors.
Figure 2 shows the DPR values of selected distributaries/minors for both seasons viz. Kharif 2016 and Rabi 2016-2017. The DPR values are mostly above than the line of equity (i.e. DPR = 1.0).

**Table 4. Delivery Performance ratio (DPR) of selected distributaries/minors**

| Canal System | Distributaries / Minors | Delivery Performance Ratio (DPR) | | Average DPR | Level of Performance |
|---|---|---|---|---|---|
| | | Kharif 2016 | Rabi 2016-17 | | |
| **Participatory Irrigation Management** | Bellaro Distry | 1.2 | 1.0 | 1.1 | Good |
| | Mir Minor | 1.5 | 1.4 | 1.5 | Poor |
| | Potho Minor | 0.4 | 0.8 | 0.6 | Poor |

From Table 4, it is concluded that Bellaro minor is performing good i.e. the discharges are as per design; where as Mir minor, and Potho minor having poor performance, i.e. either getting 30% more water or getting less than 30% water as per design.
It has been concluded that, Mir minor is only the minor which is getting 40 to 50 percent more water than that of the design. It has also been observed that this is the only distributary/minor, which mostly has reliable and sufficient water at the tail reach. The farmers are getting their due share at the tail reach. Hence, it is proposed that the distributaries be redesigned to supply the sufficient water to the stakeholders as their irrigation intensities are increased as has been pointed out by Ghumman et at. (2007).

*C. Co-efficient of Variance (CV)*

Co-efficient of variation (CV), measure of variability in discharge in any distributary/minor, depends on the water delivered from off-taking main or branch canal. Temporal co-efficient of variation depends on time. This is the variation of actual discharge with respect to design discharge of the distributary. The range of CV values are set by Molden and Gates (1990) [10]. They revealed that, if discharge variation is within ±0.1 (i.e. 10%) is considered as "Good". The coefficient of variation is "Fair" when it ranges between ± 0.1 to ± 0.30. However, greater values of variation of discharge from (± 0.30) is considered as Poor.

**Table 5. Co-efficient of variance (CV) of selected distributaries/minors**

| Irrigation System | **Distributaries / Minors** | **Coefficient of Variation (CV)** | | **Average CV values of Rabi and Kharif** | **Performance** |
|---|---|---|---|---|---|
| | | **Kharif 2016** | **Rabi 2016-17** | | |
| **Participatory Irrigation Management** | Bellaro Minor | 0.1 | 0.2 | 0.2 | Fair |
| | Mir Minor | 0.1 | 0.1 | 0.1 | Good |
| | Potho Minor | 0.1 | 0.1 | 0.1 | Good |

***D.*** *WATER RELIABILITY AT TAIL OF THE DISTRIBUTARY/MINOR*

*Water Shortage at Tail of Distributaries/Minors and Tail-End-Supply Ratio (TSR)*

In addition to water availability at head of the selected distributaries/minors, the survey was conducted to gather the actual position of tail ends of the selected distributaries. The tail gages have been observed in all three FO operated distributaries of Jamrao West branch; the gauge data was gathered from the XEN office, Mirpurkhas. However, no gauge was installed at the tail ends of selected distributaries/minors managed by Sindh Irrigation Department. This data was developed from the interviews of farmers and irrigation staff.

The Tail-end Supply Ratios (TSR) were computed using the formula given in eq. (3). From TSR, percentage of dry tails were also calculated (see Table 5)

**Table 5: Water Availability and Tail-end Supply Ratio of selected distributaries/minors**

| **Description** | **Farmers Managed Distributaries/Minors** | | |
|---|---|---|---|
| | Bellaro Minor | Mir Minor | Potho Minor |
| Water availability at head (no. of days) | 233 | 261 | 196 |
| Water availability at tail (no. of days) | 186 | 207 | 180 |
| Tail-end Supply Ratio (TSR) | 0.8 | 0.79 | 0.92 |
| Percentage of dry tails (%) | 20.17 | 20.69 | 8.16 |

The above Table 5 clearly displays availability of water at head and tail along with TSR and the percentage of dry tails. The percentage of dry tails is low i.e. (about 20 % or less) in farmers managed distributaries/minors

## IV. CONCLUSIONS

The delivery performance ratio (DPR), was computed to evaluate the degree of performance for Kharif 2016 and Rabi 2016-17. The DPR in selected FO distributaries varies from 0.4 to 1.5, which reflect an un-judicious water distribution by Area Water Board and shows that AWB fails in equal distribution of water among its distributaries/minors at the tail reach.

The Tail-End-Supply Ratios (TSR) value (varying from 0.79 to 0.92) for the selected distributaries of Nara Canal Area Water Board, it is concluded that FOs are performing well and managing the water at tail in spite of less discharge as has been observed at head in Potho minor.

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# Barriers in the Adoption of Sustainable Construction in Pakistan

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***Abstract*: Global Construction industry consumes 40 percent of the energy, 40 percent of raw materials and 25 percent of the available timber. It is also accountable for generation of 30 to 40 percent of solid waste as well as 35 to 40 percent of carbon dioxide emissions. Sustainable construction meets the anticipated performance as well as functionality by causing minimum destructive impact on environment on the other hand causing enhancement in social and economical aspects. The philosophy of sustainable construction is relatively new in Pakistan. The present study therefore is an endeavor to clear a path for the adoption of sustainable development in Pakistan. This study identifies the common barriers faced by the construction industry at global level through an extensive literature review. Further it explores the relevance of identified barriers with construction industry of Pakistan. It is envisaged that the outcome of this research will pave the way for smooth adoption of sustainable construction in Pakistan.**

***Keywords*: Barriers, Construction industry of Pakistan, Sustainable construction.**

## I. INTRODUCTION

In 55th session of United Nations general Assembly, it was resolved that substantial enhancement be brought in living standards of minimum 100 million people living in slums by year 2020 and also supply of clean water as well as enhanced sanitation be ensured at least for 50 percent of world's total population which is presently not availing these facilities '[1]. Undoubtedly there is a need of advancement on a more prominent scale in the built environment and its physical infrastructure in the rising nations, but this need must be addressed in a socially and ecologically sustainable way [2]. Socio-economic and environmental effects of construction industry is a key area of Sustainable development [3]. Harlem Brundtland defined sustainable development as the development which satisfies the current needs without effecting the capacity of future generations to accomplish their requirements [4]. Sustainable development can be regarded as a method to shift traditional construction industry towards the attaining sustainability, considering ecological and financial issues [5]. The social aspect of the sustainability encourages the up gradation of individuals' quality of life. The economic aspect resolves the economic matters such as business creation, jobs creation, creating high caliber of workplace environment which leads to higher outputs and numerous other factors. The Environmental aspect manages plan, development, functioning/upkeep and deconstruction approaches that limit the unfriendly effects on the earth such as air outflows, waste releases, utilization of water assets, land use and others. For rising the nations to seek sustainable development a two dimensional approach should have be embraced Firstly it is important to make a proficient & suitable local construction industry; secondly it is required to guarantee that construction industry can meet up with the needs of sustainable development [2] . The progress of the construction business from conventional guide towards sustainable development has drawn attention worldwide [6]. Encouraging this move is an extremely confound issue. Despite of the need and importance of sustainability, it is reported that the level of sustainability adoption in construction is not much satisfactory. Hence, several researchers have inspected main impediments and thrusts of sustainable development resulting in discovering a great sum of factors essential to encourage the adoption of sustainable construction [7]. Because of adequacy and developing interest of sustainable development, it has turned out to be important on all partners in the construction business to identify the barrier that prevail in its execution and in this manner think of measures to minimize those barriers [8] .

Like other countries, Pakistan is also observing a growth in economy, increasing population and growth in urban space. Inefficient management of natural resources as well as unplanned development has led to negative impacts on Pakistan's socioeconomic aspect as well as environment, particularly in urban space [9]. Sustainable construction meets the anticipated performance as well as functionality by causing minimum destructive impact on environment on the other hand causing enhancement in social and economical aspects [10]. This has motivated the author to conduct an exploratory study regarding sustainable development works in Pakistan. Focus of this paper was to uncover the barriers which have hindered the adoption of sustainable construction in Pakistan.

## II. LITERATURE REVIEW

Ametepy et al. in 2015 studied the barriers encounterd in the implementation of sustainability in the construction industry of Ghana. The sudy recognized and ranked the potentail barriers on the basis of their severity and proposed steps to overcome those barriers. Semi strucutred interviews and questionnaire survey as a method for data collection. Interviews were done among consultants and contractual workers where as for questionnaire survey were collected from 100 professionals associated with the field of Architecture, Quantity Surveying and Structural Engineering. Findings of the research outlined the five most potential barriers in the execution of sustainablity in construction industry of Ghana as social resistance to change, absence of government duty, dread of increased speculation costs, absence of information from experts as well a unavailability of legistlations. The authors indicated that their findings would empower the construction development industry to be fruitful in its journey as these findinsg will be helpful to expel potential barriers and enhance the adoption of sustainable development. The authors suggested the in order to shift the construction industry of Ghana towards sustainability, it is significantly important to evaluate the potential barriers and propose steps to conquer those barriers [8]. In 2015, Idris et al. proposed a framework focusing on promotion of sustainability in Malaysian Construction Industry. That research work involved quantitative as well as qualitative research. Initially a list consisting of 11 impediments identified through detailed literature review was developed. Later on, the authors conducted questionnaire survey among the developers regarding the relative importance of identified factors. Results obtained from statistical method of Relative importance index (RII) were used in qualitative mode of studies to confirm the most important impediments and suggest strategies to promote sustainable construction. This research work reported four impediments as major barriers which include issues related to finance, roles of government, unawareness and insufficient number of green product suppliers. This research work suggested that government has to play a key role in order to promote sustainable projects by ensuring supports in terms of finances as well as promotion of green product suppliers to stakeholder associated with construction sector [11].

Alsanad in 2015 carried out a study to exploring the opportunities to promote sustainable construction practices in Kuwait. The study indentified barriers to sustainable construction, drivers to encourage the implementation of sustainable construction practices, the present level of sustainable construction practices being adopted and the level of awareness & knowledge of sustainability in construction. Authors gathered data with questionnaire survey and analyzed data through descriptive analysis and inferential statistics. The study revealed low implementation of sustainable construction concept in Kuwait, remedial measures and strategies are required to encourage sustainable construction. The main barrier to the use of sustainable construction approaches in Kuwait found was lack of awareness. In that research it was suggested that Kuwaiti government must take initiatives to introduce policies, implement standards and provide incentives to promotion sustainable construction [12]. Serpell et al. believed that in order to create and complete a strategic plan to progress towards sustainable construction the fundamental aspects to be considered are economical and social conditions as well as general practices adopted by construction sector to shift towards sustainable construction. The study focused on studying the knowledge & awareness level, hindrances and driving factors of sustainable construction. Research outcomes demonstrated that construction organizations in Chile experienced the beginning period of their way to achieve sustainable construction. Their practices towards Sustainable construction were exceptionally relying on the size of organization and the primary business it is associated with. Potential barriers in the way of sustainable construction included absence of fiscal incentives, affordability; absence of an incorporated outline where as incentives provided in the form of tax reduction to an organization on the basis of its level of investment efforts on sustainable construction can be proved as a key administrative strategy to advance sustainability. Outcomes of carried this research can be termed especially valuable for different nations, especially emerging ones, and for government policy making [3] .Osman, Udin and Salleh in 2012 tried to study the current status of sustainable construction practices amongst the stakeholders of Malaysian construction Industry. They isolated the idea of sustainability into two alternate points of view which incorporate the sustainability associated with financial matters i.e. economical aspect and non-financial aspect of sustainability i.e. social and environmental aspect. Survey technique was adopted because the authors considered it as most proper research design to get in overview of social & individual, attitude and beliefs on a greater scale. They came on the conclusion that sustainability associated with financial matters was more broadly adopted than non financial sustainability. Häkkinen in 2011 endeavored to investigate the genuine barriers and driving factors of sustainable building. For that purpose, he conducted literature review, case studies and interviews. In the article the author proposed that lack of technological resources and evaluation methods are not obstructions for sustainable building, however it is rather plague with issue related to organization and procedures generated by application of new techniques[4]. Häkkinen trusted that latest technologies are opposed since they demand change in the process causing risks and unanticipated costs, such obstructions can be minimized by realizing what sort of basic leadership stages, new errands, performers, parts and methods for systems administration are required. The author delineated the Barriers as directing mechanisms, finances, lack of customer understanding, process (documentation, networking, cooperation and timing) and supporting information (comprehension & collective language, the accessibility of tools, methods and innovation). Additionally Häkkinen recommended that most essential activities to enhance sustainability requires the advancement and selection of techniques, sustainable building necessity administration, the activation of tools associated with sustainable building , advancement of creators' fitness & working in groups, and improvement of latest ideas and administrations[10]. Abidin believed that knowledge, awareness and understanding of outcomes of individual actions drive the momentum of steps to apply sustainability. Study consisted of two field studies, surveys and interviews utilized to investigate the knowledge, awareness level and execution of sustainable practices on the basis of Malaysian project developer's perception. It was realized that only large developers had started moving towards implementation of sustainability in their projects. Many developers were reluctant to pursue sustainability in their projects because of limited understanding and their distress about finances. It was reported that Government needs to play an important role to encourage constructors and developers and enhance the pace of sustainable construction practices [13]. Pitt et al. studied the factors which are significant to promote or hinder sustainability in the construction industry. Questionnaire survey helped to reveal the major barrier as “affordability”. It was suggested that financial incentives, regulations and fines enable to accelerate sustainable construction[14]. Shafii in 2006 tried to elaborate the situation and advancements occurred in the sustainable construction in Southeast Asia. Study revealed that sustainable construction in Southeast Asia was at earlier stage. Potential barriers for sustainable construction were outlined as absence of training and education, unawareness, ineffective systems of procurement[5].

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## III. BARRIERS IN THE ADOPTION OF SUSTAINABLE CONSTRUCTION

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It has been found that adoption of sustainable practices requires knowledge, awareness and interest of stakeholders. Sustainable construction practices are being adopted more frequently in bigger organizations as compared to small and medium sized organizations. A list of barriers has been identified which hinder the implementation of sustainability in the construction sector. Moreover measures to minimize the potential barriers are a fundamental and essential approach towards adoption of sustainable construction. Based on the review of previous research works, common barriers are listed in table 1 below.

Table 1: Common barriers to adoption of sustainable construction

| | | Reference | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Barriers | [15] | [16] | [17] | [18] | [19] | [20] | [21] | [22] | [8] | [12] | [23] | [24] | [25] | [26] | [3] | [22] | [10] | [27] | [28] | [14] | [29] | [5] | [30] | Frequency |
| 1 | Lack of knowledge, training and education in sustainable construction. | √ | √ | √ | | √ | √ | √ | √ | √ | | | | | √ | √ | √ | | √ | √ | | √ | √ | | 15 |
| 2 | Lack of Government Support i.e. Funds and incentives | √ | | √ | √ | √ | | √ | | √ | √ | | | | √ | √ | √ | | √ | √ | | √ | | | 13 |
| 3 | Lack of financial resources | | √ | √ | | | √ | | √ | | √ | | √ | √ | | √ | √ | | √ | √ | √ | √ | | | 13 |
| 4 | Lack of professional experts in sustainable construction. | √ | | √ | | √ | √ | √ | √ | √ | √ | | | | √ | | √ | | √ | | | | √ | | 12 |
| 5 | Lack of Public awareness | √ | | √ | | √ | √ | √ | √ | | √ | √ | | | √ | | √ | | | | | | √ | | 11 |
| 6 | Lack of technology to support sustainable construction | √ | | √ | | √ | | √ | | | | | | √ | √ | | | √ | √ | √ | √ | | | √ | 11 |
| 7 | The Perception of higher investment cost of sustainability | √ | √ | | | √ | | √ | | | √ | √ | √ | | √ | | | | √ | | | | √ | | 10 |
| 8 | Resistance to change from traditional construction practices. | √ | | | | √ | | √ | | √ | √ | √ | | | √ | | | | √ | | | √ | | | 9 |
| 9 | Lack of Building Codes and Regulation | √ | | √ | | √ | | √ | | | | | | √ | √ | | | √ | | | √ | | √ | | 9 |
| 10 | Lack of sustainability Measuring tool | √ | √ | | | √ | √ | √ | | | | | | √ | √ | | | √ | | | √ | | | | 9 |
| 11 | Lack of Clients Demand | √ | | √ | √ | √ | | | | | | | | √ | √ | | | √ | | | √ | | | | 8 |
| 12 | Risk associated with investment & new technologies and practices. | √ | | √ | | | √ | | | | √ | | | √ | √ | | | | | | | | | | 7 |
| 13 | Lack of marketing and promoting strategies. | √ | | | √ | | √ | | √ | | | | √ | | √ | | √ | | | | | | | | 7 |
| 14 | Lack of examples to demonstrate proven benefits. | | √ | | √ | √ | | | √ | | √ | | | | | | √ | | | | | | √ | | 7 |
| 15 | Lack of green products suppliers. | | | √ | | √ | | √ | √ | | | √ | | | | | √ | | | | | | √ | | 7 |
| 16 | Lack of Planning policy and Regulatory framework | | | | | √ | √ | | √ | | | | | √ | | | √ | √ | | | √ | | | | 7 |
| 17 | Lack of Database and integrated research | √ | √ | | | √ | √ | | | | | | | | √ | | | | | | | | | √ | 6 |
| 18 | Increased Documentation such as additional tendering and contract requirement | √ | | √ | | √ | | | | | | | √ | | √ | | | | | | | | √ | | 6 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | Lack of Clients awareness about sustainable construction | | | | √ | | | | √ | | | | √ | √ | | | | √ | | | √ | | | | 6 |
| 20 | Higher investment and initial cost. | √ | | √ | √ | | | | | √ | | | | | √ | | | | | | | | | | 5 |
| 21 | Lack of legislation to enforce and monitor sustainable construction. | | | | √ | √ | | | √ | √ | | | | | | | √ | | | | | | | | 5 |
| 22 | Lack of cooperation amongst construction practitioners. | √ | | | √ | √ | | | | | | | | | √ | √ | | | | | | | | | 5 |
| 23 | Uncertain economic conditions | | | | | √ | | | | | √ | | | | | √ | | | | | | √ | | √ | 5 |
| 24 | Low priority of sustainable projects. | | | | | √ | √ | | | | √ | √ | √ | | | | | | | | | | | | 5 |
| 25 | Lack of capacity of local construction industry | | | | | √ | √ | | | √ | | | √ | | | | | | | | | | | √ | 5 |
| 26 | Lack of business case understanding | | | | | √ | | | | | | | √ | √ | | | | √ | | | √ | | | | 5 |
| 27 | Unstable political situations. | | | | | √ | | | | | | √ | | | | | | | √ | | | √ | | | 4 |
| 28 | Lack of trust amongst construction practitioners. | | | | | | √ | | | | | | | | | | | | √ | √ | | √ | | | 4 |
| 29 | Incremental time | | | | | | | √ | | √ | | √ | | | | | | | | | | √ | | | 4 |

## IV. SUSTAINABLE CONSTRUCTION IN PAKISTAN

Interviews were conducted in order to determine the relevancy of the barriers of sustainable construction to the Pakistan. For these 12 randomly selected practitioners of construction industry were interviewed and asked to select the barriers from above 29 common barriers occurring globally as identified from review of research work as in table 1. The characteristic of the panel participating in interview is as in table 2.

Table 1: Common barriers to adoption of sustainable construction

| S. No | Expert | Type of Organization | Experience (years) | Working Position |
|---|---|---|---|---|
| 01 | Expert A | Client | 21 or above | Additional Director |
| 02 | Expert B | Client | 21 or above | Executive Engineer |
| 03 | Expert C | Client | 21 or above | Executive Engineer |
| 04 | Expert D | Contractor | 21 or above | Chief Executive |
| 05 | Expert E | Consultant | 21 or above | Procurement Manager |
| 06 | Expert F | Contractor | 21 or above | Owner & Chief Executive |
| 07 | Expert G | Client | 16 – 20 | Assistant Director |
| 08 | Expert H | Client | 11 – 15 | Executive Engineer |
| 09 | Expert I | Client | 11 – 15 | Executive Engineer |
| 10 | Expert J | Consultant | 11 – 15 | Team Leader |
| 11 | Expert K | Contractor | 06 – 10 | Site Engineer |
| 12 | Expert L | Client | 06 – 10 | Assistant Agriculture Engineer |

From table 2 above, it is observed that all the participants have significant experience of working in construction industry. They were holding leading positions in their relative organization. The respondents represented the key stakeholder of construction sector which include client, consultant and contractors. During interviews all the respondents endorsed that all the 29 factors identified in table 1 are relevant to construction environment of local industry. Hence it was summarized that all 29 barriers are relevant barriers which affect the adoption of sustainability in construction project of Pakistan.

## V. CONCLUSION & RECOMMENDATIONS

Sustainable construction has been gaining great interest of construction stakeholders around the Globe. However its adoption is hindered by various factors in developing countries. In order to facilitate the smooth adoption of sustainable construction, it is extremely important to identify and address the potential barriers which hinder the adoption of sustainable construction; the main contribution of this study is to identify the relevant barriers in the context of construction industry of Pakistan. Literature review revealed 29 common factors occurring globally in affecting the adoption of sustainable practices in construction projects. Expert opinion of 12 senior construction practitioners of Pakistan were sought to determine the barriers in adoption of local construction industry. From finding it was summarized that all the 29 barriers are relevant to construction industry of Pakistan. These factors can further be investigated to assess their occurrence level and impact level in affecting the adoption of the sustainable practices in construction projects of Pakistan.

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# Identification and Role of Various Stakeholders in Earthquake Disaster Mitigation

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***Abstract*: Since last few decades there is substantial increase in the urban population of developing countries. In these urban populations, there are cities having fragile infrastructure and vulnerable buildings. A major earthquake in one of the vulnerable cities can cause huge human and financial loss. As compared to developed countries, earthquake risk is more and rapidly increasing in developing countries. The history of earthquakes in the Indo-Pak region reveals that this region has faced devastating earthquakes time to time. The recent earthquake in Pakistan (October 08, 2005) caused collapse of many structures and unprecedented loss of human lives. Various stakeholders have an important role in earthquake disaster mitigation. This study identifies the level of importance of different stakeholders in earthquake disaster mitigation. Level of importance was obtained through questionnaire survey and statistical analysis by using average index method. The study explores that Engineers, Scientists, City & Regional Planners, Disaster Management Authorities, International Scientific Organizations, Hospitals and Media can play an important role in earthquake disaster mitigation at pre and post earthquake levels. In the end, the study also highlights the role of important stakeholders in earthquake disaster mitigation.**

***Keywords*: Earthquake, Disaster mitigation, Stakeholders, Pakistan.**

## I. INTRODUCTION

More than one million earthquakes are recorded every year around the world. Some of those are very small in magnitude. Whereas others are so dreadful that affect communities [1]. A number of health issues arise due to the earthquake such as respiratory infections, measles etc. The disaster interrupts ongoing healthcare delivery, damaging health system [2]. In 2005 more than 100,000 deaths were recorded. Approximately 138,000 people were injured and more than 3.5 million rendered homeless reported from earthquakes in the past years [3]. Stakeholders are those individuals and organizations that literally have a stake in the outcome of the community risk management process. They may be directly responsible for reducing a specific community risk. The primary aim of stakeholder identification is to name all those who could and should have a stake in a planning and management process [4]. Science or engineering cannot prevail over natural hazards/disasters alone. All disciplines should work together for defeating every natural disaster - from research scientists who attempt to predict earthquakes, to engineers who design structures that can withstand shaking ground, to rescue teams and emergency service personnel, to health practitioners who develop advance plans to treat the injured and the threats of disease to survivors [5].
World has faced earthquakes time to time. These earthquakes have caused huge human and financial losses. The population of developing countries like Pakistan is rapidly increasing especially in urban areas. On the other hand, due to less resources and poor economy the quality of constructions is also affected. This consequently increases the probability of losses in the event of earthquakes. Technology has developed considerably in the recent times. But technology is just one element of Earthquake Disaster Mitigation. Once technology has developed it needs institutions and people to implement workable solutions. This study therefore highlights the role of various stakeholders in Earthquake Disaster Mitigation and focuses on the management aspects.

## II. RESEARCH OBJECTIVE

The main objective is to identify and rank important stakeholder in earthquake disaster mitigation further this research also attempts to highlight the role of identified stakeholder in earthquake disaster mitigation.

## III. RESEARCH METHODOLOGY

To carry out this research work a mixed methodology was used which includes initial discussion with experts, literature review related to earth quake disaster mitigation. Unstructured interviews were carried out from concerned professionals to finalize the questionnaire. The data was collected through questionnaire from relevant stakeholders who include public sector clients, construction supervision and execution professionals, NGO's, medical institution and media representatives.

## IV. DATA COLLECTION

In this research, the data was collected through questionnaire survey. Out of 60 targeted Participants, 46 questionnaires were successfully collected. As depicted in Figure 1, sixteen (34.8%) respondents were clients, twenty (43.47 %) respondents were construction supervision and execution professionals, whereas ten (21.74%) respondents lie in the category named as 'others' shown in figure 1.

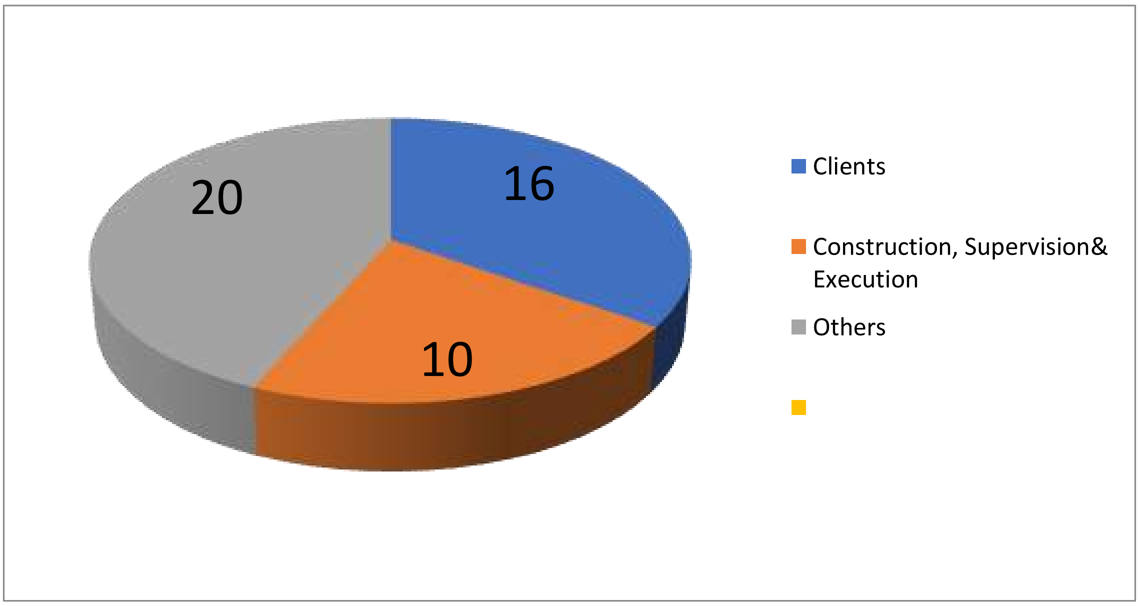


Fig. 1: Data Collection

## V. Analysis of Data and Results

As discussed earlier, Questionnaire survey has been carried out to achieve the main objective. Likert scale was used in the collection of data. The data was analyzed by using Average Index Method. The significance level of different stakeholders who can contribute in earthquake disaster mitigation at pre-and post-earthquake level were worked out. Table 1 depicts the rank and mean value of identified stakeholders:

Table: 1 Rank of Stakeholders

| S. No | STAKEHOLDER | Mean Value | Rank |
|---|---|---|---|
| 1 | Engineers, Scientists, City & Regional planners (Their Role in Providing Quality of Services in theirown Domains). | 4.737 | 1 |
| 2 | Disaster Management Authorities e.g. = Federal & Provincial Disaster Management Authorities (FDMA & PDMA) Responsible for Emergency Services. | 4.727 | 2 |
| 3 | International Scientific Organizations/Frameworks Contributing to Earthquake Risk Reduction e.g. = Global Hazards Information Network GHIN, Earthquake Engineering. | 4.474 | 3 |
| 4 | Hospitals. | 4.474 | 4 |
| 5 | Media. | 4.263 | 5 |
| 6 | International Community e.g. = International Donor Organizations like World Bank, UNO & Asian Bank. | 4.263 | 6 |
| 7 | Rescue Services e.g. = Fire Brigade, Mobile Hospitals, Ambulances. | 4.579 | 7 |
| 8 | Consulting Organizations e.g. = Design Supervisions, Consultants. | 4.053 | 7 |
| 9 | Policy Makers e.g. = Government institutions like National Assembly - Senate & Different Ministries. | 4.421 | 8 |
| 10 | Community Based Organizations & NGO. | 3.947 | 9 |
| 11 | Higher Educational Institutions e.g. = Universities &Their Role in Providing Quality in Technical & Managerial Education. | 3.789 | 10 |
| 12 | Government Development & Management Departments e.g. = Works & Services Department, Development Authorities like (KDA, CDA, HDA). | 3.684 | 11 |
| 13 | Main Contractors e.g. = Mostly Engaged in Management for Construction Works. | 3.737 | 12 |
| 14 | Law Enforcement & Defense Authorities e.g. = Police, Army. | 4.211 | 12 |
| 15 | Individual/Owner of the Property Responsible for the Construction of their own Buildings/Houses. | 3.632 | 13 |
| 16 | Sub-Contractors e.g. = Mostly Engaged in Execution for Construction Works. | 3.579 | 14 |
| 17 | Materials Suppliers e.g. = Engage in the Supplying of Construction Material. | 3.737 | 15 |
| 18 | Educational Institutions e.g. = Schools, Colleges & Their Role in Earthquake Disaster Mitigation. | 3.421 | 16 |
| 19 | Private Construction Builder e.g. = Engaged in Construction of Private Buildings. | 3.368 | 17 |
| 20 | Maintenance Departments e.g. = Municipal Corporations & Town Committees. | 3.211 | 18 |

Table 1 indicates that Engineers, Scientists and Regional planners have very important role in earthquake disaster mitigation with a mean value of 4.737. Disaster Management Authorities, International Scientific Organizations, Hospitals and Media are other important stakeholders who have been ranked significantly higher with mean values of 4.727, 4.474, 4.474 and 4.263 respectively.

## VI. Significant Stakeholders and their role in earthquake disaster mitigation

The role of top five stakeholders as identified in this study is discussed below:

### *A. Engineers, Scientists, City & Regional Planners*

Engineers, Scientists, City & Regional Planners can play their role in earthquake disaster mitigation at pre-and post-disaster level. At Pre-Earthquake level the engineering has great approach in different features of earthquake like resistant structures, convince multiple clients for different projects, Designing earthquake resistant building structures, and the seismic assessment of buildings and its mechanism and Improving existing buildings and infrastructure facilities according to upcoming earthquake disaster. At Post-Earthquake level, in developing world the different strengthening techniques and repairs methods must be used for identifying the damaged dangerous structures.

### *B. Federal and Provincial Disaster Management Authorities*

Federal and Provincial Disaster Management Authorities can play their role in effective Earthquake Disaster Mitigation by implementing the programs based on preventive measures at pre-earthquake level and should develop the post disaster strategies based on past experience and situation analysis. These strategies should be designed to protect human and financial loss.

### *C. International Scientific Organizations*

International Scientific Organizations can play their role in Earthquake Disaster Mitigation by sharing the technological developments with affected countries and start technical projects which help in assessment of risk and the methods to mitigate the risk.

### *D. Hospitals*

Hospitals can play their role in Earthquake Disaster Mitigation by providing them a good supervision of available hospitals and current hospital resources and main body, faculty which can wholly improve the awareness for earthquake disaster.

### *E. Media*

Media can play vital role in Earthquake Disaster Mitigation by enlightening the community about disasters, it warns people about different hazards, collecting and transmitting information about the warning of hazards, gathering and transmitting information about bumped areas, alerting government officials, relief organizations, and the public to specific needs, and facilitating discussions about disaster preparedness and response. At Pre-Earthquake level media can contribute in: Promoting information and alternative programs for general and counseling different government organizations in identifying existing hurdles, their possible causes and removal and serious reviews on research directions, education and course of actions. At Post-Earthquake level contribution of Media includes: Special news bulletins and programs related to happenings; Highlights of mitigation techniques; and Realistic reporting and highly professional journalism.

## VII. Conclusion

This study has identified the main stakeholders who can effectively contribute in earthquake disaster mitigation. Important stakeholders as identified in this study are: Engineers, Scientists, City and Regional Planners, Disaster Management Authorities, International Scientific Organizations, Hospitals and Media. The importance of the role of above mentioned stakeholders in earthquake disaster mitigation is also discussed. Based on the discussion it is concluded that effective role of important stakeholders will significantly help in reducing the losses which usually occur because of earthquakes in developing countries like Pakistan.

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# Women in Construction Industry of Pakistan- Roles Challenges, Opportunities and Trends

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***Abstract*— Construction Industry of Pakistan is lagging behind as lack of skilled workers is becoming a local problem, this gap can be filled in by women- working in partnership with men. This infusion of women, in the construction industry sector is not easy as there are some barriers hindering their entrance such as, gender-based discrimination, the harsh work environment of the construction site, lacking adequate knowledge regarding construction site and shortage of successful women in construction as role model. This paper identifies the role of Women in construction industry and the prevailing challenges faced by them. This study also highlights the present opportunities that can be availed by women.**

**Keywords: Women role, Construction industry.**

## I. INTRODUCTION

Construction sector is the world's largest industrial employer with seven percent of total world employment and 28 percent of industrial employment [1]. Men have been found dominating the construction industry, which however is going in their own loss. Men are preferred over women hiring, as women are deemed to be shy at times and less supportive and less competitive. In Pakistani region, Women are often hired for cumbersome tasks of which they do not get enough pay. This lack of trust and gender-based discrimination is demoralizing the attitude of women in any industry. Pakistani construction industry is male dominant and women play a back-stage role. In this new century, keeping in view the increased female population, there is a dire need for the construction sector to look into the matter and utilize the efficient and effective women for the rise and development of construction industry.

The previous trend shows how women has been labeled as 'foolish, emotional and unskilled workers' and hence was usually sent to the bottom-end of the company or were left invisible as a head-load carrier. The emerging trend seems welcoming to the women, as women has proved their presence and competence globally and have been successful in acquiring the positions once they only dreamed of. The scope of this study is to pinpoint the factors hindering or supporting the position of women in construction profession of Pakistan, through an interview-based survey. In this report, the challenges, opportunities, roles and trends of women have been discussed in detail as to learn the factors that contributed to the obstacles faced by women towards the way of construction industry and how they unblocked it.

## II. LITERATURE REVIEW

In India it is estimated that up to 30 per cent of workers in construction industry are women [1]. Several researches have recognized the fact that there is a gender inequality in workplaces and that those are usually more unadorned against the women. A study observed for various issues of inequality due to gender and found out that women face problems related to work such as wage discrimination, gender and sexual harassment and unhealthy job relationships [2].

Men and women perform differently on the different tasks. This variance can be attributed to a degree to their sex. Women are employed in the construction industry where there are lighter construction trades and are not engaged in significant numbers in trades containing more laborious tasks. A very less information is available on active recruitment of women. According to many studies, it is still indecisive to the successful recruitment of women in the construction industry. This is due to the lack of training and recruitment programs for women and also a dire need of creating the atmosphere for women to work with respect among the men experts at the industries part. The industry needs to look more closely at what benefits there are for women to enter the construction industry, both for themselves and for the companies in which they will effort. So many questions like how the industry will hire women with such atmospheres at workplaces and what hindrances there are for women who are entering the construction industry must be focused including presumptions, internal barriers, and external barriers and which successful strategies should be followed in hiring and retaining women employees in the construction industry. In 2007 a study was carried out which declared that 18 women-owned construction companies comprise more than 12% of the market [2]. A frequent number of women has concluded that a career in construction industry will provide them with better opportunities like higher wage rates of construction commonly attractive to the women with children. It has been found by the researches that on average, women worked longer and did more work, completed more work which was considered to be correct and the work was more effective and efficient than men hitherto they are not rewarded or esteemed for their work which produces the feelings of uselessness and insecurity [3].

Gender discrimination at workplaces can prove to be detrimental for the organizations as well as the country. It has been observed that the gender variances in hiring, gender biasness in up gradation and gender disparity in provision of goods and facilities have adverse impact and a negative relationship with productivity and efficiency of the workers [4] (Abbas, 2011). Women limits to work in construction industry as it doesn't involve as such qualifications. Moreover, women are not given an opportunity to be casually trained like men hence they lack capability to compete as men do [5]. Women may be shying away from employed in the construction industry because of presumptions about the work. Ordinarily, women's lack of attentiveness in male blue-collar work, such as construction, has been accredited to either socially developed partialities for sex fitting occupations and/or the result of men's behavior with women who do enter these nontraditional occupations [1].

A little is acknowledged about the role of women in construction industry and the factors hindering the equal occurrence of men and women, despite wide contribution of women in science and engineering. Among the common barriers are social acceptances of employment, sexually-inappropriate occupation, sexual discrimination, sexual irritation, physical incapability, outright for blue-collar jobs and labor conditions such as extreme weather, unfavorable work-hours and experience to risks. Contrary, there have been few studies concentrating on factors influencing women entry into construction and what their prospects are. The participation of women in the building sector is an exception rather than a rule. In most countries of the world the building industry is almost exclusively the domain of men.

In India a large number of women are enthusiastically involved in the construction process itself. In spite of their large numbers, women construction workers are seen as secondary/ fleeting workers with rarely any chances for training, upward mobility, wage assurances, fringe benefits or social protections [1].

### A. OBJECTIVES

The objective of the study is to determine

- the prevailing roles and trends of women in construction industry,
- Challenges and Opportunities faced by women with regard to their presence in construction industry.

## III. METHODOLOGY

This research was undertaken to inspect the deemed trends, roles and challenges of women in construction industry of Pakistan-more specifically Karachi with regards to their job and working environment. It was suggested by an expert, to conduct interviews for collecting required data. Potential recipients of the survey were then considered, and a list of contact information was compiled, the target interviewees were from contactors, consultants, Estimators, Construction Management firms and Designing firms.

The sample selection used in this survey comprised of all kinds of employee positions ranging from junior to senior or in other words bottom- to top level hierarchy. It was decided that the interview would be conducted from women specifically, as men could have been biased. A total of 10 respondents were interviewed from 8 different firms, the mode of interviewed varied from person to person. Interview modes varied from calls, in-person and email-based interview. Initially 20 working women were targeted but unfortunately could not get response from more than 10 women. These women were approached through direct/personal contacts as well as indirect/professional contacts.

This interview-based survey took nearly three weeks to complete as of the packed schedule and time constraints of the respondents. The project team visited the firms, made an interview call but, in the end, found that face-to face interview was highly effective as people were found to be quite responsive and the details could be given to them right at the moment as to why this survey has been organized and how could it effect the status of women in construction industry of Pakistan.

The results of the interview were analyzed manually by evaluating the response based on higher weightage, and hence graphical and tabular representation was made.

## STUDY DESIGN

An interview-based survey was designed to recognize the main objectives of the paper to obtain qualitative information on roles, challenges, opportunities and traits of a women working in the construction industry of Pakistan. The first part of survey was based upon the demographic information about the interviewee and the construction company being surveyed, the questions being asked in the first part were as name, age, experience and position of the interviewee including name of the company, ratio of female employees, highest positioned women in the company, their specialization and region where does the company serve. The second part of the survey about the recruitment of female employees in that company, whether any policy for hiring the women is being followed or not and is gender considered while assigning any work. After that some questions were curtailed with the expert advice and literature review to meet the proposed objectives of the paper those were:

## IV. DATA ANALYSIS

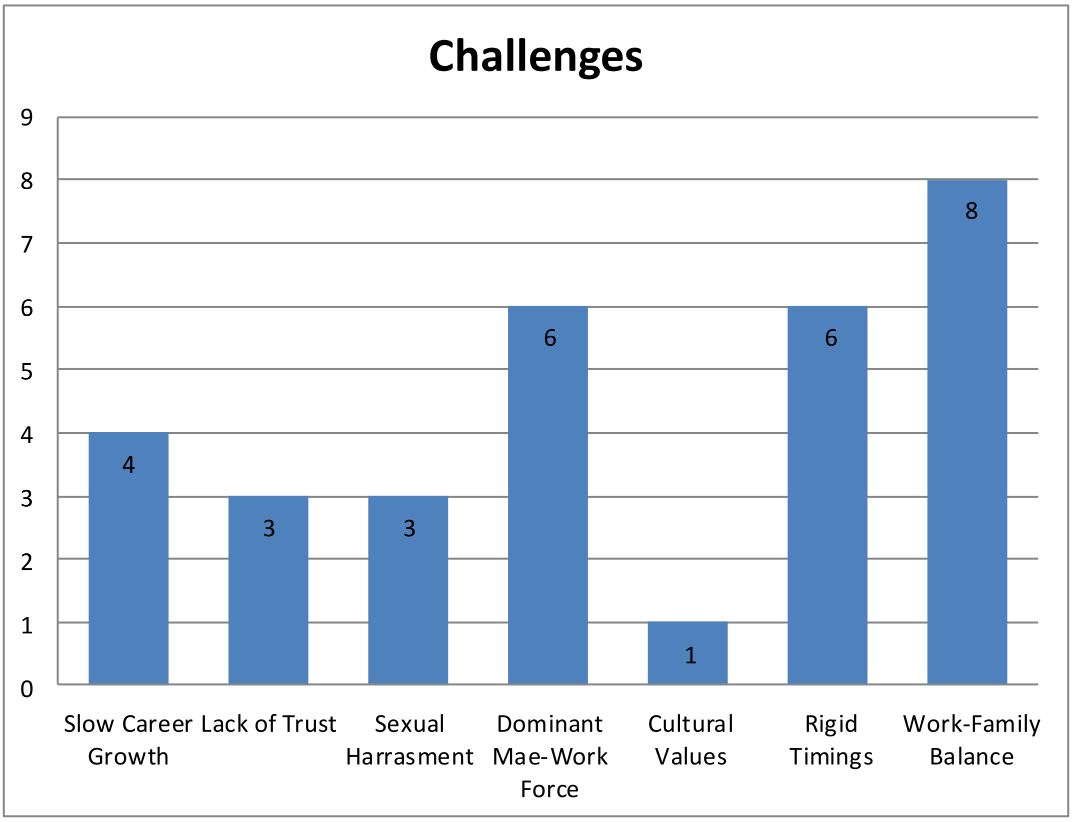
The first part of each survey was designed to collect demographic information about the respondent and the company being surveyed. Female interviewees at different positions from different construction companies were interviewed for the questions mentioned in the study design. They were asked for the highest position of a female employee in their company and their own current role as mentioned in Table 01. And these roles varied from the top management to trainee.

| **Table 01 Position of Working Women in Construction Industry** | |
|---|---|
| Highest Position Assigned to the women in the Respondents Firm | Respondent's Job Position |
| Project Manager | **Architect** |
| Planning Engineer | **Quantity Estimator** |
| Chief Executive Officer | **Junior Design Engineer** |
| Senior Structural Engineer | **Research Assistant** |
| General Manager | **Trainee** |
| Design Engineer | **Design Engineer** |
| Senior Structural Engineer | **Trainee** |
| Contracts Engineer | **Tender Estimator** |
| Head of the Department | **Planning Engineer** |
| Senior Planning Engineer | **Cost Estimator** |

## V. CHALLENGES FACED BY WOMEN IN CONSTRUCTION INDUSTRY

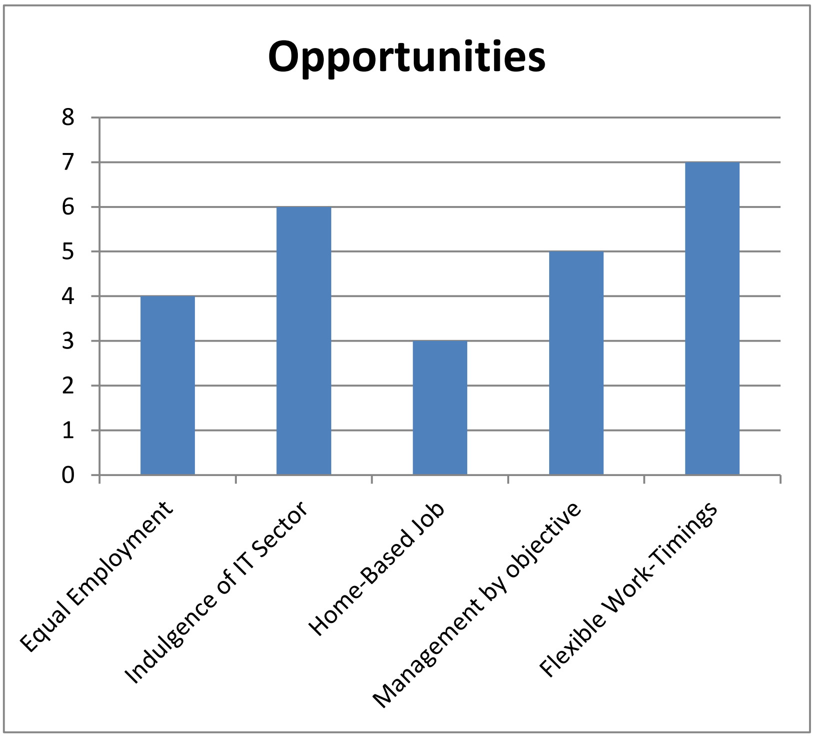
After that another category was filled by them in which they were asked to tell for the challenges they have been facing since they have started working in the construction industries (either generally or specifically observed challenges).

It was observed that work-family balance factor where women has to look after her family and work together becomes difficult for her to tackle and to maintain a balance between the two, remained at the top and after that rigid timings like late night shifts and male dominancy factor which is observed in most the construction and even other companies of Pakistan was highlighted. Moreover, the factors like slow career growth, lack of trust, cultural values and sexual harassment were also taken into consideration and discussion.




## VI. OPPORTUNITIES

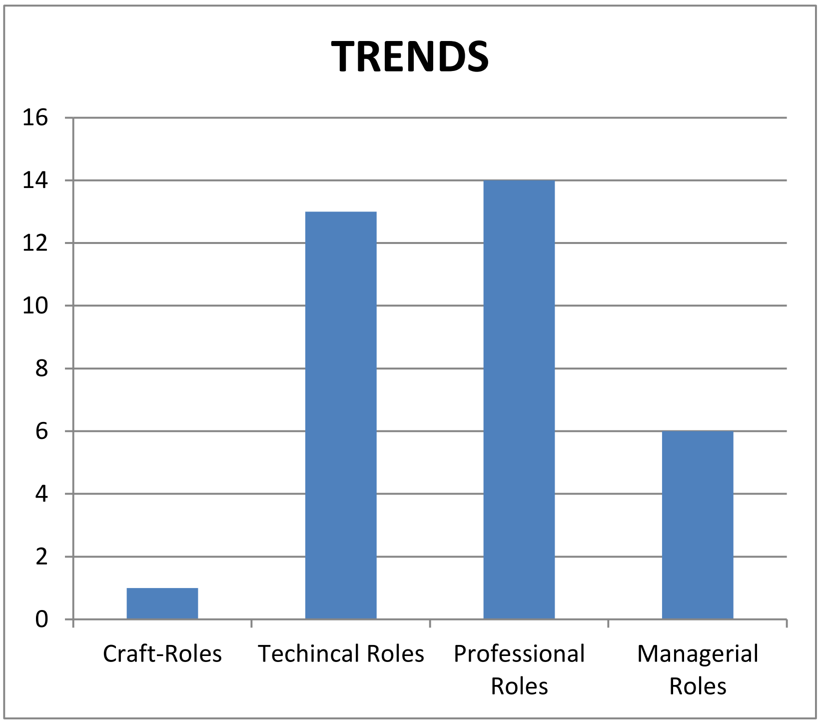
While asking for the opportunities they have gone through, the highest considered opportunity was flexible work timings as most of the firms are now taking this factor into account to facilitate the women so that they can easily tackle the problems. Indulgence of IT sector has increased which has also produced a chance for women to work at home as well and a office based work concept. Management by objectives, where the firm's objectives are made clear to the employees and then they are left to work for it in their own ways, this strategy has worked for the women in most of the sectors where they can have a balance for family and work. It has also been observed that women and men are working shoulder to shoulder in a single platform having equal rights and facilities.

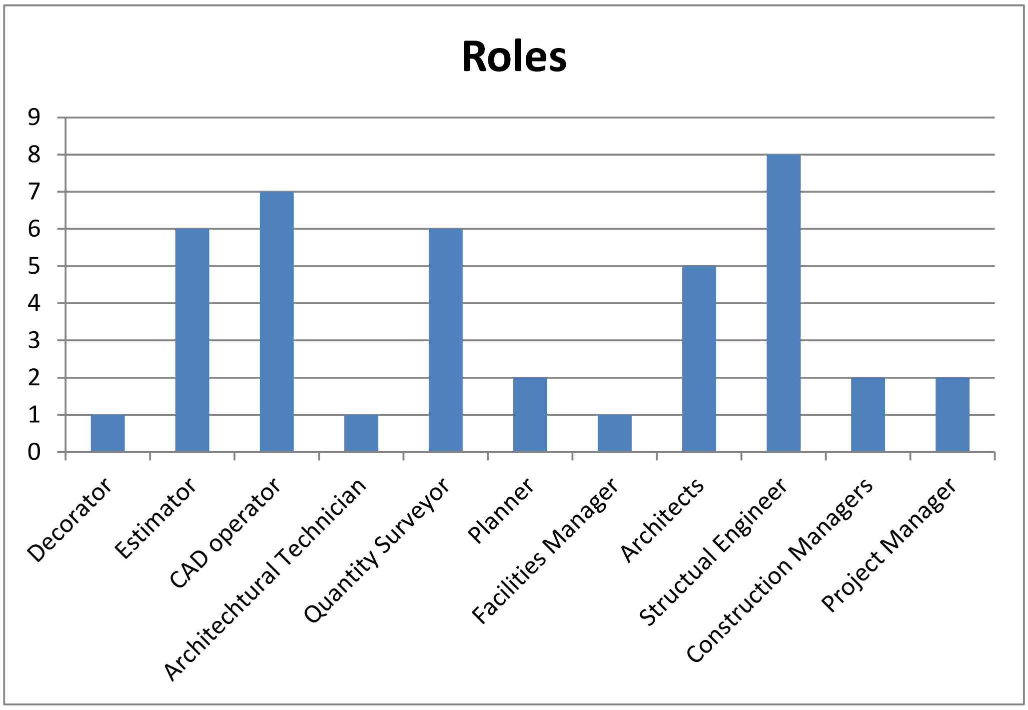



## VII. TRENDS

They (interviewees) were asked to tell about the trends they have been observing for women being in construction industries as what are the roles which have remained most common for them.

After observing the responses, it was analyzed that professional roles like Architecture, Quantity Surveyor and structural engineer are mostly occupied by the women of Pakistan. After that they closely prefer to go for the technical roles like CAD operator and estimator. Very few women were observed with the occupations like Architectural technician, project managers, facilities managers, planners, construction managers (managerial) and decorators (crafts).




## VIII. CONCLUSION AND RECOMMENDATION

The idea of this research began, when there was a need of skilled employment in construction industry rather than wrong hiring of non-relatable people. This research shows that construction industry fears to recruit women in their companies as if they are having no surety about their job sustainability. It is not discrimination all the time as most of the time they find that women lack the potential.

It was also found that Pakistani construction industry has a trend of women construction engineers as Structural Engineer as it is an office job, and they have to spend their job time in an enclosed area.

The study also shows that the construction industry is having women working in top level managerial post however are too low. But a part of that we cannot claim their lack of trust as these respondents have done well that they are compatible with the prevailing positions. The respondents vary with the experience and firm operation and thus we cannot clearly defend our points. Further studies on this topic need to be done with larger no of responses.

Some recommendations are suggested as follows:

- Think of gender differences as a positive advantage and should focus on finding skilled labor force.
- Training Programs must be initiated.
- Women must be given task-oriented job.
- Further research/study would help in identifying the traits.

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# State of Awareness with LDA Building Regulations in Lahore and Strategies to Ensure Better Compliance

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*Abstract:* **Building regulations are meant to ensure safe, healthy and conducive environment for the inhabitants. In this context planning authorities are responsible for ensuring effective compliance of these regulations. The general perception is that people do not comply fully with building regulations due to lack of awareness. Based on interviews with the concerned officials of Lahore Development Authority (LDA) and selected residents of approved housing schemes, this study explores the state of awareness of building regulations and identifies factors that contribute to non-compliance. The study found lesser incidence of violations of building regulations in co-operative housing schemes as compared to public and other types of private housing schemes. This is mainly because co-operative housing schemes have their own management playing the role of a watchdog to ensure compliance. The paper also suggests ways to improve awareness as well as strategies for ensuring better compliance with building regulations.**

*Keywords:* **Building regulations, Housing schemes, Lahore development authority, State of awareness.**

## I. INTRODUCTION

Building regulations are as historic as man's evidence on the Earth. The ways of strengthening the built structures kept on changing from caves to houses, multi-story plazas to under water structures etc. Each structure is constructed for a purpose and the best purpose can be served when the building is constructed by following proper building regulations which have evolved over centuries-old tradition [1]. The key motivation behind formulation of building regulations is to give a safe, healthy and conducive environment to the inhabitants. They provide a framework of flexible functional requirements within which buildings can be designed and constructed. The role of building control is to help ensure that all relevant building work accords with these objectives. At the same time this service should be cost effective and efficient so as to avoid delays in construction [2]. Building regulations are made under powers provided in the Acts or Ordinances and are implemented to the controlled area of the relevant authority. They set out the procedures to follow when starting, carrying out, and completing building works. Regulations also specify the standards that the individual aspects of building design and construction must meet to ensure health and safety of building users as well as energy conservation.

Review of literature suggests that several factors influence on effective implementation of building regulations including: political interests [3], lack of considering affordability level of the communities [4], absence of public participation in decision making process [4], and lack of awareness about building regulations [5]. Low level of awareness among the people leads to lack of sense of ownership of regulations and hence less effective compliance. Tantamount to that, household size and income have significant impact on the level of compliance with the building regulations [6]. Generally, the low-income families with large household size have low level of compliance. However, reference [7] found that the rate of violations of some specific provisions of building regulations, (e.g. floor area ratio) was high among higher income families. It was also found that "…the lower the level of awareness was, the higher the frequency of the violations became. Interestingly, those who had a lower level of awareness also had stronger economic motives for committing violations" p.231 [7].

Lack of awareness regarding building regulations and small economic gains in terms of covering more floor area or adding additional floors beyond the approved plan becomes a dilemma in a society which can cause ill impacts of development and loss of human lives. This happened in Bangladesh where the Rana Plaza factory building "…generated global headlines as survivors and bodies were pulled from the rubble where the building once stood in Savar, a sub-district outside the capital city of Dhaka. The collapse of the eight-storey complex killed over 1,100 people and injured 2,500 more… It later emerged that the multi-storey building itself had been constructed a number of storeys higher than approved and was also not engineered for the industrial machinery and numbers of people working there. Although charges were brought against several people based on negligence, this tragedy highlights wider legal issues, such as a lack of building codes and failures in the enforcement of existing codes." [5].

Similarly, the lack of public accountability among the officials regarding development also takes place because of lack of awareness. There are laws and regulations available regarding the whole system, but people are not fully aware about the system and their rights. If the community has all the awareness, there would be more of accountability of officials and they will work in a better way for the welfare of the society in any case. Such service will add to the overall development perspective of the communities. The use of media can be powerful tool to this end since media is considered to have a pivotal role in developing and in enhancing public dialogue [8], [9], [10], [11].

In Lahore, the second the largest city of Pakistan with a population of 11 million, the Lahore Development Authority (LDA) as the principle planning agency framed building regulations with the view to ensuring safe and healthy environment for the inhabitants within its jurisdiction [12]. However, one of the key issues the LDA has been facing in respect of building regulations is related with proper enforcement. Often it has been observed that people intend for house building without the consent of the LDA. Raising awareness about the building regulations and the benefits likely to be accrued can possibly help improving their compliance. In this context, LDA has been using different tools with the view to enhance awareness and ensure better compliance with building regulations. How far these tools are contributing to raising awareness is yet to be explored thoroughly. Some studies in the past have been conducted, for instance reference [13] on the topic of building regulations, but none focused on identifying the role of awareness raising in better compliance with building regulations. This study aims to fill this gap.

## II. MATERIALS & METHODS

In order to assess the state of awareness about building regulations, a two-prong strategy was adopted. Interviews were conducted with relevant officials of LDA to discuss efforts made by the Authority in promoting awareness about building regulations amongst general public. Household survey was done using a questionnaire with a sample of 120 households drawn from multiple housing schemes approved by LDA and located variously within its jurisdiction (see fig. 1). The questions to be asked covered number of variables including education and income level of respondents, household size, size of plot, house plan approval status, knowledge about building regulations, awareness about tools adopted by LDA to disseminate information about building regulations and process of house plan approval, and reasons for compliance and non-compliance with building regulations. Simple random sampling method was used to select the housing schemes and the households since the study was focused on analyzing the awareness situation in LDA controlled areas. Only those residents were interviewed who owned the house and passed through the experience of constructing their houses. The analysis of data has been done and presented in tabular and graphic forms.

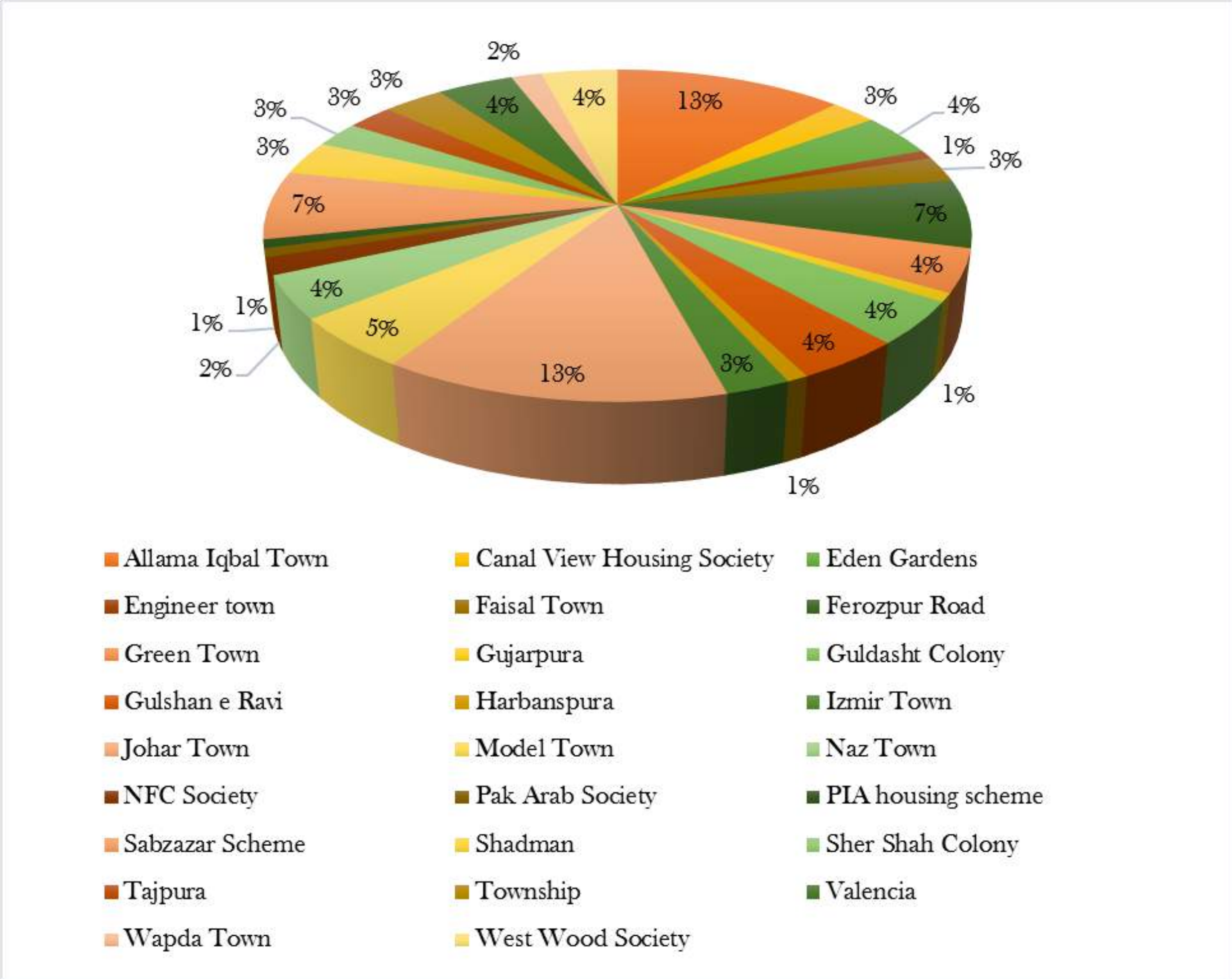


Fig 1: Distribution of Sampled Households with respect to Sampled Housing Schemes

## III. RESULTS

### *A. Tools of Awareness Adopted by LDA*

The Lahore Development Authority (LDA) was created under the LDA Act 1975 with the mission to establish a comprehensive system of metropolitan planning and development in order to improve the quality of life in the metropolitan area of Lahore. The Town Planning wing of the LDA is mainly responsible for approval of building plans within the controlled area of the Authority. The plans are approved in the light of building regulations revised in 2014. Interviews with LDA officials revealed that in response to request made through advertisement in newspapers for feedback on proposed revisions in building regulations, the general public showed low level of interest. This was presumably because majority did not know much about those regulations or their significance in enhancing quality of life. However, nearly all the interviewed officials agreed that compliance to building regulations can surely be enhanced through awareness raising in general public. They argued that frequent site visits are surely one of the most effective strategies to ensure effective building control, but they generally lag behind in this matter due to limited man power, large extent of the areas, inadequate number of official vehicles and limited fuel provision for visits.

Interviews with LDA officials further revealed that the key tool used for awareness is the website which is regularly updated by the staff of concerned section of the Authority. Another instrument used for awareness raising is advertisements in newspapers but for this LDA has limited budget and hence use this option judiciously. The information desk at one window cell operating in the LDA since November 1999 with the view to streamline public interaction with LDA office is yet another tool to provide awareness about building regulations and ensuing requirements. But most people in the city are unaware of this service.

As far as the electronic media, it was stated that LDA is not supported positively by the media and the biased attitude has resulted many a times in giving negative image of LDA to the general public. In particular, the demolition actions which LDA has to undertake against gross violators of building regulations are never random. The Authority first issue warnings/show cause notices and carry out demolition operations only if the offenders do not respond to any of such warnings/notices. This in fact reflects the indifferent behavior of the people and their obstinate nature not to follow the rules until they are to be dealt with coercively.

The interviewed officials acknowledged that while both the website of LDA and one window cell serve as means to provide awareness about building regulations, these tools are helpful to those visiting the website or LDA office and willing to construct buildings as per prescribed regulations. Moreover, despite the fact that Lahore is the hub of education institutions, not everyone has quick access to the internet and many still may find it difficult to make some sense out of the material uploaded on the website concerning building regulations for being available in English language.

In response to the question for further improving public awareness about building regulations, it was suggested that there are several other ways which LDA may adopt like SMS alerts, pamphlets distribution, advertising on local cable networks, communicating through e-mails, or even direct interaction with LDA officials through public meetings. While there was no clear consensus on what the best strategy of should be raising awareness regarding building regulations, the need for more resource allocation and spending was emphasized by the interviewed officials to ensure LDA take this as an important activity to ensure better compliance.

*B. Community Awareness about Building Regulations*

The household survey revealed that majority of respondents were educated with 48% possessing bachelor's and 37% having master's degree. Similarly, most of them (76%) were residing either in less than 125 sq. yds. to 250 sq. yds. houses and some of them (23%) in 500 sq. yds. houses. The houses of as many as 82 out of total 120 sampled households were double storeyed and the average household size was found comprising of 5.6 members. Majority (76 out of 120) of respondents were living without renting out any portion of their houses while others (44 out of 120) had given a portion of their house on rent to tenants. The reported monthly income level of house owners showed that a majority (38%) was earning between Rs. 30000 to Rs. 45000 followed by those (26%) earning between Rs. 45000 and Rs. 60000 with 20% having monthly income of more than Rs. 60000. As many as 95 surveyed household sought approval of building plan from LDA whereas 25 acknowledged they constructed their houses without obtaining the requisite approval.

During the survey, only 45% of the sampled households confirmed that they were aware of the mandatory requirement of getting the house plan approval from LDA at the time of starting construction of the house. Further inquest revealed that in spite of knowing about such requirement, 21% of the interviewed households still didn't obtain house plan approval from LDA and constructed houses illegally. While they were reluctant to provide any justification to this end, this scenario does point to general apathy towards meeting regulatory requirements. Fig. 2 presents data about plan approval with respect to beginning of house construction activity of the remaining 79% respondents who got approval of house plan from LDA.

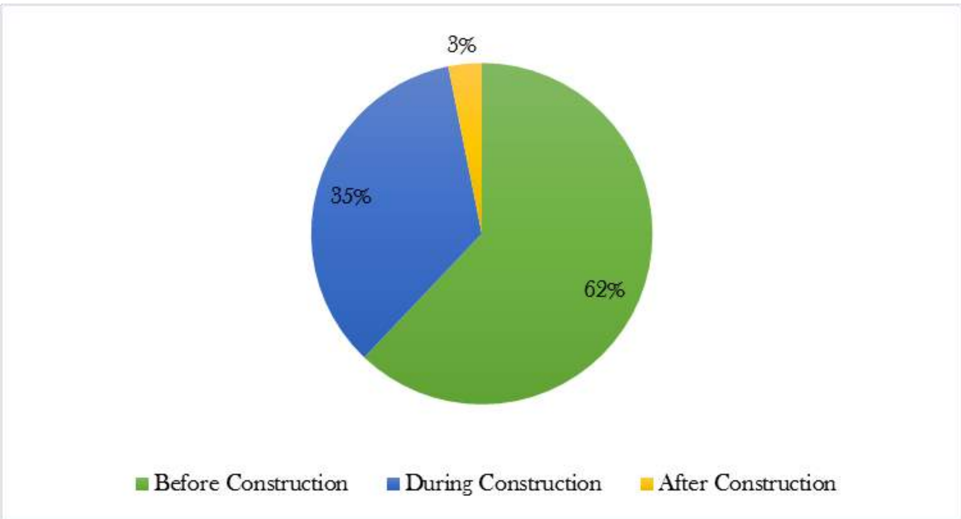


Fig. 2: House Plan Approval Status with respect to Beginning of Construction Activity

Fig. 2 clearly shows that while majority got approval for their house plans before construction as per regulations, a reasonable number of respondents sought approval during construction and some even after completion of the house construction process. In fact, majority of them came to know about the need to get building plan approval for their house either through contractors (32%) engaged both for plan preparation and construction of house or the Architects (26%) hired for drawing out building plans (see fig. 3). Some 18% of them got the information about requirement for building plan approval through various sources like relatives and friends whereas another 16% from neighbors and the remaining 6% through notices received during construction from LDA. Further, in this connection, all the surveyed households were asked about the website maintained by LDA to disseminate information including that for building regulations and approval requirements, and a majority (79%) was completely unaware of availability of such information service. Thus, LDA's efforts in providing information to general public through website are not proving effective.

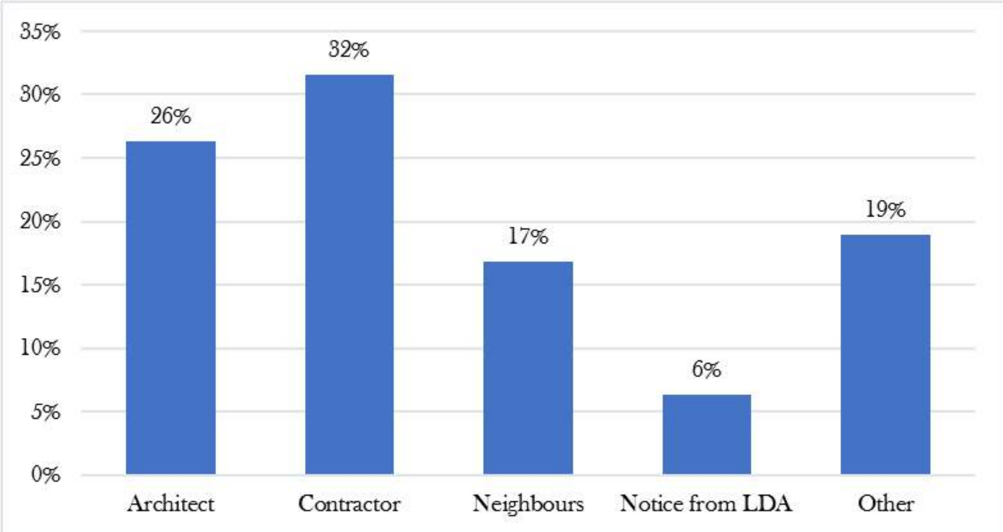


Fig. 3: Sources of Awareness about the Requirement to Get House Plan Approval

Some interesting findings emerged in reply to a question from those respondents who obtained house plan approval from LDA concerning house construction according to approved plan. Although majority (66%) reported that their houses have been built as per approved plan, a good number (34%) acknowledged they could not resist deviations from the approved plan (see Table I). The deviations comprised of additional bathrooms (42%), covering part of setbacks (40%) or adding a new storey (18%). As many as 64% of them made these changes after obtaining house plan approval whereas 36% did violations after getting the completion certificate from LDA which points to the need on the part of LDA to have a strong system of continuous surveillance even after issuing completion certificates. When asked why they constructed house in violation of approved plan, 50% lamented stringent nature of building regulations and hence decided to go ahead for changes to accommodate family requirements. Another 26% did so on the pretext that they will get the violations compounded later from LDA whereas 24% believed since every other person violates building regulations so did they too.

It was pertinent to note the incidence of violation of building regulations with respect to plot size and table I also portrays the requisite data to this end. It is clear from table I that there appears to be more trend of violation of building regulations in small to medium sized plots as compared with plots of larger size. Moreover, majority of all of those 32 households who acknowledged they constructed their houses in deviation of the approved plan either were living in less than 125 sq. yds. or 150 to 250 sq. yds. houses. These finding in fact confirms that people tend to violate in case of small and medium sized plots to meet family requirements.

Table I: Status of House Construction as per Approved Plan with respect to Size of Plot

| Size of Plot (sq. yds.) | House Construction as per approved plan | |
|---|---|---|
| | Yes | No |
| <125 | 11 (79%) | 3 (21%) |
| 150-250 | 36 (64%) | 20 (36%) |
| 275-500 | 15 (63%) | 9 (37%) |
| >500 | 1 (100%) | 0 (0%) |
| Total | 63 (66%) | 32 (34%) |

A comparative analysis was also done to find out what relationship exists between education level of respondents and house construction as per approved plan. As Table II indicates, people who are educated have mostly shown better concern for house construction as per approved plan. This finding supports the argument that higher level of education is instrumental in encouraging the compliance with building regulations.

Table II: Status of House Construction as per Approved Plan with respect to Education Level of Respondent

| Education Level | House Construction as per approved plan | |
|---|---|---|
| | Yes | No |
| Matric | 3 (50%) | 3 (50%) |
| Graduation | 27 (63%) | 16 (37%) |
| Masters | 25 (68%) | 12 (32%) |
| Higher | 7 (78%) | 2 (22%) |
| Total | 62 (65%) | 33 (35%) |

Finally, data on status of house construction as per approved plan was also cross tabulated with respect to type of scheme and as clear from table III, the incidence of violation of building regulations is lowest in cooperative housing schemes as compared with public sector or with other types of private sector housing schemes. This situation is mainly due to effective surveillance which becomes possible because of presence of site office as well as concerned staff with the responsibly of keeping an eye on construction activities only within the confines of a single housing scheme. This appears a handy task for staff of cooperative housing schemes as compared with LDA staff who are generally starved of resources to enable them to make frequent site visits and because of difficulties in visiting number of housing schemes by limited staff assigned to perform such field activities.

Table II: Status of House Construction as per Approved Plan with respect to Type of Housing Scheme

| Type of Housing Scheme | House Construction as per approved plan | |
|---|---|---|
| | Yes | No |
| LDA and other public sector housing schemes | 27 (52%) | 25 (48%) |
| Cooperatives housing schemes | 21 (91%) | 2 (9%) |
| Other private sector housing schemes | 14 (70%) | 6 (30%) |
| Total | 62 (65%) | 33 (35%) |

It is pertinent to point out here that all of those 25 households who acknowledged they constructed house without obtaining approval of building plan from LDA either were living in LDA schemes (15) or private housing schemes (10). This further substantiate the point made earlier about lowest incidence of violation of building regulations in cooperative housing schemes.

The research also involved analyzing whether the educated respondents were cognizant about building regulations of LDA. The data presented in table IV shows that even they didn't know enough personally about the building regulations. Most of them at best could reply they only knew about the requirement to get house plan approval from LDA even after going through plan approval process. In response to a question if they have gone through the building regulations by themselves, all replied they have never seen the regulations simply because they never felt the need to do so.

Table IV: Awareness of Building Regulations with respect to Education of Respondent

| **Education Level** | **Awareness of Building Regulations of LDA** | | | **Total** |
|---|---|---|---|---|
| | I know all the regulations | I partially know the regulations | I don't know about regulations, but I know house plan approval from LDA is needed | |
| **Matric** | 0 | 7 | 2 | 9 |
| **Graduation** | 3 | 24 | 31 | 58 |
| **Masters** | 1 | 12 | 31 | 44 |
| **Higher** | 2 | 3 | 4 | 9 |
| **Total** | 6 | 46 | 68 | 120 |

The respondents were further asked to reflect upon what they believe are generally the reasons that instigate or stimulate people to comply with building regulations. It appears from table V that while increasing awareness about building regulations is the predominant reason, people also go for compliance chiefly due to fear of receiving enforcement action or the probability of facing action if found defiant in the wake of good surveillance on the part of regulators.

Table V: Reasons of Compliance with Building Regulations

| Reasons | Cumulative Responses | Percentages |
|---|---|---|
| People know about regulations | 83 | 41 |
| People have fear of enforcement action | 54 | 27 |
| They don't naturally desire to violate regulations | 23 | 11 |
| Good surveillance in the area | 34 | 17 |
| Ethical concerns | 8 | 4 |
| Total | 202 | 100 |

## IV. CONCLUSIONS

The analysis presented above shows that there are multiple reasons behind violation of building regulations in Lahore. Inadequate enforcement from LDA and lack of awareness amongst general public about building regulations also contribute to non-compliance. It is all the more a daunting task for the LDA to ensure adequate surveillance through frequent field visits of concerned staff owing to limited man power, large extent of the areas, inadequate number of official vehicles and limited fuel provision for visits. The lower incidence of violations of building regulations in cooperative housing schemes further highlight the importance of field visits of concerned staff in preventing or reducing such violations. The presence of site offices and staff of co-operative housing schemes serve to play the role of a watchdog to ensure better compliance.

It is interesting to note that the LDA has taken initiatives to enhance awareness for instance through regularly updated and maintained website and setting up of information desk at one window cell, but these do not appear to have been making significant impact. Equally important factor relating to non-compliance is the attitude of people to deliberately flout the regulations. The results of survey of selected households revealed that although most of them obtained approval for house building plan from LDA, a reasonable number still committed violation of some sort from the approved plan. The key motivation to deviate from legal provisions come from compelling family needs. That the tendency to violate is prevalent more in case of small and medium sized plots owned by low income people further lend support to this argument. Similarly, people do violations of building regulations also perhaps because of sense of immunity from enforcement in the wake of low level of field visits by LDA staff and the prospects to get the violations regularized later through payment of penalties.

Nevertheless, the study finds a good relationship that exist between higher level of education and low incidence of violation of building regulations. These findings further strengthen the internationally held view point that lack of affordability and low level of awareness are the major causes of non-compliance of building regulations in developing countries [7], [14]. However, development controlling agency's administration culture and unnecessarily strict building regulations may also have impact on the extent of compliance [6]. That is why, while both LDA officials and surveyed households acknowledged the role of awareness raising in promoting culture of compliance, the fact that most of the respondents also considered some building regulations as stringent cannot be ignored simply. Such a viewpoint may be argued to have the potential to generate tendency to violate the law and hence worth contemplative for the regulators whether to revise regulations.

## V. RECOMMENDATIONS

It is recommended that LDA should be strengthened with additional staffing and resources. The enforcement mechanism also need to be more strong and effective such that it facilitates to enhance the level of compliance for building regulations in the community. Although awareness is one of the key factors behind non-compliance towards the LDA's building regulations, but this scenario can be improved with better enforcement mechanism, increased number of field visits by concerned officials and utilization of enhanced resources. Similarly, there is need for the decision makers in LDA to review the regulations to ascertain how realistic the claim that some building regulations are stringent is and whether opportunities exist to relax these especially for small plots without compromising the real purpose of having the building regulations.

It is important for LDA to adopt measures to publicize website and information desk at one window cell but also consider and apply a variety of other ways to raise awareness among masses and highlight the benefits of complying with the building regulations. This may take the form of initiating helpline service, occasionally holding awareness march on popular routes in the city, periodic advertisement on cable and in leading newspapers, display of banners/billboards at carefully selected places and conveying appropriate messages to promote compliance with building regulations, distribution of handbills, and SMS information alerts. The options of engaging active volunteers from local areas to act as mobilizers and involving developers of housing schemes to oversee building regulation compliance in the field by offering some form of incentive may also be explored.

## ACKNOWLEDGEMENTS

The authors are grateful to LDA officials and respondents of the households for sparing valuable time and providing the requisite information. This article is based on a research project undertaken at the Department of City and Regional Planning (DCRP), University of Engineering and Technology (UET), Lahore. under the supervision of first author [15]. While no funds were obtained, a conducive research environment provided by the DCRP is duly acknowledged.

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# Water Supply and Demand Analysis of Thatta City using WEAP Model

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***Abstract:*** **Indus River is the one of largest river in world and Pakistan's biggest irrigation networks. It fulfills the needs of domestic water and agricultural water requirements for most of the places in Pakistan. The management of water resources in Indus river basin is a problem of high importance due to socio-cultural and economic values. Water Evaluation and planning (WEAP) is a tool which provides a continuous combination of both the physical hydrology and water management of the region that ensures the distribution of available water resources to fulfill the different water demands. This paper uses the WEAP model to analyze the water supply and demand for Thatta district of Sindh, Pakistan.**

***Keywords*: Indus River, Water demand, Water resources, Water supply, WEAP model.**

## I. INTRODUCTION

Water is an essential component for sustaining life and growth of the community. The demand of water required for the overwhelming population, industrial and agricultural sectors has increased dramatically over the period of time. A rise in water demand has decreased the water availability in the dry seasons and caused the water problems in the watersheds [1]. Thus, the rise in demand of the scant water resources by various sectors are not only affecting the consumers but also the environment. The Indus River is the major source of surface water in Pakistan. The river has a total length of 3,180 kilometers that makes it the largest river of Pakistan [2]. After 1947, different departments are monitoring Indus river basin, the basin is well monitored but its data is hard to be found in the digital world.

Kotri command also known as Ghulam Muhammad Barrage was built on the Indus River in 1955 [3]. It is located near Hyderabad and has a total length of 900 meters. It supplies water for about 28, 00,000 acres of land which grows cotton, rice and wheat. The K.B feeder also called Kalri canal on the right bank of the barrage provides water to Karachi city. The lower KB feeder offtakes from Keenjhar lake and meets the essential water requirements of Thatta and its four Talukas; Keti Bandar, Gharobhari, Kharo Chan and Mirpur Sakro. Kalri Lake through KB feeder provides drinking water to Karachi. Whereas, the Kotri Barrage supplies water to other off-taking canals on the left bank namely; Fuleli, Pinyari and Akram Wah. [4].

It has been reviewed that the water demand of the Thatta City often remains unmet due to a sudden drop in the level of water in Keenjhar Lake caused by the shortage in upstream of Kotri barrage [5]. Subsequently, the outlets of Sakro branch, Jam Wah, Udero branch remains dry and causes acute shortage of water in the Thatta city. Agriculturists said that decline in water level of KB feeder lower causes the withering of standing crops and adversity for the people of Thatta.

This study analyses the gap between water supply and demand for urban and the rice crop irrigated area of the Thatta City that can help decision makers plan a well-organized strategic policy for future water allocation. Water Evaluation and Planning (WEAP) model is used to simulate the current behavior and future trends between water supply and demand of the Thatta city for the domestic and agricultural use.

Water Evaluation and Planning (WEAP) software was used in this study to achieve the intended research objective. WEAP is useful for constructing water management scenarios [6]. WEAP is a software of high significance for the simulation of the water demand and supply in the particular area [7]. WEAP model is an excellent tool to evaluate complicated water system [8]. It has been widely used all over the world since the last decade and proved helpful in depicting the different scenarios of water supply and demand [9].

## II. MATERIALS & METHODOLOGY

### A. Study Area

Kotri Barrage is constructed on the Indus River between Jamshoro and Hyderabad in the Sindh province of Pakistan as shown in Fig. 1. K.B canal off-takes from the right side of the Kotri Barrage, whereas on the left bank of Kotri Barrage, three canals namely: Phuleli, Pinyari, Akram Wah.

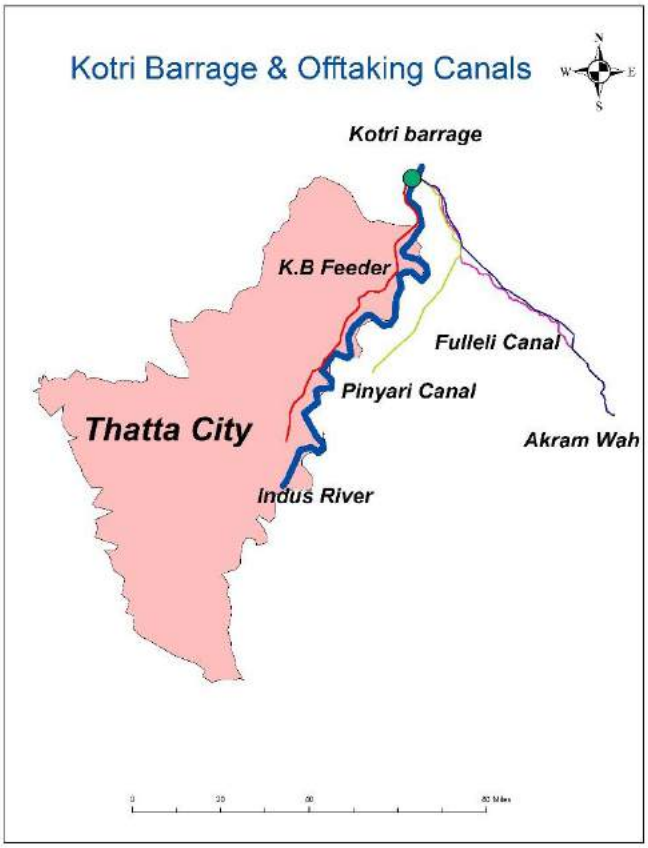


Fig. 15: Map of Kotri Barrage offtaking canals and Indus River

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### B. WEAP Model

WEAP model was developed by the Stockholm Environment Institute (SEI). It is one of the great water management tools that evaluates the basin characteristics along-with the several waters related activities in a particular area. The main function of WEAP is to balance the water supply and demand in a balancing water supply and water demand in a lucid manner [10]

There are five main setups namely; Schematic, Data, Results, Overview and Notes in the model. In order to develop WEAP of a specific area, a systematic and step-wise approach is followed. At first, the geographical map of the area is developed. Then the data is entered for the various water supply and demand sites. At the end, the comparison of results with observations is done for various scenarios.

In this study, secondary data for water supply and demand of K.B feeder is collected from the Kotri Barrage office. The database of the K.B feeder and Thatta is created using ArcMap 10.3. The WEAP model is employed to assess the current situation and future trends in water supply and demand in the Thatta district. The current accounts year is 2010 and the water supply and water demand data is inserted for the 2010 year in the WEAP model. The model is run for the reference account year 2011-2015. The average per capita water demand per day varies in Pakistan, therefore 150 liters is taken as lpcd. Thus, the annual per capita demand is 54 cubic meters. The monthly demand in percent for the rice irrigated area is taken accordingly to the requirement in the Kharif season. The rice irrigated crop area in the Thatta city is 107870 Hectares [11]. Therefore, the total irrigation water requirement for rice crop is 1500 mm. [12]

Table 7: The monthly demand in percent for rice irrigated area

| Month | Annual demand (percent) |
|---|---|
| January | 0 |
| February | 0 |
| March | 0 |
| April | 5 |
| May | 10 |
| June | 10 |
| July | 20 |
| August | 30 |
| September | 25 |
| October | 0 |
| November | 0 |
| December | 0 |

Table 8: Supply data of KB Feeder

| Month | Discharge (cusecs) | Cumecs |
|---|---|---|
| January | 3228 | 91.406 |
| February | 3334 | 94.408 |
| March | 2969 | 84.072 |
| April | 1297 | 36.726 |
| May | 1982 | 56.123 |
| June | 4319 | 122.300 |
| July | 6285 | 177.971 |
| August | 3037 | 85.998 |
| September | 4591 | 130.002 |
| October | 5618 | 159.084 |
| November | 3827 | 108.368 |
| December | 2663 | 75.407 |

Source: Kotri Command Office

The total estimated population of the Thatta city was 1778043 in the 2010 [13]. This population was inserted as per standard 3% growth rate in the base year 2010 in the WEAP model. The total domestic water consumption computed is 96.01 million cubic meters, taking 150 liters per capita per day.

## III. RESULTS

The WEAP model performs the calculations on the given water supply and water demand data for the urban area and agriculture area. The results of the water supplied, water demand, unmet demand, water coverage for the 2010, 2011, 2012, 2013, 2014 and 2015 are shown in the Fig. 2, Fig. 3 and Fig. 4 (a) below.

The results show that the annual domestic water supplied was 89.4 MCM (million cubic meters) in the current account year 2010. However, the domestic water demand was 96 MCM. Hence, unmet water demand is 6.7 MCM. So, for the 2015, the domestic water supplied is 299.3 MCM. However, the water demand is 329.6 MCM. Hence, the unmet water demand is 30.3 MCM.

Similarly, annual agricultural demand for rice crop in the current account year 2010 was the 1266.4 MCM. However, the agricultural water demand was 1618 MCM. Hence, the unmet water demand is 351.7 MCM. Moreover, for the year 2015, the unmet water demand is 408.1 MCM.

The Fig. 5 shows that the domestic and agricultural has shortfall in the months of April, May and August. When the rice crop needs the most water. The Thatta city lacks water due to the low quantity of water in K.B feeder. Therefore, the results showed that the unmet water demand for the domestic as well as agricultural area is increasing on the yearly basis.

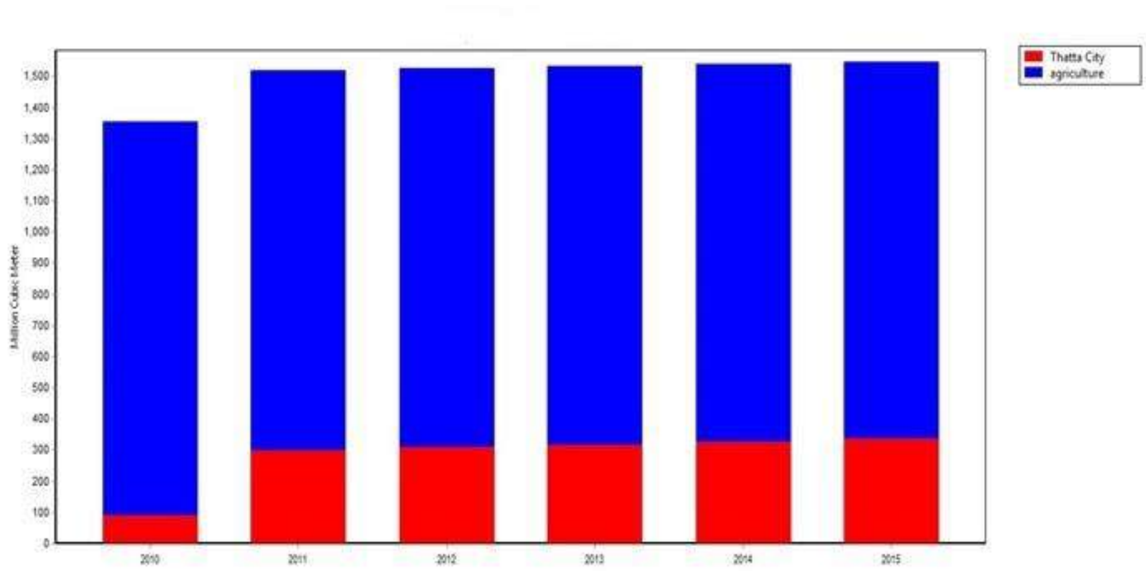


Fig. 16: Representation of the annual Water Demand for Thatta City and Agriculture

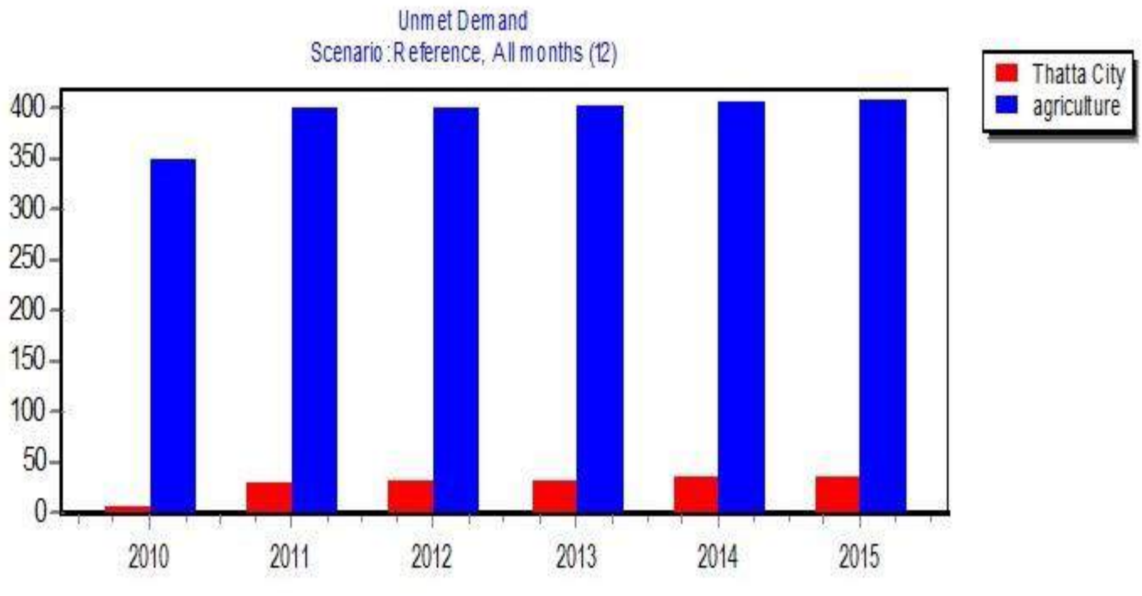


Fig.3: Unmet water demand

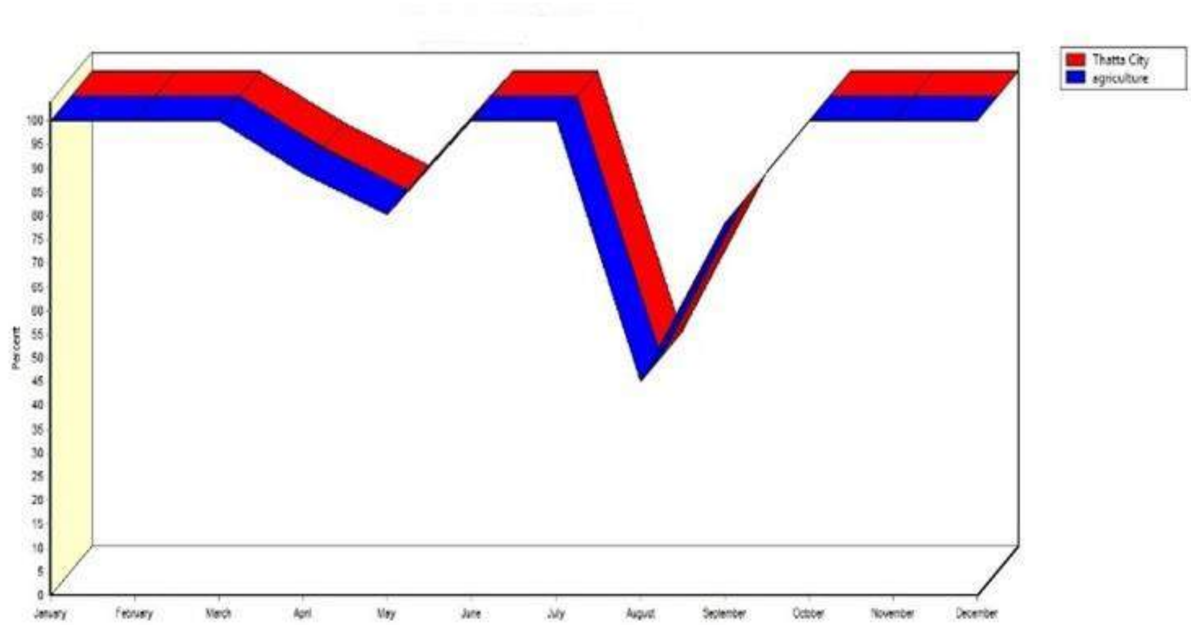


Fig.4: Water coverage for urban and agricultural area

## IV. CONCLUSIONS

In this study, the water supply and demand of the Thatta city was analyzed using WEAP model. The year 2010 was taken as the current account year. The analysis for the water demand for urban and rice irrigated crop area is performed upto the 2015.
In line with the objective of the research, it has been found that the unmet demand has increased dramatically for domestic and agricultural sector. The computed results depicted that the annual water supplied for the urban and agricultural area is not meeting the water demand of Thatta city.

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# Analysis of Groundwater Quality for Drinking Purpose in Hyderabad Sindh

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***Abstract*— Safe drinking water is a basic need for good health. The study was carried out for groundwater quality sampling in Hyderabad urban areas. In this connection, three different regions were selected and total numbers of 20 water samples were collected. Different physico-chemical parameters were measured in the laboratory. The pH, EC, TDS were measured through YSI instrument. Total hardness ($CaCO_3$), Total alkalinity, Chloride and Fluoride were measured by color change test strips. However, the Arsenic was determined by using Arsenic Kit. The results revealed that pH varies from 7.02 to 8.03, EC 662 to 17674 µS/cm, TDS 487.5 to 10160 mg/L, total hardness 245 to 425 ppm, total alkalinity 190 to 240 ppm and Arsenic 0.1 to 0.01 mg/L. It concludes that out of 20 samples only 9 samples are suitable and can be used for drinking purpose having TDS value within permissible limit (less than 1000 mg/L) and EC less than 1700 µS/cm. This analysis also revealed that about 55% of groundwater samples confirm not to be used due to crossing the maximum permissible limits prescribed by WHO and National Standards for Drinking Water Quality (NSDWQ) standards. Therefore, the groundwater of Hyderabad city may not be considered completely safe for dinking purpose. Keeping in view the limited number of samples and rapid urbanization in Hyderabad, it is suggested that samples from other areas be tested for water quality analysis before using for drinking purpose.***

***Keywords:* Groundwater, Physico-chemical, Water quality parameters, Hyderabad Sindh.**

## I. INTRODUCTION

Water is the most precious gift awarded by Allah without which human being cannot survive. Due to intrinsic purification of soil, groundwater is considered as good source for drinking purpose [1]. The fresh water is essential and basic need of human lives and also for animals. Pakistan is blessed country having water in abundant quantity but unfortunately Pakistan is facing many problems of water quantity and quality due to improper management [2].

Use of polluted water for drinking purposes may generate serious health issues such as cause of diarrheal diseases and high death rate in developing countries [3].

Fresh water is already a limiting resource in many parts of the earth, therefore surface water is treated for domestic and other purposes. Water is present in large quantity, but fresh water is present below 3 % on the earth, which can be used for drinking and other purposes [4].

Ground water quality is also deteriorating in Pakistan due to unplanned urbanization and over burden of population [5].

Nowadays Pakistan is known as a water stress country with availability of about 1200 cubic meter per capita but unfortunately it is declining rapidly [6].

Due to unplanned urbanization and rapid growth has led to tremendous increase in water demand for domestic use. Lack of extensive shortage of surface water people mostly use groundwater in selected areas of Hyderabad Sindh to meet their demand. It is noticed that this is a main issue of the unsuitable handling of drainage of waste water in most of the area of Hyderabad, so groundwater quality of Hyderabad is deteriorated. Water purity assessment is very necessary before use it for drinking purposes [7].

## II. METHODOLOGY

### *a. Study Area*

Hyderabad is one of the largest cities of Pakistan. It is located in south-east of the country having Latitude 25°22′45″N and Longitude 68° 22′ 6″E in semi-arid region. Three different regions (Hyderabad city, Latifabad and Qasimabad) were selected for the study area. Figure 1 shows the study area. Maps given below were made through Google Earth Pro and ArcGIS 10.3.1

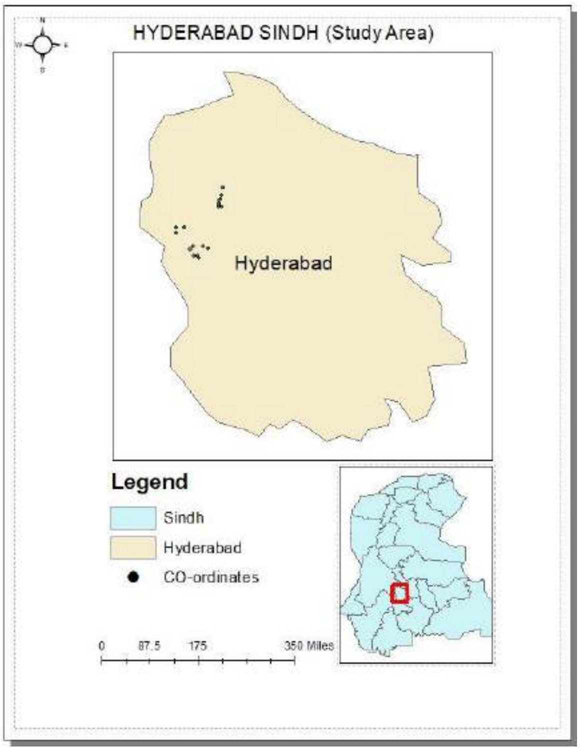


Fig.1: Study Area

*b. Sample Collection*

To evaluate the groundwater quality of Hyderabad, 20 groundwater samples were collected from the study area. Regions were selected so that majority of that areas are using groundwater for drinking purpose. Figure 2 shows the locations from where the samples have been collected


**Fig. 2: Locations of sample collection**

Average six to seven samples were collected from each region to evaluate groundwater quality. All samples were tested at USPCAS-W MUET, Jamshoro laboratory. The pH, TDS and EC of all samples were measured through YSI meter. Total alkalinity, Total hardness, chloride and fluoride were tested by color changing test strips. Arsenic was measured through Arsenic KIT. After conducting above tests, all results were compared with WHO standards.

Table 1 shows the locations from where samples had been collected and locations which are bolded in below table, those samples are suitable for drinking purpose.

Table.1: Locations of the samples

| S. No. | Location | S. No. | Location |
|---|---|---|---|
| 1 | **Hala Naka 2nd sample** | 11 | Ghumnabad |
| 2 | **Malik Petrol Pump** | 12 | Malak petrol pump |
| 3 | Wahdat Colony (Home) | 13 | **Sultan shah colony** |
| 4 | Anwar vilaz | 14 | Latifabad Unit#5 |
| 5 | Momin Nagar 1st sample | 15 | **Latifabad Unit#6** |
| 6 | Momin Nagar 2nd sample | 16 | Latifabad Unit#8 |
| 7 | **Lalo Lashari** | 17 | **Latifabad Unit#9** |
| 8 | **Kari mori chok** | 18 | Latifabad Unit#10 |
| 9 | **Saima plaza** | 19 | Latifabad Unit#11 |
| 10 | **Hala Naka 1st sample** | 20 | Latifabad Unit#12 |

## III. Results and Discussion

### *a. pH*

The fundamental water quality parameter pH is measure of hydrogen ion concentration in pure water. The pH value for drinking water, recommended by WHO standards ranges from 6.5 to 8.5 [8]. All the samples collected in this study area showed a satisfactory limit (Figure 3).

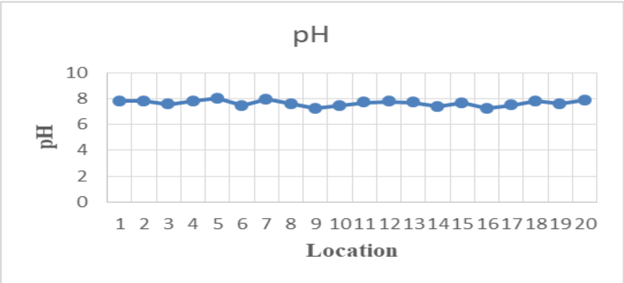


Fig.3: pH of groundwater in selected regions of Hyderabad Sindh.

### *b. Total dissolved solids (TDS):*

Sum of all dissolved chemicals present in water is expressed as Total Dissolved Solids. WHO limit for drinking water ranges from 600-1000 mg/L [9]. The experimental result showed that TDS level in marked locations was between 383 to 10160mg/L (fig 2).The result shows that out of twenty samples, nine samples have TDS within the limit (figure 4).

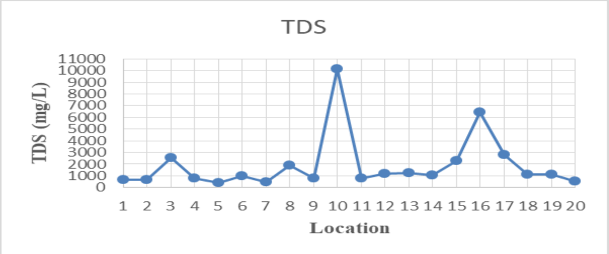


Fig.4: TDS of groundwater in selected regions of Hyderabad Sindh.

### *c. Electrical conductivity (EC):*

Number of dissolved solids present in water indicates the electrical conductivity of that water, because pure water is good insulator and is free from ion concentration. Maximum limit for EC according to WHO standards is 400 µS/cm [6]. Experimental results were between 662 to 17674 µS/cm. It was observed that nine samples can be used for drinking purpose according to Water Quality Standards [14] (Figure 5).

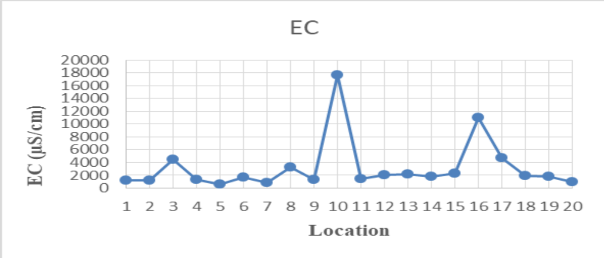


Fig.5: EC of groundwater in selected regions of Hyderabad Sindh.

*d. Total hardness:*

Total hardness is physical parameter of water that represents the total concentration of calcium and magnesium ions. It is usually expressed as the equivalent quantity of Calcium carbonate. When amount total hardness is excess it reduces the ability of soap to clean clothes and leaves a sticky film on clothes [10]. According to WHO standards total hardness should be 500 mg/L. The experimental results showed values between 240 to 425mg/L. These results show that total hardness of water is within the limit (Figure 6).

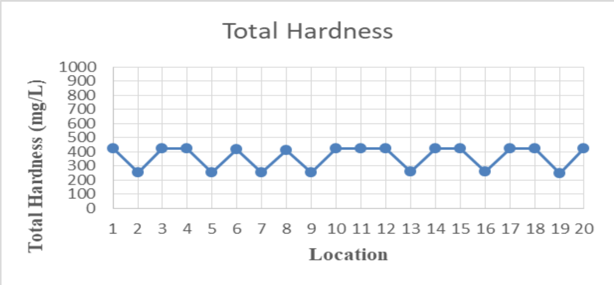


Fig.6: Total hardness of groundwater in selected regions of Hyderabad Sindh.

*e. Arsenic:*

Arsenic is highly toxic in its inorganic form. Drinking contaminated water including arsenic can create problems such as; chronic arsenic poisoning, skin lesions and skin cancer etc. [11]. WHO limit for arsenic ranges from 0.01 to 0.1mg/L. Twenty locations were analyzed shown in figure 7. All locations have arsenic value within WHO standard.

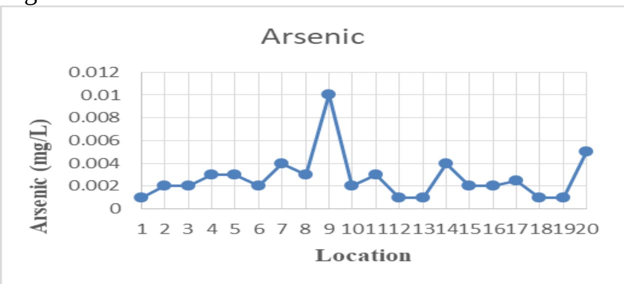


Fig.7: Arsenic of groundwater in selected regions of Hyderabad Sindh.

*f. Total alkalinity:*

Alkalinity is a total measure of the substances in water that have "acid-neutralizing" ability. Alkalinity measurements are used for interpretation and control of waste water treatment processes, but high levels of alkalinity may change the taste of water. Alkalinity can be finding only in terms of total dissolved solids (TDS). According to WHO standards its value should not exceeds to 500 mg/L [12]. Results indicate that alkalinity of all samples is within the range i.e. 190 ppm to 240 ppm (Figure 8).

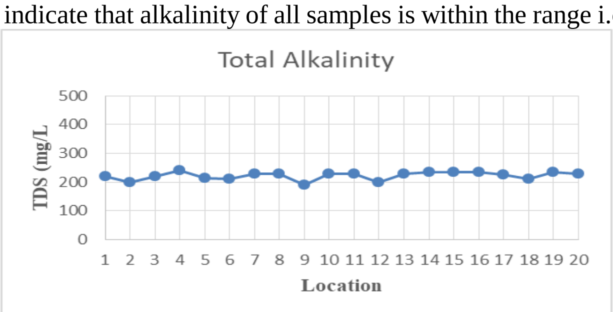


Fig.8: Total alkalinity of groundwater in selected regions of Hyderabad Sindh.

*g. Chlorine:*

The bacteria and viruses present in drinking water that causes diarrheal diseases can be inactivate by free chlorine, but excess amount of free chlorine gives unpleasant test and odor. Chlorine limit should not exceed to 2mg/L [13]. The experimental results indicate that all samples are within limit (Figure 7).

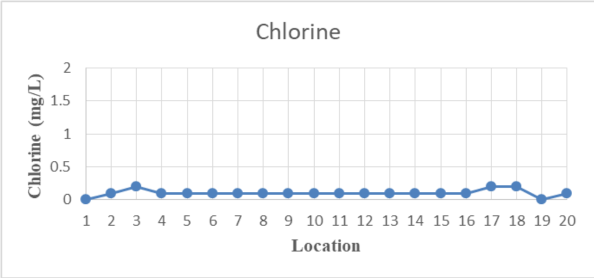


Fig.9: Chlorine of groundwater in selected regions of Hyderabad Sindh.

*h. Fluoride:*

When fluoride is present in small concentration in drinking water it gives beneficial affects to human body, but when concentration of fluoride increases it may cause for dental diseases. According to WHO standards fluoride limit should not exceed to 1.5mg/L [5]. The experimental results show that all samples are within limit (Figure 10).

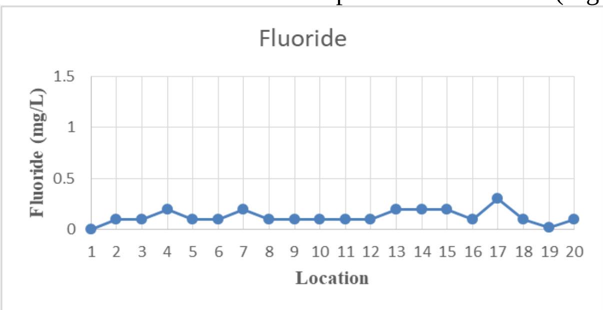


Fig.10: Flouride of groundwater in selected regions of Hyderabad Sindh.

## IV. CONCLUSION

Three different regions of Hyderabad Sindh (Qasimabad, Latifabad and Hyderabad city) were selected for groundwater analysis. The sites were selected where mostly people use groundwater for their drinking purpose. 20 samples were collected and tested in the laboratory. After analyzing it was concluded that pH, total hardness, total alkalinity, chlorine, fluoride and arsenic were within limit. Out of 20 samples only 9 samples have TDS within limit of WHO standard and having EC values less than 1700 µS/cm; which can be used for drinking purpose. Water having TDS and EC out of limit are harmful for human being. Therefore, in order to control water-borne diseases current study suggests that before using groundwater for drinking purpose, it is very necessary to check the quality of that water.

## ACKNOWLEDGEMENT

The authors are sincerely thankful to Miss Naila, for her suggestions and help in the laboratory and US Pakistan Center of Advance Studies in Water, MUET, Jamshoro for providing facilities.

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# Access of Low Income People to Housing: How Far Khuda Ki Basti-4 Housing Project Kala Shah Kaku, Lahore is Meeting Housing Need of Low Income People?

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***Abstract*. Like many other cities in the developing world, Lahore is also facing a severe housing problem. In this regard, government has taken number of initiatives, but these have proved to be inadequate and un-affordable to low income people due to high land prices. Private sector has also taken initiatives to provide housing. In this context Saiban, an NGO has launched Khuda-Ki-Basti-4 housing project at Kala Shah Kaku in Lahore with the view to replicate Khuda-Ki-Basti housing scheme initiated at Hyderabad and which proved to be a successful project primarily due to incremental development approach. This research attempts to assess that whether KKB-4 is serving its purpose and that land speculators have not jeopardize the access of low-income people to housing. Results of interviews with residents show that the criteria necessitating stay in the reception area within 45 days is one of the key factors ensuring that only low-income people have access to plots. People are happily living there and proud to be part of Khuda-Ki-Basti project despite some concerns relating to infrastructure and amenities. The project has the potential to be replicated by the public sector agencies provided it gets conceptual acceptance of decision makers.**

*Key words:* **Housing, Incremental development, Khuda-ki-basti, Low income people.**

## I. INTRODUCTION

Housing has been observed and conceptualized in different ways in the literature. As a shelter it is described as a social necessity recognized all over the world in terms of most important need of the man, after food [1]. Housing as a basic necessity holds an important place in the general strategy of development for its socio-economic characteristics [2]. Housing can be regarded as a fundamental right since it forms an indispensable part of human's life and ensures their dignity, protection and privacy. It fulfills social needs of basic gathering and acts as an important source where relationships are forged and nurtured. The right of adequate housing should be interpreted in a wider spectrum. It contains freedom and entitlements such as protection against forced evictions, arbitrary destructions and demolition, security of tenure, availability of facilities, affordability, habitability, non-discriminatory access, cultural adequacy, restitution of housing, land and property along with participation in housing related decision making at national and community level.

In cities of developing countries, urbanization and arising pseudo-urban economy is giving birth to immense poverty among rapidly growing urban population [3]. In most of the developing countries, these urbanization processes have led to a massive shortage of housing and qualitative deficiencies [4] and as a result vast majority of urban population cannot afford cost of conventional housing. This puts a great pressure on existing housing supplies as national governments and private developers in developing countries are unable to cope up with the ever-increasing demand. Different projects that were initiated to address the housing issues ended up in a fiasco and many of them which were meant for urban poor ended up in middle class housing. As a result, different modes of rental accommodations have been built in the developing countries for vast majorities and majority of the poor live on rent [5]. Similarly, there are hardly some developing countries which any low-income housing arrangement in the form of slum or squatter settlement do not have providing housing to the poor. In fact, slums and squatter settlements are a synopsis of poor-quality houses and it is conventionally supposed that such settlements exhibit a major housing problem and are clear indicator of housing shortages in the cities of developing countries.

Pakistan is rapidly urbanizing country in South Asia. Due to its ever-expanding cities, access to affordable housing has emerged as a key issue for middle- and lower-income class [6]. As per the World Bank statistics, the 37% of the total population of Pakistan is now living in urban areas and it is expected to grow further in the near future [7]. Like many other developing countries, Pakistan is also facing severe problems of housing shortage and the situation is more precarious in urban areas. Reference [6] highlights that the urban housing shortage is estimated at 3.5-4 million units, nearly all amongst the segments of population with low affordability. For instance, in Lahore the second largest city in the country, households at the bottom 68% of the income distribution can only afford 1% of the available housing stock, while households at the top 12% of the distribution can afford 56% of available housing. Similarly, in the Punjab Province, a number of factors have been contributing to negatively affect urban land and housing markets and thus forcing poor people to live-in low-quality housing. In particular, "the supply of serviced land is constrained by widespread public ownership of land; inadequate trunk infrastructure provision to developable sites; complicated property rights; land titling and registration systems, and inappropriate and inefficient land use plans and regulations; rent controls; and highly and distorting taxes. These impediments make it difficult for land and housing markets to respond to housing demand and, as a result, land and housing prices are expensive. Consequently, most households are priced out of the formal market and nearly 50 percent of housing is produced through informal procedures without infrastructure, titling, and planning." [8].

The Government of Pakistan has been trying to address the problem of housing shortage. The national housing policy [9] suggested different strategies to improve the prevailing housing conditions. These comprised of institutional development and capacity building by empowering stakeholders, introduction of innovative approaches for screening of eligible households for incremental housing finance, endorsing new ideas such as reduce standards, regulating squatter settlements, introducing incremental approach, and promoting community participation. Despite the fact that the government endeavored to provide housing, the efforts could not produce desired results as expected owing to various reasons ranging from institutional and financial inadequacies, inappropriate policies and regulations through to scarcity of developed land, hike in land prices in the wake of land speculation and corruption [10], [11].

Nevertheless, the incremental development approach adopted by the Hyderabad Development Authority (HDA) in Sindh Province proved to be amongst few examples of successful initiatives to meet the challenge of low-income housing. With the help of local administration and community building, the Khuda Ki Basti (KKB) housing project in Hyderabad commenced by HDA in 1986 appropriately managed to fulfill the social, economic and cultural needs and aspirations of targeted community. Enduring the incremental housing principles, the conceptual and design framework of KKB allowed sufficient leverage and wider flexibility to accommodate the changes in family structure and prevailing minimum housing standards [12]. Additionally, the people coming to KKB were facilitated in various ways. For instance, residents and newly arrived inhabitants received building and design assistance, orientation of public infrastructure and amenities, and guidance on procurement of suitable building materials from informal construction sector. Such a provision of social and technical assistance coupled with well-designed site and layout plan, which included the designation of 15% of the area for public amenities and public spaces, contributed to the relatively fast consolidation of the KKB community.

Furthermore, the local authorities and KKB administration managed to eliminate land speculations in the project area. For instance, the applicants had to present themselves with all the family members and all the household's belongings at the `reception area' where they had to live for about a fortnight to prove themselves as deserving family before gaining access to the plot. Secondly, the beneficiaries did not receive allotment letters for their plots, immediately after access to plot. Instead, after a first, modest down payment, a small, easily payable and negotiated amount had to be deposited for infrastructure provision. Once the full costs of the plot and infrastructure have been paid, only then the allotment papers are issued. This also help to ensure that any long absence from the plot can be punished by cancelling the allocation of plot [12].

The innovative approach of incremental development followed by HDA at KKB proved to be a viable alternative to the public sector's attempts to provide housing for low income groups. It represented a change in the traditional sites and services housing schemes by ensuring the provision of infrastructural services in increments according to the need and ability of plot holders to pay for such services. Following the incremental development approach of KKB, the first project was developed as Gulshan-e-Shahbaz housing scheme in Hyderabad. Since then, it has been followed by very few housing projects in the country. This paper analyses the Khudaki Basti-4 (KKB-4) project launched by Saiban at Kala Shah Kaku, Lahore in 2006. The Saiban is an NGO headed by former Director General of HDA who the mastermind behind the successful implementation of incremental housing approach at Gulshan-e-Shahbaz housing scheme at Hyderabad was.

## II. RESEARCH METHODOLOGY

The KKB-4 housing project at Kala Shah Kaku, Lahore is a step in the right direction since it attempts to ensure that the low-income people also get a proper place to live. Proper implementation of the incremental development approach as adopted in KKB-4 can serve to guide as a model for replication in other cities with the view to providing shelter to low income groups. This has been the main concern of the present research [13] and in order to assess progress of KKB-4 in ensuring provision of housing to low income groups, the methodology adopted to this end included literature review, structured interviews with officials of Saiban, the NGO which look after all the structural and operational mechanisms of KKB-4, and survey of the residents of the KKB-4. Amongst the total residents at the time of survey in 2015, 50% of those occupying ordinary plots (low income people) were selected for interview using systematic sampling technique. This involved interviewing every second resident thus bringing the total surveyed residents to 90 out of the total of 180.

## III. RESULTS

### *A. Introduction to Khuda-Ki-Basti-4 Housing Project*

Situated in the North West at a distance of around 20km from the Lahore city across the river Ravi and within the metropolitan area at Kala Shah Kaku, KKB-4 is the fourth consecutive project based on incremental housing development approach. It vows to institutionalize the process of incremental housing by enhancing social, cultural and political acceptability. It predominantly tends to address the failure of public housing for low income urban residents and significantly enrich on the solutions provided by informal sector that have been widely practiced across urban concentrations in developing countries. However, it varies in scale and political support as compare to earlier projects, but its planning dynamics and financial framework remains same.

The Khudaki Basti Schemes 1-3 have been launched on government sponsored land in Karachi. However, due to lack of any support by any development authority, Saiban had to purchase the land for the commencement of KKB-4 near Kala Shah Kaku in Lahore with the help of few donors and investor at the rate of Rs. 10 lac per acre. The site is easily accessible from G.T road and it stretches over an area of 24 acres. It is planned on equally divided 11 blocks ensuring compliance with planning and design standards and accompanied by park/open space in the center to enhance livability. The KKB-4 administration obtained approval of the scheme from Tehsil Municipal Administration Ferozewala that took almost one year due to lengthy and cumbersome procedure.

The scheme comprises of 460 plots having dimensions 24' x 34' with certain exceptions due to geometrical constraints. By the time of survey (in 2015), two schools, a mosque and few shops, electricity and sewerage at KKB-4 have been made available to meet the needs of the residents. A communal hand pump is used by residents to get water for various needs. This appears to be slight departure from original concept of providing all services incrementally as done in case of KKB-1 at Hyderabad because of different target market in Lahore. However, other development works including water supply, street lights, and parks are planned to be executed gradually. The plots have been divided into two categories i.e. ordinary and prime. Ordinary plots are exclusively meant for low income households on subsidized and affordable price following procedural and validation requirements set by Saiban. On the other hand, prime plots-located on central spine and periphery-are sold on market rate to cross subsidize infrastructural provision and affordable housing. This, in turn, helps to contribute towards financial sustainability and portrays an endeavor to set a precedent for self-sustained low-income housing projects. The ordinary and prime plots were available at the time of survey at the price of Rs. 1, 20,000 and Rs. 3, 90,000 respectively.

*B. Procedure for Allotment of Plots at KKB-4*

The prospective applicant comes to the reception area along with his family and the household belongings. The field staff of Saiban provides the applicant with temporary shelter after verifying the household and household belongings. This serves as filtering process to weed out speculators from buying plots at KKB-4. After the preliminary approval of the application, the applicant is required to deposit a certain amount (typically around one-fourth of the price of plot) in the prescribed bank and submit the receipt at site office. After verifying the continuous presence of the family at the reception camp, the Saiban staff issue a provisional letter to the applicant upon receiving another sum of money as prescribed as well as approval from the in-house allotment committee. The remaining amount is to be paid in easy monthly installments. The applicant has to ensure continuous presence at the allotted plot and have the responsibility of building his own house. The allotment is cancelled in case of a continuous absence of 3 months from the plot without any reason. The plot is allotted provisionally for the initial 5 years and afterwards the plot ownership is transferred in the name of the applicant upon fulfilling all the terms and conditions.

*C. Results of Interviews with selected residents of KKB-4*

The results of interviews with selected residents of KKB-4 are presented in this section. Table I presents data about income level of residents with respect to occupation of head of household. It is clear that majority of the residents belonged to low income group and were either privately employed or doing small business with income level ranging between Rs. 10, 000 to Rs. 20, 000 per month. Further inquiry revealed that majority were either salaried workers (52%) or earning from their small business (26%) whereas remaining were laborers/daily wagers (22%).

**Table I: Monthly income of household head with respect to occupation**

| Occupation | Income (in Rupees) | | | | | Total |
|---|---|---|---|---|---|---|
| | > 5000 | 5001-10000 | 10001-15000 | 15001-20000 | < 20001 | |
| Laborer | 1 | 0 | 6 | 10 | 0 | 17 |
| Govt. Job | 0 | 0 | 1 | 10 | 1 | 12 |
| Private Job | 2 | 7 | 18 | 4 | 3 | 34 |
| Entrepreneur | 0 | 2 | 12 | 4 | 7 | 25 |
| Others | 1 | 0 | 1 | 0 | 0 | 2 |
| Total | 4 | 9 | 38 | 28 | 11 | 90 |

Table II provides information about distance of work location of head of household from KKB-4. It is clear that majority (54%) had to travel more than 15 km daily to reach their work places which mainly were located in the city. Moreover, most (78%) of them spent Rs. 1000 to Rs. 3000 per month in respect of travelling expenses (see table III). Further investigation revealed that as many as 86% of interviewed residents used either public transport or motorcycle as mode of transport which also indicated that majority belonged to low income class.

**Table II: Distance of work location of household head from KKB-4**

| Distance (km) | Frequency | Percentages |
|---|---|---|
| <5 | 4 | 4.4 |
| 5-10 | 22 | 24.4 |
| 11-15 | 15 | 16.7 |
| >15 | 49 | 54.5 |
| Total | 90 | 100.0 |

Selected residents were asked also about the reasons for moving out from previous place of residence to KKB-4 and the responses are presented in table IV. It is clear that most (60%) of residents shifted to KKB-4 because they were living in rented houses and could not afford to own a house somewhere else. Similarly, some (12%) left their previous residence due to family problems and for some (9%), KKB-4 offered ray of hope to turn the dream of owning a house into reality.

**Table III: Cost incurred per month on transport**

| Travel cost (Rs) | Frequency | Percentages |
|---|---|---|
| > 1000 | 10 | 11.1 |
| 1000-2000 | 47 | 52.2 |
| 2001-3000 | 23 | 25.6 |
| < 30001 | 10 | 11.1 |
| Total | 90 | 100.0 |

**Table IV: Reasons for moving to KKB-4**

| Reasons | Frequency | Percentages |
|---|---|---|
| Proximity to work place | 5 | 5.5 |
| Family problems | 11 | 12.2 |
| Wish for own house | 8 | 8.9 |
| Previously living in a rented house | 54 | 60.0 |
| Better living environment at KKB-4 | 6 | 6.7 |
| Affordable installments to pay for purchasing the plot | 6 | 6.7 |
| Total | 90 | 100.0 |

Under speculation phenomenon, a plot is sold several times through different owners at a much higher price. In order to verify if speculation phenomenon prevails at KKB-4, residents were asked about from whom they bought the plot. In reply all the selected residents reported that they bought their plots from KKB-4 management except one resident who bought the house from previous owner who sold it after fulfilling the condition of five years of demonstrated presence at the plot as imposed by Saiban to curb speculation. Moreover, sale and purchase of plot is restricted and can only be done through KKB administration thus further lowering the chances of speculation.

It was equally important to confirm whether residents of KKB-4 had paid the price of plot in installments. Out of 90 interviewed residents 62 had already paid all the installments. Table V shows that out of those 62 residents, majority (49 of them) paid installments over a period ranging from 2 to 5 years which obviously is a reasonable timeframe for low income groups to pay the price of plot at the rate of around Rs. 1000 to Rs. 2000 per month. When asked, majority (82%) managed to pay monthly installment through personal savings to buy the plot at KKB-4.

**Table V: Time taken to pay all installments from the year of purchase of plot**

| No of Years | Year of purchase of plot | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | |
| 1 | 1 | 1 | 0 | 0 | 5 | 0 | 0 | 2 | 9 |
| 2 | 2 | 0 | 0 | 3 | 4 | 3 | 2 | 1 | 15 |
| 3 | 2 | 0 | 6 | 1 | 1 | 2 | 0 | 0 | 12 |
| 4 | 1 | 0 | 5 | 4 | 1 | 0 | 0 | 0 | 11 |
| 5 | 1 | 0 | 3 | 7 | 0 | 0 | 0 | 0 | 11 |
| 6 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 8 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total | 9 | 3 | 14 | 15 | 11 | 5 | 2 | 3 | 62 |

KKB4 offers incremental construction approach for the convenience of low-income people without any condition of building completion period. In this regard, a question was asked from the residents whether they agreed with it or not. As many as 58% agreed with the incremental approach, 33% disagreed and opined that it was easy to build the house in one go whereas 8% remained indifferent to this question. Table VI presents data about construction status of house with respect to year of occupation.

**Table VI: Year of occupation of plot and status of house construction**

| Year of occupation of plot | Construction Status | | Total |
|---|---|---|---|
| | Constructed house | Partially constructed house | |
| 2007 | 2 | 2 | 4 |
| 2008 | 11 | 5 | 16 |
| 2009 | 5 | 7 | 12 |
| 2010 | 6 | 13 | 19 |
| 2011 | 10 | 6 | 16 |
| 2012 | 5 | 10 | 15 |
| 2013 | 2 | 2 | 4 |
| 2014 | 3 | 1 | 4 |
| Total | 44 | 46 | 90 |

It is clear that more than half of the interviewed residents were yet to complete the construction of their house with some even after 7 or 8 years of plot occupation. This finding is in line with the fact that generally low income people often find it difficult to construct the house in single phase primarily because of lack of adequate finance needed to do so. This argument was further supported by the fact that vast majority of residents of constructed houses in KKB-4 proceeded with the construction in phases as evident from table VII.

Table VII: Sequence of house construction

| Sequence | Frequency | Percentages |
|---|---|---|
| Constructed in single phase | 4 | 9.1 |
| Room, compound wall, bath, kitchen | 8 | 18.2 |
| Room, bath, kitchen, compound wall | 15 | 34.1 |
| Room, kitchen, bath, compound wall | 3 | 6.8 |
| Room, bath, kitchen | 3 | 6.8 |
| Room, bath, kitchen, drawing room | 7 | 15.9 |
| Room, bath, kitchen, floor | 4 | 9.1 |
| Total | 44 | 100 |

In response to a question regarding construction mechanism of the house, 50% of the interviewed residents built their houses on self-help basis, 46% employed a contractor whereas 4% reported that they adopted both mechanisms at different phases of construction. When asked whether approval of house plan from concerned planning agency was obtained, majority (78%) replied no as opposed to only few (22%) who got house plan approval. The key reasons for lack of house plan approval included lack of awareness and capacity to fulfill requirements of concerned planning agency regarding house plan approval.

The opinion of residents on condition of KKB-4 to reside in the reception area within 45 days of approval of application was also obtained. The analysis shows that 52% agreed with this approach and the timeframe so given while some 18% remained indifferent to this question. But another 30% didn't agree and argued that either it should not be mandatory or the time period to report to KKB-4 administration for stay in reception area after approval of application should be enhanced since this involves considerable time to leave old place of residence, bring all belongings and invest life savings at a newer place.

The positive attitude of administration and efficient delivery is a key factor towards success of any organization. Therefore, a question was also asked to judge satisfaction level of residents with KKB 4 administration. While 7% remained indifferent, as many as 52% interviewed residents were satisfied with the administration due to their cooperative behavior and efficient response to issues and queries. Still 41% were not satisfied primarily due to inefficient provision of infrastructure particularly roads and piped water in the wake of incremental approach adopted by the KKB-4 administration to provide infrastructural services progressively using proceeds from sale of prime plots and installments from occupants of ordinary plots. Nevertheless, on the whole majority (65%) of interviewed residents had feeling to be proud of being part of KKB-4 initiative as compared to small minority (18%) for not feeling so while 17% preferred not to answer this question.

## IV. CONCLUSIONS

The occupation of plots by speculators, middle and high-income people in the housing projects undertaken for low income people in the Punjab has been a long-standing issue and a cause of failure of such projects to meet the housing need of target group [14]. The approach adopted in KKB-4 housing project helped to weed out land speculators and ensured that only low-income people had access to a plot. Maintaining physical presence as well as the condition to permit sale and transfer of plot ownership after five years of occupation and that too through KKB-4 administration further contributes to effectively control speculation. The KKB-4 has been successful in offering a window of opportunity to low income people to build a home with legal title for the first time in their lives since most of the people who have moved to KKB-4 were previously living in rented houses. Although some residents have concerns about pace of infrastructure provision, most of the residents feel proud to be part of KKB-4 due to the fact that they got their own house. The study highlights that Saiban applied the incremental development approach at KKB-4 with some adjustments in the original approach applied at KKB-1 which points to the fact that the said approach is flexible and can be replicated by adapting to local circumstances, a point already noted by reference [15].

## V. RECOMMENDATIONS

The experience of KKB-4 indicates that housing at an affordable price can be delivered to meet the need of low income people without burdening the state. In this context it offers great insight and a viable option for public sector planning agencies to replicate such initiatives having potential to ensure affordable housing development. But this obviously cannot be achieved without conceptual acceptance by the decision makers and bringing changes in existing regulations to accommodate incremental housing development. A detailed investigation to understand the dynamics of successful development of KKB-4 will be necessary to come up with lessons for replicating such projects not only elsewhere in the country but also in other developing countries to address the challenge of housing low income groups. Based on such an assessment, standard guidelines may be developed to facilitate the replication process while keeping in view the local variations in conditions within which such a project is to be executed. Similarly, while the layout plan of KKB-4 is according to official standards with reasonably wide streets and equally divided blocks with a park in the center of each block. Furthermore, the layout plan was approved by the local planning agency though after taking considerable period of time. But this situation calls for a separate set of regulations both for low income housing projects involving incremental development approach as well as house construction under such projects so as to ensure replicating this approach with minimal bureaucratic hurdles and more ease.

## ACKNOWLEDGEMENTS

The authors are grateful to Saiban officials and households for sparing valuable time and providing the requisite information. While no funds were obtained, a conducive research environment provided by the DCRP is duly acknowledged. We are thankful to anonymous evaluator for the comments which helped improving the quality of the paper.

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# Laboratory Study of Tile Drainage under Different Depths of Impervious Layer

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***Abstract*: A laboratory study was carried out on tile drainage criterion in the Hydraulic laboratory, Mehran University of Engineering and Technology, Jamshoro. The experiment was conducted in the Permeable tank using sandy clay loam soil under different impervious layer from the lateral drains. During the experiment, the hydraulic parameters such as, drain specific discharge (q), hydraulic heads (h), hydraulic conductivity of the soil (k), drain depth above the impervious layer (D), drain radius (r) and spacing between the lateral drains (L) were recorded. The research work includes establishing an empirical relationship for the appropriate design of tile drainage. Using statistical analysis, the relationships of $qL^2$ with khr, kdh, and $kh^2$ were developed separately in the form of empirical equations. The research results show that the drain spacing varies directly with the depth of impervious layer below drain, hydraulic conductivity of the soil, hydraulic head between the drains and drain size; whereas drain discharge varies inversely with drain spacing.**

***Keywords:* Drain spacing, Design of tile drainage, Tile drainage.**

## I. INTRODUCTION

Pakistan's major income source comes from agriculture and its irrigation system is mainly depend on canal networks that start from upper Indus Basin to lower Indus basin but unfortunately, our agricultural land is highly affected to water logging and soil salinity problems by continuous seepage from irrigation canals and from over irrigation systems. The water level and soil salinity are directly affected by crops and its yields so that it is necessary to control these problems for improving the agriculture land.

For removing the surplus amount of water from the field areas, the drainage system is required and that system is also used for the reclamation of agriculture field. The drainage has two types one is natural drainage and other one is artificial drainage. The properties of soil that affect the artificial drainage are permeability, infiltration, soil texture, soil structure and soil color as well, so that its necessary to have a knowledge related to drainage when design the drainage system in field. In this regard, the drainage design is also required the knowledge of design parameters of drainage such as soil hydraulic conductivity, impervious layer from the drains, drain effluent discharge, and the drain spacing these parameters also have an importance for the economic point of view. The drainage experts have worked in drainage field and share their research experience such as;

In different cities of Australia, the dry land salinity is emerging, the combination of vegetation treatments and tree planting is considered to be the main solution for dry salinization, and the planting trees can greatly reduce the groundwater level [1]. Drainage has played a vital role to prevail over these interference problems [2]. Selecting a proper drainage system always has been discussed in agricultural or other fields [3]. The water (drainage water) freely removed from drains and flow occurs due to changes in water level fluctuation; therefore, a positive outlet that was adverse to their processes should be assembling [4]. The subsurface drainage has a significant impact on hydrology, detected both field scales as well as watershed scales. The value of hydraulic conductivity gives only the information of the main length and spacing of drain, but it cannot explain about the location of drain [5]. The single tile drainage system is applied in order to predict the hydrological watersheds on watershed areas where random/irregular drainage systems are occupied [6]. The drainage (tile) system can easily relieve the pesticide and nutrition, thereby contributing to environmental pollution [7]. Due to the large spacing of the drains (reducing the number of drainages, thus reducing the cost), the horizontal drainage system is superior to the vertical drainage system [3]. It was found that the resistance coefficient inlet decreased with increasing porosity and mean diameter of soil but for fine texture soil and high porosity the resistance coefficient of inlet is increased [8]. The agricultural land drainage experts team came from Netherlands in 1976 at the drainage reclamation institute of Pakistan (DRIP), Tandojam to assist the Pakistani drainage Engineers to resolve the drainage problems in association with International Land Reclamation Institute (ILRI). The irrigation and agriculture drainage study on stochastic models was carried out and anticipated [9], [10], [11], [12] and [13]. The drainage research generally invisible in irrigate on systems because of crop input or weather as well. Field drain spacing depends on the contribution of percolating water through rainfall/ irrigation. Analysis shows that the significant changes in crop response to various spacing and areas with highly flexible soil properties. The design parameters of tile drainage and concluded that the effluent discharge increased with hydraulic head above the drains and decreased with the increase in the depth of impervious layer [14].

Keeping in view above works, the study has been conducted to determine the drain spacing situated at various depths from the impervious layer and hydraulic heads and developed the empirical equations on different drain parameters.

## II. MATERIALS & METHODS

The experimental work was conducted in the main Hydraulic laboratory, Mehran UET, Jamshoro. The permeability tank was used as a main apparatus; the dimensions of the tank were 2m x 1m in plan and 0.1 m in width as shown in Fig: 1. one side of the apparatus was made of aluminum sheet and another side of transparent glass. The additional accessories used during experiment included; the water-tank located below the main apparatus, from which the water was re-circulated by the mean of a centrifugal pump. The stainless-steel perforated pipes wrapped properly with the synthetic nylon filter material were used as field laterals/drains fitted with the permeable tank to the side of the aluminum sheet at different depths from the impermeable layer (i.e. the bottom of the permeable tank). The transparent rubber tubing connected with lateral drains were used to measure the water-levels/drawdown curve between the lateral drains, while drains were kept operational. The overflow pipe was provided at seepage source to maintain constant water head at this source. The drain out pipe was attached at the bottom of the tank to drain water completely from the soil when the experimental setup was needed to change. The steel cover plate was fitted at both end of the permeable tank and an adjustable overflow pipe was attached at one side of apparatus as providing for the constant head at the seepage source into the soil.

Fig:1 The main apparatus along with accessories.

The water table depth in the permeable tank for sandy clay loam was maintained during the experiment at 0.29, 0.32, and 0.36 m for both drain depths (i.e. D = 0.195 and 0.295 m) from the impervious layer (I.L). The lateral length and diameter were 0.59 m and 0.015 m respectively.

The drain effluent discharge was computed by a volumetric method for a different change in hydraulic head (h). The drain spacing was observed while keeping the drawdown curve in steady state condition.

## III. RESULTS AND DISCUSSIONS

To overcome the objectives, the data was collected during the experiment using sandy clay loam soil texture of soil and two drain depths from I.L. the data was gathered for the required data collection were used during the experiments. Using dimensional analysis, the useful parameters of the same dimension such as $qL^2$, khr, kDh, and $kh^2$ were calculated (Table 1).

Table 1: Observed and calculated parameters for steady state flow condition using sandy clay loam soil [15].

| **k** | **h** | **Q** | **A = b*h** | **q = Q/A** | **D** | **L** | **r** | **$qL^2$** | **khr** | **kDh** | **$kh^2$** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| m/d | m | $m^3/d$ | $m^2$ | m/d | m | m | m | $m^3/d$ | $m^3/d$ | $m^3/d$ | $m^3/d$ |
| **At drain depth of 0.295 m above I.L.** | | | | | | | | | | | |
| 1.244 | 0.0174 | 0.00171 | 0.0017 | 1.035 | 0.295 | 1.87 | 0.0075 | 3.6190 | 0.0002 | 0.0064 | 0.00038 |
| 1.244 | 0.0108 | 0.00097 | 0.0010 | 0.949 | 0.295 | 1.87 | 0.0075 | 3.3178 | 0.0001 | 0.0040 | 0.00015 |
| 1.244 | 0.0068 | 0.00043 | 0.0007 | 0.660 | 0.295 | 1.87 | 0.0075 | 2.3073 | 0.0001 | 0.0025 | 5.8E-05 |
| **At drain depth of 0.195 m above I.L.** | | | | | | | | | | | |
| 1.244 | 0.0254 | 0.000844 | 0.0024 | 0.350 | 0.195 | 1.87 | 0.0075 | 1.2229 | 0.0002 | 0.0062 | 0.0008 |
| 1.244 | 0.0169 | 0.000531 | 0.0016 | 0.331 | 0.195 | 1.87 | 0.0075 | 1.1573 | 0.0002 | 0.0041 | 0.0004 |
| 1.244 | 0.0126 | 0.000344 | 0.0012 | 0.288 | 0.195 | 1.87 | 0.0075 | 1.0054 | 0.0001 | 0.0031 | 0.0002 |

b = length of the drain lateral = 0.095 m;

### *III.1 Data analysis/development of the equations*

Using statistical analysis of simple regressions, the empirical relationship of $qL^2$ with khr, kDh, and $kh^2$ were established. The developed equations and correlation coefficient values ($R^2$) are shown in Figs. 2 - 4, where the values of $R^2$ show a good confident relationship between the parameters.

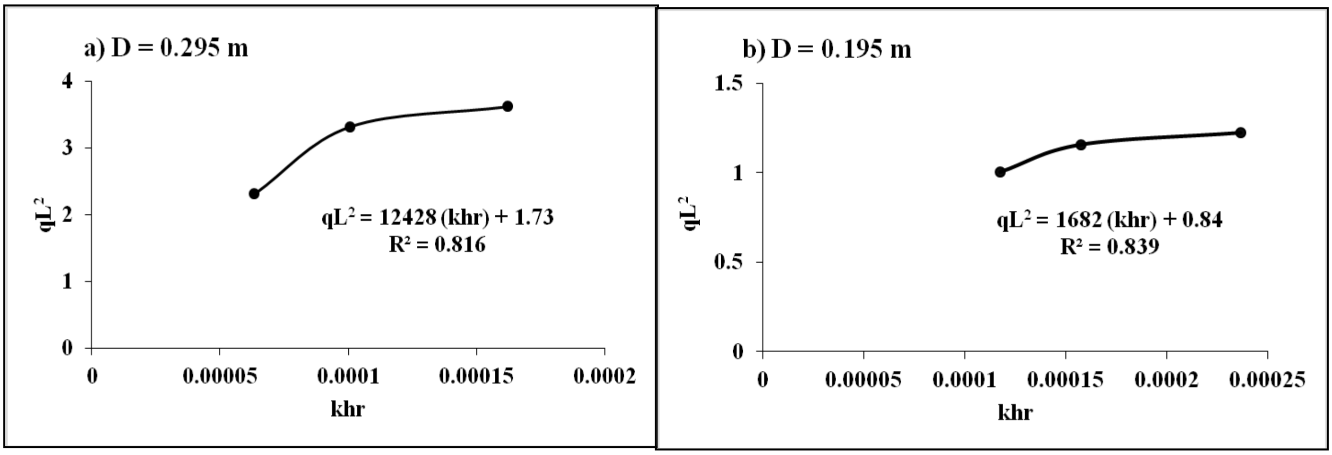


Fig. 2: Relationship of $qL^2$ vs khr at different depths

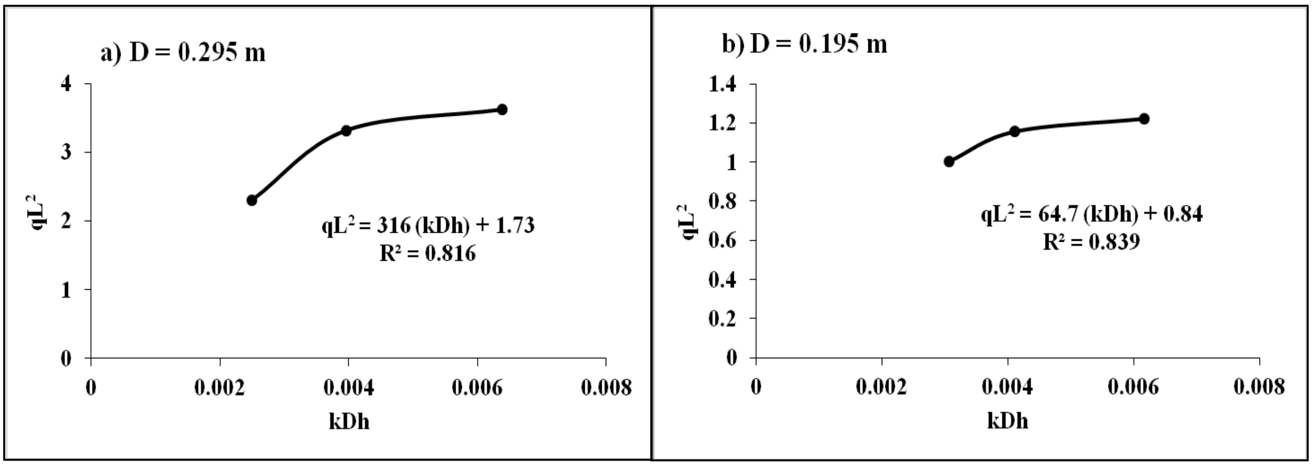


Fig.3: Relationship of $qL^2$ vs kDh at different depths

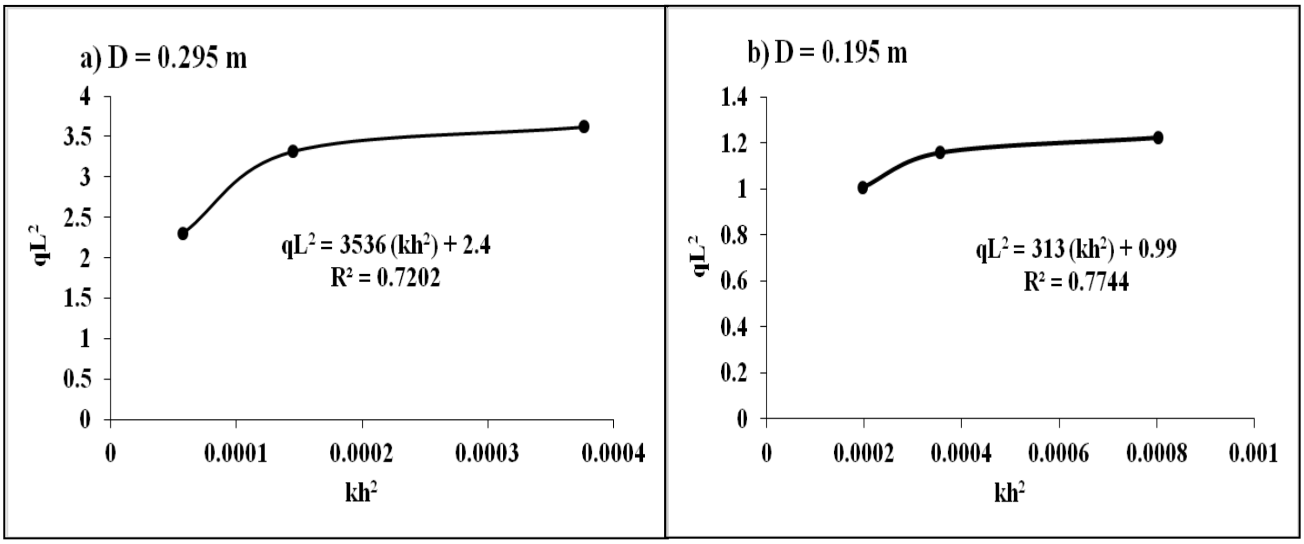


Fig. 4: Relationship of $qL^2$ vs $kh^2$ at different depths

### III.2 *Summary of the developed empirical formulae*

Using statistical analysis, the linear regression has yielded the relationship of $qL^2$ with the relationship of khr in the form of the empirical equation, which is shown along with the value of correlation coefficient in the following equation.

$$qL^2 = 1243\,\text{khr} + 1.73$$

$$\text{or}\;\; L = \sqrt{\frac{(1243\,\text{khr} + 1.73)}{q}} \qquad R^2 = 0.816 \qquad (1)$$

Similarly, the relationship for other parameters shown in Figs: 2-4, comes out as:

$$L = \sqrt{\frac{(1682\ khr + 0.84)}{q}}; \qquad R^2 = 0.839 \qquad (2)$$

$$L = \sqrt{\frac{(316\,kDh + 1.73)}{q}}; \qquad R^2 = 0.816 \qquad (3)$$

$$L = \sqrt{\frac{(64.7\,kDh + 0.84)}{q}}; \qquad R^2 = 0.839 \qquad (4)$$

$$L = \sqrt{\frac{(3536\ kh^2 + 2.4)}{q}}; \qquad R^2 = 0.720 \qquad (5)$$

$$L = \sqrt{\frac{(313\ kh^2 + 0.99)}{q}}; \qquad R^2 = 0.774 \qquad (6)$$

## IV. CONCLUSIONS

The empirical equations show that the drain spacing varies directly with the depth of impervious layer below drain, hydraulic conductivity of the soil, and hydraulic head at mid of between the drains and drain size; whereas drain discharge varies inversely with drain spacing.

The percentage errors of observed and calculated drain spacing are presented in Table 2. It is seen that there is the meager difference in observed and calculated drain spacing for both drain depths from the impervious layer.

Table 2: Comparison of observed and calculated drain spacing (L) for the relationship of *Sandy clay loam* soils

| Drain depth, D = 0.295 m from I.L. | | | | | | |
|---|---|---|---|---|---|---|
| Observed | Calculated (eqn.1) | Error (%) | Calculated (eqn.3) | Error (%) | Calculated (eqn.5) | Error (%) |
| 1.87 | 1.903 | 1.761 | 1.903 | 1.764 | 1.899 | 1.546 |
| 1.87 | 1.773 | 5.190 | 1.773 | 5.188 | 1.752 | 6.297 |
| 1.87 | 1.954 | 4.476 | 1.954 | 4.478 | 1.986 | 6.223 |
| Average | | 3.809 | | 3.810 | | 4.689 |
| Drain depth, D = 0.195 m from I.L. | | | | | | |
| Observed | Calculated (eqn.2) | Error (%) | Calculated (eqn.4) | Error (%) | Calculated (eqn.6) | Error (%) |
| 1.87 | 1.883 | 0.697 | 1.883 | 0.716 | 1.882 | 0.618 |
| 1.87 | 1.829 | 2.215 | 1.829 | 2.194 | 1.822 | 2.591 |
| 1.87 | 1.901 | 1.665 | 1.902 | 1.689 | 1.910 | 2.133 |
| Average | | 1.525 | | 1.533 | | 1.781 |

Using above equations (1-6), the comparison of observed and calculated drain spacing was made and the results show the consistency and closeness between observed and calculated values of drain spacing (Tables 2).

The analysis also shows that for drain placed at depth 0.195 m above the impervious layer has very less percentage error whereas the drain placed at 0.295 m above the impervious layer slightly shows more percentage error.

## V. SUGGESTIONS

The analysis shows, the study of drain spacing, the impervious layer plays an important role. For further analysis, this study can be extended by using different soil textures and drain size. The same study should be conducted on stratified soils with different hydrodynamic conductivity (k) values to obtain stronger research results.

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# Value for Money Drivers in Infrastructure Public Private Partnerships: A Life Cycle Approach

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***Abstract*: Public Private Partnerships (PPPs) are embraced by the different governments around the world to uplift their basic infrastructures. As a matter of fact, PPPs are legal frameworks that are developed to accommodate private business opportunities in public infrastructures. Such frameworks are the based upon a promise that private provision of a public infrastructure can deliver extended value for money (VFM) to the taxpayers, especially the users of the infrastructure. Nevertheless, the anticipation of the extended value rests upon a range of various factors that belong to different domains, such as public partners, existing regulations, national economic situations, etc., and the different project stages as well. Therefore, the VFM drivers are spread across the project lifecycle, and needed to be focused throughout project life. This paper discusses such spread of VFM drivers that are needed to take care of, in order to attain the anticipated value from any infrastructure PPP project. This paper identifies a list of VFM drivers, and illustrates their probable span in a PPP project lifecycle. The results of a pilot study over the importance of such VFM drivers are then discussed within the lifecycle of PPP project. The findings of this paper will help industry and academia in understanding the life cycle approach of the VFM in infrastructures PPPs.**

***Keywords*: Public private partnerships, Infrastructure, Value for money.**

## I. INTRODUCTION

PPP is a long-term contractual consensus between public and private parties, public parties such as the local or provincial state, etc. The PPP are mostly used for major projects in which public party invites bids from contractors and private entities invest in the financial resources and design, build, operate and maintain the facility and earn the revenue in the form of toll (users' fees for using facilities). Government is not directly interested in making money for earning revenues, but it focuses to construct a facility for social welfare of a country. PPP projects help in developing the national infrastructure of country for social wellbeing and delivers a best value for money [1].

The essence of adopting private provision over the public is the anticipated value for money (VFM) that a private sector can deliver. The embedded VFM in a PPP deal acts as a soul of the project. VFM is not based on the lowest cost of an asset but, it satisfies the economy, efficiency and effectiveness. It is not only based only on financial factors (cost) but also based on non-financial factors (Quality). Moreover, VFM is a tool to determine whether economy, efficiency and effectiveness have been achieved in projects. VFM is the combination of whole-of-life costs i.e., quantitative and quality (or fitness for purpose) of goods or services to fulfill the user's requirement. VFM is not the choice of delivery of services based on the lowest cost for the project [3]. VFM is the composition of a whole of life cost (capital cost, repair and maintenance cost) and non-financial factors; i.e., subjective or qualitative meeting users' requirements (fitness for purpose) [4].

The presence of VFM is taken as an assessment tool used by various governments to check the viability of PPPs projects. The VFM is not only restricted to financial beneficial outcomes based on a low cost, but on also to take account of other intangible benefits; e.g., social development and capacity enhancement etc.

It is to be noted that there isn't any hard rule to test VFM, it is not fixed and are different from country to country, even for projects to project. VFM is determined at different points while procurement is intended; however, such VFM points are located in a whole life cycle of a PPP project. This paper attempts to unveil all such VFM points in a PPP project life cycle. The next paragraph determines the methodology adopted for this paper and then the next section elaborates identified VFM drivers.

## II. RESEARCH METHODOLOGY

This is an exploratory study attempting to unveil hidden VFM drivers in a PPP project life cycle. Therefore, the prime reliance is made upon the published literature on PPP projects. The literature consulted for this research includes, research papers from renowned journals, reports and guidelines from the governments around the world, magazine and news articles and independent articles by different independent organizations, such as the World Bank etc. The literature review revealed numerous VFM drivers, which are then assessed and merged to indicate a particular domain in a PPP project life cycle. Figure 1 shows the identified VFM drivers. Certain drivers are limited to one stage, while few are cross categorical, however their behaviour is continuously changing from one project stage to other. All such changing dimensions are discussed in the following section.

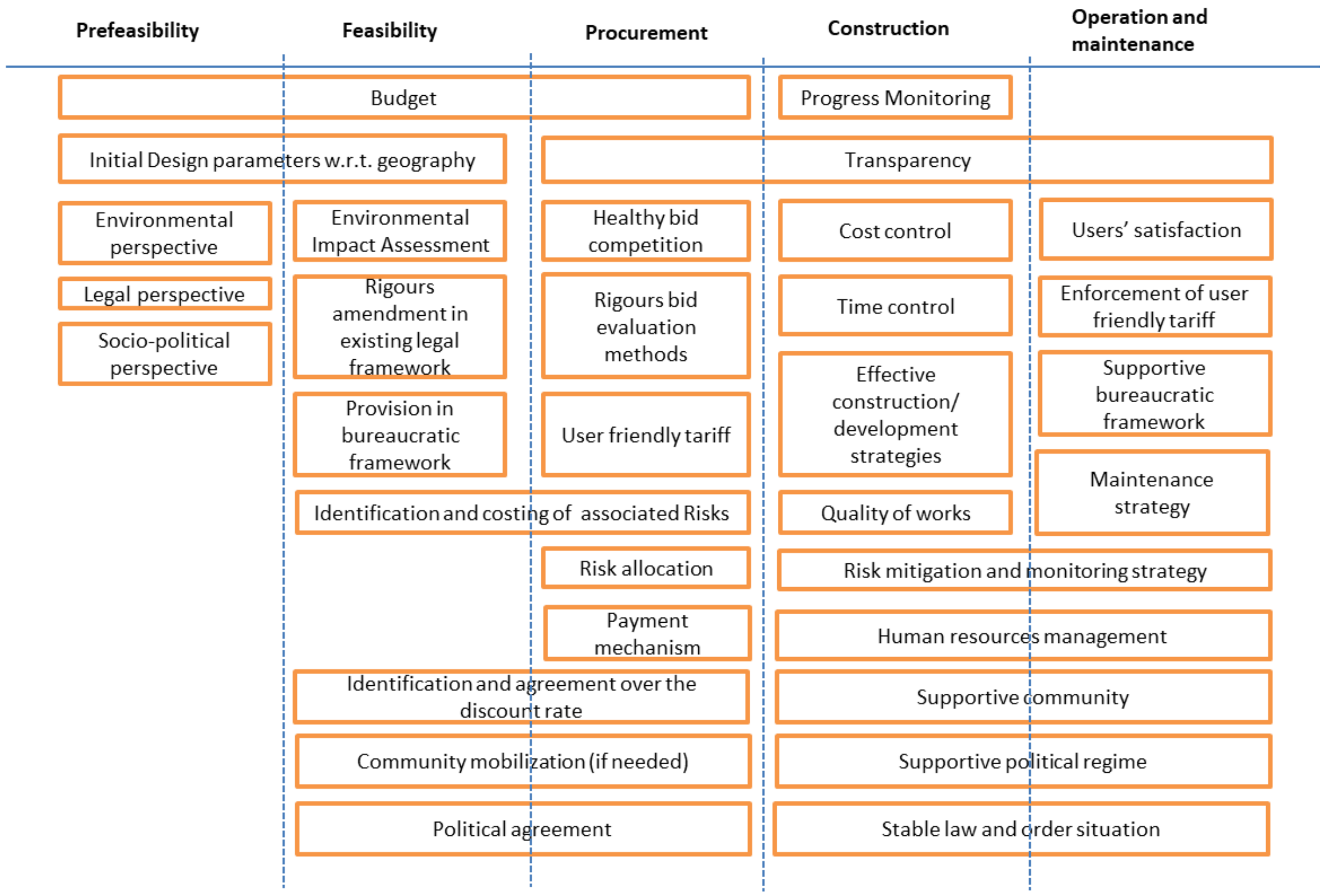


Figure 17 Value for Money drivers in PPP project life cycle

## III. VFM Drivers In A PPP Project Life Cycle

### A. *Prefeasibility and Feasibility*

Rigors Feasibility is usually considered a precursor for any successful development project, and the same is true for a potentially successful infrastructure PPP project. A rigorous feasibility study unveils all potential value aspects.

The budget limitation or the cost is the fundamental factor that defines a public or private provision of the project. The ref [3] defines cost as the major influential factor that judges the smoothly running of projects; and in addition, it is the most crucial element deciding the VFM element in a PPP project. The cost of project needs to satisfy a series of VFM tests in order to proceed with the private provision of the project.

For an infrastructure project, it is necessary that it is well merged with an existing system e.g., for a new metro it is necessary that it is well connected with the existing transportation system. Takim and Ismail [5] considered initial design parameters with respect to geography as a key VFM driver, and concluded that an infrastructure PPP should be cleared, well communicated, and should be established with consensus of both the parties it should not be changed on latter stage so, land use pattern must be studied before commencement of design.

Land use patterns are then connected with potential environmental impact of the project. The ref [5] has considered the environmental perspective as a potential VFM driver. This study has been placed it across prefeasibility, feasibility, and construction stage because it has a crucial role in achieving VFM. The ref [6] identified a number of projects that were shelved because they were failed to satisfy environmental concerns. In prefeasibility stage, it is necessary to assess the impact of project on environmental sustainability. Then, later in feasibility phase, it is necessary to conduct a detailed environmental impact assessment (EIA), so as to focus the impacts and their potential solutions to reduce harmful impacts on the environment.

As discussed earlier that the VFM is a generic idea that encompasses a wide range of value attributes to the public and therefore, socio-political and legal perspectives are the prime factors that need to be assessed; and necessary amendments are to be devised if necessary. Positive legal as well as political conditions have a true effect in achieving the VFM in ppp projects [7].

In developing an infrastructure projects, the community mobilization factor helps in securing potential value. It is an essential to know the opinion of people over the planned development, i.e., either they are agreed or not, and then to make arrangements to achieve a consensus of the community in the project vicinity and the public in general. A Community mobilization process may continue throughout the project life cycle and project public relation office may be established to maintain contact with the public.

### B. Procurement Stage

Procurement of a PPP project is a stage where things take drastic turn and requires doing the things on a micro scale; such as costing risks that were indicated in feasibility and prefeasibility stage, deciding upon PPP models and user terrify setting etc.

PPP projects are to design private business activities in public infrastructure, and therefore the transparency becomes a crucial element in order to maintain the trust of all stakeholders, especially the general public. Special care about the transparency should be started in the procurement stage. Public sector should not be biased towards any bidder, as it may badly affect on the selection of a potential value bid; and it may also damage the confidence for future investors and other stakeholders. The public sector should play an unbiased role and try to bring fairness in procurement [8]. Transparency is a factor that should be continued thoroughly the project life cycle.

It is said that Healthy competition is a vital VFM driver. VFM is enhanced by competitive bid market and making a best policy framework and management and allocation of risk [9] Healthy competition refers to the most optimize number of bidders, i.e., not many and not less. [10] suggested such optimize number as three bidders at max and two bidders as the minimum number. The selection of competitive bidder is a crucial element. Therefore, for selection of competitive bidder a healthy competitive environment is essential to achieve VFM. In a healthy competitive bidding environment, bidders try to bring best of them, i.e., innovative solution at a controlled risk. Healthy bid competition as a potential VFM driver is confirmed [5,7, 11]

After bid competition, identification and decision over a user-friendly tariff is the crucial VFM driver. A user-friendly tariff is the toll fees, for using constructed facility or associated services, which can be easily paid by users and established users' friendly tariff should be enforced at operation phase [5]. Identification of optimized tariff is indeed a VFM driver, which ultimately lead towards the user satisfaction.

A PPP project entails a lot of risk, as it spans over longer time periods. Therefore, identification of all such potential risk and their probable occurrence is necessary to safeguard the targeted VFM. Usually, identification and costing of risks initiates from the feasibility stage to procurement phase to achieve VFM. All the risks associated with projects should be identified at feasibility, or prior initiating procurement, and the cost associated with risk must be incurred in procurement.

Risk costing then lead the public sector to decide upon the transferable and retained risks. Such decision of retention and transferring risk is commonly known as the risk allocation. Risk allocation is a VFM driver, as it helps to achieve VFM in PPP projects. The ref [12] also considered the risk allocation as a helpful VFM driver. In addition to the ref [12], several authors considered risk allocation as VFM driver in their research works including [5, 8, 12, 13, and 14]. Risk is usually allocated, in procurement phase, in such a way that the party retaining a particular risk can manage it efficiently and skillfully with the least cost. Risk allocation process has two components; i.e., retained risk and risk transfer. The risks retained by government are retained risk, such as political risk, legal risk, etc.; while, risks transferred to private partner are considered as the transferred risk; the usual examples are demand risk, cost risk etc.

Payment mechanism is an important VFM driver [15] and it affects all primary stake holders; i.e., the public sector, private partners and users. The payment mechanism defines the way a private operator may be compensated for the development and operation of a constructed facility. Payment mechanism depends upon, and may vary, with respect to the performance of the private partner, project demand, regional inflation and the market situations.

The payment mechanism is influenced by the discount rate at which all transactions are to be discounted. Therefore, identification and agreement over a discount rate is also drive potential quantities of value foe the public.

### C. Construction Stage

Efficient progress monitoring is the process that makes sure that all anticipated value aspects established in procurement are intact. In the construction stage, progress monitoring is to check about cost, time and quality of works; which all are identified as the VFM drivers. Cost is the major influential factor that judges the smoothly running of projects. The cost of project is the most crucial deciding VFM element in PPP projects [3]. While, the time control is also crucial to secure VFM, and therefore, it becomes important to build the facility within specified time duration. Several authors have considered time as a VFM driver in their research work including [5]. Moreover, quality of works helps to achieve VFM as it satisfies users' needs. Quality of works can be enhanced by maintaining transparency and efficient progress monitoring in PPP projects [2].

In maintaining cost, time and quality it becomes ancillary to develop a good human resources management strategy [5]; as the humans, working in PPP projects, are the elements that basically drive the value in PPP projects. Human resources management should be properly managed from the construction stage to operation and maintenance phase as to enhance VFM in ppp projects.

Risk mitigation strategy is another aspect that may influence significantly over the anticipated value. The project risk monitoring mechanism is served as a guardian for VFM [15] and other VFM drivers, such as cost, time and quality etc. The risk management mechanism must be established prior project enters in to a construction stage. It is also suggested that a separate risk management team, consist of personnel from both public and private parties, should be formed [15]. All potential risks and their possible mitigation measure are usually established in procurement phase; however, their monitoring and quick responses strategies are implemented in construction and operation stage.

As discussed earlier, supportive communities and political regimes are keen to bring the value from an infrastructure PPP projects. Such support is deeply is influenced by the community mobilization efforts made in feasibility and later stages. In addition, stable law and order situations are also keen to develop trust of foreign investors and to maintain smooth operations of the project.

### D. Operation Stage

There are merely any new VFM drivers at this stage. In fact, VFM at this stage is largely depending upon the VMF drivers at previous stage. Users' satisfaction is the prime factor that ensures the smooth running of the project. The users' satisfaction is largely associated with the toll or the service fees they are paying. Therefore, to attain positive feedback from users, enforcement of affordable toll price is necessary. In establishing and regulating affordable toll, the role of bureaucracy cannot be neglected. Supportive bureaucratic offices in this regard are vital to secure value for money.

Maintenance strategy is another VFM driver that is crucial to other VFM drivers in the similar stage. A rigorous maintenance plan will make sure that facility operations are optimized, and users are not facing any quality issue. This VFM driver is more important for sustainable operations of the facility.

## IV. CONCLUSIONS

PPPs are meant to bring the extended value to the public and specifically to the constructed facility users. Nevertheless, the value from infrastructure PPPs is based upon certain factors that are spread over the life cycle of the project. Such factors are interdependent on each other and to drive a value attribute from PPPs, it is necessary to safe guard them at all project stages. This paper has presented such a view, in which value for money drivers are identified throughout a PPP project life cycle and their interdependence is discussed. This paper concludes that VFM from a PPP project doesn't rests over a single or predefined factors, rather it varies, but however can be guarded through certain pivotal value drivers.

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# Study of Urban Sprawl and Its Social and Environmental Impacts on Urban Society in Latifabad Town, Hyderabad, Pakistan

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***Abstract*: Urban sprawl expansion is becoming a serious problem of many urban areas due to not much a picture of sprawl in priority, urban areas lack the infra structure and basic facilities like treated water supply, electricity, sanitation services. By the year 2016, Latifabad town accommodates 0.7 millions, which was essentially proposed for 60,000 people. Some of the problems of Latifabad town include excessive traffic congestion; pollution, increment infrastructure costs for community services; fragmentation of housing with low density areas and increase in energy consumption that causes social segregation and environmental degradation. For evaluating social and environmental impacts of sprawl, various factors were derived based on socio-environmental impacts. Quantitative results were generated using Yeh's index of satisfaction and software SPSS; which were based on questionnaires having filled by 480 occupants. The average satisfaction index from this analysis is found out to be -41.1431, which shows a highly dissatisfaction level of residents of Latifabad town. Some smart growth opportunities can be useful in reducing the urban sprawl as to advertise the problem and raise awareness; to enforce population control, compact developments to suit their needs and enhance the use of new technology to facilitate more people to be able to work from home. The research is beneficial to reduce the sprawl as the result of this study can give the directions to local development authorities, if considered the research proposal results, the urban sprawl can be controlled at certain level.**

***Keywords*: Urban sprawl, Urban growth, Urban development, Urbanization.**

## I. INTRODUCTION

Urbanization is well thought-out a constructive progression associated to modernization, industrialization and universal assimilation has economically profitable to a marginal of the urban populace [1-3]. It is the substantial sign of all the productive movement that convoys rapid development [4]. It is the change from rural economy to new developed one [5, 6]. Current developments of land uptake for built-up areas clearly disagree with the spirit and the principles of sustainability in many places in the world. Its scattered areas leave undeveloped blocks results as an pointer of environmental hazards [7, 8]. Sprawl states the structure of subsidize access way together through movement to the suburbs [9]. Many urban planners consulted on the most sustainable urban structure, gave decisions in favor of sustainability measures and against urban compaction and dispersion. However, it is clear that other areas of expertise have to be involved, for improvement of urban sprawl. However; the research work can be useful for the controlling of the urban sprawl and for the making future sustainable strategies of the urban environment. The easy and most uncomplicated reason for the cities expansion is that citizens demand more areas and so they shift from city centers with limited lot sizes to urban edges and outer reaches of cities. Noise, heavy traffic, air population and lack of green space are also among major qualities in relation with urban sprawl [9]; Which causes many impacts of urban sprawl, but the major impacts are social and environmental impacts. Land cover changes are chief dynamic forces for biogeochemical set, climate transform, and production of food from local to worldwide scales [10-15]. The dynamic of built-up growth is important in the study of present-day urban studies, includes the urban sprawl as an indefinite type of growth, or expansion [16, 17]. People living standards always have an impact on their social lives. Social factors include the demographic and cultural aspects as, education standards, socio-economic status and neighborhood class, with the interaction of neighbors that live as close, impacts directly or indirectly in living standards. They actually play their role in increasing of public costs, because the changes in infrastructures and services are paid by contributing to the existing inhabitants that live in it. Some of the researches carried out as [18, 19] focused on the connection between city form and travel activities, consequently not dealing with the multifaceted links between transport-energy competence, atmospheric emission, and human contact [20]. However agricultural loss to city sprawl found both in developing and developed countries [21-28]. There are also many environmental impacts to the urban sprawl that can cause the serious problems, the change of cultivated lands into built up lands can make hazardous the natural habitat that live in these lands, by displace them and it can really cause a ripple in the environment. The negative collision of urban sprawl includes impacts on eco environment leads to increase in air or water pollution and conservatory gases due to increase in the consumption of fossil fuels. Due to excess use of private vehicles, pollution is also being increased; people are getting overweight and are also having to deal with disorders such as high blood pressure and other diseases that come with obesity.

Urban sprawl in Latifabad is being occurred due to different causes. As sprawl differentiates to other types of city expansion, such as crimes, high taxes, deficiency of infrastructures; a number of educational hubs are existing in central areas which strengthens sprawl. Land value is the other factor that has also pointed out in research study.

Latifabad unit no: 01 has become the densely-populated area, due to which the requirements of commercial areas led the conversion of residential areas into commercial strips in front of the houses. Latifabad unit no: 02 was constructed on planning, but now 10 percent of infra structure remains due to highly negligence in maintaining and restricting accompanying land. Encroachment and slums are also found. Latifabad unit no: 03 also faced the problem of densely population and spread towards the formation of slums.

Latifabad unit: 04, unit: 05 and unit: 10 exists near the river Indus channel, due to which much people avoid accommodating themselves in these areas; although Slums are formed due to which some of its residential units have also been converted into commercial areas. Latifabad unit: 06 is a very planned and developed area, but due to densely population, encroachment and slums are also found. Latifabadunit: 07 and unit: 08 are faced by heavy encroachment and slums due to its distinction by size and disperse commercial activities. Much of the plots of Latifabad unit: 09 and Latifabad unit: 11 had been Sub divided to accommodate the maximum no: of families that makes the reasons of destroying infrastructures of both units. Latifabad unit: 12 is also highly unplanned residential area, almost lacks the fully basic infra structure, and some of the areas are hilly in this unit, which also discouraged the developed ratio.

Latifabad is named following the name of celebrated poet of Shah Abdul Latif Bhitai king of melody, the Indus river flows along the western boundary of the huge district. Latifabad township scheme came into existence during the year 1952 under Government: Gazette Notification. 1850 acres were acquired for Shah Latifabad Sattelite Town from Mir Muhammad Ali Retired Chief engineer Kotri Barrage; a descendent of the ruling family of talpurs. The township was originally planned in 1953-54 to accommodate 1500 plots/units triggered to accommodate a population of 60,000 people. The same area along with its latest extensions accommodates population of approximately 0.772 million people and its boundaries expanded and strained in form of slums approximately covering an area of 2975 acres. Latifabad is divided into twelve units, comprising 17 union councils. Hospital and number of schools exists in each unit all along with mixed land uses residences and very active commercial areas as shown in Fig. 1


Fig: 1 Latifabad Map

There had been seen the sudden growth of Latifabad Township just after the developing phase by the years 1991 in an involuntary and haphazard manner typically within the town and surroundings due to have the attractions to social and environmental perspectives such as formation of proposed bungalow units, open spaces, schools, commercial markets and offices etc. Currently 0.7 million people are living in Latifabad town, which was actually designed for 60,000 people.

## II. RESEARCH METHODOLOGY

### A. *Research Factors*

In challenge to measure urban sprawl, population, availability of schools, hospitals and services, working and recreational areas, and migration rate were focused as done by [29], through which various factors are derived through above studies to analyze the growth of urban sprawl in Latifabad such as, living criteria, mode of transport vs. time factor, encroachment and parking Space, fulfillment of shops and commercial areas, education level, social problems, enough space for parking, traffic noise, encroachment, parks available, conversion of parks, street furniture, health problems, usages of utilities properly, political influences and land mafia.

### B. *Research Approach*

This research has employed a qualitative approach. Qualitative measures were done using software SPSS, which were based on questionnaires having filled by 480 occupants. The qualitative data were gathered to formulate the results based on living criteria, transportations with time factors, encroachments, availability of various services in their existing residential units of the people lives in Latifabad and found satisfactory and unsatisfactory indexes by using the software SPSS and Yeh's index of satisfaction. The qualitative approach was made to determine the capacity of Latifabad people with regards to impact in social interaction and environmental factors in order to achieve the drivers and factors for sprawl and establishing the linkages for Latifabad town.

### *C. Research Design*

Based on factors derived through studies, the questionnaire was generated and the sample size of respondents was determined by [30]; which should be minimum 384 respondents for the current Population of Latifabad i-e 0.77 million. The questionnaire was circulated among the 480 respondents of Latifabad.

#### *1. Living Criteria*

The questions were asked about the number of family members live per unit, area of home and housing availability. The no: of factors were asked to migrate from other areas, as Latifabad had been the attraction for city dwellers since it was planned as shown in Table 1.

Table 1 Living Criteria of Latifabad Residents

| The area of your House is ____ | | | Did you migrate from other areas to settle in Latifabad? | | Total |
|---|---|---|---|---|---|
| | | | Yes | No | |
| 40-80 sqyds | How many family members do you live at home | 2-4 | 1 | 4 | 5 |
| | | 5-7 | 8 | 14 | 22 |
| | | 8 or more | 6 | 15 | 21 |
| | Total | | 15 | 33 | 48 |
| 120-150 sqyds | How many family members do you live at home | 2-4 | 17 | 22 | 39 |
| | | 5-7 | 34 | 72 | 106 |
| | | 8 or more | 28 | 65 | 93 |
| | Total | | 79 | 159 | 238 |
| 200 sqyds or more | How many family members do you live at home | 2-4 | 4 | 21 | 25 |
| | | 5-7 | 26 | 55 | 81 |
| | | 8 or more | 23 | 64 | 87 |
| | Total | | 53 | 140 | 193 |
| Total | How many family members do you live at home | 2-4 | 22 | 47 | 69 |
| | | 5-7 | 68 | 141 | 209 |
| | | 8 or more | 57 | 144 | 201 |
| | Total | | 147 | 332 | 479 |

The survey reveals there is a less ratio of migration, 31.25% of 40-80 sq yards are not the permanent residents, 33.19327% of the 120-150 sq yards are migrants and 27.461% of more than 200 sq yards are migrants. Over all 30.688% has a migration level that shows that 69.311% of the Latifabad town is the permanent residents.

#### *2. Mode of Transport Vs Time Factor*

The questions were asked about the usages and types of transport with time factor with respect to private and public transport to reach their destinations as shown in Fig. 2 and Table 2.

Table 2. Mode of Transport Vs Time Factor

<table>
<tr><td colspan="3" rowspan="2">Do you find the traffic problem in your area?</td><td colspan="3">How much time do the road tracks take to reach workplace from your home?</td><td rowspan="2">Total</td></tr>
<tr><td>15-20 mins</td><td>30-40 mins</td><td>more than 40 mins</td></tr>
<tr><td rowspan="3">Yes</td><td rowspan="2">What kind of transport do you use for your daily out back?</td><td>public transport</td><td>63</td><td>69</td><td>2</td><td>134</td></tr>
<tr><td>private vehicles</td><td>151</td><td>78</td><td>0</td><td>229</td></tr>
<tr><td colspan="2">Total</td><td>214</td><td>147</td><td>2</td><td>363</td></tr>
<tr><td rowspan="3">No</td><td rowspan="2">What kind of transport do you use for your daily out back?</td><td>public transport</td><td>23</td><td>8</td><td></td><td>31</td></tr>
<tr><td>private vehicles</td><td>61</td><td>24</td><td></td><td>85</td></tr>
<tr><td colspan="2">Total</td><td>84</td><td>32</td><td></td><td>116</td></tr>
<tr><td rowspan="3"></td><td rowspan="2">What kind of transport do you use for your daily out back?</td><td>public transport</td><td>86</td><td>77</td><td>2</td><td>165</td></tr>
<tr><td>private vehicles</td><td>212</td><td>102</td><td>0</td><td>314</td></tr>
<tr><td colspan="2">Total</td><td>298</td><td>179</td><td>2</td><td>479</td></tr>
</table>

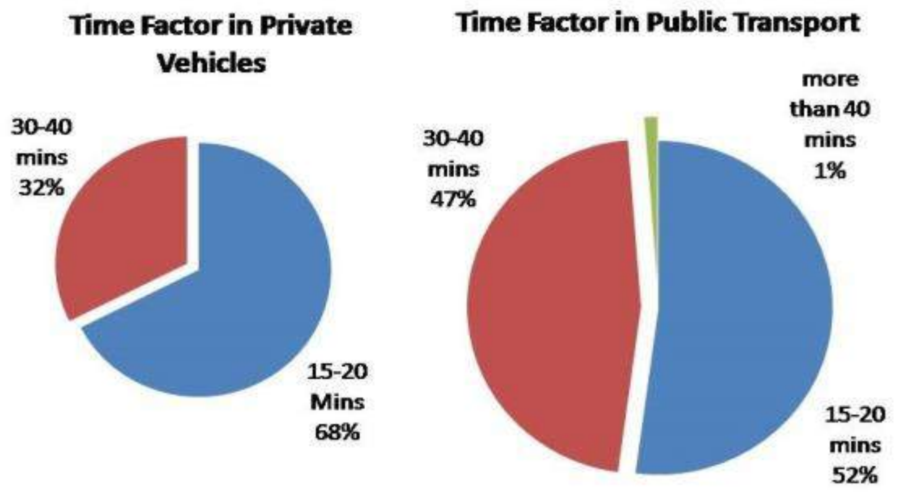


Fig: 18 Mode of Transport vs. Time Factor

The data reveals that 52.121 % of public vehicle and 67.515 % of the private own vehicles users spend 15-20 minutes to reach their destinations. 46.666 % of public vehicle and 32.418 % of the private own vehicles users spend 30-40 minutes to reach their destinations. 1.212 % of public vehicle users spend more than 40 minutes to reach their destinations as shown in Fig. 2, moreover, 65.553 % of people who keep the private own vehicles, 72.929% of private own vehicle face traffic problem as shown in Fig. 3.

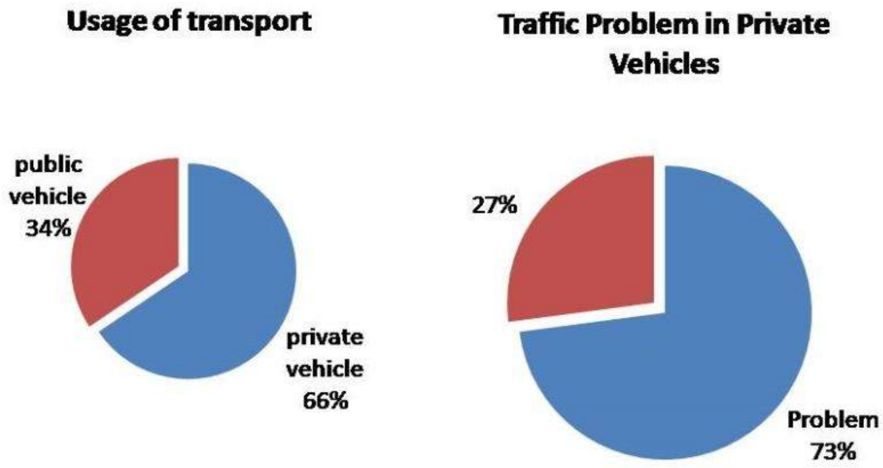


Fig: 19 Mode of Transport Facing Problem

*3. Encroachment and parking space*

The questions were asked about the encroachment in front of their houses or found in their areas as shown in Table 3.

Table 3 Encroachment and Parking Space Area

| | | Do you find enough space for parking in your area? | | Total |
|---|---|---|---|---|
| | | Yes | No | |
| Do you find the encroachments of houses in your area? | Yes | 141 | 250 | 391 |
| | No | 35 | 54 | 89 |
| Total | | 176 | 304 | 480 |

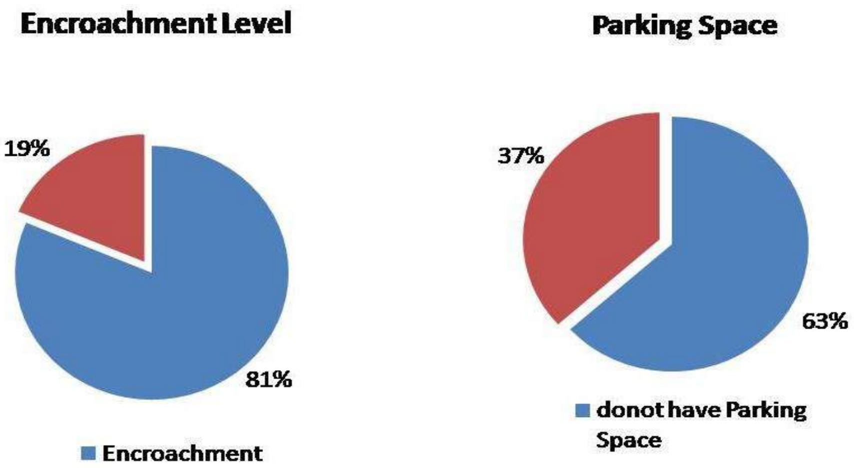


Fig: 20 Encroachment and parking Space

The data shows that the 81.458% respondents face the encroachment in their areas, whereas, 63.33% of the respondents do not have the enough parking space as shown in Fig. 4.

## III. RESULTS

### 1) SATISFACTION INDEX OF PHYSICAL AND FUNCTIONAL ACTIVITIES

Average satisfaction index was carried out to find out the level of satisfaction by two points as" satisfied" and "dissatisfied" by the formula of YIS(Yeh's index of satisfaction) as done by [31]. The following formula is used to compute satisfaction index as Eq 1.

$$YIS = \frac{\text{Satisfied-Dissatisfied}}{\text{Total Respondents}} \times 100 \qquad \text{(Eq: 1)}$$

It is easily shown to the table 4 that there is a much level of dissatisfaction for Housing availability, Traffic problem, Social problems, Enough space for parking, Traffic noise, Encroachment, Parks availability, Conversion of parks, Street furniture, Health problems, Usages of utilities, Political influences and Land mafia involving in land conversions from different attributes to built ups or within built ups classifications as residential to commercial etc.

The Education level of standard got the 50% -50% of both Satisfaction and Dissatisfaction level, where as other Routes Availability, Shops near to area, and Shops and Commercial Fulfillment got much satisfaction level.

The average satisfaction index from this analysis found out to be -41.1431, which shows a highly dissatisfaction level of Latifabad residents, so, there is a lot of need to improvement and implementing strict policies to get over these issues. Table 3 presented the satisfaction index of physical and functional activities.

Table 3 Satisfaction Index of Physical and Functional Activities

| S.n | Activity | Satisfied | Un Satisfied | Satisfaction Index |
|---|---|---|---|---|
| 1) | Housing Availability | 231 | 249 | -3.75 |
| 2) | Traffic Problem | 116 | 364 | -51.66 |
| 3) | Other Routes Availability | 299 | 181 | 24.583 |
| 4) | Shops Near to Area | 400 | 80 | 66.666 |
| 5) | Shops & Commercial Fulfillment | 327 | 153 | 36.25 |
| 6) | Education Level | 255 | 225 | 6.25 |
| 7) | Social Problems | 138 | 342 | -42.5 |
| 8) | Enough Space For Parking | 176 | 304 | -26.66 |
| 9) | Traffic Noise | 150 | 330 | -37.5 |
| 10) | Encroachment | 89 | 391 | -62.9166 |
| 11) | Parks Available | 232 | 248 | -3.333 |
| 12) | Conversion of Parks | 269 | 211 | 12.083 |
| 13) | Street Furniture | 36 | 444 | -85 |
| 14) | Health Problems | 208 | 272 | -13.333 |
| 15) | Usages of Utilities Properly | 220 | 260 | 8.333 |
| 16) | Political Influences | 229 | 251 | -4.583 |
| 17) | Land Mafia | 191 | 289 | -20.4166 |

The main cause of sprawl is the rapid urban growth, which is in practice by doing the major violation of byelaws. The situation is going to be dangerous as the transformation is taking place. The increased urbanization may have various negative impacts on physical and functional activities, basic infra structure, energy, use and economical development.

## IV. CONCLUSION

In many cases, definitions are based on implicit value statements that make the concept questionable for understand in scientific research. The sprawl is dealt with qualitative and quantitative measures of urban sprawl. Various attempts of measuring urban sprawl are formulated in the literature.

The qualitative data was gathered and formulated results based on living criteria, transportations with time factors, encroachments, availability of various services in their existing residential units of the people lives in Latifabad, and found satisfactory and unsatisfactory indexes.

It is estimated that 30.688% has a migration level that shows that 69.311% of the Latifabad town is the permanent residents. There is a ratio of 65.553 % of people who keep the private own vehicles, and 72.929% of private own vehicle face traffic problem. The 81.458% respondents face the encroachment in the areas, whereas, 63.33% of the respondents do not have the enough parking space.
The average satisfaction index from this analysis found out to be -41.1431, which shows a highly dissatisfaction level of Latifabad residents, so, there is a lot of need for improvement and implementing strict policies to get over these issues.

## V. RECOMMENDATIONS

Urban sprawl is noticeably a huge problem in Latifabad nowadays and it needs to be fixed before it grows to such a point of severity that it cannot be fixed, stopping urban sprawl would mean stopping the development of barren lands around city areas completely, which cannot occur with the increase in population of Latifabad.
Although, the problem of urban sprawl illustrate no signs resolving itself in future, if the insight of the suburbs can be changed, there can be the some of the above mentioned ways to solve the issues. After all, the people are the main ones who can make a change when it comes to restrictive suburban expansion to solve even greater issues, such as pollution, health problems, and the crumbling infrastructure.

Urban sprawl can only be slowed down by achieving the Sustainable strategy in order to recommend appropriate policy and management options.
An ideal sustainable strategy can be envisioned as that in terms of development along with diversity, which should be compact and offer array of mixed zones or land uses supported by provisions of sustainable mass transit system, should be energy efficient by means of innovative technology relaying on solar energy and promote ecological protection through greening.
The other Strategies are designed as Follows,

1) To make people aware of the problem, anything to advertise the problem and raise awareness, would make people notice the amount of harm they are causing by developing such large areas of animal / natural habitat.
2) Another way is to enforce population control. The main cause of urban sprawl is Latifabad's (Currently most populated Taluka in Hyderabad District) increasingly large population. As there are so many people living here, as the population rises and people move,
3) New developments must be created to suit their needs. Latifabad has to aim for a happy medium. Not too many people, not too few.
4) A third way to slow down urban sprawl is to enhance the use of new technology to facilitate more people to be able to work from home. Currently, people are dependent on accessing workplaces and public services offered only by a large city. There can be an incentive to live near the city because of the perks that the city offers its inhabitants.

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# Biological Treatment of Jamshoro Soil

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***Abstract*: The subject of soil stabilization is diverse as are its methods, ranging from being chemical based to mechanical, but these contribute to global carbon emission along with other gaseous emissions. This study focuses on the ecofriendly method of soil stabilization by Microbial Induced Calcite Precipitation (MICP). Previous research shows increment in shear strength and other properties of groups of soil when concentration of bacteria is 1% to 3%. This technique has shown significant increase of shear strength in clay soil, with injection of bacteria (Sporosarcina Pasteurii) using urea hydrolysis to influence the natural calcium precipitation process of bacteria. In this study metabolic pathway of bacteria is utilized to induce calcite precipitation throughout the soil mass. To analyze the increase in strength; 1% to 3% concentration of this bacteria is used. The MICP requires bacterial growth at laboratory scale along with nutrients to form bio slurry. The basic parameters likewise shear strength and maximum dry density (MDD) of the soil matrix were observed before and after treatment. This technique is ecofriendly which does not produce oxides of carbon in the environment.***

***Keywords:* Microbial induced calcite precipitation (MICP), Clayey soil, Bio grout, Shear strength, Maximum dry density.**

## I. INTRODUCTION

As we have seen construction on weak soils is inevitable as the quantity of suitable lands is diminishing due to global construction demands thus weak soils must be stabilized in order to help overcome this problem these have been characterized as having low strength and high compressibility and have consolidation. These soils occur in many areas which are filled with clay and silt intermixed with sand and also in tropical zones which are connected to water which cause them to have soft strata and high compressibility and liquify under loads and consolidate which causes major problems in constructed buildings. As time passes we need to improve our soil improvement techniques as the addition of chemical and cementitious grout has proven to improve soil properties but it has major adverse effect in the ecosystem and it contaminates soil and groundwater which is harmful for environment down the road this hazardous characteristics must be rectified by a relatively green and sustainable techniques. *One such technique is the usage of bacterial improvements in soil matrix or microbial induced calcite precipitation (MICP) has been introduced in recent years.* This technique relies on biochemical process to improve the soil and its engineering properties (MDD. shear strength). The application of this technique is diverse as it can be applied in concrete strength and durability and brick durability and improve impermeability of materials.

The bacteria in question called *Sporosarcina Pasteurii* this bacterium when comes in contact with chemical reagent or bio grout excretes calcite precipitation which harden after some time and causes cementation between soil particles but this technique requires bacteria to be mixed in soil mass and them a curing period to be done to soil mass so that bacteria can use its urease hydrolysis and start the cementation process for the soil and this is relatively how MICP process works.

## II. THEORY

### HOW MICROBIAL INDUCED CALCITE PRECIPITATION WORKS?

Microbial induced calcite precipitation is a bio-geochemical process that induces calcium carbonate precipitation within the soil matrix. Biomineralization in the form of calcium carbonate precipitation can be tracked back to the Precambrian period. The main groups of microorganisms that can induce the carbonate precipitation are photosynthetic microorganisms such as cynobacteria & microalgae*;* sulfate reducing bacteria and some species of microorganisms involved in nitrogen cycle.

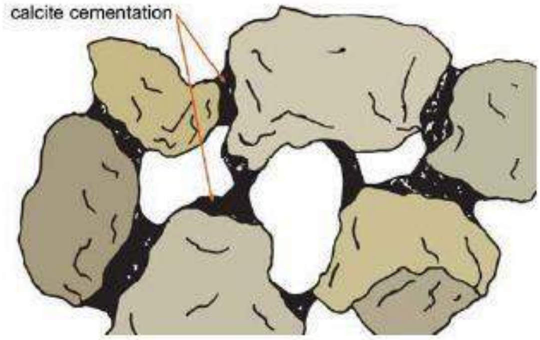


*Fig: 1 Diagram of calcite cementation occurring at grain to grain contacts*

In particular, Sporosarcina pasteurii (Bacillus pasteurii) has been found to be a very effective producer of urease and an effective inducer of calcite deposition Sporosarcina pasteurii (Bacillus pasteurii) is ideally suited for larger scale activities, such as rammed earth construction, because of its ability to survive desiccation through In addition, *Sporosarcina pasteurii (*Bacillus pasteurii) has proven to be a good candidate for microbial induced calcite precipitation of sandy soils due to its tendency not to aggregate, thereby allowing for thorough dispersion throughout the soil structure. Furthermore, the size of these microbes allows them to move freely through granular sandy and silty material. The urease enzyme supplied directly into soil or produced insitu by bacteria, decompose urea (CO (NH2)2) in the soil through a chemical reaction known as hydrolysis of urea:

*Urease Hydrolysis:*

$$CO(NH_2)_2 + 2H_2O \longrightarrow 2NH_{4+} + CO_3^{2-} \quad \dots\ (1)$$

The ammonium ($NH_{4+}$) released from the urea hydrolysis results in a local pH rise that commences the precipitation of calcium carbonate (calcite). Calcite is precipitated through the reaction between carbonate ions ($CO_3^{2-}$) from the urea hydrolysis and calcium ions ($Ca^{2+}$) from the supplied calcium chloride:

$$Ca^{2+} + CO_3^{2-} \longrightarrow CaCO_3 \quad \dots\dots\ (2)$$

The calcite (CaCO3) formed is responsible for improving the engineering properties of soil.

## III. Materials

**a) Soil Sample:**

Soil sample was collected from Latitude 25.39

Longitude 68.25 which is behind the Mehran university's Civil Engineering Department from the department the site of excavation is about 100ft away. After excavation we of soil we used quartering method to get a representative soil sample.

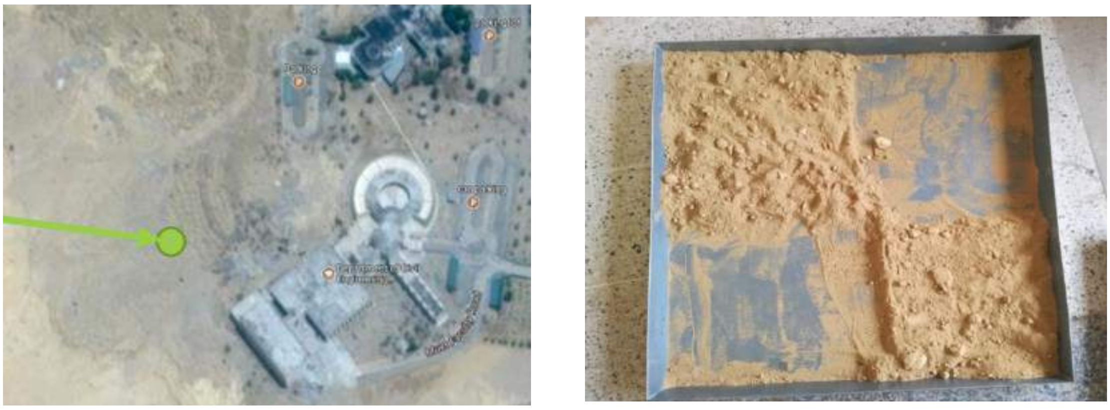

*Fig: 2 Site Location and Representative soil Sample*

**b) Micro-Organism:**

Sporosarcina pasteurii (Bacillus pasteurii) They are bacteria which were prepared for us by Karachi university microbiological department. they have been found to be a very effective producer of urease and an effective inducer of calcite deposition Sporosarcina pasteurii (Bacillus pasteurii) is ideally suited for larger scale activities, such as rammed earth construction, because of its ability to survive desiccation through In addition, *Sporosarcina pasteurii (*Bacillus pasteurii) has proven to be a good candidate for microbial induced calcite precipitation of sandy soils due to its tendency not to aggregate, thereby allowing for thorough dispersion throughout the soil structure. Furthermore, the size of these microbes allows them to move freely through granular sandy and silty material.


*Fig: 3 Bacillus Pasteurii Bacteria wraped in black plastic to protect from sunlight*

**c) Preparation of Nutrient solution and Reagent solution:**

Preparation of Nutrient solution for producing the calcite the reagent use in MICP is urea & calcium chloride. In terms of 1 lit. volume of distilled water the equal ratio of 0.5M of urea ($CO(NH_2)_2$) and calcium chloride ($CaCl_2$) is essential in order to achieve complete production of calcite. For preparation of Nutrient solution urea and calcium chloride is mixed with broth solution & cultivated bacteria were released into the nutrient solution.

*Fig 4: Urea [$CO(NH_2)_2$]*

*Fig 5: Calcium Chloride ($CaCl_2$)*

*Fig 6: 0.5M per liter constituent of urea and calcium chloride (30.03 g urea, 55.49 g calcium chloride)*

## IV. EXPERIMENT STUDY

### a) Test Sample preparation:

In this study, shear strength and compressive strength properties of soil were firstly determined in the natural form of soil. Liquid limit test, plastic limit, Dry density through modified Procter test., direct shear test, were also be carried out on natural soil.

Then bacterial solution and reagent solution was added in specific percentages (1%, 2% and 3%) by weight of the sample required for different test we added the test samples were all of each of 5kg weight. The bacteria were added in 50ml, 100ml and 150ml solution respectively to each sample. The three samples were given 1 litre reagent solution each at first curing to allow reagent solution to enter soil matrix fully so as to allow bacteria to easily access it and start its natural process of carbonation. After the addition of Bacterial solution with specific percentage (1%, 2% and 3%) by weight, the modified proctor test and shear box test were carried out on test samples to determine the change in properties observed by the MICP technique.

### b) Curing of Test Samples:

When the bacterial solution and reagent solution are added to soil matrix it does not give results directly the bacteria need some time to grow and excrete calcium carbonate and thus this process takes time and reagent solution is to be applied constantly for 7 days with refilling of each test sample after every 12 hours. We were able to use almost 8 liters of reagent solution in 7 days for 3 test samples of 5 kg each

*Fig 7: Soil samples after 1st curing*

TABLE I: DETAILS OF SAMPLE PREPARED

| S. No. | Nutrient solution Concentration (%) | Curing Period (Days) |
|---|---|---|
| 1. | 1 % | 7 |
| 2. | 2% | 7 |
| 3. | 3% | 7 |

### c) Experimentation Methods

Following are procedures of the experiments that were conducted.

***1)*** *Water Content Determination by Oven Drying Method*

*It involves the following steps:*

i. Clean, dry and weight the container
ii. Take the required quantity of soil specimen and weight it
iii. Keep the container in oven and maintain the temperature of oven between 105°C to 110°C
iv. After 24 hours take out the container from oven.
v. Then cool the sample container in the desiccators and weight the dry soil with container.

***2)*** *Liquid Limit Using Casagrande's Method*

It involves the following steps:

i. About 120 gm. of air dried soil from thoroughly mixed portion of material passing 425 microns IS sieve is obtained.
ii. Distilled water is mixed to the soil thus obtained in a mixing disc to form uniform paste. The paste shall have a consistency that would require 30 to 35 drops of cup to cause closer of standard groove for sufficient length.
iii. A portion of the paste is placed in the cup of Casagrande device and spread into portion with few strokes of spatula.
iv. It is trimmed to a depth of 1 cm. at the point of maximum thickness and excess of soil is returned to the dish.
v. The soil in the cup is divided by the firm strokes of the grooving tool along the diameter through the center line of the follower so that clean sharp groove of proper dimension is formed.

vi. Then the cup is dropped by turning crank at the rate of two revolutions per second until two halves of the soil cake come in contact with each other for a length of about 12 mm. by flow only.
vii. The number of blows required to cause the groove close for about 12 mm. is recorded.
viii. A representative portion of soil is taken from the cup for water content determination.
ix. The test is repeated with different moisture contents at least 3 times for blows between 10 and 40.

***3)*** *Plastic Limit Test AASHTO Designation*

It involves the following steps:

i. Take about 100gm of oven dried soil from thoroughly mixed portion of the Material passing No.40° sieve.
ii. Mix it with sufficient distilled water to make it plastic enough to be shaped into a ball.
iii. 3) Take a small quantity of plastic soil, make a ball of it and roll it on the glass Plate with hand and with just sufficient pressure to roll the soil mass into a thread of 3mm Size uniform diameter.
iv. Collect the crumbled soil thread in the air tight container and keep it for water Content determination

***4)*** *Sieve Analysis*

Firstly, the soil sample is thoroughly washed and sieve through a No.200 SIEVE (0.075mm in size) in order to remove the material finer than 0.075mm in size. Then it is dried in drying oven at temperature of 105°C for 24hours. The sample is the cooled at room temperature and weighed. After this, the sample is separated into series of sieves using the required sieves. The sieving operation is conducted by means of a lateral or vertical motion accompanied by a jerking action so that the sample is kept moving continuously over the surface of wires. The motion of the sieves is accompanied by mechanical shaker and hand. Finally, the weight of material retained on each sieve is accurately determined on a balance.

***5)*** *Modified Proctor Compaction Test*

i. Fist take sufficient quantity of soil or representative soil and air dry pulverize it with rubber mould, sieve the soil sample through NO.4 sieve and reject the coarser materials
ii. Take sufficient amount of soil add water to bring its water content to about 3% the estimated (OMC) mix it thoroughly
iii. Clean the mould, measure its diameter, height and weight without collar
iv. Fit the collar and compact the sample in 5 equal layers with 25 blows on each layer on 4” dia mould.
v. Remove the collar, trim the compacted soil and weight it.
vi. Remove the soil from mould, spilt it and take about 100gm sample or some suitable soil for water content determination.
vii. Break the soil lumps, mix it with remaining soil in tray, add water about 2 to 3%by by weight to increase water content and repeat the procedure of compaction.

***6)*** *Direct Shear Test AASHTO Designation:*

Prepare a soil specimen of size (6cm 6cm 2cm) from the soil sample soil specimen may directly be prepared in the box by compaction. Then the shear box with specimen and plain grid plate over the top of the specimen is filled in to the position and the shear box assembly is mounted on the shearing machine (loading frame) the lower part of the shear box is set to bear against the load jack and proving ring is set to zero and the upper part of the box was set to shear against the proving ring. After this a load of two kilograms is put on the hanger yoke and the reading of the displacement dial gauge is noted. It means that the shear fore at the failure of soil sample to the normal load was measured with the help of proving ring.

## V. RESULTS AND COMPARISON

### 1. NATURAL SOIL:

TABLE 2: SOIL CLASSIFICATION

| |
|---|
| Soil Classification According to AASHTO: |
| #200 Passing = 51.009 |
| Liquid Limit (From Casagrande Method) = 41% |
| Plastic Limit = 31% |
| Plasticity Index = 10 |
| Soil Group (From AASHTO Soil Classification Table) = A-5 |

TABLE 3: MODIFIED PROCTOR NATURAL SOIL

| **Moisture Content (%)** | **Dry Density (gm/cm3)** |
|---|---|
| 2.75 | 1.664 |
| 4.28 | 1.764 |
| 6.58 | 1.870 |
| 9.19 | 1.930 |
| 10.79 | 1.900 |

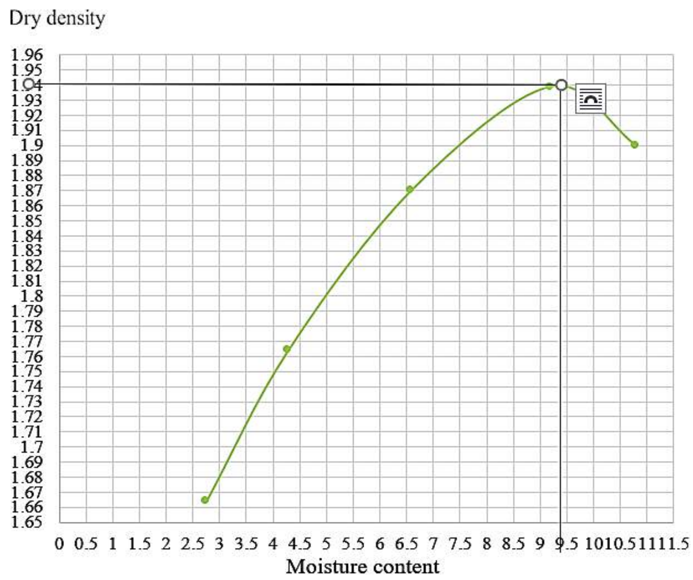


*Fig 8: Modified Proctor of Natural Soil*
*OMC = 9.45% Dry density max = 1.94gms/cc*

TABLE 4: Shear Strength of Natural Soil

| *Sample No:* | *Normal stress (kg/cm2)* | *Proving ring readings kg/division* | *Maximum dial gauge readings* | *Shear stress Kg/cm2* |
|---|---|---|---|---|
| *1* | *(24.5/36) =0.680* | *0.15* | *196* | $\frac{196}{36} \times 0.15 = 0.82$ |
| *2* | *(44.5/36) =1.236* | *0.15* | *360* | $\frac{360}{36} \times 0.15 = 1.5$ |
| *3* | *(84.5/36) =2.347* | *0.15* | *576* | $\frac{576}{36} \times 0.15 = 2.4$ |

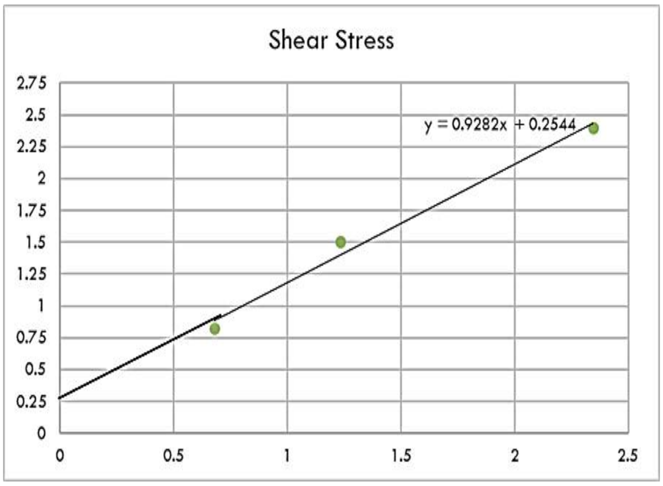


*Fig 9: Shear Strength of Natural Soil*
*Cohesion (C) = 0.25 kg/cm$^2$ Angle of internal friction = 21*

## 1. BACTERIAL SOIL SAMPLES:

TABLE 5: MODIFIED PROCTOR SAMPLE 1(50ML)

| Moisture Content (%) | Dry Density (gm/cm3) |
|---|---|
| **1.34** | **1.78** |
| **3** | **1.92** |
| **4.9** | **2.05** |
| **5.39** | **2.12** |
| **8.13** | **2.07** |

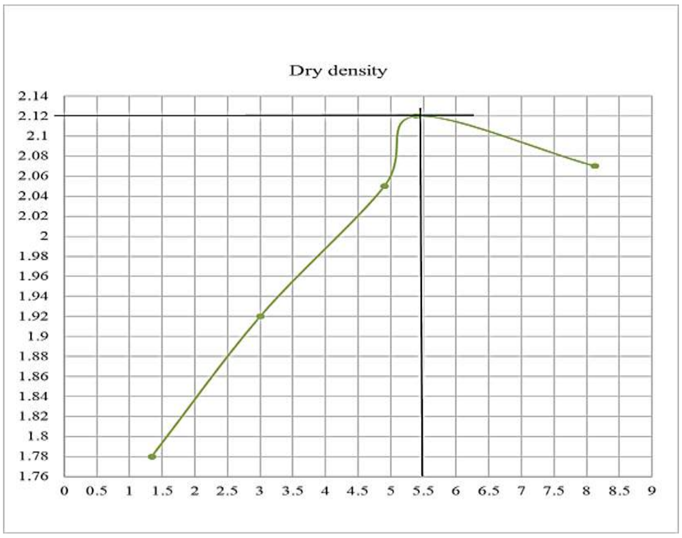


*FIG 10: MODIFIED PROCTOR OF* SAMPLE 1(50ML)
*OMC = 5.5%Dry density max = 2.12gms/cc*

TABLE 6: Shear Strength of Natural Soil

| *Sample No:* | *Normal stress (kg/cm2)* | *Proving ring readings kg/division* | *Maximum dial gauge readings* | *Shear stress Kg/cm2* |
|---|---|---|---|---|
| *1* | *(24.5/36) =0.680* | *0.15* | 228 | $\frac{228}{36} \times 0.15 = 0.95$ |
| *2* | *(44.5/36) =1.236* | *0.15* | 576 | $\frac{576}{36} \times 0.15 = 2.4$ |
| *3* | *(84.5/36) =2.347* | *0.15* | 744 | $\frac{744}{36} \times 0.15 = 3.1$ |

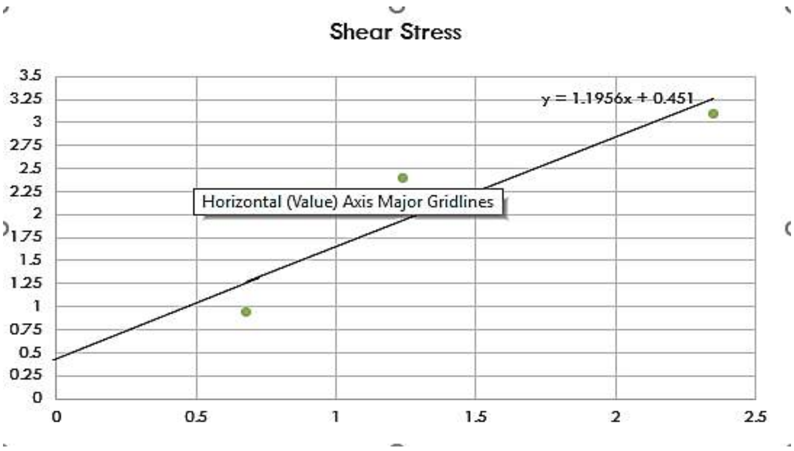


*Fig 11: Shear Strength of Sample 1(50ml)*
*Cohesion (C) = 0.5 kg/cm2 Angle of internal friction = 24°*

TABLE 7: MODIFIED PROCTOR SAMPLE 3(150ml)

| **Moisture Content (%)** | **Dry Density (gm/cm3)** |
|---|---|
| **3.23** | **1.86** |
| **4.92** | **1.97** |
| **6.64** | **2.012** |
| **8.59** | **2.08** |
| **10.4** | **2.01** |


*FIG 12: MODIFIED PROCTOR OF* SAMPLE 3(150ML)
*OMC = 8.5%Dry density max = 2.08gms/cc*

TABLE 8: Shear Strength of Natural Soil

| *Sample No:* | *Normal stress (kg/cm2)* | *Proving ring readings kg/division* | *Maximum dial gauge readings* | *Shear stress Kg/cm2* |
|---|---|---|---|---|
| *1* | *(24.5/36) =0.680* | *0.15* | 228 | $\frac{228}{36} \times 0.15 = 0.95$ |
| *2* | *(44.5/36) =1.236* | *0.15* | 576 | $\frac{576}{36} \times 0.15 = 2.4$ |
| *3* | *(84.5/36) =2.347* | *0.15* | 744 | $\frac{744}{36} \times 0.15 = 3.1$ |


| *Sample No:* | *Normal stress (kg/cm2)* | *Proving ring readings kg/division* | *Maximum dial gauge readings* | *Shear stress Kg/cm2* |
|---|---|---|---|---|
| *1* | *(24.5/36) =0.680* | *0.15* | 228 | $\frac{228}{36} \times 0.15 = 0.95$ |
| *2* | *(44.5/36) =1.236* | *0.15* | 576 | $\frac{576}{36} \times 0.15 = 2.4$ |
| *3* | *(84.5/36) =2.347* | *0.15* | 744 | $\frac{744}{36} \times 0.15 = 3.1$ |


*Fig 13: Shear Strength of Sample 3(150ml)*
*Cohesion (C) = 1.48 kg/cm²Angle of internal friction = 14°*

2. COMPARISON:

Stabilization Test sample 1 1% (50ml) Bacterial Solution

- Maximum dry density increases from 1.94 kg/$cm^2$ to 2.12 kg/$cm^2$ , net increase 9.27%,
- OMC decrease from 9.45% to 5.5%, a decrease of 44.44%
- Cohesion value increase from 0.25kg/$cm^2$ to 0.5kg/$cm^2$, net increase 100%
- Shear strength is increased on 24.5kg load 0.82 kg/sqcm to 0.95 kg/sqcm which is increase of 15.85%

Stabilization Test sample 2 3% (150ml) Bacterial Solution

- Maximum dry density increases from 1.94 kg/$cm^2$ to 2.08 kg/$cm^2$ ; net increase 7.21%, OMC decrease from 9.45. % to 8.5% a decrease of 15.34%
- Cohesion value increase from 0.25kg/$cm^2$ to 1.48 kg/$cm^2$; net increase 492%,
- Shear strength is increased on 24.5kg load 0.82 kg/sqcm to 1.90 kg/sqcm which is increase of 131.70 %

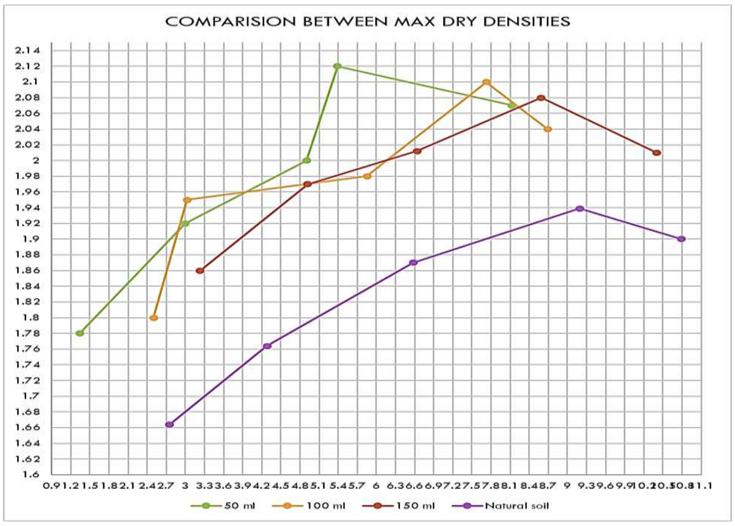


*Fig 14: Comparison Between Modified Proctor Results*

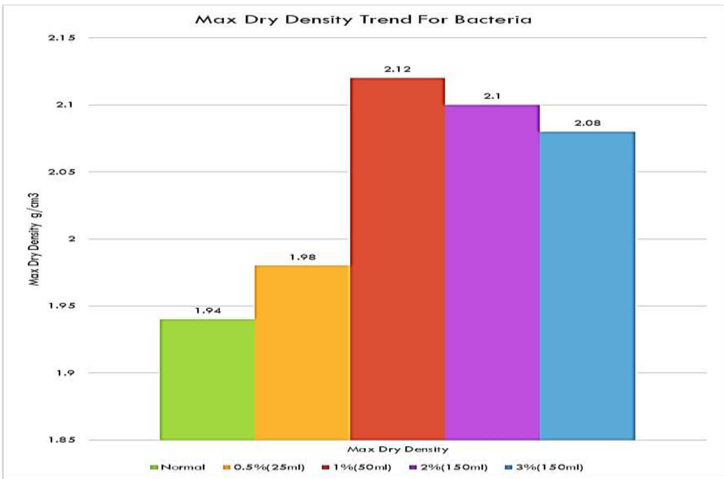


*Fig 15: Comparison Between Modified Proctor Results*

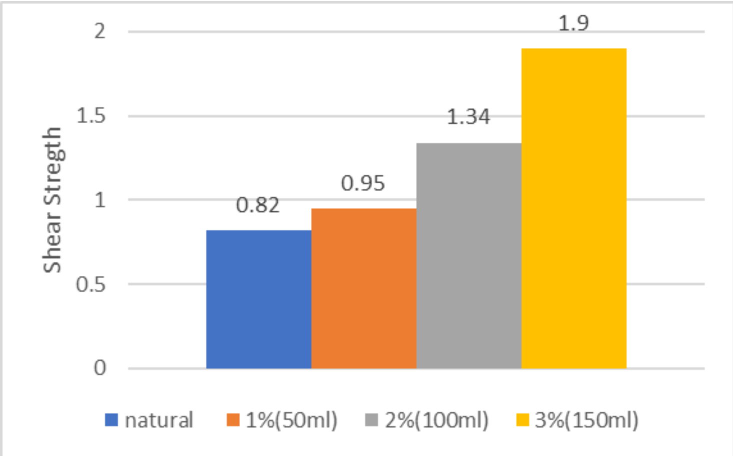


*Fig 16: Comparison Between Shear Strength Result*

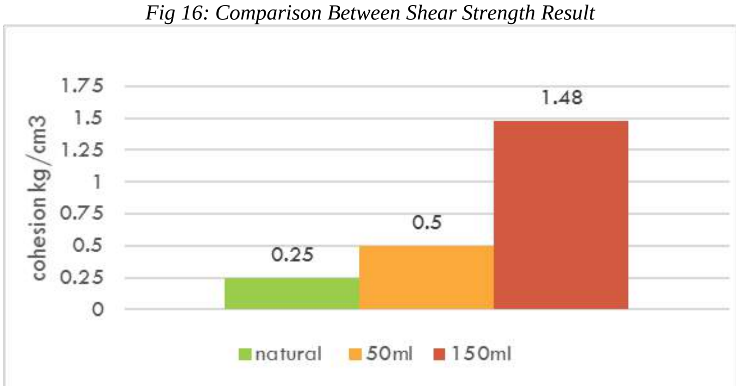


*Fig 17: Comparison Between Cohesion Results*

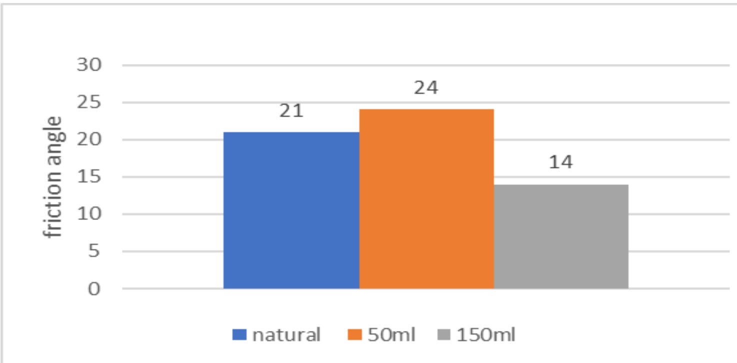


*Fig 17: Comparison Between Internal Angle of Friction Results*

## VI. CONCLUSION

The testing of soil and its classification revealed few aspects about MICP technique which are able to shed a more detailed look on which parameters the soil has improved in these include the maximum dry density and shear strength of soil which will lead to conclusion of which soil is better in regard to shear. The bacterial addition increased the soil by the excretion of calcium carbonate which is a cementing agent present in everyday cement we have seen it in the thesis in form of whitish lines or patches the bacterial addition proves that 1%(50ml) bacterial addition gives us the best result in max dry density but the best result in shear is governed by the 3%(150ml) bacteria other factors might also play a factor in this like evaporation rate of reagent solution or the densification of soil the permeability of soil to let reagent solution and bacterial solution to pass through it.

We also had a limited amount of bacterial solution to carry testing with but it is seen that the bacterial solution which benefits the soils is in the range of 1 to 3 % which is dependent on type of soil and also on type of injecting technique but the results are rather same after 3% addition. With this we know what bacterial calcite precipitation is a viable technique which may require larger sample testing to specify its worth but is can be used a very environment friendly technique of soil stabilization. Also, its application is very simple and easy to understand.

## VII. RECOMMENDATIONS

I would recommend this technique be used in field which have poor shear and compressive value but with a suitable constant pumping of reagent solution be applied to soil with a good draining technique to insure a proper transfer of bacterial and reagent solution in soil to allow bacteria to fully utilize its potential and provide good result in stabilization of soil and as it is relatively new technique a large testing should be conducted on soil to further insure its viability in different soil types at different

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# Correlations between Relative Density and Compaction Test Parameters

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***Abstract.*** **Soil is naturally occurring, uncemented or unaggregated deposits of minerals so it is difficult to maintain its properties while bringing representative sample in laboratory for testing. So, the project involves developing a suitable correlation between different parameters (these parameters help us in using various equations) by using single linear regression and multiple linear regression analysis. For this purpose, we used non-cohesive sandy soil (c=0) from different places of Sindh, and performed different physical and mechanical tests on that soil for determining its condition such as, sieve analysis for determining (coefficient of uniformity, coefficient of curvature), specific gravity, water content, relative density, standard proctor, modified proctor, sand equivalent etc. From this research it is concluded that equations we made by comparing these results can be utilized on (A-3) Soil with confidence. Equations developed by using multiple linear regression analysis are more reliable than single linear regression.**

***Keywords:*** **Single linear regression, Multiple linear regression, Relative density, Sand equivalent.**

## I. INTRODUCTION

Just like other construction materials soils has its own scientific analysis with regards to its abilities on dealing with forces. Being the oldest construction and probably engineering material soil is one of the most complex fields in civil engineering.i.e. the uncertainty in soil analysis and design is higher [1]. As the soils are covering large portion of earth's crust naturally occurring materials, thus Soils are highly variable and complex materials, possessing different engineering properties that may be very difficult to find [2]. Soil classification tests, such as sieve analysis for sand soil, are relatively quick and easy to perform and are considered to be not expensive. However; the tests required for the determination of compaction parameter are relatively expensive and need some testing time. The availability of correlations between the tests results would reduce the effort and cost by guessing with confidence any compaction properties. In this research, different tests were carried out such that sieve analysis, specific gravity, standard and modified proctor compaction tests. Also, minimum and maximum void ratio, were tested using Egyptian specification. The test results are used to evaluate the different soil properties required for investigation of possible correlations between them. The relationships between tested minimum and maximum void ratio, tested minimum void ratio and coefficient of uniformity, and tested and calculated minimum void ratio were studied. Then correlation between degree of compaction, RC and relative density then, relationship between coefficient of uniformity and maximum dry density tested by using standard proctor test sand calculated using relative density [3].

## II. LITERATURE REVIEW

All tests were carried out in order to investigate possible correlations of compaction parameters. THE SUSCEPTIBILITY of a cohesionless Soil to settlement is critically dependent on its in-situ density. Because of the difficulties and expense of obtaining truly Undisturbed samples or access to determine In situ density [4]. The geotechnical requirements are very important for the designers to define the efficient foundation to be chosen for any construction for suitable type of soil. Some empirical relationships exist in geotechnical engineering between one soil property and another [5] Maximum and minimum density tests, conducted on a variety of sands, show that the minimum and maximum void-ratio limits are controlled primarily by particle shape, particle size range, and variances in the gradational-curve shape, and that the effect of particle size is negligible [6] more numbers of fines used to make sand uniform and that uniform sand densifies by vibration more effectively than well graded sand [7]. The dilatancy of silty sand based on relative compaction is evaluated. [8 The analysis of all geotechnical problems such as transmission structure foundation design, require the adoption of a soil behavioral model that must include all relevant soil properties. These soil properties are not known in advance and require a design engineer to either measure or estimate properties using correlations [9]. degree of compaction in terms of relative density, as compared to percent of maximum density, requires using different standards for both the level of compaction required and the limits within which compaction would be considered acceptable [10]. when cone penetration resistance is replaced by relative density, performance is comparable for tests conducted in the two sands at the same relative density [11].

## III. MATERIALS & METHODS

### *A. Sand*

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand is silica (silicon dioxide, or $SiO_2$), usually in the form of quartz.

Fig: 1 Sandy Sample Used In Reserach

Fig: 2 River Sand Used In Research

### *B. River sand*

**River sand** is a product of natural weathering of rocks over a period of millions of years. Itis mined from the **river** beds. **River sand** is becoming a scarce commodity now. **River** (Freshwater) **sand** is farsuperior for construction purposes than any other **sand** used in construction.

Table 1: location of samples collected for laboratory tests

| Sample | •location |
|---|---|
| SAMPLE 1 | Baz site 1 |
| SAMPLE 2 | Niaz baz kando |
| SAMPLE 3 | Niaz khoso dika |
| SAMPLE 4 | Niaz dika |
| SAMPLE 5 | Niaz dika open |
| SAMPLE 6 | Al -Manzar Sand |
| SAMPLE 7 | Mula katyar Sand |

### C. *Methodology*

In total, seven Samples of sandy soil were collected from different regions of sindh whose (c=0) were tested in laboratory. The aim of this research is to introduce a co-relation between relative density and compaction test parameters by performing different physical and mechanical test to develop an equation so, that we can directly use that equation in field .Bringing representative soil to the laboratory and performing different test on the sample is very much time consuming and costly .The sample which is bought to the laboratory may not be the proposed sample of proposed site .Thus it becomes cumbersome to evaluate actual test results. So all the tests were carried out in order to investigate the possible correlations of compaction parameters.

Table 2: Various Codes & Standard followed in Laboratory Testing

| PROPERTY | •CODES/STANDARD |
|---|---|
| Natural Moisture Content | •AASHTO T 265, ASTM D 2216. |
| Classification | •AASHTO T87,88.ASTM D 421,422, 2217 |
| Sand Equivalent | •AASHTO T176.ASTM D-2416-02. |
| Specific gravity | • AASHTO T100.ASTM D 854-92, 70 |
| Relative density | •AASHTO T8990.ASTM C-128-15. |
| Dry Density (maximum) | •AASHTO T 180,ASTM D-1557 |
| OMC | •AASHTO-T 265, ASTM D 2216. |

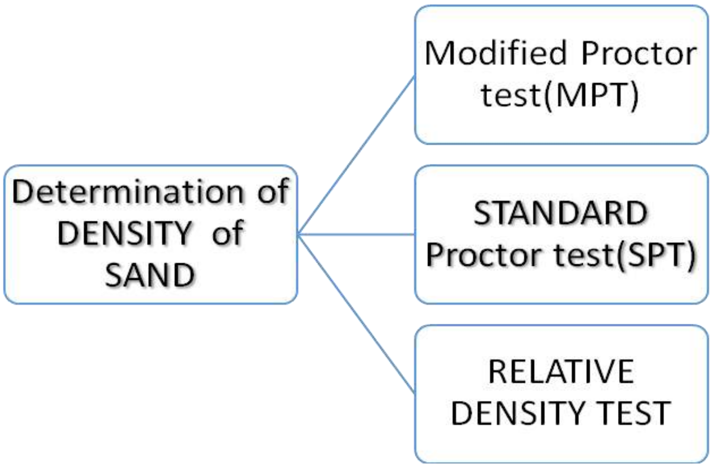


Fig 3: test performed with addition for density determination

## IV. RESULTS

### A. *Soil Classification:*

According to AASHTO classification, if the soil sample passing from #200 sieve is greater than 35% then the material is said to be "Silt-clay material" and if the percentage passing is less than 35 then soil is said to be "Granular material" in nature.

Table 2: Group of soil

| Plastic limit | %fines | Group |
|---|---|---|
| Non plastic | 4.4 | A-3 |
| Non plastic | 3.2 | A-3 |
| Non plastic | 2.9 | A-3 |
| Non plastic | 4.1 | A-3 |
| Non plastic | 1.28 | A-3 |
| Non plastic | 9.164 | A-3 |
| Non plastic | 74.98 | A-5 |

NOTE:
From above table it is concluded that properties of sample no :7 are completely change from all sample so we don't use that sample in our correlation.

B. *Modified Proctor Test (MPT):*
We performed both standard and modified proctor curve of some samples are shown ,from the shape of curve it is concluded that proctor test is not reliable for the soils used in this research so Relative density test were conducted (because fine content are less than 12%).

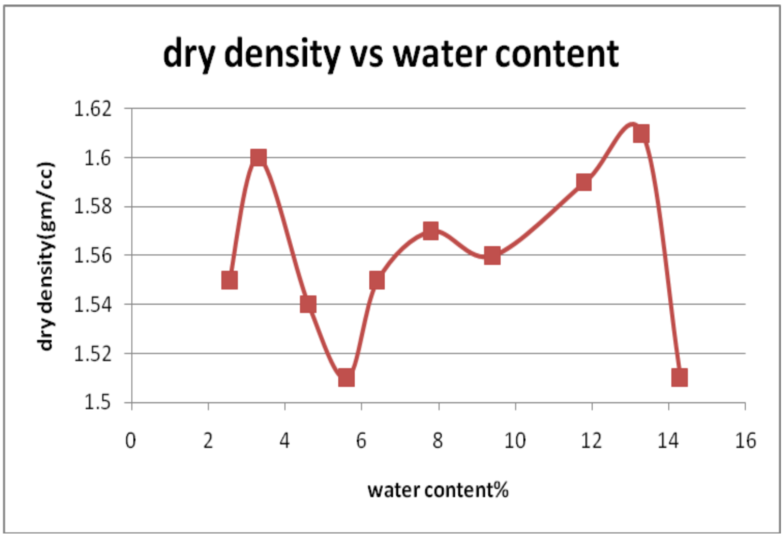


Fig 3: one of the sample of proctor graph

Note:From classification given above that all samples are classified as (A-3) so their fine content are less than 12% ,thats why their proctor curve is not wel.We suggest relative density for such samples.

Table 3 Table used for correlation

| Sam ple | Tested | | Grain size Distribution | | | Tested | Standard Proctor | | Modified Proctor | | Relative density test(gm/cm3) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No** | $e_{max}$ | $e_{min}$ | **cu** | **cc** | **%fines** | **Gs** | $\gamma d_{(max)}$ | **O.M.C %** | $\gamma d_{(max)}$ | **O.M.C %** | $\gamma d_{(max)}$ | $\gamma d_{(mini)}$ |
| 1 | 0.786 | 0.48 | 4.57 | 0.60 | 4.4 | 2.55 | 2.09 | 6.15 | 2.06 | 1.97 | 2.06 | 1.76 |
| 2 | 0.79 | 0.48 | 4.5 | 1.39 | 3.2 | 2.54 | 1.8 | 4.2 | 1.98 | 7.4 | 1.99 | 1.68 |
| 3 | 0.78 | 0.47 | 5.76 | 0.871 | 2.9 | 2.60 | 71.9 | 7.4 | 2.009 | 4 | 2.07 | 1.82 |
| 4 | 0.781 | 0.47 | 6.15 | 0.82 | 12.1 | 2.60 | 1.9 | 4.1 | 2.02 | 6.9 | 2.065 | 1.760 |
| 5 | 0.81 | 0.499 | 1.05 | 0.13 | 4.83 | 2.68 | 1.96 | 7.2 | 2.14 | 6.4 | 2.145 | 1.885 |
| 6 | 0.796 | 0.49 | 2.25 | 1.17 | 9.164 | 2.65 | 1.61 | 13.3 | 1.85 | 10.56 | 1.740 | 1.38 |
| 7 | 0.76 | 0.45 | 44.4 | 62.67 | 74.98 | 2.73 | 1.78 | 16 | 1.87 | 13.4 | 1.64 | 1.34 |

Note: We have used values of first 6 samples as you see the properties of sample number 7 are change ,it belongs to (A-5) group.

Single Linear Regression Equations

In **simple linear regression**, we predict scores on one variable from the scores on a second variable. The variable we are predicting is called the criterion variable and is referred to as Y. The variable we are basing our predictions on is called the predictor variable and is referred to as X.

Multiple Linear Regression Equations

It is most common form of linear regression analysis as a Predictive analysis, the multiple linear regression is used to explain the relationship between one continuous dependent variable from two or more independent variable.

Note: we have developed many single linear and multiple linear regression equations but here we show only few equations whose ($R^2$ IS greater than 85%) means which are very reliable.

| GRAPHN RELATION | POLYNOMIAL EQUATION | LINEAR EQUATION |
|---|---|---|
| emax vs cu | emax = + 0.005(cu)2 - 0.025(cu) + 0.830<br>$R^2 = 0.975$ | e(max) = - 0.016ln(Cu) + 0.8105<br>$R^2 = 0.9662$ |
| $\upsilon$dmini vs %finer | $\upsilon$dmin = - 0.004(%FINER)3 + 0.066(%FINER)2 - 0.291(%FINER) + 2.163<br>$R^2 = 0.941$ | $\upsilon$dmini = - 0.0622%FINER + 1.9744<br>$R^2 = 0.9$ |
| $\upsilon$dmin vs. $\upsilon$dmax ($I_D$) | $\upsilon$dmin = - 2.108($\upsilon$dmax I?)3 + 12.81($\upsilon$dmax $I_D$)2 - 24.58($\upsilon$dmax $I_D$) + 16.47<br>$R^2 = 0.989$ | $\upsilon$dmin = 1.23$\upsilon$dmax ($I_D$) - 0.7593<br>$R^2 = 0.9879$ |
| $\upsilon$dmax VS % FINER | $\upsilon$dmax = - 0.003(%FINER)2 - 0.012(%FINER) + 2.141<br>$R^2 = 0.909$ | $\upsilon$dmax ($I_D$) = - 0.0498%finer + 2.2195<br>$R^2 = 0.8845$ |

Some reliable multiple linear regression equations:

[1] $\%finer = -0.51141Cu + 2.791250907Cc + 20.89321429SG - 49.87403079$ $R^2 = 0.604815$

[2] $Cu = -67.422e(max) - 120.947e(mini) - 5.67792SG + 130.1798$ $R^2 = 0.994069$

[3] $\%FINER = -581.381e(max) + 643.6377e(mini) + 29.69709SG + 77.4978$ $R^2 = 0.921247$

[4] $e(max) = 0.934553e(mini) + 0.058599SG + 0.189361$ $R^2 = 0.859891$

[5] $e(max) = 1.266633e(mini) - 0.00164\%FINER + 0.189382$ $R^2 = 0.942803$

[7] $e(max) = -0.58225e(mini) - 0.00793Cu + 1.102074$ $R^2 = 0.952473$

[8] $Sand\ equivalent = 0.688908Cu - 4.83098Cc + 0.473279I? + 50.13317$ $R^2 = 0.95287$

[9] $Sand\ equivalent = -12.9534e(max) - 112.287e(mini) + 0.60689I? + 104.4119$ $R^2 = 0.895783$

[10] $Sand\ equivalent = 0.660814Cu + 0.660814I? + 36.37227$ $R^2 = 0.902192$

[11] $\%FINER = 3.836409ãdmax(I?) - 17.5624ãdmini(I?) + 26.576$ $R^2 = 0.900536$

[12] $e(max) = 1.052269e(mini) - 0.00744Cc + 0.291587$ $R^2 = 0.883688$

## V. CONCLUSIONS

- From this study the following conclusions were obtained.
  Different correlations between different parameters were developed by utilizing single linear regression and multiple linear regression
- It is observed that equations developed from MLR are more reliable than SLR.
- Some of the reliable equations with value of $R^2 > 0.90$

(1) $Cu = -67.422e(max) - 120.947e(mini) - 5.67792SG + 130.1798$ $R^2 = 0.994069$

(2) $e(max) = -0.58225e(mini) - 0.00793Cu + 1.102074$ $R^2 = 0.952473$

(3) $\upsilon dmin = -2.108(\upsilon dmax\ I?)3 + 12.81(\upsilon dmax\ I?)2 - 24.58(\upsilon dmax\ I?) + 16.47$ $R^2 = 0.989$

(4) $\upsilon dmax = 2135(SG)3 - 16700(SG)2 + 43533(SG) - 37817$ $R^2 = 0.952$

(5) $e(max) = 7.455(\upsilon dmax\ I_D)3 - 43.40(\upsilon dmax\ I_D)2 + 83.96(\upsilon dmax\ I_D) - 53.$ $R^2 = 0.959$

## VI. RECOMMENDATIONS

These equations are recommended for non plastic soil (c=0) belongs to A-3 group according to classification having coefficient of uniformity upto 7.

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# Statistical Assessment of Compressive Strength of High Strength Concrete Mixtures with Hybrid Blends of Metakaolin and Fly ash

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***Abstract*: This research aims to investigate the influence of binary and ternary blending on compressive strength of high strength concrete mixes prepared with metakaolin (MK) and fly ash (FA) as a partial replacement of cement. The experiments were designed by using response surface methodology (RSM) prior to performing the test. Total nine mixes were prepared with various combinations of aforementioned materials. The replacement proportions for MK were used 5% and 10% and those for FA were 15% and 30% by weight of cement respectively. The effect on compressive strength was evaluated by analysis of variance (ANOVA) at 7 and 28-days. The empirical relationship between MK and FA was obtained by using regression analysis. It was observed that the MK showed better strength enhancement than FA. The workability of concrete mixes was significantly improved with FA, whereas the drop in compressive strength was recorded at all ages of concrete. Binary blends of cement with 10% MK presented highest compressive strength of concrete, whereas, concrete mixtures prepared with ternary blends of cement, MK and FA excluded the adversative effects on compressive strength caused by the binary blending of cement with FA. The concrete mix with 15% FA and 10% MK provided almost similar compressive strength compared to control concrete mix at 28 days.***

***Keywords:* Compressive strength, Fly ash, High strength concrete, Metakaolin, Response surface methodology, Workability.**

## I. INTRODUCTION

Concrete is the man-made construction material, which is most commonly used for the construction of various civil engineering structures [1]. Ordinary Portland cement (OPC) concrete is used in numerous structural applications and it is favorable for normal construction projects. However, due to some of its limitations for complex structures, certain requirements have been difficult to satisfy especially in terms of strength and durability. The need for the development of high-strength and high-performance concrete has extensively increased in order to meet requirements for advanced and complex structures [2]. The development of high-strength concrete (HSC) requires a large amount of cement and the production of cement is considered as the most energy-intensive component for the production of concrete. The emission of $CO_2$ is a major concern for the environment during the production of cement. It is a well-known fact that approximately one ton of $CO_2$ is released into the environment through the one-ton production of Portland cement. Moreover, cement manufacturing is blamed to be responsible for 5% to 7% of $CO_2$ emission into the environment from industrial sources. Without compromising the performance of the concrete structures, the use of Portland cement needs to be reduced in concrete structures so as to reduce the $CO_2$ emission-related to cement production and the sustainability of construction needs to be taken into consideration [2-4].

Partial substitution of cement by a combination of cement replacing materials (CRMs) are advantageous not only from the economic point of view but also for its mechanical, durability and microstructural characteristics [5]. The use CRMs into concrete has gained the popularity with the emphasis on increasing the service life of concrete structures [6].

Many CRMs are commercially available which can be used in concrete. Some of the most common materials are fly ash (FA), metakaolin (MK), and silica fume (SF) etc.[7]. Fly ash is a byproduct obtained from coal consumption. It is one of the most adopted partially replacement material in the concrete because of its widespread availability. However, the use of fly ash shows less strength development at early ages, but it gradually increases on later ages due to its delayed pozzolanic activity. There are two most commonly used pozzolans in construction projects which are metakaolin and silica fume. The performance of both pozzolans are almost identical with similar replacement level for enhancing the compressive strength and improving the permeability of concrete [8]. However, the use of metakaolin offers higher strength development of interfacial transition zone than the silica fume [9].

Metakaolin is a natural pozzolanic material and it is a primary product which is obtained by incinerating kaolin clay within the temperature range of 650-800ºC. Over past decades MK has been commercially introduced in concrete construction industry [10]. There are several studies conducted by many researchers on strength development of concrete containing MK in concrete. Those studies have revealed that the use of MK showed considerable enhancement in strength development.

Poon et al.,[11] studied the effects of MK content on compressive strength and durability properties of concrete. They reported that, increasing the amount of MK in concrete enhances the strength and decreases the concrete porosity. MK concrete having 0.5 w/b ratio performed better as compared to 0.3 w/b ratio MK concrete in regards of strength development. The porosity and pore size of concrete were significantly decreased at 28 days of curing. Whereas Jin and Li, [12] reported the similar trend. In the study of Si-Ahmed et al.,[13] it was observed that the compressive strength and flexural strength of concrete were improved by substituting 15% MK in concrete. The performance of MK concrete was also better for permeability related properties of concrete. Dinakar et al.,[14] observed, replacement of 10% MK in concrete as the ideal substitution for compressive strength. With 533kg/m$^3$ of cement and 10% replacement and 0.30 w/b ratio, 106 Mpa concrete compressive strength was achieved whereas splitting tensile strength and values elastic modulus also showed the similar trend. In relation to this, the findings are also consistent with other studies [15, 16]. Recently, Ferreira et al.,[17] have observed large improvements on chloride permeability incorporating all percentages of MK. The combination of MK and FA with cement presented higher early age characteristics of concrete. Substitution of 20% MK showed improved microstructure and significant decline in the porosity of concrete. Higher substitution of MK also showed higher compressive strength and electrical resistivity.

The incorporation of FA in concrete requires less water demand and enhances workability. Furthermore, approximately 5% to 15% demand of water can be reduced compared to OPC concrete [18]. In the study of E. Güneyisi et al.,[19] it was observed that the binary blends of cement and fly ash showed reduction in compressive strength at all ages of concrete. Ramezanianpour and Malhotra, [20] observed significant strength reduction, higher porosity and higher permeability with substitution of 25% and 58% of FA into concrete. Fly ash concrete was observed more sensitive in strength development due to poor curing. Recently, Sarkar et al.,[21] Replaced 20% to 40% of FA with cement and reported the strength reduction of 32% than control mix. Substitution of 40% FA in concrete presented best performance against durability properties. The lesser particles size of FA provides less permeable and higher resistance against aggressive agents in concrete. [22].

In the available literature there are limited number of studies are available on the individual and combine effects of MK and FA as cement replacing material in concrete. Several types of mineral admixtures are used in concrete but their effects on concrete properties with binary and ternary blends is not much investigated. The main object of this paper is to investigate the individual and combine effect of MK and FA with cement on compressive strength of concrete, since the compressive strength of concrete is an important parameter, and all other properties of concrete are judged on the basis of its compressive strength. In addition to that, the statistical assessment on compressive strength of concrete using RSM has been performed in order to investigate the effectiveness of each material on the basis of its compressive strength.

## II. MATERIALS

Materials used in this research were Type I ordinary Portland cement (OPC) confirming the requirements suggested by ASTM C150, metakaolin, and fly ash. FA was classified as class F fly ash in accordance with ASTM C618 specifications. The chemical composition of cement, metakaolin and fly ash is specified in Table I. Coarse and fine aggregates with a maximum size of 14mm and 4.75mm respectively were used. Sika viscocrete-2044 superplasticiser (SP) was used. Tap water was used in the mixes with SP in order to maintain the workability of concrete.

TABLE I: CHEMICAL COMPOSITION OF MATERIALS

| **Oxides Composition** | **Cement (%)** | **Metakaolin (%)** | **Fly ash (%)** |
|---|---|---|---|
| $SiO_2$ | 25.21 | 53.3 | 35.80 |
| $Al_2O_3$ | 4.59 | 35.1 | 14.00 |
| $Fe_2O_3$ | 2.99 | 2.73 | 22.90 |
| CaO | 62.85 | 0.58 | 18.00 |
| MgO | 1.70 | 0.27 | 2.66 |
| $Na_2O$ | 0.98 | - | - |
| $K_2O$ | 1.68 | 2.94 | 2.09 |
| $TiO_2$ | - | 1.76 | 1.45 |
| $SO_3$ | - | 0.14 | 1.11 |
| Specific Gravity | 3.15 | 2.50 | 2.38 |

## III. Mix Proportion

The proportions of materials used in concrete mixes were designed by using response surface methodology (RSM). Total 9 mixes were prepared using single and multiple blends of MK and FA. The total binder content and water to binder ratio was 500kg/m$^3$ and 0.35 respectively. In the absence of well-established comprehensive methods for the design of HSC, several trials were performed to obtain a mix with the desired strength of about 90±5 MPa. The final mix proportions for the HSC mixes were partially replaced by cement with (5% and 10%) of MK and (15% and 30%) of FA. The ratio of 1:1.5:1.9 by weight was adopted i.e. ratio of binder content: fine aggregates: coarse aggregates. The mix ID used for labeling the mixtures were adopted in such a way that they clearly show the materials and their proportions. HSC stands for high strength concrete which is followed by the binder content MK and FA which signifies metakaolin and fly ash respectively. The number associated with materials shows their percentages in the concrete mix. Details of concrete mixtures are given in Table II.

## IV. MIXING AND TESTING

All concrete ingredients were mixed in the laboratory using 0.8 m$^3$ pan mixer. All materials were dried mix into the mixer in the order of aggregates, which were thoroughly mixed for one minute than half of cement, FA and/or MK were added and left for two minutes for mixing. The remaining portion of

TABLE II: Mix Proportions of concrete containing MK and FA

| Mix ID | Cement (%) | MK (%) | FA (%) | Sand (%) | Coarse aggregates (%) | SP (%) | Slump **(mm)** |
|---|---|---|---|---|---|---|---|
| CM | 100 | 0 | 0 | 1.5 | 1.9 | 0.50 | 100 |
| MK5 | 95 | 5 | 0 | 1.5 | 1.9 | 0.60 | 101 |
| MK10 | 90 | 10 | 0 | 1.5 | 1.9 | 0.83 | 130 |
| FA-15 | 85 | 0 | 15 | 1.5 | 1.9 | 0.38 | 115 |
| FA-30 | 70 | 0 | 30 | 1.5 | 1.9 | 0.40 | 120 |
| FAMK-5-15 | 80 | 5 | 15 | 1.5 | 1.9 | 0.53 | 104 |
| FAMK-5-30 | 65 | 5 | 30 | 1.5 | 1.9 | 0.55 | 100 |
| CFAMK-10-15 | 75 | 10 | 15 | 1.5 | 1.9 | 0.70 | 102 |
| CFAMK-10-30 | 60 | 10 | 30 | 1.5 | 1.9 | 0.75 | 105 |

the material was added and left for mixing for another two minutes after that water was added slowly along with superplasticiser (SP) and mixing continued for further several minutes in order to obtain a homogenous mixture and left for two minutes for mixing. The remaining portion of the material was added and left for mixing for another two minutes after that water was added slowly along with superplasticizer (SP) and mixing continued for further several minutes in order to obtain a homogenous mixture. Immediately after mixing the fresh concrete was discharged from the mixer and slump test was carried out within the six minutes of freshly prepared concrete. The fresh concrete was poured in the molds and compacted on the vibrating table in three layers. Finally, surface finishing was carried out in order to acquire even surface. All concrete mixes were compacted on a vibrating table. After molding all concrete mixes were left in the room, for 24 hours at room temperature. After 24 hours of mixing, the cubes were unmolded and placed in a water at approximately 24±2 $^{o}$C for until desired testing day.

The slump was determined immediately after mixing in accordance with ASTM C143.

The compressive strength at different ages 7and 28 days were recorded at a loading pace of 3kN/s on the 3000kN machine for each concrete mix on 100mm$^3$ cubes.

## IV. Results and Discussion

### A. Superplasticiser Demand

In order to attain workability in the range of 100-130mm, different amount of SP was added to all concrete mixtures. It can be seen from Table II that increasing the MK content the demand of SP increases. This is due to the higher specific area of MK than cement. i.e. 10, and 5% MK mixtures needed 39, and 16% more SP dosage than the control mix. The presence of fly ash into concrete enhanced the workability due to the spherical morphology of its particles. The demand for SP decreased with the inclusion of FA in order to sustain targeted slump value for the corresponding concrete mix.

### B. Compressive Strength

The values for compressive strength of concrete mixes are presented in Table III which indicates, each concrete mix in this research is regarded as high strength concrete. The variation of compressive strength at seven days was observed between 60 to 75 MPa. For 28 days, the strength variation was seen between 79 to 101 MPa.

The variations in compressive strength with respect to MK, FA and combination of MK and FA is shown in Figure 1 at 3, 7 and 28 days. Concrete containing 10% of MK showed the highest strength of 100.7 MPa at 28-days. The combination of 30% fly ash and 10% replacement of MK showed the 18% and 7% decrease in compressive strength referring to the concrete with and without incorporation of 10% MK. Highest strength achieved among all concrete mixes used in this research is 100.71 MPa. This shows that incorporation of 10% MK was optimum in terms of compressive strength which is better than the 15 % replacement described in an earlier study with water/binder ratio of 0.30 [14]. The reduction in compressive strength caused by fly ash is due to its slow pozzolanic activity at early ages. In order to achieve high strength at early ages, it is essential to limit the content of FA unless suitable measures are to be considered to quicken the early strength of fly ash concrete. Incorporation of FA leads to long term strength development and after a certain time it shows the same strength development as that of the normal concrete by providing sufficient curing [23].

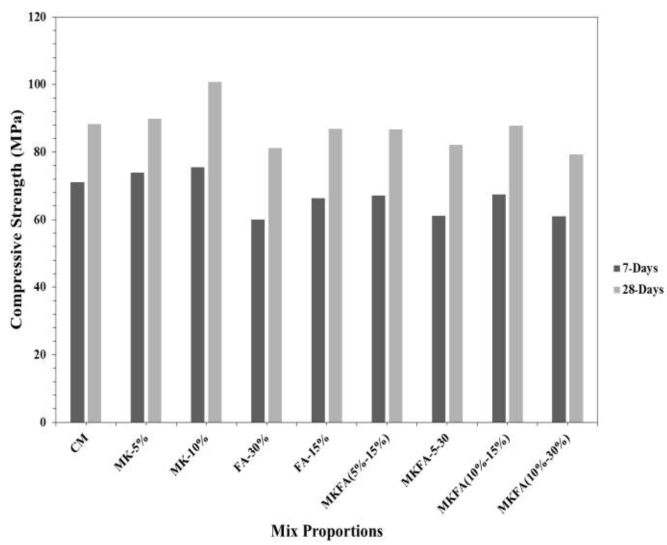


Fig. 1. Compressive strength variation against MK percentages and combination of 30% FA.

TABLE III: Analysis of variance results for concrete properties

| | Source | Sum of Squares | DF | Mean Square | F -Value | P-Value | Remarks | Contribution Parameters |
|---|---|---|---|---|---|---|---|---|
| Compressive strength 7-Days | **MK** | 6.96 | 1 | 6.96 | 45.12 | <0.0001 | Significant | 2.73 |
| | **FA** | 244.35 | 1 | 244.35 | 1585.15 | <0.0001 | Significant | 96.01 |
| | **MK×FA** | 3.19 | 1 | 3.19 | 20.67 | 0.0014 | Significant | 1.25 |
| | **Error** | 0 | 4 | 0 | | | | |
| Compressive strength 28 Days | **MK** | 21.92 | 1 | 21.92 | 8.50 | 0.0171 | significant | 7.54 |
| | **FA** | 217.32 | 1 | 217.32 | 84.30 | <0.0001 | significant | 74.75 |
| | **MK×FA** | 51.48 | 1 | 51.48 | 19.97 | 0.0016 | significant | 17.70 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Error** | 0 | 4 | 0 | | | | |

## V. STATISTICAL ANALYSIS

This section involves the statistical assessment of experimental results through ANOVA analysis using design expert software. The experimental test results for compressive strength, at 7 and 28-days of all the mixtures are given in Table IV. The analysis has been executed at 0.05 significance level in order to quantify the statistical significance of the experimental outcome. The tested parameters of concrete such as compressive strength is signified as dependent factor whereas MK and FA are indicated as independent factors. The analysis results are presented in Table III.

TABLE IV: ANALYSIS OF VARIANCE RESULTS FOR CONCRETE PROPERTIES

| **Mix ID** | **Compressive Strength** | |
|---|---|---|
| | **7-Days** | **28-Days** |
| CM | 71.07 | 88.3 |
| MK5 | 73.86 | 89.87 |
| MK10 | 75.50 | 100.71 |
| FA30 | 60.06 | 81.25 |
| FA15 | 66.30 | 86.83 |
| MKFA-5-15 | 67.2 | 86.79 |
| MKFA-5-30 | 61.16 | 82.21 |
| MKFA-10-15 | 67.47 | 87.83 |
| MKFA-10-30 | 60.92 | 79.31 |

A parameter is said to be significant if the P-value is not greater than 0.05. It can be seen in Table III. The effects of all parameters on compressive strength are designated to be statistically significant since the P-values of parameters are less than 0.05.

The contribution percentage of parameters shows the effectiveness of each parameter on compressive strength of concrete. The magnitude of the contribution parameter in terms of percentages is also presented in Table III. Based on the results obtained, it is obvious that FA showed significantly excessive contribution for a reduction in strength of concrete. However, the incorporation of MK showed significant increments in compressive strength contribution. The interaction of both parameters such as metakaolin and fly ash were observed less effective at an early age but relatively higher at later curing ages. This is because of the delayed pozzolanic reaction of fly ash.

The mathematical relationship between factors was obtained by regression analysis based on compressive strength results of concrete. The final equations based on the analysis are shown in Table V, which shows the significantly higher values of R-square. The general equation of model is presented as Eq. (1).

$$Cp=A_1(MK)+A_2(FA)+ A_3(MK\times FA)+C \qquad (1)$$

Where Cp is a tested property of concrete such as compressive strength, MK and FA are independent linear parameters, (MK×FA) is the interaction parameter, C is a constant, and $A_1$, $A_2$, and $A_3$ are the coefficients of the equation. The compressive strength of concrete was enhanced with MK whereas the decline was observed with FA. Furthermore, the combination of MK and FA content also showed a drop in strength but the strength was nearly similar to control mix. The relationship between the metakaolin and fly ash content on compressive strength of concrete is illustrated in Figure 2 and 3 at 7-days and 28 days respectively.

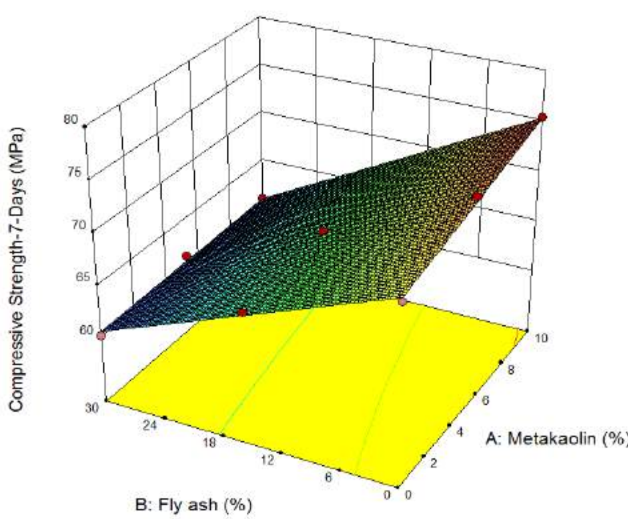

Fig. 2. Effect MK and FA proportions on compressive strength at 7-days

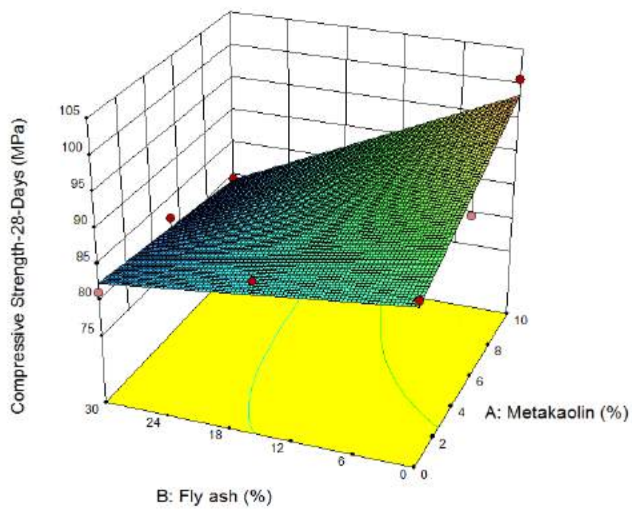


Fig. 3. Effect MK and FA proportions on compressive strength at 28-days

TABLE V: MATHEMATICAL RELATIONSHIP BETWEEN MK AND FA AT 7 AND 28-DAYS

| Factors | Equation coefficients | Compressive strength 7-days | Compressive strength 28-days |
|---|---|---|---|
| | | MPa | MPa |
| Constant | C | 67.10 | 86.94 |
| MK | $A_1$ | 1.08 | 1.91 |
| FA | $A_2$ | -6.38 | -6.02 |
| MK×FA | $A_3$ | -0.89 | -3.59 |
| R-square | | 0.994 | 0.926 |
| Adj R-Square | | 0.992 | 0.901 |

## VI. CONCLUSION

High strength concrete designed with varying percentages of MK and class F FA were studied. Total binder content and water to binder ratio were kept constant. The outcome of these modifications on compressive strength of concrete with binary and ternary blends were investigated. Following conclusions have been made from experimental results:

- The concrete mixtures with binary blends of cement and metakaolin were more effective for the strength development at early and later curing ages of concrete. The highest compressive strength of more than 100 MPa was observed by replacing 10% MK with cement.
- The binary blends of cement with fly ash showed significant reduction in compressive strength in all ages. However, their effects may be realized on durability related characteristics of concrete. The reduction in compressive strength is attributed to slow pozzolanic reaction which is caused by decrease in the amount of cement in concrete.
- The presence of fly ash in concrete required lesser demand for superplasticizer in concrete due to spherical morphology its particles. The Smaller amount of superplasticizer is required in order to sustain the same slump value for corresponding concrete.
- Ternary blends of concrete with MK and FA showed lesser compressive strength, but approximately equal to the control concrete mix at 28-days. It can be concluded that, the high strength of concrete can be achieved by replacing 40% of cement.

ACKNOWLEDGMENT

The author is thankful to Universiti Teknologi PETRONAS for financial support to conduct this research.

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# Experimental and Theoretical Investigation of Flow Behavior Passing over Rounded Edge Drop Structure in Open Channel

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***Abstract:*** **An experiment was conducted to study the flow characteristics pass over the rounded edge drop structure in rectangular channel. The data regarding hydraulic drop and hydraulic jump was recorded during the experiment including the flow discharge (Q), drop length ($L_d$), jump length ($L_j$), depth of flow at the toe of the jump ($Y_1$), tail water depth ($Y_2$) for different heights of drop structure (h) and various bed slops of the channel (S) with rectangular channel width (b). The dimensional data was converted into non-dimensional parameters to develop dimensionally balanced empirical equations using multiple regression analysis for the appropriate design of rounded-edge drop structure. The research results revealed that $Y_1$, $Y_2$, $L_d$ and $L_j$ depend on discharge intensity (q=Q/b), drop height (h), and channel bed slop (S). It was found that $Y_2$, $L_d$ and $L_j$ varies directly with $q$ and $S$ but inversely with $h$; whereas$Y_1$ varies directly with $q$ but inversely with $h$ and $S$.**

***K*eywords: Drop structure, Hydraulic drop, Hydraulic jump, Flow characteristics.**

## I. INTRODUCTION

The projects relating with water resources engineering have been rapidly and extremely built-up all over the world. It is the engineering used to control and utilize the various sources of water by construction of hydraulic structures such as weirs, barrages, dams, reservoirs, regulators, drops/falls etc, which are used to distribute water safely through the delivery structures on the field. The drop structure is provided in such a longitudinal section of irrigation channel where land gradient is steeper than designed slope of the channel. A large number of falls are constructed in different provinces of Pakistan, e.g. in the Khyber PakhtunKhwa Province canals in mountainous areas; even in plains canals are offered by some falls, such as falls in Rohri Canal in Sindh. The water passing over drop structure, changes its surface profile in such a fashion that it is broken abruptly, in consequence the hydraulic jump is formed on downstream apron of the structure. The formation of hydraulic jump is very indispensable hydraulic tool for dissipating kinetic energy that is produced due to super-critical flow to avoid the erosion problem on downstream side of the structure. Hydraulic jump also increases water weight on downstream floor apron to counterbalance the uplift pressure acting on the bottom of the floor if the structure is laid on permeable base. Numerous researches have been done on flow characteristics of drop structures built on horizontal and sloping bed channels. In this regard, generally relationships between flow parameters of hydraulic drop and hydraulic jump have been established in the form of empirical equations.
Many researchers like Bakhmteff and Fredoroff [1], Moore [2], Rand[3], Bhutto [4], Shoro [5], Shaikh, et al. [6] and Shaikh, et al., [7], Kori et al.[8] have worked on various flow parameters of drop structure, constructed on horizontal channel bed and developed empirical relationships between them. Rand [3] established his experimental data and relationships based on that of his previous predecessor:

$$\frac{Y_1}{h} = 0.54D^{0.425} \qquad (1)$$

$$\frac{Yp}{h} = 1.00D^{1.22} \qquad (2)$$

$$\frac{L_d}{h} = 4.30D^{0.27} \tag{3}$$

Some researchers have established formulae for hydraulic drop and hydraulic jump characteristics on sloping bed channel, such as Stevens [9] derived the following analytical equations for calculating jump length on glacis:

$$L_j = \frac{9.3Y_1\left[\left(1+\frac{16K}{1-m\,Tan\,\alpha}\right)^{0.5}-1\right]}{2K^{0.185}} \tag{4}$$

Where, m = 9.3/ $F_1^{1.7}$ ; $F_1$ is initial Froude number

Chow [10] established the following formula:

$$\frac{Y_2}{Y_1} = 0.5\left[\left(1+8G^2\right)^{0.5}-1\right] \tag{5}$$

where, $G = \dfrac{F_1}{\left[\cos\theta - \dfrac{K\,L_j\,\sin\theta}{(Y_2-Y_1)}\right]^{0.5}}$

where additionally, K is the shape factor

Kori, et al. [11] worked on straight drop structure in rectangular sloping bed channel and developed relationship of all length and depth indices with drop number (D = $q^2/gh^3$) accounting channel bed slopes as cumulative. Later on, Kori et. al. [12] conducted a comprehensive study of free over-fall passing over straight drop structure in a rectangular channel with positive bed slopes and establish the relationships of length and depth indices with drop number (D) using statistical analysis of linear regression, the developed formulae are given below:

$$\frac{Y_1}{h} = D^{0.435}(0.497-5.297S) \tag{6}$$

$$\frac{Y_2}{h} = D^{0.274}(1.421+10.434S) \tag{7}$$

$$\frac{Y_p}{h} = D^{0.292}(1.463+7.286S) \tag{8}$$

$$\frac{L_d}{h} = D^{0.2035}(2.928-28.32S) \tag{9}$$

$$\frac{L_j}{Y_2} = D^{-0.017}(4.431-68.109S) \tag{10}$$

$$\frac{L_j}{h} = D^{0.257}(6.351-67.954S) \tag{11}$$

To extend the previous work, it is however desirable to study the hydraulic characteristics of Hydraulic drop/jump while flow passing over rounded-edge drop structure in rectangular positive bed slope channel.

## II. MATERIALS & METHODS

### II.1 Experimental setup and procedure

The experiments were carried out in the Hydraulics main laboratory on rectangular tilting flume, Mehran UET, Jamshoro. Working section of the tilting flume was encompassed with a steel floor and transparent glass side, having length, breadth and depth of 600 cm, 7.6 cm and 25 cm respectively. The channel bed slope was adjusted by an adjustable sloping wheel fixed at the upstream end of the flume section, and the f1ow depth at downstream of the structure was regulated by a tail-gate. Water flow was allowed from water tank through a control valve connected to the centrifugal pump and the discharge was measured with a discharge-gauge meter connected by the pump. The sliding pointer-gauge was used to measure water depths at required positions of the working section in the flume (Fig. 1).

### II.2 Data collection and procedure of analysis

A. Total 36 experiments were conducted in the hydraulic laboratory using two different drop heights viz: 12.90 and 15.78 cm placed in the flume. By changing flow discharge, the experimental data was collected on six different channel bed slopes (i.e. 0.0, 0.5, 1.0, 1.5, 2.0 and 2.5%) for each drop height. During the experimentation, great attention was paid to stabilize the position of the drop and jump. The data concerned with hydraulic drop and hydraulic jump characteristics was recorded during the set of experiments, including flow discharge (Q), drop length ($L_d$), jump length ($L_j$), initial depth (i.e. depth of flow at the toe of the jump) ($Y_1$), tail water depth ($Y_2$) for different heights (h) and two different radius (i.e. 7.5 and 10.25 cm) of rounded-edge laid on aforementioned channel bed slops for each drop height (Table 1). The flow geometry with flow characteristics passing over drop structure is shown in Fig. 2. For analyzing the data, the buckingum π-theorem was used to evaluate non-dimensional parameter to create the dimensionally balanced equations. By using multiple regression technique the empirical equations were established for the appropriate design for safe structure.

Fig. 1: Flow of water over rounded-edge drop structure in rectangular flume.

## III. RESULTS

The observed data for flow parameters and computed dimensionless parameters are arranged in Table 1. The relationship of dimensionless parameters, viz; depth indices (i.e $Y_1/h$, $Y_2/h$ and $Hj/h$); and length indices (i. e. $L_d/h$ and $Lj/h$) individually with non-dimensional parameters (i.e $q^2/gh^3$ and $S$) were established as under:

Using multiple regression of statistical approach, the relationship for $Y_1/h$ with $q^2/gh^3$ and $S$ (taking values from Table 1- cols. [11], [16] and [2]) was established, the empirical equation with correlation coefficients ($R^2$) is presented in eqn. (12);

$$\frac{Y_1}{h} = 1.56\frac{q^2}{gh^3} - 0.0076S + 0.055 \qquad R^2 = 0.974$$

or

$$Y_1 = h\left(1.56\frac{q^2}{gh^3} - 0.0076S + 0.055\right); \qquad R^2 = 0.974 \qquad (12)$$

Similarly, the relationship of $Y_2/h$, $Hj/h$, $L_d/h$ and $L_j/h$ with $S$ and $q^2/gh^3$ (taking values from Table 1) were developed, the empirical equations with correlation coefficients ($R^2$) are narrated as below:

$$Y_2 = h\left(7.33\frac{q^2}{gh^3} + 0.0179S + 0.337\right); \qquad R^2 = 0.917 \tag{13}$$

$$H_j = h\left(5.78\frac{q^2}{gh^3} + 0.0255S + 0.2824\right); \qquad R^2 = 0.892 \tag{14}$$

$$L_d = h\left(13.36\frac{q^2}{gh^3} + 0.007S + 0.754\right); \qquad R^2 = 0.927 \tag{15}$$

$$L_j = h\left(13.96\frac{q^2}{gh^3} + 0.04S + 1.356\right); \qquad R^2 = 0.591 \tag{16}$$

**Table 1: Observed and non-dimensional calculated parameters**

| Sr. No. | Observed data | | | | | | | | | Calculated Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | h (cm) | Q ($cm^3/s$) | $Y_1$ (cm) | $Y_2$ (cm) | $L_d$ (cm) | $L_j$ (cm) | $H_j$ (cm) | q = Q/b ($cm^2/s$) | $Y_1/h$ | $Y_2/h$ | $H_j/h$ | $L_d/h$ | $L_j/h$ | $D=q^2/gh^3$ |
| [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] | [13] | [14] | [15] | [16] |
| 1 | 0.0 | 12.90 | 1107.72 | 0.93 | 5.28 | 12.28 | 17.83 | 4.35 | 145.75 | 0.072 | 0.409 | 0.337 | 0.952 | 1.382 | 0.010 |
| 2 | 0.0 | 12.90 | 1607.72 | 1.2 | 6.49 | 13.55 | 20.25 | 5.29 | 211.54 | 0.093 | 0.503 | 0.410 | 1.050 | 1.570 | 0.021 |
| 3 | 0.0 | 12.90 | 2094.6 | 1.47 | 7.45 | 15.57 | 22.66 | 5.98 | 275.61 | 0.114 | 0.578 | 0.464 | 1.207 | 1.757 | 0.036 |
| 4 | 0.0 | 15.78 | 1062.12 | 0.89 | 5.47 | 12.41 | 21.46 | 4.58 | 139.75 | 0.056 | 0.347 | 0.290 | 0.786 | 1.360 | 0.005 |
| 5 | 0.0 | 15.78 | 1583.21 | 1.19 | 7.03 | 14.41 | 26.13 | 5.84 | 208.32 | 0.075 | 0.446 | 0.370 | 0.913 | 1.656 | 0.011 |
| 6 | 0.0 | 15.78 | 2104.3 | 1.38 | 7.98 | 15.59 | 28.72 | 6.6 | 276.88 | 0.087 | 0.506 | 0.418 | 0.988 | 1.820 | 0.020 |
| 7 | 0.5 | 12.90 | 1107.72 | 0.87 | 5.42 | 12.67 | 18.18 | 4.55 | 145.75 | 0.067 | 0.420 | 0.353 | 0.982 | 1.409 | 0.010 |
| 8 | 0.5 | 12.90 | 1607.72 | 1.12 | 6.56 | 14.12 | 20.73 | 5.44 | 211.54 | 0.087 | 0.509 | 0.422 | 1.095 | 1.607 | 0.021 |
| 9 | 0.5 | 12.90 | 2094.6 | 1.38 | 7.53 | 16.16 | 23.28 | 6.15 | 275.61 | 0.107 | 0.584 | 0.477 | 1.253 | 1.805 | 0.036 |
| 10 | 0.5 | 15.78 | 1062.12 | 0.85 | 5.55 | 12.86 | 21.61 | 4.7 | 139.75 | 0.054 | 0.352 | 0.298 | 0.815 | 1.369 | 0.005 |
| 11 | 0.5 | 15.78 | 1583.21 | 1.12 | 7.13 | 15.01 | 26.51 | 6.01 | 208.32 | 0.071 | 0.452 | 0.381 | 0.951 | 1.680 | 0.011 |
| 12 | 0.5 | 15.78 | 2104.3 | 1.29 | 8.08 | 16.30 | 29.26 | 6.79 | 276.88 | 0.082 | 0.512 | 0.430 | 1.033 | 1.854 | 0.020 |
| 13 | 1.0 | 12.90 | 1107.72 | 0.81 | 5.59 | 13.07 | 18.49 | 4.78 | 145.75 | 0.063 | 0.433 | 0.371 | 1.013 | 1.433 | 0.010 |
| 14 | 1.0 | 12.90 | 1607.72 | 1.05 | 6.73 | 14.72 | 21.07 | 5.68 | 211.54 | 0.081 | 0.522 | 0.440 | 1.141 | 1.633 | 0.021 |
| 15 | 1.0 | 12.90 | 2094.60 | 1.30 | 7.75 | 16.77 | 23.66 | 6.45 | 275.61 | 0.101 | 0.601 | 0.500 | 1.300 | 1.834 | 0.036 |
| 16 | 1.0 | 15.78 | 1062.12 | 0.81 | 5.62 | 13.3 | 21.79 | 4.81 | 139.75 | 0.051 | 0.356 | 0.305 | 0.843 | 1.381 | 0.005 |
| 17 | 1.0 | 15.78 | 1583.21 | 1.05 | 7.28 | 15.61 | 26.8 | 6.23 | 208.32 | 0.067 | 0.461 | 0.395 | 0.989 | 1.698 | 0.011 |
| 18 | 1.0 | 15.78 | 2104.3 | 1.22 | 8.3 | 16.76 | 29.67 | 7.08 | 276.88 | 0.077 | 0.526 | 0.449 | 1.062 | 1.880 | 0.020 |
| 19 | 1.5 | 12.90 | 1107.72 | 0.75 | 5.74 | 13.38 | 18.74 | 4.99 | 145.75 | 0.058 | 0.445 | 0.387 | 1.037 | 1.453 | 0.010 |
| 20 | 1.5 | 12.90 | 1607.72 | 0.97 | 6.82 | 15.12 | 21.34 | 5.85 | 211.54 | 0.075 | 0.529 | 0.453 | 1.172 | 1.654 | 0.021 |
| 21 | 1.5 | 12.90 | 2094.6 | 1.20 | 7.86 | 17.08 | 23.95 | 6.66 | 275.61 | 0.093 | 0.609 | 0.516 | 1.324 | 1.857 | 0.036 |
| 22 | 1.5 | 15.78 | 1062.12 | 0.77 | 5.70 | 13.74 | 21.93 | 4.93 | 139.75 | 0.049 | 0.361 | 0.312 | 0.871 | 1.390 | 0.005 |
| 23 | 1.5 | 15.78 | 1583.21 | 0.98 | 7.39 | 16.11 | 27.02 | 6.41 | 208.32 | 0.062 | 0.468 | 0.406 | 1.021 | 1.712 | 0.011 |
| 24 | 1.5 | 15.78 | 2104.3 | 1.11 | 8.42 | 17.22 | 29.86 | 7.31 | 276.88 | 0.070 | 0.534 | 0.463 | 1.091 | 1.892 | 0.020 |
| 25 | 2.0 | 12.90 | 1107.72 | 0.72 | 5.88 | 13.78 | 19.01 | 5.16 | 145.75 | 0.056 | 0.456 | 0.400 | 1.068 | 1.474 | 0.010 |
| 26 | 2.0 | 12.90 | 1607.72 | 0.97 | 6.91 | 15.72 | 21.61 | 5.94 | 211.54 | 0.075 | 0.536 | 0.460 | 1.219 | 1.675 | 0.021 |
| 27 | 2.0 | 12.90 | 2094.6 | 1.24 | 7.96 | 17.69 | 24.26 | 6.72 | 275.61 | 0.096 | 0.617 | 0.521 | 1.371 | 1.881 | 0.036 |
| 28 | 2.0 | 15.78 | 1062.12 | 0.75 | 5.78 | 14.18 | 22.08 | 5.03 | 139.75 | 0.048 | 0.366 | 0.319 | 0.899 | 1.399 | 0.005 |
| 29 | 2.0 | 15.78 | 1583.21 | 0.97 | 7.50 | 16.80 | 27.24 | 6.53 | 208.32 | 0.061 | 0.475 | 0.414 | 1.065 | 1.726 | 0.011 |
| 30 | 2.0 | 15.78 | 2104.30 | 1.11 | 8.55 | 17.97 | 30.12 | 7.44 | 276.88 | 0.070 | 0.542 | 0.471 | 1.139 | 1.909 | 0.020 |
| 31 | 2.5 | 12.90 | 1107.72 | 0.67 | 6.05 | 14.10 | 19.26 | 5.38 | 145.75 | 0.052 | 0.469 | 0.417 | 1.093 | 1.493 | 0.010 |
| 32 | 2.5 | 12.90 | 1607.72 | 0.91 | 7.05 | 16.15 | 21.88 | 6.14 | 211.54 | 0.071 | 0.547 | 0.476 | 1.252 | 1.696 | 0.021 |
| 33 | 2.5 | 12.90 | 2094.60 | 1.18 | 8.16 | 18.03 | 24.56 | 6.98 | 275.61 | 0.091 | 0.633 | 0.541 | 1.398 | 1.904 | 0.036 |
| 34 | 2.5 | 15.78 | 1062.12 | 0.71 | 5.85 | 14.63 | 22.20 | 5.14 | 139.75 | 0.045 | 0.371 | 0.326 | 0.927 | 1.407 | 0.005 |
| 35 | 2.5 | 15.78 | 1583.21 | 0.91 | 7.64 | 17.24 | 27.45 | 6.73 | 208.32 | 0.058 | 0.484 | 0.426 | 1.093 | 1.740 | 0.011 |
| 36 | 2.5 | 15.78 | 2104.30 | 1.04 | 8.74 | 18.88 | 30.37 | 7.7 | 276.88 | 0.066 | 0.554 | 0.488 | 1.196 | 1.925 | 0.020 |

## IV. CONCLUSIONS

Following conclusions have been drawn from this study:

1. Looking on equations (12-16) it is indicated that initial depth, $Y_1$, depth at tail water, $Y_2$, Jump height $H_j$, Length of hydraulic drop, $L_d$ and Jump length, $L_j$ depend on discharge intensity ($q=Q/b$), drop height, $h$, and channel bed slop, $S$.
2. Further, results revealed that $Y_2$, $H_j$, $L_d$ and $L_j$ varies directly with both $q$ and $S$ but inversely with $h$; whereas$Y_1$ varies directly with $q$ but inversely with $h$ and $S$.

## ACKNOWLEDGEMENT

The authors are grateful to Mehran University of Engineering and Technology, Jamshoro, Pakistan, for providing laboratory facilities for experimentations in the Institute of Irrigation Water Resources Engineering and Management. Special thanks are due to Professor (Late) Dr. Haji Mahmmood Memon, Emeritus Professor, MUET, Jamshoro, for his valuable suggestions during the study.

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# Effectiveness of Screens in Energy Dissipation Characteristics of Tuned Liquid Damper

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***Abstract*: This paper investigates the performance of tuned liquid damper (TLD), a water tank, in energy dissipation of structure during lateral movement. A free vibration test is performed on TLD mounted on top of single degree freedom steel structure model. The Efficiency of TLD without screen and with screen is evaluated for different water depths in tank on the basis of damping ratio. In case of simple TLD, it is found that there exists an optimum depth of water at which maximum damping ratio of structure is achieved. Further TLD is found effective for small range of water depth in tank. Focus is made to further optimize the current technique so that it can work for different liquid depths. For this purpose, the same test is performed on TLD carrying slat screen in the mid length in the direction of liquid motion. Screen in TLD altered the sloshing behavior of water. The system is found more effective in energy dissipation for wide range of water depths.**

***Keywords:* Damping ratio, Energy dissipation, Free vibration, Tuned liquid damper (TLD).**

## I. INTRODUCTION

Reducing structural displacements due to wind or earthquake has always remained a challenge and primer design requirement. Active dampers and Passive dampers are commonly used as one of the methods to control the structural drift. Passive dampers, if designed properly, can reduce the structural displacements without adding any supplementary devices. Tuned liquid damper (TLD), a passive energy damper, is an overhead water tank-based system mounted on top of the building. It can control structural vibration subjected to ground motion by increasing inertial and viscous friction forces developed due to sloshing of liquid in tank. The sloshing behavior of fluid in tank increases the damping ratio of structure.

Several experimental work and numerical modelling have been carried out to check how TLD reduces the seismic vibration of structure [1] investigated rectangular tuned liquid damper through shake table tests and numerical modellings for large excitation amplitudes. They found the TLD effective for wide range of frequencies if excitation frequencies increases. [2] tested TLD for different ground motion and concluded that TLD works effectively if installed at the top level of building and if properly tuned to the natural period of structure.[3] studied single degree of freedom (SDOF) structure subjected to earthquake ground motion through a technique of numerical simulation. He emphasized on three parameters of TLD that are Tuning, mass ratio and depth ratio. They suggested the stepwise design method for practical use of TLD in structures. [4] conducted a series of experiments on scaled model of structure-TLD system under harmonic excitation. They studied the performance of both square and rectangular TLD for different tank orientation by changing water depth ratio and frequency ratio. They found that maximum reduction in response of structure is attained at optimum level of water in TLD under resonance condition.

[5] have performed shake table test on scaled model of one-dimensional tuned liquid damper to study the sloshing response of water in tank. They also introduced screens in water damper which was found to be an effective method of increasing inherent damping. [6,7] and studied the effect of screen of different configuration. They determined that natural water sloshing frequency in TLD with screen depend on solidity ratio, number of submerged screen gaps and the liquid depth.[8] assessed the impact of screen of different slat height in term of drag coefficients by performing shake table tests at various frequencies and amplitudes of harmonic motion. They found that TLD with large slats perform well even at small excitation amplitudes.

In this study, a free vibration test is used to assess the effectiveness of screens in TLD in term of damping ratio i.e. dynamic characteristic of structure and results is compared with that of simple TLD.

## II. MATERIALS & METHODS

### *A. Experimental Setup*

Figure 1 shows a single degree freedom steel model with TLD, mounted on unidirectional shake table. The shaking motion of shake table is based upon SDOF system with table size 1.5-meter square, operated through hydraulic actuators. The structural model is consisting of 8.5mm thick diaphragm made of mild steel supported on four steel rods of length 85cm having cross section of 8mm square solid. The model is attached to the shake table through baseplate and bolts. Square water tank made of transparent acrylic sheet of 8mm thickness is mounted centrally on diaphragm of steel model with bolts. The tank is 35cm square having height of 20cm. A horizontal slatted screen made of 5mm acrylic sheet having equal slat and gape size of 5mm alternately, inserted in the middle of tank in the direction perpendicular to the liquid motion. Accelerometer and displacement transducer are attached to the model at diaphragm level connected with data acquisition system in order to record the data during experiment.

**Fig 1: Experimental setup of model.**

### *B. Testing Procedure*

A free vibration test is performed to evaluate the response of structure in both cases, TLD without screen and TLD with screen at various depth of water ranging from 0 to 12cm. In each case, the structure is initially excited by small jerk through shake table. Response of structure is recorded in term of acceleration and displacement from data acquisition system.

## III. RESULTS

In this study the performance of TLD without screen and with screen is assessed by evaluating the dynamic characteristic of structure-TLD system for all the cases. Past study reveals that damping ratio truly describes the energy dissipation characteristic of structure equipped with TLD. DADISP software is used to plot acceleration data and to evaluate frequency of a structure and damping ratio of structure which uses the basis of logarithmic decrement technique.

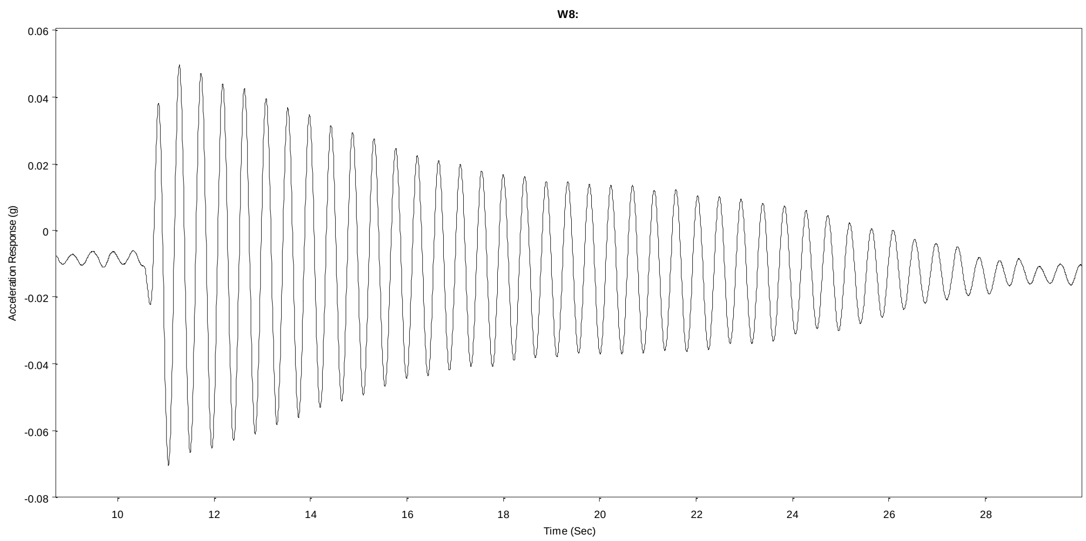


Fig 2: Acceleration response of structure under free vibraiton.

Figure 2 shows the response of structure-TLD with zero depth of water during free vibration. The natural frequency and damping ratio are evaluated with logarithmic decrement method, which results in structural frequency of 2.21 Hz and damping ratio of 1.56%. The same technique is used to find the frequency and damping ratio of structure at various depths of water. For better understanding, the water depth is represented by depth ratio which is defined as ratio of depth of water in tank to the length of tank.

*A. Performance of tuned liquid damper without screen*

A free vibration test is performed on model with simple tuned liquid damper at different fluid depth varies from 0 to 12 cm i.e. depth ratio varies from 0 to 0.36. In figure 3, percentage increase in damping ratio is plotted against depth ratio. Percentage increase in damping ratio for all cases is determined with respect to the structure-TLD containing no water.

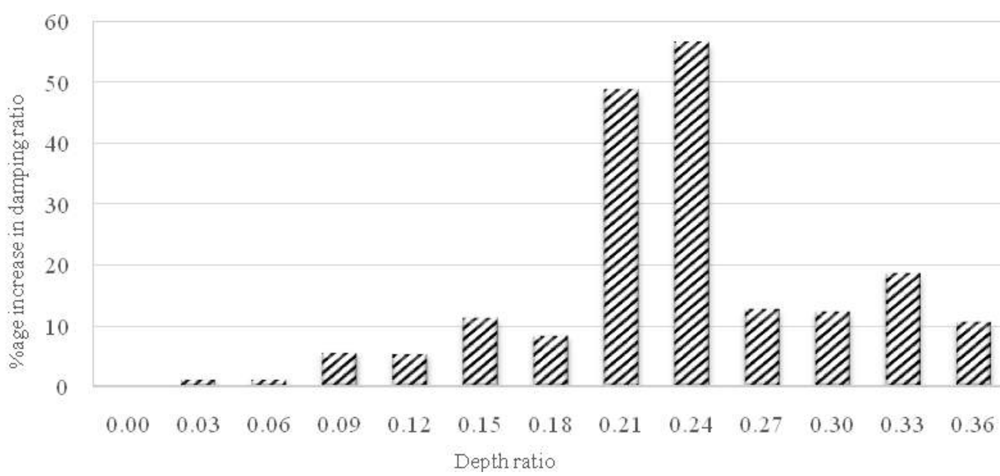


Fig 3: Performance of tuned liquid damper without screen.

Results shows that a simple TLD can only cause structural vibration control at some specific level of water in tank i.e. depth ratio 0.21 and 0.24. For most of the time, a simple TLD remains ineffective in energy dissipation of structure during lateral displacements induced because of base excitation.

### *B. Performance of Tuned liquid damper with screen*

Another set of free vibration test is performed on model with simple tuned liquid damper equipped with screen at mid length for different fluid depth varies from 0 to 12 cm i.e. depth ratio varies from 0 to 0.36. In figure 4, percentage increase in damping ratio is plotted against depth ratio. Percentage increase in damping ratio for all cases is determined with respect to the structure-TLD containing no water.

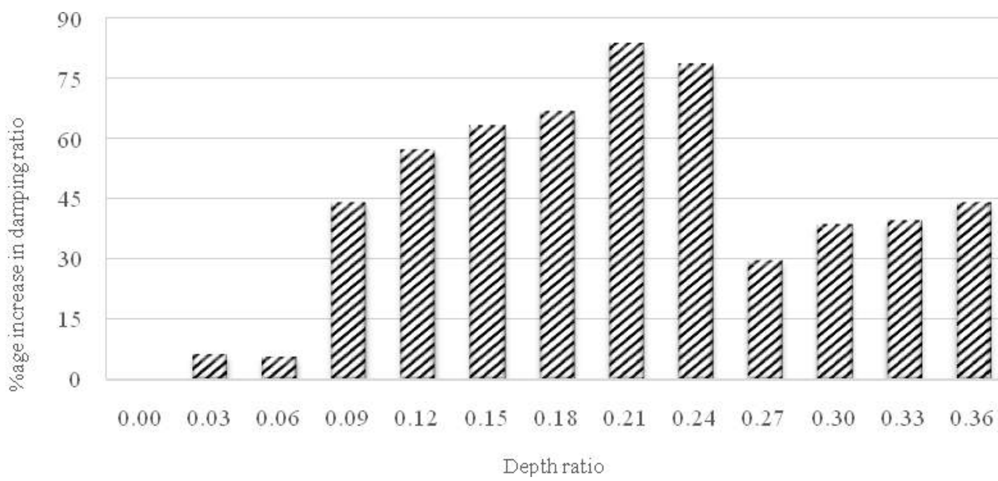


Fig 4: Performance of tuned liquid damper with screen.

The figure 4 shows that TLD with screen causes structural vibration control at almost all levels of water in tank. For most of the time TLD containing screen remains effective in energy dissipation of structure during lateral displacements induced because of base excitation.

## IV. CONCLUSIONS

From the result analysis it can be concluded that TLD without screen cannot control vibration for wide range of fluid depth in tank. TLD equipped with screen causes further increase in damping ratio and remains effective for wide range of fluid depth in tank.

## V. RECOMMENDATIONS

It is further recommended to assess the efficiency of TLD for different configuration of screen and to conduct a forced vibration test for different vibration frequencies and amplitudes.

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# Effect of Waste Polymers in Enhancing the Properties and Performance of Hot Mix Asphalt

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***Abstract*: This paper presents a comparative analysis of properties and performance of HMA (Hot Mix Asphalt) modified by various polymer based waste materials which included Low Density Polyethylene (LDPE) in the form of polyethylene bags (shopping bags), High Density Polyethylene (HDPE) in the form of waste plastic beverage bottles and crumb rubber (CR) from waste tires. Polymer was added to coat the aggregate (dry method) and as a modifier in bitumen (wet process). Marshall method was used for analysis of control and modified asphalt mixes. Dry method yielded better asphalt mix properties. Optimum polymer content was determined as percentage of optimum bitumen content. Polymer modified bitumen exhibited improved stiffness and reduced susceptibility to high temperature effects. Polymer modified asphalt mix, is found have increased stability, rutting resistance, and load bearing capacity in comparison to unmodified asphalt mix. HDPE modified mix was found to be most effective in improving stability and rutting resistance. The research also highlights safe, efficient and environment friendly disposal of waste plastics. Road construction with CR modified HMA was found to be most cost-effective with Rs. 0.166 million saving per lane km, compared to conventional, LDPE and HDPE modified HMA.**

***Keywords*: Hot mix asphalt, Pavement performance, Waste polymers.**

## I. INTRODUCTION

Main challenge of pavement management is to maintain the roads in the environment of increasing traffic loads and scarcity of adequate maintenance funds. Several factors influence the performance of flexible pavement, e.g., the properties of the components (binder, aggregate and additive) and the proportion of these components in the mix [1]-[3]. Addition of polymers typically increases the stiffness of the bitumen and improves its temperature susceptibility [2]-[4]. The growth in various types of industries together with population growth has resulted in enormous increase in production of various types of waste material, globally. The generation and disposal of non-decaying waste materials such as blast furnace slag, fly-ash, steel slag, scrap tires, plastics, etc. have been posing challenging problems in developed as well as in developing countries [5]-[7]. The use of plastics, in the form of shopping bags and beverage bottles, has become a common practice all over the world. However, the disposal of these plastic wastes in large quantities has been a problem and is of great concern, particularly in big cities. They either get mixed with municipal solid waste and or thrown over land area. Their present disposal is either by land filling or by incineration. Both the processes are not eco-friendly [8]-[9]. Under these circumstances, an alternate use for the waste plastics is also the need of the hour. Mixing up of these waste plastics with other bio-degradable organic waste materials in the garbage of the urban areas has been the main cause of the problems in waste management. Therefore, attempts are being made in some countries to limit or even to prohibit the use of the thin plastic bags for packing and other common use, so as to control this "undesirable waste material" from getting mixed up with the other organic garbage. Utilizing the polymers, available in domestic waste, for asphalt mix preparation can prove to be a cost effective and efficient solution to pavement problems and waste management issues simultaneously [6]. Keeping the aforementioned aspects of pavement performance and waste management in perspective, this research focused on a simple but comprehensive comparative analysis of properties and performance of hot mix asphalt (HMA) modified by various polymer-based waste materials. Waste polymers included Low Density Polyethylene (LDPE) in the form of polyethylene bags (shopping bags), High Density Polyethylene (HDPE) in the form of waste plastic beverage bottles and crumb rubber (CR) from waste tires. Objectives of this research also included determining the best method of adding polymer in asphalt mix. Polymer was added to coat the aggregate (dry method) and as a modifier in bitumen (wet process). Marshall Mix design method was used to determine the optimum bitumen content and then modified asphalt mix properties were tested. Economic analysis is also conducted as the culminating component of the over comparative analysis.

## II. LITERATURE RIVIEW

Few studies investigated the viability of using high and/or low-density polyethylene as a modifier in HMA [6], [10], [11]. Results revealed enhanced performance of polymer modified asphalt mixtures than conventional mixtures. A study presented possible advantages of introducing waste polyethylene, in the form of HDPE as a bitumen modifier and cross-linked polyethylene (PEX) as partial surrogate of the aggregates, in asphalt mixtures [12]. That study found that the use of PEX considerably decreases the density of the mixtures and PEX modified mixtures, have similar performance to the conventional one in terms of water sensitivity, improving the permanent deformation resistance and reducing the temperature susceptibility. A study evaluated the use of polyethylene terephthalate (PET) in asphalt concrete mixture as aggregate replacement, named the modified asphalt mix as “Plastiphalt”, and evaluated the reduction in the environmental effects of PET disposal. The results of that study revealed enhanced asphalt mix performance, Marshall Stability, flow, Marshall Quotient and density as compared to conventional mix [6]. Focusing on use of tire crumb rubber (CR) as an additive in HMA, various important studies made various important observations including improvement in softening point, reduction in penetration and ductility indicating improvement in individual characteristics of bitumen; also crumb rubber modified bituminous mix exhibited better stability and rut resistance as compared to conventional mix [4], [13]-[16]. As evident from the literature search, relatively very few studies focused on utilization of waste polymers for HMA performance enhancement and there is a severe lack of research that focused on the comparative analysis of properties of HMA modified by various indigenous or polymer based waste materials. This study intends bridging highlighted gap in the existing body of knowledge by presenting a comprehensive comparative analysis of the performance of HMA modified by various polymer based waste materials.

## III. RESEARCH METHODOLOGY

Bitumen and aggregates quality tests were carried out on both control (un-modified) samples and samples modified with varying percentages of polymer. Several tests were performed necessary for performance evaluation of both the mixes (modified and un-modified). The optimum asphalt content was determined using Marshall Mixture Design method. Using this optimum asphalt content, wet and dry processes (for mixing polymer in HMA) were performed to explore the effects of variation of polymer content with bitumen and finding out the optimum polymer content on the basis of Marshall Stability. Hamburg Wheel Tracking test was carried out to determine the rutting resistance of both control and modified samples. Cost-effectiveness analysis was carried out to complete the matrix of comparative analysis. On the basis of results comparison, pertinent and important conclusions were preferred.

Asphalt binder 80/100 was used in this research. The coarse and fine aggregates used were crushed limestone quarried from Margalla (Pakistan) as per NHA (National Highway Authority Pakistan) Class-A specifications as shown in Table 1 [17]. Polymer based waste materials to be analyzed in this study include; Low Density Polyethylene (LDPE) in the form of polyethylene bags (shopping bags), High Density Polyethylene (HDPE) in the form of waste plastic beverage bottles and crumb rubber from waste tires. Waste polymer materials were shredded to a desired size i.e., passing 4.75 mm sieve. Shredded polymers are shown in Fig. 1.

Table 1: NHA specifications for aggregate gradation

| Sieve size | | Percentage Passing (NHA Specifications) | Percentage Passing (Used) |
|---|---|---|---|
| Mm | In | Class A | Class A |
| 25 | 1 | 100 | 100 |
| 19 | ¾ | 90-100 | 90 |
| 12.5 | ½ | 75-90 | 68.5 |
| 9.5 | 3/8 | 56-70 | 65 |
| 4.75 | #4 | 35-50 | 45 |
| 2.38 | #8 | 23-35 | 33 |
| 1.18 | #16 | 5-12 | 12 |
| 0.075 | #200 | 2-8 | 3.5 |

Shredded LDPE (Plastic Bags) | Shredded HDPE (Plastic Bottles) | Shredded CR (Waste Tires)

Fig. 1 Shredded polymers used in the study

## IV. RESULTS AND ANALYSIS

### *A. Tests on Un-modified and Modified Bitumen*

Conventional bitumen tests including penetration, ductility, softening point, flash point and fire point, were performed on the unmodified and polymer modified binders and the results are illustrated in Tables 2, 3 and 4. To prepare modified bitumen samples, shredded polymers were added in various percentages by weight of bitumen in the samples, i.e., 0.5%, 1%, 1.5% and 2 %. During the preparation of modified bitumen samples, it was observed that LDPE was soluble in bitumen up to the extent of 2% (by weight of bitumen in the sample) and beyond 2%, it did not yield a homogenous bituminous mix with prominent separated solid deposits/pieces of polymer. HDPE yielded non-homogeneous mix even at 0.5% polymer (by weight of bitumen in the sample). Shredded crumb rubber, however, could be added to virgin bitumen in percentages greater than 2%. For comparative analysis, results are presented for addition of polymer up to 2% by weight of bitumen in the sample.

Results show that the virgin (un-modified) bitumen satisfied all the specifications as shown in Table 2. It was observed that the penetration and ductility decrease with increase of polymer content in bitumen (Table 3). This shows enhancement of stiffness in bitumen by addition of polymer. LDPE caused greater reduction in penetration value compared to CR, revealing greater potential of LDPE in enhancing bitumen stiffness than CR. Compared to un-modified bitumen (i.e., 0% polymer content), penetration decreased by 16% in case of LDPE while it reduced to 10% for CR at 2% polymer content (Table 3). On the other hand, CR caused greater reduction in ductility compared to LDPE. Compared to un-modified bitumen, ductility decreased by 66% in case of CR, while reduced to 45% for LDPE at 2% polymer content (Table 3 and Fig. 4). Therefore, addition of polymers enhances the resistance of bitumen against high temperature effect. Addition of LDPE and CR in bitumen was found to increase the bitumen softening point in similar pattern. Though LDPE caused marginally greater increase in softening point compared to CR, revealing greater potential of LDPE in enhancing the resistance of bitumen to high temperature compared to CR (Table 4).

Table 2: Results of conventional bitumen tests performed on virgin (unmodified) binder

| Tests | Results | Specification | Standard |
|---|---|---|---|
| Penetration | 86 | 80-100 | ASTM D5 |
| Softening Point | 56 °C | 43°C min | ASTM D36 |
| Flash Point | 240 °C | 232 °C | ASTM D 92 |
| Fire Point | 250 °C | 242 °C | ASTM D 92 |
| Ductility | 89 cm | 100 cm | ASTM D 113 |

Table 3: Penetration and ductility test results of polymer modified bitumen

| `Polymer | Penetration | | Ductility (cm) | |
|---|---|---|---|---|
| % | LDPE | CR | LDPE | CR |
| 0 | 86 | 86 | 89 | 89 |
| 0.5 | 80 | 85 | 80 | 79 |
| 1 | 77 | 82 | 71 | 59 |
| 1.5 | 75 | 79 | 63 | 34 |
| 2 | 72 | 77 | 49 | 30 |

Flash and fire points describe the flammability of bitumen. Effect of CR in increasing flash and fire point was quite pronounced compared to LDPE. In comparison to un-modified bitumen, CR caused 71% increase in flash point while LDPE yielded only 12.5 % increase in flash point at 2% polymer content (Table 4). Moreover, CR caused 68% increase in fire point compared to only 12

% increase by LDPE at 2% polymer content with respect to un-modified bitumen (Table 4). Increase in flash and fire point consequent to addition of polymer in bitumen represents better resistance to burning and fire hazards.

Table 4: Softening point, fire and flash point test results of polymer modified bitumen

| % of Polymer (by weight of Bitumen) | Softening Point $^{0}$C | | Flash Point $^{0}$C | | Fire Point $^{0}$C | |
|---|---|---|---|---|---|---|
| Polymer Type | LDPE | CR | LDPE | CR | LDPE | CR |
| 0 | 56 | 56 | 240 | 240 | 250 | 250 |
| 0.5 | 59 | 57 | 245 | 271 | 256 | 283 |
| 1 | 63 | 60 | 257 | 309 | 270 | 323 |
| 1.5 | 66 | 63 | 263 | 386 | 275 | 395 |
| 2 | 68 | 67 | 270 | 410 | 280 | 419 |

*B. Tests on Un-coated and Polymer Coated Aggregates*

Aggregate wear resistance and relative strength properties were explored using Los Angeles Abrasion Value (LAAV) test, AASHTO T 96 and impact tests, respectively. For the preparation of polymer coated samples, shredded polymer was mixed with the heated aggregates at 170$^{0}$C. Polymers were added to aggregates in various percentages by the weight of aggregates in the samples, i.e., 2%, 4%, 6%, 8% and 10%. Fig. 2 shows the polymer coated aggregates.

a. LDPE coated aggregates    b. HDPE coated aggregates    c. CR coated aggregates

Fig. 2: Polymer coated aggregates

It was revealed that LAAV decreases with increase in polymer content, i.e., CR, HDPE and LDPE, showing improved wear resistance due to use of polymer (Table 5). Overall, LDPE was observed to cause greatest enhancement in wear resistance compared to other polymers. With 10% LDPE content, 64 % enhancement in wear resistance (reduced LAAV) has been observed compared to uncoated aggregate (Table 5). At 10% polymer, HDPE and CR yielded 62% and 57% enhancement in wear resistance in comparison to uncoated aggregate (Table 5).

Table 5: Comparison of % of polymer with L.A.A.V

| % of Polymer | LAAV ( % ) for CR | LAAV ( % ) for HDPE | LAAV ( % ) for LDPE |
|---|---|---|---|
| 0 | 30.36 | 30.36 | 30.36 |
| 2 | 25.61 | 28.20 | 24.44 |
| 4 | 21.65 | 24.57 | 20.10 |
| 6 | 19.62 | 19.85 | 17.25 |
| 8 | 14.8 | 12.78 | 12.12 |
| 10 | 13.2 | 11.48 | 11.01 |

Table 6: Comparison of % of polymer with aggregate impact value

| % of Polymer | Aggregate Impact Value ( % ) CR | Aggregate Impact Value ( % ) HDPE | Aggregate Impact Value ( % ) LDPE |
|---|---|---|---|
| 0 | 12.25 | 12.25 | 12.25 |
| 2 | 10.2 | 10.7 | 11.2 |
| 4 | 8.1 | 8.8 | 9.6 |
| 6 | 6.5 | 6.4 | 7.6 |
| 8 | 5.1 | 5.0 | 6.3 |
| 10 | 4.3 | 4.1 | 4.5 |

In case of Impact Value test, relative strength is observed to increase (with reduced Impact Value) owing to increase in polymer content (Table 6). CR and HDPE are observed to yield enhancement in relative strength in almost same extent, which is higher compared to the strength increase caused by LDPE. Compared to uncoated aggregates, coated aggregates with 10% CR and HDPE yielded 65% and 67% improvement in the strength, respectively (shown by reduced impact value) (Table 6).

*C. Preparation of Control Samples (Determination of Optimum Binder Content-OBC)*

Marshall mix design method was adopted to determine the optimum bitumen content (OBC) of the mixture. The Marshall Stability test provides the performance measure for asphalt concrete mixture's stability and load carrying capacity. Total of 18 samples (3 samples for each % of bitumen) were prepared for determination of the optimum bitumen content (OBC) with varying percentages of bitumen (i.e., 3.5%, 4%, 4.5%, 5%, 5.5% and 6%). The OBC was found out to be 4.5%.

*D. Preparation of Modified HMA Samples*

Marshall mix design process was repeated to determine the optimum polymer content in the binder. Percentage of the polymer yielding the highest Marshall stability was designated as optimum percentage of the polymer (optimum polymer content-OPC). Two processes namely dry process and wet process were tested for preparation of modified HMA samples and determination of OPC.

*Wet Process*

In this process bitumen was heated to 160°C and then the shredded polymer was added in hot liquid bitumen. While carrying out quality tests on bitumen it was observed that LDPE was soluble in bitumen up to the extent of 2% (by weight of bitumen) and beyond which a non-homogenous bituminous mix with prominent separated solid deposits/pieces of polymer was yielded. While HDPE produced non-homogeneous mix even at 0.5% polymer. For this reason a comparative analysis of wet process based modified HMA samples could not be carried out. Hence wet process was found unsuiatble for LDPE and HDPE modified HMA preparation.

*Dry Process*

In this process aggregates were heated to 170°C and then shredded polymer was added and mixed to coat the aggregates. In this study six proportions (4, 6, 8, 10, 12, and 14%) of polymer by weight of OBC (4.5%) were selected to be tested for preparation of polymer modified HMA samples and determination of OPC. After coating the aggregates adjusted/reduced amount of unmodified binder was used to manufacture the modified mixture in this process. The total percentage of binder (OBC) in the mix remained constant (4.5%) for unmodified and modified mixtures. Meaning there by the amount of bitumen was reduced proportional to the percentage of the polymer used in the process e.g. for a mix with 4% polymer, the amount of bitumen was reduced by 4% by weight of OBC used in the mix.

*E. Determination of Optimum Polymer Content-OPC*

Three samples for each polymer percentage (i.e., 4, 6, 8, 10, 12, and 14%) were used in Marshal mix design method. Marshal stability values were determined for each percentage of polymer. Figure 11presents OPC corresponding to highest stability value for each polymer. OPC was found to be 8% at 17.4 KN for HDPE, 8% at 16.3 KN for LDPE, and 10% at 20.4 KN for CR (Fig. 3). It is observed that stability values increase with the increase in polymer content upto OPC and beyond that the stability values start to decrease in case of three polymers showing decreased strength in the mix due to considerable reduction in bitumen content (the main binder material) due to its replacement by polymer. Upto 8% polymer content, HDPE exhibited higher stability values compared to other two polymers while CR exhibited higher stability values beyond 8% polymer content compared to other two polymers (Fig. 11). It is also observed that CR caused an increase in stability by 98% at OPC (i.e. from 10.3 to 20.4 KN) in comparison to un-modified/conventional HMA. LDPE and HPDE yielded 58% and 69% increase in stability at OPC compared to conventional HMA, respectively (Fig. 3).

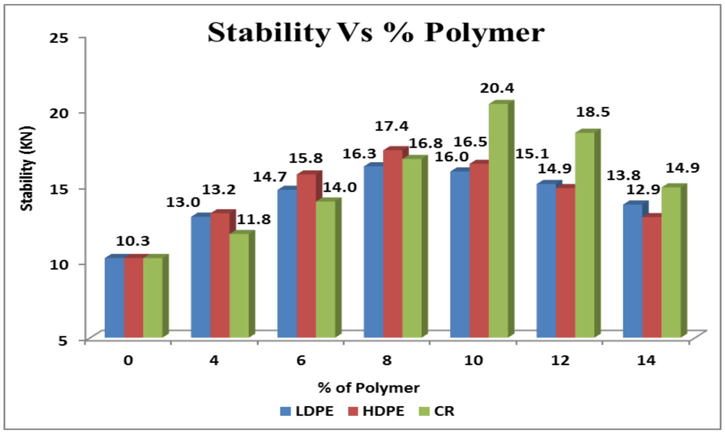


Fig. 3: Comparison of % of Polymer Vs. Marshall Stability Value by Dry Process

*F. Evaluation of Rutting Susceptibility of Mixtures*

Rutting susceptibility of control and polymer modified mixtures was evaluated by Hamburg Wheel Tracking (HWT) test in accordance with AASHTO T 324. Roller compacted slab were tested in dry condition at 450C. Both; unmodified and modified samples were prepared using OBC and OPC, respectively. For control mix uncoated aggregates were utilized whereas coated aggregated with OPC were used for modified mixture using dry sample fabrication process. HWT test results presented in Fig. 12 indicated that modified mixes containing polymer were considerably less susceptible to rutting as compared to conventional bituminous mixes. HDPE modified mix exhibited the highest resistance to rutting compared to conventional HMA and that modified by other two polymers. At 10,000 passes HDPE modified mix resulted in 78%, 35%, and 48% reduced rutting compared to conventional mix, CR and LDPE modified mix, respectively. Moreover, CR modified HMA exhibited better rutting resistance than LDPE modified and conventional mix (Fig. 4).

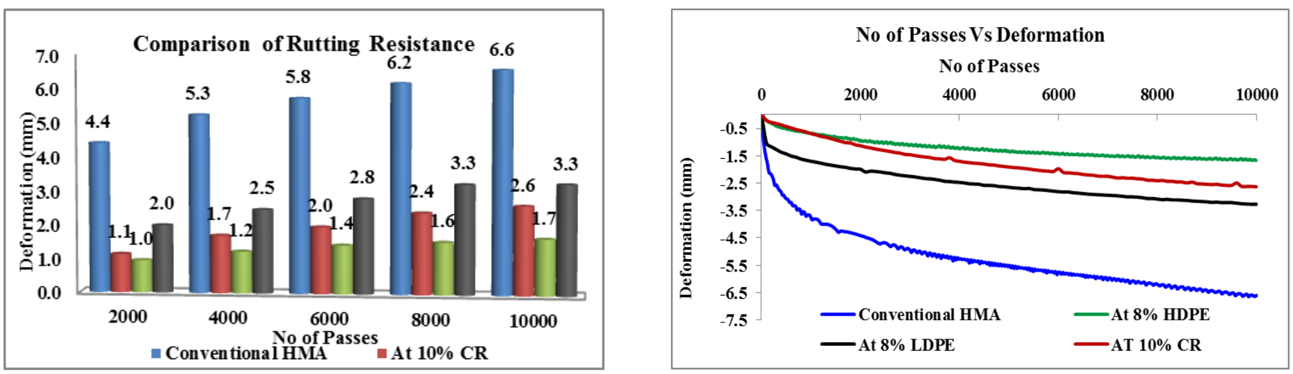


Fig.4: HWT Test Results for Control and Polymer Modified Mixtures

*G. Economic Analysis*

In order to compare the cost-effectiveness of the three-polymer modified bituminous mixes, economic analysis was also carried out considering the material requirement for paving 4 inch thick wearing course on standard 12 feet wide lane of one kilometer length roadway section. Important aspects of economic analysis are presented in Table 7.

CR modified HMA was found to be most cost-effective, followed by LDPE and HDPE modified HMA. Results show that a road constructed with CR modified HMA yields a saving of Rs. 0.166 M per lane-km compared to road construction with conventional HMA. Also, it is observed that CR modified HMA is approximately 6% and 14.5% more cost-effective compared to LDPE and HDPE, respectively.

Table 7**:** Economic Analysis Using Polymer Modified HMA

| No | Description | LDPE (OPC 8%) | HDPE (OPC 8%) | CR (OPC 10%) |
|---|---|---|---|---|
| 1 | Quantity of asphaltic concrete in 4 inch wearing course (ton per lane-km) | 876 | 876 | 876 |
| 2 | Amount of bitumen required at 4.5 % OBC (ton per lane-km) | 39.42 | 39.42 | 39.42 |
| 3 | Bitumen saved in modified mix at OPC (ton per lane-km) | 3.15 | 3.15 | 3.94 |
| 4 | Cost saving due to reduced bitumen use (Rs. per lane-km) | 252,288 | 252,288 | 315,360 |
| 5 | Cost of polymer including processing (per ton) | 30,000 | 34,000 | 38,000 |
| 6 | Cost of polymer used in wearing course (per lane-km) | 94,608 | 107,222 | 149,796 |
| 7 | Total saving (Million Rs. per lane-km) | 0.157 | 0.145 | 0.166 |

## V. CONCLUSIONS

Following conclusions could be drawn from this study:

- LDPE has less solubility in bitumen compared to crumb rubber while HDPE was found to be in soluble in hot 80/100 bitumen even at 0.5 % by weight of bitumen and it yielded a non-homogenous bituminous mix with prominent separated solid deposits/pieces of polymer.
- Penetration and Ductility of bitumen decreases with increase in polymer content showing enhanced stiffness in bitumen.
- LDPE exhibited greater potential of reducing penetration value of bitumen compared to CR.
- CR caused greater reduction in ductility of bitumen compared to LDPE.
- Addition of polymers, LDPE and CR, were found to increase bitumen softening point as compared to un-modified bitumen, showing greater resistance of modified bitumen against high temperature effects.
- With respect to reduction in sofetning point due to addition of polymer, LDPE exhibited marginally greater potential of enhancing the resistance of bitumen to high temperature compared to CR.
- Addition of CR in bitumen caused pronounced increase in bitumen flash and fire point compared to LDPE, revealing better resistance to burning and fire hazards.
- Polymer coating of aggregates increases abrasion/wear resistance (in terms of LAAV) and impact resistance (in terms of impact value) of aggregates thus improving strength properties of the treated aggregates.
- Coating of aggregate with polymers introduces improved aggregate wear resistance (LAAV) and relative strength (Impact Value).
- LDPE caused greatest enhancement in aggregate wear resistance (LAAV) compared to HDPE and CR; while HDPE performed better than CR in this regard.
- HDPE coated aggregates exhibited greatest enhancement in relative strength (Impact Value) compared to LDPE and CR; while CR performed better than LDPE in this regard.
- Wet process was found to be unsuitable for LDPE and HDPE modified HMA preparation.
- It was revealed that dry process of polymer addition could accommodate relatively higher percentages of the polymer however; limited amount of binder could be replaced with polymer in the mix without leaving uncoated aggregates and without compromising the stability/strength requirement.
- Marshall Stability value was found to increases with the increase in polymer content upto OPC and beyond that the stability values started to decrease; primarily because of decreased strength in the mix due to considerable reduction in bitumen content due to its replacement by the polymer.
- OPC was found to be 8% at 17.4 KN for HDPE, 8% at 16.3 KN for LDPE, and 10% at 20.4 KN for CR.
- Upto 8% polymer content, HDPE exhibited higher stability values compared to LDPE and CR modified HMA.
- CR caused an increase in stability by 98% at OPC (from 10.3 to 20.4 KN) in comparison to unmodified/conventional HMA while LDPE and HPDE yielded 58% and 69% increase in stability at OPC, respectively.
- Ploymer modified HMA exhibited increased rutting resistance as compared to unmodified HMA.

- HDPE modified HMA exhibited the highest rutting resistance compared to conventional, LDPE and CR modified HMA.

Basing on economic analysis, road construction with CR modified HMA was found to be most cost-effective with Rs. 0.166 million saving per lane km, compared to road construction with conventional, LDPE and HDPE modified HMA.

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# Analysis of Transportation Potential of Rivers in Pakistan

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***Abstract:*** **A recent National Highway Authority report predicts over 4-fold increase in trade volume by 2025 in Pakistan. Current trajectory of transportation infrastructure development in the country points that highways and motorways would take the bulk of this volume. The existing literature, however, suggests that inland waterways can handle 70 and 16 times more cargo than roads and railroads respectively. Additionally, waterways are 700/70 times safer in terms of accidents, 5/3 times more fuel efficient, and, 11/1.5 times less emitting than roads/railroads. Inland waterways, therefore, are an obvious mode for transportation both in developed and developing countries. However, despite having sizeable rivers in Pakistan this mode of transportation remains absent. This study has investigated the potential of inland water transportation in Pakistan and finds that it is technically possible and can become socio-economically sustainable when implemented with a systematic phase-wise plan. The study also points that existing water usage in the agriculture sector, due to its inefficiency and wastage, is the biggest impediment to reach the optimum potential of the inland navigation in our rivers and recommends a parallel approach in improving irrigation efficiency along with the development of inland waterways.**

***Keywords*****: Indus inland waterway, Indus river, River navigation, Sustainable development,**

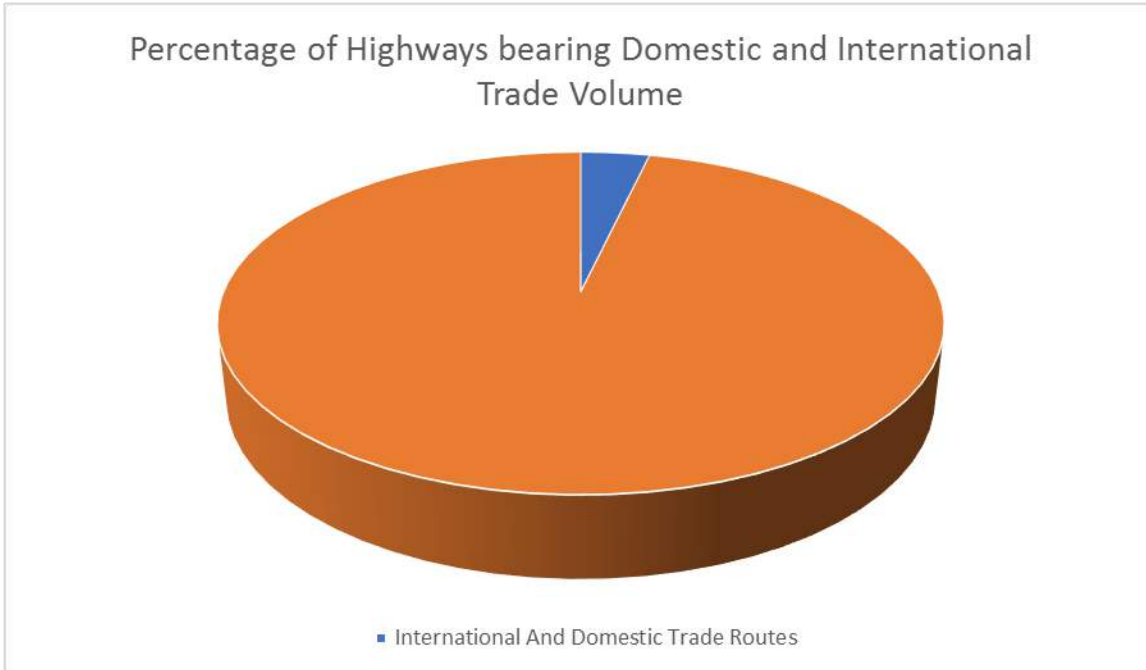
## I. INTRODUCTION:

### *A. General*

Pakistan, with over 200 million people, annually generates a total domestic transport load of around 239 billion passenger kilometers and 153 billion ton kilometers. Domestic trade accounts for various agricultural and industrial products transported between provinces. This load of domestic and International trade is supported by a 9,574 km long National Highway and Motorway network constituting only 3.65% of the total Road network but carrying 91% of the national passenger traffic and 96% of the freight. Present freight density on our roads is about 170 billion tons/km which is expected to increase to 600 billion ton/km by 2025 if no new roads are added to the network. In order to just maintain the current density, 350% increase in roads length will be required. And with an average cost of over $1 million/km for a highway, a budget of around $35 billion is required just to maintain the current trade volume density – not to mention that 170 billion tons/km already points to an over-stressed road network, and $35 billion spending on road networks alone within the next eight years for the feeble economy of Pakistan seems difficult.

On the other hand, Indus River with its five tributaries and established canal system provides a potential of 3,000 km of Inland waterways – three times more than the length of the current road networks. Furthermore, the construction costs, logistic barriers/costs of land acquisition, community relocation and compensation, etc., are absent in this case. The development of inland waterways, thus, could be explored as a potential transportation solution for the country.

This study investigates the potential of development of inland waterways in Pakistan as a means to accommodate increased demand of the transportation sector and suggests an implementation plan that demonstrates its viability.




*B. Comparison of modes of domestic freight transport*

A study on comparison of modes of domestic freight transport, i.e. water (barge), road (semi-tractor/trailer) and rail road (rail cars) is discussed as follows [1]:

*1) Cargo Capacity:*

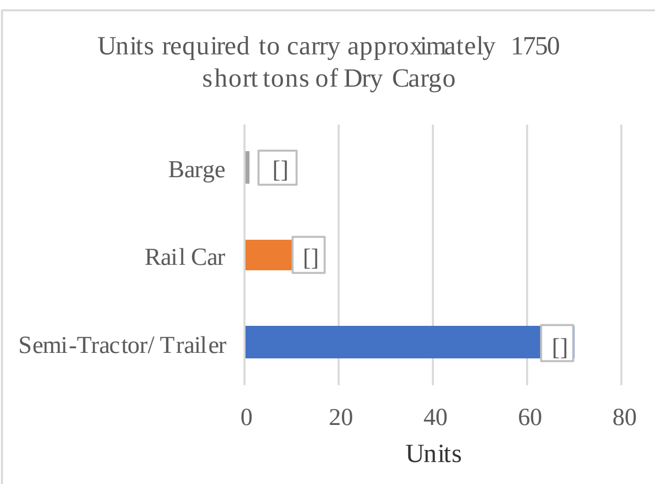



Fig. 2 Dry Cargo Carrying Capacity [1]

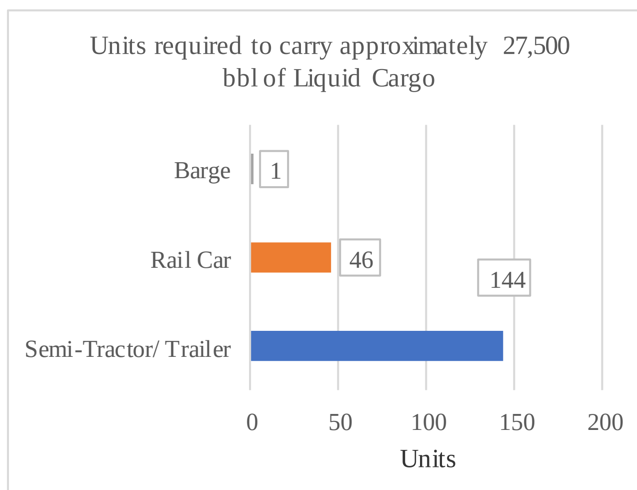



Fig. 1 Liquid Cargo Carrying Capacity [1]

Fig. 2 illustrates that in case of dry cargo, a single barge is able to carry goods weighing 1750 short tons as compared to 70 trucks on road and 16 rail cars. Similarly, Fig. 1 shows that in case of liquid cargo, a barge is able to transport 27,500 barrels compared to 144 trucks on road and 46 rail cars respectively. The comparison clearly states the fact that barges running on inland waterways have way more cargo carrying capacity than its counterparts running on roads and railways.

*2) Green House Gas Emissions:*

Fig. 3 compares the emissions of Green House Gases (GHG) from the years 2005, 2009 and 2014, and clearly illustrates that waterways are the least emitting of the three modes of transport.

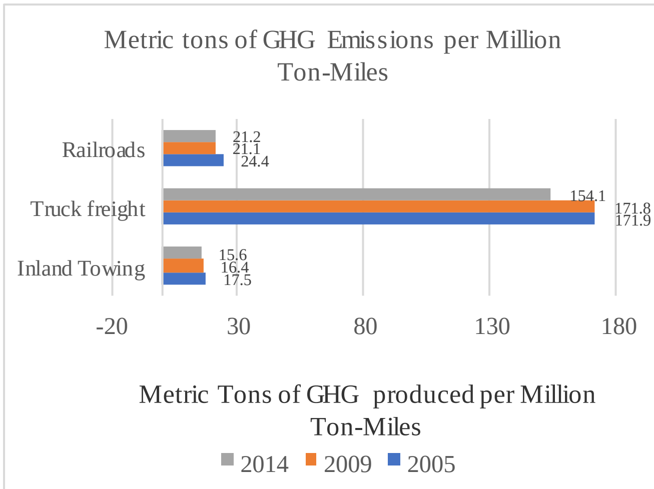



Fig. 3 Metric Tons of GHG produced per Million Ton-miles (2005, 2009, 2014) [1]

*3) Fuel Efficiency:*

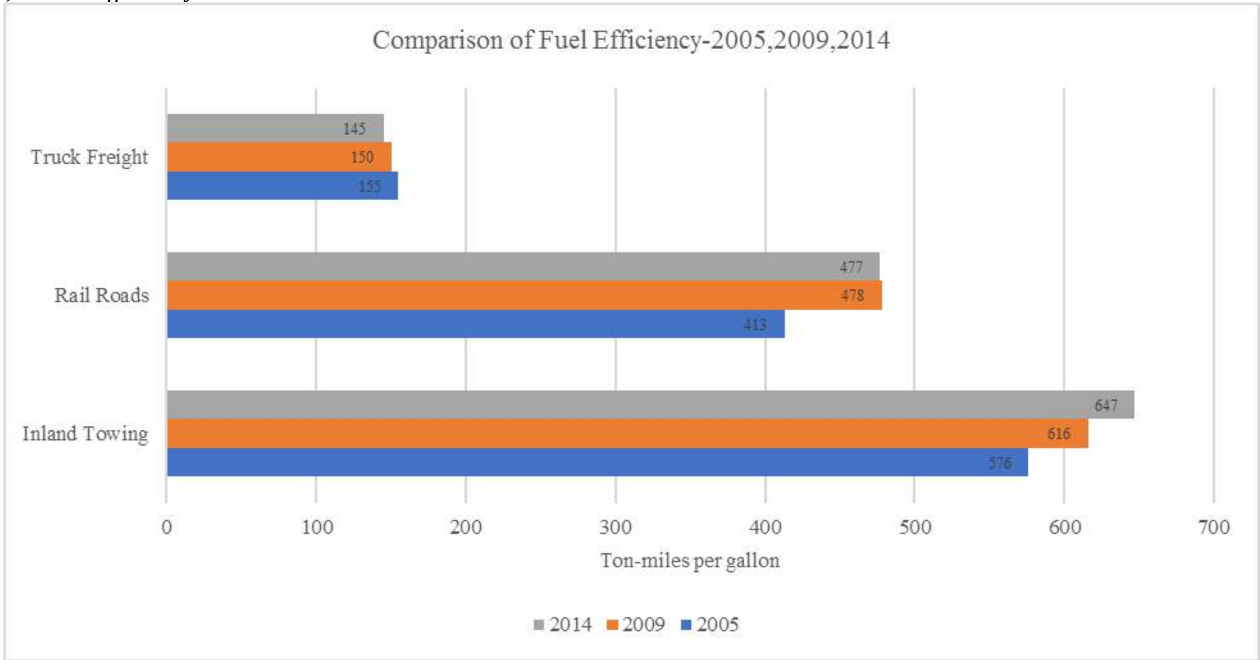



Fig. 4 Comparison of Fuel Efficiency 2005, 2009, 2014 [1]

The comparison in **Fig. 4** shows that ton-miles moved per gallon using inland towing is the most energy efficient.

*4) Safety*

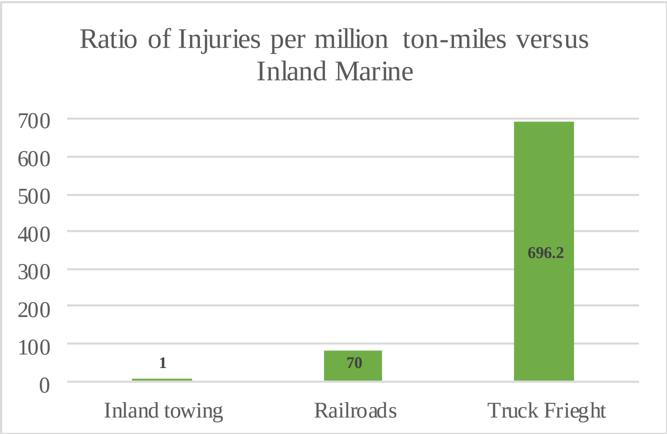



Fig. 5 Ratio of Injuries per Million-ton miles versus Inland Marine [1]

**Fig. 5** gives a graphical comparison between the injuries caused on roads, rails and inland towing. The statistics show that inland towing is 700 and 70 times safer than the truck freight and railroads respectively.

The potential of such a safe, fuel-efficient, environmentally friendly and capacitive mode of transport should therefore be explored to meet the immense future demands of transport in the country [1].

### C. Historical Perspective

Following is a brief historical account of inland navigation from ancient China and 19th century USA and how it transformed the socio-economic portrait of those regions. This is followed by history of Indus river system and its limited use for navigation in the past.

#### 5) The Grand Canal China:

The oldest and longest man-made canal running 1,794 kilometers and a history of over 2,500 years starts at Beijing in north and ends at Hangzhou in south connecting five great rivers [2].

Originally built to control the flood-prone terrain and being used as a line of defense against enemies, it served as a main artery between northern and southern China. Northern and southern China thrived with trade. Linking north and south China, it provided safe transportation insulated from the threats of storms and pirates on the high seas [3]. Although it was mainly used for shipping grain, it also transported other commodities and the corridor along the canal developed into an important economic belt and facilitated China to establish trade with South East Asia [4]. Historians also attribute the integration and unification of China to The Grand Canal [3].

#### 6) The Erie Canal

The Erie Canal's construction started in 1817 and completed in 1825. 363 miles of canal through the wilderness connected Lake Erie to Hudson River [5]. The canal system gave New York a competitive advantage into becoming the international trade center [6].

Although the canal was only 4 feet deep and 40 feet wide, it turned out be an immediate success. Tolls and import duties collected provided funds to pay the construction debts within the first year of its operation [7]- [8]. It lowered the cost of shipping between Midwest and Northeast [9]- [10]. The canal facilitated exports to Britain, Europe and Canada. The canal is said to have strengthened the union and kept them together during the Civil War [11].

#### 7) Indus River

Indus river and its tributaries emerging from the mountains in north connect many major cities of Afghanistan, Pakistan and India with the Arabian Sea. Historically, the potential of connecting major business centers of sub-continent with the sea through inland navigation in Indus has existed since the times of British Raj [12]. In 1638 Henry Bonford successfully sailed from Lahore to Thatta in a flat-bottom boat. Alexander Hamilton, a merchant and adventurer, published in 1727 that Indus is navigable as high as Kashmir. In order to control Sindh, Punjab, strengthen their influence in the northwest and Afghanistan, and, counter any threat from Russians, the British knew that control on river Indus would be vital. British, therefore, authorized a comprehensive survey of river Indus to access its navigational potential. In 1831 Alexander Burnes carried out this survey and optimistically declared the river navigable. In 1836, four British engineers – Wood, Carless, Leech and Heddle – were sent to test Burnes's optimistic assertions. They found out that the river was not as easy and as suitable for navigation as suggested by Burnes because of the shifting nature of the river and problems in delta.

Officers of East India Company had imagined Indus as an Indian Mississippi/Hudson for steam ships navigating the fresh waters. Burnes also made an economic proposition that Indus should be opened for trade and navigation. Indus flotilla had operated between Kotri and Multan carrying goods and passengers. And, although, proposals were put up for intercity linkage canals through the Indus, the British engineers saw more economic potential in building irrigation canals on the model of Ganges [13].

While development of railways took care of inland transportation needs, the rivers were diverted into irrigation canals to transform the river basin into what is now known as the largest contiguous irrigation system of the world – IBIS (Indus Basin Irrigation System). The prime reason, however, as to why inland transportation on the lines of America could not take off on Indus, even before the construction of canals, seem to be the lower primacy of the British Raj to develop and maintain a reliable and safe passage through the difficult delta into the sea [12]- [13].

The problems posed by the delta only worsened as the development of canal irrigation networks continued to expand. Finally, the large dams under Indus Basin Treaty almost sealed the fate of an inland water way through Indus [12].

Historically inland waterways have played a significant role in trade, commerce and regional integration. The potential of Indus river in this regard has existed in past but never fully exploited. This potential still exists, hence, it is worth exploring this potential in the present day scenario.

## II. METHODOLOGY

This study proceeds on the following grounds:

1. Review of literature on history of Inland navigation in ancient China, 19th century America and Indus Basin
2. Critical review of three river basins using inland waterways, one each from the underdeveloped, developing and developed regions of the world
3. Current situation of Indus Basin and its comparison in 2. above in terms of hydrology and navigational potential
4. Conclusions from 1., 2. and 3. above
5. Proposed methodology to exploit Indus as a potential inland waterway

## III. WATERWAYS OF THE WORLD

The following paragraphs discuss Congo River as an example from underdeveloped world, The Nile from the developing world and Mississippi from the developed world.

### *A. The Congo River*

The Congo River with a length of 4,700 km runs mainly through The Democratic Republic of Congo in Africa forming the backbone of its inland transportation system. An average discharge of 40,000 $m^3/s$ and navigable depths varying from 5 to 15 meters make Congo river and its tributaries one of the best natural network of waterways in the world. [14] The inland waterways provide 9,320 miles of navigable route, out of which 8,390 miles are in Congo River system and 930 miles are routes on navigable lakes. About 40 % of the all the surface traffic moves over the inland waterways. About 1.3-million-ton cargo transport was recorded in 1970 in which most of the tonnage was domestic. The upstream limit of navigation, waterway traffic is interrupted at several points by falls and rapids which divides the route into six navigable reaches. Rail lines bypass the unnavigable stretches making the inland transport possible. [15]

### *B. The Nile*

Maritime transport is the most dominant mode of transport for moving freight between the Nile countries and the global market. Maritime transport is important as a transit route for international trade, and accounts for 92 to 97 % of the region’s international trade. Egypt, which has about 2,450 kilometers of coastline on the Mediterranean and Red Seas, has the most developed maritime system. Nine of the 11 Nile riparian countries have navigable water bodies, and a total of 72 inland water ports between them, with Egypt and Uganda having the highest number. [16]

### *C. The Mississippi*

The United States has an outstanding system of inland waterways, consisting of more than twenty-five thousand miles of navigable rivers and canals, of which twelve thousand miles are commercial waterways and carrying more than 600 million tons of domestic freight each year. This amounts to approximately 16 percent of the total intercity freight movements in the country. [17]This commerce has an overall value of about $70 billion, substantially contributing to America's economic strength. Waterways transport more than 60% of the nation's grain exports, about 22% of domestic petroleum and petroleum products, and 20% of the coal used in electricity generation. This system of waterways is maintained by the U.S. Army Corps of Engineers with a project depth of between 2.7 and 3.7 m (9 – 12 feet) to accommodate barge transportation. [1]

## IV. CURRENT SITUATION OF INDUS RIVER AND ITS POTENTIAL

The above mentioned waterway systems provide evidence of existence of mass inland navigation in different hydrological, economical and spatial spectrums. Indus lies in a developing economy with comparable hydrology and spatial stretches, making it a candidate for inland navigation as well. However, despite its potential, the river has not been used for navigation. The following paragraphs discuss the current situation of the river vis a vis. its potential for navigation.

### *A. Hydrological modifications in the Indus*

Indus river system is one of the most extensively modified river systems in the world. The river which used to dump around 280 billion cubic meters (BCM) of water annually on its delta is now a mere 25 BCM due to dams and diversions upstream. However, before these extensive modifications in the river hydrology, the state of the river is discussed below.

As discussed in the historical accounts of Indus above, British explored the navigation potential of Indus. Alexander Hamilton published in 1727 that the Indus is navigable as high as Kashmir with certain stretches which can receive ships up to 200 tons. In 1831, Alexander Burnes surveyed Indus and suggested that Indus is navigable with a minimum available draft of 15 feet all around the year. In 1836, Wood, Carless, Leech and Heddle in their survey of Indus, concluded that frequent course-changes, high-floods in the upstream plains and shifting nature of Indus Delta posed tough challenges for river navigation and waterway connection to the sea.

The prominent features of the Indus River before the construction of dams and diversions were:

1. The river flow reached delta all around the year.
2. Frequent course-changes
3. High floods in the upstream plains
4. Annual flow of 250 BCM
5. The river delta expanded over 3500 km$^2$

The Indus presented potential both for navigation as well as development of irrigation. However, latter was fully exploited while the former was completely ignored over the course of last 150 years or so, and the following explains how and why.

1. In 1798, Thomas Melthas presented his famous work in which he pointed out the that the population growth was exponential while growth in food production was linear and predicted food shortages when the two curves cross. The famine of 1837-38 triggered the canal fed mega irrigation schemes on Indus and its tributaries. And then again, after the famine of 1876-77, British went on a binge for developing one large irrigation scheme after the other on Indus, starting with completion of Madhupur Headworks in 1879. In 1898 exactly 100 years after Thomas Melthas, William Cook presented his famous essay "The Wheat Problem" in which he predicted that if additional grain supplies are not catered for, there will be food shortages by 1930's. Such events motivated British to continue their binge of making more and more irrigation projects in plains of Indus. These irrigation schemes started producing food surpluses and became the source of revenue for the British Crown.

2. By mid-19th century, because of Afghan misadventures and the fear that Russians might take advantage of an inland navigational infrastructure in the region, the British were already losing interest in developing Indus for navigation. But in the end, it was irrigation which gave the fatal blow to the development of navigation in Indus river system.

3. After the construction of Sukkur Barrage in 1932, the river flow didn't reach delta except for the monsoon. British left the sub-continent in 1947 but both Pakistan and India continued where British had left.

4. Sutlej, Beas and Ravi were completely choked by India with the construction of Bhakra, Pong and Thien dams respectively, along with other major diversions

5. In Pakistan, after the completion of Kotri Barrage in 1958, the river flow to delta stopped altogether, except in monsoons. With the construction of Warsak, Mangla and Tarbela dams thereafter, on rivers Kabul, Jehlum and Indus respectively, and other additional diversions for irrigation, the flow downstream of Kotri Barrage exists only in high floods.

6. As a result of the above mentioned hydrological modifications both in India and Pakistan, the annual average flow in Indus has reduced from an average of 280 BCM to a mere 25 BCM.

Emerging from the mountains in the North, Indus carries around 435 million cubic meters of silt load every year which is vital to prevent erosion and sea water intrusion into the delta. As a result of hydrological modifications, around 250 million cubic meters of the silt load is lost in the dam lakes and irrigation canals [18]. The diminished flow and silt load has caused the delta to run dry. 15 acres of land per day is lost to the sea as a result of delta erosion and sea water intrusion. Consequently, the delta has shrunk from 3500 $km^2$ to a mere 250 $km^2$ [13].

The historical impediments pointed out by Burnes et al. and the apparent sorry state of the river might suggest that its navigation potential may have been completely lost. However, this may not be the case because: -

1. The problems of shifting river course and difficult to navigate delta as pointed out by the British in the past may not hold as true because due to reduced flow in the rivers, its confinement by flood protection levees, the course changes are not as frequent. And due to diminished supply of water in the delta, it is not as boggy and marshy nor as big as it used to be.
2. 12 BCM water is still being supplied up to Kotri Barrage to feed the irrigation canals which implies that the river is not dry upstream of Kotri and carrying substantial flow.
3. Despite diminished flows in the river channel, mild slopes of the plains through which the river is running, offer an excellent ground to build parallel still canals for navigation. Moreover, it is possible to manage water from Kotri barrage for a still canal running through the delta and connecting to the sea.

The above points imply that it is still technically possible to make Indus navigable with few engineering modifications.

## V. IMPEDIMENTS AND THE WAY FORWARD:

Although the navigation in Indus is technically possible, the following impediments may not allow it to be used at its full navigation potential:

1. Barrages and bridges presenting obstacles across the river channel. The structural solutions to negotiate these obstacles would increase the cost of developing inland navigation
2. Irrigation inefficiency forces 136 BCM out the river to serve the agricultural needs. Some of this water can be returned to the river by adopting efficient irrigation practices.
3. Intermittent flow in the river may pose a problem. However, to manage small amount of water in still canals may not be too difficult, given that the Indus is naturally a perennial river.
4. $18^{th}$ amendment in the constitution makes water resource management a provincial matter. However, basin-scale navigation requires one central authority controlling the resource.

## VI. SUGGESTED IMPLEMENTATION APPROACH

The Indus inland navigation may be planned with a holistic phase-wise implementation approach. To make the project economically viable and self-sustainable for future expansions, the first phase of the project needs to address the most essential component of inland navigation i.e. the connection to the sea. On the lines of Erie Canal, the first phase of development would connect Arabian sea with Indus delta all the way up to the Kotri barrage where the first Inland port could be established. This would attract enough clientage from the international trade that can breakeven the investment in a reasonable time and enable the project to take-off as a revenue generating venture.

Most of the small-scale international trade has practically no attraction towards Pakistan due to the delays faced by the cargo ships owing to limited berths and cargo handling capacity of two existing ports in Karachi which adds to transportation costs of both import and export cargo. The cargo from international trade can directly load and unload in deep sea waters on anchored ships bringing down transportation costs significantly making the local and international market more competitive in Pakistan. In addition, this would release the stress on Karachi for handling the import and export cargo of the whole country.

This first phase of the project will create an economic engine which is likely to not only breakeven the investment from the revenue collected in terms of tolls and businesses generated but also pull the other business centers, upstream on Indus, into the system.

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# Sources and Impacts of Heavy Metals: A Case Study of Civil Hospital Hyderabad

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***Abstract:*** **Heavy metal contamination is the emerging issue nowadays due to human and industrial activities. Humans are being exposed to heavy metals through different pathways such as ingestion, inhalation and skin contact. Humans are unaware about the sources of heavy metals contamination, that's why different diseases become a part of human life. Heavy metals are also known as carcinogens according to United States Environmental Protection agency (USEPA). In this paper, a case study of Civil Hospital Hyderabad has been considered. The aim of this paper is to analyze the sources and impacts of heavy metals that causes chronic diseases in humans. The first section of this paper is focused on the explanation of heavy metals, its sources, pathways and impacts. The second section is focused on the unstructured interviews and questionnaire survey of Civil Hospital Hyderabad. The third section is focused on the findings of the survey. All of these sections are followed by the conclusion.**

***Keywords:*** **Heavy metals, Impacts, Occurrence, Pathways.**

## I. INTRODUCTION

Heavy metal is described as any metallic element that is toxic even at low concentration. Heavy metals are distinct metals that can affect human health. These are important components of the environment. Their presence is unique as it is challenging to eliminate them from the environment when they enter in it. Exposure of heavy metals to humans is done through different pathways such as, ingestion, inhalation and skin contact. Humans are also exposed to heavy metals when they are living nearby any industry or working in any industry. These are natural occurring substances found in nature. Heavy metals are persistent environmental chemicals since they cannot be degraded or destroyed. These can emit into environment through natural and man-made sources. These can be emitted into environmental in both forms, i.e. element and compound. Humans are unaware about the sources of heavy metals. A case study of Civil Hospital Hyderabad has been taken in this research. The purpose of this research is to analyze the sources, exposure pathways and impacts of heavy metals on human health. According to demographic data of 2017, Hyderabad has a population of 8.7 million, including 18,480 people per square kilometer.

In this research, 24 different heavy metals are studied, including their sources, exposure pathways and impacts on human health. Heavy metals, i.e. lead, mercury, zinc, copper, cadmium, antimony, bismuth, chromium, cobalt, gallium, germanium, molybdenum, nickel, selenium, silver, tin, iron, lithium, barium, beryllium, silicon, aluminum, arsenic and yttrium are considered.

1) ***Selenium*****:** Selenium is used widely in photocells, light meters and solar cells. It is present in glass, plastics, paints and pharmaceuticals. Human exposes to selenium through ingestion of food and drinking water, skin contact with water or soil that are contaminated with selenium. Selenium poisoning may even cause death. Exposure to high amount of selenium may cause fever, sore throat, abdominal pain and diarrhea [1].

2) ***Arsenic:*** Arsenic is used in manufacturing of glass, as a wood preservative. Human exposes to arsenic through ingestion, inhalation and skin contact with soil or water. arsenic can cause various problems, such as stomach and lung irritation, and skin changes. [1-5].

3) ***Copper:*** Copper is a reddish metal. Copper is used for electrical equipment, construction, coins and household items. It can be found in food, drinking water and air. Human exposes to copper through inhalation, ingestion of water and food. Exposure to copper can cause nose, mouth and eye irritation. It also causes headaches, dizziness, vomiting and diarrhea. High dose of copper may damage liver and kidney and even death. [3]

4) ***Mercury:*** Mercury compounds are used in manufacturing processes, fluorescent light bulbs and thermometers. Human exposes to mercury through ingestion of drinking water and food. It can affect lungs, kidney, brain and skin severely [1-6].

5) ***Lead:*** Lead is a bluish-white metal. Lead is found in the lead-acid battery that is used in car batteries. It is also used television and computer screens, where it protects the viewer from radiation. Human exposes to lead through ingestion of water and food. It can cause several unwanted effects, such as, rise in blood pressure, kidney and brain damage and diminished learning abilities of children [1-7].

6) ***Cadmium:*** Cadmium is present in coal, mineral fertilizers, industrial dust, polluted water and food. Humans may be exposed to cadmium through inhalation, ingestion of food. Inhalation of cadmium can damage the lungs and nervous system, irritates the stomach and also cause cancer [1-7].

7) ***Chromium:*** Chromium is a hard metal. It is used in stainless steel and metal ceramics. Human exposes to chromium through inhalation, ingestion of drinking water and food and skin contact. It can cause lung cancer, kidney and liver damage leads to death [1,4,6-7].

8) ***Nickel:*** Nickel is silvery-white and ductile metal. Nickel is used in steal and other metal products. It is present in industrial dusts and aerosols. Human exposes to nickel through inhalation, ingestion of food and water, skin contact with water that is contaminated with nickel. Exposure to too large quantities of nickel causes lung cancer, nose cancer, dizziness and heart problems [3, 6-7].

9) ***Lithium:*** Lithium compounds are used in pottery, as a preservative in order to extend the performance and life of alkaline storage batteries. Humans may be exposed to lithium through inhalation, ingestion of medicines. Exposure to lithium can cause cough, abdominal pain and sore throat [6].

10) ***Beryllium:*** Beryllium is used in X-ray detection diagnostic field and in the manufacturing of various computer equipment. Human exposes to beryllium through ingestion of food and water, inhalation. Inhalation of beryllium can damage the lungs and cause pneumonia and heart problems [6].

11) ***Barium:*** Barium is used in spark plug electrodes. It is found in medicines, ceramics and bricks. Human exposes to barium through inhalation and ingestion of drinking water. Exposure may cause paralyses, stomach irritation, muscle weakness, kidney and heart damage. Barium is not a carcinogen [1,6].

12) ***Silver:*** Silver is used in electrical industry. It is found in jewelry, coins, medals and medicines. Human exposes to silver through inhalation, ingestion of medicines, eye and skin contact. Exposure may damage brain, kidney, eyes and lungs [1,7].

13) ***Tin:*** Tin is found in industrial dusts and medicines. Human exposes to tin through inhalation, ingestion of food and skin contact. It can cause irritation in eye and skin, dizziness, breathlessness and headache [3,7].

14) ***Zinc:*** Zinc can be used as a pigment in plastics, cosmetics, wallpaper, rubber manufacture, cement industry, medicines, etc. Human exposes to zinc through ingestion of food and water. Zinc deficiency can cause vomiting, skin irritation, decreased sense of taste and smell, birth defects etc [6-9].

15) ***Antimony:*** Antimony is present in ceramics, glass and plastics. Human exposes to antimony through inhalation, ingestion of drinking water and food. Long term exposure can cause eye, skin and lungs irritation [7].

16) ***Bismuth:*** Bismuth compounds are used as pharmaceuticals. Human exposes to bismuth through inhalation, ingestion of medicines and skin contact. Large doses can be fatal. It can cause skin problems and depression. It may disturb liver and kidney functions [7].

17) ***Cobalt:*** Cobalt is used in petroleum and chemical industries, paints, inks and jewelry. Humans may be exposed to cobalt through inhalation, ingestion of drinking water and food, skin contact with water or soil. Exposure of cobalt causes vomiting, loss of vision, thyroid damage and asthma [7].

18) ***Gallium:*** Gallium is used in thermometers, porcelain and glass. Human exposes to gallium through ingestion of water, fruits and vegetables. Exposure to gallium irritates the throat, causes breathing problems and chest pain [7].

19) ***Germanium:*** Germanium is mainly used in electronic devices and camera lens. Humans may be exposed to germanium through inhalation. Exposure to germanium causes negative impact on skin, eye and blood. Acute Exposure may result in death [7].

20) ***Molybdenum**:* Molybdenum is used in microwave devices, electrodes and inks for circuit boards. Exposure of molybdenum to humans through ingestion of water and food causes joint pains in knees, hands and feet. [7].

21) ***Iron:*** Iron can be found in meat, whole meal products, potatoes and vegetables. Exposure of iron through inhalation may cause lung cancer. Iron deficiency in humans leads to anemia [7, 9].

22) ***Yttrium:*** Yttrium is found in color televisions and camera lenses. Humans may be exposed to yttrium through inhalation. Exposure to yttrium can be a threat to the liver, when it accumulates in the human body [7].

23) ***Silicon:*** Silicon is used in glass, cement and ceramics. Human exposes to silicon through inhalation and skin contact. Exposure of silicon causes the irritation in skin, eye and lungs [10].

24) ***Aluminum:*** Aluminum is derived from alum (potassium aluminum sulfate). It is used in cans, foils, ceramics and machines. Human exposes to aluminum through inhalation, ingestion and skin contact. Exposure to aluminum can cause loss of memory, severe trembling and kidney problems [9, 11].

## II. METHODOLOGY

This section illustrates that how data was collected and analyzed in this research work. Data was collected in two phases, first one was unstructured interviews and the second one was questionnaire survey of patients and doctors in Civil Hospital Hyderabad. After that data analysis was done with the help of pervious literature.

### *A. Data Collection Phase 1(Unstructured Interviews):*

In this phase, data was collected through unstructured interviews of patients and doctors in Civil Hospital Hyderabad. While conducting interviews, two types of respondents (patients) were found. From those respondents, one type of respondents was unaware about the actual cause of their disease they were suffering from a long period of time. The main cause of their disease was not identified. The other type of respondents was aware about the actual cause of their disease. They were also aware about the environmental factors that can affect human health as well as they were also aware of the exposure pathways of particular heavy metals to them.

### *B. Data Collection Phase 2(Questionnaire Survey):*

In this phase, a questionnaire survey was designed for the collection of data about the source, exposure pathway and health impacts caused by different heavy metals. Interviews were conducted from different patients and doctors. Different questions were asked from the patients about the symptoms, severity of disease, time period of disease, source and quality of drinking water, exposure of disease etc. After collecting data about health effects, actual cause of health effect was identified on the bases of literature review that through which source and exposure pathway, heavy metals were exposed to humans. This survey was based on following table that shows the heavy metals, its occurrence, exposure pathway and health impacts of human health.

Table 1: Occurrence, exposure and health effects of Heavy metals

| Heavy Metals | Occurrence | Exposure | Health Effects |
|---|---|---|---|
| Selenium | Glass industry, Electronics industry, Plastics, Inks, Rubber, Paints, Pharmaceuticals [1]. | Ingestion of food and drinking water, skin contact with soil [1]. | Abdominal pain, Fever, Heart and muscle problems etc [1]. |
| Arsenic | Industrial Dusts, Medicines, Polluted Water [1-5]. | Ingestion of drinking water and food, skin contact with soil or water [1-5]. | Stomach and lung irritation, skin changes [1-5]. |
| Copper | Electronics, Coins, Household items [3]. | Inhalation, ingestion of food and water [3]. | Headaches, dizziness etc [3]. |
| Mercury | Coal-fired power plants, medical or municipal waste incinerators, fluorescent light bulbs, thermometers [1-6]. | Ingestion of water and food [1-6]. | Effects on lungs, kidney, skin, brain [1-6]. |
| Lead | Paint, Household Dust, **Water Pipes, Toys, Eyeliner and Lipstick, Soil, Vehicle Batteries [1-7].** | Ingestion of water, food [1-7]. | High blood pressure, Kidney and brain damage, Diminished learning abilities of children [1-7]. |
| Cadmium | Industrial Dust and Fumes, Polluted Water and Food, coal, mineral fertilizers [1-7]. | Inhalation, ingestion of food [1-7]. | Lungs Damage, Bone fracture, central nervous system Damage, Cancer [1-7]. |
| Chromium | Industrial Dust and Fumes, Contaminated Food [1,4,6-7]. | Inhalation, ingestion of food and drinking water, skin contact [1,4,6-7]. | Lung cancer, kidney and liver damage leads to cause of Death [1,4,6-7]. |
| Nickel | Industrial Dust and Aerosols [3,6-7]. | Inhalation, ingestion of drinking water and food, skin contact with water [3,6-7]. | Lung cancer, Nose cancer, Heart disorders [3,6-7]. |
| Lithium | Pottery industry, Medicines, Air conditioning systems [6]. | Inhalation, ingestion of medicines [6]. | Cough, sore throat, abdominal pain [6]. |
| Beryllium | Aerospace industries, X-ray windows [6]. | Ingestion of drinking water and food, inhalation [6]. | Lungs disease, heart problems [6]. |
| Barium | Spark plug electrodes, Medicine, Drilling muds, Paint, Bricks, Ceramics, Glass, Rubber [1,6]. | Inhalation, ingestion of drinking water [1,6]. | Stomach irritation, muscle weakness, kidney and heart damage[1,6]. |
| Silver | Jewelry, Electronic equipment, Dental fillings, Coins and medals, Medicines [1,7]. | Ingestion of medicines, eye contact, skin contact, inhalation [1,7]. | Brain damage, Kidney, Eye, Lung disease [1,7]. |
| Tin | Medicines, Industrial Dusts [3,7] | Ingestion of food, inhalation, skin contact [3,7]. | Eye and skin irritations, dizziness, Breathlessness, |

| | | | |
|---|---|---|---|
| | | | Headaches [3,7]. |
| Zinc | Rubber manufacture, Ceramic industry, Medicine, Food additive, Pigment, Coatings, wallpapers, plastics etc [6-9]. | Ingestion of water and food [6-9]. | Vomiting, Skin irritations, Decreased sense of taste and smell, Birth defects, Stomach cramps [6-9]. |
| Beryllium | Aerospace industries, X-ray windows [6]. | Ingestion of drinking water and food, inhalation [6]. | Lungs disease, heart problems [6]. |
| Barium | Spark plug electrodes, Medicine, Drilling muds, Paint, Bricks, Ceramics, Glass, Rubber [1,6]. | Inhalation, ingestion of drinking water [1,6]. | Stomach irritation, muscle weakness, kidney and heart damage[1,6]. |
| Silver | Jewelry, Electronic equipment, Dental fillings, Coins and medals, Medicines [1,7]. | Ingestion of medicines, eye contact, skin contact, inhalation [1,7]. | Brain damage, Kidney, Eye, Lung disease [1,7]. |
| Tin | Medicines, Industrial Dusts [3,7] | Ingestion of food, inhalation, skin contact [3,7]. | Eye and skin irritations, dizziness, Breathlessness, Headaches [3,7]. |
| Zinc | Rubber manufacture, Ceramic industry, Medicine, Food additive, Pigment, Coatings, wallpapers, plastics etc [6-9]. | Ingestion of water and food [6-9]. | Vomiting, Skin irritations, Decreased sense of taste and smell, Birth defects, Stomach cramps [6-9]. |
| Beryllium | Aerospace industries, X-ray windows [6]. | Ingestion of drinking water and food, inhalation [6]. | Lungs disease, heart problems [6]. |
| Barium | Spark plug electrodes, Medicine, Drilling muds, Paint, Bricks, Ceramics, Glass, Rubber [1,6]. | Inhalation, ingestion of drinking water [1,6]. | Stomach irritation, muscle weakness, kidney and heart damage[1,6]. |
| Silver | Jewelry, Electronic equipment, Dental fillings, Coins and medals, Medicines [1,7]. | Ingestion of medicines, eye contact, skin contact, inhalation [1,7]. | Brain damage, Kidney, Eye, Lung disease [1,7]. |
| Tin | Medicines, Industrial Dusts [3,7] | Ingestion of food, inhalation, skin contact [3,7]. | Eye and skin irritations, dizziness, Breathlessness, Headaches [3,7]. |
| Antimony | Batteries, Pocket calculators, Ceramics, Glass, Plastics [7]. | Inhalation, ingestion of drinking water and food [7]. | Irritation of the eyes, Skin, Lungs [7]. |
| Bismuth | Medicine, Synthetic fibers, Rubbers [7]. | Inhalation, ingestion of medicines, and skin contact [7]. | Skin problems and Depression [7]. |
| Cobalt | Petroleum industries, Chemical industries, Paints, Inks, Pottery, Jewelry [7]. | Inhalation, ingestion of drinking water and food, skin contact with soil or water [7]. | Vomiting, loss of vision, Heart issue, Thyroid damage, asthma [7]. |

| | | | |
|---|---|---|---|
| Gallium | Porcelain, Glass and Coal [7]. | Ingestion of water, fruits and vegetables [7]. | Throat irritation, breathing problems, chest pain [7]. |
| Germanium | Electronic devices, Camera lens [7]. | Inhalation [7]. | Negative impact on Skin, Eyes & Blood [7]. |
| Molybdenum | Microwave devices, petroleum industry, inks for circuit boards, pigments, electrodes [7]. | Ingestion of water and food [7]. | Joint pains in the knees, hands, feet [7]. |
| Iron | Food containers, Washing machines, Paper staples, Appliances [7,9]. | Inhalation [7,9]. | High risk of lung cancer [7,9]. |
| Yttrium | Color TVs, camera lenses [7]. | Inhalation [7]. | Negative impact on liver [7]. |
| Silicon | Glass, Cement, Ceramics, Semiconductor devices, Pottery, Computer chips [10]. | Inhalation, skin contact [10]. | Skin, eye and lungs irritation [10]. |
| Aluminum | Cans, Foils, Machines, Ceramics [11]. | Ingestion of food, inhalation, skin contact [11]. | Loss of memory, severe trembling, kidney problems |

*C. Data Analysis (Integration of Questionnaire Survey and unstructured interview):*

From unstructured interviews and questionnaire survey, data was collected but after collection how to analyze that data was a big issue because mostly in these types of studies impacts(symptoms) are identified by examining the occurrence of heavy metals in the source. After examining, if it is verified then the source connects towards the type of exposure, health effects from that exposure of heavy metals are identified. The whole scenario is also explained below in the line diagram.

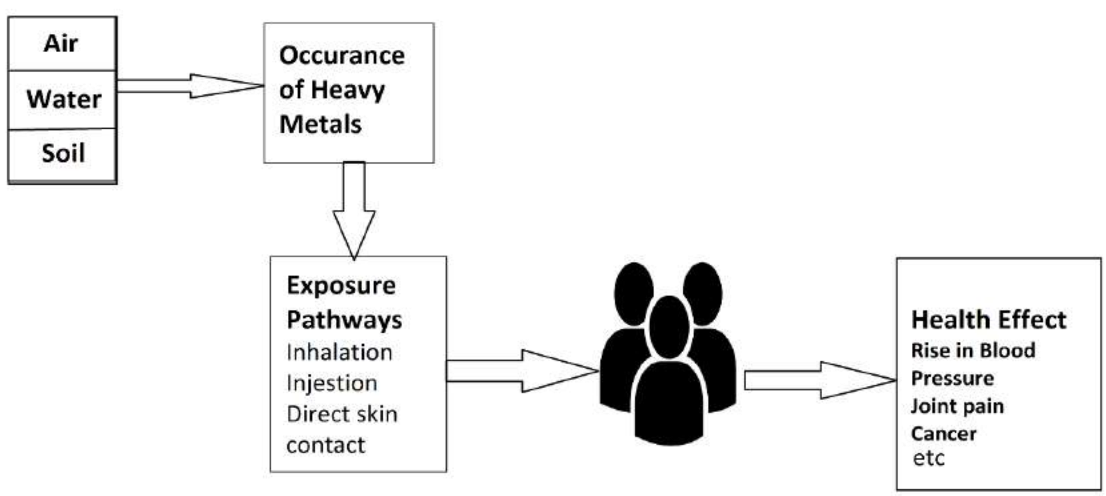


Fig.1: Impact identification diagram

Fig. 1 is a flow diagram in which impact identification is done by considering the above steps but in this research paper, the methodology of analyzing the data is the invert of above diagram.

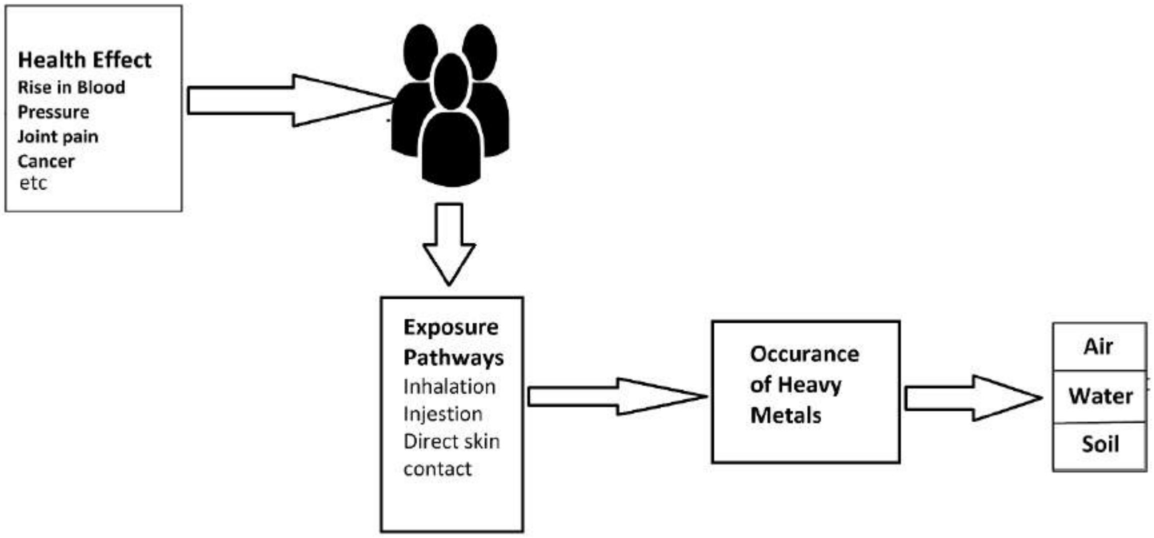


Fig.2: Heavy Metal and source identification diagram

Fig. 2 is the invert diagram of the above impact generation diagram. Heavy metal and source identification diagram explains the methodology of this work. In this diagram, the whole scenario is explained through which the exposure and sources are identified. Step one illustrates the different kind of health effects, the second step illustrates that how these impacts are occurred from different exposure pathways, step three is the identification of heavy metals that through which source, they are exposed to humans. In last step, the source, i.e. air, water and soil is identified.

## III. DISCUSSION

This research is focused on the identification of sources, exposure pathways and impacts of heavy metals on human health. According to the previous studies, heavy metals were assessed through quantitative determination and speciation analysis methods in order to detect the heavy metal concentration in different environmental samples, but methodology of this research is based on the unstructured interviews and questionnaire survey in order to collect and analyze the data about the sources and exposure pathways of heavy metals through signs symptoms of diseases. A case study of Civil Hospital Hyderabad was taken specifically in this research. While conducting the unstructured interviews from different patients, it was examined that there were two types of respondents (patients). The one type of respondents was unaware about the actual cause of their diseases. There was a girl, who was suffering from abdominal pain. She was also suffering from cough, headache, sweating, throat irritation and lung disease. The source of drinking water was groundwater, but she did not know about the contamination of water due to the existence of heavy metals in water. Main causes of her diseases were not identified, as she was unaware about the presence of heavy metals. The other type of patients was aware about the actual cause of their diseases. There was a boy, who was suffering from different diseases, such as lung irritation, kidney problem, skin irritation, breathing problems, stomach problem, vomiting and diarrhea. The source of drinking water was groundwater. They tested the water quality. It was found that the quality of water was poor due to the presence of high concentration of total dissolved solids (TDS), mercury and arsenic. After that interviews were conducted from patients and doctors through questionnaire survey and it was observed that through which sources and exposure pathways, they are exposed to heavy metals. It was also observed that heavy metal such as mercury present in groundwater caused the problem in lungs and kidney, however, these effects were also identified through different previous studies. Lead present in water damaged the kidney. Arsenic present in water caused stomach problems, lung irritation and skin diseases. Presence of selenium in water caused the abdominal pain. Lithium existence in the workplace caused sore throat, abdominal pain and cough. Beryllium present in the water caused the lungs and heart problems. Chromium exposure through inhalation and ingestion of drinking water and food caused the lung cancer, kidney and liver damage. Zinc exposure through ingestion of food and water caused the vomiting and skin irritations. Copper present in water and food caused the headaches and dizziness. Exposure of antimony through inhalation and ingestion of water and food caused the irritation in eyes, skin and lungs. Cobalt exposure through inhalation, ingestion of water and food and skin contact with water caused the vomiting and loss of vision. Gallium exposure through ingestion of water, fruits and vegetables caused the breathing problems and chest pain. These all health effects caused by different heavy metals were the basis of analysis of sources and exposure pathways through which they are exposed to it. In this research, analysis of data is based on the literature review.

## IV. CONCLUSION

Heavy metals are important components of the environment. Their presence is unique as it is challenging to eliminate them from the environment when they enter in it. Humans exposes to heavy metals through different pathways such as, ingestion, inhalation and skin contact. Humans are also exposed to heavy metals when they are living nearby any industry or working in any industry. Data was collected and analyzed through the unstructured interviews and questionnaire survey of patients and doctors. Different sources and exposure pathways of heavy metals was analyzed through which they are exposed to humans. This research is based on the literature review.

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# Comparision of Surface Drip Irrigation and Raised Bed Irrigation for Onion Productivity

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***Abstract*: A research work was carried out to determine the onion productivity with the surface drip irrigation system and the raised bed irrigation system. The experimentations were carried out at a farmer's field in Tando Muhammad Khan. The total area of the field covering the experiment was 1000 $m^2$ and it was divided into two equal portions where both the irrigation systems were installed. The soil available at the experimental site was sandy loam. The field capacity and permanent wilting point of soil were calculated to be 26% and 12% respectively. The average bulk density of the soil for 0-90 cm depth was 1.31 $g/cm^3$. The PH value of the soil was determined to be 7.15. The results of the research suggests that the surface drip irrigation system saved 45.65% of water and gave 21.20% more yield when compared to raised bed irrigation system. Thus, it is suggested for the farmers to adopt the surface drip irrigation system for better results.**

***Keywords*: Surface drip irrigation, Raised bed irrigation, Water use efficiency, Yield.**

## I. INTRODUCTION

Onion is one of the most important sustenance widely consumed in Pakistan. It is a significant food crop of the country, and is grown in all four provinces of Pakistan. The Onion crop is cultivated in Rabi season in Pakistan. The Sindh province being the major producer of the onion crop contributes almost 40.9% to the total production of onion in Pakistan with Hyderabad, Tando Muhammad Khan and Sanghar being the major districts contributing towards its high yield [1]. It is due to the fertile soil (ph 6-7), optimum temperature (20-25°C) and favorable topography; the yield of onion is higher in Sindh. In planting of onions different methods are implied with transplanting method being preferred more. The onions are initially sowed in seedbed and later the plants are transferred to the field. The nursery for onion crop is put up in the month of July and from then onwards the seedlings are conveyed to the field in August for harvesting of bulb to take place later in the month of December. [2] Onions have shallow root system and it is important that proper moisture content is maintained for the growth of roots. [3] The onion crop along with other food crops majorly depend upon the availability of irrigation water. As agricultural production and high crop yield is sought essential for food security, the government is encouraging farmers to seek alternatives to increase the productivity of crops and net return per unit of water is used by implementing modern farming practices like Surface drip irrigation system and Raised bed irrigation system.

The efficiency of the surface drip irrigation system and raised bed irrigation systems is being evaluated with respect to the consumption of water and production of crops. New innovations are being introduced into agriculture fields of Pakistan as the farming systems that are more sustainable environmentally, economically, and socially are being preferred. Modern day irrigation systems like drip and raised bed irrigation systems are being adopted by the farmers. [4] Farmers that continue to use traditional irrigation methods may get benefit by using these irrigation methods that may save their water consumption and give more yields for crop production. The selection of proper irrigation method will prove to be advantageous to manage the water supplies and increase the crop production.

The Surface drip irrigation method provides significant advantages over the raised bed irrigation which mainly comprises of high water use efficiency and high crop yield. [5] Drip irrigation also has other major advantages like high fertilizer use efficiency, reduced labor expenses and high water savings. [6] The drip irrigation system can be utilized to grow onion larger in size and more premium in quality, which can be stored later for longer period of time. [7] Onion yield and grade is however sensitive to soil water content, which is measured as soil water tention (SWT). In the semi arid region, the ideal SWT the drip irrigate onion is near to 20 centibars (cb). [8] Considering the ideal conditions available, onions grow well under the drip irrigation system and saves costs of the farmers in long term.

The research work of onion productivity under surface drip irrigation system and raised bed irrigation system was carried out in Tando Muhammad khan farmer's field. The prime objective of this research was to study the water use efficiency, yield productivity of onion and water saving of surface drip irrigation system and raised bed irrigation system.

## II. METHODOLOGY

This section presents the systematic approach followed to compare the efficiency of the two irrigation systems for the productivity of onions.

### *A. Site Investigations*

The site investigations were conducted at a farmer's field in Tando Muhammad Khan, Sindh, Pakistan (latitude 25°7'8.59"N, longitude 68°32'11.9"E, and altitude 18.99m + MSL). The onion (the local phulkara variety from Sindh) was initially seeded in the seedbed of the site plots and the temperature at the time of sowing was measured to be 20-25˚C. The Phuleli canal was the main source of water reservoir for irrigation in this research. The local climate of the site was arid and humid, accounting for average annual rainfall of 120 mm.

The soil available at the site was tested to be sandy loam. The physical and chemical characteristics of the soil of experimental plot were evaluated prior to the experiments. The field capacity $(Ufc)$ and permanent wilting point $(Uwp)$ of the soil were determined as 26% and 12%, respectively. The onion crop usually takes 210–230 days to mature in Sindh and it is suited to the prevailing climate in Rabi. The experiments were carried out from 1st July 2016 to 30 February 2017.

### *B. Layout of site*

The experimental area of the plot was 1000 m². It was further divided into two plots 20 m × 25 m area for surface drip irrigation system and 20 m × 25 m area for raised bed irrigation system. The soil at site was ploughed to a depth from 15 cm to 20 cm. And the seedbed was leveled with the help of planking. The onions were transferred to the plot at plant to plant spacing of 10 cm and were set apart at 25 cm apart in rows. For the experiment, shallow cultivation was adopted to protect the onion crops from weeds. The experimental designs of the surface drip irrigation system and raised bed irrigation system at the site have been shown in figure 1 and 2.


Figure 1 Surface Drip Irrigation

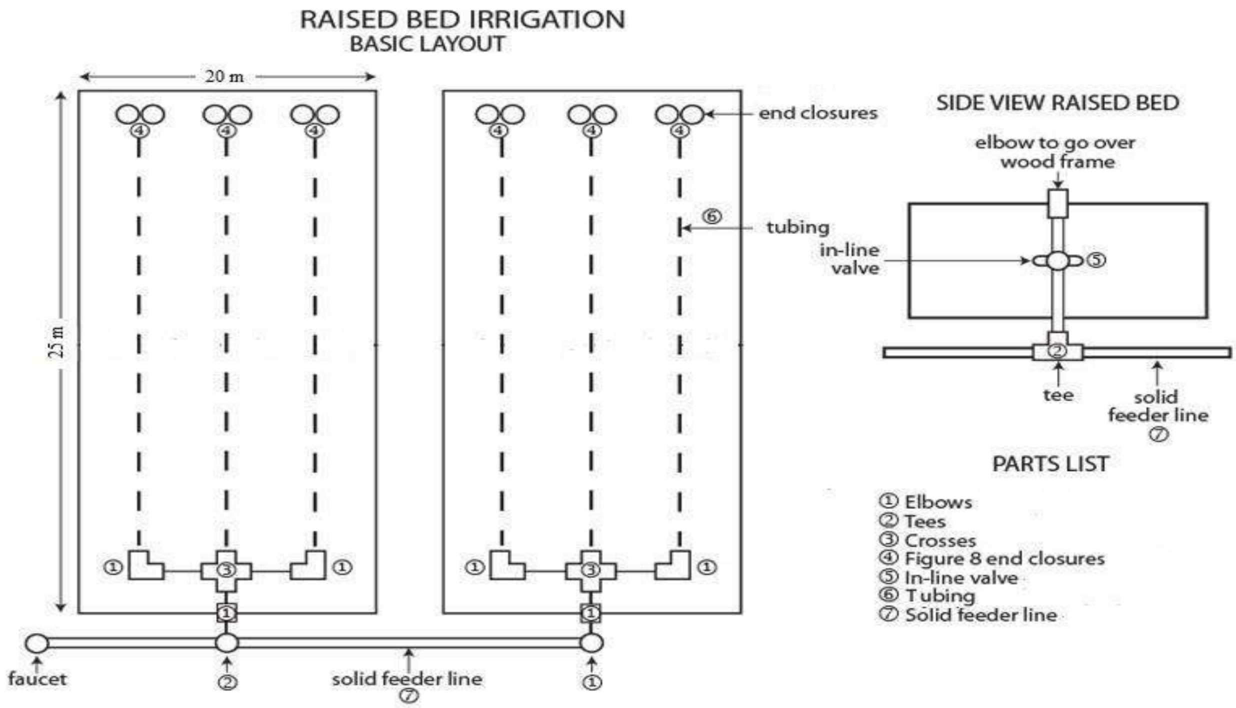


Figure 2 Raised Bed Irrigation

### C. *Land Preparation*

The experimental site was prepared conventially. The land was ploughed with two-wheel power tiller followed by rotavator. After ploughing the site was then leveled.

### D. *Installation of Surface Drip Irrigation System*

The surface drip irrigation system was preinstalled at the site in the farmer's field. The system comprised of 120mm pipe mainline connected to the 70 mm PVC sub-main line pipe, which was affixed to Turbo Type lateral line having discharge of 0.005m³/hr. In total 30 laterals were set on the ground surface along with 100 emitters with the length of line of plants being 30 m. The Media filters were installed in pairs with diameter of 14 inches.

### E. *Performance of Surface Drip irrigation system*

The performance of the surface drip irrigation system was determined by calculating the coefficient of variation and the emission uniformity. The containers were set under the emitters to collect the flowing water. The graduated cylinders were used to measure the collected water with respect to time.

### F. *Coefficient of Variation Value*

The coefficient of variation is used to determine the flow rate uniformity of the emitters. It is the ratio of the standard deviation and the mean flow rate. The following formula was used for calculating the value of coefficient of variation.

$$Cv = \frac{\sigma}{p\ (avg)} \times 100$$

Where;
Cv = Coefficient of Variation Value
σ = Standard of Deviation
q = Average Flow rate

### G. *Emission Uniformity (EU) of Flow*

The emission uniformity of flow is calculated as a percentage, and it is the relative index of the variability between emitters installed in an irrigation block. It was used to predict the variation of emitter fole along a lateral line. The emission uniformity was calculated by using the following formula:

$$EU = 100 - [1.0 - 1.27 \frac{Cv}{n^{\frac{1}{2}}}] \frac{qm}{qa}$$

Where;
EU = Emission Uniformity
Cv = Coefficient of variation
N = Number of emitters installed
qa = average flow
qm = minimum flow

*H. Preparation of Raised Bed irrigation system*

Raised bed was constructed on a level site and soil of the site was tilled. Raised Bed irrigation system was made by creating flap-topped mounds 8 inches high. The beds were formed 1 day before transferring the plots according to the layout of the experiment.

*I. Soil Collection*

The soil samples were obtained after the preparation of plot. The soil samples were collected at the depth of 0 cm to 90 cm. The soil samples were collected for the determination of the physical and chemical characteristics of the soil.

*J. Dry Bulk Density of Soil*

The Bulk density is the weight of soil sample in a given volume. In order to determine the dry bulk density for the research work, soil samples of 15 cm diameter were collected from the plots of the experimental field with the use of core sampler. The samples were brought to Mehran university geotechnical laboratory and the samples were placed in oven for 24 hours. The weight of each sample was the weighed with the help of electric balance. The formula used for calculating dry bulk density was as follows:

$$\text{Dry Bulk Density} = \frac{Dry\ weight\ of\ soil}{Total\ volume\ of\ soil}$$

*K. Field Capacity of Soil*

The soil samples obtained from the field were measured with respect to their field capacity. It was determined by using the Hendricksen method.

*L. Water Samples*

Water used for the irrigation was tested with respect to its quality. Five water samples were obtained at different intervals of the irrigation from start to the end. These samples were analyzed for water salinity (ECw), potential of hydrogen (PH), Residual sodium carbonate index (RSC) and Sodium Absorption ratio (SAR).

*M. Transplanting of seedlings*

The seedlings were uprooted from the seedbed and then transferred on the same day. The seedlings were transplanted at row spacing of 30 cm and crop top crop spacing of 20 cm.

*N. Water Application*

Phuleli canal was the main source of irrigation in this research work. In order to maintain the moisture content in top few inches of the soil, the water was applied immediately after sowing and transplanting. The water was discharged at the rate of 0.005$m^3$/hr in surface drip irrigation system through the emitters. Onions were irrigated after 10 days intervals. The flow of water was determined by using the flow meter installed in the sub-main. Also in the raised bed irrigation system the flow of water was measured by using the flow meter. Irrigation was discontinued before the neck fall for the ripening off of bulbs.

*O. Fertilizer Application*

The fertilizers applied during the research work were as follows:

(1) 35-45 kg/ac Nitrogen (N)
(2) 20-30 kg/ac Potassium (K)
(3) 45-60 kg/ac Phosphorous (P)

The fertilizers were applied at the time of final land preparation.

*P. Crop Harvesting*

Harvesting of the onion crop was carried out by using the pedal tresher.

*Q. Water Saving (%)*

In order to compare the water saving in the drip irrigation system and the raised bed irrigation system, the following formula was used:

$$\mathrm{WS}(\%) = \frac{(Wr - Wd)}{Wr} \times 100$$

Where;
WS = Water Saving %
Wr = Water used in the raised bed irrigation system ($m^3$/ha)
Wd = Water used in the surface drip irrigation system ($m^3$/ha)

*R. Yield of crop (%)*

The yield of the onion crop was determined for each surface drip and raised bed irrigated plot. The yield was calculated by using the following formula:

$$\mathrm{Yield}(\%) = \frac{(Yd - Yr)}{Yd} \times 100$$

Where;
Yd = Yield obtained in the surface drip irrigation system (kg/ha)
Yr = Yield obtained in the raised bed irrigation system (kg/ha)

*S. Water Use Efficiency*

The efficiency of the usage of water for the surface drip and raised bed irrigation system was calculated by using the following formula:

$$\mathrm{WUE} = \frac{\mathrm{Y}}{Wc}$$

Where;
WUE = Water Use Efficiency (Kg/$m^3$)
Y = Yield of the onion crop (Kg/hec)
WC = Water consumed for onion crop production ($m^3$/hec)

## III. RESULTS AND DISCUSSION

### A. *Soil properties*

The physical and chemical soil characteristics of the soil samples are demonstrated in Table 1 and 2. From table 1 it can be observed that dry bulk density of soil of soil varies at different depth intervals. The average dry bulk density of soil is 1.30 (gm/cm²). Table 2 indicates that the PH value of soil is 7.15 which is desirable for the production of onion crop. The electrical resistivity of soil is 1.20.

Table 1 Physical property of the soil layer at various depths

| Depth(cm) | Particle size distribution (%) | | | Bulk density (gm/cm$^3$) |
|---|---|---|---|---|
| | Sand | Silt | Clay | |
| 0–15 | 52.8 | 26.2 | 22.4 | 1.24 |
| 15–30 | 55.6 | 25.7 | 18.1 | 1.31 |
| 30–45 | 57.8 | 25.2 | 19.5 | 1.33 |
| 45–60 | 56.2 | 23.6 | 24.6 | 1.32 |
| 60–90 | 54.5 | 20.8 | 25.2 | 1.38 |

Table 2 Chemical Properties of the soil layer at various depths

| S. no. | Parameter | Value |
|---|---|---|
| 1 | Ph | 7.20 |
| 2 | ECa (mMHO) | 1.15 |
| 3 | Nitrogen | 1.90% |
| 4 | Phosphorus | 1.20% |
| 5 | Potassium | 0.90% |

### B. *Performance of surface drip irrigation*

The performance of the drip irrigation system was evaluated by determining the coefficients of variation and emission uniformity of the laterals. The results are tabulated in Table 3. From the results it was observed that the performance of drip irrigation was satisfactory.

Table 3 Performance of Drip Irrigation

| Lateral No. | Minimum Discharge qm (lit/hr) | Average Discharge qav (lit/hr) | $\sum$ (qm – qav)$^2$ | Standard Deviation σ | Coefficient of variation (Cv) | Emission Uniformity (EU) |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 4.04 | 4.16 | 0.0144 | 0.012 | 0.288 | 93.56 |
| 10 | 4.02 | 4.13 | 0.0121 | 0.011 | 0.266 | 94.04 |
| 20 | 4.03 | 4.13 | 0.0100 | 0.010 | 0.242 | 94.58 |
| 30 | 4.04 | 4.15 | 0.0121 | 0.011 | 0.265 | 94.07 |
| 40 | 4.03 | 4.14 | 0.0121 | 0.011 | 0.266 | 94.05 |
| 50 | 4.02 | 4.16 | 0.0144 | 0.012 | 0.288 | 93.10 |

### *C. Performance of surface drip irrigation*

In order to evaluate the performance of the drip irrigation system the coefficients of variation and emission uniformity of the laterals were determined and tabulated in Table 3. From the results it was observed that the performance of drip irrigation was satisfactory.

### *D. Water Characteristics*

To measure the quality of irrigation water utilized in surface drip and raised bed irrigation systems, five water samples were obtained at regular intervals from the start point to the end point during the research work. The results of the samples are mentioned in Table 4. It can be observed from the results that the water used for the research work was appropriate for irrigation.

Table 4 Irrigation water quality

| Sample # | ECw (mmhos/cm) | PH | SAR | RSC |
|---|---|---|---|---|
| 1 | 590 | 7.7 | 2.0 | 0.0 |
| 2 | 580 | 7.7 | 2.2 | 0.0 |
| 3 | 560 | 7.7 | 2.0 | 0.0 |
| 4 | 530 | 7.7 | 2.1 | 0.0 |
| 5 | 510 | 7.7 | 2.2 | 0.0 |

### *E. Irrigation Water Applied*

The total volume of irrigation water used for the growing of crop under drip irrigation was 2280.85 $m^3$/hec. Likewise the total volume of water used for the growing of crop under raised bed irrigation was 4120 $m^3$/hec. The results indicated in figure 3 suggest that the total volume of water applied under drip irrigation was less as compared to raised bed irrigation system.

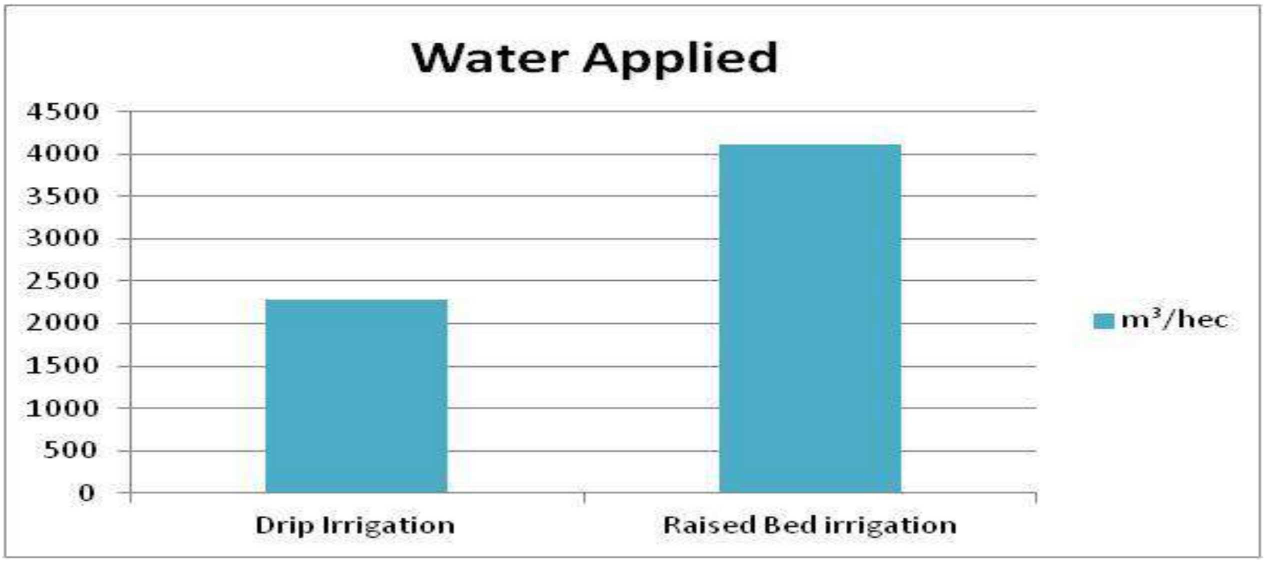


**FIGURE 3. RESULTS OF IRRIGATION WATER APPLIED**

*F. Crop Yield*

The yield of onion crop under the surface drip and raised bed irrigation system are calculated and it is plotted in figure 4. The total yield of onion crop under the surface drip irrigation was determined to be 12128 kg/hec. Correspondingly, the total yield of onion crop under raised bed irrigation system was measured to be 9560 kg/hec. It can be observed from the results that the total yield of onion crop under surface drip irrigation system was more as compared to raised bed irrigation system.

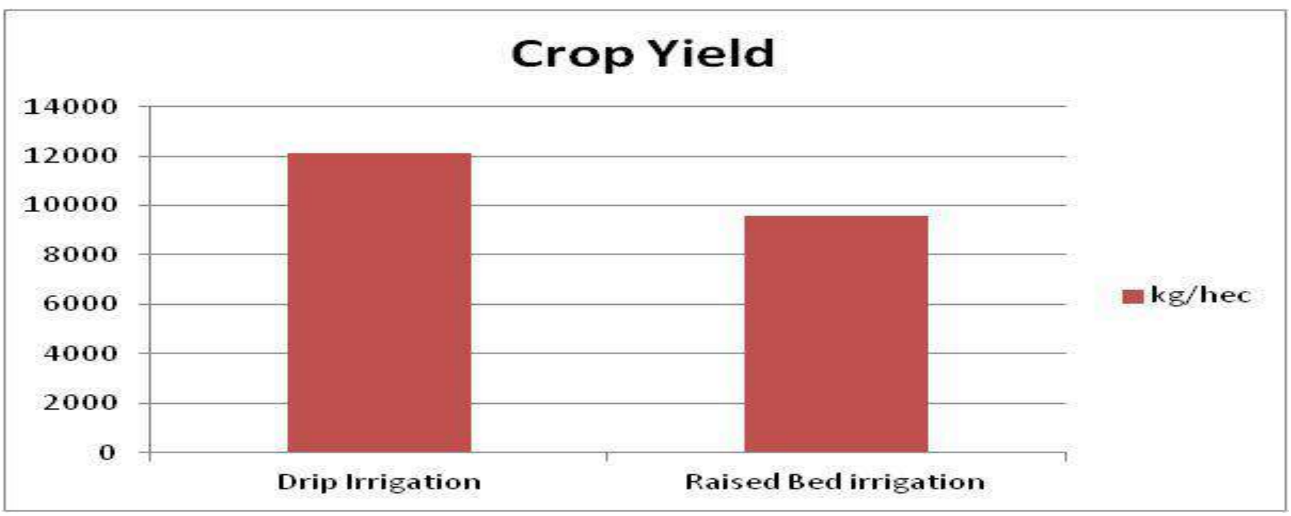


**FIGURE 4. CROP YIELD**

*G. Water saving*

It was observed from the results that the water saving under the surface drip irrigation system was 45.65 % while under the raised bed irrigation system was 21.20 %.

*H. Water use efficiency*

It was observed from the results that the water use efficiency of the surface drip irrigation system was about 5.31 kg/m³ and the water use efficiency of the raised bed irrigation system was about 2.32 kg/m³. The results are plotted in figure 5.

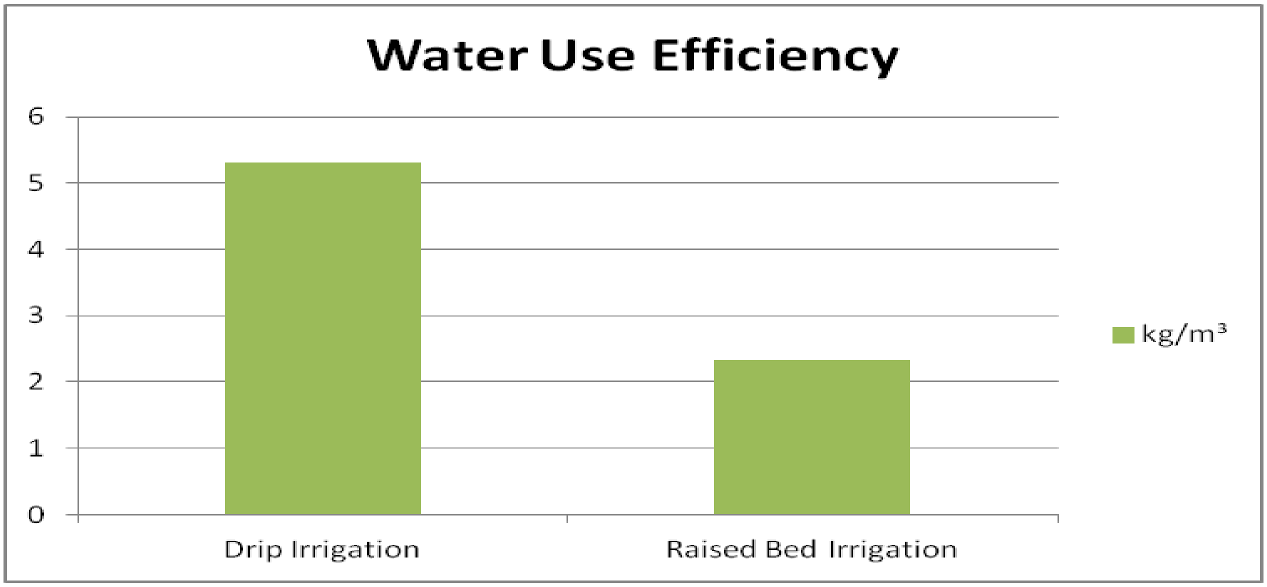


**FIGURE 5. WATER USE EFFICIENCY**

## IV. CONCLUSION

In this research it can be observed that the production of onion was ideal under the surface drip irrigation system as compared to the raised bed irrigation system. As per the results, the surface drip irrigation system saved 45.65% and gave 21.20 % more yield as compared to that of raised bed irrigation system. Also, the surface drip irrigation method resulted in high water use efficiency about 5.31 kg/m³; whereas raised bed irrigation resulted in low water use efficiency of about 2.32 kg/m³. Thus, it can be concluded that the surface drip irrigation method for the production of onion is more efficient and yielding when correlated to raised bed irrigation system.

## V. SUGGESTIONS

In the recent years, the surface drip irrigation system has gained significant recognition as a result of water efficiency and better yield of crops. The raised bed irrigation system proves to be less effective when compared to the surface drip irrigation system in terms of water saving and water use efficiency. Through this research it is suggested to the farmers to adopt the surface drip irrigation system as it will prove to be more economical in long term. And it will save more water and yield better results of crops for the farmers of Pakistan.

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# Study of Ageing Characteristics of SBR Modified Bitumen

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***Abstract:*** **This study investigates to assess the conventional properties of bitumen concrete mixture from the effect of bitumen modifier. In this study conventional asphalt bitumen of penetration grade 60-70 was used, modified with Styrene Butadiene Rubber (SBR) at various modification levels i-e 1 % - 5 %. More durable asphalt Concrete mixtures with better serviceability are obtained by using 3% SBR. Laboratory tests are performed on neat and modified bitumen by testing various percentages of SBR and the results are then determined. By using SBR enhanced physical properties namely increased softening and ductility values and reduced penetration values are observed. In this study effect on physical properties in terms of softening point test, penetration test, and ductility test before ageing and after ageing are also measured. The binders are aged using Thin Film Oven Test (TFOT) by short term ageing. The results shows that after ageing softening point, ductility increases and penetration decreases with increasing percentage. The mixtures modified with SBR polymer showed permanent deformation characteristics and improved stability under ageing conditions from the experimental results. The use of SBR exhibits betterment in texture of surface as compared to conventional pavements using bitumen which eventually enhances the safety of roads.**

***Keywords*:** **Ageing, Ductility, Penetration, SBR, Softening Point.**

## I. I.INTRODUCTION

Bitumen is known as one of ancient road material[1] . From hundreds of years it has been used in particular styles, e.g. as sealant, preservative, adhesive, waterproofing agent and pavement binder. The neat bitumen which is usually in the earth's surface is directly used by the earliest people [2]. In many countries, development is rapidly increasing due to which higher traffic volume, traffic load has been increased and maintenance is inadequate which gave rise to severe distresses (e.g. fatigue, cracking and rutting) of road surfaces. Therefore, efforts are needed to investigate bitumen modification. The most popular approach to modify bitumen is polymer as compared to other modification method of bitumen. Styrene-Butadiene Rubber (SBR) is a co-polymer of rubber which was produced in Germany by I. G. Farbenindustrie in the 1930's. SBR, a type of elastomer is the most important sort of synthetic rubber. It is one of the most commonly used copolymers in the asphalt industry. As a result of its outstanding stability and abrasion resistance, it is widely used as a part in the making of car tires and that is why this rubber is most important for the rubber industry [3].SBR liquid is used in both cold and hot modified binders. It is also mostly used in cold applied binders for bond coats, seals, micro-surfacing and crack sealants. For seals hot modification of bitumen with SBR is most commonly used and also to a lesser extent in asphalt. Improved flexibility and elasticity are being provided to the seals cracks, binder and prevents water ingress into the pavement. In hot mix asphalt applications, they enhance fatigue properties, reduce the deformation resistance, and retard crack reflection [4].SBR has been broadly utilize as modifier in bitumen [5][6] had carried out research in SBR polymer and discovered that the by using SBR the bituminous pavement will resist cracking at high temperature. Some of the significant roles of SBR in asphalt binder include raising the ductility of binder, improving its elastic recovery, decreasing viscosity and enhance its ageing by reducing the rate of oxidation. The increase in ductility due to SBR polymer makes the pavement more crack resistant and flexible at reduced temperatures [6]. SBR has been seen as one of the most efficient modifiers for paving asphalt pavement among the other asphalt modifiers. The benefit of using SBR in the modification of binder is that it has excellent stability on aging and reduces the changes in the properties of binder like stiffness because of ageing. One of the best significant aspects of SBR in asphalt binder is raising its ductility, improving elastic recovery, decreasing viscosity and also helps the ageing by reducing the rate of oxidation. The ageing of bituminous binders is the major point in finding out the endurance of the pavement made from asphalt. The method of ageing includes chemical and physical alterations in properties which commonly causes the bitumen material to be brittle and hard, hence the possibility of pavement breakdown increases. Ageing-related modes of deterioration in pavements comprise of cracking (thermal or traffic induced) and raveling. Increase in ageing of the binder occurs due to cracks on the surface of pavement due to greater area of exposure to climatic oxygen. Mainly, bitumen aging occurs in two steps that is short term ageing at increased temperature while blending of asphalt, storage and laying, and long-term ageing at surrounding temperature. Thin Film Oven Test TFOT test reasonably simulates ageing particularly during mixing process in an asphalt mixing plant in short-term ageing at increased temperature. Ideally, a laboratory analysis should be capable of predicting changes in physical and chemical characteristics of the bitumen which would happen after some years on asphalt pavement. This can be obtained by performing an aging test on fake extreme conditions, e.g. at pressures more than ambient pressure and at temperatures more than pavement service temperature. Characterization of binders was performed using conventional tests (penetration, softening point, ductility).

## II. MATERIALS & METHODS

Penetration Bitumen of grade 60/70 is used. This grade bitumen is widely used in Pakistan and other countries. By using blending techniques some samples are prepared. About 500gm of bitumen was heated in oven till liquid condition was obtained while maintaining these conditions:

- SBR was moderately added that is 1-5%
- Speed of the mixer was sustained at 2000 rpm
- Temperature was maintained within 163°C.

The proportions of SBR that were used are 1 %, 2 %, 3 %, 4 % and 5 % by weight of the blend. For producing a homogenous mixture the mixing was continuously blended for 1 hour. These tests will be performed on the prepared samples: penetration, softening point, ductility.

### A. *Penetration Test*

This test examines the density of a sample of asphalt binder by calculating the distance which s in tenths of a millimeter.

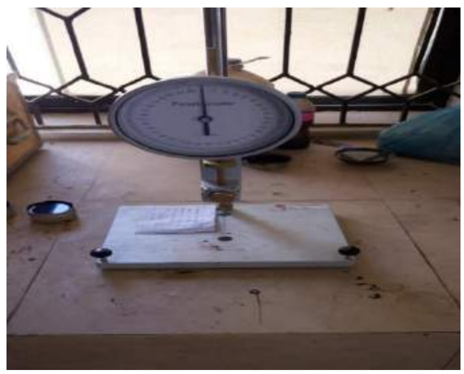

Fig 1: Shows the apparatus for penetration test.

### B. *Softening Point Test*

The average of the temperatures at which the asphalt binder disks melt and slag downwards covering an area of 25mm under the weight of a steel ball is known as the softening point.

Fig 2: Displays the apparatus for Softening Point

*C. Ductility Test*

*A. When tension is applied to a material it breaks, the property of a material that elongates before breaking when tension is applied to it is called ductility.*

## III. RESULTS

In this section the outcomes of the tests conducted on the bitumen modified with SBR additive are discussed. The results of each test have been presented and shown in the form of tables or graph to simplify it and make it uncomplicated for the analyzing process. There are four different types of tests implemented in this study i.e. softening point test, penetration test, ductility test, and the short-term aging test using TFOT.

### A. *Penetration Test Results*

Penetration measures the bitumen consistency. The penetration's depth is calculated in 0.1 mm units and recorded in units of penetration (e.g. if penetration of the needle is 8 mm, then penetration number of asphalts is 80). The penetration test is done by Penetration Grading. The results of penetration are shown in Table I of neat bitumen and modified bitumen.

Table I: Penetration results for modified and neat bitumen 60-70

| **Aging Hours** | **Penetration Test Results** | | | | | |
|---|---|---|---|---|---|---|
| | **% SBR by weight** | | | | | |
| | **0** | **1** | **2** | **3** | **4** | **5** |
| **0** | 66 | 61.8 | 51.7 | 49 | 48.5 | 48 |
| **1** | 60 | 58.8 | 49 | 48 | 47 | 46 |
| **2** | 57 | 54 | 46 | 45 | 46.5 | 45 |
| **3** | 55 | 51 | 45 | 43 | 45 | 45 |

Fig 3 shows the penetration results after the effect of SBR concentration. As the amount of SBR increases up to 3% the penetration decreases. This clarifies that there is a considerable change on penetration value after adding SBR. From the figure it can be showed that as the quantity of SBR increases from 1 % to 5 % the penetration number reduces from 66 to 43 slowly. This proves that SBR has a good impact on decreasing the value of penetration by rising the rigidity of SBR binder, thus, it makes the binder less affected and in conclusion lead to resistance to deformation like rutting but on the other hand it can affect the resistance to fatigue cracking.

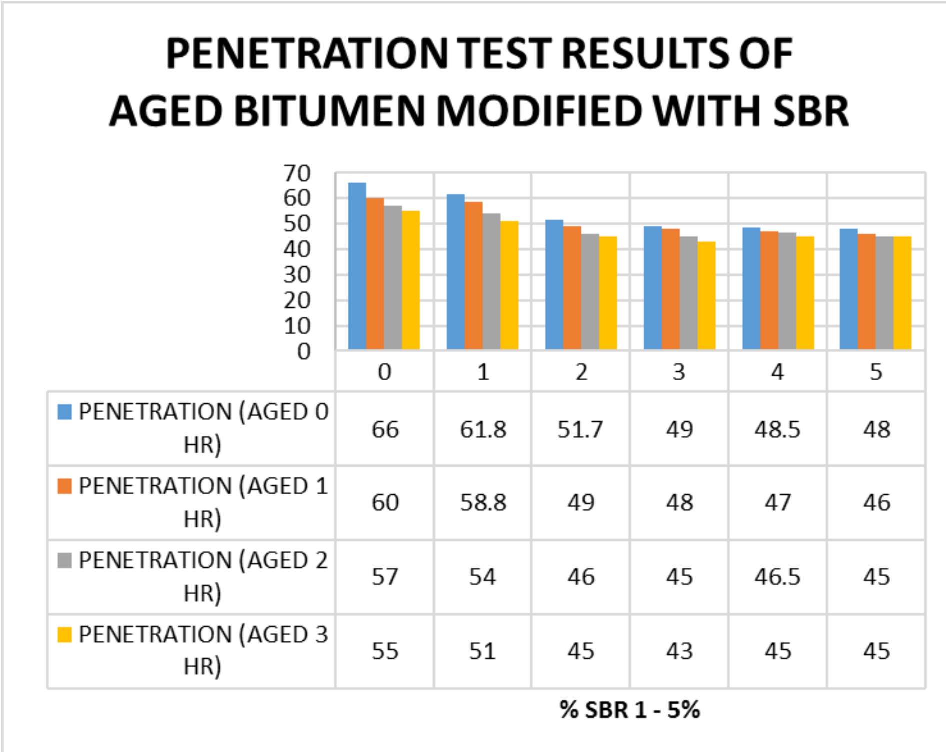


Fig 3: Penetration test results for modified and neat bitumen 60-70

### B. *B. Softening Point Test Results*

The softening point is explained as the temperature whereupon the heaviness of a 3.5-g steel ball can no longer be supported by the sample of bitumen. Firstly, two disks of bitumen are heated that are casted in shouldered brass rings at a regulated temperature in a liquid bath. These rings support the steel balls. The softening point is described as the average of two temperatures where the two disks get soft sufficiently to allow each ball that is covered in bitumen, to fall apart at a distance of 25 mm. The softening point values of modified and neat bitumen are shown in Table II.

Table II: Softening Point results for modified and neat bitumen grade 60-70

| **AGING HOURS** | **SOFTENING TEST RESULTS** | | | | | |
|---|---|---|---|---|---|---|
| | **% SBR by weight** | | | | | |
| | **0** | **1** | **2** | **3** | **4** | **5** |
| **0** | 45 | 47 | 49 | 53 | 53.5 | 53.5 |
| 1 | 45.5 | 48 | 49.5 | 53.5 | 54 | 54.5 |
| 2 | 46 | 48.5 | 50.5 | 54 | 54.5 | 55 |
| **3** | 47 | 49 | 51 | 56 | 55.5 | 55.5 |

Fig 4 shows evidently that the increase in the percentage of SBR, there is an increase in the softening point. For bitumen 60-70 penetration grade, it is observed that when 1% SBR content is added to the weight of bitumen, softening point is 47ºC, whereas when 3% SBR is combined with the weight of bitumen, softening point temperature reaches to 56ºC which as compared to the neat bitumen 45ºC. Based on the chart of softening point it can be seen that as the softening point increases there is minimization of susceptibility at increased temperature. This procedure indicates that resistance of the binder by the effect of heat is raised and it will minimize its tendency to soften in hot weather. Thus, with the addition of SBR, the modified binder will be less susceptible to temperature changes. Therefore it is expected that by using SBR in the bituminous mix, the rate of rutting will decrease due to the increase in softening point.

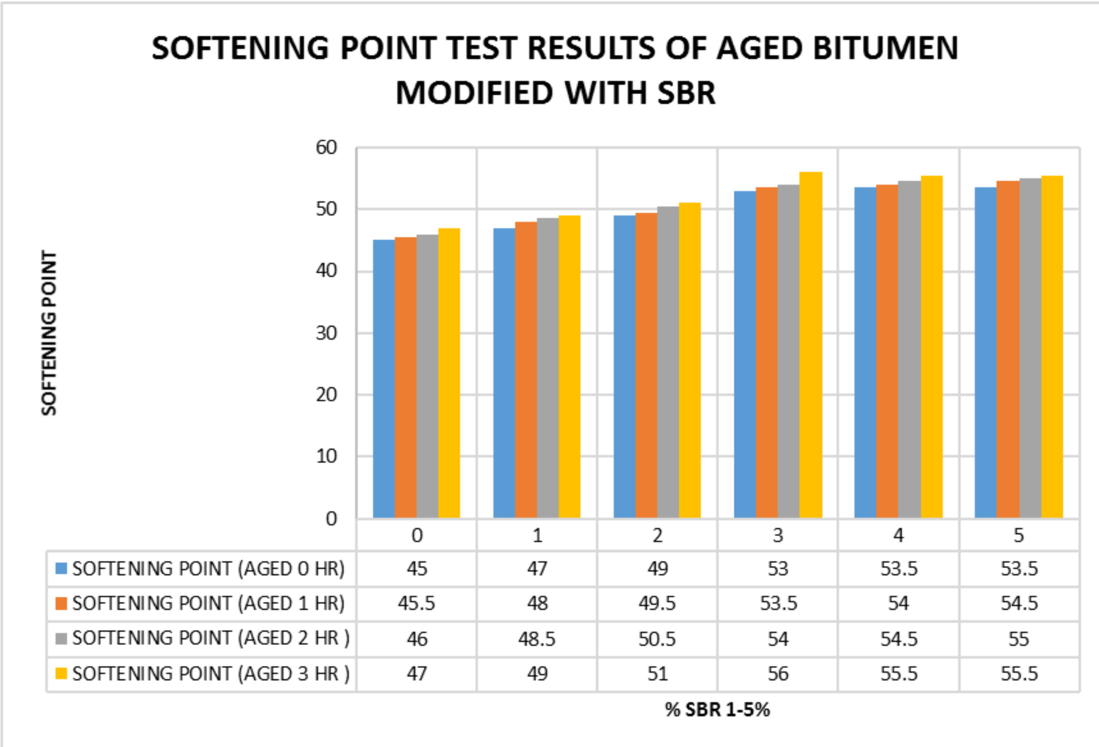


Fig 4: Softening Point test results for modified and neat bitumen grade 60-70

### *C. C. Ductility Test Results*

The effects of SBR concentration on ductility value of the 60/70 grade type bitumen are studied and found that the ductility values are significantly increasing.

Table III: Ductility Test Results for modified and neat bitumen

| **AGING HOURS** | **DUCTILITY TEST** | | | | | |
|---|---|---|---|---|---|---|
| | **% SBR by weight** | | | | | |
| | **0** | **1** | **2** | **3** | **4** | **5** |
| **0** | 140 | 140 | 140 | 140 | 140 | 140 |
| **1** | 138 | 140 | 140 | 140 | 140 | 140 |
| **2** | 135 | 139 | 140 | 140 | 140 | 140 |
| **3** | 134 | 136 | 139 | 140 | 140 | 140 |

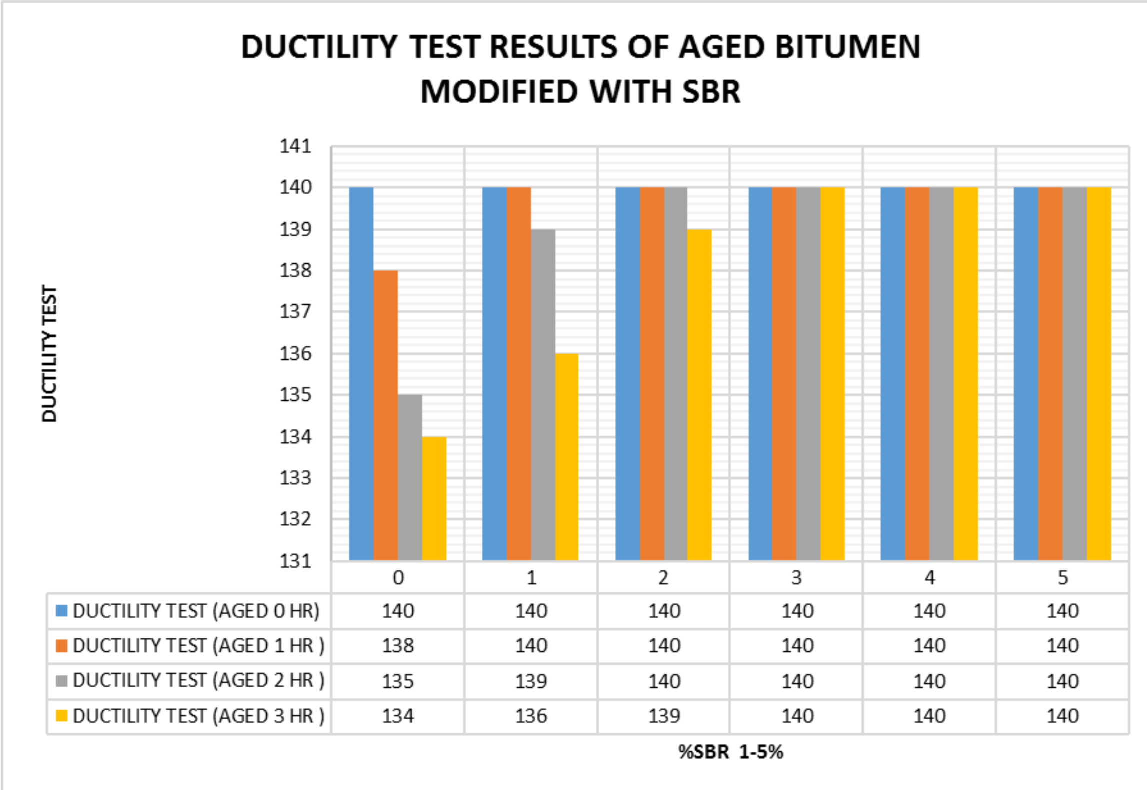


Fig 5: Ductility Test Results for modified and neat bitumen grade 60-70

## IV. CONCLUSION

The results show that the additive content has an obvious effect on the temperature susceptibility. When the SBR content increases from 1% to 5%, it decreases the penetration grade and thereby increases the softening point of bitumen. SBR modified bitumen exhibit less temperature susceptibility compared to base bitumen with increasing SBR content, especially of 3%. With the increase in SBR content, the softening points of the SBR modified bitumen samples increase, which imply that the properties of bitumen would be improved by SBR to some extent. When the content of SBR is fixed at 3%, the SBR modified bitumen shows the highest softening point of 53.0ºC. For the different SBR contents studied, 3% leads to the highest value of the ductility. Therefore, it is concluded from the laboratory test results of bitumen grade 60/70, 3% SBR is suggested for 60/70 bitumen grade. Such percentage also showed better performance by offering better fatigue resistance and permanent deformation better than conventional bitumen grades.

## *V. RECOMMENDATIONS*

1. In the country like Pakistan, especially in the province of Sindh, due to heavy vehicles and because of hot climate the problem of rutting can be solved if 3% SBR is used which in this study is found to be the optimum percentage for modification of bitumen.
2. To study another addition material which can be mixed with the SBR modified bitumen.
3. The optimum percentage of SBR additive found to be 3% in this study. Due to that is recommended to not use percentage higher that 3% by weight of the binder.
4. Furthermore, 3% of SBR is an appropriate content of SBR modified bitumen; otherwise the industrial production cost will be high.

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# Effect of Gradation on Moisture Susceptibility of Asphalt Paving Mixtures

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***Abstract*: Moisture Damage is one of the chief reasons of premature failures in asphalt pavements. It majorly depends on the gradation of aggregate used in the mix. This study was carried out to evaluate the effect of gradation on moisture susceptibility of asphalt paving mixes. Three kinds of aggregate gradations namely NHA-B (lower), SP-2 (middle) and MS-2 (upper) were used along with two types of asphalt binders of grade 60/70 from different refineries. Modified Lottman Test (AASHTO T-283) was conducted on unconditioned and conditioned samples to find the Tensile Strength Ratio (TSR) of all the mixes. The upper gradation with Nominal Maximum Aggregate Size (NMAS) of 12.5mm showed better resistance to moisture damage, because of its dense structure, followed by middle gradation with NMAS 12.5mm and lastly the lower gradation. Although the Indirect Tensile Strength (ITS) of lower gradation was the highest because of its NMAS of 19mm.**

***Keywords*: Asphalt mixtures, Aggregate gradation, Moisture damage, Tensile strength ratio.**

## I. INTRODUCTION

Environmental problems such as air, water and temperature significantly effect the durability of bituminous mixtures. Asphalt pavements suffer from premature distresses which are mostly associated to moisture damage. It is the progressive weakening of asphalt mixtures predominantly due to action of water. When water replaces the film of bitumen from the aggregate surface, it is called stripping. It largely depends on the chemical composition of aggregate materials and binder, and the affinity between them. The damage due to moisture directly upsets the asphalt mix integrity (mechanical properties) eventually decreasing pavement life span and performance. It accelerates almost all type of distresses like rutting (permanent deformation), thermal and fatigue cracking, stripping, raveling, potholes and rutting of unbound layers of soil. Therefore, it has a great influence on the economy due to increased restoration and preservation cost.

HMA has three major constituents: aggregate, bitumen and air voids. There are two ways in which asphalt gets damaged in the presence of moisture: Loss of adhesion bond amongst surface of aggregate and bitumen and/or cohesion loss within the asphalt binder. Therefore, the selection and chemistry of aggregates and binder play a vital role in moisture sensitivity. Stripping is more in aggregate with siliceous origins because of high silica dioxide [1].

RP Lottman performed a research under NCHRP Project 4-08(03) and developed a test method called Lottman test and then later modified it which is a standard AASHTO test and is termed as T-283. It is more suitable to test samples prepared and compacted in laboratory, mixed in field and compacted in laboratory and also for cores obtained from field. Initially it was developed for Marshall mix procedure using a 4-inch diameter samples but currently it is also mentioned by SHRP to evaluate moisture proneness of asphalt concrete mixtures in mix design practice.

## II. BACKGROUND LITERATURE

Moisture susceptibility has been acknowledged as an important cause of distresses like raveling, cracking and rutting and is considered as a major mixture design criterion for long time [2]. The premature failure of pavements is often caused by the presence of moisture/water in the shape of isolated distresses due to debonding of film of bitumen from the exterior surface of aggregate or due to early rutting/fatigue cracking because of reduced strength of the mixture [3]. The most direct and damaging result of moisture effect is the reduction in the pavement strength. It is one of the hidden effects as bottom portion of the asphaltic layer holds water for longer time because the evaporation rate is slow from the surface layers. The lower portion of asphalt layer is in tension under the load of traffic. In the presence of moisture and applied traffic loading the cohesion and adhesion bond within the binder-aggregate matrix starts degrading and it leads to bottom up earlier fatigue cracking [4].

When moisture penetrates the asphaltic wearing course, it detaches the asphalt film from the surface of aggregate. Heavy traffic and high temperature cause an emulsification process and deteriorates the binder's adhesion. Although an extensive range of laboratory tests are developed to assess the moisture susceptibility but the Modified Lottman Test (AASHTO T - 283 or ASTM D

- 4867) is commonly used to find these results because Superpave Mix Design system identified it as basic test to for moisture damage [5]. The damages due to moisture result in permanent deformation, stripping, raveling, cracking of the pavement and failures like potholes. It has also been found that the high viscosity asphalt is better to resist damages by moisture as compared to the low viscosity asphalt [6]. In ITS test a specimen is diametrically loaded until failure; the mix having high strain at failure recommends that it will resist cracking. Also, in 1998, Maine DOT accepted the Superpave method of mix design. This method recommends considering the Tensile Strength Ratio of the moisture unconditioned and conditioned samples as the most appropriate measure of moisture damage [7]. The mix having the range of smallest air void content and whose radius of the voids was small, was highly susceptible to be damaged by moisture as compared to asphaltic mixture having more void radius [8].

## III. OBJECTIVE

Evaluation of influence of aggregate gradation on moisture resistance of asphalt paving mixes through Modified Lottman Test.

## IV. MATERIALS & METHODS

### *A. Materials, Gradations and Optimum Binder Content*

A single type of aggregate, obtained from Margalla quarry, and two types of binder of same penetration grade of 60/70 from refineries of ARL and Parco (due to different production techniques) were used in this study. Three types of gradations were used which are given in Figure 1 and explained as follow:

a. NHA-B: It is the coarser gradation among the three, commonly used in Pakistan, and is defined in NHA specifications of 1998. Its nominal maximum aggregate size is 19mm.

b. SP-2: This gradation is given in Superpave manual and is finer than NHA-B with a NMAS of 12.5mm.

c. MS-2: It is Asphalt Institute Manual gradation with NMAS of 12.5 and the finer gradation.

Marshall Mix design mentioned in Manual Series-2 was used to find the OBC for all the mixture combinations. Triplicate specimens were fabricated at 0.5% increment of bitumen content and tested for stability, flow, Gmm and Gmm to find air voids, unit weight and voids in mineral aggregate. The bitumen content to produce air voids of 4% in the mixture was selected as the OBC. The OBC for mixes are given in Table 1.

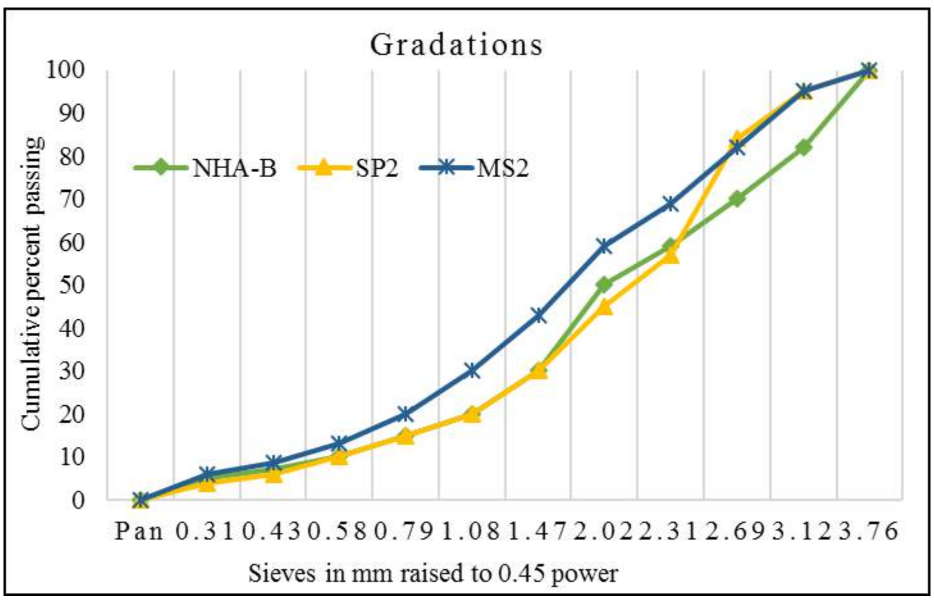


Figure 1 Aggregate gradations for asphalt wearing course

Table 1: Optimum Binder Content (OBC) of Asphalt Mixtures

| Gradation | Binder | ID | OBC % |
|---|---|---|---|
| **L**ower (NHA-B) | **A**RL | LA | 4.35 |
| **M**iddle (SP-2) | **A**RL | MA | 4.8 |
| **U**pper (MS-2) | **A**RL | UA | 5.0 |

| | | | |
|---|---|---|---|
| **L**ower (NHA-B) | **P**arco | LP | 4.3 |
| **M**iddle (SP-2) | **P**arco | MP | 4.7 |
| **U**pper (MS-2) | **P**arco | UP | 5.1 |

### *B. Moisture Susceptibility Test (Modified Lottman Test)*

It is performed by following AASHTO T-283 procedure by finding the TSR of each asphalt mixture as TSR is an important criterion to judge an asphalt mixture for moisture susceptibility. Since it involves freeze-thaw cycle therefore, it is a more severe method to determine and evaluate moisture damage of different mixtures. Six Marshall samples (4inch diameter and 2.5inch height) were prepared and were separated into two groups of three samples each. One subset was tested unconditioned by placing between plates of the machine and tested for ITS and maximum load that cracked the specimen was recorded for each specimen. The conditioned set was saturated up to 70-80%, wrapped in a thin plastic film and placed in a plastic bag with little water and subjected to freeze-thaw cycle. After completion of freeze and thaw cycle the set of specimens were place in water bath of 25 ± 1oC for 1 hr. to attain room temperature. This set was then tested for ITS. The TSR is indicator of potential for water damage and is the ratio of unconditioned tensile strength to that of conditioned set. TSR was found by using equation (1) given below:

$$TSR = \frac{S2}{S1} \text{x}\, 100 \qquad (1)$$

Where
S1 = Tensile Strength (Average) of Dry Subset
S2 = Tensile Strength (Average) of Conditioned Subset

## V. RESULTS

The results given in Table 2 and Figure 2 indicate that the mixtures prepared with ARL 60/70 binder performed better than mixes prepared with Parco 60/70 even though both are same penetration grade binders. Viscosity is a significant factor in resisting the stripping of asphalt mixtures because bitumen of high viscosity keeps the water away for more time and hence provide better adhesion of the bitumen on the aggregate surface. The results of TSR illustrated in Figure 2 show that the asphalt mixes prepared with finer gradation (upper gradation) of MS-2 provide better resistance to moisture damage followed by mixes produced with middle gradation and finally lower gradation. NHA class B gradation is coarser gradation among the three therefore its TSR is the least. As moisture susceptibility highly depends on gradation therefore coarser or lower gradation is less resistance to moisture damage as compared to highly dense finer gradation. This can also be explained as coarse gradation contains less material passing from sieve # 200 (75µm) which in turn reduces the TSR. These fine particles fill the voids consequently increasing the density of the mix making the mix more resistant to water damage. During compaction larger aggregate particles present in the mix are broken producing uncoated aggregate surfaces (as shown in Figure 4) which absorb water easily and cause stripping in the mix.

Table 2: Results of Moisture Damage Test

| Tensile Strength Ratio TSR | | | |
|---|---|---|---|
| Mix ID | Tensile Strength Unconditioned kPa | Tensile Strength Conditioned kPa | TSR % |
| LA | 877.72 | 777.63 | 88.60 |
| MA | 825.91 | 753.20 | 91.20 |
| UA | 813.98 | 755.10 | 92.77 |
| LP | 792.53 | 685.76 | 86.53 |
| MP | 783.11 | 696.80 | 88.98 |
| UP | 781.40 | 703.97 | 90.09 |

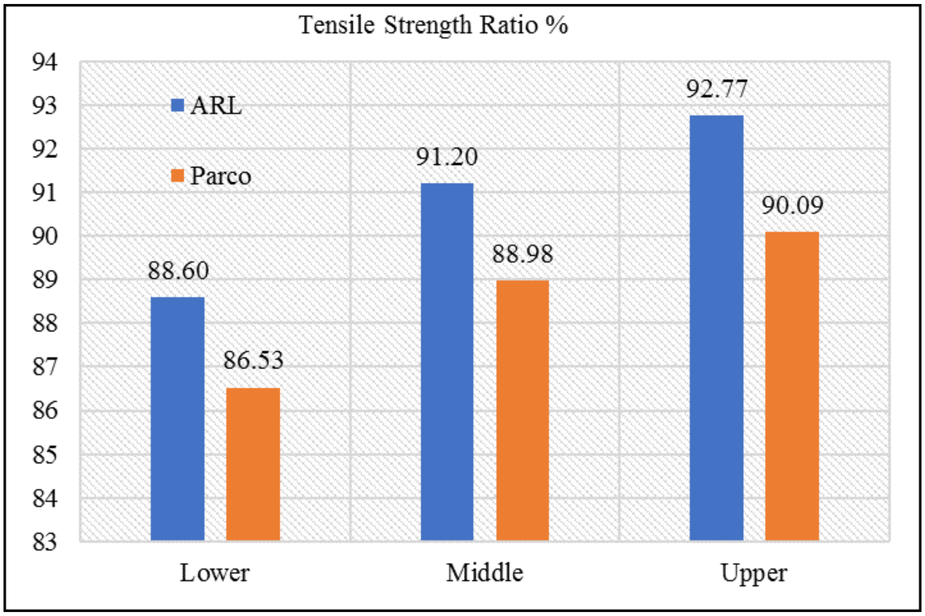


Figure 2: Tensile Strength Ratio TSR %

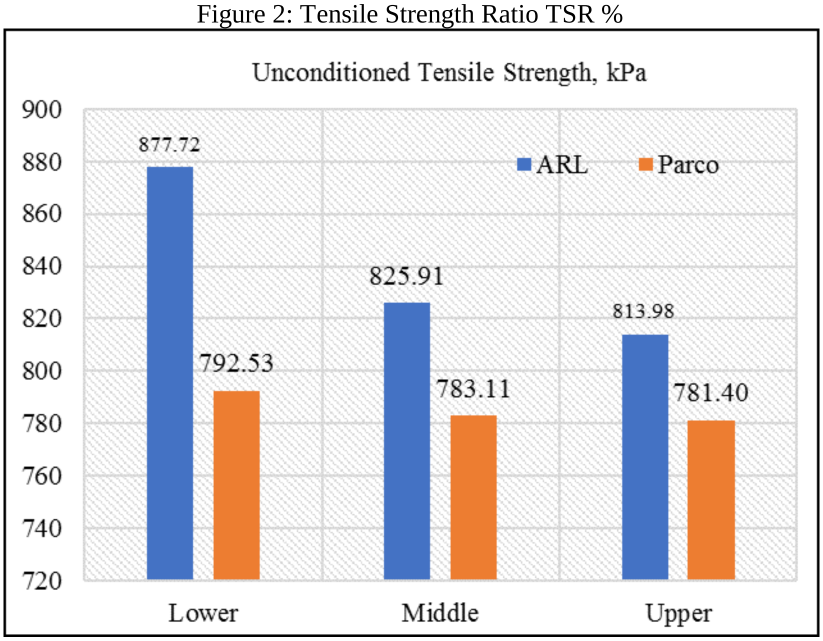


Figure 3: Results of ITS Tested Unconditionally

Figure 3 shows the comparison of indirect tensile strength of all the mixes when tested unconditionally. Mixes produced with ARL 60/70 indicated better performance than that of Parco 60/70. Lower gradation displayed higher tensile strength than mixes prepared with middle and upper gradation. The NMAS of lower gradation is 19mm while middle and upper gradations both have NMAS of 12.5mm. The increase in tensile strength of coarser gradation is because it contains larger aggregate particles providing better tensile strength to the mixture. Mixes produced with upper gradation showed the lowest tensile strength. It can be explained by the inability of fine particles to sustain more load.

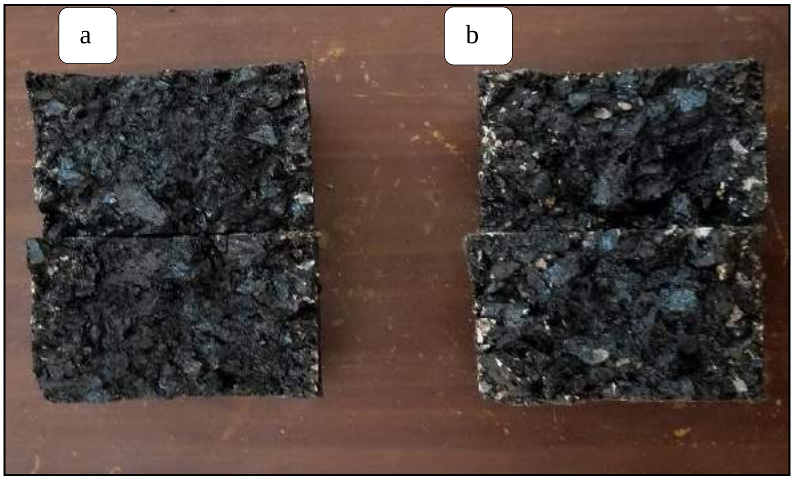


Figure 4: Specimens Tested: (a) Unconditioned (b) After Conditioning

## VI. CONCLUSIONS

Six different kinds of asphalt mixes were prepared by combining three gradations of aggregate with two different binders to check the moisture damage effect. All the mixes passed the test as the minimum limit of TSR is specified as 85%. The upper gradation of asphalt wearing course performed the best with highest TSR value followed by middle gradation and finally the lower gradation. Although the lower gradation showed higher ITS value when tested unconditioned, but it was less resistance to moisture damage because it contains less amount of particles passing from #200 sieve and more uncoated aggregate surfaces due to breaking of aggregate during compaction.

## VII. RECOMMENDATION

It is recommended that the upper gradation should be used in areas having high amount of rains, keeping in view the traffic loadings. In areas of high rain falls and heavy traffic middle or lower gradation should be used because of their high tensile strength as well as justified values of TSR.

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# Assessment of Housing Characteristics of Katchi Abadi Dwellers in Old Wahdat Colony Hyderabad Sindh

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***Abstract*: Housing is often considered one of the basic human needs. It ranks second after food and clothing with an insightful impact on the lifestyle, health, happiness as well as efficiency of the individual. The living condition and lifestyle of the households can be assessed indirectly by asking respondents about their housing characteristic. Old Wahdat Colony is a Katchi Abadi of Hyderabad in which most of the people have a low income, so they are unable to improve their living conditions. The aim of the study is to examine the housing characteristics, which put a direct impact on housing dwellers in order to provide guidelines to improve their lifestyle. A close-ended questionnaire was established for data collection regarding housing characteristics. After the collection of data, it was analyzed through frequency and percentage distribution. Findings from the study revealed that the living conditions of residents were substandard as their income level was too low. It was also found that contaminated water was supplied in the area. So, there is a critical need for the installation of a proper water supply system for providing clean drinking water. There is a need to exploit resources present in the study area. We can use these resources to uplift their economic condition.**

***Keywords*: Dwellers condition, Housing characteristics, Substandard living.**

## I. INTRODUCTION

Housing is a basic form of shelter. Recent trends in the housing sector highlighted that the living standard is now improving [1]. Housing is not only a basic human need; it founds a dynamic element of man's welfare, life sustenance, and survival. In the pyramid of man's needs, housing has been placed second to food. It has an intense influence on the health, efficiency, social behavior gratification and general welfare of the community [2]. Housing should be a home, a relaxing place with the fundamental purpose of a secure, satisfying, happy or at least a comfortable space [3]. Housing represents the living status of the family in both the wider community and in the nuclear family setting itself. While the quality and quantity of housing stock is a reliable barometer of measuring the technology, culture and above all, civilization level of any nation. It contributes to the general wellbeing of a people, race or community [4] Housing problems disturb the lives of individuals as well as of a state; hence both nature and society ascribed great importance to the part it plays in bringing about human comfort. The importance of providing adequate and quality housing in any country cannot be overstated nor disputed in time or space. It is a stimulant to the national economy. However, the recurrent nature of housing needs and the unending desire for good housing tend to confirm the widespread impression that there is hardly any society that has been able to cope satisfactorily with its housing requirement [5]. Characteristics of housings, including household size, income level housing condition access to electricity, the source of drinking water, type of sanitation facilities, construction and flooring materials of housing [6]. For many years, the housing characteristics as one of the key factors that affects human health. Housing conditions are the basis of many factors influencing residential health. The quality of housing plays a decisive role in the lifestyle of the residents [7].

Housing problems disturb the life of individuals as well as of a country; hence both nature and society recognized the great importance to the role it plays to bring about human comfort [5]. Consequently, the dwelling is a more concentrated issue among living standard. Housing issues in slum areas are now a problem of critical concern to the residents [3]. Housing conditions of the slum residents are generally very low. They are crowded in nature and lack of the cross ventilation is found in their houses [8]. All the houses of the slum dwellers were over-crowded and poor both in terms of structure and housing condition [9]. Slum residents are facing various types of problems like absence of drinking water facility, latrine services and lack of electric connections in the slums [10]. The aim of this study to examine the housing characteristics, which put a direct impact on housing dwellers in order to provide guidelines to improve their living condition.

## II. RESEARCH METHODOLOGY

Old Wahdat Colony is a Katchi Abadi of Hyderabad Sindh. The location of this Colony situated nearby Gidu Chowk adjacent with Thandi Sarak at the verge of Ponam road can be seen as (Fig. 1). According to Sindh Katchi Abadies, authority dwelling unit in old Wahdat Colony is 200


**Fig. 1. Location map of Old Wahdat Colony**

The People are living in this settlement have low income due to which they are unable to improve their living standards and lifestyles. The main problems of this area are poor drainage, inadequate sanitation and unhealthy drinking water system which are causing great health hazards in dwellers. Due to open drain in houses over the flow of water in rainy season results in damage to structures which in turn causes poor living environment in the settlement. Hence this study solves the problem related to housing characteristics which direct impact on their living condition.

There are several sources of data collection, for this study, a questionnaire survey method was selected to gather data [11]. To obtain data, the household survey was conducted in the area. The standard level is (5 – 10%) of the total population that can be taken as a sample of the total population [12]. The random sampling technique is used for selecting the respondents [2]. For this study, a questionnaire survey tool was used to gather the required data. Variables were formulated for the questionnaire to collect the required data in order to examine the housing characteristics (Occupation, income level, civic facilities, sanitation facility, and ownership status, and education level, house type) of the residents of Old Wahdat Colony.

**2.1 Sample Population:**

For this research, the simple random sampling is adopted which allows the researcher to select the sample households from the Old Wahdat Colony. The standard level is (5–10%) of the total population that can be taken as a sample of the total population [13].

Table 1. Population Sample (Estimated)

| Study Area | Assume household | Dwelling unit | Population | Sampled questionnaire 5%) |
|---|---|---|---|---|
| Old Wahdat | 6 | 220 | 1320 | 66 |

Table 1 shows the sampling plan for the study area. Due to lack of available demographic data on secondary resources "Compound interest formula" was used to estimate the population of the study area so that the sample populations can be derived from it. Researchers' assumed household size six for the population projection, which is estimated to be 1320 according to the formula. The standard level is 5% of the total population that has taken as a sample of the total population which is estimated 66.

## III. RESULTS

The main purpose of this study was to analyze the housing characteristics of dwellers of the study area. For this purpose, some variables were formulated for the questionnaire to collect the required data in order to examine the housing characteristics

(Occupation, income level, civic facilities, sanitation facility, and ownership status, and education level, house type). Percentage analysis through SPSS (V22) was used to analyze the housing characteristics of the dwellers of Old Wahdat Colony.

Table 2. Occupation

| **Occupation** | **Frequency** | **Percentage** | **Cumulative Percent** |
|---|---|---|---|
| Govt servant | 17 | 27.4 | 27.4 |
| Private servant | 20 | 30.4 | 57.8 |
| Private Business | 22 | 35.5 | 93.3 |
| Others | 3 | 6.7 | 100 |
| Total | 62 | 100 | |

Source: By Questionnaire

Table 2 shows the occupation status of respondents in the study area. Results indicate that 27.4% respondent is government servants, 30.4 % of respondents are a private servant, 35.5 % of respondents are doing 'private business' and 6.7% are respondents those have other occupation. Conclusively most of the people are doing private business.

Table 3 Income Level

| **Income level** | **Frequency** | **Percentage** | **Cumulative Percent** |
|---|---|---|---|
| 1000-5000 | 12 | 19.4 | 19.4 |
| 5000-10,000 | 27 | 43.5 | 62.9 |
| 10,000-20,000 | 16 | 25.8 | 88.7 |
| Above | 7 | 11.3 | 100.0 |
| Total | 62 | 100 | |

Source: By Questionnaire

Table 3 shows the income level of respondents. Results revealed that 88.7% respondent's income level in the range of 1000-20000 and 11.3% respondents have income above twenty thousand.

Table 4 Ownership Status

| **Ownership status** | **Frequency** | **Percentage** | **Cumulative Percent** |
|---|---|---|---|
| Own | 37 | 59.7 | 59.7 |
| Rented | 25 | 40.3 | 100.0 |
| Total | 62 | 100 | |

Source: By Questionnaire

Another element of housing characteristic is house ownership. Table 4 illustrates that 59.7% of respondents have own house and 40.3 respondents are living in a rented house.

Table 5 Basic Facilities

| Facility | Available % | Not Available % | Satisfied % | Not Satisfied % |
|---|---|---|---|---|
| Electricity | 82.3 | 17.7 | 80.6% | 19.4% |
| Gas | 71 | 29 | 69.4% | 30.6 |
| Drainage System | 85.5 | 14.5 | 38.7% | 61.3% |
| Water | 77.4 | 22.6 | 33.9% | 67.7% |

Source: By Questionnaire

Table 5 provides the information regarding the basic facilities. Results explain that almost 82.3% of respondents have a legal connection of electricity. Among the respondents, 71% have a gas connection but 29 % of respondents have not gas connection in houses. Result also describe that 30.6% of people are not satisfied with the available facility of gas as gas pressure is very low. The result illustrates that most of the respondents got water from water supply scheme. Contaminated water is being supplied in the area due to this about 22.6% respondents collect water from other sources such as shops, filter plant and about 66.1% people are not satisfied with the quality of water supply in the area. The result indicates that 82.3% of respondents have drainage system but

in which 61.3% people are not satisfied with the drainage system because drainage lines are damaged that is causing over the flow of water on the streets.
Furthermore, researchers asked a question of respondents regarding their education level. Researchers found that 38.7% respondents' education level is intermediate, and 30.7% respondents have education level between primary and secondary, 14.5% respondents education level is graduation.

Overall Findings of the result is that the people in Old Wahdat Colony are mostly involved in small business such as shopkeepers and fruit seller. In the study area, most of the inhabitants belong to the low-income level, i.e. under 10,000. Due to the low-income level, they are incapable to develop their housing condition. Unclean water has been supplied in the study area due to this reason 66.1% people are not satisfied with the quality of water and 22.2% people get water from other sources such as shops, filter plant etc. According to respondents, drainage line is in bad condition that is cause overflow in the streets and creates an unhygienic environment in the study area.

## IV. CONCLUSIONS

Housing condition is often low quality in Pakistan. According to UN-Habitat report, Pakistan ranks eighth among the ten countries that collectively hold sixty percent of substandard housing across the world. Housing condition can be improved by analyzing the housing characteristics of any area. For this research, Old Wahdat Colony a Katchi Abadi in Hyderabad city was selected for analyzing the housing characteristics. The aim of this research is to examine housing characteristics which include occupation pattern, household income, household size, and level of education, the source of water, civic facilities, and sanitation facilities. These elements were analyzed through frequency percentage distribution. Overall findings of the study indicate that the housing condition of dwellers is not satisfying. According to the analyzed results, the people in Old Wahdat Colony are mostly involved in small business such as shopkeepers, a fruit seller, etc. In the study area, most of the residents belong to the low-income level, i.e. under 10,000. Due to the low-income level, they are unable to improve their housing condition. Contaminated water is also a big issue which is being supplied in the area due to this reason 66.1% people are not satisfied with the quality of water and 22.2% people get water from other sources such as shops, filter plant etc. According to respondents, drainage and sewage line are in bad condition that causes overflow in the streets and creates an unhygienic environment in the study area. For the improvement of the housing condition of the study area, some recommendations are thrown.

## V. RECOMMENDATIONS

On the basis of findings and results, recommendations had drawn. The recommendation of the study can be described as follows.

### 1. Improve Water Quality

Hyderabad Water Supply Company should rehabilitee water supply mechanism and it must be made sure that treated water should be equally supplied in the area.

### 2. Drainage and Sewage System:

Municipal authority should carry out repair works for drainage and sewage line in order to avoid contamination and overflow in the streets.

### 3. Income Level:

The government should identify their resources and utilize the skills of inhabitants in their resources in order to increase their income level so that they can improve their living and housing conditions.

### 4. Education Level:

The government should promote education in old Wahdat Colony and also provide adequate education facilities so that they can increase their education level**.**

### 5. Gas Facility:

Sui northern department should install more pipelines in the area because 30.6% people do not have a gas facility. Sui northern department makes the sure equal distribution of gas facility in the area.

## ACKNOWLEDGMENT

This journey would not have been possible without the support of our family, professors and friends. To our family, thank you for encouraging us in all of our pursuits and inspiring us to follow our dreams. We are especially grateful to our Parents who supported us emotionally and financially.

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# Problems Caused Due to Low Bid Award System: A Case Study of Public Sector Construction Projects in Pakistan

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***Abstract:*** **The bid procurement is an essential and considerable component of construction project management. Bid procurement problems are widely connected with players of construction industry. The core objective of undertaking this study was to identify the issues confronted by public sector projects due to lowest bid award system. In order to achieve the objective of the study both qualitative and quantitative research methods were applied. Problems caused by lowest bid award system were identified by literature review and questionnaire survey. It was found that poor performance, selection of inexpert and non-qualified contractors, schedule and cost overruns, delays, risk exposure to client were the major problems faced by public sector projects due to lowest bid award system. In context of identified problems, this study suggests some measures for improvement in award of public sector projects.**

***Keywords:*** **Construction, Bid procurement, Low bid award, Public sector.**

## I. INTRODUCTION

Procurement is the process of obtaining goods and services for the completion of project objectives at best feasible time, cost and quality [1]. Procurement performs a crucial role from commencement to completion of construction projects. The procurement process is conducted at different phases of project such as conception, designing, planning and execution. The successful completion of projects depends on an effective and efficient procurement process [2]. The procurement of bids is an important component of construction project management. Being a complex business construction industry faces many issues. Bid procurement problems are widely connected with participants of construction industry. Low bid procurement is one the obstacles to improvement in public sector projects [3].

In Pakistan and other developing countries contracts are awarded to the lowest responsive bidder. It is approved by Public Procurement Regulatory Authority (PPRA) that bids of public sector projects be procured on the basis of low bid award system and bid should be awarded to the lowest responsive bidder [4]. Despite the fact that prequalification process is conducted, however, the prequalification focuses on the past performance and financial status of the contractor. Consequently, schedule of the project, contractor's plan to handle the project, capability of the contractor, are neglected. As a result of above facts public sector projects are facing issues due to award of contract on basis of low bid contract award system [5].

Considering the problems of low bid award system developing countries are using alternative contract award systems such as multi parameter method, best value procurement [6]. Therefore, it is necessary to find out issues of the projects awarded on the basis of low bid award system and suggest some measures to improvement in award of contracts of public sector projects.

## II. LITERATURE REVIEW

In public procurement the enterprises obtain materials, goods, services and works by usage of public funds. Pakistani government being a major client of construction sector started reforms in procurement by establishing Public Procurement Regulatory Authority (PPRA) in 2002. According to the PPRA rules 2004 the public-sector projects should be procured by competitive sealed bidding process and contract is awarded to the bidder who is lowest responsive [7]. An efficient procurement system should be transparent, competitive, and accountable and give maximum value to the client. The low bid award system is inefficient because it is not producing results as desired by the client due to the poor performance of the contractor [8].

The process of procurement should apply the regulations to all customers' suppliers etc. equally and maintain its procedures as well. Due to lack of transparent system low bid award method selects the non-expert contractor. The other reasons behind selection of non-expert contractors is price as the only criteria in evaluation of bids. Therefore, contractors submit unjustified low

bids in order to win the contract of the project. The lowest bid contract award method of awarding contract is not successful in investigation of potential of contractors resulting in selection of non-qualified and incapable contractor [9].
During the award of the contract the contractor plans to handle the project and capability of contractor are not taken into account which increases the risk of delays, schedule and cost overruns. The selection of contractors on basis of lowest price only does not result in achieving maximum value for money. In order to attain value for money a vendor should understand and fulfill the client's expectations. Accepting the lowest price bid does not results into lowest price and value for money in projects [10]. In Pakistan due to procurement of public sector projects on low bid award method more direction, control and management is required by the client. As a matter of fact, the public sector client face pressure to enhance the quality of work, performance of contractor, completion of project on time and reduction in management cost of the public sector construction projects. Due to absence of quantitative model to evaluate the lowest quoted price the public sector client face challenges causing cost overruns and sometimes project failure. In order to save money contractors often hire low-level sub-contractor and craftspeople resulting in low quality of work [11].
It is universally accepted that the low bid award system failed in achieving and meeting client's expectations. Therefore, developing countries are using various alternative contract award system such as best value procurement, multi parameter bidding method, Average bidding method, negotiated bidding methods and A+B method. In Japan, Netherland, USA and Canada contract is awarded on value basis by considering both price and non-price factors. Bids closest to average are awarded the contracts in South Korea and Denmark while in Australia contract is awarded through negotiation method. Thus, use alternative contract award systems is gaining importance around the world due to poor performance of low bid award system [12].

## III. RESEARCH METHODOLOGY

The research study was carried out by using both quantitative and qualitative methods. Initially an extensive literature review was conducted by reviewing, journals, research papers and books. Finally, questionnaire was designed and floated in public sector industry. Results were drawn on basis of analysis of the collected data. The methodology used in the research is shown in following Figure 1.

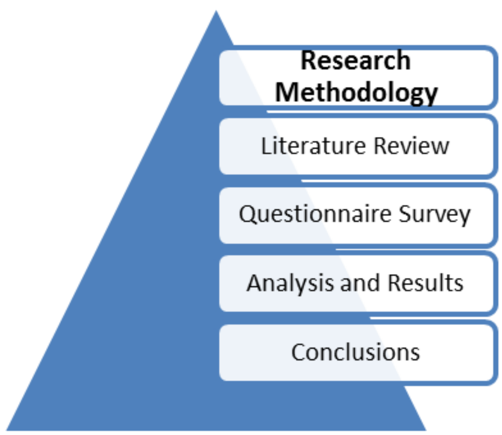


Figure 1: Research Methodology

## IV. DATA COLLECTION

Questionnaire was distributed to the public sector client working in public sector departments of Sindh and Balochistan. A total of 120 questionnaires were administered to public sector owners/clients who work in National Highway Authority (NHA), Irrigation, Public Health Engineering & Ruler development, Works & Services, Planning & Development and Council for Works & Housing Research of Sindh and Balochistan. Seventy (70) were accepted and considered for analyzation of the data. The response rate was 58.67% which is more than minimum rate of 20-30% as shown in the following figure 2. The experience of respondents is shown in Figure 3.

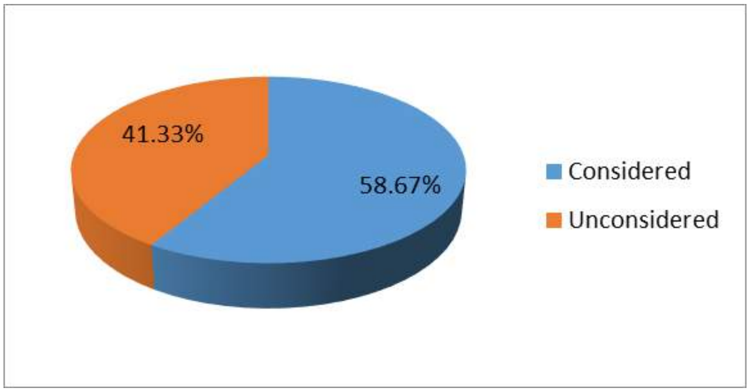


Figure 2: Statistics of Questionnaire

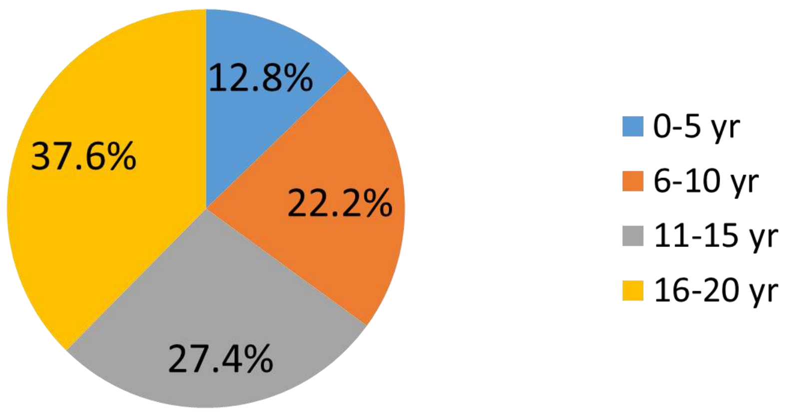


Figure 3: Experience of Respondents

## V.RELIABILITY OF DATA

The consistency of the data was quantified by Cronbach Alpha. The value of Cronbach's alpha varies from 0 to 1. The least required value is 0.7 [13]. The value of Cronbach's alpha was quantified as 0.75 which is acceptable.

## VI. ANALYSIS AND DISCUSSION

The respondent was asked to specify the degree to which following issues mentioned in questionnaire are the problems faced by construction public sector projects due to lowest bid contract award system according to given scale as shown in Table 1.

Table 1: Given Scale

| Strongly Agree | Agree | Slightly Agree | Disagree | Strongly Disagree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

The Statistical Package for Social Sciences (SPSS) was used to analyze the collected data. The issues caused due to lowest bid contract award system in construction public sector projects of Pakistan were identified and ranked according to their mean as shown in the Table 1.

Table 2: Identified Problems of lowest bid award system

| Problems Caused due to lowest bid award system | Mean | Rank |
|---|---|---|
| Poor performance of the contractor | 4.32 | 1 |
| Selection of non-expert contractors | 4.25 | 2 |
| Awarding contract to non-qualified contractors | 4.23 | 3 |

| | | |
|---|---|---|
| Schedule and cost overruns | 4.15 | 4 |
| Risk exposure to clients | 4.10 | 5 |
| Low bid environment requires more direction, management and control by client | 4.08 | 6 |
| Contractor submit bid of unreasonable low price | 3.74 | 7 |
| Low bid award system results in low sub-contracting | 3.56 | 8 |
| Change orders | 3.42 | 9 |
| Adverse relation between owner and contractor | 3.26 | 10 |
| High competition | 3.12 | 11 |
| Disputes | 2.90 | 12 |
| Work suspension | 2.16 | 13 |
| Encourages corruption | 1.74 | 14 |
| Increased no of claims | 1.5 | 15 |

It is observed from Table 2 that poor performance of contractor ranked 1st with a mean score value of 4.32,followed by selection of non-expert contactors with mean value of 4.25,awarding contracts to non-qualified contractors with mean score of 4.23, schedule and cost overrun with mean value of 4.15 and low bid environment requires more direction, management and control by client with a score of 4.08.The table also depicts the minimum caused issues like disputes, work suspension, encourages corruption and increased no of claims with mean score of 2.90,2.16,1.74 and 1.5 respectively.
So, the main complications caused due to lowest bid award system in construction public sector projects are poor performance of the contractor, selection of non-qualified and non-expert and contractors, cost and schedule overruns and low bid environment requires more management and control by the public sector clients. Similarly, the issues of unreasonable low bid, low subcontracting, change order and adverse relation between the contractor and client were also produced due to award of contract on low bid award system which only revolves around the price. The traditional system does not take into account the other non-price factors like capability of the contractors, past performance of contractor, contractors plan to handle the projects.

## VII. CONCLUSIONS AND RECOMMENDATIONS

Following conclusions are drawn based on the results of this research study. Poor performance of the contractor is one of major problem caused due to low bid award system. The low bid award system is also responsible for the choosing of non-qualified and non-expert and vendors which are resulting in low standard of work. It was also observed that cost and schedule overruns in construction public sector projects are frequently occurring issues due to award of contract to lowest bidder. The research study indicates that in low bid award system the public sector client feel pressure of management costs as the traditional system of awarding contract requires more direction and control by client. It is also concluded that contractors in order to win the contract submit unreasonable low bids. Low subcontracting was also identified as one issues causing low quality of work and adverse relation between the client, contractor and subcontractor. High competition among the contractors also compels them to quote unreasonable low prices to win the bids which cause project failure. It is concluded that non-price factors should be given due importance during evaluation of bids to make the public sector projects successful and get maximum value for money as well.
Following recommendations are made from results and conclusions for further research study

- A study on identification of various alternative contract award approaches being used around the world can be carried out.
- A study on applicability of alternative contract award system can also be carried out in public sector projects of Pakistan.

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# Evaluation of Boron and Other Physicochemical Parameters in Ground Water of Tandojam Town

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***Abstract*: The aim of this research work is to analyze groundwater for determination of physicochemical parameter and compare those parameters with WHO guideline values. The groundwater samples were fetched from different locations of Tandojam. Locations included Pakistani Chock, Garibabad Colony, Shahi bazaar, Meer colony and Sindh Agriculture University Colony. Mostly sample were acquired through groundwater pumps. A physicochemical analysis was conducted for collected samples in order to determine its quality and suitability for usage. According to results the TDS value of Pakistani chock was high, and which was around 4000 parts per million (ppm). Which shows the quality of water from Pakistani Chock is not well, but TDS of SAU colony was within limit. In Garibabad colony, Shahi Bazar and Pakistan Chock, the condition of water is very displeasing. Because samples from these areas contain salty test followed by high level of TDS value. Other physicochemical parameters, such as chloride, sulphate, boron and hardness, were also exceeding WHO guideline values. This poor situation of groundwater has already drifted the spread of many waters borne diseases, such as diarrhea and cholera. Furthermore, the samples from only two places were found within WHO limits. Those were University Colony and Meer colony and water is considered suitable for drinking and other domestic usage.**

***Keywords*: Boron, Physicochemical, Groundwater.**

## I. INTRODUCTION

The drinking water in Pakistan is commonly acquired through rivers, canal, lakes and groundwater reservoirs. The groundwater quality is get decline caused by disposal of untreated domestic, agricultural and industrial effluents. [1] Due to this reason the river water species are getting adversely affected with deposition suspended and dissolved impurities. [1, 2] The quality of groundwater has also impacted by geological parameter and its quality vary from area to area. According to a study, many areas of Pakistan contain salt, iron, arsenic, and other dangerous pollutants in ground water. In Mianwali and Kasur districts the groundwater contains high range of fluoride ranges from 5 to 29 mg/l in samples which were obtained hand pumps and shallow wells. [2, 3] The samples, from Kharan. Umar kot, Makran, Tharparkar and Mastung Valley, also contain excessice fluoride. [7] UNICEF sampled the water from Sargodha, Jhelum and Gujrat districts and arsenic was found above the WHO guideline values. [7] PCRWR (Pakistan Council of Research for Water Resources) conducted an analysis of water samples from Shekhupura, Multan, Lahore and Bahawalpur and those were above WHO guideline values. [7] The water of southern, central and northern Punjab including Islamabad also contains high concentration of nitrate residues caused by excessive use of fertilizer [3]. Sulfide, chromium and TDS contents were also found in ground water samples of Kasur city [3]. Similarly, the groundwater of major cities, such as Faisalabad, Karachi and Rawalpindi also contain constituents of parasites. [4] The values of groundwater quality parameters are represented in table 1. Which shows the fecal coliform and total coliforms are also found in groundwater samples from some major cities of Pakistan.

The groundwater quality of lower Indus region majorly variegated in different seasons of year. [6] It was assessed that values of alkalinity, fluoride, iron and arsenic concentration found different in winter and summer seasons, in different areas of Thatta district. [6] Similarly Nitrate concentration were also exceeding World Health Organization guidelines values. [6]
Normally the subsurface water is getting polluted by natural borate in dissolved form. The borate is introduced in water majorly through untreated wastewater effluents. It is used as a washing agent at domestic level. [8] Groundwater is basically contaminated through leaching of borosilicate and borates from soil and rocks. Globally boron concentration ranges from 0.3 t0 100mg/L in groundwater. [9]
During this study groundwater samples were collected from different areas Tando Jam city. Those samples were analyzed in laboratory of Institute of Environmental Engineering and Management. The prime purpose of this study was to assess the

groundwater quality of Tando Jam city. Boron was never analyzed in the area or any other areas within 100 km. Therefore, it was a novel factor this research project.

| Table 1 Groundwater quality data of some cities of Pakistan [3,5] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| City | Total Dissolved Solids(ppm) | Hardness (as $CaCO_3$ in ppm) | Arsenic (ppb) | Fecal Coliform (per 100 ml) | Total coliform (per 100ml) | Iron (ppm) | Chlorides (ppm) | pH |
| Karachi | 211-467 | - | - | 15-460 | 150-2400 | - | - | 7.3-7.6 |
| Hyderabad | 167-1140 | 105-600 | - | - | - | 0.03-0.2 | - | 7.1-8.2 |
| Khushab | 300-500 | 138-160 | - | 0-1 | 4-8 | 0.2-0.6 | 8-11 | 7.4-7.6 |
| Islamabad | 190-589 | 130-400 | 0-10 | - | 0->240 | 0.03-1.53 | 3-25 | 7.8-8.3 |
| D.I. khan | 230-300 | 143-160 | - | 1-2 | 10-40 | 1-8.7 | 14-30 | 7.4-7.5 |
| D.G. Khan | 230-240 | 140-152 | - | 0-2 | 7-9 | 0.2-0.9 | 17-20 | 7.7-8.0 |
| Rawalpindi | 209-1042 | 150-540 | 0-10 | - | 0->240 | 0.2-0.4 | 5-163 | 7.0-8.3 |
| Quetta | 400-950 | 170-480 | 0-10 | - | - | 0.2-0.4 | 24-121 | 7.6-86 |
| Kohat | 500-560 | 280-330 | - | - | - | 0.1-0.2 | 46-64 | 7.4-7.7 |
| R.Y. Khan | 300-500 | 150-170 | - | 1-2 | 11-12 | 0.2-0.9 | 12-20 | 7.3-7.5 |
| Values represent ranges. | | | | | | | | |

## II. .MATERIALS & METHODS

### *A. Area of Study*

The Tando Jam city is located in the Hyderabad district. Its elevation is 23 m above mean sea level, with coordinates of latitude of 25°25'60 N and longitude 68°31'60 E. The climate of the region lies in semi arid zone and weather is stable. Summer is very hot in day time and monsoon starts from July and ends upto September. Winter is slightly cold and coldest period of year is from december to january.

### *B. Sampling Methodology*

Total five areas Pakistani Chowk (A-1), Shahi Bazar (A-2), Garibabad (A-3) Meer Colony (A-4), and University Colony (A-5) have been selected and six samples from each area has been collected. These samples were collected from Hand pumps and tube wells in 1 liter of sterilized polyethylene bottles.

**Analysis of Physico-Chemical Parameters.**

The following parameters were analysed

Total dissolved solids, pH, Electrical conductivity, Hardness, Turbidity, Chlorides, Sulfates and Nitrates, Boron,

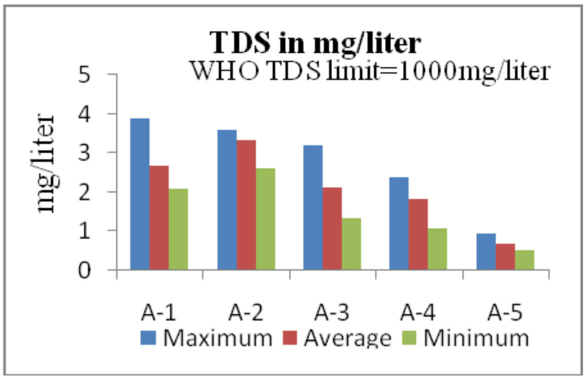
| Table 2; Methods of analysis | | |
|---|---|---|
| S:No | Parameters | Methods |
| 01 | E.C/TDS | E.C/TDS Meter |
| 02 | Ph | Ph. Meter |
| 03 | Sulphate | Turbuditrimetric method |
| 04 | Nitrate-Nitrogen | Brucine Spcetrophotometric method |
| 05 | Turbidity | Nephlometric method |
| 06 | Chloride | Argentometric Titration |
| 07 | Total Hardness | EDTA Titration method |
| 08 | Boron | UV. visible spectropotometric method |

## III.RESULTS

The result of each parameter is mentioned in graphical form and discussed below,

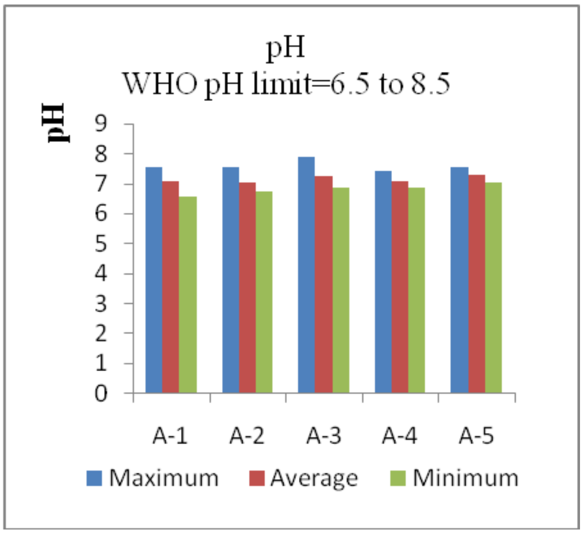
### (i) Total Dissolved Solids

The TDS present in the ground water of Pakistani Chowk, Shahi Bazar and Garibabd is high in the range of 2000 to 4000, according to WHO limit are very high(1000mg/liter) and the TDS value of university colony is in WHO range. Anthropogenic sources such as solid waste dumping, domestic waste water and agricultural activities may affect the TDS concentration in the ground water Tarasha et al (2009). High observed values of TDS may cause diseases such as gastrointestinal and cancer Tarasha et al (2009)



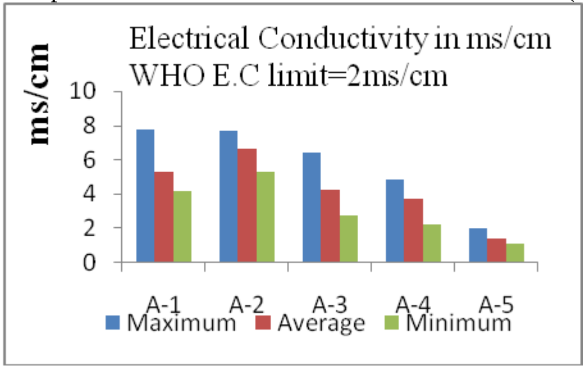

### (ii) Ph

All collected samples pH values are in the range of the WHO guidelines values



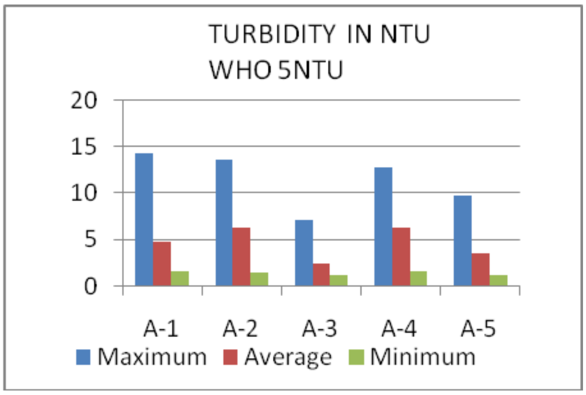

### (iii) Electrical Conductivity

The E.C values of Pakistani Chowk, Garibabd, Shahi Bazar and Meer Colony are high. The Electric Conductivity values depend upon the values of TDS and the presence of minerals and salts G.F Berunia et al (2013)



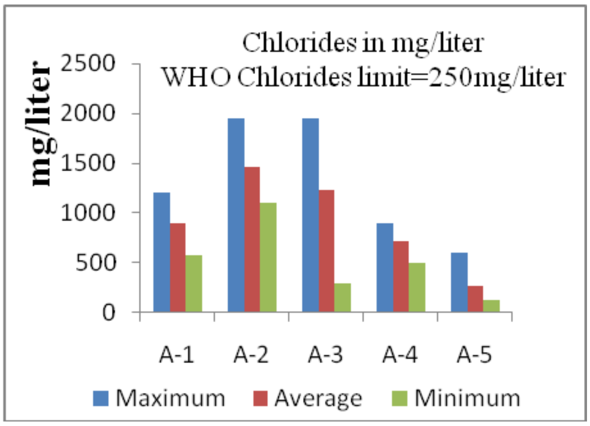
**(iv) Turbidity**

The graph shows that the Turbidity values are high and specially the Pakistani Chowk and Shahi Bazar Clay particles and suspended mud present in ground water causes the turbidity of ground water Dhore et al (2014)



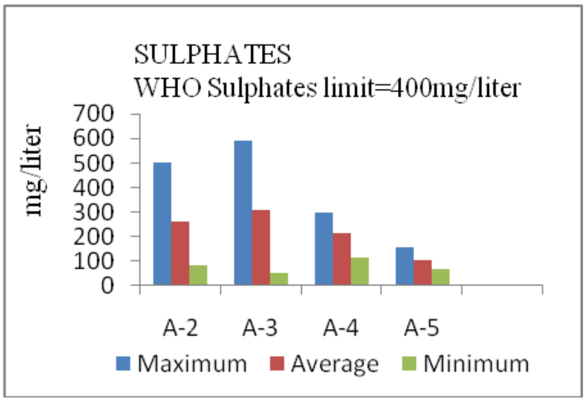

**(v) Chlorides**

The areas Garibabd, Shahi bazar and Pakistani chowk contain high values of Chlorides. Chlorides depend upon the depth and concentration of minerals. It produces salinity and odor to water Mahesh et al (2014).The high concentration of Chloride in ground water may cause intrusion Rajasooriyar et al (2002).



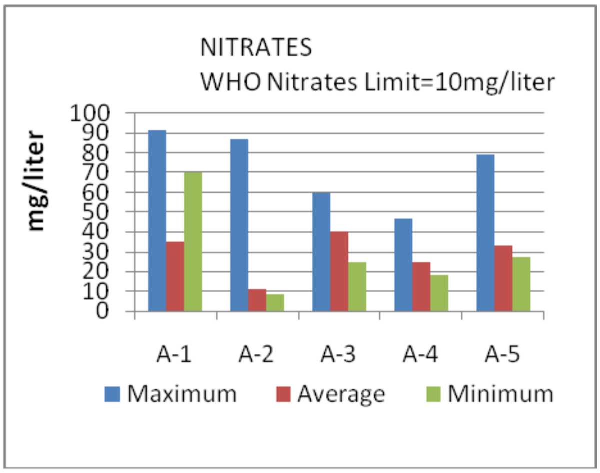

**(vi) Sulfates**

Graph showing that sulfates in Garibabd and Shahi Bazar are high because sulfates are key constituent of TDS. Sulfates are form of salts, excessive amount of sulfates often impart salinity to ground water and give bad taste. The high concentration of sulphates in the ground water may creates dehydration, catharsis and gastrointestinal diseases Mahmood et al (2014). The use of fertilizers to agriculture land adds the sulphates to ground water Hamen et al (2007).



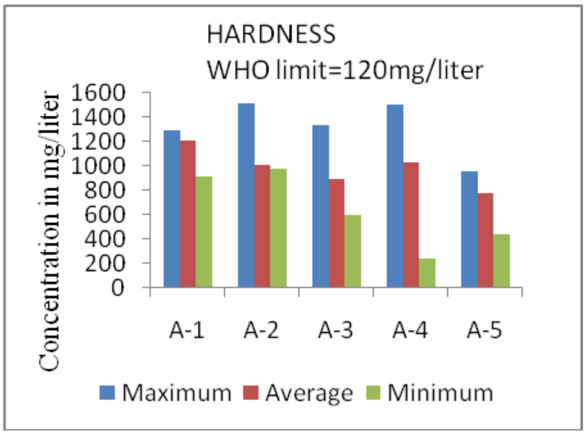
**(vii) Nitrates**

The graph showing that high concentration of nitrates in ground water, except Pakistani Chowk and Shahi Bazar. The high concentration is due to the agricultural runoff, containing nitrates compounds such as like Ammonium Nitrate Aamir et al (2006). The poor drainage system, use of fertilizers and rain water runoff the chief sources of nitrates to ground water Mahmood et al (2012).




**(viii) Hardness**

The Hardness concentration of Shahi Bazar and Meer Colony were observed higher. The infiltration of waste water to the ground water adds the hardness Bampher et at (2013). The causes of low concentration in other study areas because of application of fresh water to agricultural land which reduces the bicarbonates and bicarbonates Kupwade et al (2013).




**(IX) BORON**

The boron found in within limits in all areas of the Tando Jam city. The highest value of boron found in samples of Garibabad colony and that was 0.708 mg/l, which again safe to consume as per WHO guidelines.

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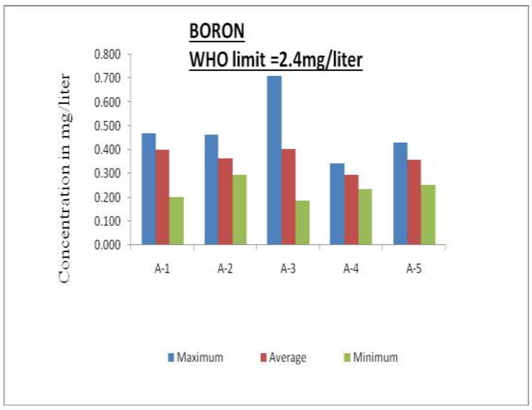

## IV. CONCLUSION

This study has been conducted to analyze the ground water quality of Tando Jam. Total five areas of Tando Jam has been selected and physio-chemical parameters has been tested. The obtained results show that the ground water of Tando Jam contains higher values of TDS in the range of 1200 to 4000mg/liter. Chlorides were observed in the range of 400 to 2000 mg/liter which exceeds the WHO limits. The values of Sulphates, Nitrates and Ph are found as in the range of WHO guidelines. In case of Boron the, the water is free from it, contains values in the range of 0.2 to 0.8mg/liter

## V. RECOMMENDATION

- To improve the ground water quality Solar Reverse Osmosis plants and solar desalination plants should be installed to remove the Total Dissolved Solids and Other impurities.
- At low level the residents should boil the water before it is being used for drinking water.
- Since water is a basic need therefore it is suggested that government should install and maintain well the water purification plant.
- The sewerage system of Tando Jam should be developed to overcome the leachate and mixing of waste water with the fresh water.

## ACKNOWLEDGEMENT

This research paper is part of ME thesis submitted to MUET Jamshoro.

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# Relationship between Demographical Factors and Construction Safety Management

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***Abstract:*** **The construction industry plays an important role in the economic and social development of the world. The construction company deals with the construction projects executed by the number of workers, thus the safety of these workers should be investigated and provided properly. In the developed and developing countries the safety in the construction industries is considered a major issue. In Pakistan many construction companies are working on different projects, but the safety and health facilities provided to the workers by the organizations are not meeting to the standards. In this research an attempt is made by using the safety climate questionnaire and several statements of demographic factors with the Likert scale, the survey was conducted over thirty-six construction projects in different cities of Pakistan. The foremost objective of the research-study was obtained by keeping in view the relationship between demographic factors with the construction safety climate, together with construction company type, project types, nature of employee, age and educational level of the workers.**

***Keywords:*** **Safety, Saftey climate, Operation and maintenance, Mean safety climate score, Demographic factors.**

## I.Introduction

Keeping in view serious injuries worldwide, the construction industry is among the furthermost injury prone industries among the different industries of the world, covering the aspects such as disability, mortality, hospitalization and lost work time [1] Therefore, it is essential to improve worker safety at project sites. Developments in working environment and advanced equipment which are being used in construction industry are not sufficient while improving safety routine [2]
The organizational principles and human factors also play vital roles for the improvement of safety climate. For the sake of the safety of the employee at project sites and considering interest for researchers in recent years, safety culture is becoming critically significant, due to the variation in workforce behavior which totally depends upon perceptions [3]. Safety practices are distinguishing in constructions industries because of many factors including stakeholders, demographics and legislation. In different developing countries of the world like Pakistan, the health, environmental and safety practices are rare that cause lots of accidents [4].
Workforce of a country, 16% directly and 30% - 40% indirectly associated with the construction industry of that country [5]. As per report from Survey of Pakistan from the year 2002 to 2009 there is a gradual increase in percentage for occupational health & safety injuries and diseases from 12.54 to 14.54, which shows that there is a lacking safety culture in Pakistan. Combined and degree of higher uncertainties avoidance comportment of workers declare on different construction project sites are differentiated in demographics. Poor safety performances are caused due to the fewer incentive insurance mechanism because the insurances depend on rules and regulations. The workers are site exhibit improper safety behavior due to the lack in awareness about health and safety knowledge. Safety climate calculate the observations of the working personnel. The factors like experience, type of employment, education, age, smoking habits, marital status and dependents are the major demographical factors that influenced the construction safety [6]

## 2. Safety

Safety is a situation in which risks are managed to the acceptable levels. It is the activity that seeks to minimize or eliminate hazardous conditions that can cause bodily injury [7]

### 2.1 Occupational Safety

Occupational safety is related where people work and the corresponding risks in the areas, normally these areas include construction sites, offices, farms, manufacturing plants and commercial as well as retail facilities [8]

3 SAFETY CLIMATES

Considering the term safety climate, it was defined as a summary of molar perceptions that employees share about their work environments [9] . The term of safety climate with respect to its definition is sometimes used interchangeably with the term safety culture [10]. In order to define the attitudes of the employees towards safety both safety culture and safety climate terminologies can be accepted widely [11]. Safety climate is frequently observed as a reflection of fundamental culture followed by any organization. Safety climate is sometimes also considered as a sub-component of term safety culture, which means the comparative importance of safety inside the organization [12]

## II. RESEARCH METHODOLOGY

In this research study the multiple data collection method was used. Questionnaire survey was the main data collection tool. After the collection of data Cronbach's Coefficient Alpha method and Shapiro-Wilk Normality Test were performed for the reliability of collected data.

4.1 SAMPLE

Total 460 valid responses were collected from 36 different construction site within Pakistan that is equal to 90.53% of distributed questionnaires. It is representing a true sample of data collection. The response from clerical staff was the least that is only nine which termed to be unclassified categories and discarded from the sample, so the sample size reduced to 208 and the ratio of Managers, Supervisors and workers was about 1.6: 1.0: 2.3. From the 460 employees, according to the data collected, 1.3% of the responded workers were found to be younger than 20 years, more than 55.5% of workers were found between the ages of 21 to 30 years old, almost 26.0% of the responded workers were found between 31-40 years, almost 8.20% of the workers were found between the age of 41 to 50 years old and rest 8.6% of the workers were found older than 50 years. So, it means that in majority of the civil engineering construction projects the workers are quite young and energetic.

5. MEAN SAFETY CLIMATE SCORE (MSCS)

With respect to demographical factors the Mean Safety climate score, projects types and company category provides insight for different dimensions.

DEMOGRAPHIC FACTORS

Demographic factors like employment status, education level, age, education level, marriage status, experience in the industry and dependents, have been considered for this study.

It is clear from the Figure 1 that the age group (41 to 50 Years) has better mean safety score among the others and hence this group has strong and better perception towards construction safety on the construction sites.

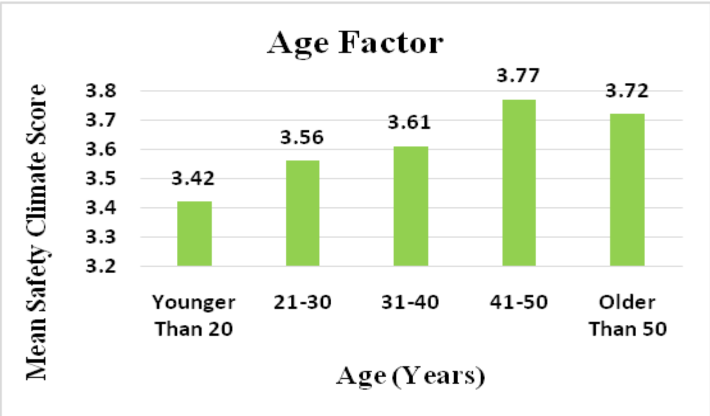


*Figure 1:* MSCS – Age

It is clear from the Figure 2 that the married respondents have better mean safety climate score then the single respondents and that is why their perception towards construction safety is much higher and better on construction sites.

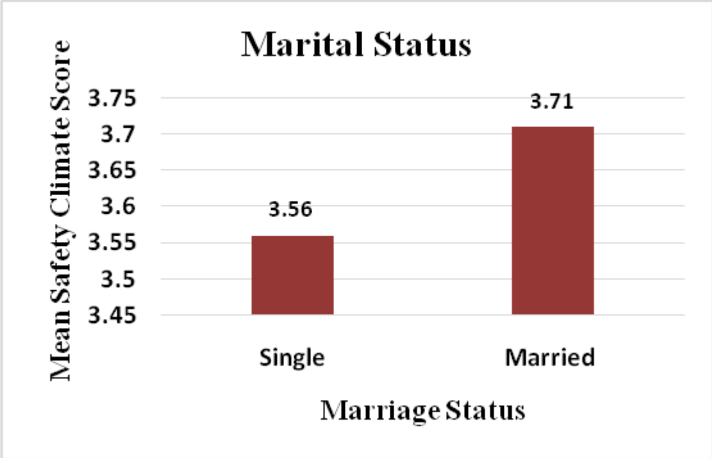


*Figure 2:* MSCS - Marriage Status

It can be seen from the Figure 3 that the respondent having more dependents (>7) have much better mean safety climate score of strong perceptions towards construction safety.

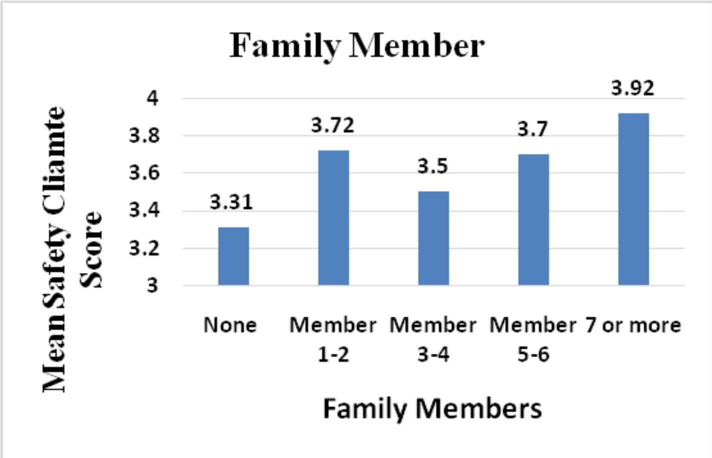


*Figure 3:*MSCS - Family members/dependents

It is clear from the Figure 4 that mean safety climate score is more than average level for all the education level of employees working at sites.

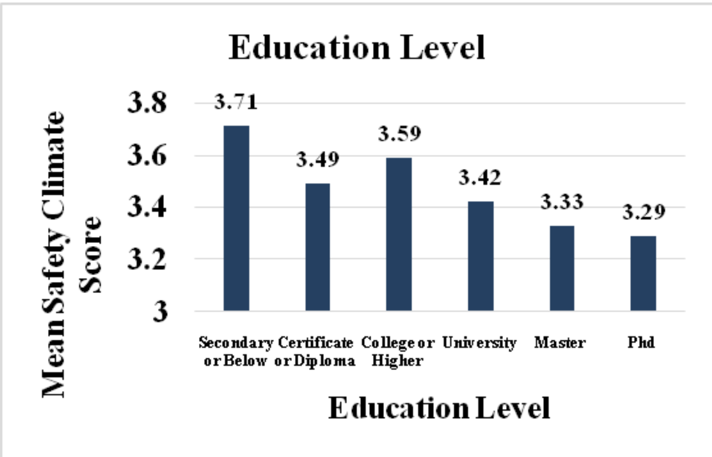


*Figure 4:* MSCS - Educational level

It is clear from the Figure 5 that the respondents working in the projects of joint venture have better mean safety score among the others and that is why they have better perceptions towards construction safety.

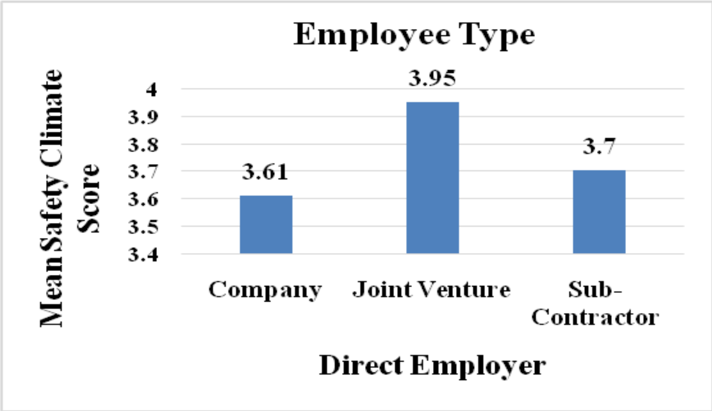


*Figure 5:* MSCS – Direct Employer

It is clear from the Figure 6 that the respondents having more than 16 years' experience have better mean safety score, have better perceptions towards the construction safety.

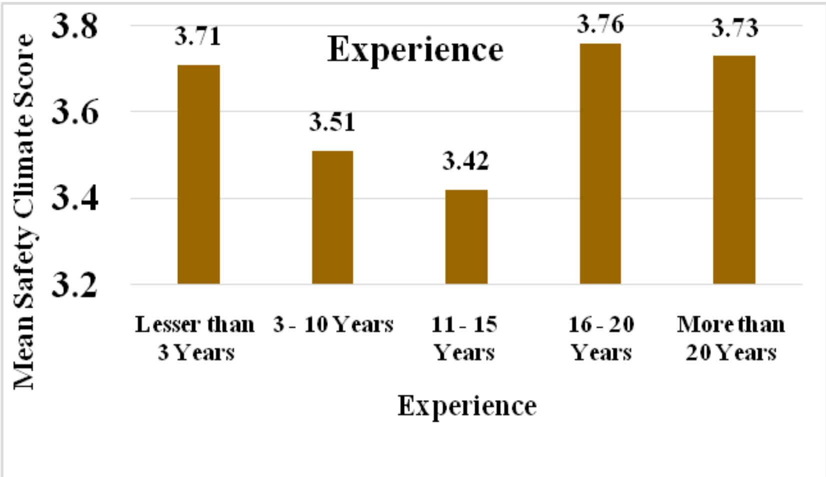


*Figure 6:* MSCS – Experience

If we talk about the effect of project type of the construction safety, from different types of projects at least three projects have been taken. From the data the lowest score (2.35) has been found for the Facility Building projects and Bridge projects found on highest side (4.12) among all the projects types.

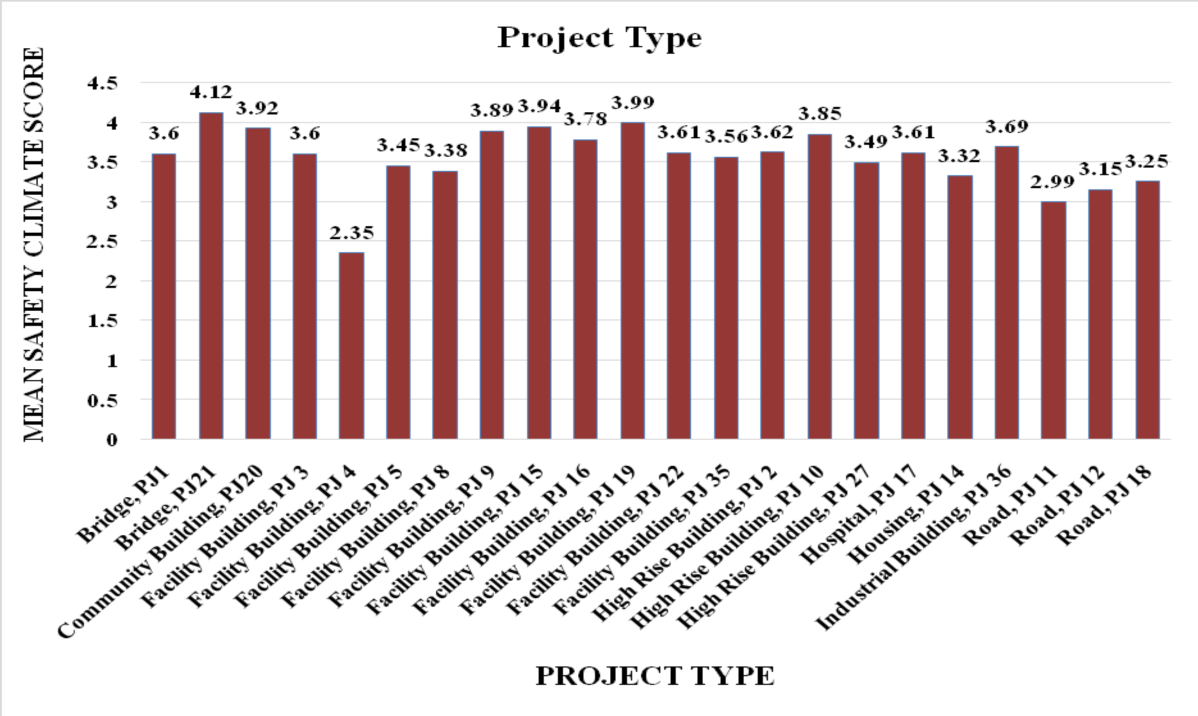


*Figure 7:* MSCS – Project Type

It is clear from the Figure 7 that Bridge Projects have better construction safety than other projects as the Bridge Projects are very complex in nature and the lot of hazards can be there at the site of Bridge Projects. As there is lesser complexity and lesser hazards in the building projects that is why these projects have lesser construction safety score.

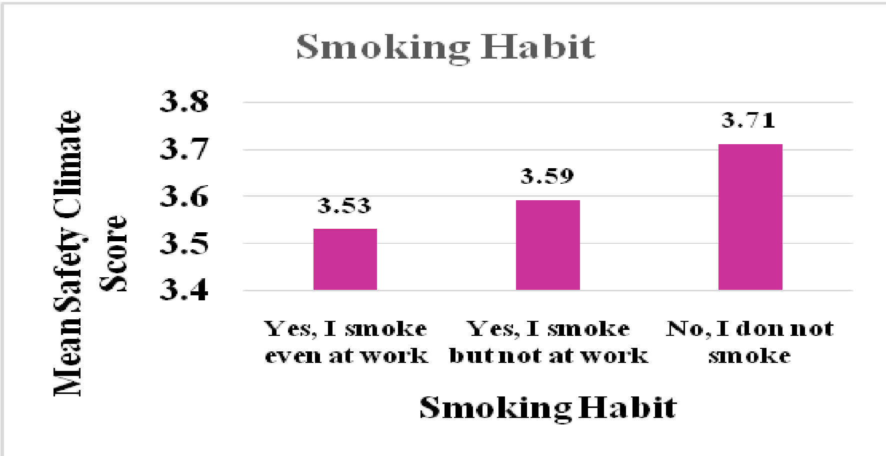


*Figure 8:* MSCS – Smoking Habit

It is clear from the Figure 8 that the respondents who do not have smoking habit have better mean safety score and that is why have better perception towards the construction safety at site.

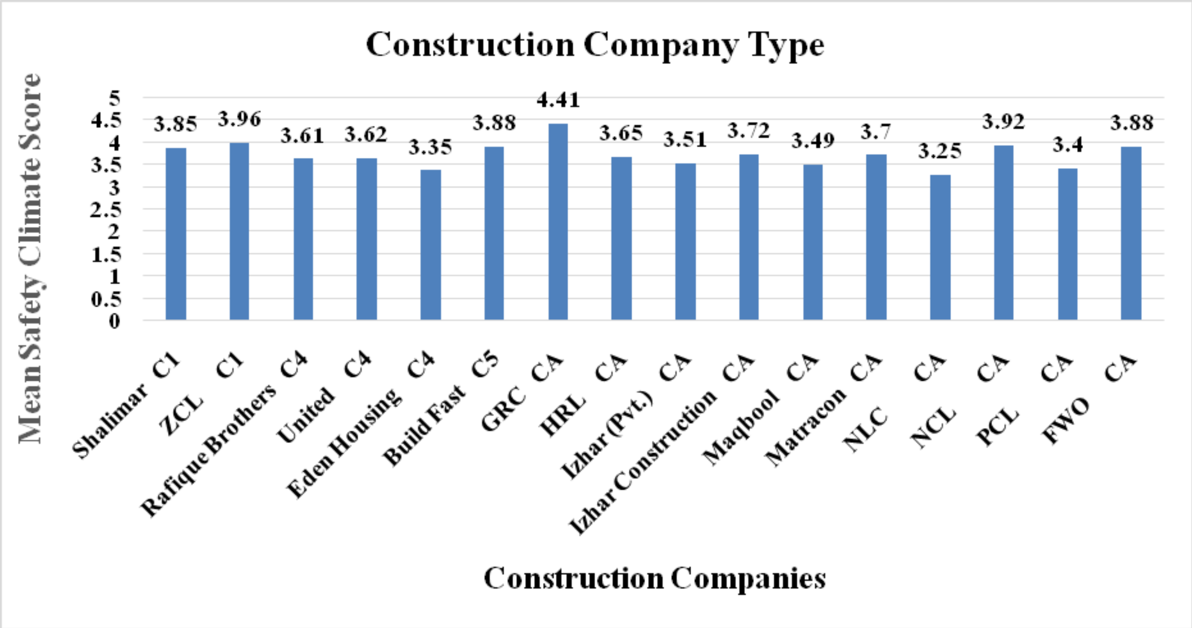


*Figure 9:* MSCS – Company Type

It is clear from the data analyzed that among 21 constructions company's categories ranged as CA, CB, C1, C2, C3, C4, C5, and C6 by Pakistan Engineering Council (PEC), the construction safety climate level has been investigated. It can be seen from Figure 9 that CA companies have minimum 3.25 construction safety score and CA have maximum construction climate safety score 4.41. Companies in Low category have better perception towards construction climate safety as compare to the larger companies.

## III. Conclusions and Recommendations

The basic theme of this study was achieved by using the relationship between the mean safety climate score with the demographical factors including company type, project types, nature of employee, age and educational level of the workers. The results were obtained by comparing the mean construction safety score and the values that obtained from the questionnaire. In this study the factors which were reviewed were age factors, marriage status, number of family members, educational level, employee type, total experience, smoking habit, project type and the company type. The factors that have clear perceptions are married respondents, respondents with more than 7 family member dependents, age group (41 to 50 years), respondents having only basic education level, respondents working in joint venture projects, respondents having more than 16 years' experience, and respondents who do not smoke,

The maturity level of the workers is going to increase in the later stage of their service life and with the help of this experience they used to address more safety aspects and scrutinized the hazardous situations. The social obligation that is connected to life of people is catering in the better way by the marriage people as compare to the single ones.

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# A New Open Iterative Method for Solving Nonlinear Equations Arising in Civil Engineering Problems

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***Abstract:*** **In this paper, a new open iterative method has been suggested and analyzed for solving Civil Engineering problems. The purpose of proposed iterated method is proposing a mathematical tool for solving all possible root of polynomial of higher degree functions and transcendental functions. Open iterated method has second order of convergence and derived from Quadrature Formula. Few physical problems to demonstrate the competency of proposed iterative method with the Newton Raphson Method. C++ and EXEL are used to examine the outcomes and graphical representation of proposed method. Henceforth, it has been observed from the results and comparison of new open method is that the new second order open method is superior than Newton Raphson Method.**

***Keywords:*** **Application Problems, Quadrature formula, Order of convergence, Accuracy, Error.**

## I. INTRODUCTION

The world is occupied of such physical phenomena that can be modeled mathematically, finding solutions to those physical problems is worth knowing. It is often the case while finding out solutions to the physical world problems by applying mathematics in the form of an equations, that the exact formulas or analytical schemes are not capable of handling complexity of such problems, there numerical techniques are employed to get the solutions [1]. Moreover, the root finding problem is one of the most relevant and attracted problems. It arises in a wide variety of practical applications in Physics, Chemistry, Biosciences, Engineering [2-3] for example: Distance, rate, time problems, population change, Trajectory of a ball, such as non-linear equation

$$f(x) = 0 \qquad ---(1.1)$$

Due to importance of Eq. (1.1) several numerical methods had been offered and investigate under certain circumstances. Such as one of the most effective method is Newton Raphson Method. This method is fast converging and second Quadratically converge techniques but are not reliable because keeping pitfall [4]. However, it is most useful and vigorous numerical techniques. Similarly, in literature several modifications had been done by using Newton Raphson techniques for finding a single root of a nonlinear equation [5-7]. In numerical analysis order of convergence and computational efficiency become an efficient way to obtain approximate solution and it has been vigorous field of research. various numerical methods have been developed for order of convergence and computational efficiency using different techniques including finite differences, Taylor series, homotopy perturbation method and its variant forms, quadrature formula, variation an iteration method, and decomposition method [8-14]. In this paper, a new open method has been offered for solving Civil Engineering problems. To apply this technique, we first use the new series representation of the nonlinear function. We rewrite the nonlinear equations as a coupled system of nonlinear equations. Proposed open iterative method is very simple as compared with existing method. The proposed method has second order of convergence, and it has derived from Quadrature rule. Several numerical examples are given to illustrate the efficiency and the performance of the new open iterative method. Our results can be considered as an important improvement and refinement of the previously results.

## II. ITERATIVE METHOD

The New Iterative Method is developed by using Quadrature Formula and the fundamental theorem of calculus, Eq. (1.1) can also be written as,

$$f(x) = f(x_0) + \frac{h}{2}[f'(x_0) + 2f'(x_1) + f'(x_2)] \qquad (2.1)$$

Where n=2 then h become,

$$h = \frac{(x - x_0)}{2}$$

h substitute in Eq. (2.1), we get

$$f(x) = f(x_0) + (x - x_0)[\frac{f`(x_0) + 2f`(x_1) + f`(x_2)}{4}] \quad (2.2)$$

Where $x_0$ is an initial guess sufficiently close to root `x` and $f(x) = 0$, then Eq. (2.2) become

$$x = x_0 - \frac{4f(x_0)}{f`(x_0) + 2f`(x_1) + f`(x_2)} \quad (2.3)$$

As we know that numerical technique, such as

$$x_1 = x_0 + f(x_0) \quad (2.4)$$
$$x_2 = x_0 + 2f(x_0) \quad (2.5)$$

Substitute Eq. (2.4) and Eq. (2.5) in Eq. (2.3), we get

$$x = x_0 - \frac{4f(x_0)}{f`(x_0) + 2f`(x_0 + f(x_0)) + f`(x_0 + 2f(x_0))}$$

In general

$$x_{n+1} = x_n - \frac{4f(x_n)}{f`(x_n) + 2f`(x_n + f(x_n)) + f`(x_n + 2f(x_n))} \quad (2.6)$$

Hence Eq. (2.6) is a New Open Iterative Method.

## III. CONVERGENCE OF ITERATED METHOD

In this section, we give the main results of this paper. We will give here the Mathematical proof that the Algorithm Eq. (2,6) has second order of convergence.

**Proof:**

By using Taylor series, we are expanding $f(x_n)$, $f`(x_n)$ $f`(x_n + f(x_n))$and $f`(x_n + 2f(x_n))$ only second order term about `a`, we obtain

$$f(x_n) = e_n f`(a) + e^2{}_n \frac{f``(a)}{2} \quad ---(i)$$

$$f(x_n + f(x_n)) = (e_n + f(x_n))\, f`(a) + (e_n + f(x_n))^2 \frac{f``(a)}{2} \quad ---(ii)$$

$$f(x_n + 2f(x_n)) = (e_n + 2f(x_n))\, f`(a) + (e_n + 2f(x_n))^2 \frac{f``(a)}{2} \quad ---(iii)$$

By using $c = \frac{f``(a)}{2f`(a)}$ in Eq. $(i)$, Eq. $(ii)$ *and* Eq. $(iii)$ for more simplify, we get

$$f(x_n) = e_n f`(a)(1 + ce_n) \quad ---(iv)$$
$$f`(x_n) = f`(a)(1 + 2ce_n) \quad ---(v)$$

$$f(x_n + f(x_n)) = (e_n + f(x_n))\, f`(a) + (e_n + f(x_n))^2 \frac{f``(a)}{2}$$

Eq. (iv) and Eq. (v) substitute in above, we get

$$f`(x_n + f(x_n)) = f`(a)(1 + f`(a)(1 + 2ce_n))\,[1 + 2ce_n(1 + f`(a))]$$

$$f`(x_n + f(x_n)) = f`(a)\,[1 + f`(a) + 2ce_n + 6ce_n f`(a) + 2ce_n f`^2(a)] \quad ---(vi)$$

Now,

$$f(x_n + 2f(x_n)) = f`(a)\,[(e_n + 2f(x_n)) + c(e_n + 2f(x_n))^2]$$

$$f`(x_n + 2f(x_n)) = f`(a)\,[(1 + 2f`(x_n)) + 2c(e_n + 2f(x_n))(1 + 2f`(x_n))]$$

Using Eq. (iv) and Eq. (v) in above, we get

$$f`(x_n + 2f(x_n)) = f`(a)\left[(1 + 2f`(a)(1 + 2ce_n)) + 2c(e_n + 2e_n f`(a)(1 + ce_n))(1 + 2f`(a)(1 + 2ce_n))\right]$$

$$f`(x_n + 2f(x_n)) = f`(a)\,[1 + 2f`(a) + 2ce_n + 12ce_n f`(a) + 8ce_n f`^2(a)] \quad ---(vii)$$

by using Eq. $(v)$, Eq. $(vi)$ *and* Eq. $(vii)$, *we get*

$$\begin{aligned} f`(x_n) + 2f`(x_n + f(x_n)) + f`(x_n + 2f(x_n)) \\ = f`(a)\big[1 + 2ce_n + 2\big(1 + f`(a) + 2ce_n + 6ce_n f`(a) + 2ce_n f`^2(a)\big) + 1 + 2f`(a) + 2ce_n \\ + 12ce_n f`(a) + 8ce_n f`^2(a)\big] \end{aligned}$$

$$f`(x_n) + 2f`(x_n + f(x_n)) + f`(x_n + 2f(x_n)) = 4f`(a)\,[1 + f`(a) + ce_n(2 + 6f`(a) + 3f`^2(a))] \quad ---(viii)$$

by using Eq. $(i)$ *and* Eq. $(viii)$ *in* Eq. $(2.6)$, *we get*

$$e_{n+1} = e_n - \frac{4e_n f`(a)(1+ce_n)}{4f`(a)[1+f`(a)+ce_n(2+6f`(a)+3f`^2(a))]}$$

$$e_{n+1} = -e_n f`(a) - ce^2{}_n(3-5f`(a)-3f`^2(a)) \quad ---(ix)$$

By using Eq. (1.1) in Eq. $(i)$ then substitute in Eq. $(ix)$, we get

$$e_{n+1} = f``(a)e_n{}^2 - ce^2{}_n(3-5f`(a)-3f`^2(a))$$

$$e_{n+1} = e^2{}_n[f``(a) - c(3-5f`(a)-3f`^2(a))]$$

Hence this proves that the proposed iterative method Eq. (2.6) has second order of convergence.

## IV. RESULTS AND DISCUSSIONS

The proposed second order open method is applied on few physical problems, and developed method equated with the Newton Raphson Method, such as physical problems

**Example-1:** The equation $\sin^2x-x^2+1$ governing the mass of the jumper. Use the suitable techniques to compute approximately the mass of the jumper under free fall.

**Example-2:** Find the root of $f(x)=0$. The pollutant bacteria concentration in a lake varies as $2x - lnx - 7 = 0$ with $x_0 = 6$, then calculate the displacement \`x\` for the bacteria concentration.

**Example-3:** The volume of the gas depends on the temperatures. Volume $v_1$ and $v_2$ of two gases under ideal situation given by $v_1 = e^{-x}$ *and* $v_2 = cosx$ \`x\` being the temperature. For what value of \`x\` are the volumes of the gases equal (such as $e^{-x} - cosx$ =0 with $x_0$=4).

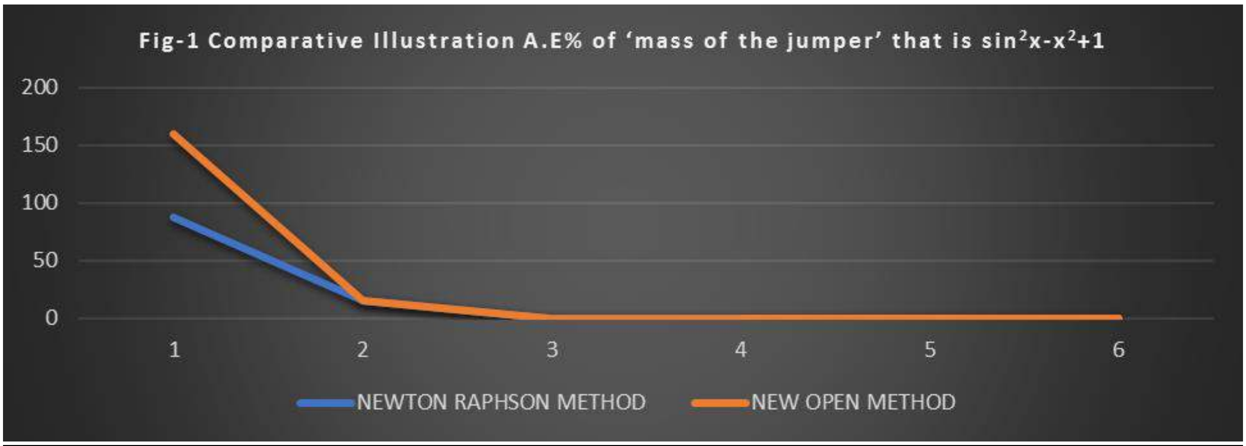
**Example-4:** In the analysis of the anti-symmetric buckling of a beam, a factor \`x\` satisfies (1, 3) and $Sinx = x - 1$. Determine the \`x\` by using any techniques.

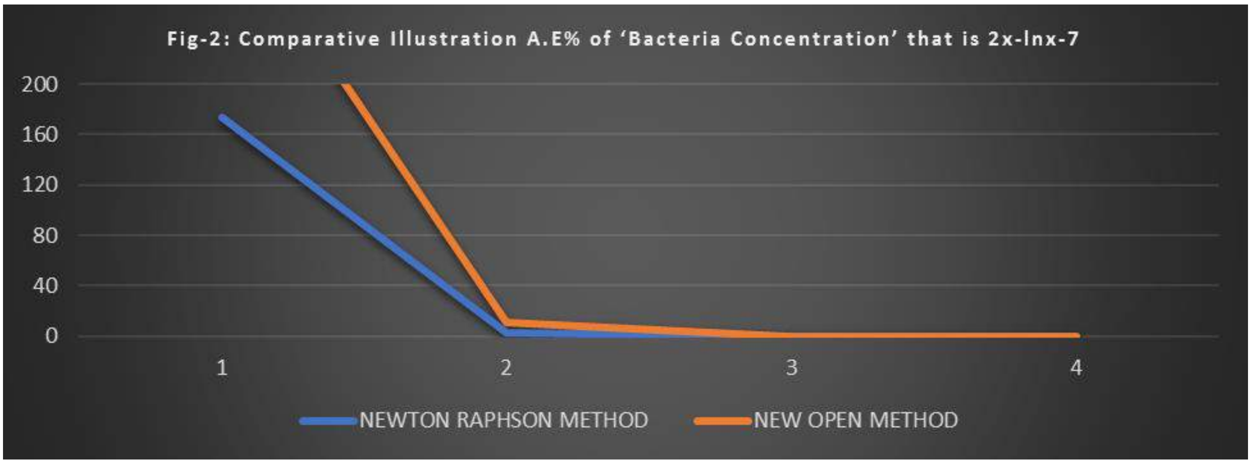
**Example-5:** Find the diameter \`x\` of the pipe which satisfies the flow equation $2x^2 - 5x - 2 = 0$ with $x_0$=0

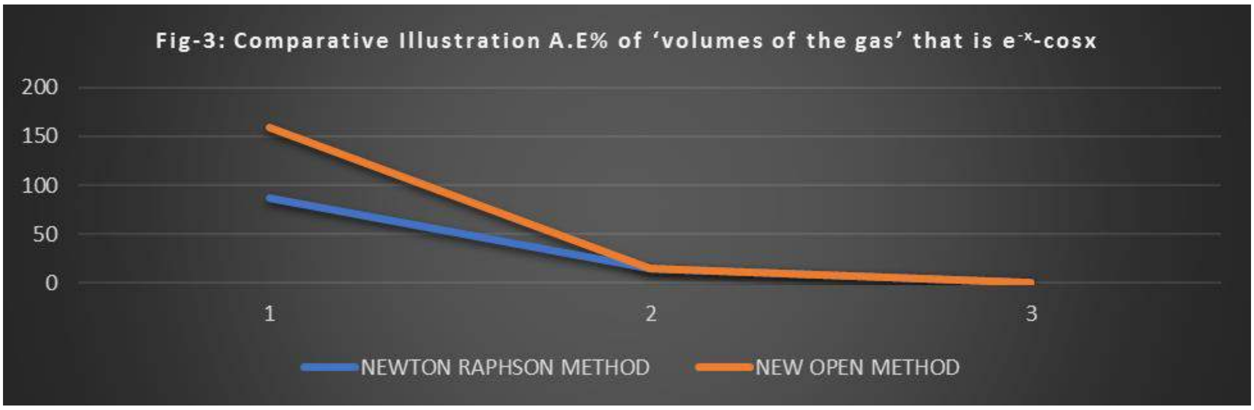
Such as Table-1 and figures, we have

**TABLE-1**

| FUNCTIONS | METHODS | ITERATIONS | X | A E % |
|---|---|---|---|---|
| **$\sin^2x-x^2+1$** | Newton Raphson Method | 5 | 1.40449 | $5.96046e^{-7}$ |
| **$x_0$=1** | New Open Method | 3 | | $2.51412e^{-4}$ |
| **2x-lnx-7** | Newton Raphson Method | 4 | 4.21991 | $4.76837e^{-5}$ |
| **$x_0$=6** | New Open Method | 3 | | $1.39236e^{-2}$ |
| **$e^{-x}$-cosx** | Newton Raphson Method | 3 | 4.72129 | $1.21212e^{-3}$ |
| **$x_0$=4** | New Open Method | 2 | | $7.47204e^{-4}$ |
| **$2x^2$ -5x-2** | Newton Raphson Method | 5 | 0.350781 | $2.98023e^{-8}$ |
| **$x_0$=0** | New Open Method | 4 | | $5.24521e^{-6}$ |
| **Sinx-x+1** | Newton Raphson Method | 5 | 1.93456 | $5.84126e^{-6}$ |
| **$x_0$=1** | New Open Method | 5 | | $1.19209e^{-7}$ |






For the physical problems in Table-1 as well as graphical representations, it has been perceived that the developed technique is reducing the number of iterations and decent accuracy standpoint as the comparison of Newton Raphson Method. Mathematical package, such as C++ and EXCEL are used to examine the proposed Iterative Method. In the interim, from results and comparison of new open Method with the Newton Raphson Method is that the new second order Iterative Method is performance healthier to find the Engineering problems.

## V. CONCLUSIONS

In this paper, a new open iterative method has been constructed for solving application problems which arises in a practical application in Civil Engineering or Engineering and Science. The proposed method is derived by using quadrature formula and the fundamental theorem of calculus. We have also proven the convergence of the proposed methods, which is of order two. During the study, it has been concluded that the proposed method is loftier than Newton Raphson Method from accuracy outlook as well as iterative perception. Henceforth the new open method is fast converging, perform-well and more competent as assessment on Newton Raphson Method for solving application problems.

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