ISSN: 1813-1786 (Print)
ISSN: 2313-7770 (Online)
Volume No. 20
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TECHNICAL JOURNAL

(Quarterly)

for online access please visit http://web.uettaxila.edu.pk/techjournal/index.html

2015

University of Engineering and Technology Taxila, Pakistan

Vol: 20 **No. III (Jul - Sep)**

AIM & SCOPE

"Technical journal is a multidisciplinary journal in the field of engineering science and technology that offers platform for researchers, engineers and scientists to publish their original and to date research of high scientific value. It is a double blind peer-reviewed open access academic journal, published quarterly by University of Engineering & Technology, Taxila, Pakistan. Articles published in the Journal illustrate innovations, developments and achievements in the field of engineering and technology. The journal is being published electronically as well as in print form."

Technical Journal

A Quarterly Journal of University of Engineering & Technology (UET) Taxila, Pakistan
Recognized by Higher Education Commission (HEC)
Y Category

ISSN: 1813-1786 (Print) ISSN: 2313-7770 (Online)
Volume No. 20 (Quarterly)
No. III (Jul - Sep)
2015

Phone: 92 - 51 - 9047298 **Fax: 92 - 51 - 9047420** **E-Mail: technical.journal@uettaxila.edu.pk**

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CONTENTS

Influence of Aggregate Characteristics on the Compressive Strength of Normal Weight Concrete

M. A. Qureshi[1], M. Aslam[2], S. N. R. Shah[3], S. H. Otho[4]

[1]*Geotechnical and Highway Division, Civil Engineering Department, Mehran University of Engineering & Technology, Jamshoro, Pakistan*
[2]*Civil Engineering Department, University of Malaya, Kuala Lumpur, Malaysia*
[3]*Civil Engineering Department, Mehran University of Engineering & Technology, SZAB Campus, Khairpur Mir's, Pakistan*
[4]*Abdullah Sports Tower, Hyderabad, Pakistan*
[4]Shahid.h.otho@gmail.com

Abstract-Experimental investigations on the properties of concrete have been performed around the globe and their correlation is interpreted in relevant design codes. The structural behavior of cement concrete significantly relies on the material resources, properties of the aggregates constituting the concrete and the local construction practice. These factors vary from place to place. Therefore, the compressive strength of concrete prepared from the aggregates available in one locality may not be directly applicable to the other areas. The purpose of this study is to evaluate the Influence of locally available coarse aggregates on the compressive strength of normal weight concrete (NWC) prepared under local environmental conditions of district Khairpur Mir's, Sindh, Pakistan. The coarse aggregates were collected from five different quarries in the vicinity of Khairpur Mir's, Pakistan. In total, 180 cubes were tested. 10 different batches were formed in order to arrange individual characterization of concrete. Each batch was contained of 18 cubes and each quarry contains 2 batches making a total of 36 cube with four different ratios for each quarry. Dry density and compressive strength of concrete was calculated and a comparison is provided as a guideline for the future construction work in the local community.

Keywords-Quarry, Aggregates, Khairpur Mir's, Cement Concrete, Compressive Strength

I. INTRODUCTION

Concrete prepared with Portland cement is considered as the most resourceful and multipurpose construction material in the civil engineering industry. Global production of concrete is about 12 billion tons a year [i] corresponding to almost 1 m^3per person per year [ii]. Yearly cement production levels are about 3 billion tons [i]. However, the relatively unreliable durability of concrete exposed to adverse circumstances for long term is always a hot issue under discussion for researchers. Since up to 80% of the total concrete volume comprises of aggregates, therefore, the properties of aggregates such as the shape, texture, grading influence workability, finish ability, bleeding and segregation of fresh concrete have important influence on the behavior of concrete.

During last few decades, the use of large-sized coarse aggregates has been considerably increased in concrete engineering for economic and environmental reasons. There is a growing research interest to understand the effect of maximum aggregate size on the characteristics of normal weight concrete (NWC) and high strength concrete (HSC) due to the uncertainty of the interfacialbond stress transition between the aggregates and matrix which are regarded as the weakest link in concrete [iii]. Following this, improper mix proportions and diversity in grading may result in durability complications. Concrete strength is determined depending upon the curing conditionseither through the bond between the cement paste and coarse aggregate and/or by the interlocking characteristics of aggregates. Irregular surfaced cubical aggregates are considered as finest solution to achieve an optimal bond between aggregates and cement, and provide high values of strength [iii].

Several researchers studied the influence of various types of aggregates on the strength of structural concrete. Reference [iv] studied the effect of aggregate size on the softening branch of concrete by conducting the uniaxial, bi-axial and tri-axial compression tests and found that the concrete made with large sized aggregates showed more ductile behavior in the post-peak branch. Their resultscould be applied only on NWC. According to [v] studied the effects of aggregate size on the softening response and brittleness of HSC by performing three point bending tests. The results showed thatin HSC without silica fume, the fracture energy increased with the largest sized aggregates. Reference [vi] performed numerical investigations and concluded that the heterogeneity of

disordered materials has a strong influence on the shape of the stress-strain curves and the loading bearing capacity of concrete prisms. Their results showed that the relatively heterogeneous specimen emitted more acoustic emission events prior to the macro-fracture as compared to homogeneous specimen. Furthermore, a higher stress drop was observed correspondent to the higher event rate in relatively homogeneous specimens. According to [vii] carried out tests on concrete containing spherical aggregates of different sizes to study the effect of the aggregate size on the performance of concrete. The study revealed that the aggregate size was inversely proportional to the tensile strength. However, the compressive strength increased slightly with the increase in the size of aggregate.

The structural behavior of concrete is considerably guided by taking into account of various factors including the source from where aggregates are collected, the estimation of properties of aggregates and the description of material sources. The knowledge of these factors can produce a handy information about locally prepared concrete to be used as a reference in future works.Indeed, the properties of concrete and the experimental testing conditionsare significantly responsible for the resultant structural performance of concrete.The experimental conditions take account of the stiffness of the testing machine, the boundary conditions, and thegeometry of samples, the strain rate, and the loading method. Concrete characteristics include variables such as the mechanical and physical properties of the cement and aggregates and the water cement (w/c) ratio. Since these parameters are different from place to place, thus the strength of the prepared concrete varies place to place.

This study intends to provide a conceptual framework for the use of aggregates based on their physical and mechanical properties for their use in local construction and evaluates the strength of structural concrete prepared with locally available aggregates of different quarries in Khairpur Mir's district under different curing time periods. The effects of the shape, texture and grading characteristics of aggregates on concrete strength were also studied. Field investigations were performed to the quarries and crushing plants of Khairpur for characterization. The gravels collected from quarries were utilized for laboratory examination. Packing density concepts and surface area concept were used for concrete proportioning. The location of quarries is shown in Fig. 1.

Fig. 1. The Locations of the sites from where the aggregates were collected

II. Experimental Programme

The coarse aggregates selected from five different quarries named as Obhan Shah Quarry (OSQ), Chattan Shah Quarry (CSQ), Goal Pahari Quarry (GPQ), Darak Quarry (DQ) and Jara Takar Quarry (JTQ). The main source of all the quarries are enormous sedimentary rocks. These rocks are blasted before performing crushing, screening and washing. Along with concrete preparation, other major utilizations of such aggregates are earth works, preparation of asphalt and rip-rap for stabilization. The other basic contents generated due to the interaction with water are removed. The high temperature of the area also destabilizes the rock to weathered condition.

A. Materials and Properties

The size of coarse aggregates selected for this study ranges between 5-20 mm. In total, 180 cubes were tested. 10 different batches were formed in order to individual characterization of concrete. Each batch contains 18 cubes and each quarry contains 2 batches making a total of 36 cube with four different ratios for each quarry. The Ordinary Portland cement (ASTM type I) with a specific gravity of 3140kg/m^3 and fineness of 351 m^2/kg is used. Potable drinking water is used in concrete mixtures. Aggregates are classified as fine and coarse aggregates and the detailed properties are given in Table I. The local mining sand was used as fine aggregate with the maximum size of 4.75 mm. The other properties of fine aggregates are: specific gravity 2.60, fineness modulus 2.51 and bulk density 1460 Kg/m^3. Fig. 2 shows the gradation of the different types of coarse aggregates and local mining sand.

TABLE I
DETAILS OF ALL THE AGGREGATES COLLECTED FROM DIFFERENT QUARRIES

Crushed stones								
Properties	**OSQ**	**CSQ**	**GPQ**	**DQ**	**JTQ**	**Allowable limits**	**Suitability**	**Remarks**
Color	Grey	Grey	Grey	Grey	Grey	-	-	-
Maximum Size (mm)	20	20	20	20	20	-	-	-
Bulk Specific gravity	2.65	2.66	2.6	2.61	2.59	2.5-3.0	2.5-3.0	-
Compacted bulk density (Kg/m^3)	2365	2350	2375	2385	2355	2400	2400	-
Flakiness Index	42.0	41.5	42.2	33.0	36.8	Max. 15%	Max. 15%	High
Elongation Index	4.32	4.8	5.35	8.95	10.1	Max. 25%	Max. 25%	Low
Water absorption (%)	0.30	0.3	0.42	0.38	0.58	0.1-2.0%	0.1-2.0%	Medium
Crushing value (%)	20.2	20.4	24.5	26.2	23.8	Max. 27%	Max. 30%	Medium
Impact Value (%)	14.8	15.6	16.4	17.7	16.8	Max. 23%	Max. 27%	Medium
LA Abrasion Value (%)	24.4	25.8	26.8	30.8	28.5	Max. 30%	Max. 35%	Medium

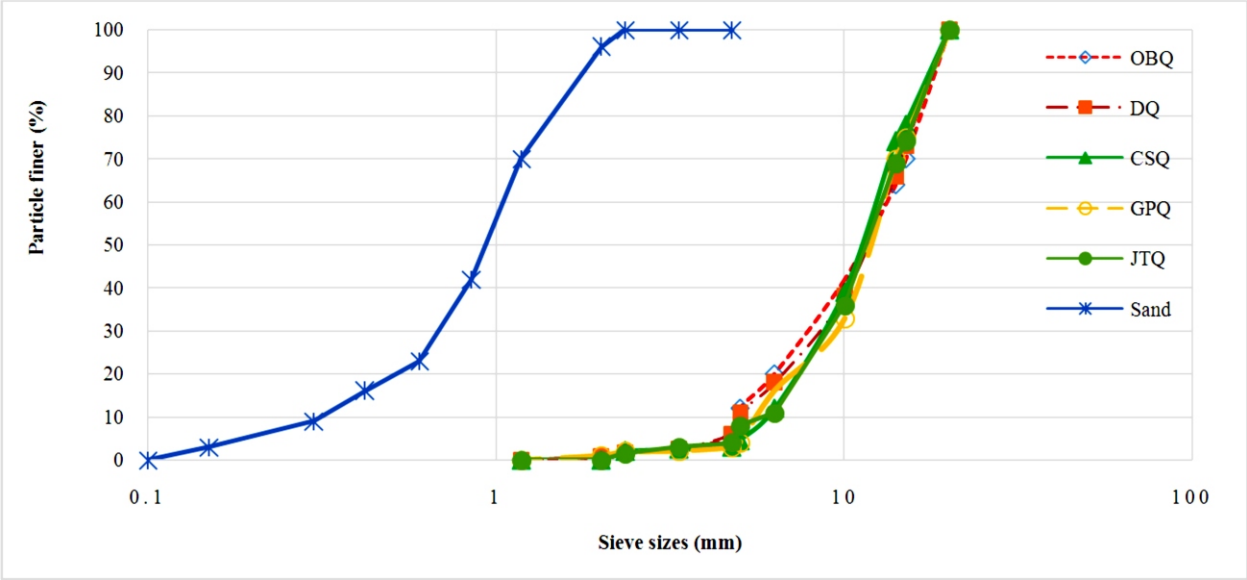


Fig. 2. Gradation of the aggregates (Coarse and Sand)

B. Mix Proportioning

The mix proportions were selected according to the requirement of different types of aggregates. The ACI mix design approach was used to design the normal weight concrete. The concrete fabrications are divided into ten different batches, two batches from each type coarse aggregate. The two different w/c ratios (0.50 and 0.55) and mix proportions (1:2:4 and 1:1.5:3) were selected to divide the specimens. The distribution of the specimens into different batches with different types of aggregates and w/c ratio is shown in Table II.

C. Test methods and curing duration

The cement and aggregates were blended in a mixer for two minutes. A mixture of 70% mixing water was added to the mixture and mixing was continued for another 3 minutes. The remaining water was further added and mixed for another 5 minutes prior to slump test. Later, the slump test was conducted. After slump test, the concrete specimens were cast in steel moulds of 100 mm cubes to calculate compressive strength. Specimens were compacted using vibrating table. The concrete specimens were demoulded one day after casting. An average result of mechanical properties was obtained after testing three specimens. For determining the effect of the curing duration on the compressive strength of concretes, the specimens were properly cured, and are as follows:

a) Continuous moist curing (C1): specimens were immersed in water at a temperature of

24±3°C for 7 days.

b) Continuous moist curing (C2): specimens were immersed in water at a temperature of 24±3°C for 14 days.

c) Continuous moist curing (C3): specimens were immersed in water at a temperature of 24±3°C for 28 days.

TABLE II
DETAILS OF ALL BATCHES OF SPECIMENS (CASTED AND TESTED)

S. No	Batch	Mix ratio	W/c ratio	Quarry	No: of specimens
1	B-1 (A)	1:2:4	0.50	OS	9
2	B-1 (B)	1:2:4	0.55	OS	9
3	B-2 (A)	1:1.5:3	0.50	OS	9
4	B-2 (B)	1:1.5:3	0.55	OS	9
5	B-3 (A)	1:2:4	0.50	CS	9
6	B-3 (B)	1:2:4	0.55	CS	9
7	B-4 (A)	1:1.5:3	0.50	CS	9
8	B-4 (B)	1:1.5:3	0.55	CS	9
9	B-5 (A)	1:2:4	0.50	GP	9
10	B-5 (B)	1:2:4	0.55	GP	9
11	B-6 (A)	1:1.5:3	0.50	GP	9
12	B-6 (B)	1:1.5:3	0.55	GP	9
13	B-7 (A)	1:2:4	0.50	D	9
14	B-7 (B)	1:2:4	0.55	D	9
15	B-8 (A)	1:1.5:3	0.50	D	9
16	B-8 (B)	1:1.5:3	0.55	D	9
17	B-9 (A)	1:2:4	0.50	JT	9
18	B-9 (B)	1:2:4	0.55	JT	9
19	B-10 (A)	1:1.5:3	0.50	JT	9
20	B-10 (B)	1:1.5:3	0.55	JT	9

III. RESULTS

A. Slump

Table III shows the slump values of all the mixes with different w/c ratios. The substitution of higher water content in the mix proportion of 1:2:4 was resulted in higher slump value as compared to the other mixes. This shows that by increasing the amount of coarse aggregates and w/c ratio in the concrete mixture, the slump value also increases.

B. Density

All types of selected coarse aggregates have closer values of the specific gravity and bulk density, Table I, hence the density of the concrete was not affected. Two types of density tests were conducted for all types of mixes. The demoulded density was measured immediately after demoulding the samples, whereas the oven dry density was measured after 28 days. It was observed that the dry density of the concrete specimens was found almost similar for all types of the concrete mixes.

TABLE III
SLUMP VALUES OF ALL MIXES

S. No	Batch	Mix ratio	w/c ratio	Quarry	Slump (mm)
1	B-1 (A)	1:2:4	0.50	OS	31
2	B-1 (B)	1:2:4	0.55	OS	35
3	B-2 (A)	1:1.5:3	0.50	OS	27
4	B-2 (B)	1:1.5:3	0.55	OS	25
5	B-3 (A)	1:2:4	0.50	CS	32
6	B-3 (B)	1:2:4	0.55	CS	34
7	B-4 (A)	1:1.5:3	0.50	CS	28
8	B-4 (B)	1:1.5:3	0.55	CS	26

S. No	Batch	Mix ratio	w/c ratio	Quarry	Slump (mm)
9	B-5 (A)	1:2:4	0.50	GP	33
10	B-5 (B)	1:2:4	0.55	GP	36
11	B-6 (A)	1:1.5:3	0.50	GP	26
12	B-6 (B)	1:1.5:3	0.55	GP	29
13	B-7 (A)	1:2:4	0.50	D	30
14	B-7 (B)	1:2:4	0.55	D	38
15	B-8 (A)	1:1.5:3	0.50	D	29
16	B-8 (B)	1:1.5:3	0.55	D	30
17	B-9 (A)	1:2:4	0.50	JT	31
18	B-9 (B)	1:2:4	0.55	JT	38
19	B-10 (A)	1:1.5:3	0.50	JT	29
20	B-10 (B)	1:1.5:3	0.55	JT	27

TABLE IV
DENSITIES OF THE SELECTED MIX PROPORTIONS

S. No	Batch	Mix ratio	Demoulded density (Kg/m3)	Ovendry density (Kg/m3)
1	B-1 (A)	1:2:4	2375	2335
2	B-1 (B)	1:2:4	2380	2345
3	B-2 (A)	1:1.5:3	2360	2325
4	B-2 (B)	1:1.5:3	2355	2332
5	B-3 (A)	1:2:4	2374	2334
6	B-3 (B)	1:2:4	2382	2347
7	B-4 (A)	1:1.5:3	2362	2327
8	B-4 (B)	1:1.5:3	2356	2337
9	B-5 (A)	1:2:4	2373	2330
10	B-5 (B)	1:2:4	2381	2345
11	B-6 (A)	1:1.5:3	2361	2325
12	B-6 (B)	1:1.5:3	2354	2335
13	B-7 (A)	1:2:4	2374	2334
14	B-7 (B)	1:2:4	2382	2342
15	B-8 (A)	1:1.5:3	2361	2330
16	B-8 (B)	1:1.5:3	2352	2332
17	B-9 (A)	1:2:4	2371	2335
18	B-9 (B)	1:2:4	2385	2349
19	B-10 (A)	1:1.5:3	2366	2330
20	B-10 (B)	1:1.5:3	2360	2331

C. Tests for Compressive Strength

The aggregates collected from different quarries had different crushing strength properties. After investigating the properties of the aggregates, a slight variation in properties was found. Consequently, all obtained concretes followed the similar trend in the result increment. The water-cement ratio and the cement content affect the response of the concrete to applied stress. The explanation can be based on two opposing effects caused by incorporation of air into concrete. Firstly, it increased the porosity of the matrix; entrained air has an adverse effect on the strength of the composite material. Secondly, it improves the workability and compatibility of the mixture; entrained air tends to improve the strength of the interfacial transition zone (especially in mixtures with very low water and cement contents) and thus improves the strength of concrete. In concrete mixtures with low cement content, it was observed that when having air entrainment accompanied by a significant reduction in the water content, the beneficial effect on the interfacial transition zone compensates the adverse effect of air entrainment on the strength of the matrix. In Table IV, column C1 shows the specimen cured for 7 days in water, column C2 shows specimen cured for 14 days in water and column C3 shows specimen cured for 28 days. The compressive strengths of all the prepared concretes (both batches) are mentioned in TableV.

The relationship of the both batches of concrete prepared from CSQ at the selected number of days is shown in Fig. 3. The maximum value of compressive strength obtained for CSQ concrete was 38.2 MPa at 1:2:4 mix proportion and 0.50 w/c ratio. The Batch 3A achieved 42% and 92% of the 28-day compressive strength at 7 and 14 days, respectively. This quarry aggregates were of reddish color and had good characteristic strength of aggregates.This quarry provided best result as compared to the other quarries.

It is a fact that the aggregate plays a progressively more important role in concrete behavior as strength increases. In normal-strength concrete, failure in compression almost exclusively involves debonding of the cement paste from the aggregate particles, will be called the matrix-aggregate interface. In contrast, in high-strength concrete, the aggregate particles as well as the interface undergo failure, clearly contributing to overall strength. As the strength of the cement paste constituent of concrete increases, there is greater compatibility of stiffness and strength between the normally stiffer and stronger coarse aggregate and the surrounding mortar. Therefore, it can be said that the bond between the CSQ aggregates and the cement paste was stronger; therefore,the CSQ concrete showed higher compressive strength as compared to all other mixtures. It is a fact that, in HSC, higher strength coarse aggregates typically yield higher compressive strengths, while in NEC, coarse aggregate strength has little effect on compressive strength [viii].

TABLE V
DETAILS OF ALL BATCHES OF SPECIMENS (CASTED AND TESTED)

S. No	Batch	Quarry	Ratio	w/c ratio	C1 (7 days)	C2 (14 days)	C3 (28 days)
1	B-1 (A)	OS	1:2:4	0.50	18.5	23.2	32.0
2	B-1 (B)	OS	1:2:4	0.55	17.0	18.3	24.0
3	B-2 (A)	OS	1:1.5:3	0.50	18.6	23.0	27.0
4	B-2 (B)	OS	1:1.5:3	0.55	19.4	21.4	25.0
5	B-3 (A)	CS	1:2:4	0.50	16.0	36.0	38.2
6	B-3 (B)	CS	1:2:4	0.55	16.1	19.0	27.0
7	B-4 (A)	CS	1:1.5:3	0.50	24.0	24.4	31.3
8	B-4 (B)	CS	1:1.5:3	0.55	19.0	20.5	27.0
9	B-5 (A)	GP	1:2:4	0.50	37.0	37.6	38.0
10	B-5 (B)	GP	1:2:4	0.55	18.0	21.0	31.2
11	B-6 (A)	GP	1:1.5:3	0.50	14.5	25.2	27.5
12	B-6 (B)	GP	1:1.5:3	0.55	19.0	21.0	25.2
13	B-7 (A)	D	1:2:4	0.50	19.4	26.1	35.0
14	B-7 (B)	D	1:2:4	0.55	21.0	25.0	30.0
15	B-8 (A)	D	1:1.5:3	0.50	23.0	27.5	32.0
16	B-8 (B)	D	1:1.5:3	0.55	17.5	20.3	29.0
17	B-9 (A)	JT	1:2:4	0.50	25.4	26.0	29.0
18	B-9 (B)	JT	1:2:4	0.55	19.4	22.5	25.7
19	B-10 (A)	JT	1:1.5:3	0.50	24.0	28.3	31.8
20	B-10 (B)	JT	1:1.5:3	0.55	19.0	21.3	25.8

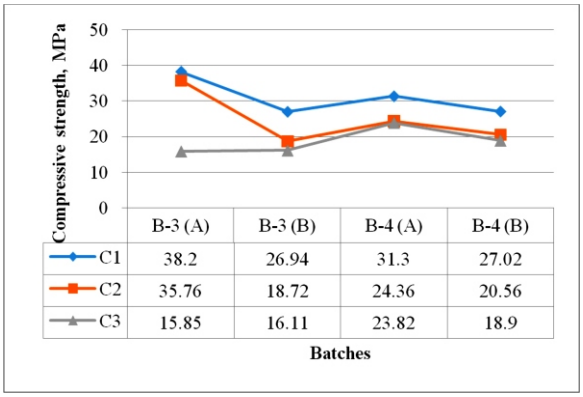
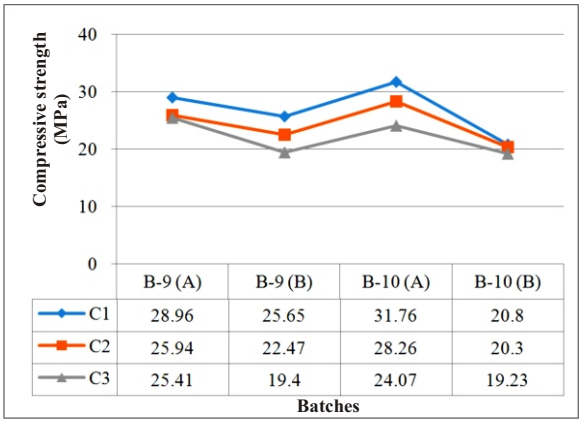


Fig. 3. Compressive strength of both batches of CSC

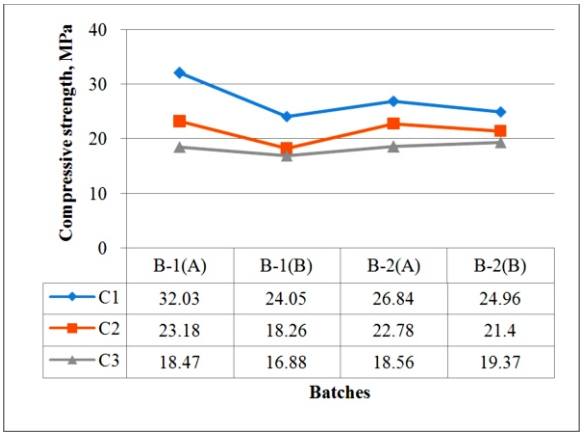
The lowest value of compressive strength was obtained for the concrete prepared from JTQ; which resulted in a 28-days compressive strength of 20.8 MPa with the mix proportion of 1:1.5:3 and 0.55 w/c ratio. Two main reasons of strength reduction were found in this concrete. First, this concrete has very high w/c ratio and secondly, the properties of the aggregates used in this concrete were very low (Table I). This quarry aggregates have mixed color (red, pink and white) which showed that the aggregates adopted from this quarry have not undergone for a proper gradation. Originally, flaky and elongated type of aggregates were obtained. This indicates that the aggregates of this quarry possess low strength as compared to the other quarries, particularly CSQ. Another reason is that, these aggregates had weaker bond with the cement paste which resulted in reduction in concrete strength. Micro cracks tend to propagate through the aggregate particles. Thus, aggregate strength becomes an important factor in high-strength concrete. Due to the poor nature of the aggregates, Batch 9A showed almost same compressive strength at all ages. The relationship of the both batches of JTC concrete were shown in Fig. 4.



	B-9 (A)	B-9 (B)	B-10 (A)	B-10 (B)
C1	28.96	25.65	31.76	20.8
C2	25.94	22.47	28.26	20.3
C3	25.41	19.4	24.07	19.23

Fig. 4. Compressive strength of both batches of JTQ

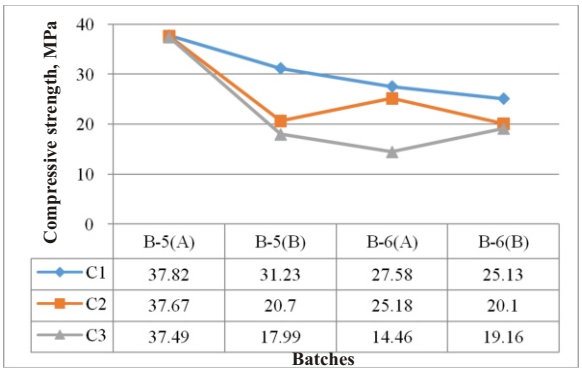
The aggregates obtained from rest of the three quarries showed 10-14% lower strength as compared to the CS concrete. It might be due to the poor properties of the aggregates as compared to the CSQ aggregates. All the batches prepared by OSQ aggregates showed a proper trend of gaining compressive strength at all ages. This indicates that the quality of the aggregates is better than the JTQ aggregates, but these aggregates are less stiff than CSQ aggregates. The relationship of the compressive strength of both batches prepared by OSQ is shown in Fig. 5.



	B-1(A)	B-1(B)	B-2(A)	B-2(B)
C1	32.03	24.05	26.84	24.96
C2	23.18	18.26	22.78	21.4
C3	18.47	16.88	18.56	19.37

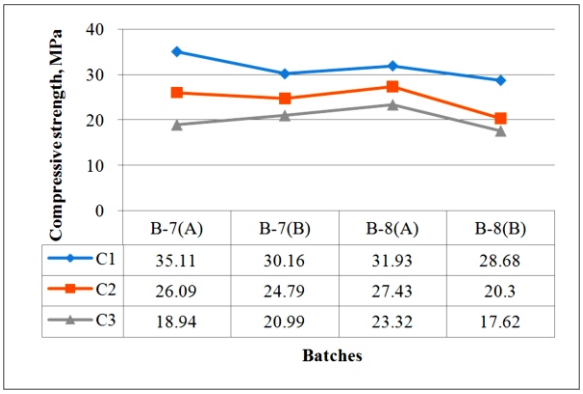
Fig. 5. Compressive strength of both batches of OSQ

Figs. 6 and 7show the compressive strength of the both batches of concrete prepared from GPQ and DQaggregates, respectively. It was observed from the test results that the mixture B-5 (A) concrete achieved its higher compressive strength at 7 days curing. It might be due to lower water cement ratio and strength achieved was almost same to the 28-day compressive strength of batch 3A. But in the rest three batches the trend was totally different. The 7-day compressive strength was on average of about 60-65% of the 28-day compressive strength. The batches 5B, 6A, 6B, 7A, 7B, 8A and 8B on average showed 27% lower compressive strength as compared to batch 3A. This was due to the poor performance of the aggregates, so that the GP aggregates might not be able to make a proper bond with the cement paste due to that it showed lower compressive strength results.



	B-5(A)	B-5(B)	B-6(A)	B-6(B)
C1	37.82	31.23	27.58	25.13
C2	37.67	20.7	25.18	20.1
C3	37.49	17.99	14.46	19.16

Fig. 6. Compressive strength of both batches of GPQ



	B-7(A)	B-7(B)	B-8(A)	B-8(B)
C1	35.11	30.16	31.93	28.68
C2	26.09	24.79	27.43	20.3
C3	18.94	20.99	23.32	17.62

Fig. 7. Compressive strength of both batches of DQ

Despite having almost similar properties of the aggregates and variable strength parameters, CSQ concrete showed higher compressive strengths.This shows that this quarry have regular size aggregates with uniform gradations. Whereas, other quarries like, GP, and DQ have shown acceptable compressive strength.

From results it was observed that the JTQ have a very low compressive strength due to poor quality stones (aggregates) with undefined shape and size and of improper gradation. It was noticed that the strength of concrete was mainly dependent of the type of aggregates. It is very important to investigate the geological characteristics of quarries including rocks, stones and their aggregates.

Results show that the most commonly used quarry in the region namely OSQ, has not given competitive results as compared to other quarries of this region. And same is the case with JTQ. In the continuation with above CS and GP quarry have given better compressive strengths. The relationship of the compressive strengths of all the batches with the number of days is parented in Figs. 8, 9 and 10 at 7, 14 and 28 days, respectively.

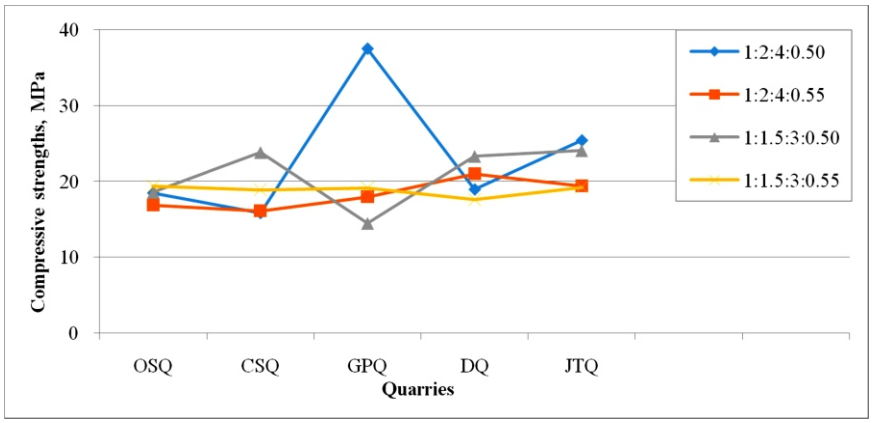


Fig. 8. Compressive strengths of all batches at 7 days

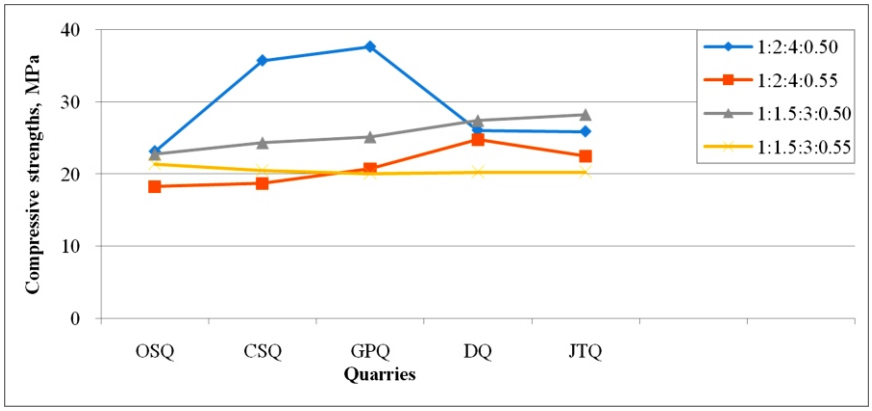


Fig. 9. Compressive strengths of all batches at 14 days

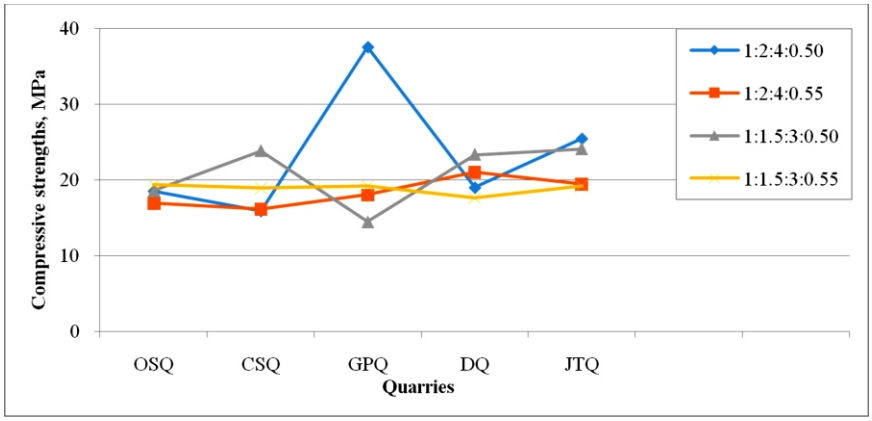


Fig. 10. Compressive strengths of all batches at 28 days

IV. Discussion

Properties of the concretes mostly depend on the characteristics of the aggregates. It was observed that except CSQ aggregates, the rest of the aggregates showed lower compressive strength. This was due to characteristic properties of the aggregates. The first condition is the shape and the surface texture of the aggregates. Shape and surface texture of the coarse aggregates play a major role on the behavior of fresh and hardened concrete. Flaky, elongated, angular, and rough particles have high voids and require more sand to fill voids and to provide workable concrete, thus increasing the demand for water. Poorly shaped aggregates may also increase segregation. Reference [ix] reported that the flaky and elongated particles tend to produce harsh mixtures and affect finish ability. According to [x], state that flat and elongated particles

should be limited to a maximum of 15 percent by weight of total aggregate. In the present study, the aggregates selected were rough and flaky except the CSQ.That is the main reason of these aggregates showing higher strength.

Aggregate porosity may affect durability as freezing of water in pores in aggregate particles can cause surface popouts. However, it the relationship between absorption and freeze-thaw behavior has not proven to be reliable [xi, xii]. Nevertheless, absorption can be used as an initial indicator of soundness. Furthermore, aggregates with low absorption tend to reduce shrinkage and creep. This might be another reason because the CSQ aggregates have lowest water absorption compared to all other aggregates (Table I).

Relative density or specific gravity also plays major role in the concrete but it is not necessarily related to aggregate behavior. However, it has been found that some aggregates have compounds of shale, sandstone, and chert that have somewhat low specific gravity may display poor performance. The CS quarry aggregates showed the higher specific gravity (Table I) compared to all other aggregates, therefore higher compressive strength was achieved as expected.

Another advantage is that the in lower strength concretes, the weakest link almost exclusively occurs at the matrix-aggregate interface and the mechanism of progressive micro cracking consists of mortar cracks bridging between nearby bond cracks. The observed behavior is that the high strength concrete are more homogeneous material. When the matrix is more compact and the voids are less in number, there is greater compatibility between the strength and elastic properties of the coarse aggregate and the mortar. Improved compatibility also lowers the stress at the matrix aggregate interface, reducing the likelihood of interfacial failure. Thus, microcracks are more likely to propagate through the aggregate, and therefore, the extent of micro cracking is reduced as concrete strength increases.

Therefore, it can be said that the bond behavior of CS quarry was much better than the aggregates of other quarries. CS aggregates have higher specific gravity and are free of lumps and voids. Thus, the interfacial bond between the aggregates was stronger. The failure may be due to aggregate itself rather than mortar joint failure.

VI. Conclusions

The following conclusions have been drawn from this research. The great variation in the compressive strength of concrete using aggregates of different quarries were observed.

The maximum 28-days compressive strength was found for CSQ concrete as 38.2 Mpa as mentioned in batch no.3A with 1:2:4 mix proportion and 0.50 w/c ratio.

The lowest 28-days compressive strength observed as 20.8 Mpa for JTQ concrete, as mentioned in batch no.10B, with 1:1.5:3 mix proportion and 0.55 w/c ratio.

Compressive strength of concrete can be increased by using various aggregates of different quarries, keeping the w/c ratio unchanged as shown in B-5A and 1:2:4:0.50 ratio is used, whereas aggregates from GPQ, good results were obtained with a compressive strength of 37.82 MPa when cured it for 28 days which nearly equals to the result of CSQ concrete.

This study will guide the local construction industry to use the aggregates of CSQ and GPQ for production of concrete in the region and as the strength of OSQand JTQas compared to others, therefore, better quarries could be adopted with reference to this study.

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Modeling and Analysis of Long Term Energy Demands in Residential Sector of Pakistan

T. Rashid[1], M.H. Sahir[2]

[1]Mechanical Engineering Department, University of Engineering and Technology Taxila
[2]Industrial Engineering Department, University of Engineering and Technology Taxila
[1]tanzeel.ur.rashid@uettaxila.edu.pk

Abstract-Residential sector is the core among the energy demand sectors in Pakistan. Currently, various techniques are being used worldwide to assess future energy demands including integrated system modeling (ISM). Therefore, the current study is focused on implementation of ISM approach for future energy demand analysis of Pakistan's residential sector in terms of increase in population, rapid urbanization, household size and type, and increase/decrease in GDP. A detailed business-as-usual (BAU) model is formulated in TIMES energy modeling framework using different factors like growth in future energy services, end-use technology characterization, and restricted fuel supplies. Additionally, the developed model is capable to compare the projected energy demand under different scenarios e.g. strong economy, weak economy and energy efficiency. The implementation of ISM proved a viable approach to predict the future energy demands of Pakistan's residential sector. Furthermore, the analysis shows that the energy consumption in the residential sector would be 46.5Mtoe (Million Ton of Oil Equivalent) in 2040 compared to 23 Mtoe of the base year (2007) along with 600% increase in electricity demands. The study further maps the potential residential energy policies to congregate the future demands.

Keywords-Energy Modeling, TIMES Model, Residential Sector, Pakistan

I. INTRODUCTION

At the current age, economic growth depends on the availability and affordability of sustained energy supplies and vice versa [i]. Energy demand is increasing globally due to population growth, improved living standards, access and availability of energy resources to the poor especially in developing countries [ii]. Several future outlooks show that by 2040, the world population is likely to increase from 7 billion to around 9 billion, with 35% more energy demand than of current level [iii-iv]. The world energy consumption has also been grown at a rate of 5.4% per annum in residential buildings since 1992 [v]. In Pakistan, the energy demand is also increasing exponentially due to a rapidly growing population and the number of households. Pakistan stands at six among the most populous countries in the world, having a population over 180 million in 2013, and the future estimates show over 350 million citizens in 2035 [vi]. At present, Pakistan is facing the severe energy crisis and energy shortage has declined the economic growth [vii]. This energy crisis has also ruined the social welfare and created unrest in the form of unemployment and mental anxiety. Based on the data of 2013-14, all major sectors (residential, industrial, commercial, agriculture, and transport) consumed nearly 60 Mtoe of final energy. The electricity balance has been severely disturbed due to 7000-9000 MW shortage in energy supplies in 2013 [viii].

In the developed countries, residential sector mostly consumes about only 20-25% of final energy and stands at a 3rd or 4th place among the other demand sectors [ix]. However, the residential sector in Pakistan consumes much higher of nearly 46% of total produced electricity[x]. Therefore, nowadays the residential sector has become the largest end-user of energy supplies both the commercial and non-commercial energy resources. This consumption has exceeded the industrial sector, which is an alarming situation to the future economic development, energy security, and sustainability. The higher level of energy consumption in the residential sector is due to non-functioning of the industrial sector - owing to also many other factors like terrorism, worse law and order situation, and energy crisis. In the recent past, the residential sector has also been enormously affected by the technology and behavioral changes due to increase in living standards since 1990. The cities having better facilities also appeal people from rural areas, and it has congested poorly planned old cities with limited resources. Estimates show that the population living in urban households is nearly 38% [xi]. Urban households consume about threefold energy than rural households. The urbanization is increasing at an average rate of 3% per year since 1995 [xii]. As the residential sector is heavily subsidized by government, both for electricity and natural gas commodities, it is a challenge to fulfill the future needs without properly planned infrastructure and deployment of proven energy management strategies.

The purpose of the study is to assess the future energy demands in residential dwellings in a long-term perspective i.e. 2040. This assessment is of great importance for future energy policies, such as the development of the nation-wide energy network and the planning of capacity expansion [xiii]. Furthermore, the precise forecast of energy demand is also vital for effective policymaking on capital-intensive projects. The study portrays the existing consumption of energy commodities in households and projects the future energy demands by modeling the household sector up to2040, for three different policy cases, slow economic growth, strong economic growth, and household sector energy efficiency at 10% to the existing base case. Section 2 of the paper offers an overview of historical trends of energy consumption by various sectors relative to the residential sector in the country. Section 3 illustrates the business-as-usual case development in TIMES energy modeling paradigm and its structuring with key assumptions. Section 4 contains the future energy demand projections resulted from the energy model and examines the outcomes of scenario cases in detail. Section 5 finally concludes and summarizes the future energy demands and limitation of study.

II. Data and Methods

A. *A Review of Sectoral Energy Consumption in Pakistan*

In developing economies like Pakistan, the residential sector dominates for overall energy demands among all other sectors because of the low scale of economic activities in the industrial, commercial, or agriculture sector [xiv]. The dwelling units consumed more than 9.5 Mtoe of commercial energy in 2012 [viii]. Moreover, shrinking the economic growth in industrial and agriculture sectors has been observed due to intense energy outages of natural gas and electricity. For 2012, total primary energy supplies were about 65.0 Mtoe including all energy resources, imported fuel, hydropower, natural gas, oil, and biomass, etc. Being agrarian society, biomass energy resources share over one third of the total primary energy supplies. Natural gas as an indigenous resource commodity provides nearly 32% share in the overall primary energy mix, while the last year oil commodities imports were over 22.0 Mtoe. Total electricity production was over 6.2 Mtoe in 2013 and the electricity consumption in the residential sector was 3.0 Mtoe [x]. Existing sectoral energy consumption and historical fuel supplies to the residential sector from 1985 to 2012 are shown in Fig. 1 and Fig. 2.

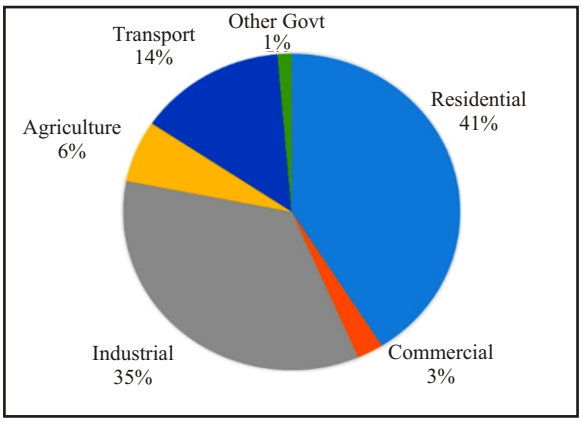

Fig. 1. Sectoral energy consumption profile among demand-side sectors

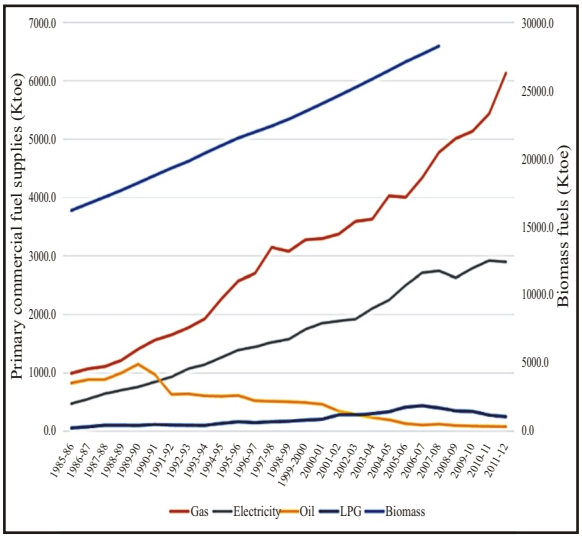

Fig. 2. Primary energy supplies, including commercial and non-commercial fuels

B. *Main Drivers of Energy Consumption*

Many factors are involved in residential energy consumption like rapid population growth, increasing urbanization and improved lifestyle [xv-xviii]. According to government statistics, electricity consumption in residential sector was 20 TWh in 2000. In 2013, the residential sector's consumption reached to 35 TWh [xviii-xx]. This rise is mainly due to higher urbanization and rapid growth in population [xxi]. The income level is another most vital factor inenergy use, as the division of resources, in poor economies and under developed countries, is dependent on the family's wealth. Accessibility and availability of energy commodities depend upon the affordability [xxii]. Estimates show that about 40% population live below the poverty line based on mostly in the suburbs and rural areas in Pakistan [xii]. This segment of society, in common, relies on minimal commercial energy resources. These households consume relatively dirty

fuels particularly for cooking purposes because of limited financial resources.

In developed countries, many studies have been carried out related to energy management in dwellings as there is a large potential in energy savings by virtue of efficient end-use devices and building equipment like insulated and glazed windows, walls, roofs [xxiii-xxvi]. Deploying energy conservation and efficiency improvement schemes in different income groups may also reduce energy use [xxvii]. In the developing world, household income is strongly related to energy expenditures intended for various energy services. The other correlated factor with household's income is the use of inferior quality and more energy consuming appliances. But the technology characterization is not only the sufficient criterion to elucidate the requirement of final energy as dwellings also exhibit varying socio-economic characteristics, even in similar geography. Some studies examined the energy requirement in households and also attempted to establish the relation between energy requirements and socio-economic factors such as income and lifestyle [xxviii].

III. TIMES-PAK METHODOLOGY

The study deploys TIMES (The Integrated MARKAL-EFOM System) energy model to reveal the required energy and technological resources, particularly in the residential sector. The approach presented in this study may provide the consistent modeling framework to evaluate the energy needs in urban and rural dwellings. Besides, this methodology has two additional advantages. Firstly, the model based on mainly bottom-up approach may capture the energy intensity of an individual social group such as urban and rural instead of assuming the sector as a whole. Secondly, it has the ability to assess the potential of energy savings by substituting different set of technologies for each end-use energy service. This type of technological characterization allows constructing detailed energy scenarios. In Pakistan, long-term integrated energy planning could not be functional in the past and hence, this study would contribute to consolidate efforts in this subject [xxix]. The starting point was the quantification of energy demand for different end-uses at household level, and we gathered data regarding fuel shares and main energy services from different published and unpublished sources.

TIMES energy modeling platform is widely used to evaluate the long term energy demands from municipal level to global level [xxx-xxxiii]. In energy modeling, exogenous variables are required like the end-use energy statistics at sector/sub sector level, existing technology characterization, competing technology datasets, and sub-models predicting population and economic growth in the future. After, the model generator solves the whole energy system on the basis of least-cost [xxxiv-xxxvi]. By setting the residential base year (2007) data, e.g. available energy resources and energy service demands subjected to many physical and economic constraints, we developed a BAU (business-as-usual) case to predict the future energy demands.

A. Utilized Data and Structuring

The residential sector in this study was modeled as a single geographic region to simplify the modeling insights in the long term planning horizon. Two approaches were used to characterize this sector; top-down decomposition and bottom-up aggregation [xxxvii]. Top-down approach was necessary due to non-availability of data such as the fuel resources used by existing stock of household end-use devices. For this activity, fuel-shares were decomposed to be used in each end-use. These shares were further cross checked by expert judgment and surveys. Two important reference documents were used to validate the fuel characterization on an average basis in dwelling units such as Energy Yearbook (2007), Economic Survey of Pakistan and Energy Sector Management Assistance Program (ESMAP) [xx]. Besides this, other necessary data was collected through many empirical research resources, technical reports, including Planning Commission, National Electric Power Regulatory Authority (NEPRA), and other government and non-government agencies.

Contrary to it and also to validate the proper formulation of input dataset, bottom-up aggregation was also used. Energy consumption patterns on daily basis were surveyed for different income group householders, and then were normalized on an average household level. These average expenditures on fuel and lighting were then aggregated to verify the results from'top-down outcomes'. The primary dataset employed in this model is the Residential Energy Survey by (UETT) University of Engineering & Technology Taxilain 2009-10 [xxxviii] and 2012-13. This study explored the dynamics of energy consumption of dwellings in different geographic divisions of Pakistan by general social behaviors.

B. Research Process

The following research process was adopted for proper characterization of this sector:

- Determination of the number of households in an urban/semi-urban and rural division in whole horizon 2007-2040;
- Estimation of specific fuel usage of households in both categories;
- Extraction of average energy purchases for each fuel by energy service type for households in each category;
- Characterization of households' appliances regarding their penetration rate, upfront cost, maintenance cost, efficiency and lifetime;

Figuring the key assumptions and time-of-use demand curve development for energy commodities;

Converting the energy use data to estimate the shares in urban and rural households;

Future energy demand projections and analysis of results.

A detailed process to model the residential sector is shown in Fig. 3.

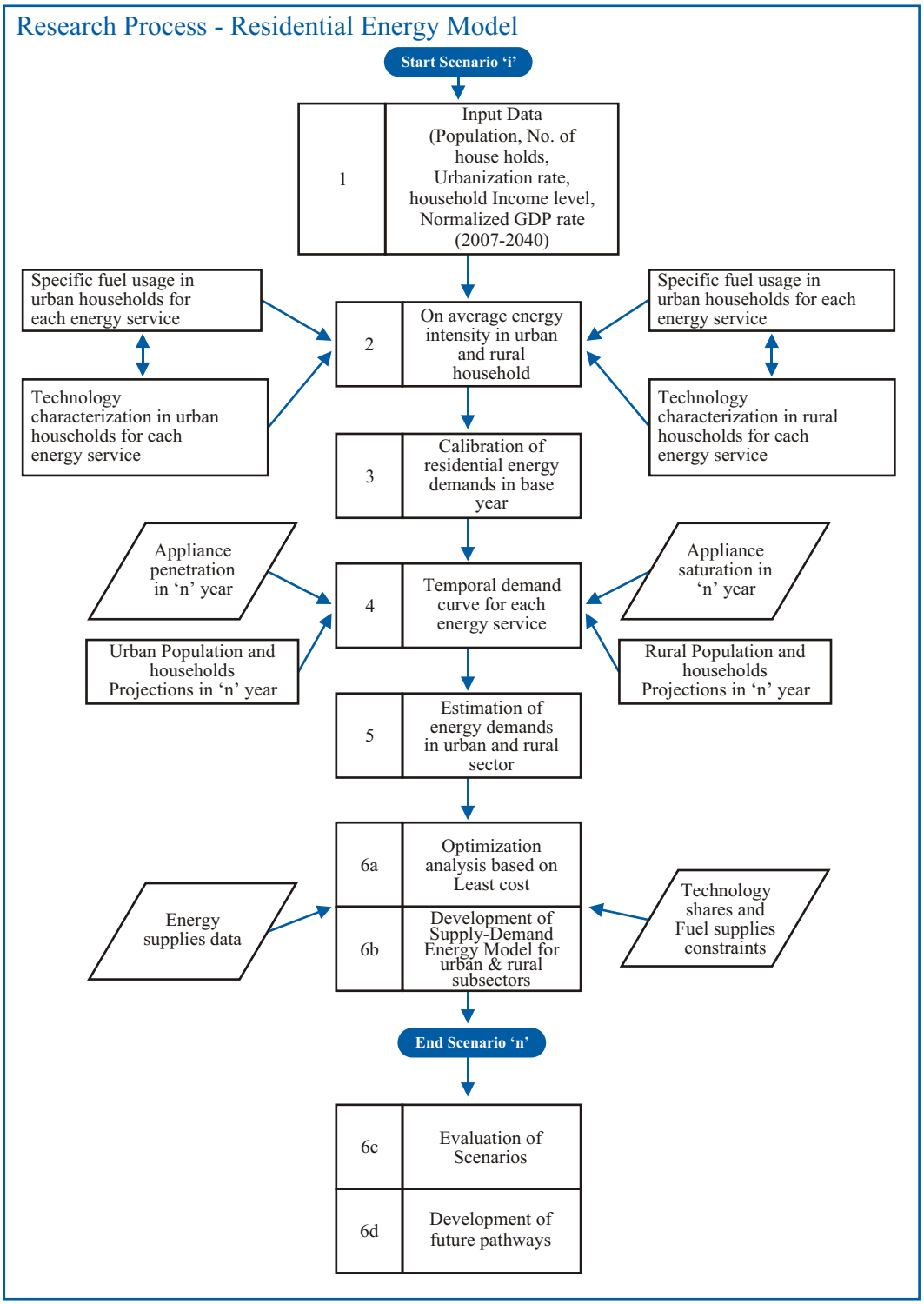

Fig. 3. Residential energy modeling flow diagram.

In the first phase of the above stated process, we determined the number of households from the statistics of PBS (Pakistan Bureau of Statistics) for urban and rural categories. Then data was further categorized to estimate electrified, non-electrified, and households connected to gas pipelines in each domain. Next, we looked for the percentage of urban/rural households using the specific fuel to fulfill their daily energy related non-transport requirements. Using the data from UETT survey [xxxix] and Pakistan Household Expenditure Survey, the energy carriers were disaggregated into residential fuels like electricity, natural gas, kerosene, coal, biomass etc., [xx] as given in the Table I. Biomass resources were further decomposed such as wood available to households at no cost and purchased-wood, (reference to Table A-II in Appendix A). Similarly, free animal dung besides the purchased dung fuel by households, particularly in rural areas was estimated. Although the differences were small, but different cost profiles have been used to distinguish the biofuels.

TABLE I
(A) END USE FUEL SHARES (DECIMALS) BY ENERGY SERVICE AND TOTAL FUEL CONSUMPTION (PJ) FOR EACH SERVICE IN AN URBAN RESIDENTIAL SECTOR IN BASE YEAR 2007

Urban Households	Total (PJ)	Kerosene	LPG	Coal	Natural Gas	Electricity	Wood fuel	Dung	Agr. Residues
Space Heating	34.8		0.01		0.91		0.08		
Water Heating	37.5		0.01		0.76		0.23		
Space Cooling (Fans)	28.9					1.00			
Space Cooling (AC & Coolers)	16.7					1.00			
Lighting	16.6	0.03				0.97			
Cooking	194.8		0.03		0.63		0.24	0.06	0.03
Refrigeration	12.9					1.00			
Miscellaneous Electric	21.7					1.00			
Total	**363.9**								

TABLE I
(B) END USE FUEL SHARES (DECIMALS) BY ENERGY SERVICE AND TOTAL FUEL CONSUMPTION (PJ) FOR EACH SERVICE IN THE RURAL RESIDENTIAL SECTOR IN BASE YEAR 2007

Urban Households	Total (PJ)	Kerosene	LPG	Coal	Natural Gas	Electricity	Wood fuel	Dung	Agr. Residues
Space Heating	33.7		0.01		0.05		0.95		
Water Heating	49.5		0.01		0.03		0.74	0.23	
Space Cooling (Fans)	9.7					1.00			
Space Cooling (AC & Coolers)	0.9					1.00			
Lighting	15.8	0.25				0.75			
Cooking	514.5		0.03		0.01		0.67	0.16	0.13
Refrigeration	1.6					1.00			
Miscellaneous Electric	3.9					1.00			
Total	629.6								

Table I shows the fuel share estimates consumed for each energy service demand in the residential sector for base year 2007. For example, common urban households on average meets its space heating needs by 91% natural gas and 8% from wood fuel. The other important data shown is total energy consumption (PJ) in each energy service of urban and rural residential sector. As for instance, urban households, on average, consumed 34.8 PJ for space heating purposes in base year. For the energy services required in a typical housing unit, these were categorized such as space cooling, cooking, lighting, refrigeration, water-heating, space heating, and miscellaneous. Space cooling was further divided into cooling by fans and air-conditioning. For the fourth action, existing appliances were grouped as standard, improved, and advanced (reference to Table A-I in Appendix A). New technology dataset has also been developed by

predicting the efficiencies and costs.

Many exogenous assumptions were taken like the growth rate of population, households, GDP linked to individual income level, fuel price data and remaining available energy resources [xl]. Table II presents the key projections of many exogenous variables used for predicting the future energy use in the residential energy model. Furthermore, the information of demand timing is required for each of the energy services to distinguish the load pattern for under consideration commodity like electricity. This data was put into the model as time-of-use of the commodity. The next step was the further split of demand timing that determined the amount of each energy service that should be met based on seasonal and time-of-day requirements. For this purpose, representation of these patterns was derived for each residential fuel. Thus the demand for each energy service has been tracked at a seasonal level, reflecting that cooling by air-conditioners is mostly required during hottest periods and space heating during the winter. The supply of these commodities should be able to meet the temporal patterns of each energy service.

In this case, decomposed utility load curves, in particular, on the sectoral and sub-sector basis could be ideal. These load curves provide information to counter the effects of varying climate on energy demands, daily or seasonal. However, due to limited information available on these fronts, the estimation of energy service demands was done mainly on surveys and empirical studies. The temporal dataset of demand profile using the hourly load available in aggregated form was calibrated from electricity providers PEPCO (Pakistan Electric Power Company) &K-Electric formerly KESC Karachi Electric Supply Company Ltd) and gas utility companies SNGPL (Sui Northern Gas Pipelines Limited) & SSGC (Sui Southern Gas Company).

TABLE II
A LIST OF KEY ASSUMPTIONS (BASE YEAR - 2007) AND PROJECTIONS FOR WHOLE TIME-HORIZON

Key Assumptions	2007	2012	2015	2021	2027	2030	2036	2039	2045
Population									
Total Population **(Million)**	158.2	173.8	183.9	205.8	230.1	243.1	271.4	286.7	320.1
Annual growth rate (%)	1.90	1.90	1.90	1.88	1.86	1.85	1.85	1.85	1.85
Urban Population **(Million)**	53.8	67.5	75.9	93.3	111.5	121.8	143.3	154.3	179.0
Annual growth rate (%)	4.82	4.00	3.50	3.00	3.00	3.00	2.50	2.50	2.50
Rural Population **(Million)**	104.3	106.3	107.9	112.4	118.6	121.3	128.1	132.4	141.1
Rural % of Total	66.0	61.2	58.7	54.6	51.6	49.9	47.2	46.2	44.1
Households									
Total Households **(Million)**	23.40	26.99	28.87	33.01	37.69	40.28	45.96	49.10	56.06
Urban Sector									
Avg. No. of occupants/HH	6.50	6.20	6.14	6.01	5.88	5.82	5.69	5.63	5.50
Total Urban Households **(Million)**	8.28	10.89	12.38	15.53	18.95	20.93	25.19	27.43	32.54
Rural Sector									
Avg. No. of occupants/HH	6.90	6.60	6.55	6.44	6.33	6.27	6.16	6.11	6.00
Total Rural Households **(Million)**	15.12	16.10	16.49	17.47	18.74	19.34	20.78	21.67	23.52
GDP growth rates									
Strong economy case (%)	5.0	4.9	6.6	6.3	6.0	5.9	6.2	6.4	5.6
Base case (%)	5.0	4.0	5.5	5.8	5.0	5.0	5.0	5.0	5.0
Weak economy case (%)	5.0	3.5	4.0	4.8	4.0	4.0	4.0	4.0	4.2

Scenario analysis method was used to explore future energy demands and potential technology pathways of the energy system.

TABLE III
DESCRIPTION OF SCENARIOS USED IN RESIDENTIAL SECTOR MODELING

Scenario	Description
Base Case (BAU)	Base case (BAU) scenario reflects the continuation of on-going and near-term trends, technologies, practices and policies, current regime of planning and effects occurring in the future. Furthermore, the overall level of demands in energy commodities and energy services will rise in association of economic growth at 5% GDP level over the time horizon. In this case, the smartly use of energy is also out weighted due to the non-acceptance of any such scheme in the society.
Weak Economy (WE)	This scenario explores the changes in energy demands, if the slow economic growth persists at 4.2% GDP level. The energy intensity level of many energy demands will fall, mainly due to energy poverty.
Strong Economy (SE)	A high energy demand scenario with an assumption of high sustained economic growth. As households get rich due to increase in disposable income, the lifestyles will be improved. Thus the existing inefficient technologies to increase the comfort level will penetrate rapidly in the society. The assumed GDP growth level is set 5.6% throughout the time horizon.
Energy Efficiency (EE)	A scenario of accelerated energy conservation and efficiency measures having the constant economic growth level as was set in BAU case. This scenario investigates how the residential sector behaves to achieve the average 10% reduction of energy demands in 2040. A technology led energy demand reduction via currently known efficient technologies.

IV. Results and Discussion

The minimum efficiency level in energy consumption of residential sector was set to 10% in energy efficiency (EE) scenario. To encompass the complexity of the evolution over a 30-year period, a number of scenarios had to be developed. The main focus of this paper is on integrated energy analysis of future final energy demand and energy savings. Two TIMES scenarios, BAU and increased EE are presented in this study. Table III shows the underlying scenarios and their economic variants. The other two economic variants of BAU are the weaker economic growth and strong economic growth.

The residential final energy consumption of 22 Mtoe in the base year 2007 increases to double in all the cases by 2040. Table IV presents the residential sector's final energy demand projections in all scenarios. This rise in energy demand is because of increase in population, and high urbanization rate. Moreover, base case scenario shows the share of electricity use of a residential sector increase from 46% (2007) to 54% in 2040, which could be even more than 59% in the weak economic (WE) growth case. Fig. 4 presents the sectoral share of electricity consumption in 2040 in all scenarios.

TABLE IV
Residential Sector's Final Energy Demand Projections in Developed Scenarios (MTOE)

Years	Base Case	Weak Economy	Strong Economy	Energy Efficiency
2007	22.52	22.52	22.52	22.52
2015	24.65	23.91	25.54	24.02
2020	25.91	25.10	29.17	25.14
2025	34.09	33.02	34.25	32.61
2030	37.65	36.03	39.62	34.94
2035	41.65	38.98	44.34	37.37
2040	46.46	43.40	50.66	41.09

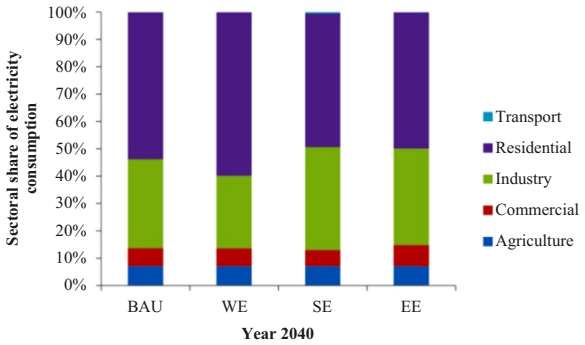

Fig. 4. Sectoral electricity consumption among demand-side sectors in 2040 in all underlying scenarios

Major energy-consumptions in the residential sector comprise of services such as cooking, space-cooling, refrigeration, and lighting. These energy-uses are calculated based on normalizing the actual fuel demands in households of different socio-economic groups. To account the energy use, energy intensity for each energy service is calculated. This includes natural gas, biomass, and electricity use within the total residential RES (reference energy system). The share of energy consumption in 2040 is decreased to 31% as compared to 40% in the year 2007, Table IV, while energy demand in the industrial sector is increased due to the stabilized economic growth of the industrial sector in BAU case.

Fig. 5 depicts the urban and rural residential end-use applications and the final energy demand by fuel type in BAU scenario over the entire time horizon.

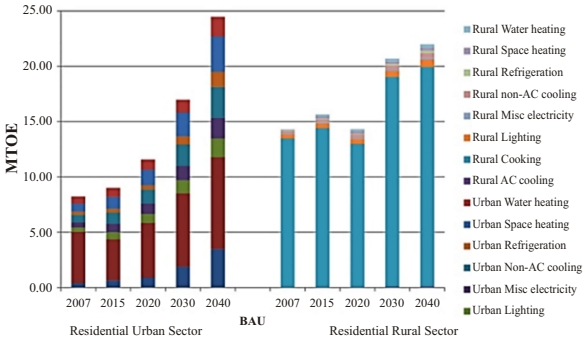

Fig. 5. *(A)* Energy service demand projections in urban and rural residential sectors.

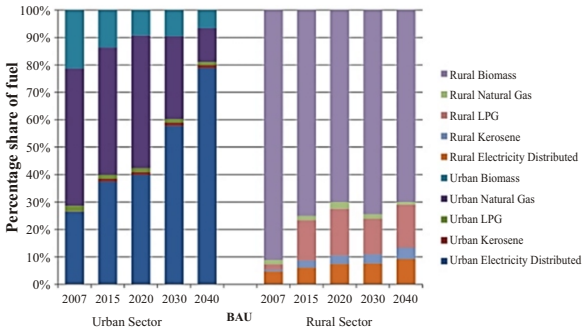

Fig. 5. *(B)* Percentage share of fuels in urban and rural residential sectors in 2040

The residential final energy demand growth is due to urbanization and access to commercial energy resources by electrification in rural areas. The uptake of appliance stock (e.g. space coolers/air-conditioners, refrigerators, and entertainment devices, etc.), and lifestyle improvements are the main drivers of future energy demands. For instance, energy use for space cooling increases as the income level of the community will increase. On the other hand, in EE scenario, the final energy demand in 2040 is 11% lower than the BAU case, and this low level in energy demand is by virtue of energy conservation and efficient measures - uptake of efficient households' appliances. The energy saving actions become cost-effective significantly, also due to projected future fuel prices.

There is significant change in the final energy between the base case and strong economic growth scenarios (see Table IV). The system-wide total energy requirements also increase as the whole energy system responds to the growing population and economic expansion. The additional energy use in the strong economy case is met by increasing energy supplies,while energy imports increase 530% in 2040 by 2007 level. In weaker economic growth, the final energy declines in 2040 by 19.5% from the reference case. This is due to the non-availability and restricted energy supplies to the masses. In this case, energy import declines by 32% in 2040 as compared to the strong economic growth case.

In each scenario, the natural gas supply is gradually decreasing due to depletion of current identified gas wells. The total energy mix shows the great vulnerability in coming years. The other dangerous trend can be seen in the restricted availability of comparatively cheaper energy resource of biomass, especially for rural households. The residential sector is mainly dependent on these two energy resources for cooking needs. In turn, the model is switched to electric applications as these two sources vanish. If an energy efficiency (EE) case does not fully work, then the final energy demand in 2040 increases more than double to base level in stronger economy scenario. These sensitivities show the importance of energy efficiency in a national energy system.

In terms of residential energy services, the share of the cooling demand increases from 5.6% in 2007 to 14.7% in 2040. The higher cooling energy demand attributes to use of more climate control technologies and a significant shift from traditional fans to an air-conditioning system that increases demand for electricity. The other category is the refrigeration that tends to increase due to high saturation of refrigerator stock in dwellings. The electricity demand further increase as these electronic gadgets become more common in the society.

A. Implications to an Existing Energy System

Fig.6 (a) and Fig.6 (b) show the overall growth in final energy-use in all main sectors, together with the required energy supplies in years 2015 and 2040 for all scenario cases.

The analysis shows that overall energy use would be tripled the current demand, while Industrial energy use increases 2.5 times in 2030. Over 570% increase in electricity consumption entail drastic modifications in an existing energy system, resource and infrastructure usage, and investment in new technologies. Fig. 7 displays an overall tremendous growth in the electricity generating capacity dominated by coal plants, together with modest expansion in non-hydro renewable technologies in base case scenario. Nuclear plants, together with some big hydro plants dominate the electricity generation in 2040. The other additions in electric capacity are imported oil and gas operated plants. This needs the huge capacity investments to fulfill the future electricity requirements. This is another negative impact on the national economy as energy imports grow to over 40% of total supply by 2030 as natural gas imports come on-line. In terms of the energy system cost in the residential sector, the incremental cost of energy efficiency scenario increases in the mid-term and is about 17.4% higher than reference case.

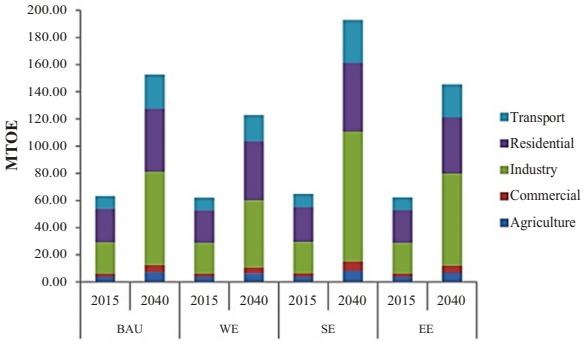

Fig. 6. *(A)* The final energy demand in demand-side sectors

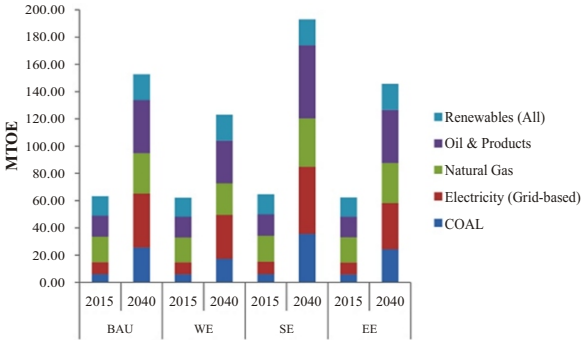

Fig. 6. *(B)* Energy supply shares of the future energy system**.**

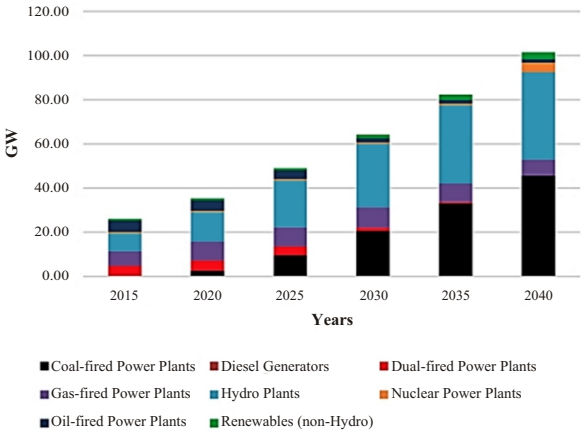

Fig. 7. A profile of electricity generating capacity by different types of power plants in BAU scenario

Fig. 8 presents the cost profile of the residential sector by projecting the investment, together with fixed and operating costs in Energy Efficiency (EE) case. The increase is due to the replacement of an existing inefficient stock of household appliances. Fig. 9 shows the total system cost in undiscounted terms among all scenarios

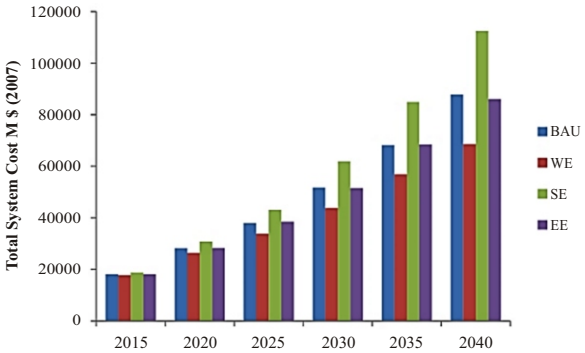

Fig. 8. The projected difference in cost profile of the residential sector

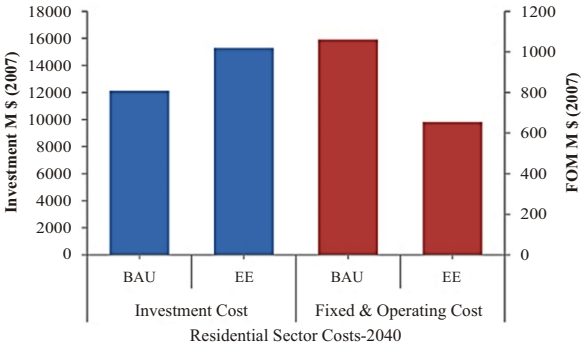

Fig. 9. Total undiscounted cost increase among all scenarios

The results from these scenarios are not only intended as future predictions, these also represent development paths for the energy sector that reflects the future energy requirements aligned with the government's projections for GDP growth. It might serve as the comparison point for GDP variant analyses. The reference case (BAU) scenario for residential domain without any newly developed national policy intervention, exhibits the insights of future energy demands and likelihood of technological evolution in the energy system. Increase in the cooling energy service by air-conditioners is significant and indicates the need of thermal insulation of buildings by deployment of building energy codes in true spirit [xli]. Cooking and water-heating are showing the upward tendency of energy-increase which account for more than half of the energy demand in the future. This projected energy demand is due to the growth in urban population along with the urbanization factor. The household energy demand is projected based on average energy intensity per household which is assumed to grow over the period due to rise in the comfort level, lifestyle of citizens and behavioral change towards the adoption of more appliances. These scenarios depend on many factors, such as prices assumed for fuel sources, demand projections in populations, GDP, urbanization rate, price and performance of technology outlook, evolution of the future energy system at supply side, and end-use technology adoption of demand side sectors.

The technology and fuel-share constraints are crucial to control the system's evolution rate. Limitations applied to reference case are comparatively tight, as it is unlikely to change the scenario radically without detailed policy interventions. Significant changes such as behavioral change of stakeholders and acceptance of cost-effective efficiency measures cannot be revolutionized in society without awareness, the proper execution of strategies, and implementation control. The policy analysis based on this base case would help to explore possible pathways for Pakistan that could be shaped by choices, circumstances, and policy alternatives.

B. Energy Efficiency

The base case (BAU) also contains restrictions which are intended to prevent overly rapid change in the energy system. These include the upper bounds on the appliance penetration rate and the degree of fuel switching in the residential sector. The penetration limits on energy efficient technologies for each energy service are considered as 10% of the whole stock by 2030. In EE scenario, more rapid uptake of energy efficient appliances in households allows for increased levels of energy efficiency. It permits many technologies such as lighting up to 50% of new technology purchases in 2030, rather than 10% imposed limit in the reference scenario. Implementing efficient practices reduces gas consumption in the residential sector due to enhanced and efficient stoves, together with electricity savings by new and modern devices. The energy efficiency measures, which also support the reduction of overall electricity consumption, concedes some large power projects such as coal and nuclear plants.

C. The Way Forward

The first attempt must be made to restructure the energy system according to some established workable plan from national to municipality level. Deployment of local energy plans' aggregation at national level would provide the pathways for future development. To reduce energy consumption particularly in the residential sector augments the better technology characterization at low costs and implementation of performance energy standards to household appliances [xlii-xliii]. Some prioritization may be set to the changeover of appliance's stock with energy efficient devices in phases. In early phase, the inefficient lighting system replacement and retrofitting by some efficient solutions is relatively easy which then follows the space cooling technologies up-gradation. Energy performance measurement for newly constructed buildings should be mandatory in an obligation of standardized practice of building energy codes in other countries. Appliance standardization and labeling should also be a prime focus to lessen the future energy requirements [xliv].

V. CONCLUSIONS

A residential energy load model for long term energy planning has been presented. The model uses hybrid approach; a bottom-up method in which the individual appliances are assessed by their power rating and availability factor to compose a household load, and the top-down approach in which energy profile of a household is made through decomposition of fuel-shares and energy services. The input dataset was mainly prepared and collected through the survey and other studies conducted by governmental and non-governmental organizations. Additionally, the dataset

used in the model was calibrated, tested and validated against federal statistical report, energy yearbook, and PEPCO mid-term energy demand forecasting respectively. The model covers the whole residential non-transport energy demands. Three scenario cases of energy demand and a special case of energy efficiency were established to develop the insights for residential urban and rural sectors.

Base case scenario shows the share of electricity use of a residential sector increase from 46% (2007) to 54% in 2040, which could be even more than 59% in the weak economic (WE) growth case. On the other hand, in EE scenario, the final energy demand in 2040 is 11% lower than the BAU case. If an energy efficiency (EE) case does not fully work, then the final energy demand in 2040 increases more than double to base level in stronger economy scenario. These sensitivities show the importance of energy efficiency in a national energy system.

This paper explores the consistent method to create possible pathways for adoption of new technologies and switching to fuels for different household energy services under different economic variants. This model also captures many trade-offs in the reduction of energy consumption. The model mainly resides and takes decisions on the basis of technology parameters and fuel costs. However, this optimization modeling framework does not consider the choices made on the basis of other social attributes such as color, design and brand of the appliance. Though it is challenging in standard TIMES generator, but this type of consumer behavior is separately controlled through logistic function sub-models for appliance penetration in the residential sector. In addition, due to the first study of its kind, preparation of large dataset may involve some associated uncertainties. The residential sector is also modelled as the division of urban and rural households, rather at full resolution of the other socio-economic basis, i.e., income groups. This weighted averaging method to conceive the energy-use profile is coarse one and should be refined further in the succeeding modeling efforts.

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APPENDIX-A

TABLE A-I
A SCHEME OF TECHNOLOGY CHARACTERIZATION IN URBAN AND RURAL SUBSECTORS.

		URBAN			RURAL		
Energy Service	**Technology**	**% stock**	**% house-holds**	**% households with appliance**	**% stock**	**% house-holds**	**% households with appliance**
Cooling (AC)	Air cooler Standard - Metal Body	0.7	0.32	0.22	0.7	0.17	0.12
	Air cooler Improved - Plastic Body	0.3	0.32	0.10	0.3	0.17	0.05
	AC standard	1.00	0.17	0.17	1.00	0.015	0.02
	1 Ton	*0.65*	*0.17*	*0.11*	*0.65*	*0.015*	*0.00975*
	1.5 Ton	*0.3*	*0.17*	*0.05*	*0.3*	*0.015*	*0.0045*
	2 Ton	*0.05*	*0.17*	*0.01*	*0.05*	*0.015*	*0.00075*
	AC improved						
Cooling (Fans)	Ceiling fan Standard	0.85	0.92	0.78	0.85	0.81	0.69
	Ceiling fan Improved	0.15	0.92	0.14	0.15	0.81	0.12
Refrigeration	Refrigerator Standard	1.00	0.56	0.56	1.00	0.26	0.26
	Refrigerator Improved						
Lighting				No. of lights (Mln)			No. of lights (Mln)
	Incandescent bulbs	0.36		#REF!	0.36		#REF!
	CFLs	0.42		#REF!	0.42		#REF!
	Fluorescent tube lights (FTL)	0.22		#REF!	0.22		#REF!
	Fluorescent tube lights (FTL) - Upgraded						
Water Pumping	Traditional	0.95	0.5	0.48	0.95	0.3	0.29
	Improved	0.05	0.5	0.03	0.05	0.3	0.02
Washing Machine	Standard	0.6	0.71	0.43	0.6	0.25	0.15
	Improved	0.4	0.71	0.28	0.4	0.25	0.10
Television	Standard	0.88	0.82	0.72	0.88	0.44	0.39
	Improved	0.12	0.82	0.10	0.12	0.44	0.05
Others	Monitor/CPU/Stereo	0.99	0.19	0.19	0.99	0.03	0.03
	Laptop	0.01	0.19	0.00	0.01	0.03	0.00
	Dry Iron-1000	0.85	0.98	0.83	0.85	0.83	0.71
	Dry Iron-2000	0.14	0.98	0.14	0.14	0.83	0.12
	Steam Iron	0.01	0.98	0.01	0.01	0.83	0.01
	17 Liter	0.95	0.12	0.11	0.95	0.005	0.00
	39 Liter	0.05	0.12	0.01	0.05	0.005	0.00
	Blender	0.9	0.58	0.52	0.9	0.07	0.06
	Food Processor	0.1	0.58	0.06	0.1	0.07	0.01
P & B (Fans)	Pedestal	1	0.11	0.11	1	0.19	0.19
	Bracket	1	0.09	0.09	1	0.04	0.04
Exhaust (Fans)	Traditional	0.66	0.75	0.50	0.66	0.29	0.19
	Plastic Body	0.34	0.75	0.26	0.34	0.29	0.10

TABLE A-II
BIOMASS ENERGY USE IN PAKISTAN RURAL / URBAN HOUSEHOLDS (TOES), 2006/07

	Wood	**Dung**	**Agr. Residues**	**Total**
Urban				
Cooking	1041	271	136	1448
Space Heating	68	0	0	68
Water Heating	204	0	0	204
Other	23	23	0	45
Total Urban	1335	294	136	1765
Rural	0	0	0	0
Cooking	7692	2036	1561	11290
Space Heating	724	0	0	724
Water Heating	837	0	0	837
Other	68	136	0	181
Total Rural	9299	2149	1561	13009
Total	10633	2443	1697	14774

Experimental Modal Analysis of Reinforced Concrete Girder using Appropriated Excitation Technique

M. A. Azam[1], Q. U. Z. Khan[2]

[1,2]*Civil Engineering Department, UET Taxila, Pakistan*
[1]asif_azam80hotmail.com

Abstract-Vibration based structural health monitoring of civil infrastructure is becoming very popular due to advancement in instrumentation and development of more robust and powerful system identification techniques. Damage alters the dynamic characteristics of a structure and this relation is used to identify, locate and assess the severity of damage. Despite of advances in vibration based methods very limited success has been reported for reinforced concrete structures particularly in field applications due to complexity of civil engineering structures, limited measurement points, measurement noise and processing errors. The success of vibration based methods relies on the ability to precisely measure the modal properties. Experimental modal analysis is often carried out to observe the modal parameters among which phase separation methods are very common. Phase resonance methods traditionally used in the field of aerospace and mechanical engineering measures the modal parameters physically rather than mathematically. This paper presents the methodology of phase resonance method with application to a typical reinforced concrete bridge girder reduced to one-fourth scale. Piezoelectric accelerometers at 54 measurement points are used to obtain five modal parameters i.e. natural frequency, mode shapes, damping ratio, generalized mass and stiffness. The comparison shows noticeable variation in extracted modal parameters.

Keywords-Vibration Based Damage Detection, Experimental Modal Analysis, Reinforced Concrete, Force Appropriation Method, Modal Parameters

I. INTRODUCTION

Civil infrastructure is exposed to aggressive environment, ever increasing traffic volume, various man-made and natural hazards which might lead to severe damage or cascading catastrophic failure. To minimize and reduce these risks, prompt and intensive monitoring is required. With the aim to diagnose the structural damages at the earliest possible stage and to evaluate the remaining useful life referred as prognosis, the concept of Structural Health Monitoring (SHM) has received increasing attention among civil engineering research community [i]. Current bridge inspection and evaluation mostly rely on visual inspection and Non Destructive Methods with their known limitations and ability to check the structure locally. The progress on new and emerging sensory technologies, sophisticated data acquisition systems and automated analysis tools has led to development of global automated structural integrity assessment techniques.

In the past few decades, significant amount of research work has been carried out on non-destructive damage detection of structure using changes in modal parameters. The extension of Vibration Based Damage Detection (VBDD) techniques for SHM of civil infrastructure is progressively gaining attention among researchers [ii]. The basis of VBDD methods is that structural modal parameters (natural frequencies, mode shapes, and modal damping) are functions of the physical properties of the structure (mass, damping, and stiffness). Damage will affect the physical properties of a system, which consequently will change the measured dynamic response of the system [iii]. Despite of advances in VBDD methods, very limited progress has been reported in field applications mainly because of errors encountered due to limited measurement points, noise, processing error and complex post cracking behavior of reinforced concrete structures. Therefore, much less research and development work has been reported for damage detection of reinforced concrete structures [iv]. It is necessary to investigate these effects to develop robust and reliable procedures for accurate and advanced methods to locate and quantify damage in reinforced concrete structures.

II. LITERATURE REVIEW

Vibration-based structural health monitoring has been subject of great interest among the field of civil and mechanical engineering communities since last two decades. Various methodologies and damage detection techniques have been comprehensively summarized by References [v-vii]. A common approach is to measure the vibration response and compare the damage-sensitive parameters to distinguish between damaged and

undamaged state. This process can be categorized into forward problem and inverse problem. In forward problem, damages are induced with known properties and their corresponding effects on modal properties are studied whereas the inverse problems are addressed with inverse approach. Reference [viii] presented an overview of inverse methods used for damage detection from measured vibration data. According to [ix] presented a review on the utilization of changes in resonant frequency to detect structural damage. Reference [x] studied the development in mode shape based structural damage identification methods. The application of vibration-based methods with special emphasis on composite materials has been described by According to [xi]. The success of any vibration based structural health monitoring technique relies on the ability to precisely measure the modal properties.

Modal parameters may be obtained analytically using finite element method (FEM) or experimentally through different experimental techniques. Normal Mode Analysis (NMA) method, also called as Phase Resonance method, has been traditionally used in aerospace industry for ground vibration testing of aircrafts [xii]. Phase resonance method was used for Experimental Modal Analysis (EMA) to identify modes and modal parameters until the advent of Fast Fourier Transform (FFT), which gave rise to the evolution of the broadband test technique (phase separation). Subsequently Multi-Degree of Freedom (MDOF) curve fitting techniques were developed to identify the modal properties from multiple Frequency response functions (FRFs). These two methods are explained in Section III.

The accurate prediction of modal properties is entirely dependent on the assumption of linearity which however cannot be justified for composite complex structures, resultantly the FRFs at operational vibration levels differ from those observed at low excitation level. As non-linearity is a major concern in phase separation method whereas in case of phase resonance, it is possible to characterize the non-linear modal behavior by iteratively varying the inputs and obtaining the output consistent with the operating conditions.

Further, the development of new display indicators such as multi Lissajous displays and automation techniques has reduced the time taken to tune each mode using multiple shakers. The combination of these two factors has revived interests in the phase resonance methods. Reference [xiii] discussed application of phase separation and phase resonance methods to both proportionally and non-proportionally damped structures with their application to an aluminum plate. For non-proportional damped structures exhibiting significant modal overlapping and in cases where close correlation with Finite Element Analysis is required, the phase resonance method employing force appropriation technique has been proved valuable.

The EMA of Reinforced Concrete (RC) structures through phase resonance method has not been presented so far. With this motivation, the author carried out EMA of reduced scale bridge girder ($1/4^{th}$) using force appropriation method for identification of natural frequency, mode shapes, damping, generalized mass and generalized stiffness. These five modal parameters were observed for both undamaged and damaged case and comparison of results shows considerable variation in observed modal parameters which can be further used for damage detection and localization purpose. The results obtained are discussed in Section V.

III. Experimental Modal Analysis

Modal parameters estimation is carried out through modal analysis performed by calculation (Finite Element Analysis, FEA) or by testing employing various methods of experimental modal testing broadly classified in two groups depending on the nature of excitation method:

Global broad-band excitation (phase separation)

Appropriated excitation (phase resonance)

The global excitation method excites all desired modes simultaneously using single or multiple broad-band excitation signals. The mode separation is carried out mathematically by applying various curve-fitting algorithms on set of measured FRF. Modal parameter estimation algorithms are used to extract mode data from each separated measured mode.

Force Appropriated Modal Testing (FAMT) also known as Normal Mode Analysis (NMA) or Phase Resonance method achieve modal separation physically rather than mathematically. The structure is excited physically by applying coherent sinusoidal vibration at a resonant frequency forcing a single mode of vibration to be sustained at a time. The excitation force distribution is tuned (automatically adjusts the amplitude and phase of the forces) to achieve mode isolation by ensuring that all velocity responses are exactly either in-phase or out-of-phase with the applied forces. Each mode is studied in isolation from all other modes in its purest possible form to obtain mode shape from array of measured responses. The generalized parameters are extracted by observing the effect of induced additional quadrature force.

A typical force-apportioned normal mode test involves following steps

The first step is to identify the number of modes and the approximate natural frequencies by applying sine sweep/random excitation across the entire frequency bandwidth.

In the second step, each mode is isolated with appropriate tuning of the level of force and frequency of excitation. The number and location of sensors and shakers should be well optimized. This iterative tuning is aided by two global

indicators i.e. the Modal Indicator Function (MIF) approaches unity while the Phase Indicator (PI) approaches zero. The tuning of both the force and phase at the excitation point may be controlled by a closed loop. A stabilization time should be allowed at each iteration for the responses to settle.

Once a mode is isolated and sustained by the appropriate forces, responses at all sensors are measured simultaneously ensuring that all the responses are in mono-phase and in phase quadrature with the excitation force vector. The mode shape may be obtained directly from array of measured response amplitudes while maintaining the structure in brief resonant dwell.

The calculations of generalized mass and stiffness are made using the Complex Power (CP) and Quadrature Force (QF) methods and damping parameters by applying frequency sweep around resonances. The CP function is derived from the summation of real and imaginary components of all drive-site-force-velocity products during a narrow frequency sweep across the natural frequency. The real or active part of CP reaches maximum and the imaginary part crosses zero at the natural frequency. The generalized parameters are extracted from the SDOF curve fit of the complex power spectrum.

Normal mode testing uses sine excitation with multiple shakers in a Multiple Input Multiple Output (MIMO) arrangement which offers an intuitive way of modal analysis with following advantages over other techniques.

In order to get sufficient vibration energy in large and complex structures using single shaker, there is a tendency to overdrive the excitation DOF which often results in nonlinear behavior and deteriorates the FRF estimation. In case of MIMO, the input force energy is distributed over more locations on the structure providing a more uniform vibration response over the structure.

Multiple location excitations also provide a better simulation of structures in real life operations.

Normal mode shapes can be obtained directly without utilizing Frequency Response Function (FRF) or modal parameter estimation techniques.

The structure is excited in a single mode by controlled force appropriation and enhances the comparison with FEA or other excitation methods.

The nonlinear behavior of structures can be accurately studied by amplitude sweeping.

The acquisition and processing of modal parameters is very fast so that test setup can be validated simultaneously.

IV. Theoretical Background

Consider a linear time invariant system with n degrees of freedom (DOF) subject to sinusoidal excitation force vector $\{f\}$ at an angular frequencyω. The n second order linear differentials equations with constant coefficients to describe the force-response relationship of the system may be written in matrix format as

$$[M]\{\ddot{x}\} + [C]\{\dot{x}\} + [K]\{x\} = \{f\} \quad (1)$$

The M, C and K matrices represent mass, damping and stiffness respectively. In general, these n equations are coupled so that these matrices have non-zero off-diagonal elements. These equations are uncoupled by normal mode testing for identification of mode shapes. The complex displacement response vector of the structure can be described as

$$\{x\} = [A(\omega) + iB(\omega)]\{f\} \quad (2)$$

Where $[A]$ and $[B]$ denotes the real and imaginary parts of the FRF matrix respectively. The phase resonance condition is said to be achieved when the response of the structure is in mono-phase (0 or 180^o phase) and in quadrature (90^o phase) with the sinusoidal excitation so that the structure is exciting in its i^{th} undamped normal mode at corresponding undamped natural frequency (ω_i). At this condition, the excitation force vector will be real, imaginary part of the response vector will correspond to undamped normal mode shape and real part will be zero, i.e.

$$Imaginary\ \{f\}_i = 0 \quad (3)$$

$$Real\ \{x\} = [A]\{f\}_i = 0 \quad (4)$$

$$Imaginary\ \{x\} = [B]\{f\}_i = \{\emptyset\}_i \quad (5)$$

Where $\{f\}_i$ is the appropriated force vector of the i^{th} mode shape $\{\phi\}_i$. The condition often holds for structures with low damping and sufficiently separated natural frequencies or when response of the structure is dominated by one specific natural frequency at the appropriated excitation force vector. The vibrating multiple DOF system can be described as generalized single DOF system at corresponding natural frequency as

$$\omega_r{}^2 = \frac{k_r}{m_r} \quad (6)$$

Where k_r and m_r are generalized stiffness and mass values, being global characterizing parameters for the individual eigenvectors respectively mode shapes. If the eigenvector Φ_r is normalized to its largest element, then these generalized properties can be calculated:

$$m_r = \Phi_r{}^T . M . \Phi_r \quad (7)$$

$$k_r = \Phi_r{}^T . K . \Phi_r \quad (8)$$

When the full mass matrix is replaced by a diagonal lumped mass matrix, the expression for the generalized mass becomes:

$$m_r = \sum(m_i . x_i{}^2) \quad (9)$$

Where *xi* are the elements of the normalized eigenvector Φ. The basis of appropriation method is empirical adjustment of inputs and evaluation of the quality of mode isolation. To evaluate the quality of mode isolation, the phase criterion and quality criterion are often used.

The phase criterion determines that phase of particular reference velocity sensor to be real (imaginary for acceleration or displacement). It gives a good approximation with low modal density i.e, other modes are not significantly coupled with the isolated mode. The quality criterion evaluates the quality of appropriation using the relative importance of measured real and imaginary responses information. Some of the quality criterion are described as under

The Multivariate Mode Indicator Function (MMIF) is the ratio of the quadrature energy to the total energy. The mass matrix is introduced to compare energies. The value of MMIF is 0 for a perfect appropriation.

$$q(s) = \frac{\{|Im\ \dot{x}|\}^T M\{|\dot{x}|\}}{\{|\dot{x}|\}^H M\{|\dot{x}|\}} \quad (10)$$

The statistical comparison between two mode shapes can be performed through Modal Assurance Criterion (MAC), which gives a correlation coefficient between two mode shapes. The coefficient value of 1.0 means that the two shapes are perfectly correlated. Practically, any value between 0.9 and 1.0 is considered good correlation. The MAC for two modes r and s can be calculated using following equation

$$MAC = \frac{|\{\varnothing_r\}^T\{\varnothing_s\}|^2}{(\{\varnothing_r\}^T\{\varnothing_s\})(\{\varnothing_s\}^T\{\varnothing_r\})} \quad (11)$$

V. Experimental Investigation

One RC girder of size 3660mm x 310 mm x 155 mm was cast with mix proportion of 1:1.25: 2.25: 0.45 (cement: Fine Aggregate: Coarse Aggregate: water cement ratio) which represents M35 grade of concrete. The Grade-60 reinforcement bars conforming to AASHT0 M31 Grade 60 steel specification were used. The geometry and cross section of the model is shown in Fig. 1. The total mass of the model is 510 kg which results in a density of ρ = 2,900 kg/m^3. The material properties are taken from actual girder. The design process of actual reinforced concrete girder followed the AASHTO LRFD bridge design specifications. The vehicle live loads were applied to produce maximum stresses as specified in West Pakistan Code of Practice for Highway Bridges 1967 (WPCHB) which includes 70 Ton tracked Military Vehicle and 54.5 Ton train of trailers. The impact loads and wind loads are taken in accordance with provision of WPCHB.

These loads were applied in combination with side walk live load of 5 KN/m^2, horizontal live load on side barriers according to Article 2.7 of AASHTO and other loads e.g. dead loads etc. The RC bridge was designed and dimension of actual girder becomes (14640 x 1240 x 620) mm in length, width and height respectively.

This model bridge girder has been scaled down to 1/4th of actual bridge girder. The dimensions and material properties of model girder are selected confirming the modeling and similitude requirements of replica scaling method. While casting the model girder, vibratory compaction of concrete was carried out to ensure removal of air and proper bond between concrete and steel to avoid slippage. Proper curing was carried out carefully.

A. Modal Testing

The model girder is mounted to vertical stands with the help of flexible bungees to simulate the free-free boundary conditions as shown in Fig. 4. The piezoelectric accelerometers having sensitivity of 6 pC/g and frequency range up to 3k Hz are calibrated and attached to model surface at 54 selected points with wax to measure the responses. The arrangement of accelerometers is shown in Fig. 1.

Electrodynamic shakers (also called modal exciters) are employed to provide a known input (force and frequency) to the structure. Working on the principle of electromagnetic induction, the electrodynamic exciter provides accurate control of the amplitude and phase of force which is very importantly required in force appropriation testing. Two exciters capable of exciting up to constant magnitude of 200 N are used with stingers as interface between exciter and the model girder. The purpose of stinger is to apply only axial forces with high fidelity and prevent lateral constraint forces and moments. The mass of the exciters is balanced through elastic cords. The exciters suspension system is used to minimize any influence of exciters mass on measurements. The experimental arrangement is shown in Fig. 4 &5.

The selection of exciters position is very critical and should be selected according to type of mode to be excited (i.e. symmetric or anti-symmetric mode). The exciters are attached at extremities of free-free model beam in a symmetrical axis for extraction of symmetrical modes and inversely arranged for anti-symmetrical modes not only to excite modes of interest but also to cancel the contribution of off resonant modes.

The excitation is controlled by P-SYS Modal software, a Dynamic Signal Analyzer transmits the signals through an amplifier which is transformed to physical excitation by electromagnetic exciters. P-Win Modal software is used to analyze the responses

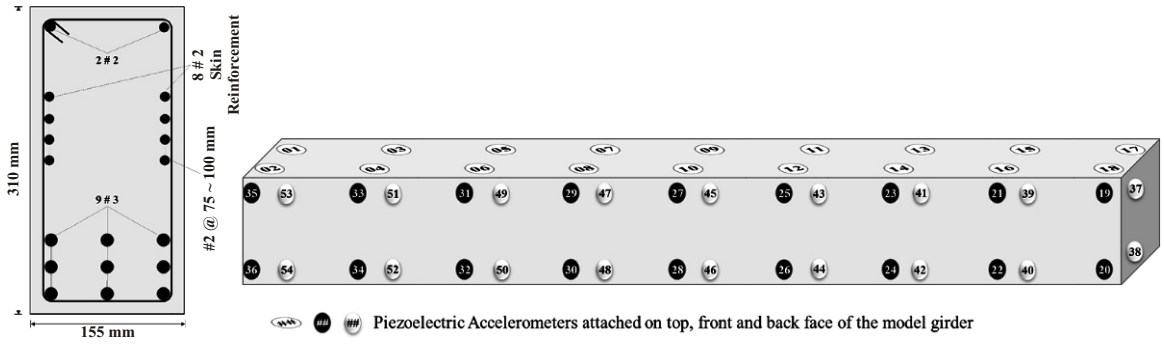

Fig. 1. Model girder cross-section and Piezoelectric Accelerometers arrangement

measured through accelerometers and compute the FRF for modal analysis. The natural frequencies, damping ratios and mode shapes are obtained through Complex Power Method.

Natural frequencies of firstly identified through an impact and then by sweeping slowly within across the identified natural frequency. The analysis found seven physical modes within a frequency range of 0 to 350 Hz.

B. Static Flexure Test

After the experimental modal analysis of undamaged model girder, the five point static flexure test was performed on the model to introduce the damages. The loading was applied with three actuators of 8 Ton maximum capacity and were equally spaced at a distance of 600mm between point loads and support span was 3300mm as shown in Fig. 2. Three Linear Variable Differential Transducer (LVDT) were fixed as shown in Fig. 2 to record the deflection at mid span as well as at a distance of L/3 from extreme ends where L is the total beam length. The maximum combined load of 24 Ton was applied with corresponding maximum deflections of 17.76mm recorded.

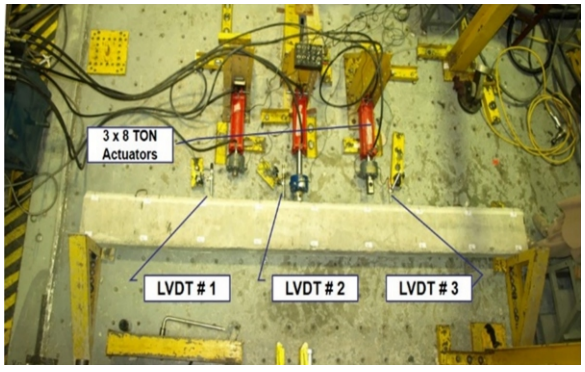

Fig. 2. Static Flexure Test arrangement

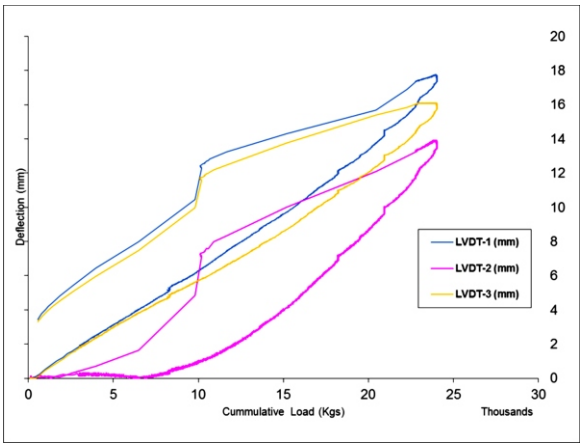

Fig. 3. Load vs Deflection plot of Static Flexure Test

Fig. 4. Experimental Modal Testing arrangement with exciter support system

Fig. 5. Experimental Modal Testing arrangement with free-free boundary conditions

The cracks pattern is studied by visual inspection. After the application of loading through static flexure test, the modal analysis of model girder in damaged state was again carried out with the similar arrangement. In the force appropriation method, a narrow frequency sweep across the resonant frequency and summation all drive-site force velocity products for each mode gives a CP spectrum.

TABLE 1
DETAILS OF FIRST SEVEN MODES IDENTIFIED

Mode	Description	Axis	Amplitude of Ref Transducer x 10^{-6} (m)		Exciter Position	
			Undamaged	Damaged	(Transducer No.)	
1	First Symmetric Bend	Y	255.45	254.63	36	20
2	First Symmetric Bend	Z	25.44	21.59	2	18
3	First Anti-Symmetric Bend	Z	5.92	4.83	2	18
4	First Anti-Symmetric Bend	Y	23.27	19.91	35	19
5	Symmetric Second Bend	Y	7.19	6.36	35	19
6	Twist	-	4.81	4.02	36	19
7	Anti-Symmetric Second Bend	Y	1.00	1.95	35	19

The real part (active power/in-phase with force) and the imaginary part (reactive power/quadrature with force) of first four mode shapes of the model girder in damaged and undamaged state are shown in figures 6 to 9 When the mode is perfectly tuned, the active component should be maximum and reactive component should be zero

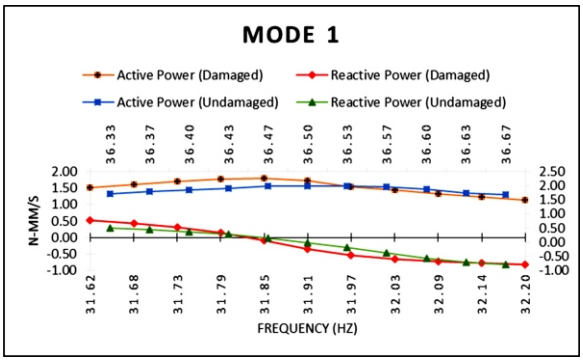

Fig. 6. Complex Power Spectrum for isolation of Mode 1

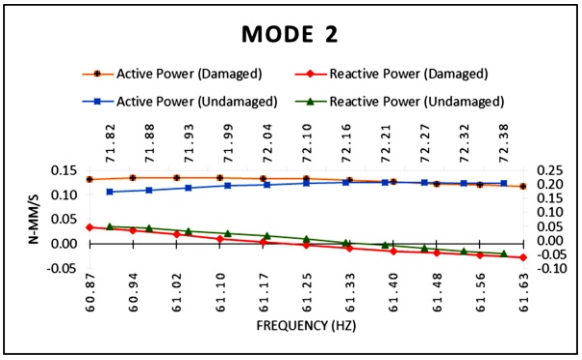

Fig. 7. Complex Power Spectrum for isolation of Mode 2

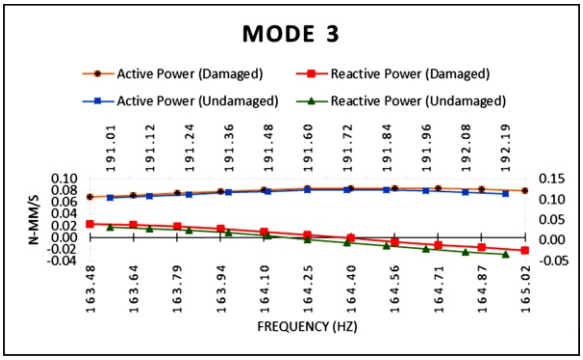

Fig. 8. Complex Power Spectrum for isolation of Mode 3

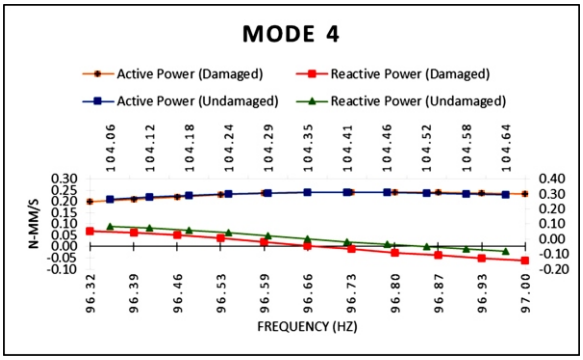

Fig. 9. Complex Power Spectrum for isolation of Mode 4

VI. Results and Discussion

A Natural Frequency

A structure subjected to certain degree of damage experiences a change in stiffness [xiv] which subsequently causes its natural frequency to change. The magnitude of the frequency shift is also an indicator of the damage severity. The results are compared which shows the reduction in natural frequency of damaged model girder in comparison with undamaged case. The magnitude of force applied simultaneously by exciters is also presented in Fig. 10.

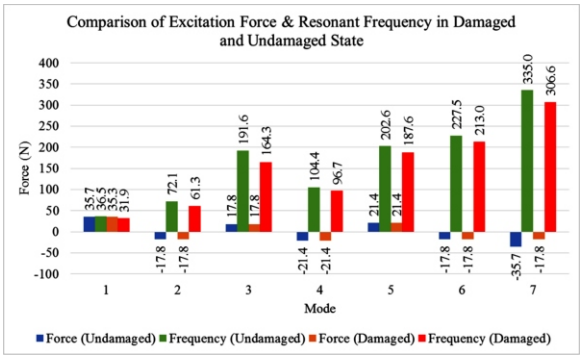

Fig. 10. Comparison of Resonant Frequency

B. Modal Damping

Modal damping of concrete member is associated with its dynamic response and can be used as a means to assess material integrity or damage occurred to the structure. Damping affects the rate at which vibrations decay and the response of the structures at resonance. The values of modal damping ratio observed for the undamaged and damaged beam are presented in Fig. 11. The results shows that damping ratios increases for the damaged beam, similar trend was observed by the author [xv, xvi].

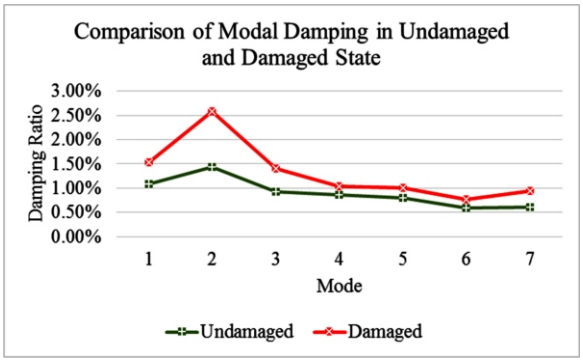

Fig. 11. Comparison of Modal Damping

C. Normalized Generalized Mass and Stiffness

The generalized mass and stiffness of each mode can be evaluated from the total driving power required to maintain the structure in resonant dwell. The calculation of generalized mass and stiffness follows complex power (CP) method. The CP function is derived by adding the real and imaginary components of force velocity products at all shaker locations. The excitation frequency is varied over a small range across the approximately identified natural frequency. The real or active part of CP reaches a maximum whereas the imaginary or reactive part crosses zero at the natural frequency. The resulted spectrum is curve-fit to obtain the generalized properties. The results obtained are shown in Fig. 12& 13.

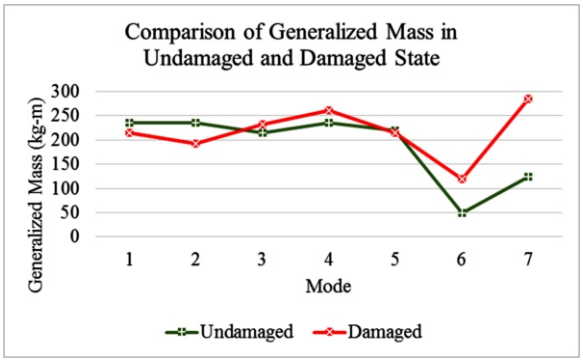

Fig. 12. Comparison of Generalized Mass

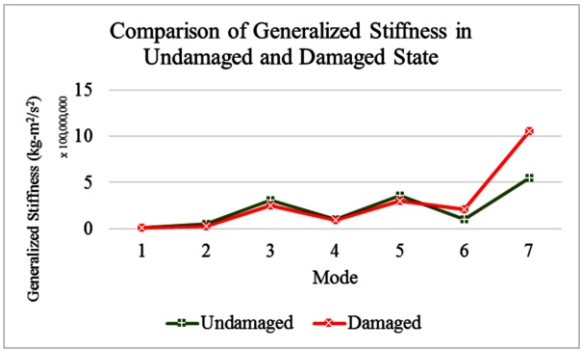

Fig. 13. Comparison of Generalized Stiffness

D. Mode Shapes

Modes are inherent properties of a structure and represents pattern of vibration executed by a structure at a particular frequency. Mode shapes are greatly affected by material and structural flaws because it changes the modal parameters. The normalized response of the measurement point in the form of mode shapes at a particular frequency and damping ratio is presented graphically in wireframe shapes (Fig. 14-27).

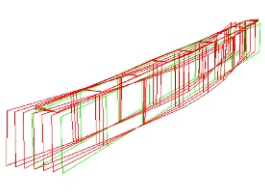

Fig. 14. Mode 1 Undamaged
36.5 Hz, 1.08%

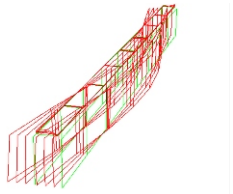

Fig. 15. Mode 1 Damaged
31.90 Hz, 1.53%

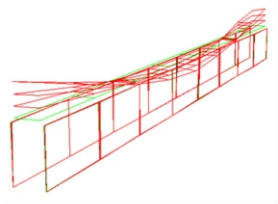

Fig. 16. Mode 2 Undamaged
72.1 Hz, 1.43%

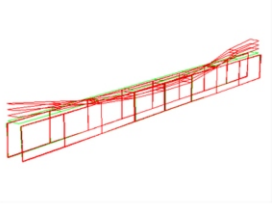

Fig. 17. Mode 2 Damaged
61.250 Hz, 2.58%

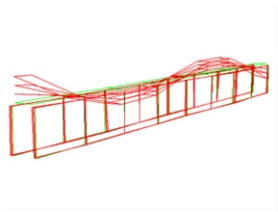

Fig. 18. Mode 3 Undamaged
191.6 Hz, 0.93%

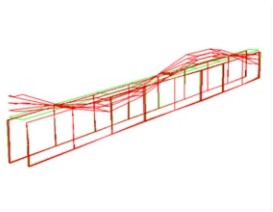

Fig. 19. Mode 3 Damaged
164.250 Hz, 1.40%

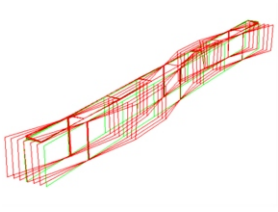

Fig. 20. Mode 4 Undamaged
104.35 Hz, 0.86%

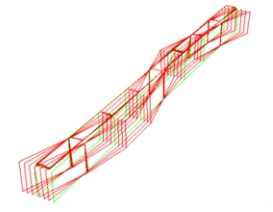

Fig. 21. Mode 4 Damaged
96.662 Hz, 1.04%

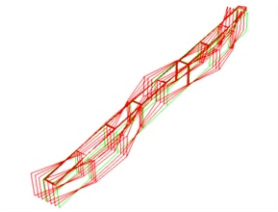

Fig. 22. Mode 5 Undamaged
202.60 Hz, 0.80%

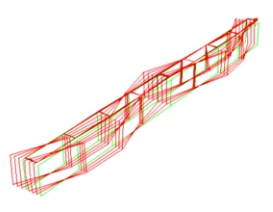

Fig. 23. Mode 5 Damaged
187.6 Hz, 1.00%

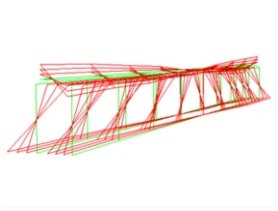

Fig. 24. Mode 6 Undamaged
227.45 Hz, 0.59%

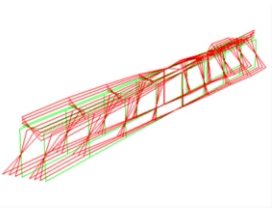

Fig. 25. Mode 6 Damaged
212.975 Hz, 0.76%

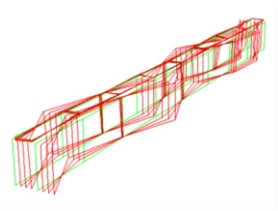

Fig. 26. Mode 7 Undamaged
335.00 Hz, 0.61%

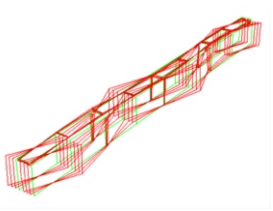

Fig. 27. Mode 7 Damaged
306.55 Hz, 0.94%

VII. Conclusion

Modal parameters are greatly affected by change in material properties or structural damages. The experimental modal analysis is performed on a RC beam in undamaged and damaged state with MIMO testing arrangement in a free-free boundary condition. Five modal parameters are observed and first seven modes are recorded with frequency range of 0 to 350 Hz. Damage was introduced thorough application of point load in 5 point static flexure test in which maximum deflection of 24mm at mid span is recorded.

The data is recorded through piezoelectric sensors installed at 54 measurement points in two lines on front side, back side and top. Two 200 N capacity electromagnetic exciters at extreme ends to free-free beam are installed. The modal analysis is carried out using force quadrature method and input force is given through force appropriation method.

The investigation through experimental modal testing confirm the detection of damage while comparing the data of undamaged and damaged states and following conclusions are made:

The appropriate force normal mode test can identify the natural parameters of each mode in isolation and provides extremely precise mode shapes even when adjacent modes overlap in modal bandwidth.

The frequency shift is observed in a range of 6.36% to 15.05%. The frequency shift is very clear in lower modes and the value reduces as the mode order increases which shows that initial modes are more sensitive to damage.

The damping ratios increases with damage in a range of 0.17 to 1.15% for respective modes. The damping ratio of both undamaged and damaged beam reduces with increase in mode number. The increase in damping ratio for damaged beam comparing to undamaged beam also exhibit the same trend.

The values of damping ratio decrease with higher modes indicating that lower modes have the tendency to decay much earlier.

The damping ratio in anti-symmetric modes of damaged structure shows more increase which shows rapid decaying capability of anti-symmetric modes.

The generalized mass decreases for symmetric modes and increases for antisymmetric modes. The increase is very significant for torsional mode and higher frequency antisymmetric mode.

The generalized stiffness decreases in first five modes and increases in case of torsional mode and higher frequency antisymmetric mode.

VIII. ACKNOWLEDGEMENT

The authors gratefully acknowledge the support of University of Engineering & Technology Taxila in the provision of financial assistance and laboratory facilities to conduct the research work.

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Investigating Students' Behavioral Intention Towards Adoption of Mobile Learning in Higher Education Institutions of Pakistan

W. U. Hassan[1], M. T. Nawaz[2], T. H. Syed[3], M. I. Arfeen[4], A. Naseem[5], S. Noor[6]

[1,2,3,5]*Engineering Management Department, College of Electrical & Mechanical Engineering, NUST*
[4]*Virtual University of Pakistan*
[6]*Project Management Department, COMSATS*
[1]waqarulhassan8@em.ceme.edu.pk

***Abstract*-**With the advent of 3G/ 4G technology in Pakistan, Mobile Learning has become a newly developing educational field, referring to the use of any kind of wireless mobile devices, where these devices allow the learner to acquire knowledge anytime, anywhere, within and beyond the traditional learning environment. Ubiquitous access to mobile devices with low cost and greater functionalities make M-learning an imperative tool, allowing the students to learn irrespective of time and place. In order to assimilate M-learning in higher education institutes (HEIs) of Pakistan, there was a need to analyse and examine the users' acceptance of the system. The aim of this study was to analyse the determinants that affect students' acceptance of M-learning and whether age or gender play a moderating role in this acceptance, based on the unified theory of acceptance and use of technology (UTAUT). In order to achieve this objective, a quantitative approach using a survey based questionnaire was utilised for collection of data. The questionnaire was distributed to a random sample of 625 students from universities operating in the twin cities of Rawalpindi and Islamabad. According to the results, 76.4% of behavioural intention to accept M-learning has been explained through the model. Performance expectancy, effort expectancy, social influence and attitude towards the use of technology were found to be positively associated with the behavioural intention towards adopt M-learning, moderated by age and gender, whereas facilitating conditions and self-management of learning were found to have no significant effect on behavioural intention. The findings of this research will prove to be useful for management of higher education institutes in making decisions when designing and implementing m-learning technology.

***Keywords*-**Mobile Learning, Technology, Acceptance, UTAUT, HEIs, Pakistan

I. INTRODUCTION

The rapid development in information and communication technologies has led to increased investments and remarkable changes in every field of life. Institutions today are now operating in a highly volatile environment, which is changing rapidly being characterized by uncertainty. The new technological era is abound with numerous opportunities and challenges for the educational system across the globe. Educational institutions have been revolutionized as learning changes are elicited by changes in technology [i]. Universities today have incorporated technology in their strategic goals, making it a substantial part of every university's budget [ii]. The technological revolution, with the introduction of 3G/ 4G mobile technologies has helped in capacity building and enhancement of faster communication and information sharing being technology enabled. Resultantly technological change has transformed the traditional ways of learning giving way to Distance learning (D-learning), Electronic Learning (E-learning) and Mobile learning (M-learning).M-learning offers an opportunity for self-study by allowing easy access to learning resources and exchange of information and feedback with the instructors [iii].

The impact of technology on society has changed overall life processes but its impact on learning and diffusion in the educational activities need to be observed with the focus on the user's readiness and acceptance of the new technology. Reluctance of users to accept the latest technology can lead to structural catastrophe and result in no benefit for the institutions [iv-v]. The opportunities and benefits offered by M-learning have not been explored completely [iv].

To ascertain the efficient use of an institute's time and financial resources devoted towards M-learning, it was essential to analyze the determinants influencing students' acceptance of M-learning before its effective deployment in higher education institutes of Pakistan. This study was conducted by applying the UTAUT model to find out the determinants as well as the effect of age and gender on the acceptance of M-learning [v]. The study would help the management to analyze and assess whether mobile technologies, with the aid of the new emerging 3G/ 4G, can become

convenient tools for learners and educators in the existing educational environment of Pakistan. The information and results obtained from this study will assist in developing a theoretical model, enabling the educators, administration and management of HEIs of Pakistan to understand the students' intentions to use M-learning to study academic contents anywhere, anytime. Firstly, this paper describes the literature review regarding the theory and model that can be utilized to predict the acceptance of a new technology. The paper then explains the research methods and hypothesis, followed by the results and conclusion at the end.

II. Mobile Learning in Higher Education

The omnipresent access to mobile devices has inspired higher education institutions to incorporate these technologies in the learning processes through M-learning. According to [vi], mobile learning can be explained as the learning done through ubiquitous communication by using mobile devices and intelligent user interfaces. M-learning employs wireless devices such as mobile phones, smart phones, handhelds, laptops, palmtops, iPods and PDAs in the learning process [vi]. However, some researchers have emphasized on mobility while defining m-learning, eliminating laptop from the definition, restricting to only those particular devices that are completely portable and flexible in the learning process [vii].

Mobile devices today are furnished with newest features that support students in their learning process. Being smaller in size, mobile devices are easier for students to carry everywhere they go. These devices help the students to establish a constant connection with their learning resources while on the go, enabling them to do everything they want to do on a desktop computer such as processing or storing data. Due to lesser cost and ease of use, as compared to desktop computers, these devices have become more attractive for students [viii]. According to [ix], mobile devices have the following five unique educational attributes:

a. Portability: devices provide mobility
b. Social interactivity: devices enable users to interact and communicate easily
c. Context sensitivity: devices enable users to gather real data according to their respective location, time and environment
d. Connectivity: devices can be linked through a shared network
e. Individuality: devices enable discrete education

A number of features are available in mobile devices that can be utilized to enhance learning like messaging, access to the internet, and multimedia convergence [ix]. The widespread use of the internet has enabled most of the institutions to offer online and distance education programs. This has led to the question that whether online programs are equally effective as compared to traditional learning environment. In the past, 688 studies have been analyzed, to identify difference of motivation level of students who were studying in a traditional classroom or were taking distance learning courses [x]. Likewise, 96 studies were carried out which concluded with similar results, indicating that online and traditional learning are both equally motivating [xi]. Thus it can be established that m-learning is motivating for students as it provides them control over their learning goals and supports social interaction making learning entertaining and enjoyable [xii].

Numerous previous studies have been done to investigate about the advantages of using mobile devices to pursue education and promote learning [vii], [xv-xvi], the foremost advantage being that mobile learning can result in improved understanding of the learning contents, through different and interesting methods of teaching that create student's interest in learning contents. Moreover, features such as student group discussions and feedback may increase students' motivation and memory retention. Mobile devices may also serve to be a good assessment tool for students enabling the shy students to express their ideas in a better way [xiv]. Using mobile devices in learning process can also result in enhanced feedback, promoting interaction between the instructors and students [xiii]. M-learning allows an interactive environment, providing constant communication and collaboration in learning activities. The data interchange can take place through different channels such as emails, blogs, forums and messages, enhancing the level of interaction between peers, students and instructors [xiv]. Being a subcategory of E-learning, M-learning has similar advantages to the prior such as the privilege of self-studying, easy access to learning contents, self-assessment and instant feedback [iii], [xvi].

Although m-learning provides multiple learning opportunities for users, providing them the facility to make learning mobile, it has some limitations and issues that need to be resolved for its success, such as physical limitations of mobile devices (small screen size, limited battery life), psychological barriers of students, network speeds, security aspect and cost.

III. Theory Under Investigation

Many theories have been developed in the past in order to explain the users' acceptance of any new technology. The most extensively used model is the Technology Acceptance Model (TAM) illustrated in Fig. 1, which provides a hypothetical basis to elucidate the impact of external variables and intentions to adopt the system [xv]. TAM has gained the reputation of being the most widely used model in the field of IT due to its simplicity and ease of use [xvi]. The key strength

of the TAM model is its consistency as it shows only 40% variance in the use of behavior and intentions of people in organizations [xv].

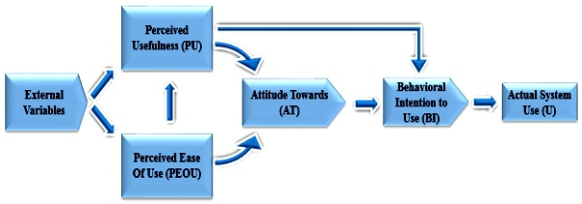

Fig. 1. Technology Acceptance Model (TAM), Davis (1989)

A relatively more recent and prevalent model is the Unified Theory of Acceptance and Use of Technology (UTAUT) model [v] as illustrated in Fig. 2. It incorporates and compares various elements from 8 different models: Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), Motivational Model (MM), Theory of Planned Behavior (TPB), Model of PC Utilization (MPCU), Innovation Diffusion Theory (ITD), Social Cognitive Theory (SCT) and Combined TAM and TPB (C-TAM-TPB).

The formulation of the UTAUT model is a consequence of merger of eight models/theories, that is useful in integrating the systems' and the users' characteristics to predict the acceptance level of any new technology. According to [v], the model comprises of the following basic constructs: Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions. Operational definitions of these constructs are, Performance Expectancy,"the extent to which a person believes that using the system will assist him in achieving his objectives in job performance", Effort Expectancy"the amount of ease linked with the usage of the system", Social Influence" the extent to which an individual perceives significant that others think that he should make use of the new system", Facilitating Conditions, "the extent to which one believes that a structural and methodological structure exists to support the system usage", Behavioral Intention, "an individual's personal opinion that that he or she will behave in a certain manner". The mediating variables include gender, age, experience and voluntariness of use. The UTAUT model can help managers in assessing the users' behavior intention to adopt any new technology

According to [v], model shows a 70% variance in intention and it can aid the managers in assessing the success of the new technology [xvii]. However, there are still some empty areas in the UTAUT model that require further researches to cater for the technology that falls between the 30% unexplained acceptance [xviii]. Moreover, individual factors such as self-management of learning, attitude towards technology and perceived playfulness are not included, which may prove to be helpful in assessing the users' acceptance of a new technology.

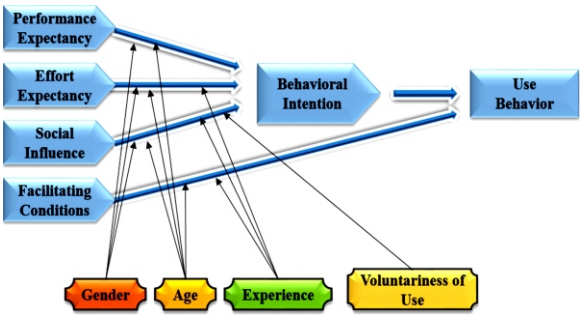

Fig. 2. Research Model UTAUT, Venkatesh (2003)

A. Theoretical Framework

The UTAUT (Fig. 3) model was selected in order to analyze the relationships between the independent and dependent variables. The model exemplified below has been established for the study based on the relationships between Behavior Intentions as dependent variable and Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Condition, Perceived Playfulness, Self-management of Learning and Attitude towards use of technology as independent variables, with gender and age as the moderating factors. Three additional constructs, i.e. Perceived Playfulness: "the degree to which a person perceives that his interest or attention is focused on m-learning, is curious during the interaction, and finds the interaction enjoyable" [xix], Self-management of Learning: "the extent to how much a person perceives that he can maintain self-discipline and can engage in self-directed learning" [xx] and Attitude towards use of technology: "the overall aptitude of an individual towards the use of technology" [v], have been included in the UTAUT model.

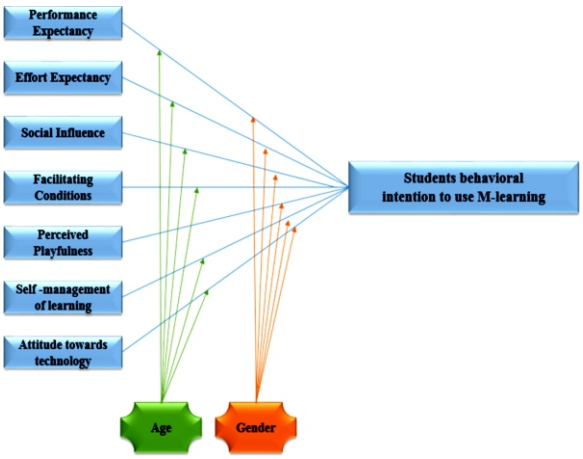

Fig. 3. Theoretical Framework

1) Performance Expectancy (PE)

H0: There is no relationship between Performance Expectancy and behavioral intention to use

M-learning.

H1: Performance Expectancy has a positive relationship with behavioral intention to use M-learning.

H2: The effect of Performance expectancy on behavioral intention to use M-learning will be moderated by gender and age.

2)Effort Expectancy (EE)

H0: There is no relationship between Effort Expectancy and behavioral intention to use M-learning.

H3: Effort expectancy has a positive relationship with behavioral intention to use M-learning.

H4: The effect of Effort Expectancy on behavioral intention to use M-learning will be moderated by gender and age.

3) Social Influence (SI)

H0: There is no relationship between Social Influence and behavioral intention to use M-learning.

H5: Social influence has a positive relationship with behavioral intention to use M-learning.

H6: The effect of Social Influence on behavioral intention to use M-learning will be moderated by gender and age.

4) Facilitating Conditions (FC)

H0: There is no relationship between Facilitating Conditions and behavioral intention to use M-learning.

H7: Facilitating conditions has a positive relationship with behavioral intention to use M-learning.

H8: The effect of Facilitating Conditions on behavioral intention to use M-learning will be moderated by gender and age.

5) Perceived Playfulness (PP)

H0: There is no relationship between Perceived Playfulness and behavioral intention to use M-learning.

H9: Perceived playfulness has a positive relationship with behavioral intention to use M-learning.

H10: The effect of Perceived Playfulness on behavioral intention to use M-learning will be moderated by gender and age.

6) Self-Management of Learning (SML)

H0: There is no relationship between Self-Management of learning and behavioral intention to use M-learning.

H11: Self-management of learning has a positive relationship with behavioral intention to use M-learning.

H12: The effect of Self-Management of Learning on behavioral intention to use M-learning will be moderated by gender and age.

7) Attitude towards Technologies (ATT)

H0: There is no relationship between Attitude towards Technology and behavioral intention to use M-learning.

H13: Attitude towards the use of the technologies for learning is positively related to behavioral intention.

H14: The effect of Attitude towards use of technologies on behavioral intention to use M-learning will be moderated by gender and age.

IV. Research Design

In order to achieve the study objectives, across-sectional study having a quantitative approach was conducted using a survey based questionnaire for collection of data.The unit of analysis of this survey comprises of students from higher education institutes of Pakistan. Due to time, budget and resources constraints, sample frame selected for this study encompasses the chartered universities from twin cities of Pakistan, i.e. Rawalpindi and Islamabad. The questionnaires were distributed among 625 respondents, from ten recognized degree awarding universities of Pakistan, selected on the basis of random sampling.

The questionnaire consists of two main parts: Section A of the questionnaire comprises of 10 questions related to the demographic details and opinion of the respondent regarding internet usage through mobile devices for educational purpose. Section B comprises of 31 questions related to the determinants affecting the behavioural intentions. Five point Likert scale was used for the questionnaire and the data collected was analysed using SPSS V20.

The main constructs and items pertinent to the study were adopted from past studies of [v] whereas the items used to measure perceived playfulness and self-management of learning were adopted from another study [xix-xx]. Furthermore, constructs and items in the questionnaire were verified by a number of experts to validate the language and comprehensiveness of the questionnaire in order to meet the research framework; see Appendix A for question statements in full. A detailed pilot study (Table I) was also conducted by handing out the questionnaire to 55 students of HEIs, resulting in 37 responses, out of which 35 were valid responses, making the response rate 67.9%. The valuable suggestions received were incorporated into the questionnaire and the questions were updated. The items were considered reliable and consistent as the results of the pilot tests showed the reliability being greater than 0.7. Therefore the questionnaire was further distributed to respondents to gain more results.

TABLE I
PILOT TEST RESULTS

Constructs	Cronbach's Alpha	No. of items
Facilitating Conditions	0.856	4
Perceived Playfulness	0.765	5
Self-Management of Learning	0.836	4
Attitude Towards Learning	0.880	3
Behavioral Intentions	0.909	3
Social Influence	0.848	4
Effort Expectancy	0.965	4
Performance Expectancy	0.951	4

V. DATA ANALYSIS AND RESULTS

625 questionnaires were distributed amongst students of 10 chartered universities of Rawalpindi and Islamabad. About 433 filled questionnaires were received back from the respondents, out of which 25 were ineligible (incomplete). Thus a total of 68% active response rate was achieved.

A. Demographic Analysis

The results showed (Table II) that the data has been collected from a total of 408 respondents, out of which 300 were males and the remaining 108 were females. Furthermore, the respondents belonged to different age groups, with 150 respondents belonging to an age group of less than 20 years, 131 respondents having their ages between 20 to 24 years, 83 respondents having their ages between 25 to 30 years and the remaining belonging to the age group of above 30 years. Most of the respondents were undergraduate students, belonging to the age groups of under 20. This is because according to the statistics obtained from HEC, the highest ratio of students in Pakistan belong to the undergraduate group, which will be affected the most by the introduction of m-learning in Pakistan. Thus, it was evidently important to cater to their responses.

The maximum number of respondents are using smart phones. Smart phones are now available in cheap prices and have become affordable for students, enabling them to perform various computational functions. This can lead to more users incorporating m-learning in their education, as they can easily access educational content through their mobiles. A number of users also have access to PDAs and other similar devices that support the use of m-learning. This shows that most of the students studying the higher institutes of Pakistan have the required resources to support M-learning.

The results indicate that a large number of students use their mobile phones daily. This means that if they are offered m-learning, they would be able to use it very frequently. Around 263 respondents i.e 64.5% have the facility to access internet through their mobile phones. This shows that majority of the students can access educational material through their mobile phones, anytime, anywhere, which is the main idea behind m-learning. Thus according to these results, students are well equipped with the facilities required to use m-learning on their own.

A large number of respondents, i.e. 78.2% are already accessing educational applications through their mobile devices. This means that they are already in a habit of using various educations apps for their studies. Moreover, this shows that students are already accessing especially designed educational software or apps for Android or Apple mobile devices. Thus if they are offered the opportunity to learn through their mobile devices, they will be able to excel in this field easily.

About 45.6% of the respondents access educational content through their mobile devices. This includes searching online, reading e-books or papers online, viewing educational lectures and videos, and doing other kinds of educational work such as storing and saving information on their mobile devices. Being already in a habit of reading educational content using mobile technology for educational purposes, if students are offered M-learning, they will accept it enthusiastically.

Respondents around 68.6% have already heard about m-learning and know about its requirements and procedures. This large value can also be because of the explanation of M-learning given in the beginning of the questionnaire which has enabled the respondents to gain knowledge about the subject.

This is further supported by the result of 72.8% respondents think that learning while on move is a decent idea and are ready to practice it in the future, because students consider technology be an important part of their education and find using M-learning tools exciting and flexible. Thus according to the demographic results, we can deduce that most of the students, especially the students belonging to the undergraduate group, have the required resources e.g. smart phones and PDAs with internet access, and are of the opinion that they would like to use m-learning as they are already accessing educational contents through their mobile devices.

TABLE II
CHARACTERISTICS OF THE RESPONDENTS

	Frequency	Percent	Valid Percent	Cumulative Percent
Gender				
Male	300	73.0	73.5	73.0
Female	108	26.5	26.5	100.0
Age				
Less than 20 years	150	36.8	36.8	36.8
20 to 24 years	131	32.1	32.1	68.9
25 to 30 years	83	20.3	20.3	89.2
Above 30 years	44	10.8	10.8	100.0
Qualification				
Under Graduate	220	53.9	53.9	53.9
Graduate	146	35.8	35.8	89.7
Post Graduate	42	10.3	10.3	100.0
"My mobile device can be best classified as"				
Call & Text	103	25.2	25.2	25.2
Smart phone Connectivity	193	47.3	47.3	72.5
PDA	51	12.5	12.5	85.5
Tablet PC	45	11.0	11.0	96.1
Other devices	16	3.9	3.9	100.0
"How often do you use the internet from your mobile device?"				
Daily	247	60.5	60.5	60.5
Weekly	107	26.2	26.2	86.8
Monthly	42	10.3	10.3	97.1
Rarely	12	2.9	2.9	100.0
"Do you access the internet using 3G/4G mobile network?"				
Yes	263	64.5	64.5	64.5
No	145	35.5	35.5	100.0
"Have you used any educational application on your mobile device?"				
Yes	319	78.2	78.2	78.2
No	89	21.8	21.8	100.0
"Do you access educational contents using 3G/4G mobile networks?"				
Yes	186	45.6	45.6	45.6
No	222	54.4	54.4	100.0
"Have you heard about Mobile Learning (M-Learning)?"				
Yes	280	68.6	68.6	68.6
No	128	31.4	31.4	100.0
"What is your opinion of M-Learning?"				
Good idea and like to use	297	72.8	72.8	72.8
Good idea and not like to use	57	14.0	14.0	86.8
Think not a good idea	25	6.1	6.1	92.9
Others	29	7.1	7.1	100.0

B. *Descriptive Analysis*

TABLE III
DESCRIPTIVE STATISTICS OF FACTORS AFFECTING M-LEARNING

Constructs	Mean	Std. Deviation
Performance Expectancy	4.233	0.9987
Effort Expectancy	4.159	0.9656
Social Influence	4.203	1.0605
Facilitating Conditions	4.010	0.9980
Perceived Playfulness	4.169	0.9782
Self-Management of Learning	4.053	0.9902
Attitude Towards Technology	4.181	1.0219
Behavioral Intentions	4.076	0.9722

The average response of the respondents for all variables varies between 4.010 and 4.233 (Table III), with the standard deviation ranging between 0.9656 and 1.0605. The mean value of PE is 4.233 indicating that students find m-learning useful, helping them to increase their learning productivity and increase their knowledge. EE has a mean value of 4.159 implying that students perceive m-learning to be easy and convenient to use, with clear understanding. The mean of SI is 4.203 indicating that students are positively influenced by others to use m-learning. They will be supported by their institution and administrative staff to use m-learning. Facilitating Conditions has a mean value of 4.010, meaning that they have the required resources to use m-learning and they will be able to get help from others whenever they face difficulty in using M-learning. Perceived Playfulness has a mean value of 4.169 indicating that students believe that m-learning will be enjoyable to use and will stimulate their curiosity and exploration. The mean of Self-management of learning is 4.053 showing that most of the students will be self-directed and self-motivated to use m-learning, setting their own pace and time of study and allocating their time responsibly for all the tasks to be performed. Attitude towards the use of technology has a mean of 4.181 indicating use of M-learning is an enjoyable activity, whereas Behavioral Intentions has a mean value of 4.076 implying that students intend using m-learning in the future thinking of it as an attractive option.

C. *Goodness of Fit*

In order to successfully run statistical tests, it is mandatory for the data to be normally distributed. The values of skewness for all the variables, as showing in table below lie in between +1 to -1[xxi], demonstrating that the data distribution is typical/ normal. Moreover, the values of the result for kurtosis for all the variables are within the range ± 2.58 [xxi] demonstrating that the data distribution is normal.

TABLE IV
NORMALITY TEST RESULTS

Constructs	Skewness	Kurtosis
Performance Expectancy	-0.195	2.554
Effort Expectancy	-0.367	1.911
Social Influence	-0.501	1.852
Facilitating Conditions	-0.518	0.600
Perceived Playfulness	-0.520	2.104
Self-Management of Learning	-0.353	1.459
Attitude Towards Technology	-0.240	1.913
Behavioral Intentions	-0.513	1.470

D. Reliability And Validity Analysis

Table V demonstrates the values of the Cronbach's Alpha or reliability coefficient of all the determinants used in this study. All of the Cronbach's Alpha reliabilities of determinants are more than 0.7, lying between 0.826 to 0.927. Therefore, all the variables in this research are good and reliable as meeting the minimum acceptance level which is 0.7 [xxii], implying that the variables can be used for further analysis in the study.

TABLE V
RESULT OF CRONBACH'S ALPHA FOR RELIABILITY ANALYSIS

Variables	Cronbach's Alpha	No. of items
Facilitating Conditions	0.873	4
Perceived Playfulness	0.911	5
Self-Managementof Learning	0.890	4
AttitudeTowards Technology	0.893	3
Behavioral Intentions	0.826	3
Social Influence	0.927	4
Effort Expectancy	0.876	4
Performance Expectancy	0.922	4

E. Correlation Analysis

TABLE VI
SUMMARY OF CORRELATION ANALYSIS

Variables	PE	EE	SI	FC	PP	SML	ATT	BI
PE	1.000	0.568	0.593	0.234	0.586	0.336	0.545	0.552
EE	0.568	1.000	0.554	0.327	0.608	0.371	0.439	0.559
SI	0.593	0.554	1.000	0.279	0.649	0.347	0.454	0.573
FC	0.234	0.327	0.279	1.000	0.320	0.355	0.213	0.281
PP	0.586	0.608	0.649	0.320	1.000	0.398	0.489	0.613
SML	0.336	0.371	0.347	0.355	0.398	1.000	0.342	0.369
ATT	0.545	0.439	0.454	0.213	0.489	0.342	1.000	0.497
BI	0.552	0.559	0.573	0.281	0.613	0.369	0.497	1.000

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Pearson Correlation analysis is done in order to ascertain the relationship and strength between different variables, identifying whether the relationship is positive or negative. Table VI illustrates that all the variables depict a positive relationships with each other with the strength of the relationship being moderate or weak. Performance expectancy, effort expectancy, social influence and perceived playfulness have a moderate relationship with behavioral intentions (dependent variable), whereas, facilitating conditions ($r = 0.281, p < 0.001$), self-management of learning ($r = 0.369$, $p < 0.001$) and attitude towards use of technology ($r = 0.497$, $p < 0.001$) have a weak relationship with behavioral intentions. Hence all the hypothesis have been found to statistically significant and positively correlated with dependent variable.

Furthermore, results depicted that there is no serious issue of multi-collinearity among independent variables as highest value of correlation is less than 0.9 [xxi] which is 0.649 between Social influence and Perceived playfulness. Thus, regression analysis can be carried out conveniently.

F. Regression Analysis (Main Effect)

Multiple Regression Analysis involves the prediction of an unknown value of a variable, through two or more known variables and analyses the linear relationship between a dependent and two or more independent variables. In order to assess the strength & nature of relationship between variables and statistical significance of each coefficient, regression analysis has been carried out.

TABLE VII
ASSESMENT FOR MODEL FITNESS

Model Summary					
Model	R	R Square	Adjusted R Square	F Value	Sig.
1	.874[a]	.764	.760	184.788	0.000***
a. Predictors: (Constant), ATT, FC, SML, SI, EE, PE, PP					

***Significant at the p = 0.001 level

Table VII shows the summary of the regression model. The value of R = 0.874 signifies a reasonably strong relationship between the independent variables ATT, FC, SML, SI, EE, PE, PP and the dependent variable i.e. BI. Adjusted R Square, which is a modified version of R Square adjusted for the amount of predictors in the model, is 76.4%. The value of R Square specifies 76.4% of the variability of dependent variable (behavioral intentions) is elucidated by independent variables and explanatory power of model is 76.4%. The remaining 23.6% of the variability in dependent variable (Behavioral Intention) is explained by other factors not considered in this research. The F ratio dictates if the regression model is good fit for the data. The value of F (7, 400) is equal to 184.7, with $p < 0.0005$ showing that the dependent variable is significantly predicted by the independent determinants. Thus the regression model can be considered as fit and statistically significant to predict m-learning acceptance amongst the students.

According to the results Performance Expectancy ($\beta = 0.133, p \leq 0.010$), Effort Expectancy ($\beta = 0.176, p \leq 0.001$), Social Influence ($\beta = 0.187, p \leq 0.000$), Perceived Playfulness ($\beta = 0.265, p \leq 0.000$) and Attitude towards use of Technology ($\beta = 0.131, p \leq 0.001$) are significantly and positively related to Behavioral Intensions of M-learning,whereas, results predict that Facilitating Conditions ($\beta = 0.032, p \leq 0.328$) and Self-Management of Learning ($\beta = 0.047, p \leq 0.190$) are positive but insignificant at $p \leq 0.001$ level. Moreover, Perceived playfulness is found to have the highest effect on behavioral intention.

G. Regression Analysis (Moderation Effect)

TABLE VIII
MULTIPLE REGRESSION ANALYSIS (MODERATION EFFECT)

Model	R Square	Adjusted R Square	Change Statistics		
			R Square Change	F Change	Sig. F Change
PE & Age	0.653	0.651	0.007	7.857	0.005
PE & Gender	0.662	0.660	0.010	11.798	0.001
EE & Age	0.649	0.646	0.006	7.447	0.007
EE & Gender	0.663	0.661	0.018	21.765	0.000
SI & Age	0.661	0.659	0.005	6.042	0.014
SI & Gender	0.672	0.669	0.012	15.180	0.000
FC & Age	0.334	0.329	0.001	0.339	0.561
FC & Gender	0.337	0.332	0.004	2.260	0.134
PP & Age	0.696	0.694	0.002	2.738	0.099
PP & Gender	0.699	0.697	0.006	8.530	0.004
SML & Age	0.412	0.407	0.000	0.186	0.666
SML & Gender	0.415	0.411	0.001	0.465	0.496
ATT & Age	0.555	0.552	0.013	11.959	0.001
ATT & Gender	0.583	0.580	0.025	24.308	0.000

Table VIII results depict that age and gender significantly moderate the effect between PE, EE, SI, ATT and BI as the value of change of R-square is significant for these variables. Therefore, age and gender play a moderating role between these determinants, leading to the acceptance of model. However, results depict that age and gender do not significantly moderate the effect between FC, SML, PP and BI as the value of change of R-square is insignificant.

H. Hypothesis Testing

Table IX illustrates the results of the hypothesis testing. Most of the correlation has been found to be positive and significant. Findings show that positive relationship exists between PE, EE, SI, PP, ATT and BI leading to the acceptance of H1, H3, H5, H9 and H13. However, FC and SML do not have a positive and significant relationship with BI resulting in the rejection of H7 and H11.

TABLE IX
SUMMARY FOR HYPOTHESIS TESTING

Hypothesis	Standardize Coefficients & significance	Results
H0: No relationship between PE and BI to use M-learning	($\beta = 0.133, p \leq 0.010$)	Rejected
H1: PE has a positive relationship withBI to use M-learning	($\beta = 0.133, p \leq 0.010$)	Accepted
H0: No relationship between EE and BI to use M-learning	($\beta = 0.176, p \leq 0.001$)	Rejected
H3: EE has a positive relationship on BI to use M-learning	($\beta = 0.176, p \leq 0.001$)	Accepted
H0: No relationship between SI and BI to use M-learning	($\beta = 0.187, p \leq 0.000$)	Rejected
H5: SI has a positive relationship on BI to use M-learning	($\beta = 0.187, p \leq 0.000$)	Accepted

H0: No relationship between FC and BI to use M-learning	(β = 0.032, p≤ 0.328)	Accepted
H7: FC a positive relationship on BI to use M-learning	(β = 0.032, p≤ 0.328)	Rejected
H0: No .relationship between PP and BI to use M-learning	(β = 0.265, p≤ 0.000)	Rejected
H9: PP has a positive relationship with BI to use M- learning	(β = 0.265, p≤ 0.000)	Accepted
H0: No relationship between SML and BI to use M-learning	(β = 0.047, p≤ 0.190)	Accepted
H11: SML a positive relationship with BI to use M-learning	(β = 0.047, p≤ 0.190)	Rejected
H0: No relationship between ATT and BI to use M-learning	(β = 0.131, p≤ 0.001)	Rejected
H13: ATT for learning is positively related to BI	(β = 0.131, p≤ 0.000)	Accepted

Moreover, a moderating effect (age and gender) can be seen (Table X) between PE, EE, SI, ATT and BI leading to the acceptance of H2, H4, H6, and H14. However, age and gender do not play a moderating role between FC, PP, SML and BI resulting in the rejection of H8, H10 and H12.

TABLE X
SUMMARY FOR HYPOTHESIS TESTING (AGE AND GENDER)

Hypothesis	Standardize Coefficients (β)		Sig.		Results
	Age	Gender	Age	Gender	
H2: The effect of PE on BI to use M-learning will be moderated by gender and age	0.353	0.428	p≤ 0.005	p≤ 0.001	Accepted
H4: The effect of EE on BI to use M-learning will be moderated by gender and age	0.344	0.578	p≤ 0.007	p≤ 0.000	Accepted
H6: The effect of SI on BI to use M- learning will be moderated by gender and age	0.295	0.457	p≤ 0.014	p≤ 0.000	Accepted
H8: The effect of FC on BI to use M-learning will be moderated by gender and age	0.096	-0.238	p≤ 0.561	p≤ 0.134	Rejected
H10: The effect of PP on BI to use M-learning will be moderated by gender and age	0.196	0.339	p≤ 0.099	p≤ 0.004	Rejected
H12: The effect of SML on BI to use M-learning will be moderated by gender and age	0.069	0.105	p≤ 0.666	p≤ 0.496	Rejected
H14: The effect of ATT on BI to use M-learning will be moderated by gender and age	0.524	0.685	p≤ 0.001	p≤ 0.000	Accepted

VI. DISCUSSION AND FINDINGS

To investigate the intentions of students to adopt M-learning, this study was conducted using the UTAUT model, by incorporating three additional determinants to the traditional model, i.e. Perceived Playfulness, Self-Management of learning and Attitude towards the use of Technology. This study is amongst the first ones conducted in Pakistan to analyse the students' behavioural intentions to adopt M-learning in the higher education institutes of Pakistan. According to the results achieved, Performance Expectancy, Effort Expectancy, Social Influence, Perceived Playfulness and Attitude towards the use of Technology were positively related to behavioural intention to adopt M-learning, while Facilitating conditions and Self-Management of Learning were found to beinsignificant. The results acquired from this research revealed several important findings and repercussions for the successful acceptance and implementation of m-learning in the higher institutes of Pakistan.

Consistent with the earlier findings [xxiii-xxiv], performance expectancy was found to be positively related (β= 0.133) to behavioural intentions. This means that students with greater level of performance expectancy have a greater inclination towards the adoption of m-learning [xxv-xxvi], [v]. Thus students are ready to accept and adopt m-learning because they believe that mobile learning is valuable and will enable them to complete their tasks quicker and more efficiently. Students also have the perception that m-learning will aid in improving their learning

productivity and achieve superior results [xxiii]. Thus to promote performance expectancy, it is important for educators to design m-learning tools that facilitate students in learning, are convenient and efficient to use, are less costly, and enable the students to complete important tasks in less time. Moreover, the developers should incorporate the demands and suggestions of the students while designing m-learning tools and facilities in order to meet their performance expectations.

Effort expectancy was also found to have a positive effect ($\beta = 0.176$) on behavioural intentions to adopt m-learning, consistent with the findings of past studies [xxiii-xxv], [v].This indicates that most of the students are of the opinion that m-learning systems should be convenient to use and should be comprehensible [xxiv] and the students possess the required skills to use M-learning. Mobiles however do have the limitations of a smaller screen size, less memory, limited computational power, short battery life and smaller keyboards which may cause difficulties for users [xxv]. So if the students think of M-learning systems as complicated and difficult to use, they may feel discouraged to use them. Thus in order to effectively meet the effort expectancy of the students, developers should create user-friendly, easy to use m-learning interfaces that are simple to understand and require least amount of storage space so that students become more willing to accept them.

Social influence was also found to be positively related ($\beta = 0.187$) to behavioural intention to use m-learning [xxiii], [xxv-xxvi], [v]. The implementation of m-learning by peers and educators can persuade students to accept its usefulness and ease of use, motivating them to adopt M-learning as well. Thus it is important for M-learning practitioners to motivate their peers and friends to adopt M-learning, as the opinions of the early adopters will positively encourage other users as well. Moreover, according to previous literature, when the amount of users reach a critical mass point, M-learning adopters will then start increasing rapidly [xxv].

According to the results of this study, Facilitating Conditions has no significant effect on the behavioural intention to use M-learning. This insignificance is not a new concept as past literature also illustrates varying findings with reference to the effect of facilitating conditions on the adoption of M-learning [xxvi-xxvii]. The original concept explained that the effect of facilitating conditions becomes insignificant on behavioural intentions, when the determinants of performance expectancy and effort expectancy are present [v]. The main reason behind this concept is that facilitating conditions when considered in the light of providing access, technical sustenance or other issues would affect the frequency of use but not the behavioural intention to adopt m-learning. The same concept is also supported by other studies [xxvi] that explain that the effect of facilitating conditions on the adoption of technology is not direct in developing countries. This is mainly because of the fact that technology users in developing countries are mostly late in the adoption of innovative technologies such as m-learning, whereas users in developed countries are quick in the adoption of pioneering technologies. However, research regarding the effect of facilitating conditions on behavioural intentions requires further work, as this relationship has been found to be positive in some past studies [xxxii], [xxviii], although it is inconsistent with the original UTAUT model.

Perceived playfulness was found to be the strongest predictor ($\beta = 0.265$) of m-learning, having a strong positive relationship with behavioural intention to use M-learning,Consistent with the studies conducted in the past studies [xix], [xxv], [xxxi-xxxii]. If the students enjoy M-learning, then they will be motivated more to use it. Thus in order to attract greater number of users, it is imperative for developers to design M-learning in such a way that it is enjoyable and fun to use for the students. Being the strongest predictor of adoption of M-learning amongst students, it is imperative that more stress should be laid on making M-learning interface such that it is entertaining, leading to increased curiosity and exploration of the students, enabling them to spend extensive time learning while enjoying the activity.

The results of this study indicated that no significant relationship exists between Self-Management of learning and behavioural intention to use M-learning inconsistent with past study [xxvii]. This additional construct has also been used in past studies as well [xxxi-xxxiii]. This non-significant relationship can be due to the fact that Pakistan, being a developing country, mostly comprises of students that are in favour of traditional classroom environment, perceiving that it will be difficult for them to set their own pace without any supervision or guidance from any teachers. M-learning can also be incorporated together with traditional methods of learning such as a blended education system [xxviii] by introducing mobile devices in traditional classroom environment to promote the concept of self-management.

According to the results of the study, Attitude towards the use of the technology for learning was found to be positively related to behavioural intention, which is in consistency with other studies conducted in the past [xxix-xxx]. However, this result contradicts with the original UTAUT model that predicts that when a strong relationship exists between performance expectancy and intention and effort expectancy and intention to adopt new technology, then attitude towards the use of technology will not have a significant relationship with behavioural intention to adopt M-learning. The positive relationship found in this study can be because of the fact that most of the students perceive M-learning as enjoyable (leading to the significant relationship between perceived

playfulness and behavioural intention to adopt m-learning), and are motivated towards using M-learning.

It was further found that age and gender play a moderating role between most of the determinants of m-learning and the behavioural intention to adopt M-learning in Pakistan. According to the results, Performance expectancy and Effort expectancy are moderated by the effects of age and gender leading to the fact that the students belonging to different age groups, whether they are males or females, perceive that their performance will increase and it will be easy for them to use m-learning. This means that age differences will be taken into account while designing the M-learning systems. This is further supported by previous researches [xxix-xxx] that identify that a person will perform his best, and enjoy his experience if he meets challenges that are matched according to his age capacity. Similarly, Social influence and Attitude towards the use of technology are both moderated by age and gender, signifying that students belonging to different ages, both males and females, will be affected by the opinion of others to adopt M-learning. Facilitating conditions and self-management of learning were both found to be insignificant, thus no moderating effect was found on their relationships with behavioural intention to adopt M-learning. However, the relationship of perceived playfulness with behavioural intention to adopt M-learning was found to be moderated by age but not by gender.

Thus it is substantial for M-learning developers and educators to design M-learning programs that are easy to use, matched according to the educational level of the students, providing contents that match the user's needs and requirements, leading to increased performance and greater satisfaction of students making M-learning an enjoyable experience.

VII. Conclusion and Recommendations

This study was conducted to analyze the behavioral intentions of students to accept M-learning in Pakistan, based on the UTAUT model and the past studies. According to the results, 76.4% of behavioral intention to accept M-learning has been explained through the model. Most of the determinants included in the study (i.e. performance expectancy, effort expectancy, social influence, perceived playfulness and attitude towards the use of technology) were found to be positively associated with the behavioral intention to adopt M-learning whereas facilitating conditions and self-management of learning were found to be negatively related to behavioral intention.

Due to the fact that M-learning is currently in its early stages being a new means of education, educators need to lay stress upon the aspects that increase students' acceptance of the new mode of learning. Thus m-learning programs should be planned in such a way that they are easy and fun to use, leading to increased curiosity and learning capability of the student. Faculty members and peers positively influence the students' perception. Therefore, they should emphasize upon the importance of m-learning, motivating their students to incorporate it in their daily lives as m-learning can be used together with traditional modes of learning to increase the learning effectiveness.

In today's ever changing environment, it is vital for every organization, including the educational sector to constantly upgrade to newer technologies to combat the requirements of the global market. M-learning presents an excellent opportunity for learners, especially in developing countries such as Pakistan, to adopt new modes of education which are convenient and easy to use, making the learning process pleasurable and motivating for students, increasing their yearning to learn constantly.

VIII. Limitation and Future Research Work

Mobile learning is a new emerging field in Pakistan. This study contributed towards the investigation to determine the acceptance of M-learning amongst students of higher education institutions of Pakistan, with the help of past empirical studies. The scope of this study is limited to ten universities (i.e engineering, business management, social sciences). Thus the results cannot be completely generalized, therefore future researchers can include more universities from different cities and varied fields of education, such as engineering, medicine, business administration and fine arts to further advance this research. Age and gender have found to play a moderating role in this study. However, additional research work can be carried out to identify the differences between the moderating effect of different age groups and different genders. Mobile devices are prone to security and privacy hazards this aspect was not covered in this study conducted therefore a future study can include these areas and investigate their impact on the acceptance of mobile learning.Future studies can also include the investigation of acceptance of mobile learning among students who are currently using D-learning or E-learning tools in their education. Other technology acceptance models can also be employed in the future to further investigate the determinants affecting the students' acceptance of mobile learning.

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Appendix A: original survey items used in the study

Performance Expectancy
PE1: I would find m-learning useful in my education.
PE2: Using m-learning enables me to accomplish learning activities more quickly.
PE3: Using m-learning increases my learning productivity.
PE4: If I use m-learning, I will increase my chances of getting better education.

Effort Expectancy
EE1: My interaction with m-learning would be clear and understandable.
EE2: It would be easy for me to become skilful at using m-learning.
EE3: I would find m-learning easy to use.
EE4: Learning to operate m-learning is easy for me.

Social Influence
SI1: People who influence my behaviour will think that I should use m-learning.
SI2: People who are important to me will think that I should use m-learning.
SI3: The lecturers and other staff at my institution will be helpful in the use of m-learning.
SI4: In general, my institution will support the use of m-learning.

Facilitating Conditions
FC1: I have the resources necessary to use m-learning
FC2: I have the knowledge necessary to use m-learning
FC3: The m-learning application are going to be similar to other systems use in mobile devices

FC4: I can get help from others when I have difficulties using m-learning

Perceived Playfulness
PP1: When using m-learning, I will not realise the time elapsed.
Pp2: When using m-learning, I will forget the work I must do.
Pp3: Using m-learning will give enjoyment to me for my learning.
PP4: Using m-learning will stimulate my curiosity.
PP5: Using m-learning will lead to my exploration.

Self-management of Learning
SL1: When it comes to learning and studying, I am a self-directed person.
SL2: In my studies, I am self-disciplined and find it easy to set aside reading and homework time.
SL3: I am able to manage my study time effectively and easily complete assignments on time.
SL4: In my studies, I set goals and have a high degree of initiative.

Attitude towards use of Technology
ATT1: Using m-Learning is good idea.
ATT2: I like to use m-Learning.
ATT3: Working with m-Learning is fun.

Behavioral intention to use m-learning
BI1: I intend to use m-learning in the future.
BI2: I predict I would use m-learning in the future.
Bi3: I plan to use m-learning in the future.

An Adaptive Secret Key-directed Cryptographic Scheme for Secure Transmission in Wireless Sensor Networks

K. Muhammad[1], Z. Jan[2], J. Ahmad[3], Z. Khan[4]

[1,2,3,4,5]*Computer Science Department, Islamia College Peshawar, K. P. K., Pakistan*
[1]Khan.muhammad.icp@gmail.com

***Abstract*-**Wireless Sensor Networks (WSNs) are memory and bandwidth limited networks whose main goals are to maximize the network lifetime and minimize the energy consumption and transmission cost. To achieve these goals, different techniques of compression and clustering have been used. However, security is an open and major issue in WSNs for which different approaches are used, both in centralized and distributed WSNs' environments. This paper presents an adaptive cryptographic scheme for secure transmission of various sensitive parameters, sensed by wireless sensors to the fusion center for further processing in WSNs such as military networks. The proposed method encrypts the sensitive captured data of sensor nodes using various encryption procedures (bitxor operation, bits shuffling, and secret key based encryption) and then sends it to the fusion center. At the fusion center, the received encrypted data is decrypted for taking further necessary actions. The experimental results with complexity analysis, validate the effectiveness and feasibility of the proposed method in terms of security in WSNs.

***Keywords*-**Cryptography, Wireless Sensor Networks, Sensor Nodes, Fusion Center

I. INTRODUCTION

A WSN consists of wireless sensor nodes that are capable to sense, compute, and communicate the data via a specific infrastructure [i]. WSNs are capable to monitor and track different activities and phenomenon that are difficult to monitor through human beings. For example, chemical environment monitoring, nuclear accident, and environment monitoring [ii-iv].

WSNs can be used to monitor different types of parameters including pressure, humidity, speed, temperature, presence of objects, lighting conditions, mechanical stress, direction, size of objects, and soil makeup. Some major and well-known applications of WSNs include under-water sensing, smart farming, forest fire detection, traffic monitoringand enforcement, anti-terrorism, target tracking, medical diagnosis, smart parking, multi-scale tracking, vineyard monitoring, image change detection, battle space monitoring by military, flood detection, networked gamming, remote sensing, habitat monitoring, smart video and audio surveillance, non-disruptive and nonintrusive monitoring of sensitive wildlife, and habitats [v-x]. Some applications of WSN in the field of engineering include civil structures monitoring, industrial plant maintenance, and modern building regulations using humidity and temperature [iii, vi, xi-xiii].

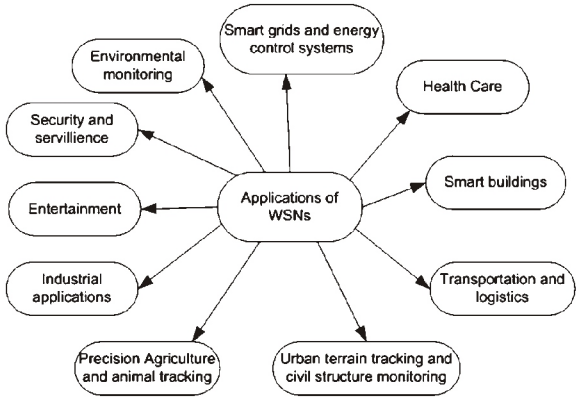

Fig. 1. Fields of Applications of WSN [xiv].

The most generic properties of WSN include limited bandwidth and energy, frequently changing topology, denser deployment of the network, multi-hop communication, autonomous management of the network, and limited transmission cost [xv]. The major issues and challenges that need to be addressed in WSN are network deployment (fixed/dynamic) depending upon the user requirements, network heterogeneity (less/more energy constraint), network scalability (Effect on the network due to node addition/deletion), uniform consumption of energy, communication model (single-hop/multi-hop), addressing based on attributes, and cluster dynamics (number of clusters, fixed/dynamic clusters, centralized/decentralized cluster head selection)[v-vi], [xvi-xviii].

A. Emerging Areas of WSN

The recent emerging areas and their challenging issues that necessitate urgent solutions and invoke the

researchers in diverse sophisticated multimedia applications of WSN are: [ii, xix]:

Image processing for network security in WSN
Localization of sensors based on images
Coverage of object view-angle using visual sensor networks
Object tracking using sensor image processing
Aggregation of images in sensor nodes
Image processing for minimizing the computations, bandwidth, and energy limitations
Pre-processing inside WSN like image compression
Efficient and effective capturing of video and images [xx]

B. Structure of a Typical Wireless Sensor Node

A typical wireless sensor node consists of four core components and some optional components. The optional components depend on the nature of application. These components are briefly described below.

a. Each sensor node comprises a central processing unit plus some specific amount of memory for storage of intermediate results and other data, and a micro-controller.
b. Each sensor node occupies an explicit sensing unit that contains one or multiple sensors plus an A/D converter used for data attainment.
c. An RF unit used for communication of data using wireless media.
d. A special unit for providing power to sensor nodes.
e. A unit known as mobilizer for configuration and location changing. (optional component)
f. A system for position and location determination. (optional component)

This paper demonstrates a secure approach to handle the security issues in WSN by using cryptography and secret key. The proposed scheme increases the security of sensitive sensed data during transmission and avoids different fraudulent behaviors of adversaries. The main contributions of this paper are:

i. A new approach to handle the security issues in WSN using cryptography
ii. Encryption of sensitive sensed data using an adaptive cryptographic scheme where the level of encryption can be controlled by secret key, facilitating users to maintain a balance between security and available resources.

The remaining of the paper is structured as follows. Section 2 provides an overview of the classical and recent issues in WSN and their solutions whose major shortcomings let us toward current proposed work. The proposed cryptographic model is detailed in section 3. Section 4 is devoted to experimental results and discussion. Finally, section 5 concludes the paper.

II. Related Work

Information security is a blooming research area. Almost all the communicating bodies want confidentiality, secrecy, and integrity of their secret information [xxi]. Since the last decade, various classical and modern approaches have been proposed by researchers to handle these security issues. But still security is a major concern in this modern era of science and technology. WSNs, which are considered as open networks, are more vulnerable to different attacks and risks. Because of this reason, security issues in WSN have diverted the attention of researchers [xv, xvi].

According to [xxii] presented an energy efficient algorithm for image compression by making use of JPEG2000 compression scheme. This method increased the network life time and reduced the transmission cost. The major shortcomings of this approach are extra processing required by sensor nodes and its vulnerabilities to different diverse attacks and risks. The transmitted data in this scheme can be easily altered by hackers due to which the final decision taken by fusion center based on received data will be wrong, resulting in horrible destruction.

An area-based clustering detection (ABCD) technique is presented by reference [xxiii] to deal with the security issues of node replication problem in WSN environment. The said technique facilitates the users with high rate of correct detection and minimizes communication overhead as compared to line-selected multicast (LSM) approach. In contrast with centralized approach, the ABCD method minimizes the number of stored messages and extends the overall lifetime of the network.

In [xxiv], the authors present a brief discussion on the WSN security issues like integrity, confidentiality, authenticity, design and context related issues. The authors also nominated practical algorithm for data security and self-originating WSN for improving the performance and security properties in WSN.

Pathan, Lee, and Hong highlighted the foremost challenges and eminent attacks of WSN environment in [xxv]. According to them, the open challenges in WSN environment are accurate collection of data, secure data aggregation, trust management, and load balancing of resource constrained devices regarding their computation and communication. The authors critically discussed a number of attacks of WSN that invokes the WSN researchers for urgent solutions. Some of the possible attacks in WSN environment are denial of service, wormhole, hello flood, selecting forwarding, sinkhole, and Sybil attack. An advanced secure routing method was presented by reference [xxvi] for gray-hole attacks and false reports detection based on statistical en-route filtering for improving the security in WSN. Furthermore, energy consumption minimization and improved security of sensitive data is achieved using elliptical curve cryptography during its transmission.

The techniques discussed in previous paragraphs provide a single layer of security to the sensed data of

wireless sensors during its transmission towards base station. To handle this issue, we propose a new approach with multiple levels of security, ensuring the secrecy of data during transmission.

III. Proposed Method

In this section, the detailed description of the proposed method is presented. The proposed method handles the security issues in WSN environment, using secret key and cryptography, making the transmission of sensed sensitive data secure from different fraudulent behaviors. In most critical networks such as military systems, multi-scale tracking, and video surveillance systems, the tiny sensor nodes constantly sense the surrounding environment and transmit the sensed data using multi hop communication to the sink nodes. Thus, each node has to play two diverse roles: data gathering and performing as a rely point. It is then the responsibility of sink node to transmit the aggregated data to fusion center for further necessary processing and actions. This transmission of sensitive data is vulnerable to many risks and attacks.

The proposed approach handles these security flaws and issues during transmission of data from one node to another sensor node and lastly to fusion center in WSN environment with the help of multiple encryption algorithms including bitxor operation, bits shuffling and secret key based encryption. The diagrammatic representation of proposed cryptographic model is shown in Fig. 2.

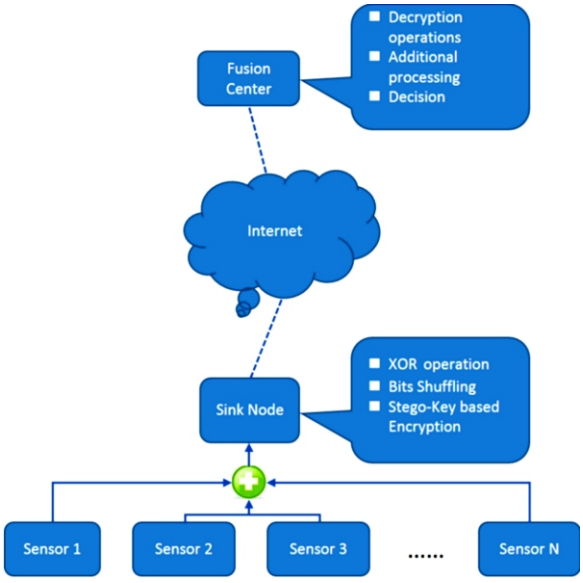

Fig. 2. The proposed cryptographic model for WSN security

The different types of sensors (audio sensors, video sensors, and scalar sensors) collect the most sensitive parameters from the surrounding specified serving area and send it to multimedia processing hub which aggregates the sensed parameters and send it to the sink node. At the sink, the aggregated sensitive secret information is encrypted via multiple encryption algorithms and is then transmitted to the base station. At the base station, the encrypted information is decrypted, some further processing is performed and an appropriate action is taken accordingly. Although, the proposed technique increases the processing of sensor nodes up to some extent but this is not a major issue for the most sensitive and critical sensor networks like atomic energy and intelligent agencies sensor networks because these networks cannot compromise on privacy and security. These reasons demonstrate that the proposed cryptographic model performs well in solving the security issues and problems in WSNs.

A. Steps for Encryption

i. Convert the secret key into 1-D array of bits.
ii. Convert the sensitive sensed data of wireless nodes into 1-D array of bits.
iii. Shuffle all the key and message bits such that the bits with even and odd indices are interchanged.
iv. If SecretKeyBit (SKB) =1
Then perform bitxor operation of secret message bit with logical 1.
Else
Do not perform bitxor operation.
End if
v. Repeat step (iv) until all secret data bits are encrypted.
vi. Apply the bitxor operation on resultant bits with logical 1.
vii. Convert the resultant bits into its actual form.

B. Steps for Decryption

i Take the appropriate secret key of particular sink node from the chunk of keys at the fusion center and convert it into 1-D array of bits.
ii Shuffle the resultant bits i.e. interchange the bits of odd and even positions with each other.
iii Convert the encrypted received information into bits form.
iv BitXOR the message bits with logical 1.
v If SecretKeyBit (SKB) =1
Then perform bitxor operation of encrypted bit with logical 1.
Else
Do not perform bitxor operation.
End if
vi Repeat step (v) until all bits are decrypted.
vii Shuffle the resultant bits by bits shuffling algorithm to get actual bits.
viii Convert the decrypted bits into actual data form.

IV. Experimental Setup and Discussion

The proposed cryptographic encryption and decryption algorithms are implemented using

MATLAB R2013a. For experiments some random numbers are taken as sensitive sensed data of sensor nodes and is encrypted and decrypted by the proposed technique. To make the idea easy to understand and avoid huge calculations, we have taken the secret data and secret key of limited length in the coming example. A complete case study of the proposed cryptographic model for security in WSN is shown in Table I and Table II.

Table I presents an example of encrypting the sensitive sensed data of sensor nodes. Two characters "A" and "B" are taken as sensed data and character "Z" is taken as a secret key. Col#5 (C5) shows the resultant bits after when the bits shuffling algorithm is applied on col#4 (C4) bits. In col#6 (C6), secret key based encryption algorithm is applied. If the key bit is 1, then the message bit is bitxored with logical 1, otherwise message bit remains unchanged. In col#7 (C7), the resultant bits are bitxored with logical 1 in order to further modify its shape and make the attack of malicious user awful. The final encrypted data is shown in col#8 (C8) which is transmitted by the sink node to fusion center for further processing and necessary actions.

TABLE I
EXAMPLE OF ENCRYPTION PROCEDURE; MB: MESSAGE BITS, KB: KEY BITS

C1	C2	C3	C4	C5	C6	C7	C8
Secret sensitive data sensed by sensor nodes	Secret Key	ASCII Value	Binary Representation	Bits shuffling algorithm	Secret key based encryption algorithm	BitXOR operation with logical 1	Encrypted data
-	Z	90	01011010	10100101	-	-	-
A	-	65	01000001	10000010	MB:10000010 KB:10100101 00100111	00100111 11111111 11011000	Ø
B	-	66	01000010	10000001	MB:10000001 KB:10100101 00100100	00100100 11111111 11011011	Û

TABLE II
EXAMPLE OF DECRYPTION PROCEDURE: MB: MESSAGE BITS, KB: KEY BITS

C1	C2	C3	C4	C5	C6	C7	C8
Received encrypted data	Secret Key	ASCII Value	Binary Representation	BitXOR operation with logical 1	Secret key based decryption algorithm	Bits shuffling algorithm	Decrypted characters
-	Z	90	01011010	-	-	10100101	-
Ø	-	216	11011000	11011000 11111111 00100111	MB:00100111 KB:10100101 10000010	01000001	A
Û	-	219	11011011	11011011 11111111 00100100	MB:00100100 KB:10100101 10000001	01000010	B

In Table II, the decryption procedure is briefly presented. The actual encrypted data received by base station is converted into bits form as shown in column 4 (C4) and is bitxored with logical 1 (col#5; C5). The secret key based decryption algorithm is applied on the resultant bits in col#6 (C6). At the end, the bits are shuffled with the bits shuffling algorithm (col#7; C7) and are converted to actual data form in col#8 (C8).

A. Complexity analysis of the proposed method

In this section, the complexity of the proposed method has been detailed. The complexity of the proposed technique depends on the length of secret key (key space) and the number of iterations during encryption. As mentioned in abstract that WSN are bounded in terms of network lifetime, bandwidth, and processing, therefore we have chosen a light-weight encryption algorithm to balance the security and processing overheads.

Currently, we have used a 64-bit key in actual simulation of the proposed method. The complexity of the proposed security system can be calculated as follows:

Key length=64 bits

Total number of possible keys= 2^{64}

Suppose the attacker generates 1 million keys/second, then the total number of years required to break this algorithm using brute force attack will be as follows:

Number of keys generated/second=10^6

Total number of years required= $$\frac{2^{64}}{10^6 \text{ x } 86400 \text{ x } 365}$$

Average number of years required=292471

The proposed framework provides enough security to sensitive data during transmission. One can further increase the security by enlarging the key space but it can affect the performance in terms of processing time and memory consumption.

V. Conclusions

In this paper, a new cryptographic model is proposed for coping with the security issues during transmission of sensitive data in WSNs. The different sensitive parameters sensed by tiny nodes are encrypted by an adaptive cryptographic scheme and are then transmitted to fusion center securely. Although, the anticipated technique requires a little bit more processing but in top-sensitive environments such as military and atomic energy sensor networks, this factor is acceptable as such departments cannot compromise on security. The proposed technique ensures the security of data during transmission and can be an excellent tool for adaptation of law enforcement agencies and military sensor networks for utilization in critical and security applications. Finally, it is concluded that the proposed scheme satisfies the favorable demands of current security systems with no extra transmission cost which confirms its superiority and effectiveness.

In future work, the authors will focus on the following key points to increase the WSN security up to a satisfied extent.

1. Encrypting the sensed data of sensor nodes with a more powerful encryption algorithm like RSA, Blowfish or DES.
2. Utilizing the concept of steganography to embed the sensed data inside a cover image for secure transmission and better security of WSN.
3. Designing an efficient and cost-effective algorithm to minimize transmission cost, power consumption, and processing.

VI. Acknowledgment

The authors welcome the useful and constructive comments and prolific suggestions of the anonymous referees and area editors during the review process. Special thanks to Dr. Zahoor Jan, Mr. Jamil Ahmad, Mr. Haleem Farman, Mr. Zahid Khan, and anonymous referees whose valuable suggestions and encouraging comments improved the quality of this research work.

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An Effective Quality Model for Evaluating Mobile Websites

M. Bilal[1], M. Waqar[2], A. Javed[3]

[1,2,3]Software Engineering Department, University of Engineering and Technology, Taxila, Pakistan
[1]bilalbajwa3840@gmail.com

Abstract-The Evolution in Web development in recent years has caused emergence of new area of mobile computing. Mobile phone has been transformed into high speed processing device capable of doing the processes which were suppose to be run only on computer previously. Modern mobile phones now have capability to process data with greater speed then desktop systems and with the inclusion of 3G and 4G networks, mobile became the prime choice for users to send and receive data from any device. As a result, there is a major increase in mobile website need and development but due to uniqueness of mobile website usage as compared to desktop website, there is a need to focus on quality aspect of mobile website. So, to increase and preserve quality of mobile website, a quality model is required which has to be designed specifically to evaluate mobile website quality. To design a mobile website quality model, a survey based methodology is used to gather the information regarding website unique usage in mobile from different users. On the basis of this information, a mobile website quality model is presented which aims to evaluate the quality of mobile websites. In proposed model, some sub characteristics are designed to evaluate mobile websites in particular. The result is a proposed model aims to evaluate features of website which are important in context of its deployment and its usability in mobile platform.

Keywords-ISO 9126 Quality Model, Key Quality Attributes, Mobile Websites, Mobile Website Development, Mobile website Quality Model

I. INTRODUCTION

Mobiles are becoming popular and have revolutionized the IT sector. In three years over 300,000 mobile applications have been developed and the frequency of downloads for these applications has been increased every year from 2010 to 2014. But these applications are not bug-free and require testing so for their verification and validation, specific testing approaches are required. The aim of a systematic software testing approach is to maximize fault detection, enabling results reproducible and to reduce influence of external factors. A study of Gartner [i] suggested that, in second quarter of 2013, the number of Smartphone sales to end users reached 225 million which is 46.5% from the 2nd quarter of 2012, which shows the increased use of mobiles. The statistical study presented by info graphics [ii] shows that 56% of people use a smart phone and people who use mobile phone as key internet source are 50% of mobile phone users. 80% of time on mobile is consumed inside apps and 72% of tablet owners purchase online from their tablets each week. This fast proliferation has intensely amplified the requirement of mobile website development and growth. As a result of this voracious appetite, enterprises and individual developers have vast amount of opening in mobile website development. There come some challenges with these opportunities and it is very difficult to have triumph in present prosperous area of mobile website development. Assessment of quality of mobile website is the one of the biggest challenge where ease of use with respect to mobile, efficiency and enactment of mobile website are core aspects for its triumph from user's point of view. Mobile website development is analogous to desktop website development but there are few aspects that differentiate mobile websites from desktop websites, some of them are the way people use mobile websites, the latency problem in mobile and multiple flavors of OS and browsers, small size of mobile, less power consumption all make it difficult to build a quality website specifically for mobile. So, specific quality metrics for mobile website have to be designed to evaluate mobile website in specific which can guaranty of obtaining a positive feedback from user and so far there is no model which has been proposed to address the quality of mobile websites in particular. A survey is conducted where information is gathered from different users. This information is regarding problems they face while using website on mobile. On the basis of above information a thorough knowledge of constraints imposed on website by mobile platform is obtained. Specific metrics are then designed to address identified constraints. On the basis of these constraints a framework is build to assess mobile website quality which will help testers to test websites in mobile environment.

This paper includes following sections. Section II presents Literature review associated with mobile websites and mobile applications. Section III presents proposed Quality model for evaluation of mobile

websites. In Section IV Quantitative comparison is done and Section V concludes our study while Section VI presents future work.

II. LITERATURE REVIEW

The mobile website and mobile application are quite similar in a way people use it, the limited hardware and memory processing problems, multiple flavors of OS and browsers etc. are all common problem in context on mobile application or website development. But there is a key difference between mobile application and websites i.e. mobile websites are retrieved through a web browser, usually use an inert menu of navigation, needs an Internet connection and has restricted features compared to most mobile apps while mobile applications are first being installed and then can be accessed on a mobile device, typically has an communicating user interface, can be retrieved offline and can make use of phone features such as camera, accelerometer, etc.

Evaluating usability of mobile website is one of the key factors as it gives us direct response from user regarding website's ease of use. Reference [iii] focused on usability of mobile websites and to evaluate the usability of mobile websites, introduced a usability evaluation tool to use it in Guided-Based Usability Evaluation Model(GBUAM) in which an evaluation tool named Usability Evaluator (UE) is used to evaluate the usability of mobile websites according to defined set of usability rules.

Testing of mobile websites or applications is a challenging task and is not same for both desktop websites and mobile websites. According to [iv] analyzed different mobile applications and divided into two types i.e. First, traditional applications rewritten to run on mobile devices using limited resources and driven by user-inputs, called APP4Mobile. Second type is of particular APP4Mobile called MobileApp that are driven by user actions and/or surrounding environment and produce content-based outputs. To test these applications different peculiarities were implemented on each application. The peculiarities used for testing APP4Mobile were mobile connectivity, limited resources, autonomy and user interface while peculiarities for second type i.e. MobileApp were content awareness and adaption in addition to the peculiarities of APP4Mobile. To deal with these peculiarities different dimensions were used.

Although testing a mobile application or website is hectic task but some models have been proposed like Reference [v] presented a model to test mobile applications using ISO 9126 quality model [i]. They extracted core quality attributes like Functionality, Usability, Efficiency, Maintainability, Data Integrity, Portability, Security, Suitability, Adaptability and extensibility from traditional ISO 9126 quality model because these are the key attributes which affect the quality of mobile applications. This model helps to save time by focusing only on these attributes to test mobile applications rather than all of quality attributes of traditional ISO 9126 quality model. Reference [vi] proposed a quality model to assure website quality considering the technological challenges and rapid development in interaction between customers and web. To enhance the quality from both client and server sides this model is divided into three parts. First part consists of testability, flexibility, reliability, maintainability and reusability factors, called server side factors that improve the quality of server side. Second part consists of portability, usability, privacy, standard design and correctness, called client side factors to improve quality of client side. Third part consists of some factors that influence both server and client sides named which are security, efficiency, integrity and ethics.

Along with models some frameworks also have been proposed to evaluate website quality. According to [vii] proposed a framework to evaluate website quality by discovering new special factors like Visibility, Intelligibility, Creditability, Engagability and Differentiation for quality Assessments of web applications in addition to core factors which include external factors like Suitability, Installability, functionality etc. and internal factors like maintainability, sustainability, testing.etc. These special quality factors along with core quality factors provide us a best framework to evaluate website quality in future effectively within web applications domain. Reference [viii] proposed a framework for measuring quality attributes i.e. maintainability and usability of web-based application systems. The quality of a web application can be measured from two perspectives that how much the site is maintainable for the programmers and what is usability experienced by the end-users. The diverse nature of web applications makes it difficult to measure these attributes so by some refinement in Reference [ix] i.e. Factor-Criteria-Metrics structure, a new model was proposed to maintain this rapidly changing nature of the website.

According to [x] extracted few attributes out of 15 attributes to obtain the standard for evaluating the usability of web sites. They collected data from 524 sites and analyzed it by using logistic regression to determine the quality of a site. Values for these attributes were calculated with great accuracy by using an automated tool developed in JSP. Four predictive models were built after analysis with respect to the year of collected data, in which some matrices out of these 15 matrices are selected to identify that which pages are good or bad.

Reference [xi] explained the dependency between different quality attributes by using methodologies like "experience based approach" and "online survey". Fifteen relations were defined between different quality attributes of ISO 9126 quality

model, which can be used to evaluate aggregated score for a particular website.

Reference [xii] presented a new five dimensional model considering correctness, presentation, content, navigation and interaction as five quality criteria's. These criteria's are mainly considered in context of automating the testing process for web applications and design mainly for user perspective of evaluating website who can measure the website using these criteria's objectively.

All above proposed frameworks generally aim to evaluate desktop websites and not all ISO 9126 model core attributes are covered in discussed models. Most importantly, existing research work on mobile website testing is very limited. Although According to [v] presented a model to test mobile applications but no attempt has been made to evaluate mobile websites in specific which are different from mobile applications. Therefore, we aim to provide a framework which will evaluate quality of mobile websites covering all ISO 9126 core attributes. Our proposed model would help testers to evaluate mobile websites quality thoroughly. It aims to focus on those quality areas of website which are critical to its deployment and usage in mobile phones.

III. Mobile Website Quality Model

Mobile website development although fairly analogous to mobile applications but differ in variety of operating system, devices and networks, latency problem, non-conventional usage of websites in mobile, no hover state in mobile and limited screen size all are major holdups in their way. So there is a requirement to have quality criteria for mobile websites to follow, to validate both functionality and quality of mobile websites. Old-fashioned ISO 9126 quality model [xiii] underline all the quality characteristics for quality evaluation of websites in general, but these attributes are abundant and are not feasible to evaluate mobile websites. The proposed research paper mainly focus on constraints which mobile environment imposed on website. These constraints are due to limited processing ability, small screen size etc. Different information gathering techniques are used to obtain information about these constrains from mobile users like one to one interviews, group interviews, observation and questioning. Different blogs have been visited to have a sufficient knowledge of problems which mobile user face while using website on mobile. By making these problems as a baseline, a quality model has been proposed. Different distinctive quality attributes/metrics are defined to address these identified problems. For each ISO9126 core quality attribute, specific metrics are defined which are related to that core attribute. These matrices will help tester to evaluate mobile website efficiently and result will always be a better quality Website.

A. Portability [xiv]

1) Cross Browser

Websites should be able to perform along different browser like Firefox, safari etc. with same performance and efficiency.

2) Cross Platform

Websites should work similarly along different platform like iOS, android etc. with same performance and efficiency.

3) Cross Devices

Websites should appear properly having same User interface (UI) and perform with same efficiency along different mobile devices which may have different processing capacity.

B. Usability [xv]

1) Context Preservation

The common problem with long form having large amount of data in mobile is that due to small screen often user forget what user have entered previously. The solution is that context can be preserve, Summary screen or header fixed at top of form can be used to maintain context so that user remain informed about what is going on.

2) Smooth Navigation

In navigation menu, emphasize should be given to those pages that are most valuable to mobile website users. Google Analytics can be used to determine which pages users have already visited through mobile i.e. which are important. Some pages on desktop site might not even be necessary in the mobile context, so they should not be used in menu and user needs should be given priority.

3) Graphics and Color Scheme

One of the basic requirements for mobile website is to have a right distinction between the background and content of website. Appropriate level of contrast makes content of mobile website understandable and easy to read. Lacking correct amount of contrast makes it very tough for users to read website content and this problem become more severe when website content are viewed on mobile where limited screen size is a critical constraint on reading web content effectively.

4) Formatting and Positioning of Elements

The size and proximity of all clickable elements such as navigational links, control button etc. are checked to evaluate their positioning and size so that in accurate clicks and fat finger problem can be avoided [xvi-xvii].

5) Heterogeneous Input Compatibility

The multiple input types for mobile like touch, keypad. Virtual keyboard, track ball/wheel and pointer

should be checked against website to check its compatibility against different input methods.

6) Avoid Conventions

Mobile web sites don't have "hover state" that is challenging for website with lots of content so we have to keep all navigational related elements (buttons, links) prominent or visible also avoid any assumption that mobile users will use mobiles websites in a conventional way. So, use of any convention should be avoided.

7) Multiple view support

Website should be checked to see that its work equally good in devices with different sizes like tablets, smart phones of different screen size and also, website should be checked along different view types available in phones like landscape, portrait.

C. Reliability [xviii-xix]

With reference to ISO 9126 model [xiii] reliability for mobile website can be measured in term of following factors:

1) Recoverability

The property of being able to recover from internal or external interrupt. Internal interrupt includes call/message interrupt, device shutdown, remove battery, camera activated etc. and External interrupt include loss of internet connectivity, electromagnetic interference etc.

2) Error Tolerance

The ability of system to tolerate errors. There are two types of error handling which can be useful while testing mobile website error tolerance capability.

i) Erroneous Click Tolerance

It measures how much a website provide fixation to in accurate clicks which can be fixed via providing confirm scenarios or confirmation checks which makes sure that

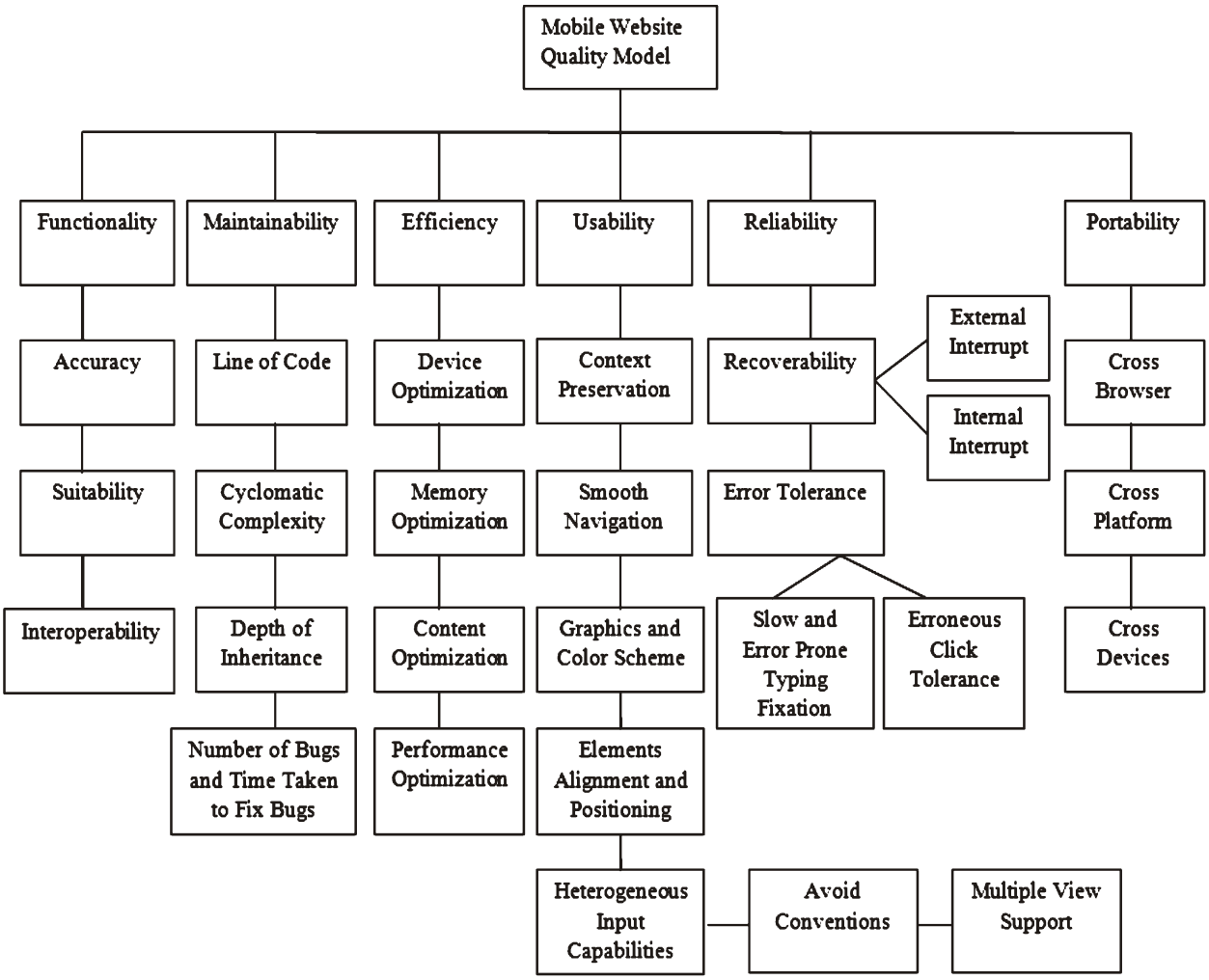

Fig. 1. Proposed Model

each input is subjected to confirmation so that wrong input can be discarded. Auto complete, inline validation, address validator can be used for correcting user input.

ii) *Slow Typing Fixation*
The small screen size of mobile often limit input typing speed so it is a better option that typing has to be absolute minimum which can be done using pre select or default text. Auto complete option can also be used to facilitate user and to increase typing speed.

D. *Efficiency [xx-xxi]*

1) Device Optimization

For mobile websites the issues of low memory and slow processing speed have to be considered in mind as different mobile devices have different processing capabilities. Also, mobile phones have limited hardware capabilities as compared to desktop systems. Because of that, it is required to consider not only user who is interacting with websites but also, device which is being used to perform required operations. So, there should be a standard development pattern which should be acceptable for making a mobile website capable of running on different devices having different performance and processing capabilities.

2) Memory Optimization

The limited memory on mobile phones and its usage in browsers often creates memory issues. Simple processes, such as we add a new node into the Document Object Model (DOM) [xxii-xxiii], can generate memory issues if not handled properly, which cause the browser to become sluggish or impassive and ultimately crashes. Images are major area of apprehension regarding memory which are loaded in the DOM, regardless of their visibility on the screen, uses extra memory. One possible way to avert this is frequent elimination of elements from the DOM when not required. So reduction in image dimensions, numbers and avoidance of flash in a mobile website is one way to achieve memory optimization.

3) Content Optimization

Content optimization is actually a way to make web content attractive for limited screen reading by using CSS in your coding. It can be achieved by reducing the image sizes and simplifying fonts and content so that it can quickly scan and mobile search and strategically sprinkling them throughout your pages. Avoidance of content duplication can also be used to optimize content.

4) Performance Optimization

Mobile devices have comparatively weak hardware and processing capability so building a website with acceptable performance speed is a major area of concern. The following are some suggestions which can increase website performance speed considerably.

i) *External Dependency Reduction*
Less files to download means fewer HTTP requests are to process which ensure faster loading times and increased performance. Otherwise, long loading time often limits mobile website efficiency.

ii) *Images Usage Reduction*
Valuable processing power and memory are used to store and manage high-resolution images so by reducing image size, numbers and resolution, we can improve performance of a mobile website by decreasing its loading time.

iii) *Client-Side Processing Reduction*
Careful consideration for the use of JavaScript and keeping it to a minimum are best, so that minimum processing time is lost on processing client side requests and validations which increase website performance.

iv) *Latency problem*
Latency is actually the amount of time a server takes to receive and process the user's request for a page object which depends on how far away the user is from server. Any internet connection can transfer a definite quantity of data in limited timescale which is called Bandwidth. Latency put constraint on users to achieve that maximum bandwidth even their connections have capability to handle it. So it must be properly managed to improve performance.

E. *Maintainability [xxiv]*

1) Line of Code (LOC)

Software metric that is used to assess the size of a source code written for any application by counting the number of lines of that code. This metric is easy to use because we can easily count up lines of code but it depends on the developer and the language used to develop the program. Two major types of LOC exist in the code: Physical LOC and Logical LOC. Physical LOC counts lines of a source code including comments and blank lines and are sensitive to logically unrelated formatting and styling conventions. On the other hand Logical LOC counts number of executable statements and are less sensitive to formatting and styling conventions. If LOC of a code is greater, code is more complex and will require more testing effort and time. Lines of code can be counted using two measurement units LOC and KLOC but we have to wait until the system is implemented completely.

2) Cyclomatic Complexity

Cyclomatic complexity [xxv] is software metric to provide a quantitative measure of the global complexity of a program to measure the testing efforts

required to test any application. If a code has greater cyclomatic complexity then code is more complex and will require more testing time and effort. Cyclomatic complexity is computed using control flow graph of the program in which nodes are used to represent one or more procedural statements and to represent flow of control from one node to another arrows called edges are used. Cyclomatic complexity is based on graph theory and measures the number of linearly independent paths comprising the program. Cyclomatic complexity V (G) is computed in three different ways:

The numbers of regions of the flow graph correspond to the cyclomatic complexity.

V (G) = E-N+2 where E is the number of edges and N is the number of nodes in flow graph.

V (G) = P+1 where P is the number of predicate nodes i.e. node containing a condition, in the flow graph.

Cyclomatic complexity helps to predict testing effort, defects, maintenance costs etc.

3) Depth of Inheritance

Depth of Inheritance also called Depth of Inheritance Tree (DIT) is the maximum length from the node to the root node of the tree. In multiple inheritance an application may consist of different number of classes inheriting methods of different classes and the DIT of a class is the maximum distance between the class and the root node. A deeper class in the inheritance tree will be more likely to inherit the greater number of methods from parent classes which makes difficult to predict its behavior and it becomes difficult to maintain the application. So, DIT should not be greater than 4 as it compromise Encapsulation and increases complexity.

4) Number of Bugs and Time taken to fix bugs

A software bug [xxvi] is any event in the program that causes an unexpected behavior. A code with more number of bugs will be difficult to maintain and will take more time to fix bugs. So it is required to avoid bugs to avoid failures to occur in the code and make maintainability an easy task.

F. Functionality [xxvii]

1) Accuracy

Accuracy is the measurement of how correct an application behaves in response of any input and produces expected output exactly without any error. A mobile application will be accurate if it produces expected output corresponding to the provided input. It includes testing of controls, storage media and other operational aspects to check how exactly everything is performing.

2) Suitability

Suitability is concerned with an investment strategy that meets the objectives and means of an investor. It is the degree to which something is suitable for a particular purpose. A Mobile application or website will be suitable if it performs a particular task for which it is designed and fulfills the customers' requirement by providing expected output. Basically it is strategy to check how much the website is appropriate for the purpose that is needed.

3) Interoperability

Interoperability is the ability of an application to communicate with other applications to exchange data and use this exchanged data. Basically it is a testing type of mobile websites to check that how will it perform when a website has to interact with database or any other website to process a request.

IV. Quantitative Comparison

Most models proposed for evaluating mobile websites or applications focus only on certain quality factors presented by ISO 9126 model [xiii]. Reference [iii] model for evaluating mobile website focuses only on usability aspect of mobile websites. Signore proposed quality model focuses only on functionality and usability aspect of mobile application while model proposed by references [iv-v] focuses on functionality, usability and maintainability of mobile applications. Table I shows the comparison of attributes discussed between models. Until now, no model has been proposed specifically to address the quality of mobile websites as there is difference between mobile website and application. Although, models have been proposed to evaluate mobile applications. The unique aspect of proposed model as shown in Table I is that it provides framework to evaluate mobile websites in specific and also covers all core key ISO 9126 quality factors and present a set of sub characteristics to evaluate all ISO 9126 core quality attributes in context of mobile website quality evaluation. To further elaborate the effectiveness of proposed model, the Graph 4.1 shows the feasibility and effectiveness of model where on x-axis different models are given and on y-axis no of attributes of ISO 9126 model are given which are six in total i.e. Functionality, usability, efficiency, portability, reliability and maintainability. Thus, we have an overall evaluation of number of quality attributes discussed by different models. Our presented model focus on all attributes of ISO 9126 model with respect to mobile website quality evaluation. In comparison to our proposed model, all other models focus only on certain attributes while proposed model underline all quality attributes. Thus, it provides a diverse view of quality of mobile website by covering all major features for evaluation.

V. CONCLUSIONS

This research work presented a quality model to evaluate mobile website quality which is actually an extension of ISO 9126 quality model [xiii] and will help in development of high quality mobile websites. This is generic model for mobile websites aims to evaluate features of website which are important in context of its deployment and its usability in mobile environment; it can be enhanced to specific domain which can increase its efficiency. This paper main focus is to point out those factors regarding mobile websites which are critical and can limit website efficiency in mobile environment.

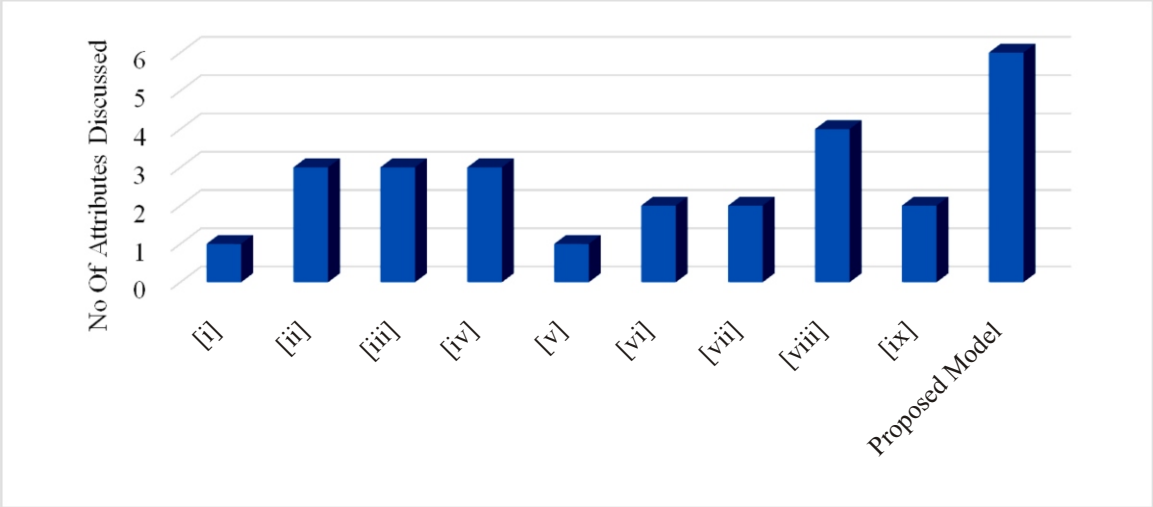

Fig. 2. Models comparison

TABLE I
COMPARISON BETWEEN MODELS

Models	Quality Attributes					
	Functionality	Usability	Maintainability	Efficiency	Portability	Reliability
Bahadir et al. [i]	X					
Henry et al. [ii]	X	X		X		
Sobia et al. [iii]	X		X		X	
Emad et al. [iv]	X	X	X			
Ronan Fitzpatrick [v]		X				
Ben et al. [vi]		X	X			
Yogesh et al. [vii]	X	X				
Hazura et al. [viii]	X	X	X	X		
Signore et al. [ix]	X	X				
Proposed Model	X	X	X	X	X	X

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A Laboratory Experimentation Based Ranking of Margalla Crush Aggregates

I. Hafeez[1], M. A. Kamal[2], K. Riaz[3], M. I. Khan[4]

[1,2,3,]Civil Engineering Department, University of Engineering and Technology Taxila
[4]Civil & Environmental Engineering Department, College of Engineering, King Faisal University, Saudi Arabia
kashif.riaz@uettaxila.edu.pk

Abstract-Aggregates are the stones used in road construction and subjected to take load coming from the vehicular traffic. Selection of aggregate source plays an important role and provides a guarantee towards the pavement performance. In Pakistan, aggregates manufactured in Margalla crush quarry is considered to be the best aggregates for the pavement construction. The source and consensus properties vary throughout the quarry. One cannot rely only on testing the physical properties from the single source. This study presents the results of mechanical and physical properties of twelve aggregate sources selected from Margalla aggregate crush quarry. A ranking based methodology has been adopted to minimize the number of sources for conduction of accelerated polish stone value and surface skid resistance test. Aggregate sources were ranked based on the specific gravity and other physical and mechanical properties. A ranking based on the difference between the 'before' and 'after' polish stone value has been used for a comparison with the physical properties. Ranking based on the original Polished Stone Values was not in line with what has been determined from the basic physical properties. This study reveals that instead of conducting a number physical and mechanical tests on aggregate, one can run PSV test and obtain similar ranking for the selection of specific aggregate source.

Keywords-Pavement, Consensus, Crusher, Ranking, Physical and Mechanical Properties

I. INTRODUCTION

Polished Stone Value (PSV) of an aggregate describes the correlation between the horizontal force and the vertical force established as a tire moves along the road surface [i]. The quality of road surface and its capacity to withstand the polishing effect of road traffic is of great significance in providing skid resistance. Aggregate polishing reduces micro texture, resulting in the rounding and smoothing of exposed particles. This is caused by wearing of particles on a microscopic scale. The higher the PSV value, the lower the rate of the traffic accidents, especially during the wet seasons [ii]

The correlation between PSV and skid resistance changes with the traffic flow, nature of pavements and other aspects. All factors must be taken into account in drafting specifications for road-works that contains test parameters for PSV. Aggregate comprising a PSV higher than 60 is considered as a high skid resistant aggregate. Lower is the PSV value, lesser will be the aggregate resistance to polishing. Aggregate used in road pavements must be hard and offer more resistance to wear against the dynamic load of the vehicles, the polishing effect due to traffic and the interior abrasive influence of repeated load. Accelerated Polishing Machine has widely been used to determine the relative quality of various sources of aggregate having similar mineral compositions [iii].

Erol studied the efficiency of aggregate imaging systems; Enhanced University of Illinois Aggregate Image Analyzer (E-UIAIA) and second generation of Aggregate Imaging System (AIMS-II), in assessing changes in shape and size properties of aggregates caused by the breaking, abrasion and polishing actions. Micro-Deval (MD) equipment was used in the laboratory to calculate such field degradation/polishing resistance of 11 aggregate samples with different mineralogical properties collected from all over the state of Illinois and adjacent states. More than 26,000 particles were scanned using both the imaging systems at different MD time intervals and monitored the changes in the overall morphological indices. In spite of differences in the image acquisition/processing capabilities, both E-UIAIA and AIMS-II successfully computed changes in morphological characteristics of particles from the MD testing. However, AIMS-II better reflects historical data on aggregate frictional characteristics obtained by Illinois Department of Transportation (IDOT). The imaging results were used to develop regression based statistical models to calculate the aggregate polishing and degradation trends by considering both the rate and magnitude of changes in shape properties [iv].

X. H. Chan studied the influence of freezing and thawing on the aggregate polishing resistance on road surface. Different aggregates samples were chosen and two plate specimens were formed using each sample. One sample was subjected to polishing load only and the other one was subjected to both loads of polishing and freeze-thaw actions. By comparing the changes in

texture and the development of skid resistance, a statement was derived on the impact of a freezethaw effect for the short-term and long-term development of skid resistance [v].

X. H. Chan categorized the surface texture of aggregate during polishing by spectral and fractal methods based on the theory of rubber friction. The profile of the surface texture and dynamic coefficient of friction were monitored during polishing. Fractal investigation has shown that the variations in curve length of the profiles and amplitude were the main contributor to the loss of friction. Spectral investigation showed that the polishing action played a vital role in the evolution of micro texture [vi].

Pardillo calculated the skid resistance of two-lane rural road network system in the Spanish state. It was studied to estimate the effect of pavement situations on safety and to assess the influence of improving pavement friction on safety. Improvement in pavement friction was found to yield substantial decreases in the crash rates of wet pavement [vii].

Tang carried out a research for better understanding of road-surface texture evolution due to polishing. Surface profiles measured at various polishing stages were analyzed. Roughness parameters describing asperity, height and sharpness were calculated and their evolution was compared with the evolution of friction [viii].

Kane developed a model predicting road skid-resistance variations. Influential phenomena were incorporated and represented by simple mathematical functions. Model parameters were obtained by fitting to data provided by laboratory tests. Experimental roads have been tracked and cores were used to validate the model. Predictions based on the study were satisfactory and elaborated the mutual influence of involved mechanisms [xiii].

Several studies have been conducted in the past to ascertain the physical properties of the aggregates. Different parameters related to shape of an aggregate were also investigated in different research studies. Most of the studies reported the influence of shapes of particles in volumetric analysis. Little efforts are found correlating the physical properties of aggregates with their field performance parameters like skid resistance or abrasion. It is important to utilize the laboratory aggregate properties in assessing their field performance parameters. As such methodologies have not been developed to ascertain the relationships among different parameters that can predict the possible field performance of an aggregate.

Present study focuses on the quality of aggregates, especially the surface polishing resistance, being produced from Margalla quarry. Twelve representative aggregates quarries were selected initially at different location within the Margalla source. The selection of six representative quarries was made based on the initial physical and mechanical properties of aggregates. Sampling and selection of aggregate sample involve comprehensive trials and testing. The selection of specified testing methodology was carefully worked out to meet the desired objectives of this study. The objectives and the scope of study was comprehensively been reviewed and finalized to achieve effective results.

II. OBJECTIVES

Following were the main objectives of present study;

Determination of the mechanical and physical properties of aggregates selected from different source and proposes ranking of source based on these properties.

Measurement of aggregates polish stone value chosen from Margalla crush quarries and determination of British Pendulum Number (BPN).

Development and comparison of ranking using physical and mechanical properties of aggregates and polish stone value tests.

III. EXPERIMENTAL PROGRAMME

Two phase study was thus conducted on limestone Quarry's aggregate particles to accomplish the study objectives. Physical and mechanical properties were determined by aggregates shape test, aggregate crushing value, aggregates Impact Value and Loss Angeles tests in phase. Samples were polished using an accelerated polishing machine in first phase of the study. In the second phase, PSV values of different aggregate samples were determined using a friction tester and the relationship between the PSV and the physical properties were established.

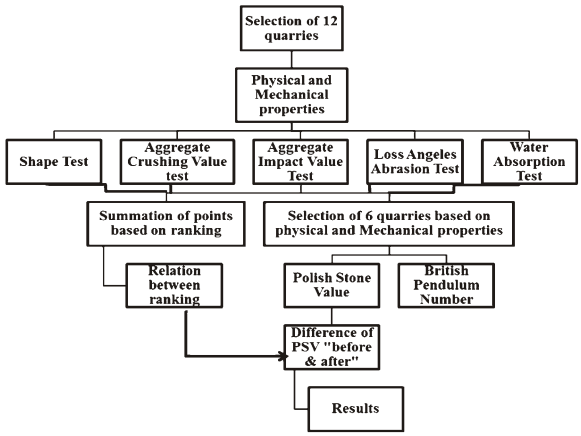


Fig. 1. Scope and methodology of the work

A. Physical and Mechanical Properties

The basic purpose of conducting such tests was to determine the aggregates quality against the pavements

requirement. This type of testing proves useful to analyze aggregates basic quality and life expectancy. The aggregates shape analysis was performed by calculating flaky and elongated particles contained in it as per BS 812-105.1 and 105.2 [ix]. Sieve analysis was performed on aggregate samples containing minimum of 200 pieces to be tested as per BS 812. Flaky material passed through the gauge and elongated material retained on the gauge were being weighed. Results of flakiness and elongated indices have been reported in Table I.

Aggregate Impact Value was performed as per BS 812: part 112 [x]. This test indicates the resistance of aggregate to absorb sudden shocks. The oven dried aggregate material passing from 14mm and retained on 10mm sieves was filled in three layers with 25 gentle blows on each layer in a cylinder. A hammer of 13.5kg was dropped 15 times at the height of 15inch and residue was sieved at 2.36mm sieve. The amount of fine to 2.36mm sieve was defined as AIV as shown in Table I.

The aggregate crushing value was determined as per IS: 2386-1963. This test indicates aggregate resistance to crushing under increasingly applied compressive load. The oven dried samples of about 3.25kg was filled in three layers with 25 gentle blows on each layer with rounded end of temping rod. Load of 4 tons/min was applied at constant rate till the total applied load reached 40 tones. The material was sieved through 4.75mm sieve and the amount of fine to 4.75mm was defined as ACV as reported in Table I.

Aggregate abrasion values were determined as per AASHTO T 96 [xi]. This test indicates the aggregates resistance to degradation and abrasion. The oven dried sample of about 5kg passing from 14mm and retained on 10mm sieve was placed in Loss Angeles machine. A fix 500 revolutions at a speed of 30-33 revolutions per minute were given. Then the material was sieved through 1.7mm sieve. The amount of fine to 1.7mm sieve was declared as loss Angeles abrasion value as reported in Table I.

Aggregate specific gravity and water absorption was determined as per AASHTO T85. Specific gravity was used in computation of voids in aggregates and volume occupied by aggregate in different mixes, whereas water absorption was used to determine variation in the mass of aggregate due to the water absorbed in the voids of the aggregates. Aggregates of about 2kg were immersed in water for approximately 15 hours to essentially fill the voids. After removing from water, the surface of the particle was dried and weighed. Then the submerged sample was weighed and finally the oven dried sample was weighed. Using the mass and weight, specific gravity and water absorption were calculated as reported in Table I.

TABLE I
RESULTS OF PHYSICAL AND MECHANICAL PROPERTIES OF AGGREGATES

Margalla Quarry	Flakiness Index %	Elongation Index %	Aggregate Crushing Value %	Aggregate Impact Value %	Loss Angles Abrasive Value %	Water Absorption (%)	Total (sum1:6)	Ranking (a)	Specific Gravity	Ranking (b)	Sum (a+b)	Selected source
	1	2	3	4	5	6	7	8	9	10	11 (8+10)	
1	15	16	23	12	20	2.5	88.5	4	2.53	9	13	4
2	18	16	29	11	15	2.6	91.6	5	2.6	8	13	
3	19	22	17	20	25	2.9	105.9	10	2.49	12	22	6
4	22	23	19	12	10	1.5	87.5	3	2.79	5	8	
5	29	18	18	18	19	2.3	104.3	9	2.51	10	19	5
6	17	21	27	22	19	2.9	108.9	12	2.8	7	19	
7	23	13	9	13	16	2	76	1	2.9	2	3	1
8	25	17	11	17	12	1.7	83.7	2	2.64	4	6	2
9	16	21	15	21	20	2.7	95.7	6	2.68	6	12	
10	20	20	12	18	25	1.9	96.9	7	2.95	1	8	3
11	17	25	17	23	18	1.8	101.8	8	2.5	11	19	
12	27	19	22	15	21	2.6	106.6	11	2.84	3	14	

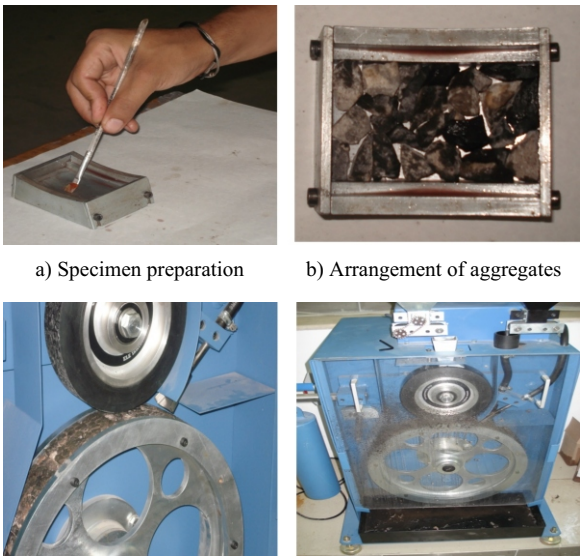
It may be noted from Table I that particles shape is within the range and production of more fines means that aggregates are soft and vice versa. Similarly, aggregate specific gravity and water absorption are also within acceptable range. Twelve sources were then ranked based on specific gravity and other test properties. A two set ranking was designed based on the index values showing an opposite trends. For example an increase in specific gravity indicates improvement in the aggregate property and vice versa. An increase in index value of other tested properties means a decrease in the mechanical properties and vice versa. The summation of ranking 'a' and 'b' as shown in Table I indicates an overall ranking of aggregate source, which was used to categorize aggregate source. Accordingly, ranking 1 and 2 as shown in the column 11 of Table I are categorized as good quality aggregate. Similarity, ranking 3 and 4 as medium and ranking 5 and 6 as poor quality aggregate, respectively. The aggregate as selected from six aggregate quarries were further subjected to aggregate PSVs and skid resistance tester.

B. Aggregate Polish Stone Value

Aggregates passing from 14mm and retained on 10mm sieves from 6 different crushers at Margalla quarry were collected. Four replicates were performed on each crusher as per BS 812: Part 114: 1989. Arrange the sample in a single layer with the most flat surface of the molds. Aggregates must be arranged with appropriate interlocking and minimum gaps between them. A total of 28 molds were prepared, four from each crusher and four from control stone.

The Accelerating Polishing machine as shown in Fig. 2 contains road wheel around which 14 specimens are fixed (simulating the road). The wheel

has speed of 320 ± 5 RPM. A rubber tired wheel is attached on a weighted arm (simulating the vehicle wheel and suspension). The machine was first operated using flour emery for 3 hours, washed and then for 3 hours using corn emery. The flour emery hopper (silver) feeds directly onto the tired wheel via a spreader chute. The corn emery hopper (black) feeds directly to the specimens via a chute at a rate of 27 ±7 g/min continuously with water on to the road wheel for a period of 3h ± 1 min as per BS 812: Part 114 [xii]. British pendulum number (BPN) was noted before and after polishing action using friction tester.



a) Specimen preparation b) Arrangement of aggregates

c) Arrangement of specimen d) Polishing action

Fig. 2. Polishing of Aggregate particles

C. Skid Resistance Tester

Skid resistance tester as shown in Fig. 3 was used to determine frictional resistance between a rubber slider (mounted on the end of a pendulum arm) and the road surface.

Fig. 3. Surface friction tester

The contact length of rubber slider was set between 125 and 127 mm on the provided scale. One slider edge can normally be used for at least 100 different settings (500 swings). Each time the slider was fixed to a small aluminum plate and this whole unit could easily be removed for replacement by pulling out the pin. New sliders were roughened before use by swinging several times over a piece of dry road.

The pendulum released from the horizontal position hit the surface and the needle position indicates reading of the pointer to the nearest whole number. This operation was performed five times, after rewetting the specimen each time, and record the mean of the last three readings to the nearest 0.1. The test was repeated if two mean values of control specimen differed more than 4.7.

IV. Results and Discussion

A. British Pendulum Number

The results obtained before and after the PSV test have been tabulated in Table II. It may be noted from Table II that the difference between the 'before' and 'after' value was sensitive to the source. However, BPN values before PSV test ranges from 62.7 to 80.8, which is relatively a more narrow range as compared to BPN values after PSV (Ranging from 45.25 to 71.03). . This reduction in the BPN range was attributed to the polishing effect. Polishing reduces the roughness and brought different source particles into more similar surface characteristics. However, the effect of source can be determined from their individual values.

TABLE II
BPN of Samples Before and After PSV Test

Crusher	BPN before PSV Test			BPN after PSV Test			Difference
	Mean	S. Deviation	Covariance	Mean	S. Deviation	Covariance	Before to after
1	70.93	1.97	2.59	57.68	3.42	5.63	13.25
3	62.75	3.23	4.18	45.25	2.33	3.84	17.5
5	71.75	3.18	4.17	56.58	2.29	3.86	15.17
7	80.78	2.74	3.6	71.03	2.03	3.42	9.75
8	77.43	1.91	2.47	67.18	2.85	4.73	10.25
10	75.78	4.12	5.28	63.4	3.75	6.17	12.38
Control	76.9	1.54	2.01	52.81	1.64	3.11	24.09

Statistical analysis were performed on the data to determine the accuracy of the results. The mean value, standard deviation and the covariance were utilized to understand the agreement between the values of replicates and the variations within the samples. PSV computed ranged between 57 and 62 as against PSV standard range of 55 to 66. It may be noted that average value of standard deviation is around 3, so the results are in a reasonable accuracy. Variation in the results of

replicates also indicates a uniform process of manufacturing of aggregate and selection of particles for testing purpose. Average value of BPN before and after the polishing has been observed as 73.24 and 60.2, respectively. Fig. 4 illustrate the results of Table II.

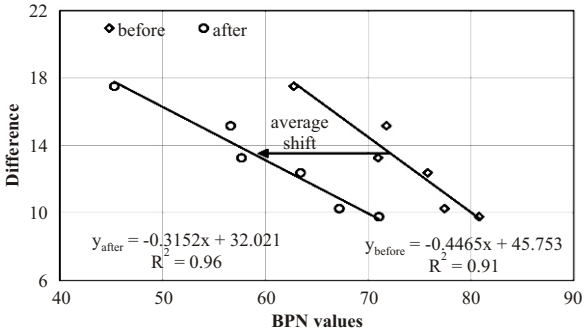


Fig. 4. Influence of PSV on BPN values

It may be noted from Fig. 4 that a significant reduction in the PSV has been observed from a polish stone value test, commonly known as BPN. A reduction of around 13% would be considered as the effect of polishing action on aggregate surface. The results of PSV test showed a reduction of BPN from 12% (good) to 28% (poor). A general range of BPN for Margalla crusher after PSV test may be considered as from 45 to 72. The effect of polishing on aggregate BPN can be ascertained from Table II.

B. Polish Stone Value

The PSV of each sample was calculated using the following relationship;

$$PSV = S + 52.5 - C \quad (1)$$

S= Mean value of BPN after PSV test

C= Mean value of BPN after PSV test

The average polish control stone value (C) of 52.81 has been used for calculation of PSV. PSVs computed for the six selected aggregate source have been presented in Fig. 5. The permissible limit has also been plotted in the same figure for a comparison purpose.

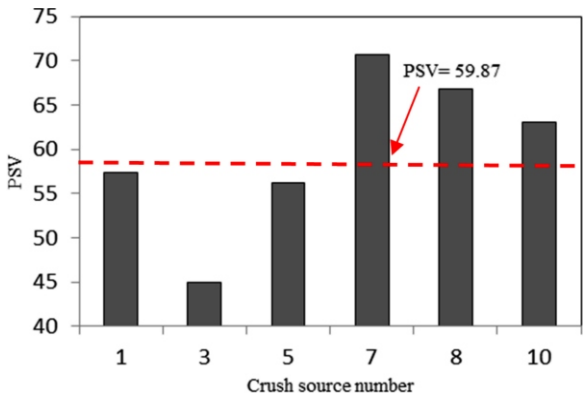


Fig. 5. Polish stone values of different aggregate crush quarries at Margalla

It may be noted from Fig. 5 that PSV is also a source sensitive properties that mainly depends on the properties of the source. This finding is in line with what has been reported in the previous literature. Only three aggregate sources meet the minimum acceptance criteria.

A comparison of aggregate source based on PSV ranking and physical and mechanical properties based ranking has been made in order to ascertain the similarity of both the rankings. Fig. 6 presents summation of ranking points based on the physical and mechanical properties and difference of PSV values as obtained before and the after.

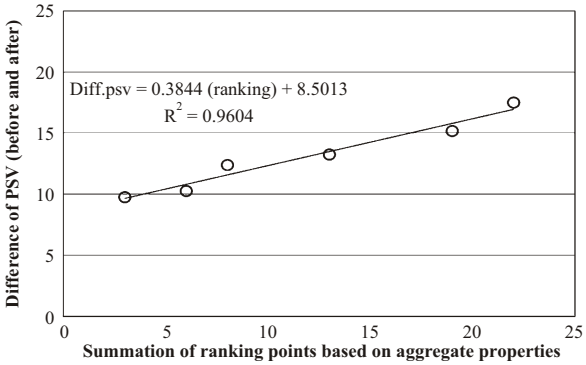


Fig. 6. Comparison of material properties based ranking and difference of PSV

It may be noted from Fig. 6 that a linear trend can be obtained between both types of ranking system. A reasonable relationship exists between both the criterions. It may be concluded from Fig. 6 that difference of PSV showed similar trends as with the physical and mechanical properties. With the proceeding discussions, it may be recorded as instead of conducting a number physical and mechanical tests on aggregate, one can run PSV test and obtain similar ranking for the selection of specific aggregate source.

V. Conclusion

Present study illustrates the experimental results of aggregate selected from different sources within Margalla crush quarry. A methodology has been proposed for ranking of materials for quality control. Twelve aggregate sources were initially selected and physical and mechanical properties were determined. A ranking based methodology has been adopted to minimize number of sources for conduction of further testing prior to their selection for any field construction job. The selected aggregates were further tested under PSV and surface skid resistance. A ranking based on the difference between the 'before' and 'after' polish stone value was also made. Results shows that polish stone value (BPN) of aggregate before and after the test does not predict aggregate material ranking, but the difference between “before” and “after” value predict

same ranking as were observed from summation of physical index properties. This study reveals that both the ranking criteria of aggregate source yield similar results. Also the effect of polishing reduces the overall range of BPN by reducing the surface roughness, but the amount of reduction also depends on the source.

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Face Recognition in Securing Optical Telecom Network Equipment

Nadeem[1], M. Ali[2]

[1,2]Electrical Engineering Department, University of Engineering & Technology (UET), Lahore, Pakistan
[1]nadeemengineer@yahoo.com

***Abstract*-**In this paper, face recognition is used with a microcontroller based hardware module to secure the telecommunication equipments like ONU (optical network units) or any other telecommunication equipment. The face recognition classifier value optimization adaption is deployed and in this scheme by increasing or decreasing the number of images in the database will automatically generate and adopt the classifier value for recognition of known and unknown persons. On recognizing an unknown person, the hardware module will send an SMS to the concerned security personnel for security preventive measures.

***Keywords*-**Optical Fiber Access Networks (OFAN), Optical Line Terminal (OLT), Optical Network Unit (ONU), Principal Analysis Components (PCA)

I. Introduction

The start of fiber optics in 1980 brought a revolution in the telecom industry [i]. It replaced the earlier transmitting media with the optical medium. It fulfilled the ever increasing demand of bandwidth. Now, the networks have moved to optical communication to utilize its huge bandwidth to satisfy their customers' requirements.

Optical networks have increased the revenue of the providers owing to less maintenance expenses and high performance. However, the risk of the theft of outdoor costly optical fiber equipment installed in mini-exchanges has increased. PTCL is the leading network provider in Pakistan and facing the critical issue of theft of costly equipment from the outdoor access networks. The need of the time is to develop and design security mechanism to stop this stealing. In this paper, face recognition is used to detect unauthorized access to optical network unit (ONU) in an optical network and an instant message is sent to the security personnel with a hardware module. The currently different security techniques such as door sensors, biometrics and CCTV presently available are based on hardwired alarms system which deployed wiring cables between alarm monitoring panels and devices. Those systems cannot deliver instant messaging alarms on malicious activities to different location at a time. All techniques are not flexible and independent from each other, they provide alarms on certain spots whereas our proposed hardware module is low cost, dynamic and flexible and can deliver different types of alarms simultaneously everywhere required for the alarms monitoring [ii]. This system is based on instant messaging on the mobile in the event of theft through GSM modem. The proposed security hardware module easily can be integrated in the existing networks and having its own independent low power consumption source. The module will continuously work successfully under different scenario such as completely isolated from other devices by power break down or by fiber cut. In this paper face recognition is utilized to authenticate the security personnel

The rest of the paper is divided into following sections: Section-II describes the architecture of OFAN; Section-III is about the security hardware module; Section-IV presents the face recognition mechanism; Section V provides the results and Section-VI concludes the paper.

II. Optical Fiber Access Network

The access network that employs OFAN [iii-iv]. OFAN bandwidth is up to several Giga bits per second (Gbps). The fundamentals parts of OFAN are shown in Fig. 1 and summarized below:

A. Optical Line Terminal (OLT) Unit

OLT is mounted at evidences of service provider [v]. Such places are the buildings of the Telephone Company or local area exchange, near the switching centre of a company and cable TV network provider ends. Various types of interfaces are available like E1/V5 interface that are used to attach the OLT and main telephone local exchange or digital distribution frame (DDF).

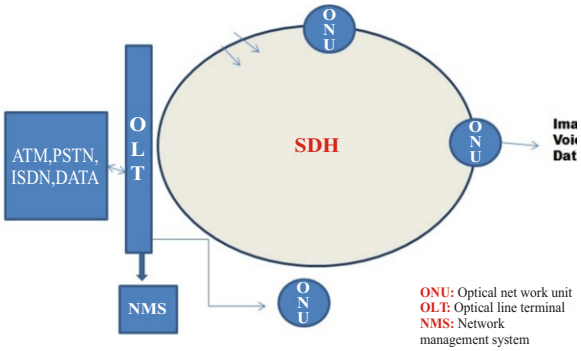

Fig. 1. OFAN Architecture for Access Networks

B. Optical Network Unit (ONU)

ONU's are installed at customer premises to execute the services to client, most probably neighborhood, within the office building, apartments or near residential home area [vi-vii]. The users of telephone, broadband services and smart TV etc., are connected to customer sides of ONU's directly by the drop wire or cable of twisted pair of different category to accomplish their demands.

As per planning and designing of the services and network, various hierarchies of structure of the ONU's formation in the geographical area can be employed like mesh topology, star, tree and ring, which provide the basis of communication between ONUs and OLT.

The transmission technology like Plesiochronious hierarchy, DWDM and SONET or SDH can be imposed for the communication in networking of the ONU typology [viii].

III. Hardware Security Module

This section presents a low cost valuable hardware module [ii] for generating instant message in the event of theft. The system will be supportive under the situations when network managing system totally fails to deliver alarms at monitoring terminals of the fiber system due to power failure, fiber cable cut or some other malicious action.

The proposed model shown in Fig. 2 which consists of the following components:

1. *Detector circuits for the unauthorized removal of equipment*
2. *Microcontroller for controlling the operations*
3. *GSM module for interfacing and communicating theft messages to the concerned security personnel for preventing thefts of costly equipment*
4. *Mobile phone to which the theft message is sent*

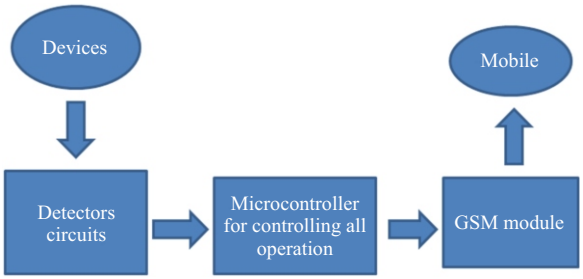

Fig. 2. Proposed model

The major hardware components of the security module are 89C51 microcontroller, GSM Module and MAX232. The interfacing of all components is shown in the schematic diagram in Fig. 3. The core part is 89C51 microcontroller in which the Hex file of C-program is burned for interconnecting the commands coming from PC/Laptop. After identification of unauthorized person, an alert message is sent through serial port reserved for GSM modem to the concerned security personnel.

The option of SPDT switches is also fabricated in the design and devices like cards, batteries and other devices can also be connected through these switches. This can provide a mechanism of alarm generation on the activation of these switches.

The complete hardware for the security protection is shown in Fig. 4. The hardware start functions on recognition of unauthorized access. The status of the hardware can be visualized with the help of different LEDs mounted on the board. LEDs give the indication of different types of communication and certain action or response by the microcontroller. Some of them represent the serial communication take place between microcontroller and PC and other represent the instant message delivery status to the concerned security personnel through the GSM modem.

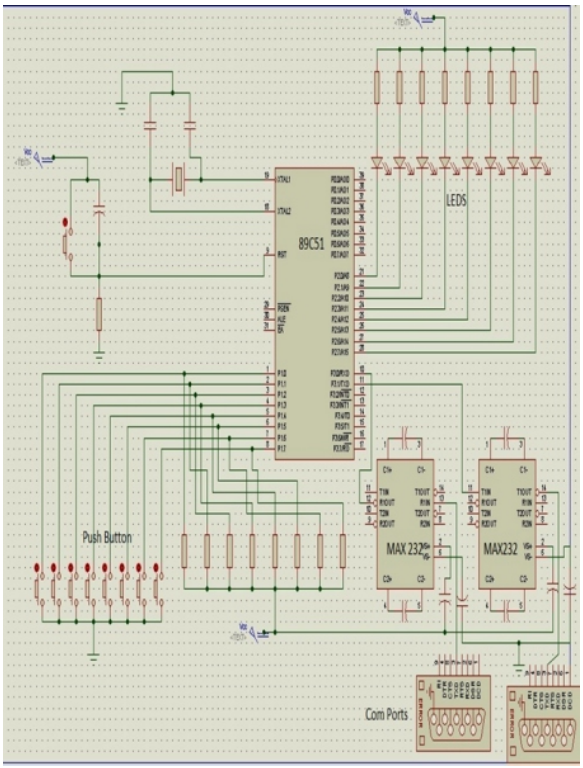

Fig. 3. Schematic diagram showing interfacing of different components

IV. Face Recognition With Threshold Optimization

After identifying an unauthorized access, a critical message is sent to the concerned authority for the preventive measures. This section demonstrates the complete development of the software based on Principal Components Analysis (PCA) [ix].

A face is a complicated multi-array visual space model and forming a computational model for face

identification is always a difficult task. The PCA is solitary of the mainly thriving techniques which were developed and used in recognition of image and works based on a statistical procedure Eigen method. The core aim of this technique is to minimize the huge dimensions of the vector space into small numbers of variables which are independent and not correlated.

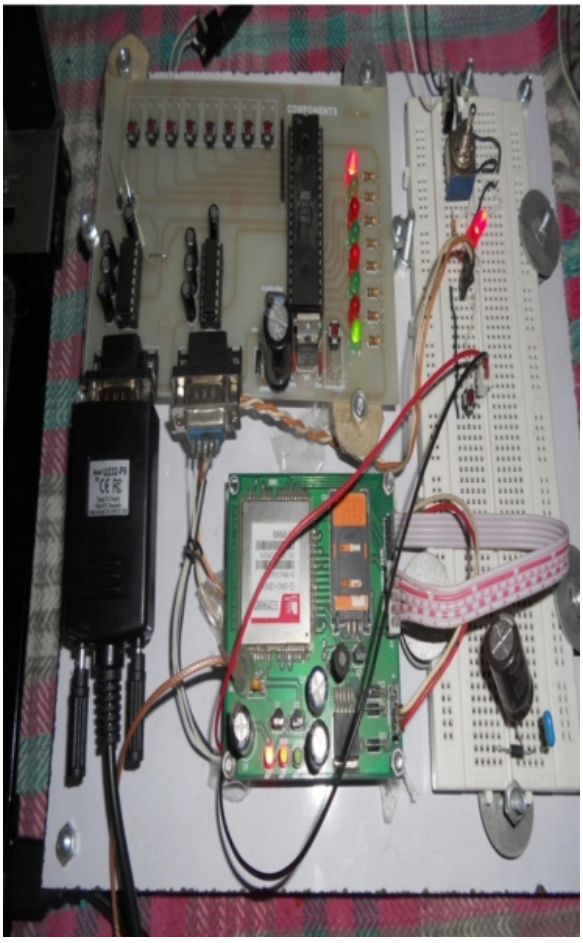

Fig. 4. Hardware module for sending SMS on unauthorized access

A. Principal Component Analysis

A mathematical procedure of principal components analysis [x] based on Eigen vector techniques that imposed an orthogonal transformation to translate the set of values of probably correlated M faces images into a set of values uncorrelated K variable called Eigen faces. The number of images in Eigen faces is always less than or equal in amount to number of original face images, i.e. $K < M$.

Since the principal components always present for the most leading direction or features of the dataset correlated variable and each preceding component shows less direction and more unwanted noise. So only the first few K-Eigen faces have been selected and discarded the remaining ones due to their less importance.

These selected K components are fully representing the whole original dataset (face images) because they illustrate major facial features or direction that makes up the dataset.

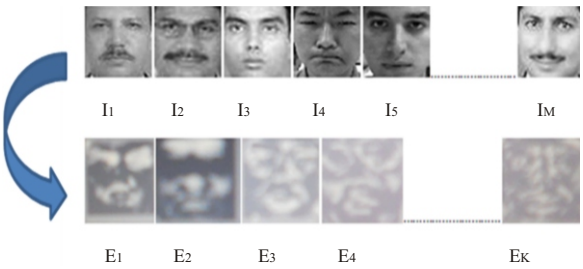

Fig. 5. Images and associated Eigen faces

So every face image in the original training databases or problem image can be reconstructed in term of these K parts of principal components. It is illustrated by the under mentioned figure.

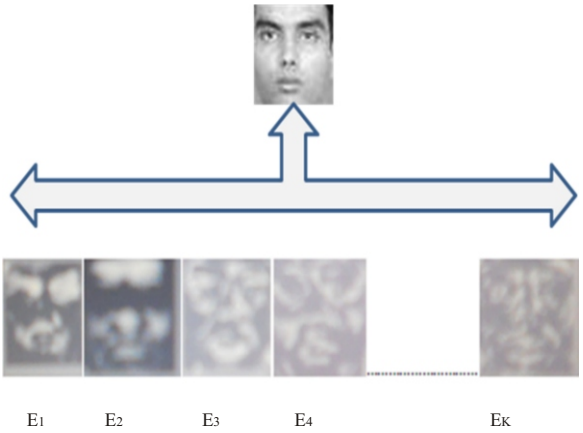

Fig. 6. Image reconstructed from Eigen faces

B. Eigen face Method

Eigen face technique used to be a satisfactory approach for implementing in face recognition due to its ease, enhancement and erudition competence. Eigenvectors are composed of the Eigen face vector sets used in the computer vision problem of human face unique pattern recognition. This technique is known as an appearance-based methodology for getting identical features of face and variation of features is to be used for comparison and coding. Huge multidimensional space is to be converted in less space by the calculation of Eigen vectors.

The procedures of the face recognition based on Eigen method [ix-xii] and adaption of classifying value algorithm consists of the following steps

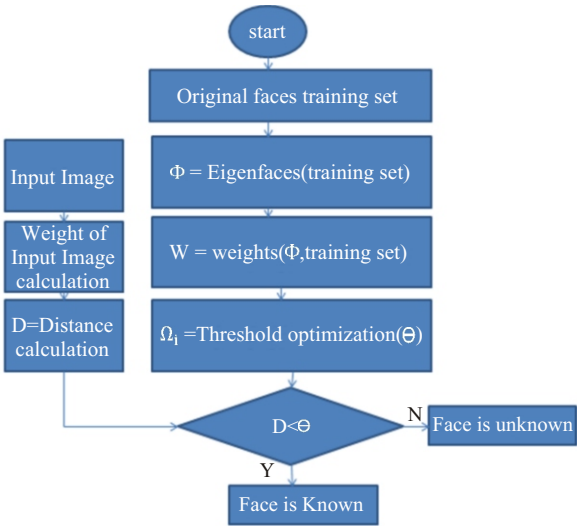

Fig. 7. Flow chart for threshold optimization

Every face image which is basically 2 dimension vector set is transformed into a column vector for the simplicity of manipulation operation [ix].

$$(Im)_i = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1N} \\ y_{21} & y_{22} & \cdots & y_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ y_{N1} & y_{N2} & \cdots & y_{NN} \end{bmatrix}_{N*N} \quad (1)$$

$$T_i = \begin{bmatrix} y_{11} \\ \vdots \\ y_{1N} \\ \vdots \\ y_{2N} \\ \vdots \\ y_{NN} \end{bmatrix}_{N^2*1} \quad (2)$$

The all images data are concatenating into a big matrix whose number of columns are equals to the number of images used for in face recognition data set. Then calculating the mean or average face vector of the big all image matrix [ix].

$$\text{Averagefacevector}(\Psi) = \frac{1}{M}\sum_{i=1}^{M} T_i \quad (3)$$

The mean face is subtracted from each face columns vector for getting a set of vectors. The purpose of subtracting the average image from each image vector is to get only the distinguishing characteristics from each face and discarding common one for simplicity [ix].

$$\Phi_i = T_i - \Psi \quad (4)$$

The covariance matrix is essential for the further manipulation and selection of the best *K* eigenvectors [ix].

$$\text{Covariance matrix} = L^T L \quad (5)$$

$$\text{Where } L = [\Phi_1\ \Phi_2 \ldots\ldots\ldots\ldots\ldots\ldots \Phi_M\ ] \quad (6)$$

The next step is to calculate the weight of every Eigenvector [ix].

$$\Phi_i = \sum_{j=1}^{k} w_j\ u_j \quad (7)$$

Each normalized training image is shown on the basis of a vector. This give the direction to find out such a vector corresponding to each image in the training set and store it for calculation.

The Eigenvectors are calculated for the training set of images and their related weights [ix].

$$w_j = u_j^T \Phi_i \quad (8)$$

$$\Omega_i = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_k \end{bmatrix} \quad (9)$$

C. Problem Image Recognition Task

The problem image face for its reorganization is projected into the vector space (the collection of Eigenvectors/faces) and find out the corresponding weights [ix]. The problem images can then simply be classified for recognition purpose.

$$\Omega = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_k \end{bmatrix} \quad (10)$$

The distance of the unknown face is calculated on the basis of the above calculation, and then the weight vector of the problem image and its distance with the weight vectors associated with each of the training image [ix].

$$D = \min\|\Omega - \Omega_i\| \quad (11)$$

D. Algorithm for Threshold Optimization

The threshold value is calculated from the distance of each image on the vector space. If the distance of the input problem image with vector space is greater than the threshold value then the image is not recognized.

Algorithm. Threshold Optimization by using histogram

Required: M Alist of images
for images in M **do**
    histogram (images)
    threshold = max (histogram)
end for

V. RESULTS

The adaption of the threshold classifier value for face recognition process is critical one and calculated on the basis of linear distances of each face image from the vector space database training set of all images. The execution time of the algorithm for finding the classifier value and instant message to the particular cell phone is mentioned in the following table

TABLE 1
EXECUTION TIME OF CODE

Execution Time for code	
Event	**Execution Time**
Algorithm code for adaption	5 s
Message sending time	30-60 second

The execution time is recorded from MATLAB and microcontroller 89C51 and Figure 8-11 provide comparison between the number of images and their associated threshold values on the basis of which the face is recognized. Fig. 8 shows the scenario in which 6 images are in the database and their corresponding threshold value is 928.The image distance less than this threshold value will be considered as recognized image. Similarly, Fig. 9-11 show the scenario of 10, 20 and 25images and their corresponding thresholds respectively. These results illustrate that the threshold value is optimized automatically as the number of images in database changes.

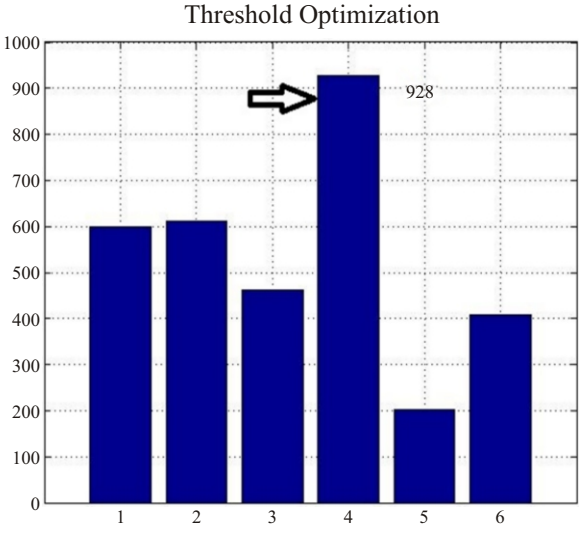

Fig. 8. Threshold value for 6 images

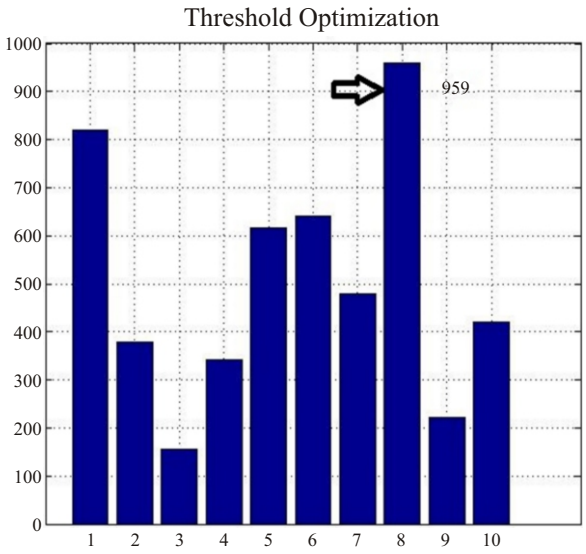

Fig. 9. Threshold value for 10 images

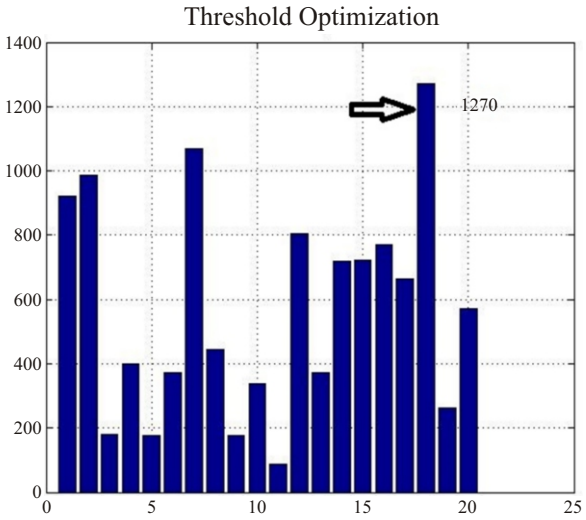

Fig.10. Threshold value for 20 images

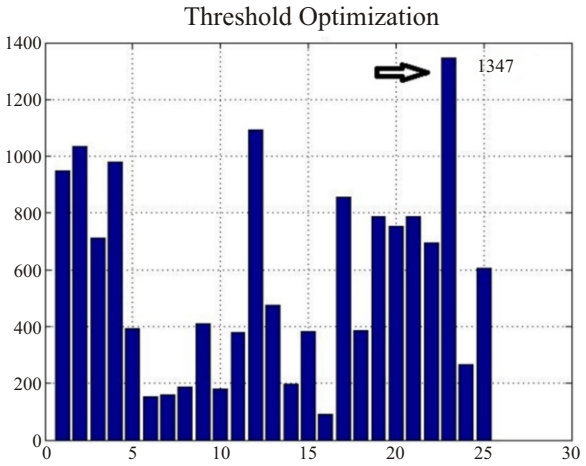

Fig.11. Threshold value for 25 images

VI. CONCLUSION

Face recognition is a biometric technique which is implemented to detect unauthorized access in the costly optical network equipment. Automatically threshold optimization of face classifier value is determined in the research and its results by increasing number of images are presented. On detection, an instant message will be sent to the security personnel, hence, minimizing the risk in security of network equipment.

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A New Testing Arrangement for Damping of Concrete

A. A. Malik[1]

[1]NFC, IET, Multan
[1]dr.akhtaralimalik@gmail.com

Abstract-The energy absorbing characteristics of a vibrating system is termed as damping. The phenomena is very important for structures subjected to earthquake and other dynamic loading conditions where small duration are involved. Damping characteristics of a material play an important role in overall stability of a structure. The higher is the damping value, the shorter will be the time to disappear the vibrations. However, damping requirement at the cost of strength of a given material is not justified in any case. This paper describes that the damping of material can be calculated from the time history curve as well as resonance frequency curve. Both these curves are available in new testing arrangements of Impulse Load Test (I. L.T.) and therefore were utilized for damping evaluation of concrete [i]. In this paper, the author is describing the I. L.T test either on cement concrete or asphalt concrete by considering relevant ASTM specifications. There are certainly different variables taken into account with respect to cement concrete or asphalt concrete. After the experiment, the conclusions are drawn in different ways depending upon either the specimen is of cement concrete or asphalt and by considering their relevant variables.

Keywords-Damping of Concrete, Earthquake, Impulse Load Test, Time History Curve, Resonance Frequency Curve

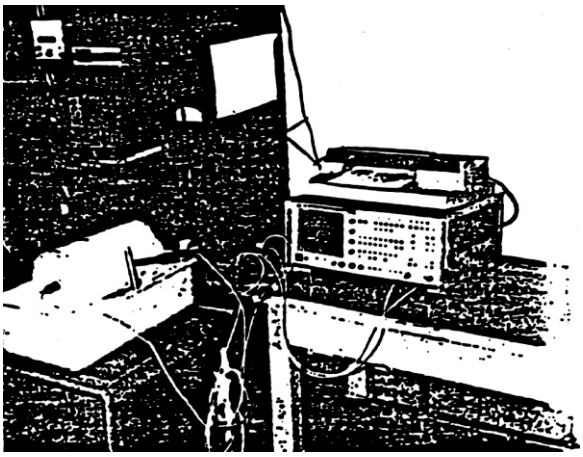

Fig. 1. Arrangement for Impulse Load Test

I. INTRODUCTION

The energy absorbing characteristics of a system is termed as damping. When a system of any material is set into a state of free vibration, the vibration will decrease in amplitude and eventually disappear. This phenomenon is very important for structures subjected to the earthquake and dynamic loading conditions. The damping of material can be calculated from the time history curve as well as resonance frequency curve. Fortunately both these curves are available in I. L.T (Impulse Load Test), which were utilized for damping evaluation of concrete. Impulse Load Testing arrangement is comprised of (a) Hammer (b) Accelerometer and (c) Fast Fourier Transform (F. F. T.) Analyzer [i]. In this testing arrangement a concrete sample is hit by the hammer and its response, through Accelerometer is received and analyzed by F. F. T Analyzer which gives both time history curve as well as resonance frequency curve. All these curves were analyzed for damping calculations and results are presented in this paper.

II. BACKGROUND

Damping consists of geometric damping, a measure of energy radiated away from the immediate region, and the material damping, a measure of energy loss due to imperfect elasticity [ii]. In order to obtain the total damping ratio of a system the geometric and material damping may be added directly.

Material damping is generally calculated from the hysteresis loop which represents the stress-strain relationship for one cycle of loading and unloading [ii].

The shape of the hysteresis loop depends on the type of material subjected to the cyclic loading. It was shown by Krizek and Franklin (5, 6) that or perfectly viscous materials a circular hysteresis loop is generated. For an elastic material the resulting graph is a straight line with a 1:1 slope, and with no area inside, indicating the absence of damping.

When a rod of any material is set into a state of free vibration. The vibration will decrease in amplitude and eventually disappear. This reduction in amplitude of vibration is caused by internal damping within the mass of the material. To predict or analyse such a response in a vibratory system, in many cases it is satisfactory to

reduce the system to an idealized system of lumped parameters. The simplest system is the classical single degree of freedom (SDOF) consisting of a mass, spring, and dash pot, representing viscous damping [i].

Hysteretic proportional damping is the type of damping used for Steady State Analysis in SAP2000. Steady State Analysis computes the steady state dynamic response to a two of harmonically varying loads (a sine and cosine term) at specified frequency increments and was used for analytical predictions of accelerance FRFs to compare to vibrating floor measurements. For any frequency of interest, the analysis seeks the peak value of the steady state response after any transient response has damped out [v]

For the purposes of selecting a damping ratio for the steel beams in the finite element model, a damping ratio of 0.2% seems appropriate. Although measures were taken to reduce the amount of damping provided by the supports in the footbridges, some amount of the global damping should be expected to come from the supports. A damping ratio of 0.2% is within the reported values for bare steel structures and steel footbridges which include connections and supports [vi]. It is clear that both the Concre Damp, latex and rubber mixtures are cost prohibitive. Additionally, the concrete supplier would not allow a latex based concrete mixture to be put into a redi-mix truck. Therefore, a mixture containing only CRM ground rubber with a 15% replacement of FA by volume was chosen [vii]. Next, multiple adjustments were made to the base mix in an attempt to control the air content. Although the exact cause of the air entrainment from the rubber is not known, the effects that the aggregates and cement have on air content can be found in literature [viii].

It is an interesting approach where they pre-coated coarse aggregate with an acrylic ester and styrene latex in an attempt to improve post cracking toughness. The purpose was to investigate more efficient methods for distributing the latex in the transition zone between the aggregates and the cement paste. The researchers premixed the latex with the coarse aggregate (in concentrations of 0.5%, 1% and 2% weight of latex solids to coarse aggregate weight) and let the mixture dry for 2 to 3 minutes before adding it to the concrete. The researchers found that this premixing method was an effective means for creating a latex coating around the aggregate and that post cracking toughness was improved. However, it was concluded that accompanying reductions in compressive strength and modulus were of enough significance that the benefit of the method was not justified [ix]. Fine aggregate replaced by mass in percentages of 5, 10, 20, and 30 percent using waste tire rubber in gradations of 0-1 mm, 1-2 mm, and 2-3 mm [x].

A. Types of Damping Forces

The damping of real system is a complex phenomenon. It involves several kinds of damping forces that are assumed to act in opposition to the motion, doing negative work and dissipating the energy of the system. Reference [ii] investigated different kinds of damping forces that are encountered in real materials and presented them in a detailed study.

When the damping forces are proportional to the velocity of the vibration, it is referred to as viscous damping. In a physical sense, viscous damping is attainable from a fluid dashpot. The viscous damping is equal to

$$F_{DE} = cZ \qquad 2.1$$

Where

c = Viscous damping coefficient
Z = Velocity of vibration

Another type of damping force is Coulomb damping, which occurs when two dry surfaces slides upon each other. This force is of a constant magnitude and can be represented by

$$F_{DE} = \mu F_N \qquad 2.2$$

Where

F_N = Normal force
μ = Coefficient of friction

A third type of damping force is hysteric damping. The damping property can be described by a viscous dashpot for which the viscous damping coefficient "c" varies inversely with the frequency of vibration ($c = h/\omega$, where h is the hysteretic coefficient). This force can be represented by

$$F_{DE} = h/\omega Z \qquad 2.3$$

Where

ω = Circular frequency

Because of the difficulty of predicting the magnitude of different damping forces, according to [xi] introduced the concept of equivalent viscous damping. This concept consists of replacing all the damping terms of the original differential equation of motion with a single equivalent damping term, proportional to the first power of velocity of motion. According to this concept, viscous forces that produce the same rate of energy dissipation as the actual damping forces are applied to the system [xi].

III. DAMPING EVALUATION

There are several methods of determining the damping capacity of a material; the two most common methods for concrete are discussed below [xii]:

A. Band-Width of a Resonance Curve Method

In this method the damping was calculated using the following equation [vii]

$$D = \Delta w / 2 f_n \text{ x } 100\% \qquad 3.1$$

The unknown in the above equation was obtained from the resonance curve of a function of I.L.T. shown in Fig. 1 (a) in which Δw is the frequency range taken at 0.707 times maximum amplitude and f_n is the resonance frequency [viii].

B. Logrithmic Decrement Method

Logarithmic decrement (δ) is defined as the natural logarithm of the ratio between the amplitudes of successive oscillation in the damped sine wave produced by the decay of free vibrations of a sample, and it is given by the following

$$\delta = l_n Z_1 / Z_2 \qquad 3.2$$

Where

$$Z_1/Z_2 = exp\{(2\pi D)/(\sqrt{1-D^2})\} \qquad 3.3$$

Therefore

$$l_n Z_1/Z_2 = \{(2\pi D)/(\sqrt{1-D^2})\}$$

Where Z_1, Z_2 are the two successive amplitudes of output spectrum in time domain of I. L. T. showing Fig. 1 (b) .If Z_1, and Z_1 are known, the damping (D) can be determined with the above equation [viii].

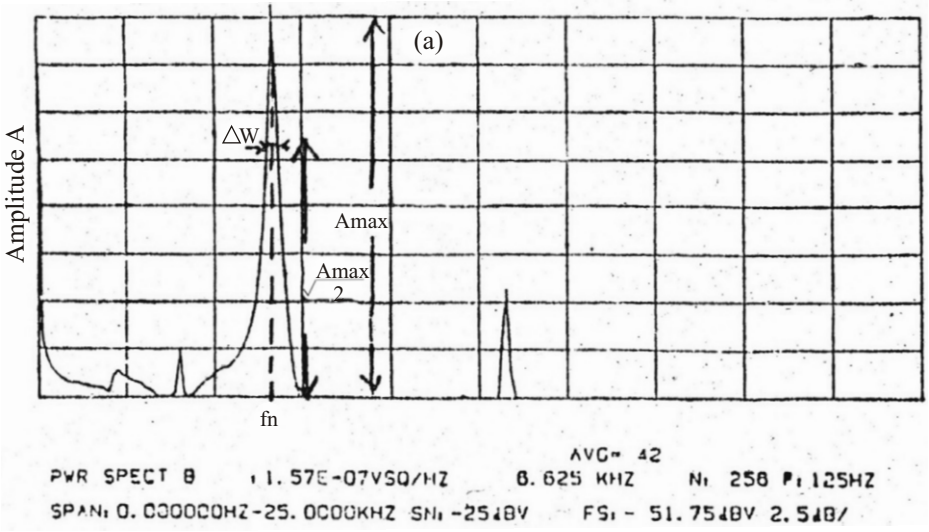

Fig. 2(a). Band width of resonance curve method

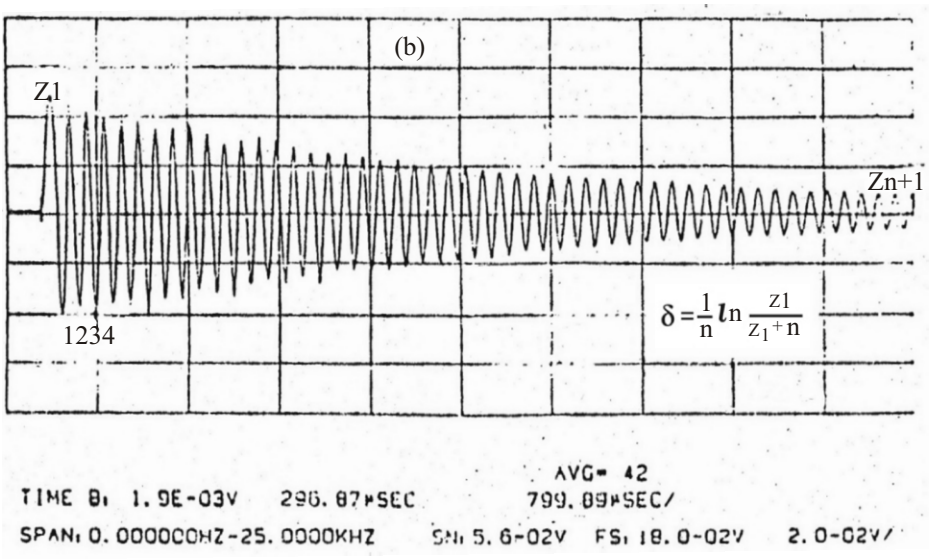

Fig. 2(b). Logarithmic decrement method

C. Comparison between two methods

It is possible to determine the damping values from the output spectrum in time domain, but analysis in the frequency domain seemed to be more convenient [xiii]. Thus the damping values for all samples were calculated by the second method. However for comparison purposes few samples were tested by the first method also.

IV. Testing Program

In order to find the damping values from I. L. T., many concrete samples made of either asphalt or cement concrete were prepared. The applicability of this technique was checked by changing either the mix design or the environmental conditions of these samples. Many variables were thus selected for both types of concrete samples. The variables selected for cement concrete were, water/cement ratio, percentage , use of admixtures, aggregate/cement ratio, compacting efforts, coarse/fine aggregate ratio, curing conditions, maximum nominal size of coarse aggregate, and quality of coarse aggregate. An average of six samples with a wide variation in a mix design was made for each variable. The bandwidth resonance curve method was used for damping calculations in these samples.

For Asphalt concrete, the maximum nominal size of asphalt, quantity of fines, and the temperature were the selected variables. Samples made for all these variables were tested in the same way as for the concrete samples.

V. Specimen Preparation

Two types of concrete samples were studied in the testing program. These concrete samples, made of either cement concrete or asphalt concrete were prepared according to ASTM procedures, briefly discussed as follows:

Cement Concrete: Cylindrical samples of 6 by 12 inches were selected and made accordance to ASTM C31 and ASTM C215-185. Single use mould fulfilling the requirements of ASTM C470-81 were used for these samples. The maximum size of coarse aggregate used in all these samples was according to ASTM C192, which describes that the diameter of the cylindrical sample shall be at least three times the maximum nominal size of the coarse aggregate. All the samples were made according to ASTM C192-81 procedure. Also, ASTM C-617 was followed for the capping of the cylindrical concrete samples.

Asphalt concrete: Asphalt concrete samples were made accordance to ASTM D3496-79 Cylindrical samples of 4 inch in diameter by 8 inch in height were selected for this study. A bituminous mixture of approximately 4000 grams was prepared for each sample, the temperature requirements of the bituminous mixture before and during compaction were according to the method ASTM D1561. This method was also used for the application of the static load during the compaction process as well as for removing the sample from the mould by a push-out device.

VI. Testing and Evaluation

In order to find the damping values from new testing arrangement of I. L. T. all the samples were tested and evaluated by Bandwidth of resonance curve obtained from transfer function of Resonance Frequency Method (R. F. M) [i]. The detail of these results is given below.

Cement Concrete: During this study it was found that damping ratio increases as the water/cement ratio increases. It shows that the damping ratio increases as the dynamic modulus decreases, which agrees with the results of reference [xiv]. It was also observed that damping ratio decreases by an increase in age, compacting efforts, course/fine aggregate ratio, curing conditions. However damping ratio increases by using air entrained admixtures and maximum nominal size of coarse aggregate thus can be justified on the facts that damping ratio is inversely proportional to the dynamic modulus value. These results are also tabulated in Table I.

TABLE I
Relationship Between Damping Ratio and Variables of Cement Concrete

S. No.	Variable	Relationship with Damping Ratio
1	Water cement ratio	Varies directly
2	Dynamic modulus	Varies inversely
3	Age	Varies Inversely
4	Compacting effort	Varies Inversely
5	Course/fine aggregate ratio	Varies Inversely
6	Maximum nominal size of coarse aggregate	Varies directly
7	Air entrained admixtures	Varies directly

Asphalt Concrete: ln this study damping of asphalt concrete was evaluated from new testing arrangement of I. L. T. Many asphalt concrete samples of different mix design variables were made and tested. Bandwidth of resonance curve method was used for damping evaluation. It was observed that damping ratio decreases with an increase in maximum size of coarse aggregate, and quantity of fines. However, damping ratio increases by an increase in temperature, which provides a good agreement with the study of reference [xv].

TABLE II
RELATIONSHIP BETWEEN DAMPING RATIO AND VARIABLES OF ASPHALT CONCRETE

S. No.	Variable	Relationship with Damping Ratio
1	Maximum size of coarse aggregates	Varies Inversely
2	Quantity of fines	Varies Inversely
3	Temperature	Varies Directly

CONCLUSIONS

The following are some detailed conclusions from the work performed.

Damping value for both types of concrete decreases as the dynamic modulus increases.

For cement concrete water/cement ratio has a major effect on its dynamic properties.

Dynamic Modulus of Asphalt Concrete decreases with increase in temperature.

Dynamic Modulus of both types of concrete increase with increase in aggregate size.

Dynamic Modulus of both types of concrete increases with increase in unit weight.

For Asphalt concrete temperature has the major effect on its dynamic properties.

Both methods of clamping evaluation almost gave the same value for both types of concrete.

For hardened cement concrete damping was ranging from 1.13% to 3.40%.

For Asphalt concrete damping was ranging from 4.80% to 8.30%. However, Asphalt samples of low temperature gave smaller damping values.

TABLE III
EFFECT OF WATER CEMENT RATIO ON DAMPING OF CONCRETE

Water Cement Ratio	Damping
48	1.1
55	1.75
62	2.4
75	3.1

COMPARISON WITH LATEST RESEARCH

Besides the ILT another latest technique is forced harmonic test. In this test, the concrete cylinder specimens were tested under cyclic axial compression loading. By plotting the applied stress versus strain, a hysteresis loop was obtained. The area of hysteresis loop were then used to calculate and compare specific damping capacities of the different specimens. Whereas in case of ILT we obtained resonance curve or history curve.

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Combustion and Emission Based Optimization of Turbocharged Diesel Engine Run on Biodiesel using Grey-Taguchi Method

M. I. Masood[1], A. N. Shah[2], A. Aslam[3], M. Gul[4], A. Naveed[5], M. Usman[6]

[1,2,3,4,5,6]*Mechanical Engineering Department, University of Engineering & Technology Lahore-54000, Pakistan*
[1]mimran.masood@uet.edu.pk

Abstract-in this work it is attempted to optimize the combustion parameters such as instantaneous heat release (IH), cylinder Pressure (P) and rate of change of pressure per degree crank angle (dP/do)) and the emissions characteristics such as NO_x and Smoke of a turbocharged direct injection (DI) compression ignition (CI) engine alternatively run on pure biodiesel (B100), diesel and biodiesel-diesel blend (B20) applying Grey Taguchi method (GTM). GTM is used to convert multi variables into a single objective function. The process environment comprising three input parameters (speed of the engine, load and type of fuel) were used in this case. The design of experiment (DOE) was selected on an orthogonal array based on L_9 (3^3). The Optimum Parameters were found on the basis of Grey Relational Grade (GRG) and signal to noise (SN) ratio using GTM. The resulted optimum combination of the input parameters was used to get maximum possible values of IH, P and least possible values of NO_x, smoke & dP/do. The higher values of IH and P measure the better performance of the engine, while lower values of NO_x, smoke and dP/do are the ultimate objectives of the study. According to the results It was revealed that B100 fuel, 1800 rpm speed and 10% load offer the optimum combination for the desired performance of the engine along with reduced pollutants. Analysis of Variance (ANOVA) based on a software Minitab 16 was used to get the most significant input parameter keeping in view responses. Fuel type and engine load were found to be the dominant factors with 48.16% and 43.18% impact on the output parameters, respectively. Finally the results were validated using Artificial Neural Network (ANN) through Mat lab.

Keywords-Biodiesel, Turbocharged, Diesel Engine, Grey Taguchi Method,ANN, SN Ratio, GRG

I. INTRODUCTION

Heat engines are deemed to be an indispensable part of modern life style owing to the dependence of smaller vehicles used in transport and agricultural equipment's in the past few years, so energy crisis and ever tighter emission standards have been the potential threats to this efficient, robust and unmatched prime mover. As a result scientists and researchers have converged their attentions for the survival of this technology by introducing not only alternative fuels but also to emission controlling Strategies. Since diesel engines and fossil fuels are considered to be the backbone of Agriculture and Transport sector especially for developing countries. The different types of heat engines came in to practice out of which diesel engine is mainly used in agriculture, The economic growth of Pakistan is mostly dependent on agriculture so diesel engines and fossil fuels plays a dominant role . Agriculture and energy are related to each other, so rapid energy consumption and environmental problems caused by emissions of petroleum vehicles are dangerous. These emissions contribute to global warming, Ice melt down due to large carbon deposits in environment. Kyoto protocol and Copenhagen conference (2009) is expected to control the greenhouse gas concentration in atmosphere [i].

It is well known that a turbocharged direct injection diesel engine shows more fuel efficiency when biodiesel was used. It has already been reported that combustion of the engine can be improved due to the increased combustion pressure. Also break specific Fuel Combustion (BSFC), maximum combustion pressure. And Injection angle was increased while BSEC, maximum rate of pressure rise, ignition lag and premixed combustion were decreased [ii]. Carbonylisis emission analysis of turbocharged diesel engines on the basis of different operating fuels i.e. diesel, biodiesel and biodiesel-diesel blends revealed maximum Break Specific Exhaust (BSE) at low load that decreases with the increase in load [iii]. Reference [iv] tested different blends of Jatropha biodiesel in a single cylinder four stroke diesel engine in order to check the performance and emission properties on the basis of parameters such as brake thermal efficiency, bmep, bsfc, exhaust gas temperature. It was concluded that BJ10 and BJ20 have better emission behavior as compared to other blends and are close to diesel. According to [v] investigated the effect of injection timing, fuel quantity per fuel pulse, and injection rate on the exhaust gas emissions like Nitrogen Oxide. It was observed

that among all these factors fuel injection has special importance in air fuel mixing and combustion of the mixture, so will determine the exhaust emissions. It was found that NO_x emissions can be controlled by controlling injection timing and rate. The percentage contributions of different engine operating parameters on engine noise, emission and BSFC was found by Taguchi based Analysis of Variance. Reference [vi] Performed experiments to check the effect of fuel injection timing, Exhaust gas recirculation and fuel injection pressure to control the Nitrogen Oxides of a stationary Diesel Engine using Crude rice bran oil (methyl ester) as fuel. It was observed that there is a reduction in NOx emission without any marked rise in the smoke concentration. Reference [vii] observed that it is really important to cut down the NO_x by some inside sources. There were many solutions but the most practical one were EGR, water injection or Fuel water emulsion, they brought the combustion temperature down which reduced the NO_x Values. But with the above method they faced the problem of BSFC and soot formation. So they used multiple simulation method for the above said there methods, the experiments were performed on heavy duty diesel engine at various working conditions. In above said method engine performance and emission was observed with special attention given to fuel and sot formation. At the end of their work it were concluded that NO_x reduction is most attractive at 30% of fuel water emulsion considering both BSFC and soot formation in mind. Reference [viii] studied the effect of castor biodiesel on the performance end emissions of a diesel engine using Castor biodiesel produced by Tran's esterification in an acid base catalyzed system. The highest value obtained was 82.5%, smoke test was performed and it was observed that B40 has minimum smoke. Performance test of diesel engine shown that BSFC of blended biodiesel engine was increased significantly; Engine power was same for diesel fuel and B20. B20 shown best combustion with minimum PM, CO and HC as compared to diesel engine.

The effect of biodiesel on emission and efficiency of stationary diesel engine with the help of Rapeseed biodiesel blends has been studied experimentally; the results of this study were compared to the similar experiments performed by other researchers. It was observed that BSFC was not showing large changes with different blend, CO_2 emissions were reduced for blended fuels, by increasing the biodiesel concentration the engine temperature increased as a result NO_x concentrations, Power and heat release rate was also increased. The results obtained in this experiment cannot be related to the moving engines, so biodiesel is useful for farmers from economic and environmental point of view [ix]. The extracted bio diesel from different kinds of fish can be used to study combustion, performance and emission of a diesel engine. Following blends B25, B75, and B100 were used for experimentation and results shown that BSFC and brake thermal efficiency is higher for B100 than pure diesel. The peak combustion pressure for above said blends was lower than pure diesel, the flue gases temperature were lower for B100 than pure diesel at different operating conditions. At full load B100 produced higher smoke, NO_x, CO and HC as compared to pure diesel [x]. Reference [xi] performed experiments on a multicylinder (4 cylinders) DI diesel engine fuelled with biodiesel and its blends (20.40,60,80 by volume of biodiesel) to examine the emission properties of the engine operating at various loads (25, 40, 65, 80%) and 2000 RPM. Biodiesel was obtained from waste frying oil. CO and HC emissions were higher at low engine speeds and lower at high speeds, NO_x and CO_2 were increased with the increase in load, in blended fuel CO and HC concentration was reduced due to better combustion and NO_x was increased due to higher combustion temperature. Buyukkaya, et al [xii] worked on the combustion, performance and emission of a diesel engine using three different blends B5, B20 and B70 obtained from neat rapeseed oil. It was observed that biodiesel produced less amount of smoke (up to 60%), greater BSFC (up to 11%) compared to diesel.B5 and B100 produced less CO emissions (9 and 32%) as compared to diesel, Observing the combustion it was concluded that ignition delay was decreased for pure biodiesel and its blends, combustion behavior of biodiesel and its blends is closely related to pure diesel.

The application of Taguchi and Grey relational analysis, to find out the optimum level and optimum performance of the diesel engine operated by different blends of Thumba biodiesel was investigated. Factors involved were Thumba biodiesel blend, CR, Nozzle opening pressure and injection timing each parameter having 3 levels. L_9 orthogonal array was used to arrange the data of performance and emission of the engine. S/N ration and grey relational analysis were used. The optimum combination came out to be 30% Thumba, CR 14, 250 bar pressure and 20 degrees injection angle. Thermal efficiency was maximum and BSFC was minimum at this combination along with minimum emissions [xiii]. According to [xiv] used Turpentine as alternative fuel for a diesel engine, Turpentine has low cetane number so cannot be used individually blends of turpentine were used. So it was tried in this work to replace diesel fuel by turpentine at maximum concentration. As multiple parametric optimization was involved so taguchi method was used, so no of experiments were reduced. ANOVA was used to show the % effect of each parameter on the needed parameter. The optimum combination was 40T, 29 degrees BTDC and 180 bar pressure, Brake thermal efficiency was increased by1-2% at optimum level, there was slight increase in NO_x, smoke was reduced by 50% and Co was also decreased at Optimum

combination.

Artificial Neural Network (ANN) is a modeling tool used for the optimization and prediction of the data for different engineering problems like in manufacturing IC engine optimizations etc. In the optimization of combustion emissions and performance of a diesel engine the experimental data is used for the training and testing purpose. In some problems some statistical tools are linked with ANN to get optimum combination and later on ANN predict the output parameters at that combination. It has been accurately used to optimize and predict the different parameters of the IC engines [xv-xviii].

Extensive research into the mechanism governing diesel combustion and emission has already been done. However in spite of many studies being conducted in the area of diesel combustion and emission, these process are still not well understood due to the complex interrelationship that exist between combustion system parameters and injection system parameters. The exhaust gases of a diesel engine strictly depend upon the combustion phenomenon, combustion process is highly dependent on combustion chamber and the injection system of the engine. Whenever we have the problems where output is dependent on many factors (variables, inputs) Taguchi method is used for design and analysis purpose which reduces the loss of time and economy by running the process using all possible combinations of values of those variables.

By carefully selecting certain combinations it is possible to find their individual effects. Conventional Taguchi method is not sufficient in handling multiple objective optimizations in single purpose function. Grey analysis based Taguchi method which has more prominent applications is used to solve problems like that. Once we have the optimal combination Minitab software will be used to perform the analysis of variance, the dependency of the each input parameter can be checked and we will chose the most significant parameter by measuring the percentage contribution. Artificial Neural Network tool given in Mat lab to find out the desired output parameters at the given optimal combination.

II. Experimental Setup & Methdology

A. Experimental Setup

The engine used for the experimentation purpose was a Turbocharged, 4 cylinder, DI compression ignition engine having intercooling connected to a test bench shown in fig 1.Further properties of the engine are given below

Bore and stroke length, 110 and 125 mm respectively

Displacement volume and compression ratio are 4752 cm^3 and 16.8:1 respectively

There are 6 nozzle holes in the injector and each of 0.23 mm diameter

The rated power and maximum Torque of the engine is 117/2300 (KW/rpm) and 580/1400 (N.m/rpm) respectively

There was no modification done on this engine during experimentation.

Following three fuels were used during experimentation

1. Pure diesel fuel
2. Pure Biodiesel (B100)
3. A blend of biodiesel and diesel having 20% biodiesel and 80% diesel (by volume) designated by B20

The properties of the fuels are given in Table.1

The following parameters were collected from the test bench during experiments

Load and speed from Electrical dynamometer (SCHENCK HT 350)

Crank Angle from Kistler corporation 2613A sensor)

Instantaneous heat release (IH) from Combustion analyzer (DEWE-5000)

Instantaneous Pressure (P) in cylinders from (Kistler 6125B, Peizo-electric sensor)

Rate of Change of Pressure per degree crank angle (dP/do CA)

NO_x Analyzer (Pier burgAMA 4000)

Smoke Opacimeter (AVL 439)

B. Methodology

The methodology used in this research is shown in the Fig 2.

C. Data Collection

The experimental setup shown in Fig.I is used to find out the input data for further study we have taken the readings of Smoke, NO_x, Heat release, pressure per Degree crank angle and cycle pressure at nine different operating conditions

D. Grey Taguchi Method

Taguchi method is used for the optimization of the experimental parameters when we are dealing with fewer trials. The number of trials depends upon the number of factors contributing to the experiments; higher number of parameters will give large number of trials for a given experiment, so it will require more time and money for experiment [xix].

Simple taguchi method was used for the optimization of a single parameter so optimization of multi parameters is a tough task than a single one. A grey based Taguchi method is used in this research incorporating the signal to noise ratio analysis [xx].

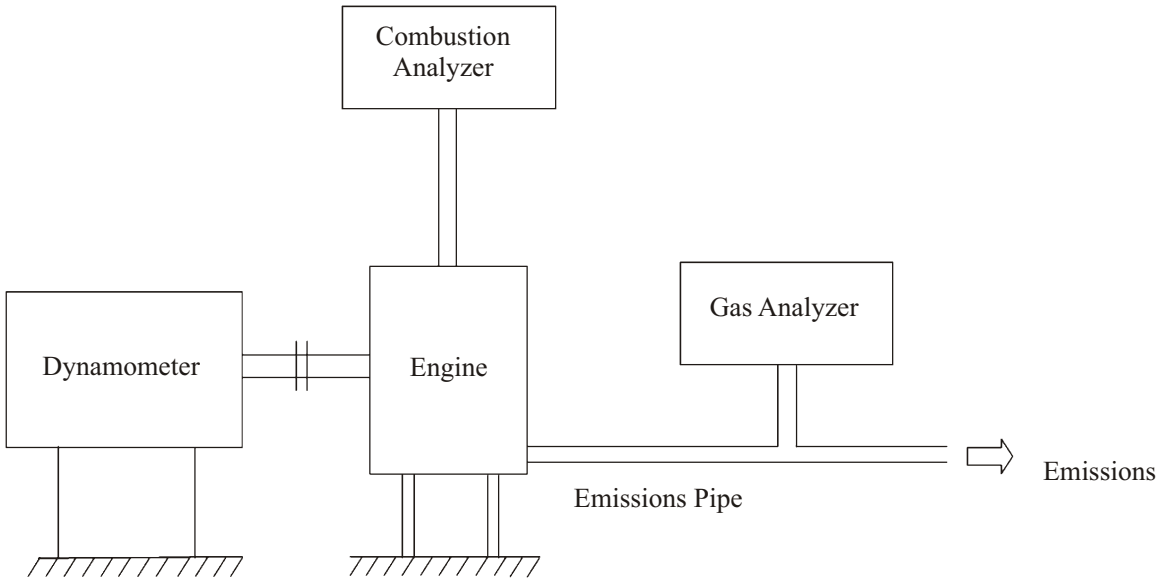

Fig.1. Experimental Setup

TABLE I
PROPERTIES OF THE FUELS

Properties	B100	B20	D	Standards[a]
Oxygen % by weight	11.33	n/a	0	Element analysis
Hydrogen % by weight	11.91	n/a	13.08	SH/T 0656-98
Carbon % by weight	76.83	n/a	86.92	SH/T 0656-98
Sulfur (mg/L)	25	n/a	264	SH/T 0253-92
Lower Calorific value (MJ/kg)	37.3	41.57	42.8	GB/T 384
Viscosity (mm^2/s) at 20 ºC	8.067	4.020	3.393	GB/T 265
Density (kg/m^3)	886.4	845.1	834.8	SH/T 0604
Cetane number	60.1	n/a	51.1	GB/T 386-91

[a] Chinese standard

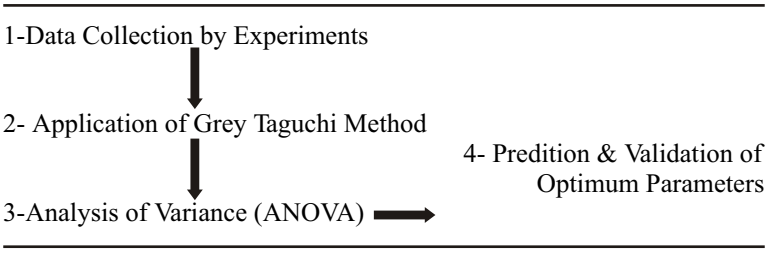

Fig. 2. Structure of Grey Taguchi Method

E. Selection of Input Factors

The input factor which effect the combustion and emission of the given engine are found with the help of experimentation. In this work we are using speed of the engine, type of fuel and load as the input factors and each of these factors has three levels which are given in Table II.

F. Orthogonal Array Design

After selecting the input parameters the orthogonal array is prepared according to the number of parameters and their level, so the OA used in this work is based on $L_9(3^3)$ is given in table 3. This table gives the total number of experiments carried out and their corresponding combination of the input parameters.

TABLE III
ORTHOGONAL ARRAY DESIGN

Run No	Type of Fuel (A)	Speed (B)	Load C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Once we have the OA the experiment is carried out according to the combinations given in the table 2 in order to find the output parameters.

G. Normalization of Data

The grey relational generation normalizes the output data. The Normalization of the data can be done by the different equations coming forward.

If we want to maximize our required output response then "the larger the better" criteria is used given below

$$x_i(k) = \frac{y_i(k) - \min y_i(k)}{\max y_i(k) - \min y_i(k)} \quad (1)$$

Here X_i (k) is the value after the grey relational formation and min Y_i (k) is the minimum value, max Yi (k) is the maximum value of the comparable sequence Y_i (k) for the kth response.

If we are interested in the minimization of the response data then "The larger the Better "criteria is used given below

$$x_i(k) = \frac{\max y_i(k) - y_i(k)}{\max y_i(k) - \min y_i(k)} \quad (2)$$

After Normalization of the data Quality Loss factor is estimated for each response using the equation given below

$$x_0(k) - x_i(k) \quad (3)$$

Here X_0 (k) is the ideal sequence of the responses

H. Grey Relational Coefficient Generation

The GRC is used to show the relation between the two sequences [ideal sequence X_0 (k) and X_i (k), i = 1, 2, 3……9]. The grey relational Coefficient is given below

$$\xi_i(k) = \frac{\Delta_{\min} + \psi\Delta_{\max}}{\Delta_{0i}(k) + \psi\Delta_{\max}} \quad (4)$$

Here $\Delta_{oi} = \| x_0(k) - x_i(k) \|$ = Difference between absolute value X_0 (k) and X_i (k), $\Delta_{\min}$ and $\Delta_{\max}$ are the minimum and maximum values of the Δ_{oi} (k) sequence; ψ is the distinguishing coefficient.

$0 \le \psi \le 1; \Delta_{\min} = \forall j^{\min} \varepsilon i \forall k^{\min} \| x_0(k) - xj(k) \|$ = The smallest value of Δ_{oi}

I. Grey Relational Grade Formation

The grey relational grade is computed by taking the average of grey relational coefficient as given below.

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} \xi_i(k) \quad (5)$$

J. S/N Ratio Formation from GRG

This ratio is calculated using Higher the better Criterion given below.

$$\text{SN (Higher the Better)} = -10\log\left(\frac{1}{t}\sum_{i=1}^{i}\frac{1}{y_i^2}\right) \quad (6)$$

Here "t" is the number of measurements for the given run; Y_i is the value of the ith run.

K. Analysis of Variance (ANOVA)

Analysis of variance is done to check the most significant and least significant input factor by calculating the sum of squares, Mean square of the Average S/N ratios and the percentage contribution of each input factor.

III. RESULTS & DISCUSSION

The response parameters corresponding to their orthogonal array are given in Table IV

The instantaneous heat released during combustion has a strong effect on the exhaust emission as we know that higher the combustion temperature high the concentration of NO_x. The cylinder pressure has a positive effect on the combustion of the engine high pressures will give us efficient combustion. The rate of Change of pressure per degree crank angle It is well known that smoke formation is mainly due to the lack of oxygen content which is normally the case for all diesel engines and even worse when the air to fuel ratio decreases. From experimentation it has been observed that smoke values increases as the load on the engine increases and 100% loaded engine has maximum smoke value.

The NOx is mainly due to the cylinder temperature during combustion and the locally available oxygen, so with the increase in biodiesel content NO_x value increases [xxi]. NO_x formation often takes place while the combustion in the combustion chamber is in the starting phase of the rapid burning owing to the great increase in the temperature in the combustion vicinity [xxii]. Zeldovich or thermal reaction consisting of three reactions generates NO having high temperature due to the burned gases left by the flame front. The chemical reactions involved are [xxiii]

$$O + N2 \leftrightarrow NO + N2$$

$$N + O2 \leftrightarrow NO + O$$

$$N + OH \leftrightarrow NO + H$$

The rate of Pressure rise (dP/d° CA) is the load applied due to combustion on the cylinder head and block [ii]. Once we have the response/output parameters according to the orthogonal array we can further apply the Rey Taguchi method.

The Normalization of this data is done by equation. (i) And (ii) which is given in table.5, after normalization the quality loss factor is calculated using equation (iii) and given in Table VI

Once we have the quality loss estimate then we can find the grey relational Coefficient and GRG using equation (IV) and (v). GRC & GRG are given in Table VII

Signal to Noise ratio is calculated using the GRG using equation (VI) and given in the Table VIII

TABLE VIII
S/N RATIO

Run	GRG	S/N Ratio
1	0.55489157	-5.115837466
2	0.564487357	-4.966915609
3	0.55192529	-5.162394112
4	0.554670406	-5.119300101
5	0.678963918	-3.363066096
6	0.777843448	-2.182156038
7	0.657911825	-3.636646153
8	0.656431275	-3.656214719
9	0.554854843	-5.116412383

Average S/N ratios are given in Table IX

Once we have the average S/N ratio we can find the combination of the input parameters for optimum combustion and emission parameters by just plotting the graph between Levels of each factor and their Average S/N ratio. These plots are given below in Fig. 3

By observing the above plot the optimum combination came out to be A2B2C1-which is 100% pure biodiesel, 1800 rpm speed and 10% load on the engine. So when engine will be operated at this combination it will give optimized value of combustion and emission.

L. Analysis of Variance (ANOVA)

The ANOVA is performed by software named as Minitab 16, which is statistical tool. This tool checks the dependency of the response factors on the input variables [xxiv]. Here it takes the S/N ratio of the response as the input and gives us the sum of square, mean square, F value and the percentage contribution of each input factor to response values at optimum combination. The table.10 shows the Minitab calculations.

The Table X shows that factor which is having higher F-Value is the most significant one because it is contributing more to the response values at the optimum combination. Here type of the fuel is the most significant having 48.16% contribution and load is the second significant factor having 43.177% contribution while speed of the engine is least significant having 8.66% contribution. So response parameters will be mostly depending on type of fuel and load.

M. Prediction of Output Response using ANN

The response parameters are predicted at the optimum combination using artificial neural network tool present in Mat lab, the predicted and experimental response values at the optimum combination obtained above are given in Table XII. The best result for the prediction using ANN is obtained at 30 neurons

If we look into Fig. 4 we can see that there is a very small difference between the experimental and ANN based predicted results of the response parameters.

The pictorial view of the ANN prediction and response validation is given in annexure 1.

IV. CONCLUSIONS

Current study addresses the optimization of turbocharged diesel engine on the basis of combustion and emissions responses using GTM. The engine was operated alternatively on B100, Diesel and B20 while three input factors were speed, type of fuel and load on the engine. The effort was made to get maximum value of P and IH, minimizing the smoke, NO_x and dP/do. Following are the key findings of this work.

There were 3 input factors and three levels of each factor giving the best combination on the basis of L_9 (3×3) OA.

GTM was selected as a better option owing to its better handling of the factors involved.

It was revealed corresponding to maximum values of combustion, NO_x and smoke were at their peaks.

On the other side if focus was on the minimization of emissions then combustion was not efficient

On the basis of optimization it was found that better combustion and emission occurred during a combination of A2B2C1 (B100, 1800 rpm and 10% load on the engine)

The Analysis of Variance of the input parameters at the optimum combination revealed that type of fuel is the most significant parameter showing 48.16% influence on response values whereas engine speed revealing the minimum effect of 8.66%.

The results were successfully predicted and validated through ANN method.

The NO_x during this optimum combination was slightly higher due to better combustion of pure biodiesel but remained within the limits. However combustion parameters like IH and P were reflected to be at their best.

TABLE II
EXPERIMENTAL FACTORS AND THEIR LEVELS

Control Variables	Code	Level		
		1	2	3
Type Of Fuel	A	B-20	B-100	Diesel
Speed (rpm)	B	1400	1800	2300
Load (%)	C	10	50	100

TABLE IV
RESPONSE PARAMETERS

OA			OP				
Type of Fuel	Speed (RPM)	Load (%)	dP/do (bar/°CA)	Smoke (1/m)	NOx (ppm)	P (bar)	IH (%)
B-20	1400	10	4.3153933887	0.0620000000	235.6585714286	61.6294053231	99.9999977654
B-20	1800	50	3.8285284936	0.0483333333	579.1052380952	89.5961307837	99.9999995120
B-20	2300	100	3.2575687529	0.1740000000	557.0000000000	104.2792712103	99.9999987393
B-100	1400	50	4.7447000000	0.0143333333	975.0000000000	89.3599000000	100.0000000000
B-100	1800	100	3.2310124859	0.0383333333	887.0000000000	115.1535713317	100.0000016536
B-100	2300	10	2.3502296302	0.0740000000	165.0000000000	74.2244611595	100.0000040684
Diesel	1400	100	3.5762439570	0.2210000000	1027.0000000000	116.1922609361	100.0000053901
Diesel	1800	10	3.3062552424	0.0633333333	235.0000000000	64.9547953486	100.0000033759
Diesel	2300	50	3.9259014726	0.1190000000	314.0000000000	94.3216997614	99.9999979013

TABLE V
NORMALIZATION OF THE RESPONSE DATA

Smaller the Better			Larger-the-better	
dP/d° CA	Smoke (1/m)	NOx (ppm)	P (bar)	IH (%)
0.179290843	0.769354839	0.9180295	0	0
0.382619688	0.835483871	0.519599492	0.512559784	0.22907589
0.62106897	0.227419355	0.545243619	0.781664842	0.127724964
0	1	0.060324826	0.508230267	0.293075283
0.632159635	0.883870968	0.162412993	0.98096343	0.50994451
1	0.711290323	1	0.230835716	0.826662212
0.487980999	0	0	1	1
0.600736086	0.762903226	0.918793503	0.060946041	0.73583434
0.341953919	0.493548387	0.827146172	0.599167585	0.017828701

TABLE VI
QUALITY LOSS ESTIMATE

dP/do CA	Smoke (1/m)	NOx (ppm)	P (bar)	IH (%)
0.820709157	0.230645161	0.0819705	1	1
0.617380312	0.164516129	0.480400508	0.487440216	0.77092411
0.37893103	0.772580645	0.454756381	0.218335158	0.872275036
1	0	0.939675174	0.491769733	0.706924717
0.367840365	0.116129032	0.837587007	0.01903657	0.49005549
0	0.288709677	0	0.769164284	0.173337788
0.512019001	1	1	0	0
0.399263914	0.237096774	0.081206497	0.939053959	0.26416566
0.658046081	0.506451613	0.172853828	0.400832415	0.982171299

TABLE VII
GREY RELATIONAL COEFFICIENT & GRG

Grey relational coefficients (Distinguishing Coefficient =0.6)					GRG
dP/do CA	Smoke (1/m)	NOx (ppm)	P (bar)	IH (%)	
0.4223243	0.722330097	0.879803451	0.375	0.375	0.55489157
0.492861593	0.784810127	0.555349609	0.55175447	0.437660988	0.564487357
0.612913455	0.437132785	0.568851738	0.733195921	0.40753255	0.55192529
0.375	1	0.389692586	0.549566435	0.459093008	0.554670406
0.619936946	0.837837838	0.417366043	0.969248069	0.550430694	0.678963918
1	0.675136116	1	0.438223526	0.7758576	0.777843448
0.539559126	0.375	0.375	1	1	0.657911825
0.600441977	0.716763006	0.880790191	0.389849879	0.69431132	0.656431275
0.476930066	0.542274052	0.77634344	0.599500967	0.379225688	0.554854843

TABLE IX
AVERAGE S/N RATIO

	Factors		
Levels	A	B	C
1	-5.081715729	-4.623927906	-3.6514027
2	-3.554840745	-3.995398808	-5.0675427
3	-4.136424418	-4.153654178	-4.0540355

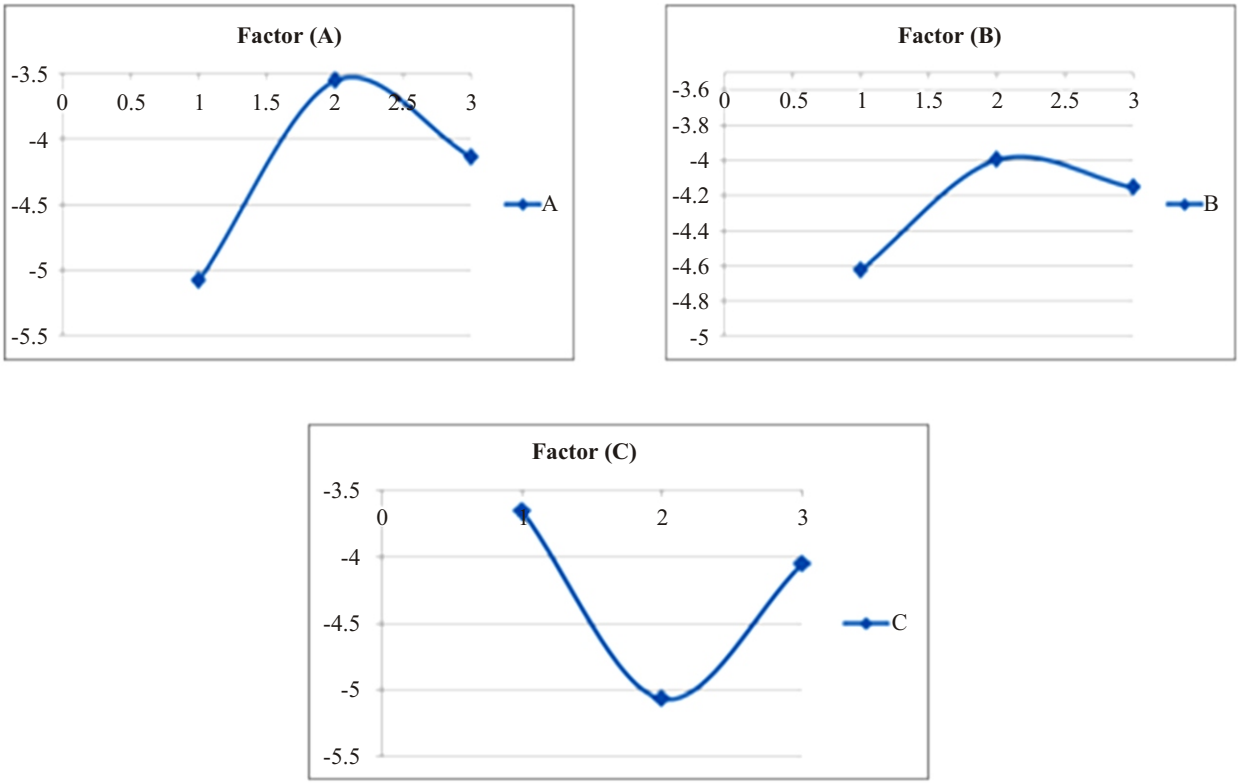

Fig. 3. Average S/N ratio Plot

TABLE X
ANOVA PERFORMED BY MINITAB.16

Factors	Levels			DF	Sum of square (SS)	Mean Square (MS)	Mean Square (MS)	F-Value	P-Value	Contribution %
	1	2	3							
A	-5.081715729	-3.554840745	-4.1364244	2	3.5632	1.7816	1.7816	1.79	0.359	48.15655747
B	-4.623927906	-3.995398808	-4.1536542	2	0.6413	0.3206	0.3206	0.32	0.757	8.665801708
C	-3.651402741	-5.067542698	-4.0540355	2	3.1948	1.5974	1.5974	1.6	0.384	43.17764083
Error				2	1.9942	0.9971	0.9971			
Total				8	9.3933	3.6996	3.6996			100

TABLE XII
EXPERIMENTAL & BASED ANN RESPONSE VALUES

Response Factors	Experimental	ANN Based
dP/do	3.381497999	4.8258
Smoke	0.042333333	0.05573
NO_x	224.6666667	233.4223
P	64.19553495	63.4433
IH	100.0000029	100

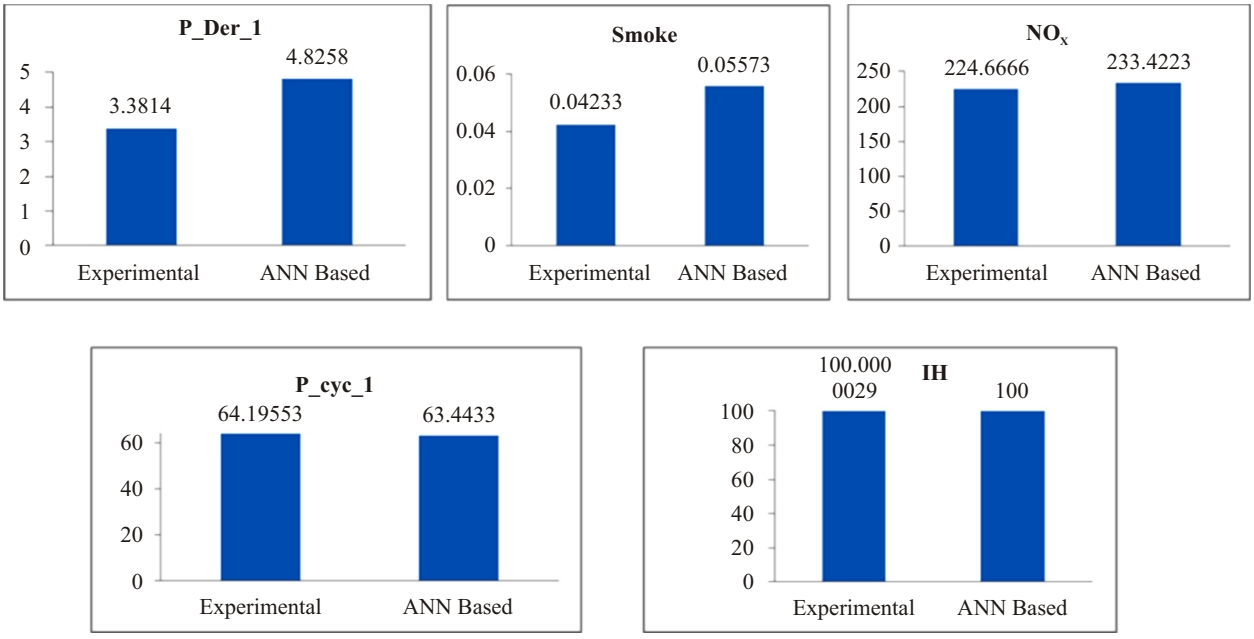

Fig. 4. Comparison between ANN and Experimental Response Values

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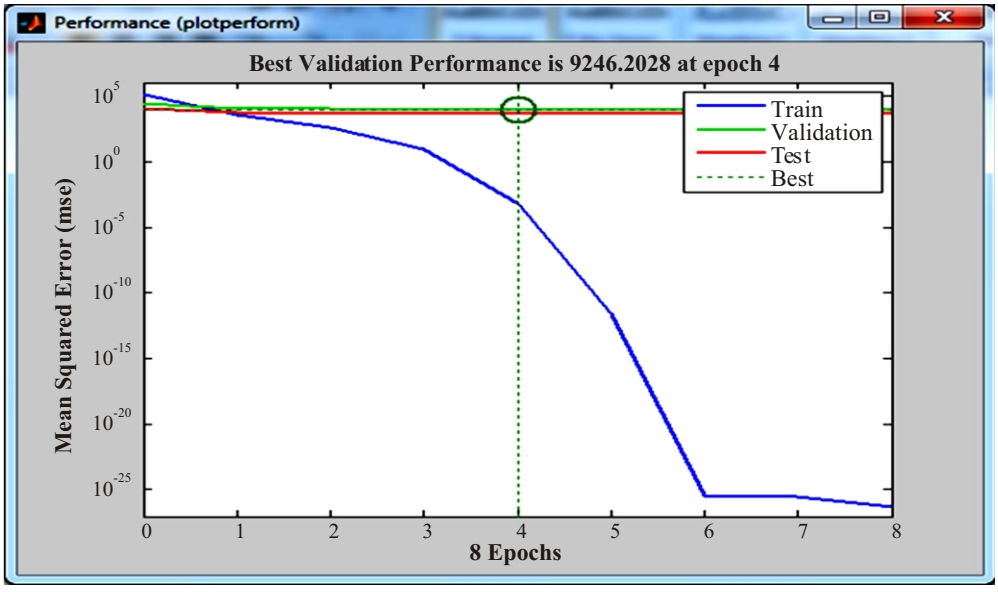
ANNEXURE I

ANN TRAINING AND VALIDATION



A Virtually Blind Spectrum Efficient Channel Estimation Technique for MIMO-OFDM Systems

M. Obaid Ullah[1], E. Alsusa[2]

[1]Electronic Engineering Department, U.E.T. Taxila, Pakistan
[2]School of Electrical and Electronic Engineering, UoM, Manchester, U. K.
[1]obaid.ullah@uettaxila.eud.pk

Abstract-Multiple-Input Multiple-Output antennas in conjunction with Orthogonal Frequency-Division Multiplexing is a dominant air interface for 4G and 5G cellular communication systems. Additionally, MIMO-OFDM based air interface is the foundation for latest wireless Local Area Networks, wireless Personal Area Networks, and digital multimedia broadcasting. Whether it is a single antenna or a multi-antenna OFDM system, accurate channel estimation is required for coherent reception. Training-based channel estimation methods require multiple pilot symbols and therefore waste a significant portion of channel bandwidth. This paper describes a virtually blind spectrum efficient channel estimation scheme for MIMO-OFDM systems which operates well below the Nyquist criterion.

Keywords-OFDM, MIMO, Channel Estimation, Virtually Blind, CFR Inversion.

I. INTRODUCTION

Owing to excessive complexity involved in the design of equalizer in the receiver, a high data rate transmission using conventional single-carrier system is not feasible [i]. Orthogonal Frequency Division Multiplexing (OFDM) a special case of multicarrier modulation (MCM) has the ability to transform frequency selective channel into a set of parallel flat fading channels and consequently requires very simple equalizers. Other advantages of OFDM include higher spectral efficiency, ability to support adaptive modulation schemes, low-complexity implementation and high flexibility in resource allocation [ii-iii].

The wireless channel distorts the amplitude and phase of each subcarrier of OFDM symbol independently which can be modelled by a single complex-valued coefficient. For coherent detection of transmitted information, this multiplicative distortion must be compensated. This compensation process is called channel equalization and requiresthe estimates of channel impulse response [ii]. Although differential PSK (DPSK) could be used in OFDM systems without requiring channel estimates, but it limits the number of bits per symbol and incurs about 3 dB loss in SNR as compared to coherent detection [iv, v]. Moreover, new standards are based on Quadrature Amplitude Modulation (QAM) and thus channel estimation is mandatory.

Channel estimation (CE) techniques developed for OFDM systems can be broadly classified into three categories: (i) Pilot-aided CE techniques, (ii) Blind CE techniques, and (iii) Semi-blind CE techniques[vi]. Pilot aided schemes exploit periodically embedded training sequences known as pilots, while blind or pilot-less techniques exploi tthe statistical behavior of received signal and the inherent redundancy present in the transmitted signal to get channel state information (CSI) [vii].

Various pilot-aided CE methods have been developed and investigated for OFDM systems and the references [iv, viii-xii]represent a good sample of such techniques. The maximum likelihood estimator (MLE) analyzed in [iv] assumes that the channel vector is deterministic. MLE is simpler to implement as it does not require the knowledge of operating SNR and channel statistics. The minimum mean square error (MMSE) and least square (LS) channel estimators are discussed in [viii]. The LS estimator does not require the knowledge of channel statistics and has high mean square error. The MMSE estimator requires a priori knowledge of noise variance and channel covariance and provides good performance but suffers from high complexity. MLE and MMSE estimators give comparable performance at intermediate and high values of SNRs as long as the number of pilots is sufficiently higher than the duration of channel vector [iv]. Low-rank approximations of linear MMSE estimator based on discrete Fourier transform (DFT) have been proposed in [iv]. Such approximations require the knowledge of operating SNR and channel frequency correlation. Channel estimator investigated in [x] uses robust interpolation that is based on 2D FFT and IFFT; and is highly robust to Doppler frequency for dispersive fading channels with noise impairment though its performance degrades at lower Doppler

frequencies. Specially designed pilot sequences [xi] can also aid in control signal estimation in addition to simple channel estimation.

Blind and semi-blind CE techniques can be further classified into two categories: subspace-based and decision directed methods. Subspace based CE techniques exploit redundancy introduced by cyclic prefix(CP) and/or virtual carriers (VCs) to estimate the channel state information [xii] and [xiii] while Decision directed (DD) CE methods exploit previous data estimates (decisions) along with few pilots to improve the accuracy of channel estimates [xiv].

Historically CE techniques were initially developed for single antenna OFDM systems. The advent of MIMO-OFDM systems then arose the need of CE methods specific to multiple antenna systems. Both the modified versions of CE for SISO-OFDM systems adapted for MIMO-OFDM systems as well as novel techniques that exploit MIMO specific features have been proposed in literature [xv].

The performance of various multipleinput multiple-output channel estimation methods using training sequences have been analyzed in [xvi]. In addition to the popular linear least squares (LS) and minimum mean-square-error (MMSE) approaches, the authors of [xvi] proposed scaled LS (SLS) and relaxed MMSE techniques which requireless knowledge of the channel second-order statistics. A robust superimposed training sequence (overlaid into the data stream) design is proposed in [xvii] for spatially correlated MIMO CE which does not require accurate knowledge of the spatial correlation matrix. This scheme is shown to outperform previously proposed robust correlated MIMO CE such as relaxed MMSE (RMMSE) and relaxed least-square (RMMSE) schemes. In [xviii], differential evolution (DE) is used for optimizing the placement and power of the pilot tones that are utilized by LS algorithm in MIMO-OFDM systems. It is shown that the performance of the LS algorithm was increased by optimizing the pilot tones with the DE algorithm instead of locating them orthogonally. A blind channel estimation approach for orthogonally coded MIMO-OFDM systems is proposed in [xix] which shows that using the semi-definite relaxation (SDR) technique, channel estimation problem can be approximated as a convex semi-definite programming (SDP) problem and can be solved efficiently usingmodern convex optimization methods.

In general, pilot-less blind CE schemes are bandwidth efficient but offer poor performance and high latency while the pilot-based CE techniques offer good performance and low latency at the cost of bandwidth wastage. Semi-blind algorithms try to improve the performance of blind algorithms by simultaneously exploiting the knowledge of both known pilot symbols and properties of the transmitted signals [ii]. Moreover, pilot-based techniques reduce the effective SNR that is available for data symbols [xx]. Motivated by this, a virtually blind (VB) CE technique for OFDM systems which uses only one pilot symbol to estimate the channel state information has been proposed in [xxi]. The original VB CE scheme proposed in [xxi] suffers from the problem of CFR inversion which drastically degrades the system performance. This paper proposes a second-derivative based approach to locate CFRI location which consequently improves the performance radically. Moreover, the extension of VB CE technique to MIMO-OFDM systems is proposed as well. The rest of the paper is organized as follows. Section II briefly describes system model. In section III, Virtually blind (VB) CE method, CFR inversion problem and its solution is described. This section also shows that the proposed VB CE technique can be satisfactorily used for MIMO-OFDM systems. Simulation results are presented in section IV while section V concludes the paper.

II. System Model

Pilot signals are the known signals which many popular OFDM standards place at regular subcarriers positions [xxii]. These pilot signals are primarily used for channel"sampling" and waste some percentage of subcarriers in every OFDM symbol. Let us consider an OFDM system where every OFDM symbol has a total of N_c subcarriers, N_p pilot subcarriers and N_c- N_p data subcarriers. Therefore, the transmitted OFDM symbol $X[k]$ can be represented as [xxi]

$$X[k] = \begin{cases} D[k] & k \notin \varphi \\ P[k] & k \in \varphi \end{cases} \quad (1)$$

Where $D[k]$ and $P[k]$ represent data symbols and pilot symbols transmitted over k^{th} subcarriers, respectively. φ is a subset of N_c subcarriers consisting of N_p pilot subcarriers. The received OFDM symbol can be expressed as

$$Y[k] = X[k] \cdot H[k] + N[k] \quad (2)$$

Where $Y[k]$ is the received OFDM symbol, $X[k]$ is the transmitted OFDM symbol, $H[k]$ is the channel frequency response (CFR) vector and $N[k]$ is the additive white Gaussian noise (AWGN) vector.

III. Virtually Blind Channel Estimation

Virtually blind (VB) channel estimation scheme uses only one pilot [xxi] which is placed at the beginning of OFDM symbol (cf. Fig. 1). This only pilot is used to initialize the estimate of the channel frequency response (CFR) at the first subcarrier using a simple least square (LS) method. If the channel is slowly varying in frequency such that there is a high

correlation between adjacent CFR samples, then channel estimate at first subcarrier can be used to decode the data symbol at the second subcarrier. This data decision acts as a pilot, and in turn, is used to estimate the CFR at second subcarrier. Hence, in general, CFR at n^{th} subcarrier is estimated using the n^{th} received symbol and data decision at n^{th} subcarrier which in turn is calculated using the estimated CFR at $(n-1)^{th}$ subcarrier. Hence, the VB CE method estimates the CFR in an iterative fashion based on the estimated CFR at previous location.

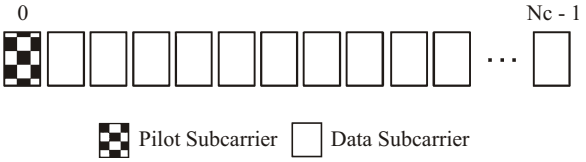


Fig. 1. Virtually Blind CE Using Single Pilot

Using the only available pilot, the LS estimate of CFR at the first subcarrier location is

$$\hat{H}_1 = \frac{Y_1}{X_1} \tag{3}$$

where Y_1 is the received symbol over first subcarrier and X_1 is the only pilot transmitted at the first subcarrier. Assuming $H_2 \approx H_1$, the estimated CFR at the first subcarrier, $\hat{H}_1$, can be used to detect the transmitted data symbol at the second subcarrier. For BPSK case, it can be expressed as

$$\hat{X}_2 = sign\left[\Re\left(\frac{Y_2}{\hat{H}_1}\right)\right] \tag{4}$$

where $\Re$ denotes the real part of complex signal and its argument represents the Zero Forcing (ZF) equalization process while $sign(\cdot)$ represents the hard decision operation. This symbol decision, $\hat{X}_2$, is used to estimate the CFR at the second subcarriers as

$$\hat{H}_2 = \frac{Y_2}{\hat{X}_2} = \frac{X_2 H_2}{\hat{X}_2} \approx H_2 \tag{5}$$

In a similar fashion, $\hat{H}_3$ can be approximated by exploiting $\hat{H}_2$, and so on. In general

$$\begin{aligned} \hat{H}_n &= \frac{Y_n}{\hat{X}_n} = \frac{X_n H_n}{\hat{X}_n} \\ &= \frac{X_n H_n}{sign\left[\Re\left(\frac{Y_n}{\hat{H}_{n-1}}\right)\right]} \\ &\approx H_n \end{aligned} \tag{6}$$

A. CFR Inversion

CFR inversion (CFRI) isthe sign reversal of estimated CFR as compared to actual CFR. It occursat the instants when the channel gain values are very small i.e., when thepower of actual CFR is in the vicinity of zero. When the power of actualCFR is very low, the received symbol's power (being a product of inputsymbol and CFR sample) is also very low. Under such circumstances, thedecoding decision occasionally gets wrong because of either additive whitenoise or zero crossing of CFR values. Consequently the estimated CFRsample gets inverted. According to (5), if $\hat{X}_2 = -X_2$ then $\hat{H}_2 \approx -H_2$ and this sign reversal of channel gain estimate causes CFR inversion. The left part of Fig. 2 depicts an instance of occurrence of CFRI phenomenon in the absence of noise for an OFDM symbol with 256 subcarriers. In this particular case, the CFR inversion hits the channel at about 45thsubcarrier after which the estimated CFR is the reflected (sign reversed) approximation of true CFR. Similarly, the right part of Fig. 2 depicts an instance of occurrence of CFRI phenomenon in the presence of additive noise at SNR = 20 dB. In this particular case, the CFR inversion hits the channel at about 145th subcarrier after which theestimated CFR is the reflected (sign reversed) approximation of true CFR.It is this CFRinversion that changes the channel estimates by 180° and is the major cause of poor performance of VB channel estimator (cf. Fig. 5).

As stated earlier, the CFR inversion may occur even in the absence of additive noise. It means no matter how strong is the signal as compared to noise,the CFR inversion may hit the channel. The noise-free CFR inversion occurs when the two consecutive CFR samples are of opposite sign i.e., when the CFR amplitude crosses the zero axis; provided the CFR poweris very small. In that case, the assumption $H_{n+1} \approx H_n$ is no longer valid, and the estimated CFR at n^{th} subcarrier can be expressed as

$$\begin{aligned} \hat{H}_n &= \frac{Y_n}{sign\left[\Re\left(\frac{Y_n}{\hat{H}_{n-1}}\right)\right]} \\ &= \frac{X_n H_n}{sign\left[\Re\left(\frac{X_n H_n}{\hat{H}_{n-1}}\right)\right]} \\ &= \frac{X_n H_n}{sign[\Re(X_n \times -1)]} \\ &\approx -H_n \end{aligned} \tag{7}$$

This shows that the CFR's “zero crossing” may cause wrong decoding decision and subsequently may lead to CFR inversion depending on the term $sign\left[\Re\left(\frac{H_n}{H_{n-1}}\right)\right]$. Let a and c be the real parts; and b and d the imaginary parts of two consecutive CFR samples H_n and H_{n-1}, respectively. Then

$$sign\left[\Re\left(\frac{H_n}{H_{n-1}}\right)\right] = sign\left[\Re\left(\frac{a+jb}{c+jd}\right)\right] = sign\left[\Re\left(\frac{ac+bd}{c^2+d^2} + j\frac{bc-ad}{c^2+d^2}\right)\right] = sign(ac+bd) \quad (8)$$

When (8) results in "-1" (cf. (7)), the receiver makes an erroneousdecision and the VB estimator suffers from CFR inversion. Therefore, itcan be concluded that the CFR inversion, even in the absence of additive noise, occurs when:

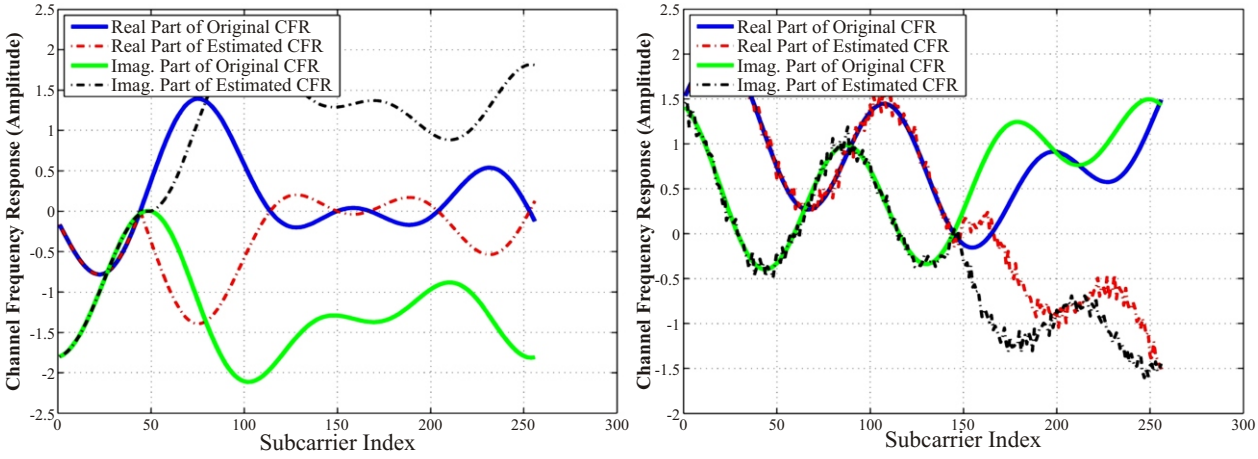


Fig. 2. CFR Inversion in the absence (left) and in the presence (right) of noie at 20 dB

Both real and imaginary CFR amplitudes cross zero axis (equivalently, both product terms and in (8) are negative).

One of the real or imaginary CFR amplitudes crosses zero axis(equivalently, either or term is negative and its magnitude is higher than that of positive product).

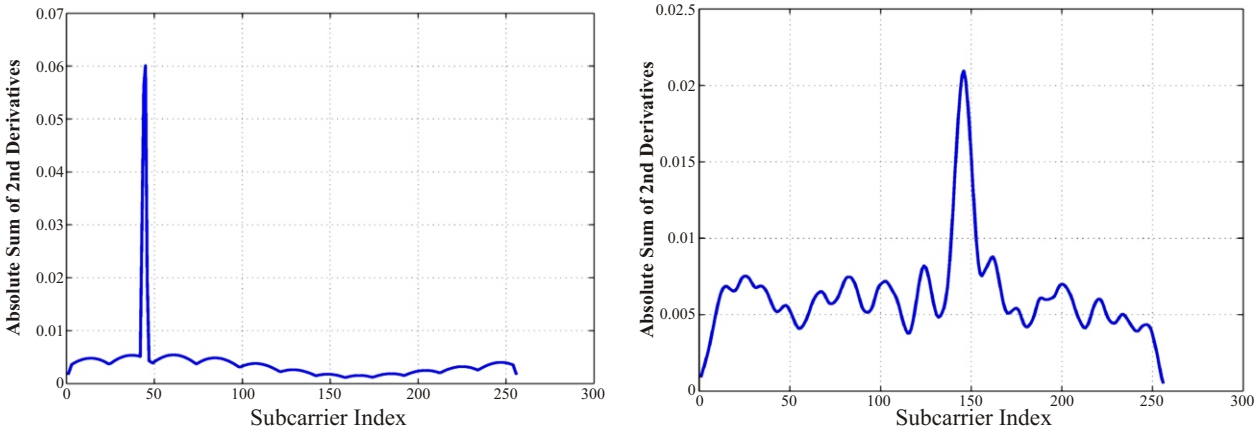


Fig. 3. Using 2nd Derivative to Locate CFR Inversion in the absence (left) and in the presence (right) of noie at 20 dB

Regardless of the original cause of CFR inversion, the CFR inversionripples forward along with wrong decoding decisions at all subsequentsubcarriers. This is because VB channel estimate at current subcarrierlocation is based on the previous estimate. The situation prevails untiland unless a second CFR inversion hits the channel. In the event of secondCFR inversion, the re-inverted CFR automatically gets rectified.

B. Locating CFR Inversion Using Second Derivatives

If we can find the exact location of CFRI by some means, then it is quite straightforward to reverse the effects of CFRI.

This section explains how second-derivative can be used to locate CFRI. The noise free case is used first to provide further insight into the CFR inversion problem. Since the amplitude of estimated CFR abruptly changes it direction at the instant of CFR inversion, the derivative of estimated CFR can help us

to locate CFR inversion position. At the point of CFR inversion, the estimated CFR abruptly changes it slope, hence the derivative at CFRI location has an abrupt change in it sign. If we take the second derivative of estimated CFR, it highlights the location of CFR inversion more clearly with a spike. If we add the absolute values of second derivatives for real and imaginary parts, it gives us a spike with higher peak to average ratio. This absolute sum of 2nd derivatives is shown in left pane of Fig. 3 where aspike around 45th subcarrier clearly indicates the CFRI location for noise-free case. The BERfor noise-free case for 256 subcarriers OFDM systems in 4-tap Rayleigh fading channel was found to be 1.96×10^{-2} using VB CE before correction. After finding the CFRI location with the help of second derivative and consequently rectifying the estimated CFR, the BER for noise-free case becomes 8.54×10^{-5}.

The location finding of CFR inversion is more challenging in the presence of additive noise. It is important to reduce the effects of noise before taking a derivative. One way to do so is to use a moving average filter which removes the noise and hence smooths a noisy signal. However, as the number of points in the filter is increased to reduce noise further, the signal becomes more and more smooth and the sharp features of the signal itself start losing their sharpness. It means that the noise reduction process also eliminates the abrupt amplitude changes at CFR inversion. Therefore, there exists a trade-off between noise reduction and locating CFR inversion. After reducing the noise, the abrupt change(s) in estimated CFR amplitude are measured by taking its second derivative. The peaks of the second derivative indicate the potential location(s) of CFR inversion. The right pane of Fig. 3 shows the use of second derivative to locate CFR inversion in thepresence of additive noise at SNR = 20dB. There is a sharp spike around 145th subcarriers in the 2nd derivative indicating the CFRI location.

C. Dynamically Allocated Additional Pilots

As discussed in section III-A, when the CFR amplitude values lie close to zero, the chances of CFR inversion increase. Therefore, when the amplitude of CFR goes below a certain threshold level, the likelihood of occurrence of CFR inversion increases. The detailed analysis of CFRI problem reveals two important points that provide us more insight regarding the behavior of CFRI. First, the probability of CFR inversion decreases as the threshold level increases at a fixed SNR. This means that the probability of CFR inversion is inversely proportional to threshold level i.e.,

$$P[CFRI] \propto (Threshold\ Level)^{-1} \qquad (9)$$

Secondly, for a fixed threshold, the probability of CFR inversion at higher SRN values is considerably less than that at lower SRN values. Both of these observations are in line with our intuition as well. Since probability of CFR inversion is inversely proportional to threshold level, hence BER decreases with the increasein threshold. Moreover, since probability of CFR inversion introduces errors in the estimated CFR, hence BER is directly proportional to probability of inversion[xxi].

Utilizing this knowledge of how probability of CFR inversion and the level of channel gains are related to each other, we can design a closed-loop system to dynamically assign additional pilots in order to improve the CE performance. This channel estimation scheme is comprised of two steps namely: acquisition and tracking. An acquisition pilot is sent at 1st subcarrier of first OFDM symbol of every OFDM frame. The receiver then performs VB CE using this only pilot according to (6) and decides about the potential locations of CFRI as well. The receiver does the latter job by utilizing the knowledge of probability of occurrence of CFR in accordance with (9). Information regarding the potential CFRI locations is then sent back to the transmitter through a feedback channel. The transmitter then responds to this information by sending pilots in the next OFDM symbol at the subcarriers pointed out by the receiver.

D. CE for MIMO-OFDM Systems

Fig. 4 shows a simple schematic for 2 × 2 MIMO-OFDM system. We use spatial multiplexing technique in order to achieve higher data rates which involves the transmission of multiple independent data streams from different transmit antennas. Furthermore, keeping in view the basic idea of VB CE method along with dynamically assigned additional pilots, it becomes clear that for 2 × 2 MIMO scheme we need two null OFDM symbols from each of the two transmitting antennas. When one of the transmit antenna transmits either initial acquisition pilot or dynamically requested pilots, the other transmit antenna must be silent at that time.

X_{mn} and Y_{mn} represent the transmitted and received OFDM symbols respectively with the first subscript, m, representing (transmit or receive) antenna index and the second subscript, n, representing the time index. For example, X_{12} is the 2nd OFDM symbol transmitted from 1st transmit antenna and Y_{24} is the 4th OFDM symbol received at 2nd receive antenna. The first two OFDM symbols received at both antennas can be expressed in terms of CFRs as:

$$Y_{11} = X_{11}H_{11} + X_{21}H_{21} + N_1 \qquad (10\,a)$$
$$Y_{21} = X_{11}H_{12} + X_{21}H_{22} + N_2 \qquad (10\,b)$$
$$Y_{12} = X_{12}H_{11} + X_{22}H_{21} + N_3 \qquad (10\,c)$$
$$Y_{22} = X_{12}H_{12} + X_{22}H_{22} + N_4 \qquad (10\,d)$$

Where N_1, N_2, N_3, and N_4 represent AWGN noise vectors. The four received OFDM symbols Y_{11}, Y_{21}, Y_{12},

and Y_{22} are used to obtain the initial versions off our channel responses i.e. $\breve{H}_{11}$, $\breve{H}_{12}$, $\breve{H}_{21}$, and $\breve{H}_{22}$ respectively. These four estimates are obtained using only two acquisition pilots with the aid of two null OFDM symbols. These initial estimates are used to estimate the potential CFR inversion locations. The potential locations are then fedback to transmitters which accordingly respond by sending additional pilot sat requested subcarriers in the next OFDM symbols. The receivers receive the additional dynamic pilots in the following four OFDM symbols:

$$Y_{15} = X_{15}H_{11} + X_{25}H_{21} + N_5 \quad (11\,a)$$
$$Y_{25} = X_{15}H_{12} + X_{25}H_{22} + N_6 \quad (11\,b)$$
$$Y_{16} = X_{16}H_{11} + X_{26}H_{21} + N_7 \quad (11\,c)$$
$$Y_{26} = X_{16}H_{12} + X_{26}H_{22} + N_8 \quad (11\,d)$$

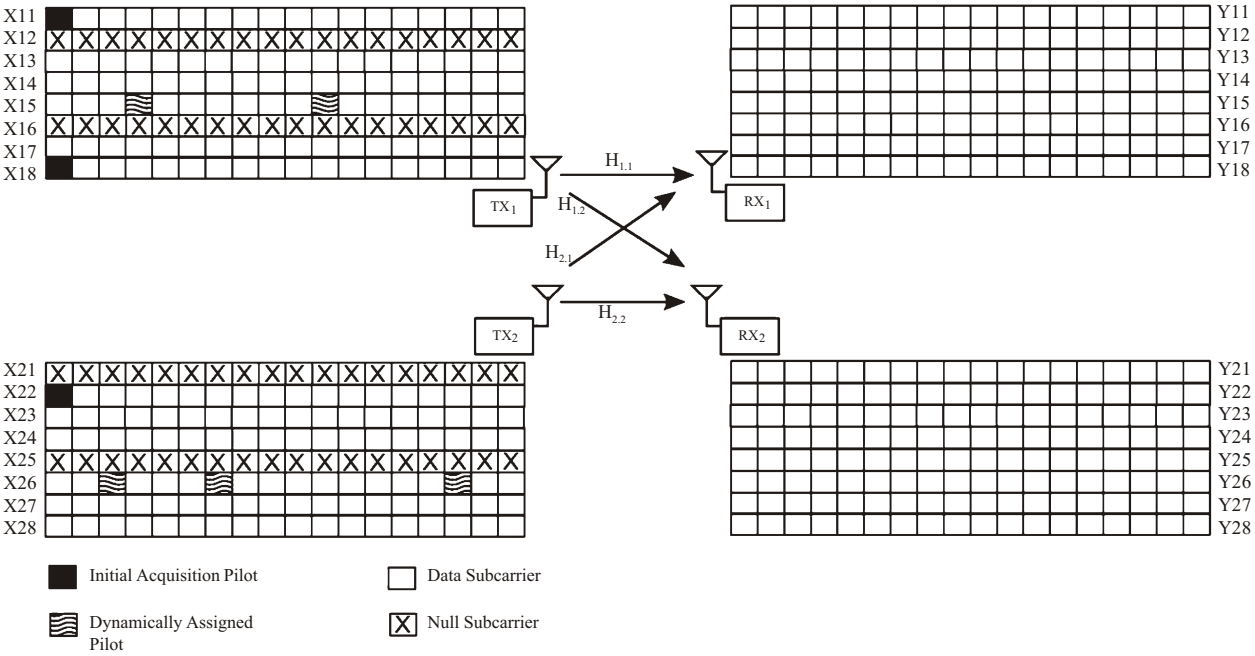


Fig. 4. Schematic For 2X2 MIMO-OFDM system Employing VB CE with Dynamic Pilots

The receivers then reconstruct the final CFR estimates $\hat{H}_{11}$, $\hat{H}_{12}$, $\hat{H}_{21}$, and $\hat{H}_{22}$ using the additional dynamic pilots in order to rectify the CFR inversion(s). These estimated CFRs are then used to demodulate the OFDM symbols using the zero-forcing (the de-correlator) receiver as follow:

$$\hat{X}_{11} = \frac{(Y_{11}\hat{H}_{22} - Y_{21}\hat{H}_{22})}{|\hat{\boldsymbol{H}}|} \quad (12\,a)$$
$$\hat{X}_{12} = \frac{(Y_{12}\hat{H}_{22} - Y_{22}\hat{H}_{22})}{|\hat{\boldsymbol{H}}|} \quad (12\,b)$$
$$\hat{X}_{21} = \frac{(Y_{21}\hat{H}_{11} - Y_{11}\hat{H}_{12})}{|\hat{\boldsymbol{H}}|} \quad (12\,c)$$
$$\hat{X}_{22} = \frac{(Y_{22}\hat{H}_{11} - Y_{12}\hat{H}_{12})}{|\hat{\boldsymbol{H}}|} \quad (12\,d)$$

where $|\hat{\boldsymbol{H}}|$ is the determinant of estimated channel mixing matrix and is defined as:

$$|\hat{\boldsymbol{H}}| \triangleq \hat{H}_{11}\hat{H}_{22} - \hat{H}_{12}\hat{H}_{21} \quad (13)$$

Equations (12a) - (12d) are the ZF solutions of (10a) - (10d).

IV. Results and Performance Analysis

The results presented in this section are based on an OFDM system with N_c = 256 in Rayleigh fading environment. The Rayleigh fading model assumes channel coefficients, h_l, as complex Gaussian random variables i.e., $h_l \sim \mathcal{CN}(0, \sigma_l^2)$, where σ_l^2 is the variance. Moreover, exponentially decaying channel power delay profile is assumed i.e., $\sigma_l^2/\sigma_0^2 \coloneqq \exp(-l/c_{att})$, l = 0,1,..., N_{ch} - 1 where c_{att} is the attenuation constant and N_{ch} is the number of multipath. The maximum delay spread of the channel, τ_{max}, is taken as 6.25% of OFDM symbol duration.

The performance of VB channel estimator for an OFDM system with 256 subcarriers in Rayleigh channel based on (6) is shown in Fig. 5. Obviously, the performance of VB estimator is quite unsatisfactory especially at higher SNR values. The BER

performance curve saturates after SNR = 40dB with an error floor above 10^{-2}. The source of this poor performance is the occasional occurrence of CFR inversion (cp. section III-A).

Fig. 5 also shows the performance of VB estimator after 2nd derivativebased correction (cf. section III-B) in Rayleigh fading environment. As evident from Fig. 5, 2nd derivative based auto-correction of CFRI brings about a significant performance improvement; especially the saturation effect at higher SNR values is no longer there. Fig. 6 shows the performance with dynamically inserted pilots for an OFDM system with 256 subcarriers in 4-tap Rayleigh fading channel.

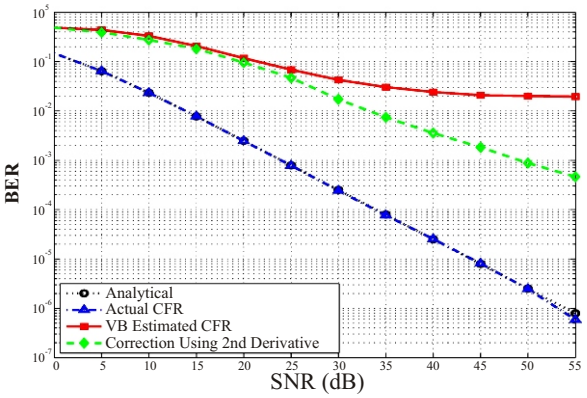


Fig. 5. Performance of VB CE Before and After Correction

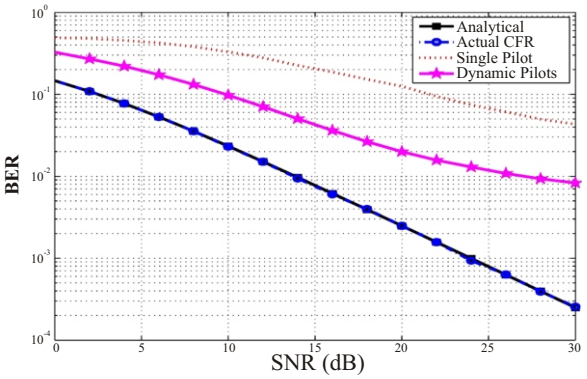


Fig. 6. BER Performance with Dynamic Pilots

As evident from Fig. 6, the dynamic assignment of additional pilots provides further improvement in BER. The reason behind this performance improvement is the dynamic insertion of additional pilots at potentially vulnerable CFRI locations by exploiting the knowledge of probability of CFRI. Every newly inserted pilot restrict the detrimental effects of previous CFR inversion, if any, up to its location at most. In other words, since every new pilot gets a new channel sample at alocation far away from the previous pilot, the detrimental effects of previous CFR inversion, if any, doesn't propagate beyond this point. The downside of this scheme, however, is the increased computational complexity and the increased latency on account of the computation of probability of CFR inversion and the inclusion of a feedback channel.

Fig. 7 shows the average number of tracking pilots per OFDM frame as a function of SNR. As evident from the Fig., the number of dynamically assigned pilots decreases rapidly with increasing SNR value. The overall average number of dynamic pilots for 256 subcarrier OFDM system is 4.9.

Fig. 8 shows the BER performance of VB CE with dynamically added pilots for 2 × 2 MIMO-OFDM system. As compared to SISO case, the BER performance offered by 2 × 2 MIMO system is substantially better. The reason for this improvement is that each MIMO receiver requests additional pilots for two different CFRs to the same transmitter. Hence, the received additional pilots are combination of request for two CFRs. Therefore, the improved performance is achieved at the cost of additional pilot overhead.

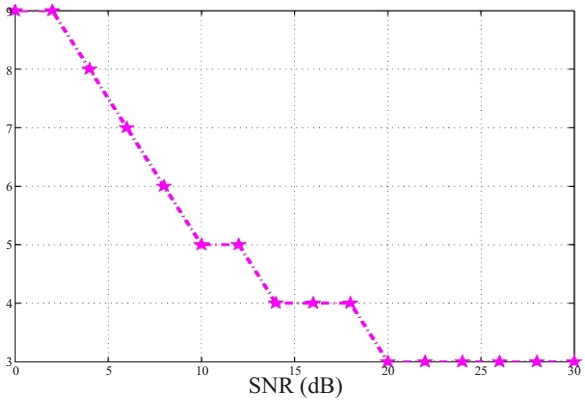


Fig. 7. Average No. of Dynamic Pilots per OFDM Frame

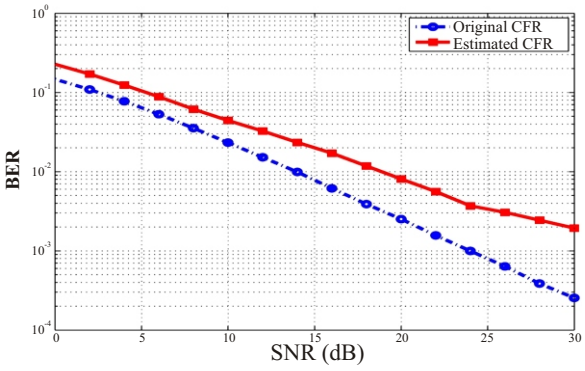


Fig. 8. Performance of VB CE with Dynamic Pilots for 2X2 MIMO-OFDM system

V. Conclusions

In this paper, a virtually blind channel estimation scheme for MIMO-OFDM systems is proposed which in its primitive form needs single pilot. This channel estimator inherently suffers from CFR inversion which

Restricts its performance. It was shown that the proposed 2nd-derivative based inversion location scheme works satisfactorily and provides radical performance improvement. Dynamically assigned pilots were then augmented with the only pilot in order to take more samples of channel and to stop propagating CFRI effect further to remaining subcarriers, if undetected by the inversion locator. The proposed scheme operates well below the Nyquist criterion. Its others features include high spectrum efficiency and high effective SNR available for data symbols. For static and quasi-static channel scenarios like WLAN, the proposed scheme can be effectively used. Unlike some popular CE techniques, the proposed scheme does not require the knowledge of channel parameters like noise variance and channel covariance matrix as well as operating SNR, and hence is easier to implement.

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Data Mapping for Transformation from RDB Schema to RDF Schema

K. R. Malik[1], T. Ahmad[2], M. M. Iqbal[3]

[1,2,3] Computer Science and Engineering Department, UET Lahore, Pakistan
[1]krmalik@gmail.com

***Abstract*-**In this paper, we discussed the data mapping for transformation from relational database (RDB) schema to resource description frame (RDF) Schema. During transformation process between these two schemas, weaknesses like compatibility issues, update query and complexity in relationships are generated. We proposed an approach to overcome these issues particularly when data is transformed from RDB to RDF for semantic web applications. As, for evolving data keeping changes intact is hard and difficult to sustain. Main focus of this study is to map up common features found in both data models of RDB and Semantic Web (SW) based schemas using either form of XML as an intermediate which will help in improving transformation results. These data mappings can further help in gaining better compatibility options for data transformation.

***Keywords*-**Data Transformation, Extensible Markup Language Schema (XMLS), Document Type Definition (DTD), Resource Description Framework Schema (RDFS), Relational Database Schema (RDBS), Data Type Mapping

I. INTRODUCTION

In Web applications, generally data is stored in the form of RDB. The web is semi-structured and unorganized in a formal way [i]. When it comes to searching and getting in touch with resources like web pages, peoples, and other web contents like video, audio etc. search engines work as a tool for web. Despite of advances made to these search engines, size of web content beats technology advancements. To overcome this problem, the Web content representation is required to be translated into machine-processable form. To translate such information into machine understandable form Semantic Web (SW) has been introduced [ii]. The need of SW increases due to its capability in providing improved methods and intelligent data seeking mechanisms and became a big evolution in the next generation of web [iii]. And to make this possible, old technologies are getting transformed into new ones. The EXtensible Markup Language (XML) based documents are getting enriched to map-up with Semantic Web [iv-vii]. Resource description framework (RDF) for the Semantic Web is a language to represent information on the internet in the form of triplets; subject, predicate and object [viii]. Which are used among resources mapped at hierarchal levels using graph based representations. Data types supported by XML play the key role in transformation to work properly. Whereas, customized data types can also be prepared using XML based tags [ix]. This is another reason due to which transformation made by different techniques and algorithm fails to support each other at their full level to support compatibility of data among systems. So, there is a need to look into different capabilities of data types supported by XML either by Document Type Definition (DTD) or XMLS along with their limitations.

II. STATE OF THE ART

The bulk of data and information are found on the Web is stored and retrieved using RDBs. Previous research shows that Semantic Web collaboration with other domains extends its utilization beyond the Web [iii]. Many methods and tools were introduced to help by providing the ways to explore relational data for availability to Semantic Web based systems [x]. Yet, there exist problems in clearly gaining results with high performance and compatibility [xi-xiii].

The standard which is known as XML document provides tags for the web. Where semi-structured and user defined, and predefine tags are stored. Though, the XML document is written either using XML schema or DTD [ix]. So, for transforming a relational schema into RDF schema, we have to do it partially as relational schema into XML schema and then XML schema into RDF schema or relational into DTD and then DTD into RDF schema. After that, transforming it back into its original form of relational schema.

Mapping can be done from RDB to RDF either by direct or indirect methods. Indirect methods like RDB to RDF Mapping Language (R2RML) involves table mapping from RDB to RDF without intermediate utilization of XML. Other indirect methods are about transforming schema from RDB to RDF using XML. XML schema can be either in the DTD or XML [xi-xiii]. Which is focusing on indirect methods based mapping.

Different researchers have attempted different approaches to fulfill the required outcome of reaching to a next generation web that is the Semantic Web. There have been attempts made for transforming a database schema into the Document Type Definition (DTD) and then into Resource Description Framework Schema (RDFS) either partially or completely. DTDs at the end of XML document for the web can be transformed and mapped into RDF schema. By looking into tags available in the XML document to pick better suitable tags for the satisfying role as a class or property [v]. On the other hand, XML documents can be updated to gain capability of being interpreted as RDF. It would be better if the XML's original structure remains unchanged and transformation process better results and coverage of the developed technique [vi, xiv-xvi].

In depth, the idea of resources linking among database, DTD and RDF is by using queries without changing context and meaning of web based data to form its semantic existence [xvii-xix]. These approaches can be captured to get a single side transformation approach. Other than these differences the major one is that each resource in RDF is assigned a unique Uniform resource identifier (URI) for identification. So, information on both of these semantic based expressions is given a shape of triples [xx].

This research can help to reduce complexity and compatibility issues for the process of transformation. As complexity and compatibility issues arise due to database schemas and ontologies are evolving at a constant speed to map with application and user requirements. Therefore, instead of mapping being redefined from scratch it should evolve on top [xiii]. The update statement concerning RDF stores is still under progress and its semantics are not yet well defined, and uncertainty remains concerned about the transformation of few SPARQL (SPARQL Protocol and RDF Query Language) Update statements. Only elementary (attribute-to-property & relation-to-class) mappings have been studied up to now. The problem of modifying relational data using SPARQL Update is the same as to view, update problem the classic database [xiii, xxi, xxii].

It is thought that one cause for the delay in the recognition of the Semantic Web is the deficiency of application and tools showing benefits of semantic web technology [xxv]. The success depends of large amount of data concerning semantic web of these tools [xxiv]. Because relational databases are considered as highly used medium for storage of data on web. The solution was to automatic manage mass of data in SW form as RDF.

It is studied that the transformation model from relational DB to RDF and storage mechanism of RDF stores in RDB. It is important to map existing relational representation among relational schema, DTD, XML schema, and RDFS [ix, xx, xxiii]. Proposed study of the above mentioned problem situation is possible through mapping of differences at schema level, enriching the DB contents on web based mapping results and identifying grey areas.

III. Proposed Work

Transformation from one data model into another comes with its limitations. In this field of study, first look into mapping between different data models. Then the process of transformation using DTD and XMLS is given. A control experiment presented to show that how transformation works and on the basis of that results are given.

A. Mapping

A tabular representation in Table I to show the corresponding schema entity for the each concept of Database. These entities are further used for proper transformation among RDB and semantic web. In Table 1 each concept of a database is mapped with it one of the possible mapped solution in DTD, XML schema, RDFS. Table I shows how each entity of a database can be stored in its corresponding mapped field and command of other technologies like DTD, XML and RDF. Furthermore, some of the cases are discussed with the help of W3C standards for all of these technologies after careful study. The Table I can play a crucial role in transforming from database to semantic web and back to the database.

TABLE I
SHOWING ALTERNATIVE SCHEMA ELEMENTS FOR EACH CASE OF RELATIONAL SCHEMA VALUE

Concepts	Relational Schema	DTD	XML Schema	RDFS
Table	Table_Name	!ELEMENT Table_Name* ATTLIST !ELEMENT	Complex type element	Class
Field	Field_Name	!ELEMENT Field_Name	Element	Rdf: Property
Cardinality	Field(>=0)	!ELEMENT Field_Name*	Restriction (Pattern)	
Cardinality	Field(>0)	!ELEMENT Field_Name+	Restriction (Pattern)	
Referencing	Field	!ELEMENT Ref Key Field_Name* IDREF #REQUIRED	Simple type element Ref	Domain (Property)
Primary Key	Field	!ELEMENT Key Field_Name? ID #REQUIRED	Attribute Use=”required”	Range
Composite key		!ELEMENT Second Key Field_Name? ID #REQUIRED	Attribute Use=”required”	Rdfs:sub Property Of
Data type	Field	PCDATA or CDATA	Type	Type

In Table I concept of database covered are tabulated, field, cardinality, referencing, data types and keys. The elements are the basic entity used for both XML and DTD which are used for table and fields. Each element can further contain a list of attributes capable to map each field of a table from database. Keys are mapping is crucial as they play the main role in database for identification of records. So, each key is mapped corresponding term in XML and RDF. For transformation to happen according to defined mapping in this study have to follow mapping table. Which will give results of transformation from RDBS to RDFS and vice versa.

TABLE II
SHOWING CAPABILITIES OF TECHNOLOGIES USED IN TRANSFORMATION

Terminologies	RDBS	DTD	XML Schema	RDFS
Referential Identifier	✓	✓	✓	✓
Unique Identifier	✓	✓	✓	✓
Composite Unique Identifiers	✓		✓	✓
Enclosed Lists	✓	✓	✓	
Formal Semantics				✓
Inheritance				✓
Datatypes	✓		✓	✓
Constraints	✓		✓	
Cardinality constrains	✓		✓	

Whereas Table II shows different terminologies of the database can be mapped into a DTD, XML schema and RDFS. This table also shows each technology capability to support in transforming along with their limitations. For example, in case of DTD only available data type is equivalent to a string.

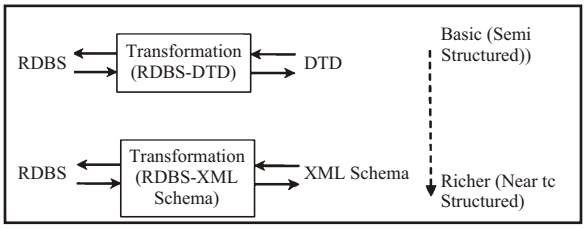

Fig. 1. Two approaches with structural level difference in Transformation Process

While trying to be more in control of data for the transformation (see Fig. 1) from RDBS to XML Schema and then back into RDBS. Then rich interface will be fine as long as all of this data passes through it to get transform up to the needed shape acceptable by the semantic web. Among semi-structured data which have a richer approach is better due to the high range of data type availability.

B. Experiment

To show the working of the elaborated process for transformation, first let's look at the RDBS of considered example of relational schema of the entity named "Organization" shown in Fig. 2. There are four tables Dependent, Employee, Manager and Department. We have used different tools like MS SQL Server 2005 for relational databases, Altova XMLSpy for XML Schema creation and an online project (X2R Converter) for RDF creation. As these tools are not meant to transform RDBS into RDF, so remaining experiment is done by coding in Java Programming Laguage to get results according to this research requirement.

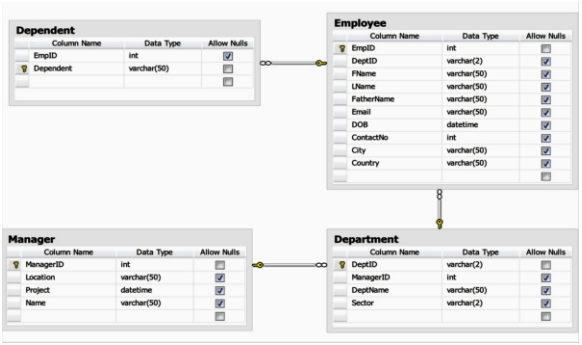

Fig. 2. Schema of RDB taken as example to show results of transformation process

Now by using Table I & III given in the Section III mappings rules for RDBS (shown in Fig. 2) is further transformed into Fig. A1 and Fig. A2, as a result, an intermediate format of web based technologies either like DTD or XML Schema is gained. Experiment is performed using tool of Altova XMLSpy.

In DTD transformed form of RDB (shown in Appendix Fig. A1) data type PCDATA is on covering the string data type of the database. In this much of the information is lost like corresponding data are of which type. Another problem in DTD which can be observed the lack of covering constraint on each data model. On the other hand XML Schema (shown in Appendix Fig. A2) is covering different data types and constraints.

TABLE III
XML PRIMITIVE DATA TYPES SUPPORTED FACETS

facets / Datatypes	pattern	whitespace	Length	min Length	max Length	enumeration	total Digits	fraction Digits	min Inclusive	max Inclusive	min Exclusive	max Exclusive
string	✓	✓	✓	✓	✓	✓						
boolean	✓	✓										
decimal	✓	✓				✓	✓	✓	✓	✓	✓	✓
Float	✓	✓				✓			✓	✓	✓	✓
double	✓	✓				✓			✓	✓	✓	✓
duration	✓	✓				✓			✓	✓	✓	✓

dateTime	✓	✓				✓			✓	✓	✓	✓
Time	✓	✓				✓			✓	✓	✓	✓
Date	✓	✓				✓			✓	✓	✓	✓
gYear	✓	✓				✓			✓	✓	✓	✓
gMonthDay	✓	✓				✓			✓	✓	✓	✓
gDay	✓	✓				✓			✓	✓	✓	✓
gMonth	✓	✓				✓			✓	✓	✓	✓
haxBinary	✓	✓	✓	✓	✓	✓						
base64 Binary	✓	✓	✓	✓	✓	✓						
anyURI	✓	✓	✓	✓	✓	✓						
QName	✓	✓	✓	✓	✓	✓						

And by using XML Schema of RDB is transformed into XML file containing data of all tables according to their dependencies (shown in Appendix Fig. A3). Here according to the relationship based dependencies of one to many each instance of Manager Table in XML contains all dependent Department instances. Similarly, a Department instance contains all Employees of that department. And then an employee information contains all its dependent instances.

So, the remaining task is to transform results into RDFS format which in our case is performed using Table 1 & 3. Whereas, Extensible Style sheet Language Transformations (XSLT) are used to transform XML into other formats in our case it is RDF. Online project X2R converter for transforming taken experiment with modifications made in the xml schema file. And the resultant RDF Schema (given is not complete, list of triples gained) are shown in Appendix Fig. A4 and A5. At last, Fig. 4 shows a directed graph of resources gained by using complete triple list.

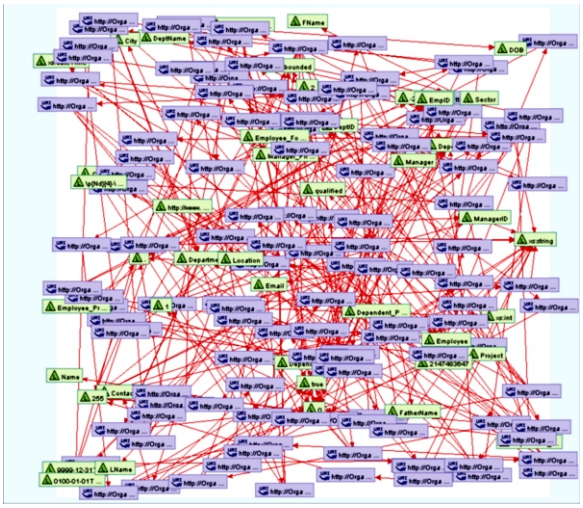

Fig. 3. "Organization" RDF Schema list translated into directed graph

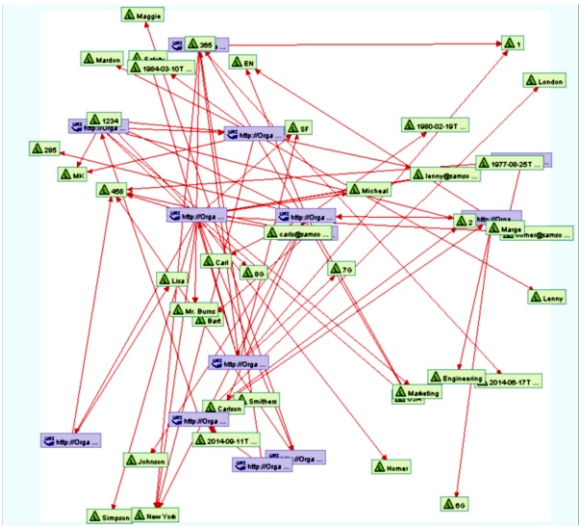

Fig. 4. "Organization" RDF triples list translated into directed graph

Then after achieving RDF file is passed it to RDF Gravity v1.0 online available tool to generate the corresponding RDF graph (shown in Fig. 3 & 4). This all have been made possible due to correct data mapping is being followed during the transformation process. Which lead us to come up with finding both schema level graphs (Fig. 3) and data level graph (Fig. 4). These graphs show us the linkage and relationship between resources used in the database of "Organization". This experiment shows that proper data type mapping is necessary to gain accurate results during the process of transformation between RDB and RDF.

C. Results

The above control experiment shows the difference between both transformations by choosing either DTD or XMLS. Whereas, DTD is less reliable than XML, as can be seen in Table IV through Fig 3.

TABLE IV
TECHNICAL COVERAGE OF DIFFERENT TOOLS USED FOR TRANSFORMATION

Technical Coverage	**Tool Capacity**				**Detail**
	RDBS	**DTD**	**XML**	**RDFS**	
Data Representation	High	Low	Average	Average	Support for data types for storage
Data Semantics	Average	Low	Average	High	Support for data based on relationships
Connector Semantics	Average	Average	Average	High	Support to relate other similar data available
Extra Functional Dependencies	High	Average	Average	Average	Support to detailed data for dependencies

In Table IV connector semantics are the triplets connecting distributed resources with having similar meanings. Distributed data connectivity and understanding becomes crucial when it comes to Web Semantics. Recourses can have different connectors with different meanings, whereas in RDB, it is not the same.

XML supports a subset of RDBS data types. As if RDFS is built upon XMLS then RDFS can support a subset of RDBS data type based superset.

Suppose X and M are Sets of data types supported by RDB and XML respectively,

Such that, M X

$\therefore N = M$ --------- (1)

where N is Set of data types supported by RDFS

Eq. 1 shows that it is hard to transform an evolving data back and forth between RDB and RDF if data types are not properly mapped. *Then the question arises that "could XML being used as intermediate between RDB and RDF based transformation".* The answer lies in the mapping mechanism used between them which should be strong enough to support both sides to ensure equivalence of data. Experiment performed gives an evaluation for proposed mappings on the basis of equivalence of concepts.

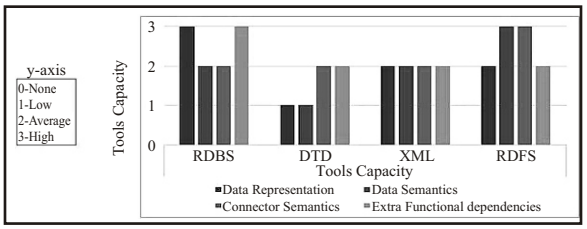

Fig. 5. Bar chart for showing Technical coverage of different tools

Results shown in Fig. 5 represents that the accuracy drops at the level of DTD compared to XMLS data type during the process of transformation .

IV. Discussion

Transformation plays a key role between systems new and old to coexist. But it is not an easy task to perform. Keeping intact all pieces of information without losing accuracy is quite hard due to limitation of each mechanism used.

By using a common feature of RDF and RDB can help with enhanced utilization and compatibility among system concerning semantic web. This can assist in inducing large scale loss free transformation of traditional systems into semantically enriched systems back and forth. As the problems found, do indicate that there are many features lost during the transformation performed unidirectional or even partial bidirectional [xiii]. For now bidirectional transformation is lacking in its full capacity. It is becoming a necessity to improve compatibility among systems using either semantic or relational data models. This can be done when new improvement in the XML standard, which can hold all necessary Meta data of each table in a separate file. Through this way, this study will directly benefit data transformation process between systems containing both traditional and semantic enriched data storage.

In the Table II DTD shows biggest challenges as it only supports the data type of string. To resolve such problematic issue the transformation requires to contain the extra information related to data. On the other hand, there is a need of keeping track of metadata for bidirectional data transformation to work without any loss of information. This will make sure that data is capable to retain its original shape for either side of data models concerning semantic web and relational DB.

Whereas example section helps in understanding how XML schema can support richer concepts of database unlike DTD. By this, it is suggested that XML schema should be prepared carefully for the data transformation between RDB to RDF.

V. Conclusion

This research contributes to look into the weaknesses generated during transformation process in both fields of data storage and retrieval from Relational Databases (RDB) into Semantic Web. Extensive distribution of data all over the web makes accurate transformation difficult to attain. Also keeping changes intact for evolving data is hard and difficult to sustain. This leads to the need for transformation to focus more on common features of these state of the art technologies. These common features can further help in gaining better compatibility options for data transformation. By this way originality of the data can also be preserved during transformation. To achieve this, mapping helped to grasp their differences at the level of data types. It's main focus is to show common features found in both data models of RDB and RDF based schemas. Using among Document Type Definition (DTD) or Extensible Markup Language Schema (XMLS) as an intermediate which will help in improving transformation results. Then these results can be analyzed and discussed based on the given results. It is aimed to show the importance of reducing the response time of DB queries and offer compatibility between web and semantically enriched data.

VI. Future Work

Yet improvements are far from being achieved to gain the same results at both ends of systems. Using this mapping for indirect transformation can help in achieving better and enhanced results for

transformation of data. Such a system can be used for retrieval and storage of data among RDB and Semantic Web with improved compatibility for bidirectional transformation. Further research on currently available tools and methodologies along with their frameworks can help for achieving state of art bidirectional transformation. It will also help us in finding weak areas and providing alternative mechanisms to transform data for bidirectional transformation.

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APPENDIX A

Figures taken as output in the form of XML and RDF document Samples during Experiment phase

```
<?xml version="1.0" encoding="UTF-8"?>
<!ELEMENT Department (DeptID, ManagerID, DeptName?, Sector?, Employee*)>
<!ELEMENT DeptID (#PCDATA)>
<!ELEMENT ManagerID (#PCDATA)>
<!ELEMENT DeptName (#PCDATA)>
<!ELEMENT Sector (#PCDATA)>
<!ELEMENT Dependent ANY>
<!ELEMENT EmpID (#PCDATA)>
<!ELEMENT Employee (EmpID, DeptID, FName?, LName?, FatherName?, Email?, DOB?, ContactNo?, City?,
Country?, Dependent*)>
<!ELEMENT FName (#PCDATA)>
<!ELEMENT LName (#PCDATA)>
<!ELEMENT FatherName (#PCDATA)>
<!ELEMENT Email (#PCDATA)>
<!ELEMENT DOB (#PCDATA)>
<!ELEMENT ContactNo (#PCDATA)>
<!ELEMENT City (#PCDATA)>
<!ELEMENT Country (#PCDATA)>
<!ELEMENT Manager (ManagerID, Location?, Project?, Name?, Department*)>
<!ELEMENT Location (#PCDATA)>
<!ELEMENT Project (#PCDATA)>
<!ELEMENT Name (#PCDATA)>
```

Fig. A1. "Organization" RDB schema transformed into DTD

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">
    <xs:element name="Department">
        <xs:complexType>
            <xs:sequence>
                <xs:element name="DeptID">
                    <xs:simpleType>
                        <xs:restriction base="xs:string">
                            <xs:maxLength value="2"/>
                            <xs:minLength value="1"/>
                        </xs:restriction>
                    </xs:simpleType>
                </xs:element>
                <xs:element name="ManagerID">
                    <xs:simpleType>
                        <xs:restriction base="xs:int">
                            <xs:minInclusive value="-2147483648"/>
                            <xs:maxInclusive value="2147483647"/>
                        </xs:restriction>
                    </xs:simpleType>
                </xs:element>
                <xs:element name="DeptName" nillable="true" minOccurs="0">
                    <xs:simpleType>
                        <xs:restriction base="xs:string">
                            <xs:maxLength value="255"/>
                        </xs:restriction>
                    </xs:simpleType>
                </xs:element>
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                            <xs:maxLength value="2"/>
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        </xs:complexType>
        <xs:key name="Department_PrimaryKey_1">
            <xs:selector xpath="."/>
            <xs:field xpath="DeptID"/>
        </xs:key>
        <xs:keyref name="Employee_ForeignKey_1" refer="Department_PrimaryKey_1">
            <xs:selector xpath="Employee"/>
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    </xs:element>
```

Fig. A2. "Organization" RDB schema transformed into XML Schema

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        <Project>2014-06-17T00:00:00</Project>
        <Name>Mr. Burns</Name>
        <Department>
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            <ManagerID>1</ManagerID>
            <DeptName>Safety</DeptName>
            <Sector>7G</Sector>
            <Employee>
                <EmpID>458</EmpID>
                <DeptID>SF</DeptID>
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                <LName>Simpson</LName>
                <FatherName>Micheal</FatherName>
                <Email>homer@samsont.com</Email>
                <DOB>1977-08-25T00:00:00</DOB>
                <ContactNo>1234</ContactNo>
                <City>New York</City>
                <Country>USA</Country>
                <Dependent>
                    <EmpID>458</EmpID>
                    <Dependent>Marge</Dependent>
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                </Dependent>
            </Employee>
        </Department>
    </Manager>
<Manager>
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        <Project>2014-09-11T00:00:00</Project>
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        <Department>
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            <ManagerID>2</ManagerID>
            <DeptName>Marketing</DeptName>
            <Sector>8G</Sector>
            <Employee>
                <EmpID>365</EmpID>
                <DeptID>MK</DeptID>
                <FName>Lenny</FName>
                <FatherName>Mardon</FatherName>
                <Email>lenny@samsont.com</Email>
                <DOB>1984-03-10T00:00:00</DOB>
                <ContactNo>1234</ContactNo>
                <City>New York</City>
                <Country>USA</Country>
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        </Department>
        <Department>
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            <DeptName>Engineering</DeptName>
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            <Employee>
                <EmpID>285</EmpID>
                <DeptID>EN</DeptID>
                <FName>Carl</FName>
                <LName>Carlson</LName>
                <FatherName>Johnson</FatherName>
                <Email>carls@samsont.com</Email>
                <DOB>1980-02-19T00:00:00</DOB>
                <ContactNo>1234</ContactNo>
                <City>New York</City>
                <Country>USA</Country>
            </Employee>
        </Department>
    </Manager>
</OrganizationDB>
```

Fig. A3. "Organization" RDB transformed into XML file using XML Schema

```
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   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:OrganizationDB="http://OrganizationDB/Property/"
   xmlns:OrganizationDB1="http://OrganizationDB/Property/xmlns:">
  <rdf:Description rdf:about="http://OrganizationDB/Resource/xs:schema">
    <OrganizationDB:hasResource>
      <rdf:Description rdf:about="http://OrganizationDB/Resource/xs:schema/xs:element3">
        <OrganizationDB:hasResource>
          <rdf:Description rdf:about="http://OrganizationDB/Resource/xs:schema/xs:element3/xs:keyref">
            <OrganizationDB:hasResource>
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            </OrganizationDB:hasResource>
            <OrganizationDB:hasResource>
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                <OrganizationDB:xpath>Department</OrganizationDB:xpath>
              </rdf:Description>
            </OrganizationDB:hasResource>
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            <OrganizationDB:name>Department_ForeignKey_1</OrganizationDB:name>
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        <OrganizationDB:hasResource>
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            <OrganizationDB:hasResource>
              <rdf:Description rdf:about="http://OrganizationDB/Resource/xs:schema/xs:element3/xs:key/xs:field">
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              </rdf:Description>
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            <OrganizationDB:hasResource>
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                    <OrganizationDB:minOccurs>0</OrganizationDB:minOccurs>
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                  </rdf:Description>
```

Fig. A4. "Manager Table of Organization DB" triples list generated using transformation algorithm XML Schema to RDFS

```
<rdf:RDF
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:OrganizationDB="http://OrganizationDB/Property/">
  <rdf:Description rdf:about="http://OrganizationDB/Resource/OrganizationDB">
    <OrganizationDB:hasResource>
      <rdf:Description rdf:about="http://OrganizationDB/Resource/OrganizationDB/Manager1">
        <OrganizationDB:hasResource>
          <rdf:Description rdf:about="http://OrganizationDB/Resource/OrganizationDB/Manager1/Department1">
            <OrganizationDB:hasResource>
              <rdf:Description rdf:about="http://OrganizationDB/Resource/OrganizationDB/Manager1/Department1/Employee">
                <OrganizationDB:DeptID>EN</OrganizationDB:DeptID>
                <OrganizationDB:EmpID>285</OrganizationDB:EmpID>
                <OrganizationDB:LName>Carlson</OrganizationDB:LName>
                <OrganizationDB:FatherName>Johnson</OrganizationDB:FatherName>
                <OrganizationDB:FName>Carl</OrganizationDB:FName>
                <OrganizationDB:Country>USA</OrganizationDB:Country>
                <OrganizationDB:DOB>1980-02-19T00:00:00</OrganizationDB:DOB>
                <OrganizationDB:City>New York</OrganizationDB:City>
                <OrganizationDB:ContactNo>1234</OrganizationDB:ContactNo>
                <OrganizationDB:Email>carls@samsont.com</OrganizationDB:Email>
              </rdf:Description>
            </OrganizationDB:hasResource>
            <OrganizationDB:Sector>6G</OrganizationDB:Sector>
            <OrganizationDB:DeptName>Engineering</OrganizationDB:DeptName>
            <OrganizationDB:ManagerID>2</OrganizationDB:ManagerID>
            <OrganizationDB:DeptID>EN</OrganizationDB:DeptID>
          </rdf:Description>
        </OrganizationDB:hasResource>
        <OrganizationDB:hasResource>
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            <OrganizationDB:hasResource>
              <rdf:Description rdf:about="http://OrganizationDB/Resource/OrganizationDB/Manager1/Department/Employee">
                <OrganizationDB:Country>USA</OrganizationDB:Country>
                <OrganizationDB:City>New York</OrganizationDB:City>
                <OrganizationDB:ContactNo>1234</OrganizationDB:ContactNo>
                <OrganizationDB:DOB>1984-03-10T00:00:00</OrganizationDB:DOB>
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                <OrganizationDB:FatherName>Mardon</OrganizationDB:FatherName>
                <OrganizationDB:FName>Lenny</OrganizationDB:FName>
                <OrganizationDB:DeptID>MK</OrganizationDB:DeptID>
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            <OrganizationDB:DeptID>MK</OrganizationDB:DeptID>
          </rdf:Description>
        </OrganizationDB:hasResource>
        <OrganizationDB:Name>Smithers</OrganizationDB:Name>
        <OrganizationDB:Project>2014-09-11T00:00:00</OrganizationDB:Project>
        <OrganizationDB:Location>London</OrganizationDB:Location>
        <OrganizationDB:ManagerID>2</OrganizationDB:ManagerID>
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Fig. A5. "Organization DB" triples list generated using transformation algorithm XML data file to RDF

Development of Bed-Furrow Intervention in the Rice-Wheat Cropping System in Punjab, Pakistan

A. Latif [1], A. A. Malik[2], M. U. Rashid[3], T. Sultan[4], U. Ghani[5], S. Ali[6]

[1, 4]Civil Engineering Department, University College of Engineering and Technology, BZU, Multan, Pakistan
[2]NFC; IET, Multan, Pakistan
[3]Civil Engineering Department, University of Management and Technology, Lahore, Pakistan
[5]Civil Engineering Department, University of Engineering and Technology,Taxila, Pakistan
[6]Civil Engineering Department, National University of Computer and Emerging Sciences, Lahore, Pakistan
[1]engrabid1997@gmail.com

***Abstract*-**The successful implementation of bed-furrow, a resource conservation intervention (RCI), for rice-wheat cropping system has become the prime goal for researchers and cultivators by developing bed-seeded crops in South Asia. The paper reviews the output, need, methods, merits, demerits and constraints for adopting bed-furrow RCI in Pakistan. The potential of this intervention and the issues of adopting permanent raised beds have also explored in the study. The application of Bed-furrow is only limited to few hectares for field demonstrations and research in Pakistan. The findings of research reveal substantial enhancement in output and profitability by including residue straw mulching on bed-furrow. The strategies that enhance the adoption, merits and output of bed-furrow for Pakistan in particular are as follows: i) selection of rice germ-plasm in aerobic circumstances gives improved output, ii) Provision of accurate and efficient seed and fertilizer at economical cost by improving the design etc. of four wheel tractors, iii) The scope and use of bed-furrow should be further enhanced by taking onboard all the state holders including farmers, agronomist, engineers, machine operators and manufacturers. Data collection and monitoring should be properly carried out for its sustainable usage within the region of South Asia and iv) to enhance the areas of farms where bed-furrow is suitable for their growing cops, soil and topographic conditions, thus offers economic profit and output/productivity.

The participation and consultation of all the stakeholders including farmers, researchers, equipment operator is utmost important to manage hurdles for acquiring potential benefits, productivity and sustainability of bed-furrow intervention.

***Keywords*-**Indo-Gangetic Plains, Rice-Wheat Cropping System, Machinery Operators, Productivity, Economic Benefits

I. INTRODUCTION

The rice and wheat systems are exercised on 12 million hectares annually in South Asia and thus characterize main food supplies. The initial studies on conserving agriculture in rice wheat system in South Asia were started by researchers belonging to National Agriculture Research System (NARS) Consultative Group of International Agriculture Research (CGIAR) and other institutions. Several studies and researches have concluded considerable saving of water and other inputs including monetary and time benefits [i-vi]. In the low-lying areas having poor drainage, the bed-furrow planting intervention is more favorable than the zero tillage [i-vi].

Due to less output and agriculture yields, there is great potential available of on-farm irrigation management interventions including laser land leveling (LLL), zero tillage (ZT) and especially bed-furrow for rice wheat system of crops developed by Cornell University, Mexico International Maize and Wheat Improvement Center and Australian Center for International Agriculture Research (ACIAR). In Pakistan, the bed furrow was first introduced and practiced by sowing wheat crop followed by rice. Now rice-wheat cropping system has been successfully exercised on thousands of acres of land in Pakistan. Easy accessibility of farming equipment at relative rates and tractors has also made ploughing conservation successful in Pakistan.

The definition along with few merits and de-merits of bed-furrow intervention is presented in Table 1.The use of bed furrow technique for sowing of wheat has now improved for South Asia for augmenting water-use efficiency. Several researchers have also recommended bed furrow in addition to laser land levelling and zero tillage under different soil and climate conditions [vii].

TABLE I
SUMMARY OF DEFINITION, MERITS AND DE-MERITS OF BED-FURROW INTERVENTION [VIII]

Intervention	Definition	Advantages	Disadvantages
Bed-furrow (BF)	It is a process in which the field is divided into narrow strips of raised beds / ridges separated by furrows. The crops are planted on the bed surface and irrigation water is applied through the furrows.	Saving of approximately 30% irrigation water. Less reduced chances of plant submergence due to excessive rain or over-irrigation. Lesser crusting of soil around plants and therefore, more suitable for saline and sodic soils. Adaptable for various crops without changing basic design / layout of farm. Increased fertilizer use efficiency due to local application.	It needs land grading so as water can travel the entire length of furrow without ponding. It needs continual slope by removing low and high spots. It is not suitable to all crops.

Reference [viii] discussed that agriculture output mainly depends on net revenue. The cost and benefits of bed-furrow along with other resource conservation interventions (RCIs) for rice-wheat cropping zone of Punjab, Pakistan is shown in Table II.

TABLE II
COST AND BENEFITS OF WHEAT BY VARIOUS INTERVENTIONS INCLUDING BED-FURROW (RS PER HECTARE) [VIII]

Interventions	Traditional	Zero tillage	Laser land levelling	Bed-furrow
Levelling	-	-	3457	-
Ploughing	9876	-	5926	5926
Planking	3951	988	988	1975
Sowing	1481	1975	1728	3333
Seeds	5920	4840	5120	4920
Irrigation	4716	3501	3975	3390
Fertilizer	19086	15975	17765	16198
Herbicide	3778	3037	3383	2765
Harvesting/ threshing	7931	7802	7778	7631
Total Cost of Production	56739	38118	50120	46138
Gross benefits	143552	161948	171534	150734
Net benefits	86813	1238302	121414	104596
Increase in net benefits	-	37017	34601	17783

The comparison of water productivity, fertilizer use efficiency and wheat yield of Pakistan has been compared with other regional and developed countries (Table III). The results indicate that the water productivity and fertilizer use efficiency of Pakistan are compatible with India and less than developed countries like Mexico and China. It indicates that there is great potential for Pakistan to enhance these parameters and make it compatible with developed countries by adopting RCIs.

This paper highlights the errors and experiments conducted in the study and execution of bed furrow resource conservation intervention in Pakistan paving way for its future sustainability.

TABLE III
COMPARISON OF RESULTS WITH OTHER STUDIES [VIII]

Output parameters	Pakistan	India	Mexico	China
Water Productivity (kg/m^3)	1.6	1.75	2.3	2.16
Wheat yield (kg/ha)	4450	4758	5591	5137
Fertilizer use efficiency (%)	20	25	30	28

II. THE KEY FEATURES OF THE BED-FURROW INTERVENTION SYSTEM

The idea of growing wheat crop on bed was initiated with prototype bed planter machinery connected to wheel tractor developed in Mexico CIMMYT with instantaneous efforts on POTS. However, bed planter machinery connected to wheel tractor which can provide seeds and fertilizers has not still developed even after three years of concentrated efforts, developments, participation and research comparable to POTS. To date with latest developments beds can be developed easily. The size of beds are generally kept 50cm to 70cm having two rows for direct transplanted / seeded rice and 2-3 rows for wheat on bed top (Fig. 1).

III. SOIL PREPARATION FOR BED-FURROW INTERVENTION

When preparing the land for seeding crop in a bed

system, several observations from the on-farm trials are important:

1. Weeds present in the fields must be eradicated earlier to making beds for sowing crop.
2. The soil must be accurately leveled where a bed-furrow intervention is to be implemented. This permits uniform water application to confirm that the beds will continue dry. When the fields are not level, water application efficiency will be curtailed and irrigation water will flow over the beds, consequentially in excessive vegetative growth and finally decreasing the crop yield.
3. Land moisture should be low sufficient to allow the beds-furrows intervention to be made to uniform depth.
4. Well-pulverizedland is required to an equal depth through the field to ensure that beds-furrows sustain the same dimensions.

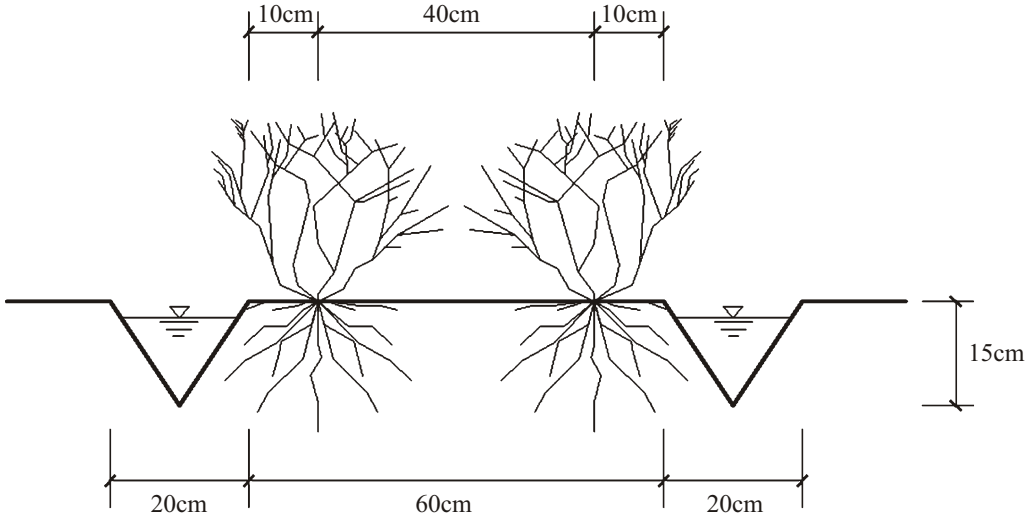

Fig. 1. Bed size developed by farmers in Pakistan

IV. Soil Preparation for Bed-furrow Intervention

A furrow and bed shaper is normally used for making the beds-furrows but a ridge can also be used. An regular bed outfit makes one bed and two furrows at a time, and in one day beds-furrows easily be completed over an area of 4-5 ha. An outfit can make parallel beds with a width of 50-60-cm and furrows of same height, and the usage of a rope can be more useful to keep the furrow straight. The machinery tractor has to be driven very slow however for making the beds; the shaper desires to be lifted at the end of the field while turning around. The rear wheel of the tractor machinery on its way back is followed in the earlier made furrow. The link between the ridge/shaper, the tractor can be adjusted to make furrow at a desire depth, e.g.30cm for sowing crop. When irrigating furrows and beds, the irrigation watercourse should be adjusted accordingly that it does not disturb the soil.

V. Issues Concerned with Adoption of Permanent Raised Beds

The following issues are concerned with growing crops on permanent raised beds need to be considered:

1. To develop multipurpose bed planter is necessary to increase the adoption of permanent raised beds. The different sizes of cotton and wheat increase the difficulty to grow both the crops on permanent raised beds and desire re-sizing of beds among crops. Moreover, a multipurpose PRB planter also needs to be developed. Besides width, technology and equipment are also required to adjust the height of beds according to the crop sown on higher beds but this height may not suit wheat or other crops which replace cotton in a rotation system.
2. The tractors are owned by most of farmers having medium size (upto 65 hp); however available bed-shapers are heavier / larger and cannot be comfortably operated by medium to small sized tractors. Thus, modification of the bed-shaper is required for the easy use. On-farm water management has developed prototype bed-shaper suited to local conditions of Pakistan on the basis of one developed by Punjab Agriculture University in Ludhiana, India. Recently, the University of Agriculture, Faisalabad, developed a bed-planter for establishing beds of suitable height and width for growing wheat and cotton. It is expected that more precise bed-planter/shaper will be available at low cost in near future for farmers of Pakistan.
3. Exclusion of carry-over cotton sticks from beds

core issue of permanent raised beds. These sticks provide safety for forthcoming crop from insects and at the same time causes shading problems including hampering spray and harvest operation and impairing productivity. It is utmost important to develop machinery/equipment to triumph these hurdles.

4. Invasion of weeds is enhanced by the permanent weeds. Manual process of cultivation is easy among the beds but requires more labor and time. Moreover, neither the mechanical equipment nor chemical method for controlling of weeds in sowing crops on beds is available.

Further studies are therefore desired to develop techniques for crops growing on PRB.

VI. Bed-furrow Intervention in Pakistan

Pakistan is a very important country regarding the production of rice-wheat crop. In Pakistan, yields of rice crop have been decreasing year by year. In order to test the raised beds with or without straw retentions about their situations, a bed presented of 0.6 hectare was placed on four farms in Gujranwala (Punjab, Pakistan) by the authors in 2010. A bed planter machine (manufactured in Pakistan) was used to shape the bed of size 60cm. The samples were taken from those four farms. The four samples of each crop on rice and wheat copping system in two years were taken. Besides, the observations constituted by both growers and authors are mentioned below.

In research areas, the soils are commonly silty clay. The yield of wheat crop that obtained from bed-furrow intervention was pretty different. It has come to know that bed-furrow intervention resulted the spike numbers per square meter and plant population significantly high as compared to common seeding method. However, it was observed that height did not change considerably between bed-furrow intervention and conventional method. In addition to these, forty percent irrigation water was saved by bed-furrow intervention compared to conventional seeding and there was less weed infestation. The wheat crop yield was considerably higher during bed-furrow intervention due to decline of weed infestation through the years and normally lower in conventional tillage as shown in Table IV.

In case of rice crops, it was revealed that the height and population of the plant, particle length, and particle numbers per square meter did not change considerably between bed-furrow and traditional intervention. But, some weeds were found in bed-furrow intervention. However, it was found that the yields of basmati rice (paddy) were significantly highest during conventional seeding as compared to that of bed-furrow intervention (Table V). It should be detected that the paddy varieties were only chosen about puddle and expectedly flooded conditions. By author, it is doubtful that the yield would be quite different, if paddy variety was selected under aerobic condition.

TABLE IV
Wheat Crop Yield in t/ha During Two Interventions of Seeding/ Tillage in Punjab, Pakistan [VIII]

Intervention	2010-11	2011-12	Mean
Bed-furrow	3.80	4.25	4.0
Traditional	3.45	3.97	3.21

TABLE V
Paddy Yield in t/haover Two Interventions of Seeding/ Tillage in Punjab, Pakistan [XVI]

Intervention	2011	2012	Mean
Bed-furrow	3.60	3.42	3.51
Traditional	3.72	3.75	3.74

Further, there was some limitations which causes crop yield on bed-furrow intervention. These limitations involved struggle in transplanting rice crop on hard beds, more rodent attack and defective equipment for bed-furrow intervention which causes poor crop stand. Therefore, it need more research expansion and availability of good equipment that are capable of shaping bed in hard soil (for both wheat and rice crop) during more residue for earlier crop.

VII. Conclusion

In Pakistan, the tasks for employing and doing research for bed-furrow cropping system consist of:

Supplying fertilizer and seed accurately. In order to get this, improvement in manufacture and design of machine is required. It is more inexpensive and trustworthy to use four wheel tractors in Pakistan.

Expansion and enhancement in the practice of bed-furrow intervention in Pakistan. Relevant stake holders, i.e. agricultural engineers, manufacturers, agronomist, farmers and machinery operators play a vital role in this regard. However, continuing to collect and monitor data on how its usage can be sustained within the Pakistan environment.

Selecting rice germ-plasm during aerobic conditions i. e. bed-furrow intervention that performs well.

Up scaling the awareness of cultivators where bed-furrow intervention appropriate their cropping system and soil and offer advantageous in economic pays as well as yield.

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Security Challenges for Virtualization in Cloud

A. Tayab[1], Junaid[2], W. Talib[3], M. Fuzail[4]

[1,2,3,4]Computer Science & Engineering Department,University of Engineering & Technology, Lahore, Pakistan
[1]awaisriaz333@yahoo.com

***Abstract*-**Virtualization is a model that is vastly growing in IT industry. Virtualization provides more than one logical resource in one single physical machine. Infrastructure use cloud services and on behalf of virtualization, cloud computing is also a rapidly growing model of IT industry. Cloud provider and cloud user, both remain ignorant of each other's security. Since virtualization and cloud computing are rapidly expanding and becoming more and more complex in infrastructure, more security is required to protect them from potential attacks and security threats.

Virtualization provides various benefits in terms of hardware utilization, resources protection, remote access and other resources. This paper intends to discuss the common exploits of security uses in the virtualized environment and focuses on the security threats from the attacker's perspective. This paper discuss the major areas of virtualized model environment and also address the security concerns. And finally presents a solution for secure virtualization in IT infrastructure and to protect inter communication of virtual machines.

***Keywords*-**VM, Virtual Machine, Cloud, Security, Attacks, Hypervisor

I. INTRODUCTION

This research paper presents the security issue that we face in virtualized environment. Virtualization is the latest technology that we use in our private or public cloud or infrastructure to reduce the cost of physical machines and make the infrastructure more efficient. Virtualization makes it possible to run more than one operating system called virtual machines (VM)ononе physical server and each and every virtual machineact as the owner of the physical server. Based on virtualization, cloud has a pool of virtualized computers and customers pay for the running applications. The use of virtual machine provides two main benefits:

sharing of resources

isolation

In the non-virtual environment, all of the resources are operating system-specific i.e. if a system has 1GB of physical memory and running tasks using 0.5GB of physical memory then the rest will be unused and cannot be fully utilized. But in the virtual environment, all resources are assigned to virtual machine and therefore, resources are fully utilized.

Virtual environment also provide isolation that is if one machine in the virtual server fails it won't affect the performance of other running virtual machines. According to American surveys [iii], more than 60% of the organizations are involved in the cloud services and are using the Virtual environment. Even the federal agencies of United States are using some services of cloud. In other words cloud is the most rapidly growing business of IT era.

[i] The next portion will describe the technical background and research that have already been introduced in terms of security threats. Later portions will describe virtualization and cloud computing in detail. The second last portion depicts the major security threats whereas in the last section the proposed security model is described.

II. TECHNICAL BACKGROUND

Virtualization and cloud security becomes serious issue of concern now a days, many researchers has put their ideas and methodologies on the security of virtual and cloud environment.

As being most growing industry in IT world, virtualization and cloud computing becomes theserious issue of concern in terms of security.

Reference [i] has proposed the idea of migrating the virtual machines from one host server to another and also the possible attacks that can be accomplished when migrating the Virtual machines. Denial of service attack and intercommunication VM attacks are more common and frequent. Un-encrypted channel when migrating the virtual machine from one machine to another can cause the man in middle attack and also guest VM can attack on the host operating machine. Access control policies, usage of firewalls,port blockage,Pre-VM firewall, encryption/decryption methods are used for the overcome of security.

Reference [ii] has proposed the idea on the security of virtualization in cloud computing. The user doesn't know where his data is residing in the cloud and user didn't know for what he is paying against services. Privacy declared as the major security concern in the cloud. His security model which composed of virtual

machine monitor VMM for monitoring of guest virtual machine in which all the activities are monitored by the detector and stored in the log file. It can monitor guest virtual machines and middleware integrity attacks while remaining transparent to users.

According to [iii] has proposed the idea on the security of cloud. Many of the organization are moving towards the cloud computing and they even don't know about the background security issues. Cyber-crimes causes loss of millions dollars for many organization, so most of the organizations compelled to discontinue to the cloud services. His proposed idea for the overcome of security is by using Virtual machine monitor, hyper safe and cloud Visor.

Reference [iv] stated that the cloud computing depends on virtualization for the distribution of services to end users and the security issues exists between the guest-to-guest virtual machines. His proposed idea is on security of cloud and virtualization. Hypervisor is the software which is used to create the virtual environment but on the other hand it also causes the security issues in guest virtual machines. There are some security attacks that occurs in the virtual environment like jail breaking, migration, client side and virtual network service. They mainly focused on the guest-to-guest virtual machines attacks in which one of the host or guest infected machine can infect all of the other machines. To protect guest virtual machines which are compromised by the attacker efficiently detects the guest-to-guest attacks and also the hidden attacker who run the tasks without appearing in the processes list.

According to [v] presented the virtual security framework which comprises of two parts: one is system security and second is security management of virtual network. The host machine is the control point of all virtual machines where we can start, stop and pause the VM's and also host machine can modify the hard disk storage, associated memory and also their physical location in hard disks. Some attacks that occurs in the virtual environment like the VM escape in which attacker runs the code in VM and gains the access to the hypervisor, poor isolation to machine can also cause the inter-VM attacks. Hissecurity model uses the virtual firewall which protects the network and virtual machines from outside attacks and also to use the vIDS/vIPS which collect the data behavior and sign of attacks in the virtual environment.

III. Virtualization and Cloud Components

Virtualization is most important element in making cloud environment. Virtualization help the IT department to host their running application on the cloud and make it easy to access and hence for this the security issue is most important and under consideration. The phrase virtual machine refers to a software computer like a physical computer, runs an operating system and applications. An operating system on a virtual machine is called a guest operating system. [Vi]

To monitor all this virtual machines the management layer is used which is called virtual machine manager VMM. Virtual machine manager is centralized monitoring tool and it shows all the resources which are utilized by all hosted virtual machines.

Most commonly used technique in virtualization is hypervisor which allows the many virtual machines called guest operating system to run parallel without degrading or effecting the performance of other virtual machines. Hypervisor monitor the execution and resource utilization of guest operating system. Hypervisor installed on the physical host server. [vii] hypervisor duty is to just run the guest machine called virtual machines.

IV. Virtualization Methods

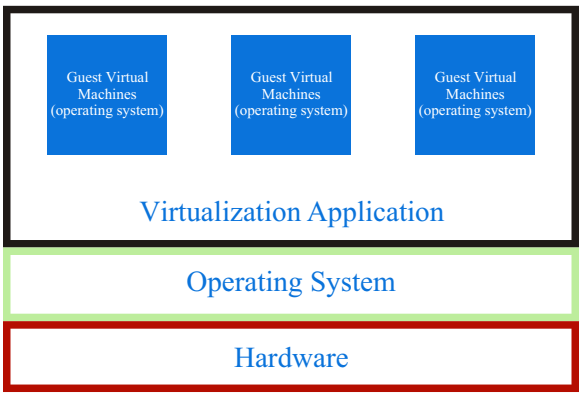
In IT departments the physical servers are directly connected to the physical switches and routers and hence the management and monitoring of traffic is not a tough task by IT professionals but in case of virtualization the virtual switch is connected to the physical server via the physical NIC so in this case the management of traffic effects the performance and lack security. [vii]

There are several methods we can used in virtualization infrastructure but every method or approach has own significant and drawbacks. [Vii] These methods are illustrated in Fig. 1. And both methods are discussed with detail.

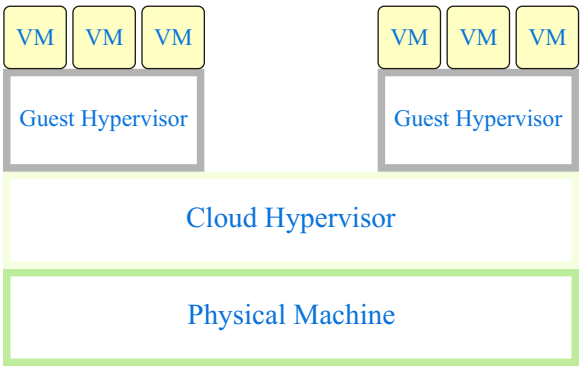
a. Operating-system based virtualization
b. Hypervisor-base virtualization

A. Operating-system based virtualization

In this method virtualization is based on the host operating system and all the virtual machines are directly influenced by the host operating system. The host operating system has all control on the virtual machines. This method is much simpler to implement but has some very serious drawbacks. Because of direct control of operating system to virtual machines, so it become more easier for attacker to inject DOS attacks or malicious attacks to kernel of operating system, so the whole virtualization infrastructure can be affected and attacker can have control all the virtual machines and can harm the virtual machines in the future. [vii]



(a) Operating-system based virtualization



Public (Cloud) Infrastructure

(b) Hypervisor based virtualization

Fig. 1 Virtualization Methods

B. Hypervisor-based virtualization

Hypervisor is available on the boot time of the machine and can be used to control the sharing of system resources across the multiple virtual machines.

As this technique is more controllable in the environment, so we can utilize additional security tools such as intrusion detection system(IDS) [vii], but problem with this approach is the single point of failure due to the reason that if the hypervisor is under attack then the attacker can take hold to all other virtual machines. But controlling or attacking from virtual machine to hypervisor is difficult. [vii]

V. Security Threats and Attacks in Virtualization Environment

The security threats found in the virtualized infrastructure are very common to the threats that we faced in the physical machines. The following are the list of some threats that are found in the virtualized environment.[v]

A. Attacks among virtual machines

Isolation is provided by the virtualized environment if deployed with carefulness. But if the structure of infrastructure is not policy based or control based then this cause the attacks between the virtual machines and the attacks among the virtual machine and virtual machine manager.[v]

One virtual machine can contaminate all other running virtual machine which exist on the same Host or physical server. The attacker just attack on the one target virtual machine and upon getting successful overtaking on one desired virtual machine the attacker can control or harm the overall virtual infrastructure and when attacker gets the full control over the hypervisor he can perform the spoofing attacks.

B. Virtual machine Outflow

Virtual machine outflow is an achievement in which the attacker/aggressor can run the scripting code and break out the limit of running operating system and can gain the access to the hypervisor on which all other virtual machines are running. Virtual machine outflow is the procedure in which attacker can negotiate the isolation among the host and virtual machines. The scripting code able to evade the VMM Layer and able to approach the other virtual machines and can also have the root privileges. In other words that the virtual machine overflow from the virtual machine boundary. [v]

C. Denial of service attack

DOS attack is passive type of attack in which the attacker over-flood the destination machine so that services offered by the destination machine will be inaccessible to the intended users. The DOS attack term is basically entertained in the computer network area but it's not limited to that but also used for CPU reserve management.

DOS attack in virtual environment can flood the destination machine with external requests so it can't able to respond the genuine traffic and purpose of this attack is to reset the machine or consuming running services and blocking the communication track between the planned user and victim virtual machine.

In virtual environment because the guest machine and host machine used the same physical resources so it is possible for guest machine attacker to inject the attack to all other guest machines and the attacker can take all conceivable resources of the schemes.

D. Data Leakage

When user move towards the cloud, they are unaware of data residing in the cloud because their data is not exist in in the local machine and secondly data is not protected by encryption or and other security algorithms. These problems cause the data over flow or data leakage. This becomes the hitches for the organization from security concern. All cloud provider's stores data on the third vendor storage. [vii]

Data leakage can be protected by a method in which user can use their encrypted keys mechanism.

All encryption based on user management key but problem with this solution is that there are many users on the cloud and to manage each user encryption management key scheme is tough task.

VI. Proposed Security Architecture

In this portion, we propose major security model which is used to secure virtual infrastructure and to protect the virtual machine from being attacked and also to secure the inter-VM communication.

A. Virtual Firewall architecture

Virtual firewall (VF) architecture shown in Fig. 2 used and positioned in virtual environment to inspect all the incoming and outing traffic and packets. The virtual firewall tends to be software based installed on the guest VM or physical machine. It can also installed and managed in Virtual machine manager. V-firewall can protects the virtual machines from spoofing or over flooding of packets.

Virtual firewall also defends the VM's from attacker or any other malware and keep the VM's secure from outside or internal threads.

On the other hand physical firewall protects the external and internal traffic but it doesn't monitor the inter-VM communication. So the attacker in your internal network can compromises the virtual machines. Virtual firewall adds the benefits by inspecting and monitoring the external traffic and also between the virtual machines.

With more and more critical applications it becomes threatening to protect the virtual infrastructure from attacks and also from misbehaving end users. Virtual firewall rules allow you to confine various type of traffic upcoming from inbound (external network) to the virtual infrastructure and from outbound (virtual machines) to the inbound and also between the virtual machines. In this way virtual infrastructure can be protected from inbound and outbound attacks.

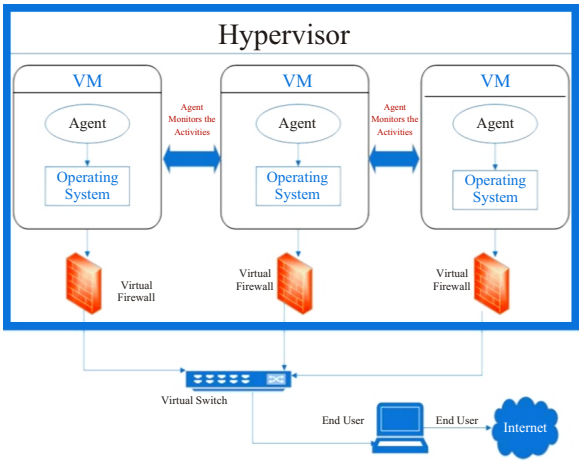


Fig. 2. virtual firewall architecture

In our proposed model, our main focus is to secure the inter-VM communication and secure traffic flow between virtual machines.

In this model, Virtual-firewall is used to install on the hypervisor machine which is either physical or virtual. Agent need to install on guest machines. Agent is service based software installed on operating system which monitors the activities on the virtual machines and send the information to V-firewall in form of logs. End users or virtual machine when tries to communicate with the virtual server the traffic flow like follows as shown in Fig. 3.

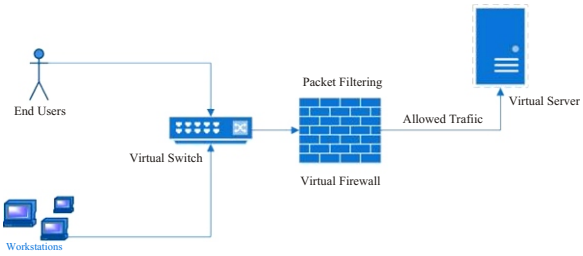


Fig. 3. virtual firewall

i. End client to virtual switch
ii. Virtual switch to virtual firewall
iii. Packet filtering
iv. Decision either to block or allow the traffic

Agent monitors the allowed inbound and outbound traffic and provide the logs.

In order to secure from the attacker prospective, only specific IP or IP ranges need to allow on the v-firewall. Expect allowed IP, all traffic will be discarded.

All virtual machines on the same hypervisor cannot communicate with each other unless they are manually explicitly allowed on the virtual firewall.

VII. Implementation

This architecture implemented on the 5nine virtual firewall and Microsoft Hyper-V as a hypervisor. 5 nine virtual firewall contains the management console and agent module. Agent module need to be installed on all guest machines. Purpose of agent is to block all incoming and outgoing traffic on the virtual machines. After installing the agent on the machine all the broadcast, TCP, UDP, ARP, ICMP etc. traffic will be blocked.

In DHCP enabled environment, machine will not able to get the IP lease from DHCP due to blockage of broadcast traffic as shown in Fig. 4.

Heartbeat service is used to check if all the security policies and rules are enforcing on the virtual machine, and virtual machine can be start and stopped in case of network filter is not communicated to prevent security exploits. Network traffic between virtual machines can be monitored and tracked to prevent from the malicious traffic. Network administrator can define the ports

based rules for incoming and outing traffic to internal and external users. Like traditional firewall rules, v-firewall rules can also base on the source and destination IP, source and destination port.

Purpose of this architecture is to secure the communication between the virtual machines and to prevent it from external and internal malicious attacks and unwanted traffic.

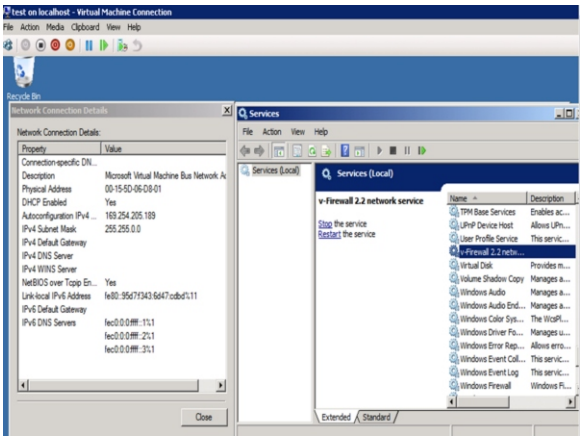


Fig. 4. DHCP Traffic Block

A . Simulation Setup and Environment

The level of access to each virtual machine is defined on the v-firewall rules. When the user access the virtual machine the traffic routes from the virtual-switch to the v-firewall before actually routing to the virtual machine and here decision has to be taken either to allow or block the traffic. All user activities are monitored and logged when user is accessing the resources of virtual machine. In this way, security layers has been added to virtual machines.

The activities of virtual machines are measured in the test environment and test environment has flowing requirement as shown in Table I.

Microsoft Hypervisor named hyper-V server 2008R2 with 4GB RAM with Intel core i5 processor used for simulation purpose. Two testing virtual machines with 4GB RAM, Intel core i5 processor and OS server 2008R2 are created on the same hypervisor. DHCP set to be enabled on both testing virtual machines in order to get the IP lease. We need to install the 5-nine virtual firewall manager on the hypervisor and agent need to be installed on the both virtual machines. By adding the virtual machines on virtual firewall manager block the incoming and outgoing traffic on the virtual machines due to agent. Agent by default blocks every traffic on the LAN card. Agent used heart beat services to communicate with the firewall manager. We need to manually add rules on virtual firewall manager to allow the required traffic on the every single virtual machine. Security between virtual machines can be enhanced by use of this agent. Only required protocol can be allowed on the virtual machine for secure communication to other virtual machine.

TABLE I
TEST ENVIRONMENT

Features	Vm1	Vm2	hypervisor
RAM	4GB	4GB	4GB
MODEL	Intel corei5	Inter corei5	Intel corei5
OS	Windows server2008 R2	Windows server2008 R2	Hyper-V server2008 R2
DHCP Enabled	YES	YES	YES

B. Results and Discussions

Test result measured by enabling the DHCP, ARP, TCP and ICMP (ping)protocol on the VM2 from the virtual firewall management console. We tried to communicate with the Virtual machine 2 using the ICMP protocol. We send the default 32 bytes packet of ICMP(ping) using the ping command on command prompt and get the reply from the virtual machine due to allowed rule on the manage console as shown in the Fig. 5. First of all when we tried to send the ICMP packet to the machine using the virtual machine IP, the traffic goes to virtual switch, virtual switch and v-firewall are bind together through the agent to inspect the incoming and outing traffic. Allowed incoming traffic should match the rule to communicate with the virtual machine.

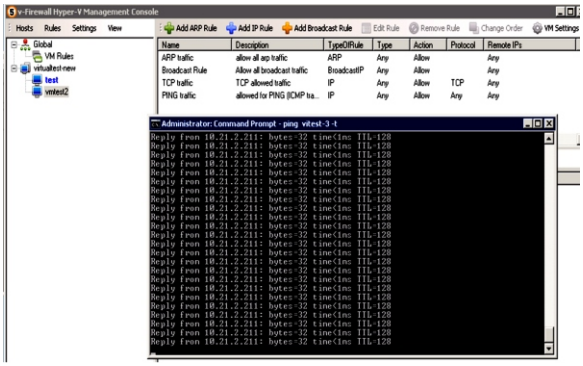


Fig. 5 Allowed Traffic

Another test result was measured by blocking ICMP (ping) protocol on virtual firewall rule so that any virtual machine on the network not able to send the ICMP or ping traffic to that machine as shown in the Fig. 6. After sending ICMP traffic to virtual machine from hypervisor, the output was “destination host unreachable”. When traffic arrives at the virtual switch which is bind with virtual firewall it checks the rule and dropped the traffic due to denied protocol ICMP rule. We can also block the incoming and outgoing traffic on source and destination IP addresses and also on the basis of source and destination ports. Most of the enterprise web application are bind to the specific ports or IP address, so traffic can be allowed or denied by use of these parameter in the firewall rule.

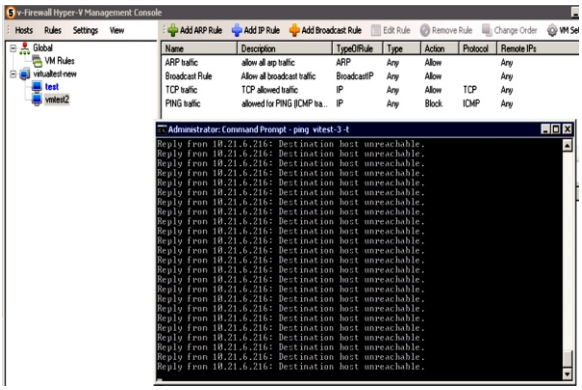


Fig. 6. Blocked Traffic

VIII. Conclusion and Future Work

In our security researched work, we present the security model for secure inter-VM communication in local and cloud environment. We tried to diminish the centralized workload from virtual machines and hypervisor. We present the security model which helps to overcome the security payload for cloud users and help them to minimize the risk of attacks in virtualized environment. We implement this model on the Microsoft Hyper-V hypervisor and calculates the results. Our future work focuses on the performance and scalability of this architecture on different platforms and hypervisors.

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Geotechnical Site Evaluation of Collapsed Margalla Tower in Islamabad due to October 2005 Muzzafarabad Earthquake

S. Shoukat[1], Z. U. Rehman[2], K. Mahmood[3], M. Ashraf[4]

[1]Civil Engineering Department, University of Hail, Saudi Arabia
[2,3,4]Civil Engineering Department, COMSATS, Abbottabad, Pakistan
[2]zrehman@ciit.net.pk

Abstract-This study evaluates the bearing capacity and settlement of collapsed Margalla Tower due to 2005 Muzzafarabad Earthquake. The geotechnical investigation was conducted at the site to investigate sub-surface profile and to and to evaluate bearing capacity and settlement analysis by field as well as laboratory tests. The soil sampling (disturbed and undisturbed samples) was done by 21 m borehole at the site. The grain size distribution and the electric resistivity test results showed that the soil beneath the tower was mainly clayey and silty soil. The shear wave velocity based on standard penetration test SPT-N value results showed a range of 175 to 350 m/s. S_D soil class was determined as per BCP 2007. The bearing capacity calculated by using laboratory as well as field test results showed a value of 253 kPa and 389 kPa at the raft foundation level. Similarly the settlement evaluation from laboratory as well as in-situ test showed 3.80 and 50 mm respectively and was within permissible limits. The geotechnical investigation reveals that the Margalla Tower was safe against bearing capacity and settlement.

Keywords-Geotechnical Investigation; Margalla Tower; Bearing Capacity; Settlement

I. Introduction

In 1992, Capital Development Authority Pakistan planned three sites for multistory buildings in Sector F-10/3 Islamabad. Among them one was Margalla Tower, situated in F-10 Sector Islamabad (33°42'1"N 73°0'33"E) having 10 stories with 60 luxurious residential apartments. The 2005 Muzaffarabad earthquake occurred at 08:50:39 Pakistan Standard Time on 8 October in the Kashmir region of Pakistan. The Muzafarabad Earthquake intensity was 7.6 and it was located 34.4 degrees North, 73.5 degrees East, about 90 km north-northest of target site. The fourth block and a portion of the fifth block of Margalla Tower Islamabad was destroyed due to this earthquake. There were 250 casualties, including foreign nationals. The collapsed tower is shown in Fig. 1.

Preliminary Investigation reports by CDA and Engineer in Chief (ENC) Branch Rawalpindi [i-ii] revealed that geotechnical investigation of this tower had flaws in it, i.e., there was no consolidation test performed although there was clay below ground level upto 8.3m and the water table was high. The unconfined strength of samples retrieved from shallow and higher depth was reported same which is contradictory. Whereas, strength of clay should improve with depth, The foundation is at 1.5 m while the weak upper strata of soil containing debris, roots and organic matter extends up to 2, 2.5 and 3.5 meters in three bore holes, Bearing capacity is 0.8 kg/sq cm.

Fig. 1. The Collapsed Margalla Tower Islamabad Pakistan

The foundation is to be placed between 2 to 3 m. The raft should be designed against bearing capacity of 1.3 kg/sq cm (vetting report of Margalla Tower by CES Pvt. Ltd.) [ii]. Letters from residents to CDA and C. C. C. Associates, reveal complaints of substandard material usage by consolidated Engineering Services.

Therefore the Geotechnical investigation of collapsed Margalla Tower in F-10 Sector Islamabad (33°42'1"N 73°0'33"E) [iii] was planned to investigate bearing capacity and settlement evaluation.

II. Geotechnical Investigation

The detailed investigation involved in-situ and laboratory testing of the collapsed Margalla Tower.

The field tests include standard Penetration test (SPT) and Electric Resistivity test (ERT). The layout of SPT and ERT is shown in Fig. 2 given below. SPT test was performed in the borehole The laboratory tests [iv-v] were conducted both on disturbed and undisturbed samples collected from a borehole at varying depth. The laboratory tests include moisture content [vi], Atterberg's limits [vii], soil classification [viii-ix], unconfined compression test direct shear test [x] and consolidation tests [xi].

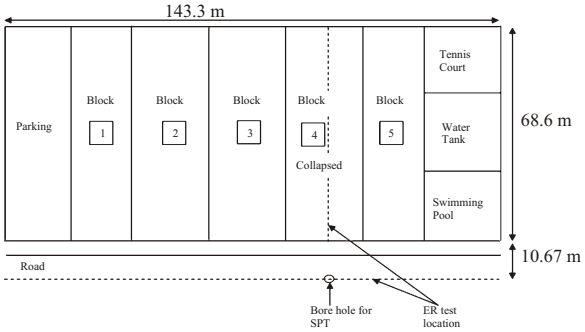

Fig. 2. The layout of Electric Resistivity Test at Margalla Tower

III. Results and Discussions

In the field work the standard penetration (N) values were calculated from SPT at different depth up to 20.5 m single borehole. These N values were then corrected for N_{60} as shown in Fig. 3. From the figure it is clear that the N_{60} values are low up to 12.5 meters, but after that there is an increase in value tremendously up to 25 m. This shows that the upper strata is weak and lower is strong.

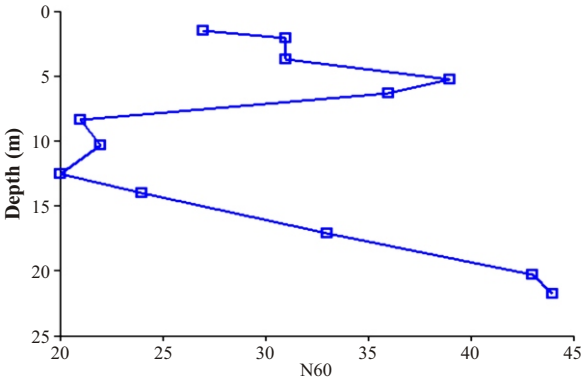

Fig. 3. Variation of N_{60} With Depth

The allowable bearing capacity based on SPT result was then calculated by using Mayerhof (N_{55} & N_{70}) and Das method at different depth of borehole [iv], [xii-xiii]. These results are shown in Fig. 4 (a, b) below.

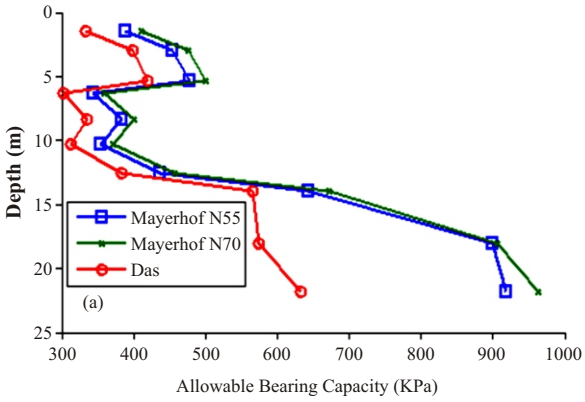

Fig. 4 (a). Allowable Bearing Capacity Based On Field Test

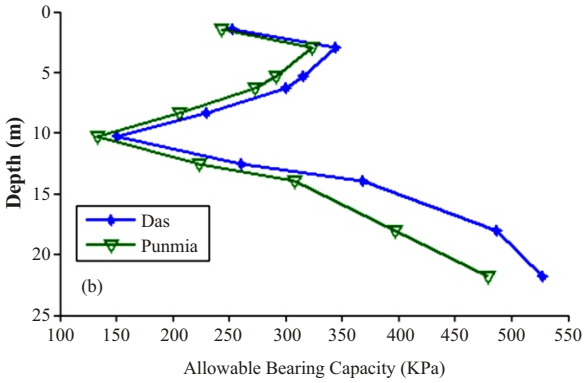

Fig. 4 (b). Allowable Bearing Capacity Based Laboratory Tests

The q_{all} from In-situ tests vary between 302.6 to 957.6 kPa and from laboratory test varies from 151.3 to 526.7 kPa. The recommended bearing capacity is 239.4 kPa. Similarly, by laboratory testing the variation of cohesion and friction angle along with the depth is shown in Fig. 5. These values show that for above 10 meter soil has a low angle of internal friction as well as cohesion indicating that an upper stratum is weak. The bearing capacity calculated from field test also indicates that the value is low for the upper stratum.

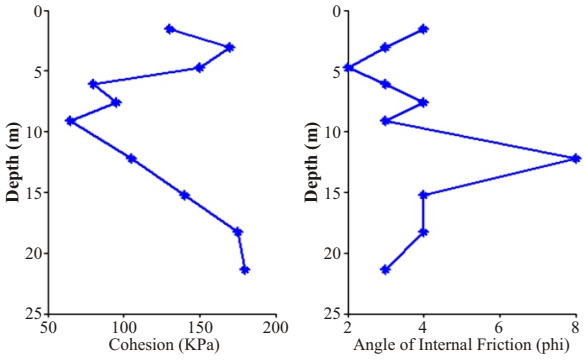

Fig. 5. Variation Of (A) Cohesion and, (B) Friction Angle With Depth

This allowable bearing capacity was also calculated based on Das and Punmia method [v xiv]. Using laboratory tests is plotted in Fig. 4b. From the Fig. 4 it is clearly shown that the allowable bearing capacity is low up to 10 m then it increases up to 25 m. The allowable bearing capacity is high from field tests as compare to laboratory tests.

After finding the static bearing capacity the dynamic bearing capacity of the soil is also figured out. We have following relations to find bearing capacity of soil. The use of equation depends on ratio of depth of footing (D_f) and width of foundation (B) i.e. D_f/B. with factor of safety of 3 the bearing capacity is calculated as under [xii].

$$q_{net\,(all)} = 1.71\, C_u \left[1+\frac{0.195B}{L}\right]\left[1+0.4\tan^{-1}\frac{D_f}{B}\right] ;\ \text{for } \frac{D_f}{B} > 1 \quad (1)$$

$$q_{net\,(all)} = 1.71\, C_u \times F_1 \times F_5 \quad (2)$$

Whereas F_1 and F_5 are,

$$F_1 = 1+\frac{0.195\,B}{L} \quad (3)$$

$$F_5 = 1+0.4\tan^{-1}\frac{D_f}{B} \quad (4)$$

$$q_{net\,(all)} = 1.71\, C_u \left[1+\frac{0.195}{L}\right]\left[1+0.4\frac{D_f}{B}\right] ;\ \text{for } \frac{D_f}{B} \le 1 \quad (5)$$

$$q_{net\,(all)} = 1.71\, C_u \times F_1 \times F_2 \quad (6)$$

Whereas F_1 and F_2 are,

$$F_1 = 1+\frac{0.195\,B}{L} \quad (7)$$

$$F_2 = 1+0.4\frac{D_f}{B} \quad (8)$$

$\frac{D_f}{B}$ is less than 1 so equation 5 is to be used. It is the same equation which is used to find out the static bearing capacity already manipulated.

The Electric Resistivity tests (ERT) were conducted along and parallel to Block 4 of Margalla Toweras shown in Fig. 2 above. The ERTresult parallel to the collapsed tower 4 is shown in Fig. 6 below.

It is clear from the Fig. that approximately 60 % stratum below the tower is soft material. Zones of high saturations were also marked. Trapped water (highly saturated zone) parallel to the underground water tank was found. This might be due to seepage from the underground water tank.

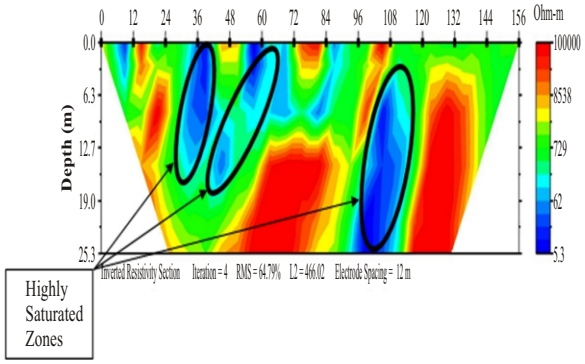

Fig. 6. Electric Resistivity Test (ERT) result of Margalla Tower

The soil classification according to Unified Soil Classification System (USCS) [viii] and American Association of Highway and Transportation Officials (AASTO) [ix] based on laboratory tests at different depth is given in TableI.

TABLE I
SOIL CLASSIFICATION BY UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

Depth (m)	Gravel (%)	Sand (%)	Silt & Clay (%)	Plasticity Index (%)	Liquid Limit (%)	USCS	Soil type	AASHTO	Soil type
1.5	0	11	89	5	16	CL-ML	Silty Soil	A-2-4	Silty or Clayey Soil
3.5	0	9	91	6	20	CL - ML	Silty Soil	A-2-4	Silty or Clayey Soil
8.5	0	7	93	12	23	CL	Clayey Soil	A-2-6	Silty or Clayey Soil
10.5	2	8	90	6	19	CL-ML	Silty Soils	A-2-4	Silty or Clayey Soil
14	1	9	90	8	28	CL	Clayey Soil	A-2-4	Silty or Clayey Soil
20.5	2	2	96	15	29	CL	Clayey Soil	A-2-6	Silty or Clayey Soil

From the AASTO and USCS soil classification system is it is clear that the soil is silty and clayey below ground level. Subsurface soil profile is shown in Fig. 7.

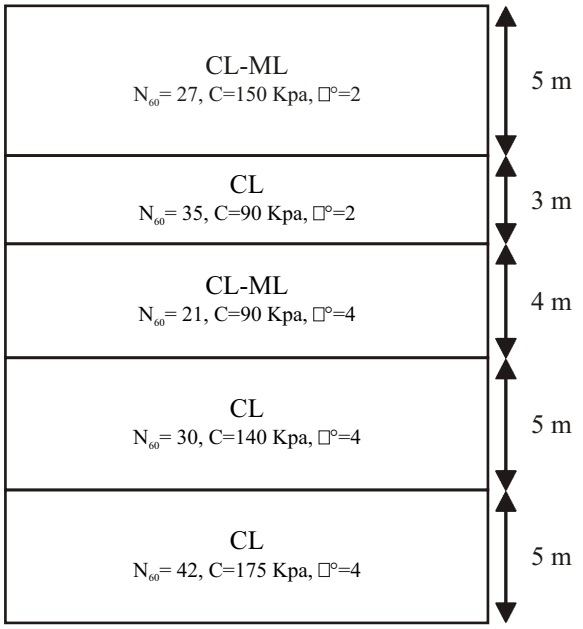

Fig. 7. Subsurface profile

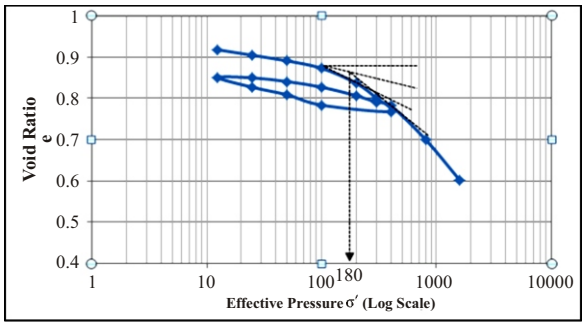

Fig.8. Void Ratio versus Effective Pressure (at 8.5 m)

The settlements were calculated at three clay samples obtained at respective depths and consolidation test was performed on these samples according to standard procedures using odometer apparatus. The laboratory test results were then used to plot graph between void ratio (e) and effective pressure to evaluate past maximum pressure ($\square_{\square}$) as shown in Fig. 8.

For under consolidated clay i.e., $\square_{\square}' + \Delta\square' > \square_{\square}'$ The equation 9 [v].

$$S_c = \frac{C_s H}{1+e_o} \text{Log} \frac{\sigma_c'}{\sigma_o'} + \frac{C_c H}{1+e_o} \text{Log} \frac{\sigma_o' + \Delta\sigma'}{\sigma_c'} \qquad (9)$$

Similarly, for over consolidated clay i.e., $\square_{\square}' + \Delta\square' < \square_{\square}'$ the equation 10 is used.

$$S_c = \frac{C_s H}{1+e_o} \text{Log} \frac{\sigma_o' + \Delta\sigma'}{\sigma_o'} \qquad (10)$$

The Table II shows the results of settlement of clay at three depths. The clay at 8.5 and 14 meters are under consolidated clays whereas the clay at 20.5 m is over-consolidated clay. These settlements were in the permissible limits (iv). It shows that the structure against settlement.

Schmertmann in 1970 proposed method based on SPT data to compute elastic settlement . To compute the settlement the soil below ground level was divided into five layers as shown in Fig. Each layer had a constant value of strain (ε) and soil modulus (E_s) by using equation 11.

$$E_S = 300(N + 6) \qquad (11)$$

The settlement was calculated by summing the influence of all layers.

TABLE II
RESULTS OF SETTLEMENT ANALYSIS

Depth (m)	e□	C_c	C_s	σ_c (kPa)	σ'□ (kPa)	Δσ' (kPa)	OCR	Settlement (m)
8.5	0.91	0.117	0.0117	180	128	60	0.95	0.0038
14	0.87	0.162	0.0162	190	280	38	0.59	0.061
20.5	0.64	0.171	0.0171	485	350	31	1.2	0.00076

TABLE III
DATA FOR CALCULATION OF ELASTIC SETTLEMENT

Layer	Elevation top (m)	Elevation bottom (m)	Δz (m)	I_{zp}	N_{60}	Es (kPa)	$\frac{I_{zp}\Delta z}{E_s}$
1	0	3.5	3.5	0.503	27	9863	0.00019
2	3.5	8.5	5	0.503	35	12300	0.00012
3	8.5	10.5	2	0.503	21	8100	0.00025
4	10.5	14	3.5	0.503	30	10800	0.00021
5	14	20.5	6.5	0.503	42	14400	0.00016
							$\sum \frac{I_z \Delta z}{E_s} = 0.00093$

$$\Delta H = C_1 C_2 \Delta q \sum \frac{I_z \Delta z}{E_s} \quad (11)$$

The following Table III shows the calculation of the $\sum \frac{I_z \Delta z}{E_s}$ at different depth.

$$\Delta H = C_1 C_2 \Delta q \sum \frac{I_z \Delta z}{E_s} \quad (12)$$

$\Delta H = 0.41 \times 1.44 \times 25 \times 0.00093$

$\Delta H = 0.01373$

$\Delta H = 13.73$ mm

Similarly the settlement against 50, 75, 100 and 125 kPa was calculated and shown in Table IV.

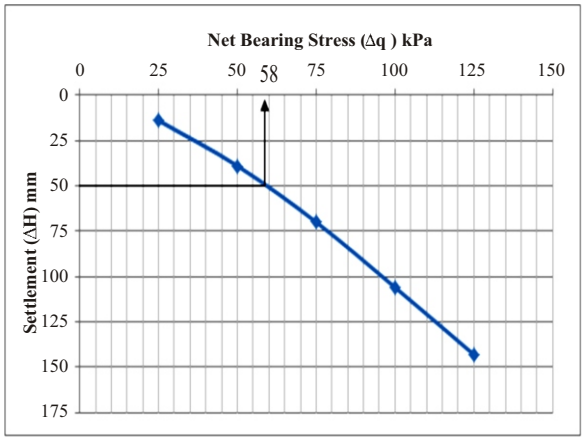

Fig. 9. Variation of Settlement with increase in Net Bearing Stress

TABLE IV
NET BEARING CAPACITY AND SETTLEMENT

Δq (kPa)	25	50	75	100	125
ΔH (mm)	14	39	70	106	143

The graph between net bearing capacity and settlement is shown in Fig. 9. The foundation of the Margalla Tower was kept at 1.5 m below ground level. The bearing pressure on the foundation was 84.58 KPa. Whereas the net bearing pressure under the footing was 56.8 KPa (unit weight of soil is 19.81 KN/m^3). The net bearing pressure (60 KPa) against 50 mm settlement was more than the applied net bearing pressure, i.e., 56.8 KPa under the foundation. Hence the Margalla tower was safe against settlement Shear velocity was calculated from observed N values based on the relationships of JRA 1980, Lee, 1990 and Imai et al., 1975 .

$$V_s = 100N^{0.33} \quad (13) \quad \text{[JRA]}$$

$$V_s = 114N^{0.31} \quad (14) \quad \text{[Lee 1990]}$$

$$V_s = 90N^{0.31} \quad (15) \quad \text{[Imai et. Al 1975]}$$

The variation of shear wave velocity and shear modulus is given in Fig. 10 (a, b). The Shear wave velocity calculated by three relations has average value of 337, 350 and 315 m/sec. These values fall in range of 175 to 350 m/sec. According to the building code of Pakistan the soil type is S_D which represents a Stiff Soil Profile [xv]. From these shear wave velocities the shear modulus was then calculated for known densities. The average values by JRA, Lee and Imai et al are 2348, 2629 and 2049 MPa, respectively as shown in Fig. 10 (a, b) below.

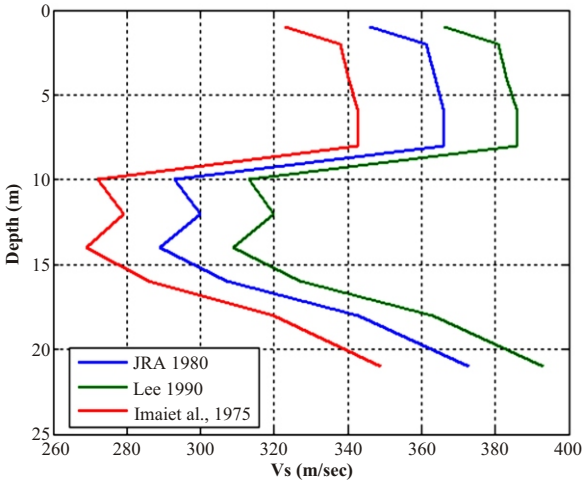

Fig. 10 (a). Variation of Shear Velocity with depth

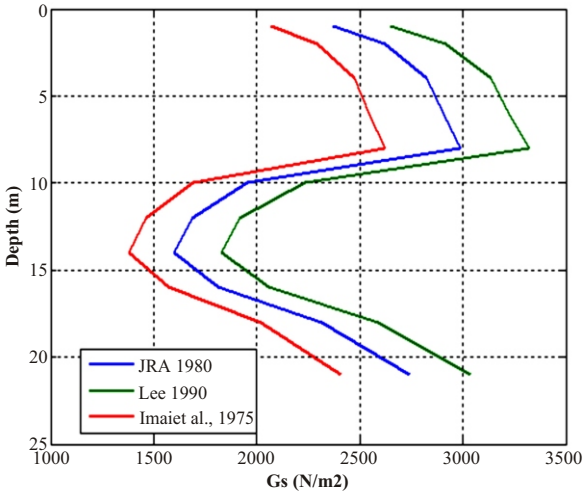

Fig. 10 (b). Variation of Shear Modulus with depth

IV. CONCLUSION

The initial geotechnical investigation reveals that there were alternate layers of clay and silty clay with some gravel. It was confirmed by AASHTO and USCS SOIL soil classification system. The soil classification was also confirmed with electric resistivity (ER) results.

The soil up to 10 m is weak that is why raft

foundation was suggested.

The average bearing capacity as calculated from the field test is 575. 94 KN/m^2 and from the laboratory tests is 386.10 KN/m^2.

The ERT result shows that there was seepage from the under -ground water tank which may be responsible for the decrease in in effective stress of the soil resulting in failure. .

The Schmertmann elastic strain method and consolidation test results showed settlement of 43 mm and 15.5 mm respectively. These values are within permissible limits for raft foundation. The Margalla Tower was thus safe with respect to settlement analysis.

The Shear wave velocity, thus calculated by three relations has an average value of 337, 350 and 315 m/Sec. These values fall in the range of 175 to 350 m/Sec indicating soil class S_D as per building code of Pakistan.

In short the evaluation of geotechnical parameters carried out in this research reveals that Margalla Tower was safe against bearing capacity and settlement. The soil stratum below Margalla Tower is firm and stiff non problematic soil. The failure was might be due to structural flaws. However, Authors would like to mention here that, the conclusions reached in this manuscript are based on bearing capacity and settlement analysis, further research on this topic like finite element modeling of building and earthquake loads during the shaking can refine the conclusions.

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Burnt Coal Treatment to an Industrial Wastewater Containing Dyes

S. M. Laghari[1], Z. M. Ali[2], A. J. Laghari[3], M. M. Tunio[4]

[1]Civil Engineering Department, Universiti Teknologi Petronas, Malaysia
[2]Chemical Engineering Department, MUET- Jamshoro, Pakistan
[3]IARSCS/ Hi-Tech Labs, University of Sindh, Jamshoro, Pakistan
[4]Energy & Environment Engineering Department, QUEST Nawabshah
[2]zeenat.ali@faculty.muet.edu.pk

Abstract-Waste material of coal or burnt coal in the form of fly ash is continuously being accumulated up to the tune of millions of tons per annum. In present study burnt coal was collected from coal powered generation house, characterized, converted into adsorbent material and utilized against industrial dye waters. Efficiency of burnt coal was checked as an adsorbent using optimum dose of 4g/L, and reduction of COD (54%), color (76%), turbidity (72%) and TSS (98%) from dye wastewaters was observed. The adsorptive capacity of burnt coal was declined when adsorbent dose was increased

Keywords-Waste, Coal, FlyAsh, Dye, Optimum, Dose

I. INTRODUCTION

Textiles industries are main consumer of dyes. The related industries of dyes and textile are producing toxic material of 100 tons directly dumped annually into canals and estuaries [i]. The production worldwide and consumption reached over $7*10^5$ tons annually of 10000 types of dyes [ii, iii]. Therefore the huge quantities of water became contaminated. The activated carbon produced from Jatropha curcas husk used for removal of toxic, anionic dyes and heavy metal and organic matter from water. The Jatropha curcas husk is the biodiesel industry waste. [iv]. It has been reported that dye wastewater is rich in color, turbidity, pH, chemical oxygen demand (COD), biological oxygen demand (BOD), temperature, acids, transition metals, alkaline and toxic chemicals [v]. Dye production decides physico-chemical parameters of wastewater [vi]. Thus it creates lots of environmental pollution issues on its discharge [vii]. The examination of effluent, discharged from dyes manufacturing plant content high load of COD, BOD and aromatic hydrocarbon. It was rich in acidic dyes, and metal complexes. On the surface of effluent the suspended matters were also floating. It was noted that conventional methods were less effective to decontaminate the effluent completely. The unchecked drain of untreated contaminants could have damaging effect for human and animal life, spoil underground water and affect fertility of soils. Physico-chemical as well as biological process efficiency varies according to the temperament and complexity of industrial effluents. Adsorption process of activated carbons depends upon specific surface area, and pore size [viii]. Waste in the form of coal fly ash from coal based power plants during combustion of coal is collected from coal fuel boilers with the help of electrostatic precipitators, creating serious problems for environmental and its safe disposal [ix]. The coal fly ash production worldwide is about 600 million tones. Whereas studies suggest Pakistan possesses coal reserves of 3,362 millions tones and Lakhra coal reserves are 1328 million tones. In FBC power plant at Khanote, with ash generation up to 55680 m^3/hr [x-xi]. In case of sugarcane Pakistan produces estimated 48000 million tones per annum, from which 13,384 millions tones bagasse production and 0.5 millions tones of fly ash production was achieved in 2009 [xii]. Fly ash has good porous structure and adsorption capacity therefore increased use is observed for production of low cost fly ash for removal of aromatic compounds [xiii], transition metals [xiv] dyes [xv] and organic contaminants [xvi]. Present research was carried out study low cost fly ash treatment efficiency to reduce parameters such as; COD, turbidity, color, and TSS from effluents of industrial dyes.

II. MATERIALS AND METHODS

Adsorbents prepared from coal fly ash samples were examined for dyes effluent treatment for reduction of organic pollutants. Different types of coal ash samples were obtained from Lakhra Power Generation Company Limited, Jamshoro. However bagasse fly ash of sugarcane was obtained from Matiari Sugar Mills (Pvt) Limited, at Matiari.

TABLE I
MATERIAL COMPOSITION OF CFA, BBCA, CCA AND SBFA

Ash Type	LIO(%)	SiO_2(%)	Al_2O_3(%)	Fe_2O_3(%)	CaO(%)	MgO(%)	SO_3(%)
Coal Fly Ash	14.48	23.61	14.09	9.15	22.89	2.71	13.13
Bottom Coal Ash	6.65	3.37	16.41	24.95	10.77	0.61	6.25
Cinder Coal Ash	3.10	38.54	29	18.32	6.20	1.91	2.94[12]
Sugarcane Bagasse Fly Ash	13.45	74.69	3.60	4.9	2.56	0.69	0.11[17]

A. Preparation of Carbon (Activated) Adsorbent from Coal Ash

Coal and sugarcane bagasse fly ash samples were ground with disc pulverizer, (type 1025 W, MFC No.8375, Yoshida Seisakusho Co. Ltd Tokyo Japan) at 560 rpm. Grinded fly ash samples were sieved at 290 rpm speed on RO-Tap Type Sieve shaker (Japan).

B. SEM Analysis of Fly Ash Adsorbents

Surface morphology and porosity of raw and prepared adsorbent fly ash samples was carried out by scanning electron microscope (SEM) (JSM-6380, JEOL, Japan) in Mining Engineering Department Advanced Research Laboratory, Mehran University of Engineering and Technology, Jamshoro. Fly ash SEM at 5 kV used for surface morphology of raw and fly ash adsorbents (i, ii).

C. Analysis and Treatment of Dyes Effluent by Adsorption

Dye samples were collected from Jamshoro dyes manufacturing plant effluent discharge and were checked for water quality. Effluent samples were checked for COD using dichromate kit method COD vial (Merck Company, Germany), and spectrophotometer (DR-2000, Hach U.S. A) with COD program option 435 and 620 nm wavelength . Color, turbidity and TSS of dyes effluents observed via absorptiometric method at 455 nm, 450 nm and 810 nm wavelengths respectively.

III. RESULTS AND DISCUSSIONS

Sorption is specific and influenced by its physicochemical properties of fly ash samples such as; pore size, surface area and chemical composition whereas alumina, iron and silica oxides in fly ash work as stable coagulants in reducing contamination concentration Table I. However, sugarcane bagasse combined with fly ash showed more surface area and porosity than simple coal ash, resulting in more adsorption capacity for contamination removal but not with simple coal fly ash. It confirms that smaller particle size with more specific surface area, promotes adsorption. In present study effluent dyes 100mL sample when treated with prepared fly ashes for removal of effluent pollutants at dose variations, it was concluded that SBFA adsorbent showed reduction in effluent chemicals as COD, turbidity, TSS and color Table II. Adsorptive capacities at dosage of 2g/100mL was found to be the optimum dose required to carry out study, however increasing adsorbent dosage from 2g does not improve adsorption efficiency (ii).

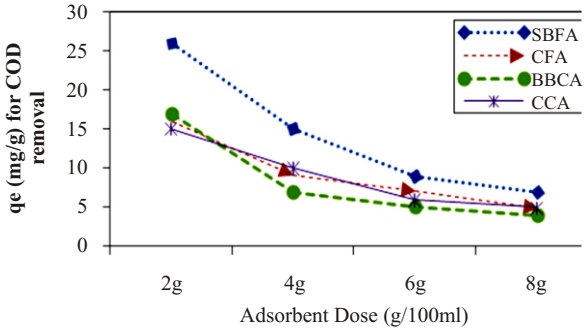
TABLE II
FLY ASHES ADSORBENTS DOSAGE EFFECTS IN SORPTION OF INDUSTRIAL EFFLUENT POLLUTANTS

COD Adsorption%					Color Adsorption%				Turbidity Adsorption%				TSS Adsorption%				
Dose	**SBFA**	**CFA**	**BCA**	**CCA**	**SBFA**	**CFA**	**BCA**	**CCA**	**SBFA**	**CFA**	**BCA**	**CCA**	**SBFA**	**CFA**	**BCA**	**CCA**
2g	44	37	34	39	48	46	44	39	68	88	48	41	24	89	87	65
4g	51	39	43	34	70	45	39	53	71	46	40	54	93	89	88	91
6g	48	48	40	37	59	48	48	46	63	51	48	49	87	81	89	91
8g	49	49	42	35	56	53	51	51	61	55	53	53	96	92	87	90

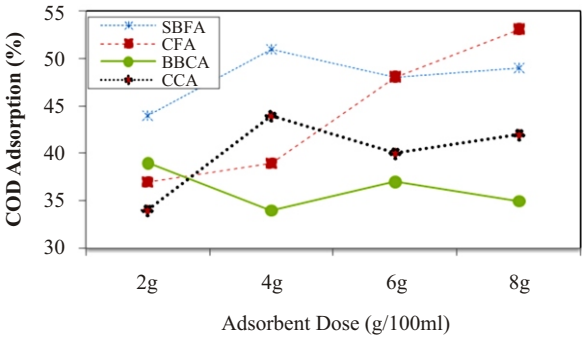
TABLE III
FLY ASH ADSORBENTS DOSAGE EFFECT ON THE ADSORPTIVE CAPACITY FOR INDUSTRIAL EFFLUENT POLLUTANTS REMOVAL

COD Adsorptive capacity (mg/g)					Color Adsorptive capacity(mg/g)				Turbidity Adsorptive capacity(mg/g)				TSS Adsorptive capacity(mg/g)				
Dose	**SBFA**	**CFA**	**BCA**	**CCA**	**SBFA**	**CFA**	**BCA**	**CCA**	**SBFA**	**CFA**	**BCA**	**CCA**	**SBFA**	**CFA**	**BCA**	**CCA**
2g	29	18	18	16	97	118	113	99	29	24	23	22	6	19	18	14
4g	17	11	9	12	66	59	52	68	15	13	12	15	9	11	9	10
6g	11	8	6	9	36	44	42	39	9	7	8	9	6	7	7	8
8g	9	6	4	6	26	37	33	31	5	7	6	7	3	5	5	4

The initial COD levels in effluent dyes were 1171 mg/L, when 100 mL sample treated at dose variations, the reductions in COD up to 54% at 4g dose of SBFA and 50% removal rate at adsorbent dose 8g of CFA was achieved. (39%) COD removal was observed with 2g BCA dose, CCA dose of 4g resulted in 44% COD removal was observed Fig.2 (b). Effect on pH not observed range was under NEQS.



(a)



(b)

Fig. 1. Adsorptive capacity of fly ashes for dyes effluent COD removal at dose variations

Dyes effluent samples contained 1280 FTU level of turbidity when treated showed removal efficiencies of 71% for SBFA and 53% for CCA respectively observed with dosage of 4g each, whereas 55% CFA and 53% BCA at dosage of 8g showed removal in turbidity of wastewater

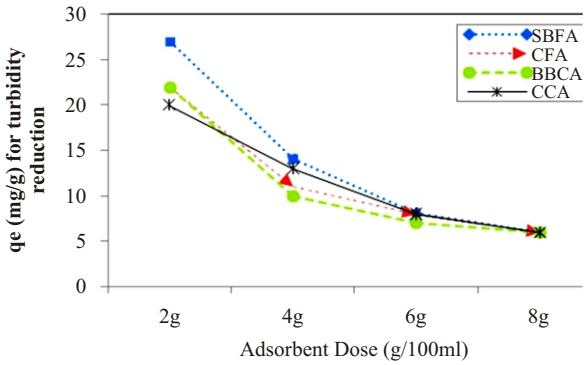


Fig. 2. Adsorptive capacity (mg/g) of fly ash adsorbents for dyes effluent turbidity reduction

Concentration of total suspended solids (TSS) in effluent dye samples stood at 349 mg/L. the wastewater solutions when subjected to 8g dosage and 30 minutes contact time, the removal efficiencies were 96%, 92%, 87% and 91% for SBFA, CFA, BCA and CCA respectively [Fig.2]. During present research work Langmuir and Freundlich isotherm models were examined and concluded that Freundlich model was suitable for effluent dyes adsorption by use of coal fly ash.

IV. Conclusion

Examination of individual and combined fly ashes regarding adsorption studies against effluent dyes resolved it to be effective reductant for COD, turbidity, color and TSS. Observation of reduction in COD (49%, 37%, 44% and 51%), turbidity (55%, 53%, 54% and 71%), color (53%, 51%, 53% and 70%) and total suspended solids (92%, 87%, 91% and 96%) using CFA, BCA, CCA and SBFA respectively.

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Nomenclature

COD: Chemical Oxygen demand

TDS: Total Dissolved Solids

TSS: Total Suspended Solids

CFA: Coal FlyAsh

SBFA: Sugarcane Bagasse FlyAsh

BBCA: Bottom Based Coal Ash

CCA: Cinder Cinder Coal Ash

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