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Section A

CIVIL, ENVIRONMENTAL, ARCHITECTURE, TRANSPORTATION ENGINEERING, CITY AND REGIONAL PLANNING

Relaxing the Planning Standards of Housing Scheme: An Approach to Enhance Affordability of Poor

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Abstract-Affordable housing is growing as major concern in the world with incremental increase in urban population and substandard provision of housing for low income sector. We can diminish housing shortage by Improving bidding power of poor for housing. Household income and expenditures are directly influential towards housing cost, so there is a need of little compromised standards for low income housing scheme. Different low cost housing scheme projects which were initiated, previously, could not serve their foremost purpose. The research attempts to chalk down planning standards which can be compromised meaningfully, in order to lower down cost of land for housing schemes by reviewing the planning standards for private development schemes in Punjab. Findings of the research shows that an increased saleable area and less housing unit cost estimates are the effective ways, which can contribute significantly to achieve objectives of low income housing.

Keywords-Affordable Housing, Planning Standards, Low Income Housing Scheme, Compromised Standards for Housing Scheme, Saleable Area, Housing Unit Cost.

I. INTRODUCTION

Global housing crisis involving inaccessibility to affordable housing is experienced by most of the countries across the world. Almost 1.6 billion people are suffering by substandard housing, whereas around 100 million are homeless. Reference [i] shows that every week, there is an increment of one million in urbanized population of developing nations. The accounting factors for this gradual increase are fertility rate and migration. Urban slums carry 32% global urban population that means nearly 1 million people across the world do not have housing facilities that are enough for their basic household needs. United Nations forecasts that if the same scenario continues, the number of slum dwellers will be doubled in next 30 years worldwide [i]. The Human Development Index (HDI) estimates that "60.3% of Pakistan's population lives on under $2 a day" [ii]. It clearly exhibits the situation that economic reach of more than half of the population of Pakistan does not allow them to afford a house due to high land prices and construction rates.

Urban planning agencies have formulated standards and regulations for housing schemes [iii] but they are not conforming to affordable charges for proper housing to the citizens that includes appropriate sanitation, drainage, availability of green spaces and utilities. Several housing schemes are designed; especially in southern part of Lahore which unfortunately are not playing any significant part as low cost housing schemes. It can rightly observe that the focus of private developers are high income group of the population. Therefore, there is a need to pay focus on improving the bidding power of low income people. It is practicable by allowing flexible planning standards for low income schemes which results into lowering housing prices. There is urgent need to devise solution to this problem.

The population growth rate in cities exceeds the national growth of 1.8% to 3%. With this substantial escalation in population, it is estimated that by 2030, almost 2/3rd of population will reside in the urban centers. Considering this, the World Bank has attributed a housing backlog of 7.6 million in Pakistan out of which 2/3rd represents low income demand having a monthly earning of less than Rs.12000 [iv]. The Integrated Master Plan Lahore (IMPL) states that formal housing supply of the city is not more than 2500 plots annually. "The proportion of house construction to the total plots in some LDA's schemes is 16% to 20%" [v]. This percentage is changed in private cooperative housing schemes which is 10.2%. High land value, costly plot construction, land speculation, inadequate facilities in housing scheme, lack of transport services and ineffective building control are the summarized causes which infer this disproportion [vi].

It is evident from the above discussion that problem of poor housing; in terms of both quality and affordability; is spread across the world particularly in Pakistan. Although planning authorities are working, but no viable solution has been delivered yet to the

practical implementation. People are facing serious problems and their affordability level is continuously dwindling day by day. This paper gives an insight at this conundrum in the Lahore context and advocates ways in which poor people can be economically and spatially integrated into low income housing schemes. A feasible way to achieve this is the introduction of flexible building regulations according to needs of the living community. This relaxation and zoning for building regulations for low cost housing schemes can help to achieve a sustainable growth of society, as it would be perfectly complying with the financial needs of people.

The research aims on devising an elucidation to lower the cost of housing unit which eventually improves bidding power of poor segment of population. In order to provide sufficient facilities, it is compulsory to ascertain space demands in a dwelling unit. The financial aspects of housing standards are required to be analyzed. The comparison of space standards of housing schemes; to make it affordable; is also another objective of the research.

II. Literature Review

A. Affordable Housing and Planning Standards

"Affordable housing refers to housing units that are affordable by that section of society whose income is below the median household income" [vii]. Household means a family living under the same roof, interacting with each other and using one kitchen for their needs. Several countries define affordable housing in their own way as per their planning developments but the actual spirit of the idea remains same as it delivers the housing needs of middle income and/ or low income sector of society. Affordable housing is a crucial matter of subject in developing countries as majority of population in such countries resides below poverty line and cannot afford to buy a house at the market price.

Reference [viii] claims that there are three types of urban poor in his book *Housing in the Modern World.* The first group of urban poor developing cities consist of street-sleepers and homeless people. Slum dwellers and high housing rent payers or tenants are encompassed in second group. Last but not least, the third group consists of people living in shanty towns and squatters. "The term 'low-income housing' is used in the present account to cover all types of housing for the poor in Third World cities" [viii].

The prime factor affecting the housing affordability is the income of a household. Reference [ix] states that middle income households spend their one-quarter income on housing; whereas the expenditures increase up to half of the income in case of low income households. Such high proportions refer to the fact that housing sector and betterment of households is greatly influenced by change in rents and housing prices. Also, the affordability is largely dependent upon distribution trends of household incomes in terms of expenditures. It explains the importance of this trend on inflating housing costs and rent burden over the poor households. [ix].

The overall policy prioritization and associated housing needs vary from place to place; the prompting factors could be history of particular area, housing market situation and political interference. In today's era, with high growth rate and shortage of housing supply, the first priority is to provide housing stock in market to overcome the growing backlog. But with minimal housing demand and high rate of vacant lots it is deduced that there is no need for new housing blocks; rather urban renewal with financial assistance is required to low paid households to support their housing expenditures. Different neighborhoods, municipalities, metropolitan areas and cities differ with their specific needs of their housing needs and scenarios. Thus, for harnessing better response from community and to have their input, it is necessary to have such strategies and policies devised which set well in the local needs and political conditions of that area [x].

Affordable housing can also be explained as that it provides housing varieties in terms of sizes according to the economic needs of society. Moreover, this housing has appropriate urban design, the finest quality of life and preservation and enactment of local heritage and culture. Another quality of affordable housing development is achievement of sustainability in terms of social, environment and economic character [xi].

Land use regulations are quite influencing over housing sector. Reference [xii] describes that land use rules and regulations serve as the best tool in shaping markets of housing. They also regulate certain housing type as per that by encouragement or prohibition through local byelaws. These regulations also indirectly manage land tenure system, rents and pricing in housing sector.

B. Housing Schemes Planning Standards Evaluation

The design and planning standards of housing schemes are needed to be amended in multiple views. The rules are extremely rigid and supposed to be same for different areas. Although different areas have different types of peculiar characteristics and hence same regulations are not applicable in all scenarios. Different people have different opinions in this regard. Most of the planners have viewpoint to change these building regulations.

The regulations for design and standards of housing schemes are formulated on the similar grounds by the Government Authorities. As a major concern, these authorities have no discrimination for standards for low income housing schemes. Sometimes developers fail to comply with the given standards in order to satisfy the housing needs of community. The reference [xiii] suggests that simple relaxations in

design standards of a housing scheme, 25% reduction in price of a serviced plot can be achieved. This alteration does not require any kind of modern low cost construction methods and techniques for price reduction as well.

A study has been conducted for accessing the comparative analysis of public and private housing for low income people in Lahore [xiv]. In the study they inquired from private developers about cutting the cost of developing of housing schemes and provision of plots for low income people as compare to housing schemes with bigger sized plots. The developers do not agree with idea that lowering of infrastructure standards would much reduce the development cost. "The provision of brick paved streets; open drains etc. would reduce the cost only about 20%, because it would involve more development charges for the increased length of services and wastes of land. They are of the view for above narrated reason of preference, the reduction of the much cost cannot entice the low income people to purchase plots in these schemes" [xiv].

C. Assessment of Low Income Housing Schemes In Lahore

Low income housing schemes in Lahore were prepared in order to provide better housing facilities to the poor households. The housing schemes prepared in this context include Lahore Township Scheme, Khuda Ki Basti and Ashiana Housing Project. All these schemes were housing projects initiated by government so the prescribed standards for housing schemes were strictly followed in scheme plan preparation. Somehow, no scheme was considered as a success milestone for provision of affordable and low income housing scheme. The assessment of reasons behind failure of these low income housing schemes is as following:

- The eligibility criteria for allotment in such projects were not completely fulfilled. In case of Ashiana House, it was fulfilled up to 85% rather than 100%
- Transparent system for allotment verification has not been ensured in low income housing schemes. Several people residing in the housing scheme belong to high income group that is contradiction of the policy of Govt. of Punjab [xiii].
- Car ownership rate of the Ashiana Housing Scheme is considerably high. The fact implies that many people that have been allotted plots do not belong to low income group of society. As people can afford to own a car so they are not really low income [xiii].
- The financial resources of the third world countries are not enough to meet the requirements of low income housing provisions. Therefore, whatever, resources are channeled into the present sites and services schemes, they are indirectly transmitted to the higher income groups [xv].
- The standards adopted in the present sites and services schemes are high and consequently they attract the higher income groups [xv].
- Due to social habits and economic conditions of low income people, they sell their plots (if they are the fortunate allottes) at high prices to the middle or high income people and revert to the slums and Katchi Abadis [xv].
- The building control regulations practiced in these projects don't give freedom to build according to the gradual affordability of low income households [xv].

These all clearly indicate that the present role of the state is oppressive rather than being supportive to the low income group. Therefore, the need of the day is that a more supportive role of state should be adopted for shelter provision.

III. Materials and Methods

The research is carried out by formulating two scenarios to exhibit the difference between adoption of prescribed standards by the public authorities and relaxation in planning standards for housing schemes. In the first scenario, defined as Scenario-I, a housing scheme plan is prepared according to design and planning standards of Private Housing Schemes Rules (2014). Whereas, the second scenario, Scenario-II, is housing scheme plan that is prepared upon compromised standards.

The low income people do not have many savings and resources to have a house; they need low cost for shelter of their family. Several housing projects have been done in this regard but are not considered successful. Hence, the research examines the benefits for preparation of low income housing schemes by using compromised standards.

The comparative analysis of the prepared schemes have been done on the basis of space standards. Moreover, cost analysis with respect to salable area is carried out to analyze the economic benefits from a scheme. The economic benefits include lesser housing unit cost for the poor households and increase in saleable area of housing scheme that is beneficial for the scheme developers.

Here the term saleable area refers to the area that can be sold by the developer in a housing scheme. The salable area majorly includes residential and commercial area. Whereas, a developer is not allowed to sale out area for public buildings, green spaces, roads and graveyard.

IV. Analysis and Discussions

In this research, two scenarios have been prepared which have the following characteristics:

Scenario-I: Planning of Housing Scheme According to Private Housing Schemes Rules, 2014

This scenario presents a low income housing scheme according to proposed standards of the Lahore Development Authority Private Housing Schemes Rules, 2014. According to these rules, the proposed standards for housing scheme is summarized as:

TABLE I
PROPOSED STANDARDS FOR HOUSING SCHEME BY PRIVATE HOUSING SCHEMES RULES (2014)

Sr. No.	Land-Use	Standard
1	Commercial	Max. 10%
2	Graveyard	Min. 2%
3	Public Buildings	4% to 10%
4	Open Spaces	7.0% or above
5	Roads	Approach Road: Min. 150' Internal Road: Min. 30'

In the light of the standards given in Table I, a Katcha Kana road as a location is selected for the planning of housing scheme. The identification of boundary of scheme is contemplated by Google map. The total area of the site was kept 1500 Kanal. The residential plots are assumed to be 3 Marla in the whole scheme for the rightful comparison with scenario II. There are exception of few corner plots which are slightly more or less than 3 Marla. The prepared scheme has roads of minimum 30 feet. Open spaces are kept as 7% of the total area of the scheme. These standards give residential area of 48.6% approx. (Fig. 1) The land-use breakup of Scenario-I is shown in Table II.

TABLE II
LAND-USE BREAKUP SCENARIO-I

Sr. No.	Land-Use	Area (Kanal)	Percentage
1	Residential	729	48.6%
2	Commercial	33	2.2%
3	Graveyard	30	2.0%
4	Public Buildings	40.5	2.7%
5	Open Spaces	106.5	7.0%
6	Roads	561	37.4%
TOTAL		1500	100%

Scenario-II: Planning of Housing Scheme by Compromising Standards

In Scenario-II, a housing scheme has been prepared by lowering the standards. This scheme is also drawn up at an area of 1500 Kanal and comprised of 3 Marla plots for residential purpose (Fig. 2). The standards are compromised in a technical manner which will be discussed in following paragraphs, so that they can provide affordable housing to the people on relatively lower costs. This housing scheme aims to increase the saleable area to provide more number of housing units that eventually results in decreasing the development charges. This phenomenon also serves as an incentive to the developer to get more profit out of it. Following is the land-use breakup for the Scenario-II in Table III.

TABLE III
LAND-USE BREAKUP SCENARIO-II

Sr. No.	Land-Use	Area (Kanal)	Percentage
1	Residential	900	60.0%
2	Commercial	33	2.2%
3	Graveyard	25	1.7%
4	Public Buildings	52	3.5%
5	Open Spaces	92.7	6.2%
6	Roads	397.3	26.5%
TOTAL		1500	100%

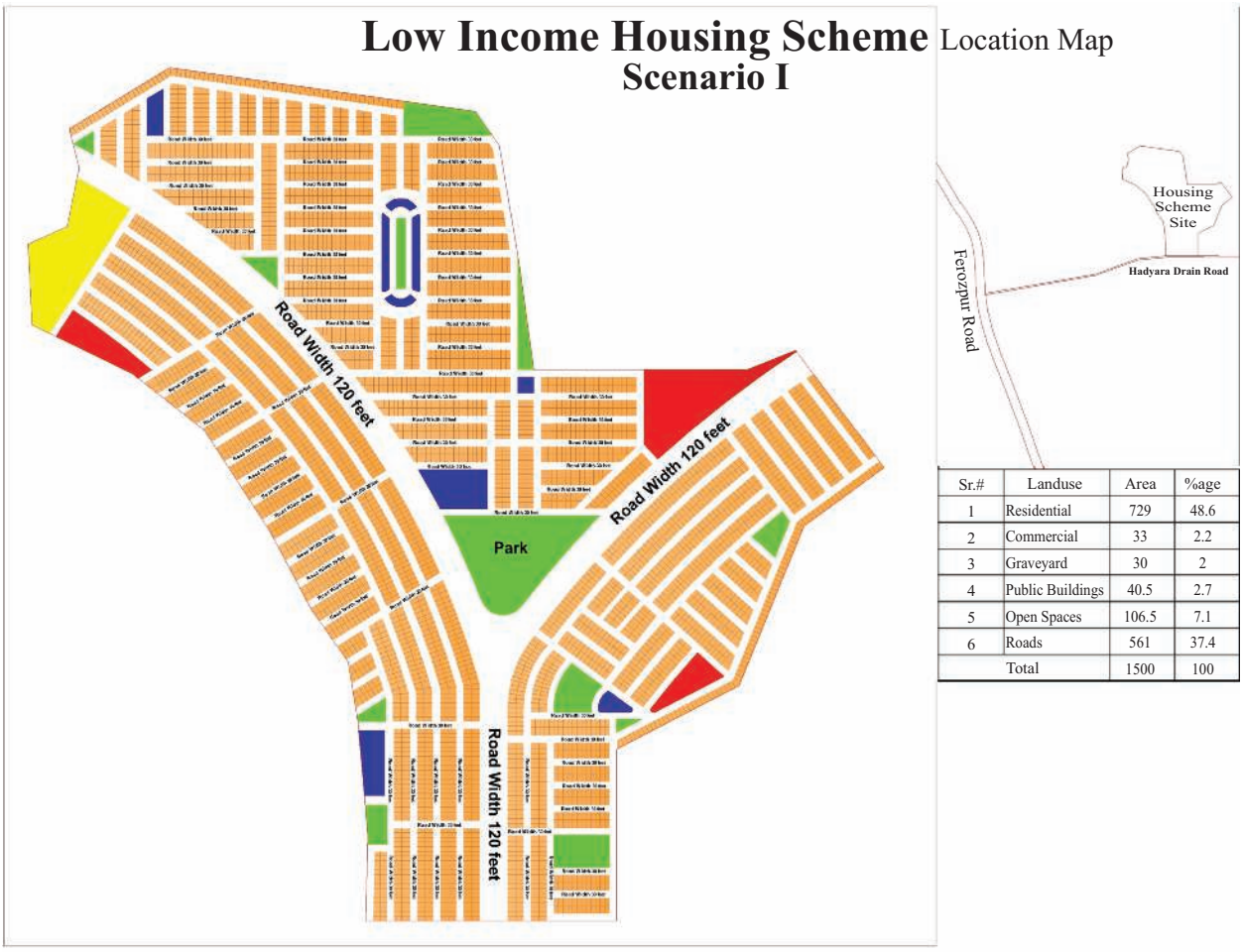
A. Comparative Analysis Of Space Standards Of Housing Schemes

The scheme has been prepared by covering technical aspects of planning. In order to increase the saleable area, the local roads have given the maximum width of 20 feet. This road width although is considered less than as per given standards but it is sufficient for needs of low income people conferring to researchers' insight. According to National Reference Manual (NRM) standards, the local access roads should have almost 7.5 m (approx. 22 ft.) carriage way for 2 way traffic. The boulevards are kept 60 ft. wide in terms of right of way in scheme. It is also as per NRM standards that consider Local Distributor Roads as 15-20 meter (approx. 50 to 65 ft.) wide right of way [xvi]. These boulevards can also be used as bus routes as well.

The area of open spaces has also been decreased up to max 6.2%. On the other hand, the open spaces and parks are designed according to the factor of accessibility. The green spaces enhance the aesthetic character of the scheme efficiently. The area for utility services are assumed to be same according to standards. The increase in saleable area and housing units will ultimately increase the per unit density as well. This situation calls for sufficient provision of services to community, henceforth, the area for public buildings is increased in housing society.

The prime objective behind this scheme preparation is to provide clean and healthy environment to the low income community. In the shape of such housing scheme, as in Fig. 2, the poor can also relish the pleasures of a planned urban settlement in affordable charges. The poor people can get permanent shelter and raise their living standard as well by improving their socio-economic conditions. The

provision of housing to low income people will also tend to decrease the housing backlog. The promotion of planned community offers greater benefits in terms of development as well.

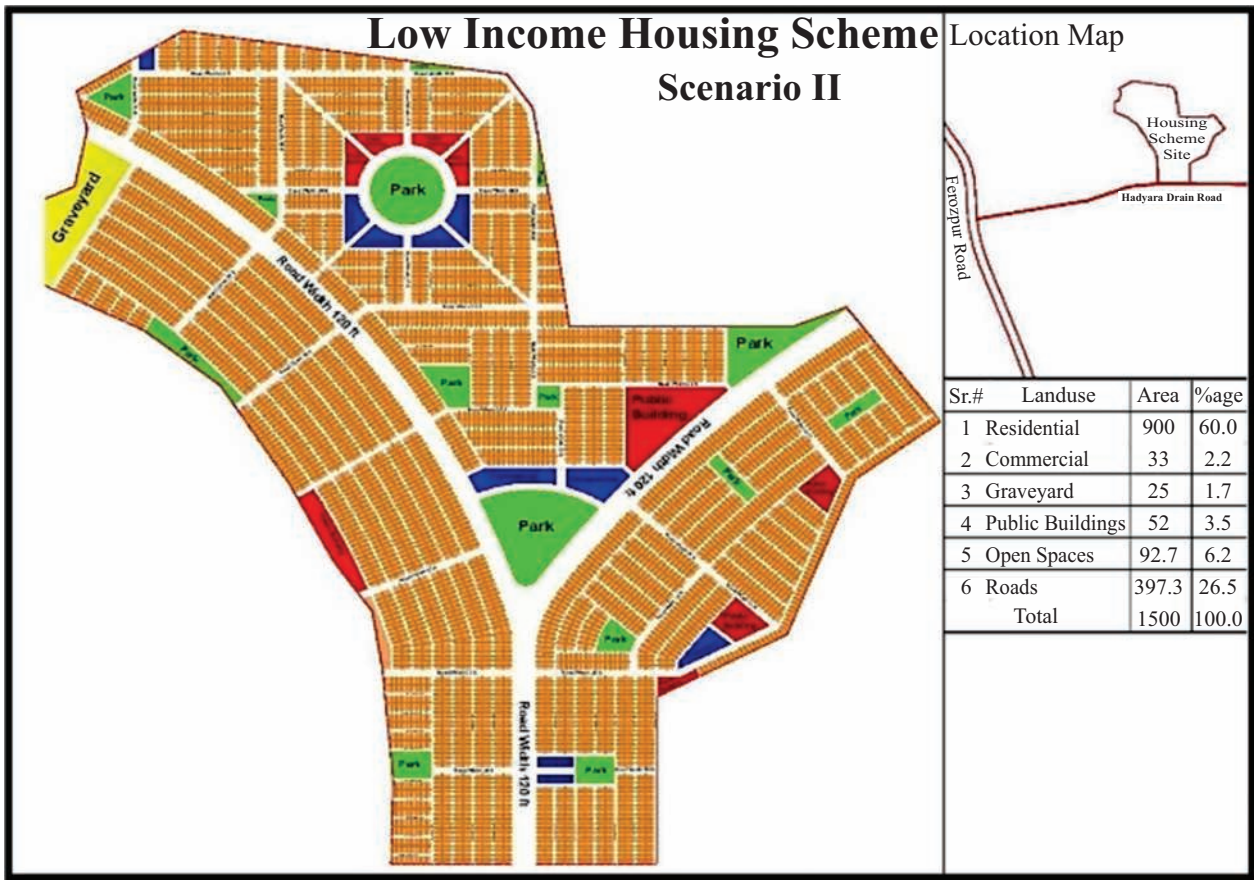


Sr.#	Landuse	Area	%age
1	Residential	729	48.6
2	Commercial	33	2.2
3	Graveyard	30	2
4	Public Buildings	40.5	2.7
5	Open Spaces	106.5	7.1
6	Roads	561	37.4
	Total	1500	100

Fig. 1. Housing Scheme Based upon Scenario-I

B. Salable Area Comparison and Cost Analysis of Scenario-I & Scenario-II

The comparison of increased saleable area with reference to its cost is the key to measure of success among both scenarios. As a matter of fact both housing schemes have same area of 1500 Kanal (187.5 Acre); with same price of 50, 00,000/- PKR per Acre or 125,000/- PKR per Marla. In scenario-I, as discussed earlier, the saleable area is less than compared to Scenario-II based upon compromised standards. The Scenario-II has 22.36% more salable area than Scenario-I. The costs are estimated by using standard costing methods referred by Urban Developers and Bahria Town. The comparison of both schemes in terms of saleable area and cost given in Table IV:



Sr.#	Landuse	Area	%age
1	Residential	900	60.0
2	Commercial	33	2.2
3	Graveyard	25	1.7
4	Public Buildings	52	3.5
5	Open Spaces	92.7	6.2
6	Roads	397.3	26.5
	Total	1500	100.0

Fig. 2. Housing Scheme Based upon Scenario-II

TABLE IV
COST ANALYSIS SCENARIO-I AND SCENARIO-II

Aspect	Cost in Scenario-I Per Marla in PKR	Cost in Scenario-II Per Marla in PKR	Change in Cost in Scenario-II
Saleable Area	61,475/-	50,241/-	18.27% Less
Roads	33,167/-	12,941/-	60.98% Less
Parks	344/-	249/-	27.61% Less
Water Supply	6,885/-	5,627/-	18.27% Less
Sewerage	12,787/-	10,450/-	18.27% Less
Electrification	14,754/-	12,058/-	18.27% Less
Advertising & Marketing	984/-	804/-	18.29% Less
3 Marla Plot	405,944/-	289,169/-	28.76% Less
Constructed House (3 Marla)	865,047/-	748,272/-	13.49% Less

V. CONCLUSIONS AND RECOMMENDATIONS

The provision of low income housing is not appropriate in local scenario. Therefore, this research aims to find out economical ways for management of low income housing for poor. The available uniform standards for housing schemes are tested in two scenarios by making two plans of low income housing scheme in which one conforms to established standard and other is based upon compromised standards. It is found that the relaxation in housing scheme standards will bring economic benefits not only for the poor but also for the developer.

The research, principally, determined that the low income housing schemes, which were prepared with compromised standards, had 22.36% increased saleable area as compare to a low income housing scheme which was prepared according to the standards. Furthermore, a housing scheme which was prepared with compromised standards had less cost estimates in terms of land, roads, parks and other necessities along with advertisement & marketing. A constructed house on such scheme had 13.49% less cost than on a scheme prepared in accordance with standards as in Table IV.

extremely stringent, rigid and same for different areas, despite the fact that different areas have different peculiar characteristics; hence same regulations are not applicable in all scenarios.

Following are some recommendations on the basis of conclusions of the research:

- The Public Authorities should establish separate set of housing scheme standards for low income housing schemes. These standards should be implemented under the supervision of regulatory agencies of government.
- Developers must be given incentives to deliver low income housing as per low income house space requirements. These incentives could be provision of less value mortgage, shared management of public buildings, provision of ease in approval process and aid in marketing & advertisement.
- The development charges should be decreased in low income housing schemes to benefit the bidding power of the poor and increase the affordability level.
- The space standards and building regulations should be revised and prepared according to peculiar characteristics of each zone for maximum compliance. The amortization plans should be prepared according to the affordability and biding capacity of low income people.

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Managing Storm Water Runoff of a Housing Scheme Employing Low Impact Development Techniques

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***Abstract*-**Development practices have directly impacted natural hydrological cycle and resulting in storm water flooding scenario as it is happening in southern Lahore. Low Impact Development Techniques (LIDs) such as Bioretention Cells, Rain Gardens, Rain Barrels, Porous Pavements, Infiltration Trenches and Green Roofs etc are the mitigation measures to compensate such disturbance in hydrological cycle. This research broadly encompasses utilization and significance of LIDs in efficient control of storm water runoff and reducing flooding problems in one of the rapidly developing area of Lahore. Land use and rainfall data of study area was collected and analyzed for preparation of IDF curves in order to analyze and predict rainfall distribution pattern in the study area. After that EPA's Storm Water Management Model SWMM 5.1 was used to carry out storm water management studies by designing a storm water drainage network of the study area and for assessing significance of LIDs. Model results exhibited that there is about 54.68% reduction in quantity of storm water runoff along with 51.29% increase in soil infiltration rate. Similarly, LIDs (chiefly rain barrels) provided water storage of about 1.455 acres feet. This depicted that LIDs are not only fruitful in efficient management of storm water runoff but also contribute towards groundwater recharge and water conservation.

***Keywords*-**Storm Water Management, Low Impact Development Techniques (LIDs), SWMM 5.1, Storm Water Management Modeling, Flooding and Ponding, New Lahore City Housing Scheme, Lahore.

I. Introduction

With the passage of time in all over the world including Pakistan, the development practices are increasing day by day thus subsequently increasing the impervious areas. Similarly, in Lahore and especially in southern region, the pace of development works/urbanization is extraordinary and about 250 private housing schemes have been approved by Lahore Development Authority (LDA) on agricultural lands up till now and the figure is still increasing. As a result broad scale urban areas flooding have been occurring in the said area during the last many decades and situation is also cumbersome in many other urban areas of Pakistan. Storm water management authorities (such as Water and Sanitation Agency, WASA) are facing severe problems and are going into crisis situation. The main reason behind such enlarged and recurrent flooding is urbanization and increased pervious surfaces such as rooftops, driveways, walkways, paved streets and parking areas are the components in modern urbanization which contribute in larger quantities of storm water flow. Similarly unplanned development in Lahore is also resulting in severe flooding in different areas of city, possessing the greater rate of growth and maximum land cost. Due to limited space and financial issues, the capacities of the existing drainage system (e.g. storm sewers and drains) cannot be restored. On the other hand, no appreciable effort has been made to assess the impacts of new development on the existing drainage network and hence it further complicates the situation.

Therefore, in order to cope with the said difficulties and especially for the topographic, geographical conditions that Lahore region have, proper storm water management techniques are required such as LIDs. Keeping in view the aforesaid key factors, this study has been planned with an aim to:

a. Evaluate the significance of different LID (Low Impact Development) techniques in better control and management of storm water runoff.
b. Propose most appropriate storm water management system for avoiding the chances of flooding.

II. Background

Over the years, many research works have been done for storm water management using Storm water management model and employing LIDs some of the important are:

SWMM was used for simulating runoff and nutrient export from a LID water shed located at Long

Island, Connecticut, USA and it was found that LID practices have storm water flow control benefits even for larger return periods storms [i].

LID techniques were used for four sites at Florida, USA and it was observed that LID design reduced the need for conveyance infrastructure and found to be a cost effective approach in development sector [ii].

A study was conducted on a development site of Fort Collins, Colorado, USA using EPA SWMM in order to investigate the significance of Low Impact Development (LID) Techniques in managing urban storm water runoff and restoring pre-development site hydrology. Four LID techniques such as grassed swales, Rain gardens, infiltration trenches, permeable pavements were used for managing storm water runoff and it was found that LIDs are beneficial in managing urban storm water runoff and restoring pre-development hydrology [iii].

Hydrological modeling of the little Crum creek watershed, Pennsylvania was carried out with SWMM. The purpose of the study was to analyze quantity and some characteristics of the quality of the water in Crum Creek Watershed for periods of rainfall between summers, 2008 to spring; 2009.The authors observed that SWMM Model can be used to find the changes occurred in stream flow as a result of change in land use. They also found that SWMM most accurately models runoff in upper part of water shed and can be used for steam rehabilitation by targeting sites with high peak flows runoff volumes or TSS concentrations [iv].

Hydrologic evaluation of Low Impact Development techniques was carried out using a continuous spatially distributed model such as SWMM 5.1 on a 4.3 acres water shed at village near Virginia Tech Campus, USA. It was concluded that LIDs if managed properly offers substantial benefits towards reducing runoff volume and pollutant loads. LID practices such as bioretention cell, dry swales, green roofs can reduce runoff volumes, peak flows, pollutant loads even further what obtainable [v].

Hence, several studies have been carried out in recent past in various different countries regarding the management of runoff quantity or quality using Storm Water Management Model with or without application of LIDs, however in fact no study has yet been conducted in Pakistan regarding significance of various Low Impact Development Techniques (LIDs) such as Rain gardens, Bioretention cells, Infiltration trenches, Permeable pavements, Rain barrels, Green roofs etc in managing storm water runoff by using latest version of Storm water management model 5.1 with LID editor.

III. Model Description

Storm Water Management Model (SWMM 5.1) developed by EPA of USA in 1971 has taken a important position among various hydrological models for dynamic rainfall runoff modeling of single occasion or long term continuous simulation of runoff quantity and quality from principally urban areas. SWMM 5.1 consists of two portions i.e. runoff portion and routing portion. Runoff component works on collection of storm water runoff from various subcatchments as a result of precipitation whereas, routing component of SWMM 5.1 transports it through system of conduits, channels, storage/treatment devices, pumps and regulators. SWMM 5.1 has also LID control editor for Low impact development studies of any area. SWMM 5.1 accounts for various hydrological processes such as time varying rainfall, evaporation, snow accumulation and melting, rainfall interception, depression storage "dp", infiltration of rainfall, percolation of infiltrated water into ground. Interflow between ground water and drainage system, non linear reservoir modeling etc. Surface runoff occurs when depth "d" of water in reservoir exceeds depression storage "dp"[vi]. Conceptual view of runoff used by SWMM 5.1 can be depicted in Fig.1.

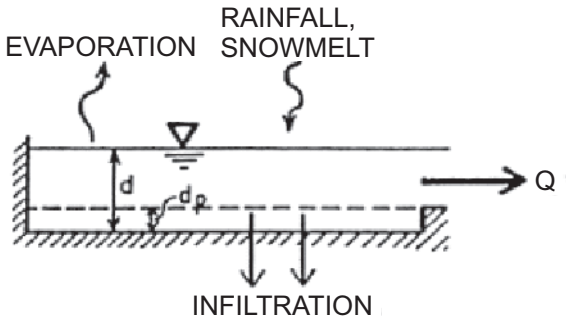

Fig.1.Conceptual view of surface runoff used by SWMM 5.1[vi]

IV. Study Area

The study has been conducted on New Lahore city Housing scheme which was approved by LDA in the year 2012 as per LDA building byelaws. New Lahore City (NLC) Housing Scheme is located on the eastern bank of Lahore branch canal between Bahria Town and Sunder Road. Fig.2 shows location of the scheme.

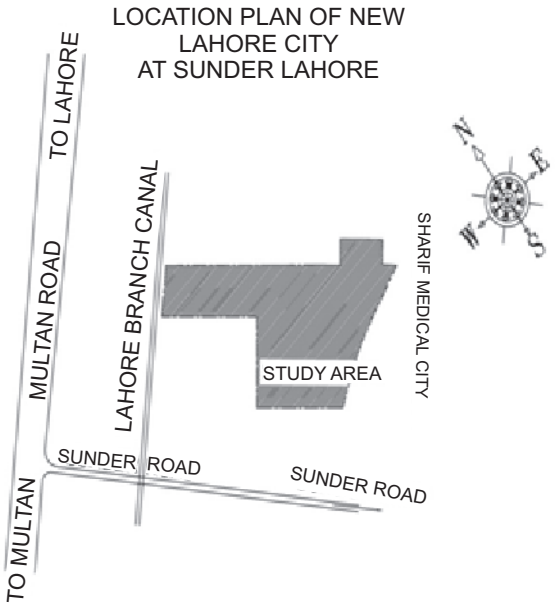

Fig.2. Location plan of the study area

The topography of New Lahore city housing scheme from mean sea level (MSL) does not vary much with reduce levels ranging from 682.043ft to 677.343ft at extreme ends. The area where this housing scheme is located is semi arid in nature with mean annual rainfall ranging from 20 inches to 25 inches. The housing scheme consists of less pervious area and located in one of the densely urbanized area of Lahore that's why it faces ponding issues during monsoon seasons. Table I gives description about the land use conditions of the housing scheme.

TABLE I
LAND USE DESCRIPTION OF NEW LAHORE CITY HOUSING SCHEME (NLC)

S.N	Land Use	Area (kanal)	Percentage Distribution
1	Residential	113.26	40.16
2	Roads	99.10	35.14
4	Parks	27.34	9.69
5	Public buildings LDA	3.66	1.30
6	Public buildings sponsor	13.58	4.82
7	Commercial and Parking	17.35	6.15
8	Grave yard	7.04	2.50
9	Solid waste Management	0.70	0.25
	Total	282.03	100

V. Low Impact Development Techniques

Low Impact Development (LID) techniques are the most comprehensive techniques used for the efficient management of storm water runoff. They were first prepared in 1999 by Prince George county Maryland, Dept of Environmental Resources.LID approach combines a hydrological functional site design with an aim to restore pre-development site hydrological conditions along with pollution prevention measures by reducing land development impacts on hydrology and water quality [vii].

Some of the well known LID techniques that have been used in the research work are:

- Bioretention Cells
- Rain Gardens
- Infiltration Trenches
- Permeable Pavements
- Rain Barrels
- Green Roofs

VI. Data Collection

The collection of metrological data of study area such as rainfall record and pan evaporation data was the first step towards carrying out research work. As there was no rain gauging station at the study area hence rainfall record of past years for study area was collected from Pakistan Metrological Department (PMD), Pilot Balloon Observatory (PBO) station Jail road, Lahore which was nearest rain gauging station to the study area. Three hourly rainfall records up to 12 hrs along with 24 hourly rainfall records (1953-2015) of PBO Station Jail road, Lahore were collected (Table II). The data also contained some missing rainfall records from 1971-1973.Similarly in past, PBO station had the facility of autographic rainfall recorder for rainfall record of shorter durations which is not being practiced now a day. Hence rainfall record of shorter durations (15, 30, 60 and 120) minutes along with 3hrs rainfall duration data for about 20 years was also collected from PBO station Jail road from 1940-1987 as shown in Table III. However, rainfall record for many years was missing in between 1940-1987. This shorter duration data is helpful in preparation of IDF curves even for shorter durations of rainfall against desired return periods. It's unfortunate to say that recording practice of smaller durations of rainfall via autographic rainfall recorder is not now being carried out by PMD since last many years. Hence, through interpolation and trend line analysis between 3hrs and shorter durations of 15, 30, 60, 120 minutes rainfall, filling up of rainfall record for years 1953-2015 was carried out. By doing this practice, rainfall data for shorter (15, 30, 60 and 120minutes) as well as longer durations (3, 6, 9, 12, 24

hours) from 1953-2015 was available. As the longer durations rainfall data i.e. of 3, 6, 9, 12 and 24 hrs rainfall was not available from 1940-1952, hence rainfall record from 1953-2015 could only be used for frequency analysis and preparation of IDF curves of study area. Mean monthly evaporation values of study areas shown in Table IV as well as reduce levels of study area were also collected. The infiltration values of study area were decided on the basis of NRCS Runoff Curve number method depending on percentage of pervious and impervious area, soil type and land use conditions of each subcatchment [viii]. As per soil strata of study area Group-C soils were selected for deciding infiltration values. Composite curve numbers calculated on the basis of land use, and pervious and impervious conditions of each and every subcatchment were determined as per requirement of the model to be feed in infiltration editor of SWMM.

A. Frequency Analysis Of Rainfall

After collection of all the rainfall record from 1953-2015 and pan evaporation data, the next step was the frequency analysis of rainfall data i.e. determination of return periods for different durations of rainfall ranging from 15 minutes to 24 hrs rainfall data (1953-2015). In order to do the same, Weibull (1939) method was used. Frequency analysis is helpful in finding probability of occurrence of past and future events of rainfall.

According to that:

$$T_r = \frac{N + 1}{M} \quad (1)$$

Where, Tr = return periods of rainfall.
N = total no of years
M = rank of different durations of storms when arranged in descending orders.

After calculations of return periods for different durations of rainfall using Weibull (1939), graphs were plotted to develop relationship between return periods and different durations of rainfall such as (15, 30, 60, 120) minutes and (3, 6, 9, 12 and 24) hours. Similarly, trend lines were drawn to select best fitted trend line on the basis of R-Square values. By using trend line equations, it became possible to calculate rainfall magnitudes and intensities against 2, 5, 10, 25 and 50 years return periods as shown in Table V. By utilizing data of Table V, Intensity Duration Frequency (IDF) curves of the study area were prepared from 1953-2015 as depicted in Fig. 3.

TABLE II
COLLECTED RAINFALL DATA (1953-2015)

Year	Rainfall Data (1953-2015) (inches)				
	3Hrs	6Hrs	9Hrs	12Hrs	24Hrs
1953	5.24	5.36	5.36	5.36	5.36
1954	8.06	8.06	8.06	8.07	8.99
1955	2.71	3.41	4.55	4.57	4.58
1956	2.59	2.61	2.61	3.17	3.19
1957	1.43	1.83	2.37	2.97	3.68
1958	4.19	4.39	4.39	6.16	8.08
1959	4.18	4.26	4.39	4.42	4.94
1960	1.76	1.76	1.76	1.76	1.76
1961	1.71	1.71	2.09	2.17	2.18
1962	3.03	3.24	3.25	3.47	3.47
1963	1.15	1.16	1.41	1.41	2.60
1964	2.79	3.0	3.96	4.52	7.88
1965	1.56	1.73	1.73	1.73	1.73
1966	0.58	1.06	1.23	1.53	1.95
1967	1.12	1.12	1.88	1.94	2.03
1968	2.83	2.88	2.88	2.88	2.88
1969	4.61	4.65	4.87	4.87	4.87
1970	1.43	1.74	1.74	1.94	1.97
1974	1.43	1.48	1.66	1.66	1.66
1975	1.67	2.01	2.75	2.75	2.75
1976	5.83	6.73	7.29	7.62	8.32
1977	2.38	2.75	2.97	3.11	3.39
1978	3.35	3.75	3.75	3.75	3.75
1979	1.51	1.92	2.23	2.23	2.23
1980	2.92	4.7	6.55	8.08	8.17
1981	2.81	4.42	4.95	4.95	4.95
1982	1.53	1.88	1.88	2.31	2.67
1983	3.34	3.54	3.54	3.54	3.70
1984	1.59	1.59	1.65	1.71	2.40
1985	1.44	2.99	2.99	2.99	4.63
1986	1.51	2.36	2.36	2.36	2.58
1987	2.34	2.34	2.34	2.34	2.34

1988	1.40	2.20	2.20	2.23	3.04
1989	0.94	1.24	1.52	1.52	1.52
1990	2.43	2.60	2.60	2.60	3.28
1991	2.10	2.42	2.62	2.74	2.99
1992	1.93	2.23	2.41	2.52	2.75
1993	1.53	1.76	1.91	1.99	2.18
1994	1.37	1.58	1.71	1.79	1.95
1995	2.13	2.46	2.66	2.78	3.03
1996	3.28	4.62	5.8	6.92	7.48
1997	1.70	2.52	3.29	4.03	5.96
1998	2.33	2.33	2.33	2.33	2.33
1999	3.30	3.45	3.48	3.48	3.48
2000	2.18	3.32	4.1	4.34	4.34
2001	2.96	3.44	3.44	3.44	3.44
2002	1.10	1.17	1.17	1.17	1.17
2003	1.75	3.32	3.32	3.32	3.32
2004	2.29	2.29	2.29	2.29	2.29
2005	5.09	5.40	5.40	5.40	5.40
2006	3.26	3.60	3.86	4.09	4.52
2007	0.80	1.35	1.60	1.71	1.94
2008	1.98	2.43	2.69	2.85	3.18
2009	0.80	1.35	1.60	1.71	1.94
2010	3.53	3.85	4.11	4.35	4.80
2011	2.18	2.62	2.87	3.05	3.39
2012	3.08	3.44	3.70	3.91	4.33
2013	5.41	5.58	5.83	6.16	6.77
2014	4.88	5.09	5.35	5.65	6.22
2015	2.11	2.55	2.80	2.97	3.31

TABLE III
SHORTER DURATION RAINFALL DATA (1940-1987) WITH MISSING RAINFALL RECORDING YEARS

Year	Rainfall Data for Shorter Durations (in)				
	0-15 Mins	0-30 Mins	0-60 Mins	0-120 Mins	3Hrs
1940	0.90	1.66	2.06	2.06	2.21
1942	0.35	0.67	1.00	1.41	2.18
1949	0.23	0.28	0.33	0.42	0.53
1950	0.21	0.41	0.71	0.99	1.69
1956	0.43	0.80	1.43	2.23	2.59
1957	0.30	0.38	0.38	0.62	1.43
1959	1.12	1.86	2.24	2.60	2.71
1960	0.51	0.91	1.25	1.47	1.76
1965	0.48	0.51	0.51	0.88	1.56
1966	0.27	0.42	0.44	0.49	0.58
1970	0.31	0.56	0.87	1.29	1.43
1974	0.41	0.80	1.36	1.41	1.43
1978	1.31	2.61	2.99	3.16	3.35
1980	0.80	1.19	1.90	2.57	2.92
1981	0.52	0.95	1.16	1.81	2.81
1982	0.60	0.98	1.41	1.57	1.57
1983	0.80	1.55	2.45	3.04	3.34
1984	0.40	0.75	0.76	1.43	1.59
1985	0.40	0.80	1.19	1.35	1.44
1987	0.40	0.72	1.03	1.03	2.34

TABLE IV
PAN EVAPORATION DATA FOR STUDY AREA

S. No	Months	Mean Monthly Pan Evaporation Rates (in)
1	January	1.40
2	February	1.72
3	March	3.13
4	April June	4.34
5	May	5.54
6	June	6.10
7	July	5.12
8	August	4.49
9	September	3.95
10	October	2.67
11	November	2.17
12	December	1.43

TABLE V
RAINFALL MAGNITUDES AND INTENSITIES FOR DEVELOPMENT OF IDF CURVES OF THE STUDY AREA

Rainfall Duration (minutes &hrs)	***Trend line Equations**	**Return Periods (years)**	**Rainfall (in)**	**Rainfall Intensity(in/hr)**
15 Minutes (0.25Hrs)	$R_m=0.262+0.440\ln(T_r)$ $R^2 = 0.986$	2	0.567	2.268
		5	0.970	3.881
		10	1.275	5.101
		25	1.678	6.713
		50	1.983	7.933
30 Minutes (0.5Hrs)	$R_m=0.390+0.875\ln(T_r)$ $R^2 = 0.985$	2	0.997	1.993
		5	1.798	3.597
		10	2.405	4.810
		25	3.207	6.413
		50	3.813	7.626
60 Minutes (1 Hr)	$R_m=0.535+1.182\ln(T_r)$ $R^2 = 0.985$	2	1.354	1.354
		5	2.437	2.437
		10	3.257	3.257
		25	4.340	4.340
		50	5.159	5.159
120 Minutes (2 Hrs)	$R_m=0.746+1.388\ln(T_r)$ $R^2 = 0.985$	2	1.708	0.854
		5	2.980	1.490
		10	3.942	1.971
		25	5.214	2.607
		50	6.176	3.088
3 Hours	$R_m=1.018+1.574\ln(T_r)$ $R^2 = 0.984$	2	2.109	0.703
		5	3.551	1.184
		10	4.642	1.547
		25	6.085	2.028
		50	7.176	2.392
6 Hours	$R_m=1.394+1.602\ln(T_r)$ $R^2 = 0.983$	2	2.504	0.417
		5	3.972	0.662
		10	5.083	0.847
		25	6.551	1.092
		50	7.661	1.277
9 Hours	$R_m=1.521+1.748\ln(R_p)$ $R^2 = 0.989$	2	2.733	0.304
		5	4.334	0.482
		10	5.546	0.616
		25	7.148	0.794
		50	8.359	0.929
12 Hours	$R_m=1.518+1.966\ln(T_r)$ $R^2 = 0.995$	2	2.881	0.240
		5	4.682	0.390
		10	6.045	0.504
		25	7.846	0.636
		50	9.209	0.767
24 Hours	$R_m=1.638+2.232\ln(T_r)$ $R^2 = 0.983$	2	3.185	0.133
		5	5.230	0.218
		10	6.777	0.282
		25	8.823	0.368
		50	10.370	0.432

***Note:** In trend line equations, Rm= rainfall magnitude (inches) and Tr = return periods of different storms (years).

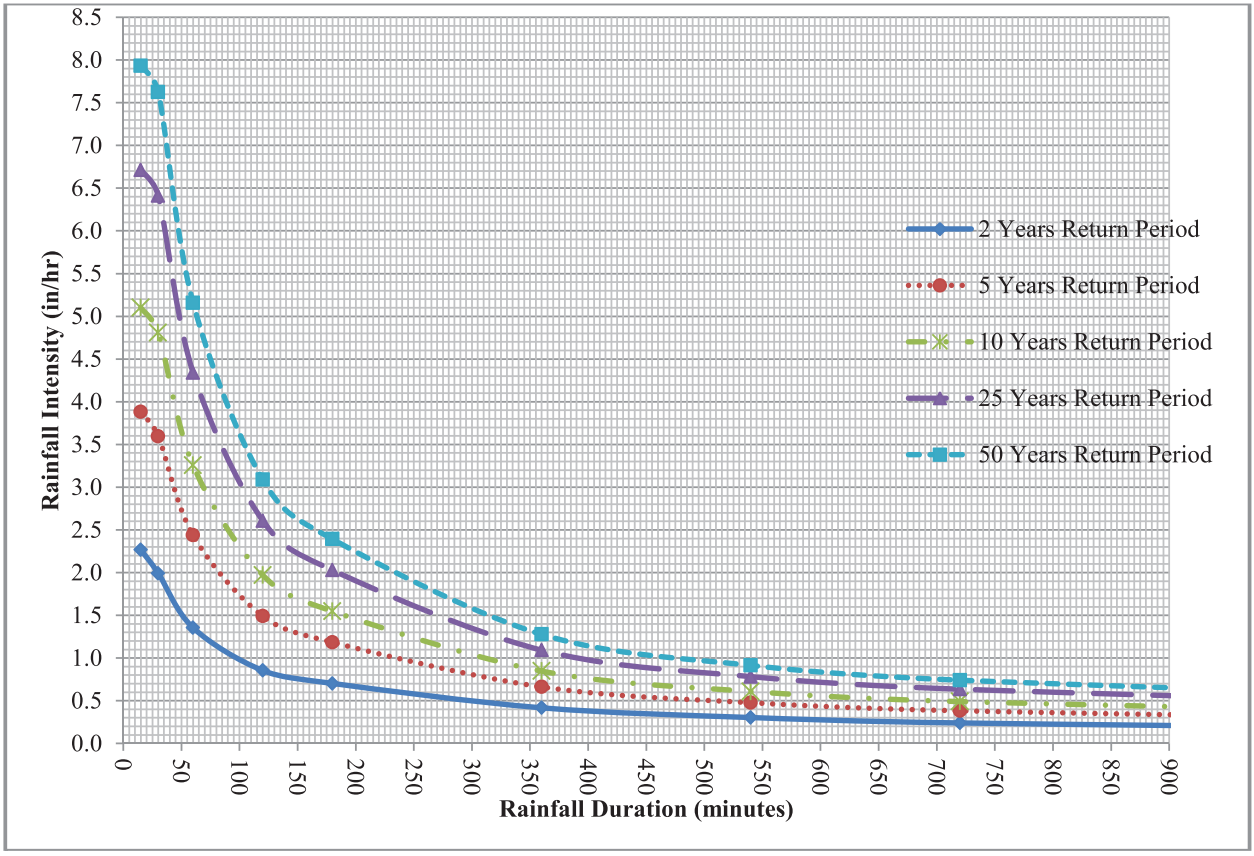

Fig. 3. Intensity Duration Frequency (IDF) curves for study area (1953-2015)

B. Selection Of Rainfall Pattern

In order to decide rainfall data to be used in rain gage property of Storm Water Management Model (SWMM 5.1), rainfall pattern for about six years was determined on the basis of Table V. However, final selection of rainfall duration for storm water management modeling in SWMM 5.1 was decided on the basis of time of concentration as calculated through rational method. Six hours rainfall pattern that was determined on the basis of Table V against different return periods is summarized in Table VI below:

TABLE VI
SIX HOURS RAINFALL PATTERN FOR DIFFERENT DURATIONS OF RAINFALL

2 Years		5 Years		10 Years		25 Years		50 Years	
Time (hr)	Rainfall (in)	Time (hr)	Rainfall (in)	Time (hr)	Rainfall (in)	Time (hr)	Rainfall (in)	Time (hr)	Rainfall (in)
1	1.354	1	2.437	1	3.257	1	4.340	1	5.159
2	0.354	2	0.543	2	0.685	2	0.874	2	1.017
3	0.401	3	0.571	3	0.700	3	0.871	3	1.000
4	0.099	4	0.060	4	0.029	4	0.010	4	0.041
5	0.122	5	0.200	5	0.251	5	0.319	5	0.370
6	0.418	6	0.161	6	0.161	6	0.157	6	0.150

C. Storm Water Management Modeling

After collection of all the required metrological data and rainfall analysis, the next step was the setting up of EPA's Storm Water Management model (SWMM 5.1) and its calibration. For setting up of SWMM 5.1model, whole study area was divided into small subcatchments and then storm water drainage conduits "C", nodes "J", rain gauge "Rain gauge" and outfall station "Out" were marked in the model view of whole scheme. Fig. 4 represents model view of whole study area as divided into 14 subcatchments along with storm water conduits, junction points, outfall station and rain gauge.

For designing the storm drainage network using SWMM 5.1 model, the various input parameters for the subcatchments, conduits, junctions/nodes and rain gage property of SWMM 5.1 were calculated. Similarly infiltration parameters of the subcatchments were also decided on the basis of NRCS runoff curve number method and Group C soils were selected. Rain gage parameters such as rainfall magnitude was decided on the basis of rainfall duration/time of concentration as calculated from rational method against five years return periods. Storm drainage networks are usually designed on the basis of 2-5 years return period because the cost of infrastructure significantly increases by designing on larger return periods; hence five years return period was selected as design period in modeling.

E. SWMM 5.1 Modeling After Employing LIDs

Finally, model was run by using different LID techniques such as bioretention cells, rain gardens, infiltration trenches, green roofs, permeable pavements, and rain barrels. Different LID techniques were utilized for evaluating and studying their significance in better control and management of storm water runoff. In order to do this design properties of different LID techniques were determined. Similarly, software was run up to the stage until it depicted no flooding or ponding/surcharging at any node or conduit in the study area. Conduits were tried to perfectly design so that neither of them may surcharge during whole span of storm event as it was done earlier before employing LIDs.

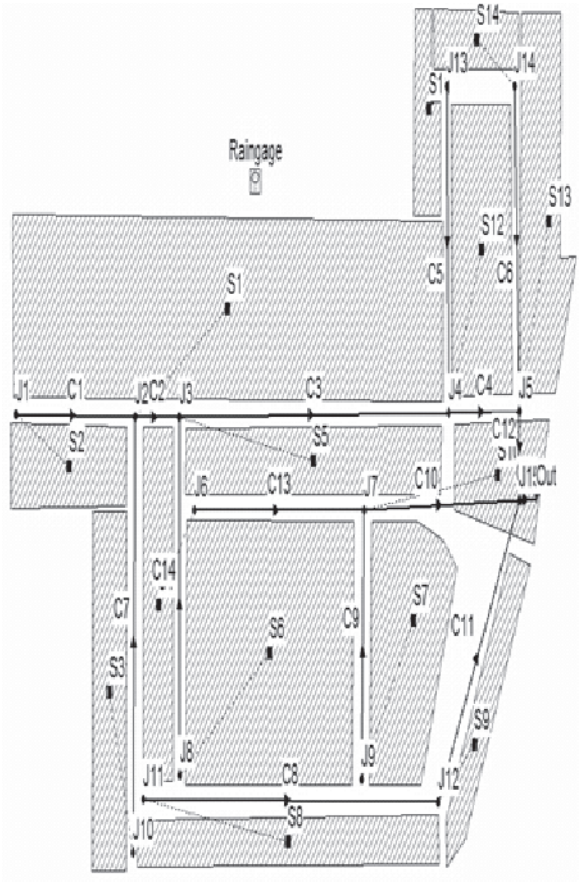

Fig.4. Model view of the study area

VII. Results And Discussions

A. SWMM 5.1 Calibration And Modeling Before Employing LIDs

When the storm water management model was operated using same rainfall duration of 60 minutes with magnitude 2.437 inches against five years return periods and under similar catchment conditions as that used for rational method, the model ran successfully. Table VIII shows comparison between the peak discharges from the rational method and SWMM 5.1 model and percentage difference between them.

TABLE VIII
Percentage Difference Between Rational Method And Swmm 5.1 Results

Rational Method Peak Discharge (cfs)	SWMM 5.1 Peak Discharge (cfs)	% Difference
72.08	72.48	0.55

Table VIII shows that output of rational method and SWMM 5.1 are same with negligible percentage difference of only 0.55%. Hence, it means that SWMM 5.1 produced realistic results similar to that of rational method. After model calibration, sizes of storm conduits were determined through SWMM 5.1 modeling at no flooding and ponding conditions in order to have perfectly designed and efficient storm water management system. Fig. 5 shows model results of the study area with different sizes of conduits (in feet) obtained before employing LIDs using SWMM 5.1 modeling at no flooding and surcharging conditions.

B. SWMM 5.1 Modeling After Employing LIDs:

Finally, the model was run after employing LIDs as mentioned. Hence, various important input parameters regarding subcatchment imperviousness, conduit and nodal properties of the model were readjusted with decrease in conduit diameters. The sizes of diameters were decreased i.e. smaller were required because of the fact that LID techniques due to their detention, infiltration properties reduced quantity of runoff that was previously entering into the conduits. The SWMM 5.1 model was operated up to the stage until no flooding or surcharging remained at junctions or conduits. After using LIDs, the sizes of storm conduits required for whole study area were reduced as the total volume of inflow/storm water runoff which the outfall station was receiving got reduced up to 1.132 million gallons than the previous one of 1.751 million gallons before application of LIDs. Fig. 6 shows SWMM 5.1 modeling results and reduction in conduit diameters (in feet) after employing LIDs at no flooding and ponding conditions.

Similarly discharge at outfall disposal station was reduced to 58.32 cusec than the previous one of 72.48 cusec after employing LIDs. Fig. 7and 8 shows flow hydrographs for two scenarios before and after employing LIDs at outfall station by SWMM 5.1.
Infiltration capacity of study area after employing LIDs was enhanced up to 0.997 acres feet from previous one of 0.659 acres feet without LIDs. From the analysis it was observed that LIDs (especially rain barrels) provided storage of about 1.455 acres feet.

VIII. Conclusions

Low Impact Development Techniques play vital role in efficient and better control of storm water runoff as after employing LIDs, total runoff volume gets reduced up to 1.132 Million gallons than the previous one of 1.751 Million gallons before application of LIDs i.e. about 54.68% reduction in quantity of runoff as a result design sizes of conduits gets reduced .

LIDs not only contribute in recharging groundwater aquifer but also helpful in restoring pre-development site ecology and natural hydrological cycle due to their detention and infiltration properties. Infiltration capacity of study area after employing LIDs has been enhanced to 0.997 acres feet from previous one of 0.659 acres feet without LIDs i.e. 51.29% increase in aquifer recharging rate.

LIDs not only reduce quantity of storm water runoff but also improve quality of runoff thus making operation and maintenance of infrastructure easier as with reduction in quantity of runoff by about 54.68% volume, pollutants loads accompanying with it will also automatically get minimal. Similarly, some LID techniques such as bioretention cells, rain gardens, green roofs and infiltration trenches with vegetation surface covers and alternate courses of sand or gravel have the ability to detain/treat and drain off surplus water to the storm conduits thereby reducing pollutants loads on conduits.

LID techniques especially rain barrels can also help in storing/conservation of rain water for future household purposes such as car washing, gardening and floor washing etc. From the analysis it is observed that LIDs have provided storage of about 1.455 acres feet.

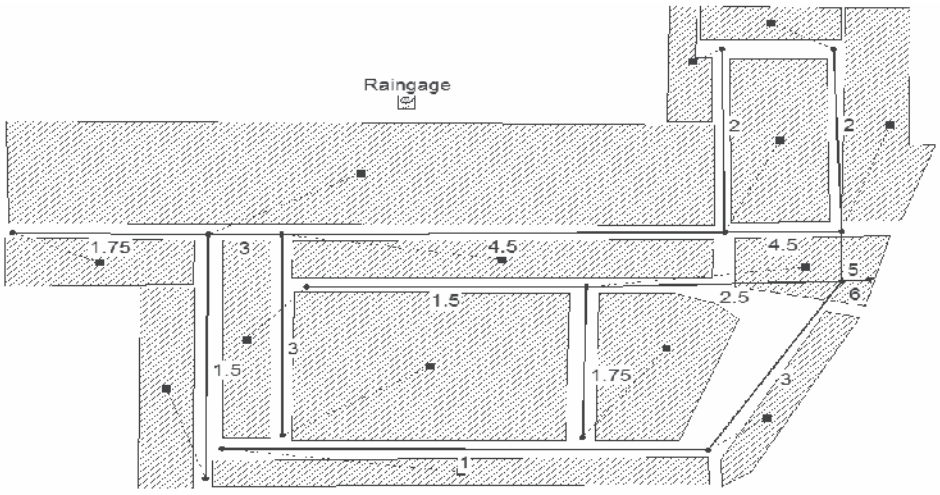

Fig. 3. Intensity Duration Frequency (IDF) curves for study area (1953-2015)Fig.5.Model view of the study area before employing LIDs at no flooding conditions (SWMM 5.1 results)

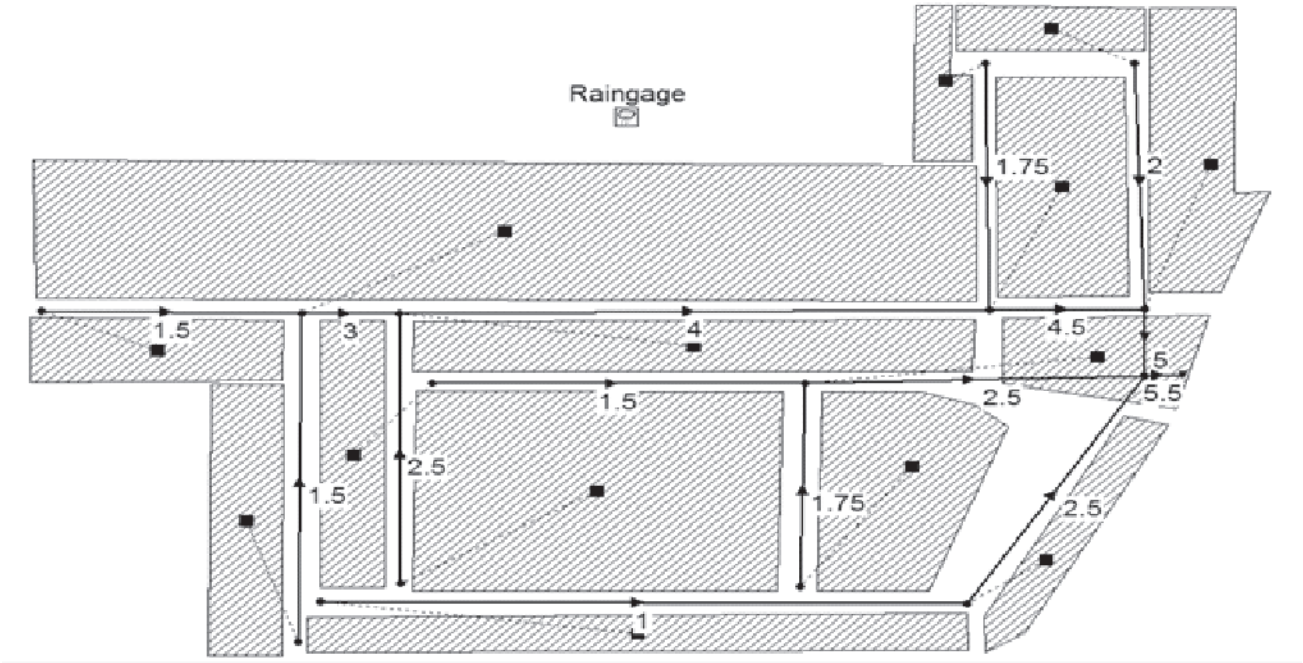

Fig.6.Model view of the study area after employing LIDs at no flooding conditions (SWMM 5.1 results)

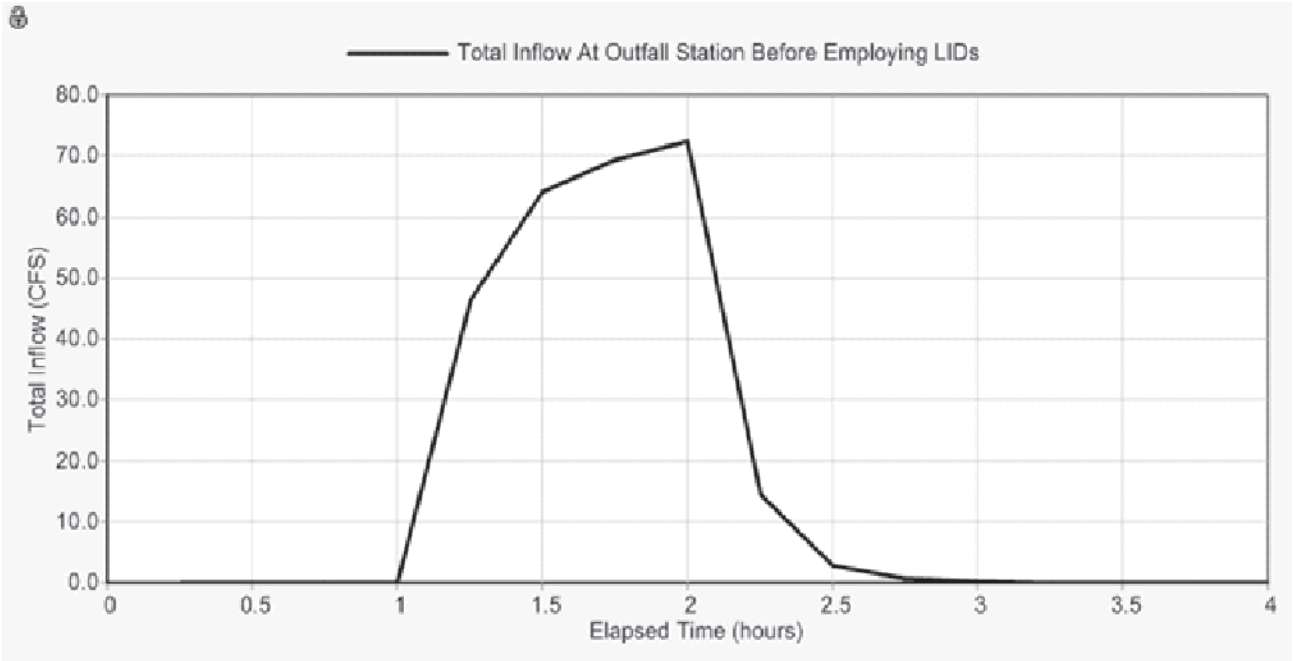

Fig. 7.Total discharge (72.48 cusec) at outfall station before employing LIDs (SWMM 5.1 results)

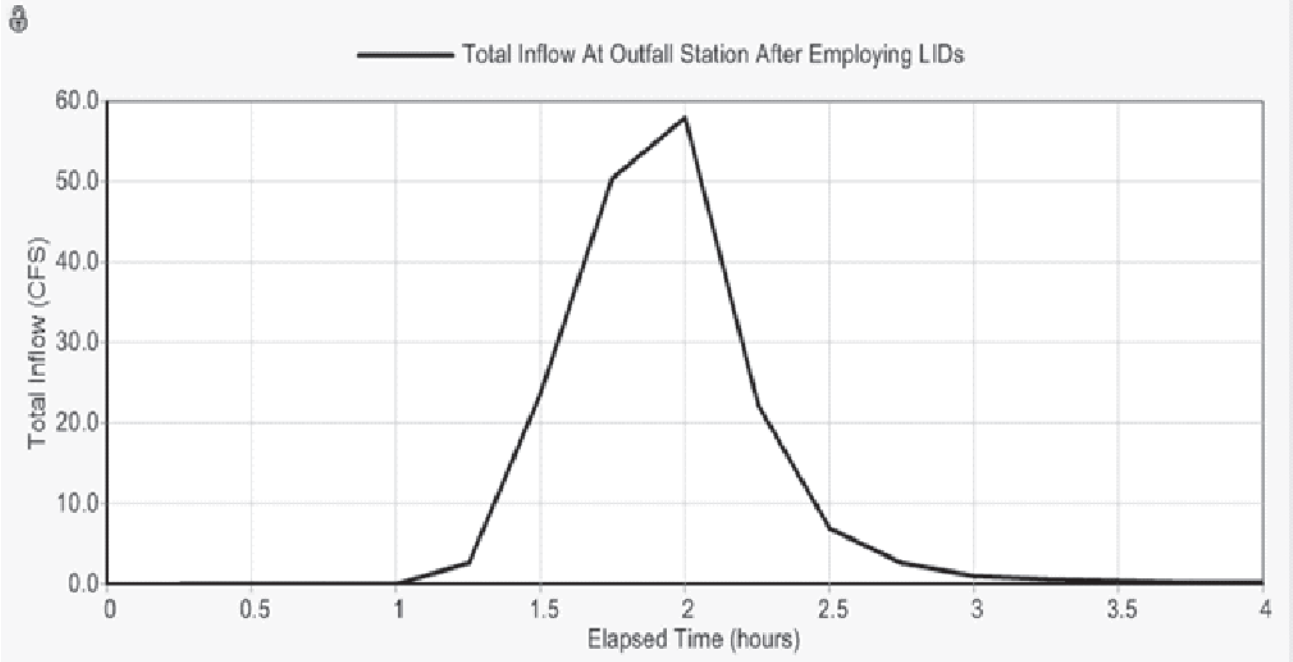

Fig. 8. Total discharge (58.32 cusec) at outfall station after employing LIDs (SWMM 5.1 results)

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Reduction of Damages Through Pre-Flood Management Strategies: Case Study of District Bhakkar in Punjab-Pakistan

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Abstract-Climate change has daunting impacts on various socio-economic sectors such as water, agriculture, health, biodiversity and forests etc. Unprecedented climate change and heavy rainfall are the most significant causes of flooding. Northern areas of Pakistan have more than 5000 glaciers and these glaciers are melting at a very fast rate(i). Rapid glaciers melting due to changes in climate is one of the causes of recent floods in Pakistan. This paper attempts to explore pre-flood management strategies for District Bhakkar to reduce the damages caused by floods. The literature on pre-flood management strategies was reviewed for this study. The findings of this paper are based on afield survey conducted with community members of District Bhakkar in Punjab, Pakistan. This survey and subsequent analysis explored the dire need of pre-flood management strategies in the case study area.

Keywords-Pre-flood Management, Damages, Strategies, Early Warning System, District Bhakkar

I. INTRODUCTION

Globally climate change is possessing serious challenges to social, economic and environmental development [ii]. Unprecedented climate change and heavy rainfall are the most significant cause of flooding. Almost 90% damages caused by floods are happening in developing countries because of their low resilience to timely cope with the situation [iii].According to Global Climate Risk Index 2014, Pakistan ranked 3rd on the list of countries most affected by climate change [iv]. Flooding is one of the devastating impacts of climate change in Pakistan [v]. Pakistan lacks a systematic approach towards floods and disaster management. Post-disaster management strategy is usually used in Pakistan. When disasters finish swallowing up lives, livestock and agriculture production then authorities come in and announce aid for affected communities. Reconstruction and rehabilitation are mostly done in flood affected areas in Pakistan [vi].

Disaster management authorities are working all over the world to make disasters less damaging (vii). Different pre-flood management approaches are used in different countries. Usually, disaster is detected earlier and communities are warned beforehand which enables them to protect their lives and belongings. Therefore, a flood early warning system is needed which serves as a foundation for pre-flood management strategies [viii].

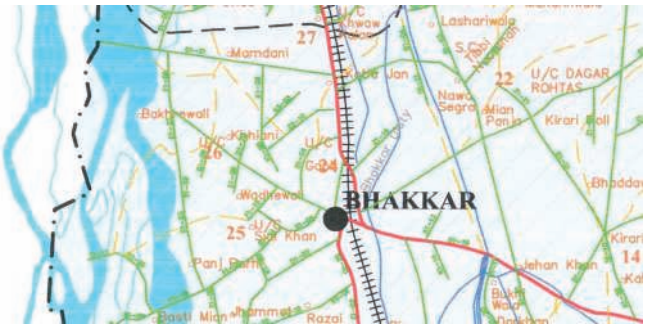
The International Strategy for Disaster Reduction (ISDR) defines early warning as "the provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response" [ix].

Early warning systems can provide the necessary information and strategies to a community to enable them to be proactive and better prepared for impending disasters. An effective system enables the concerned authorities and at-risk communities to know about the hazards at the locality, community vulnerabilities, and impending risk, to receive warning messages, and to mobilize their response capabilities to reduce risks. Pre-flood management strategies have a positive impact on the economic well being of society. These strategies facilitate communities to not only protect their lives but also their livelihoods [x].

II. MATERIALS AND METHODS

Although floods of 2010 and 2013 had caused a number of damages all over Pakistan but this study was carried out in District *Bhakkar* where aforesaid floods had caused great loss of life, livestock and the livelihood of the community [xi-xii]. *Bhakkar* is located near to Indus River(see Map 1). Floods had destroyed a large number of the population who were living near the river in *Bhakkar*. Floods had destroyed many villages of *Bhakkar* city including *Bastisial, jam, Notak, Bilal Behal,* and *Mumdani*. After a thorough and deep study of flood-prone areas of *Bhakkar*, village "*Basti Mumdani*" had been selected as case study area for detailed survey. The reason behind the selection of village *Mumdani* was its high vulnerability to floods as compared to other villages in *Bhakkar*. Primary data

was collected by conducting surveys from community members of village *Mumdani* using the questionnaire. Random sampling was used to select60 respondents' inthis village.



Map 1. Map of Bhakkar along with Indus River

Although floods of 2010 and 2013 had caused a number of damages all over Pakistan but this study was carried out in District *Bhakkar* where aforesaid floods had caused great loss of life, livestock and the livelihood of the community [xi - xii]. *Bhakkar* is located near to Indus River (see Map 1). Floods had destroyed a large number of the population who were living near the river in *Bhakkar*. Floods had destroyed many villages of *Bhakkar* city including *Bastisial, jam, Notak, Bilal Behal, and Mumdani*. After a thorough and deep study of flood-prone areas of *Bhakkar*, village "*Basti Mumdani*" had been selected as case study area for detailed survey. The reason behind the selection of village *Mumdani* was its high vulnerability to floods as compared to other villages in *Bhakkar*. Primary data was collected by conducting surveys from community members of village *Mumdani* using the questionnaire. Random sampling was used to select60 respondents' in this village.

III. Literature Review

An early warning system had been set up on the *Bhote Koshi* River by the Bhote Koshi Power Company (BKPC) in Nepal. The early warning system consisted of two sensor stations at the Friendship Bridge which transmit a warning in the event of a flood to sirens located downstream at the headwork and at Hindi village and a warning cum monitoring station at the powerhouse in Nepal. These early warning systems had reduced damages caused by floods in Nepal [xiii].

Early warning systems require contributions from a wide range of actors and institutions, including local communities, national governments, regional organizations, NGOs, the private sector, and the science community. Since 2002, Practical Action had been working on flood early warning systems for communities in Nepal. In the initial period, observation towers were set up with a siren system to watch and warn communities of impending flood disasters [xiv]. This initiative introduced the concept of early warning systems, but the technology has now been improved.

In the western region of Nepal, Practical Action and Nepalese Government's Department of Hydrology and Meteorology (DHM) had started a community-based flood early warning system in the West Rapti basin. Real-time information on water levels at the upstream gauging station operated by DHM is provided to communities to warn them of impending floods. This early warning system in Nepal had remained very successful to save peoples' lives and their belongings [xv].

Government of Philippines had installed 15 rain gauges on the slopes of Mt. Mayon - an early warning system against devastating floods. They have plan to install more sophisticated early warning weather stations to reduce the impacts of future flooding in Philippines [xvi].These examples of flood early warning system can easily be replicated in other developing countries like Pakistan.

IV. Analysis and Discussion

Sixty respondents were interviewed in this survey in village *Mamdani*. Among these sixty respondents, the distribution of male and female was unequal. Females were reluctant to take part in answering the questionnaire. Therefore 48 males and only 12 females could be interviewed (see Fig 1).It shows that females are less active than males in this area to take part in any social activity.

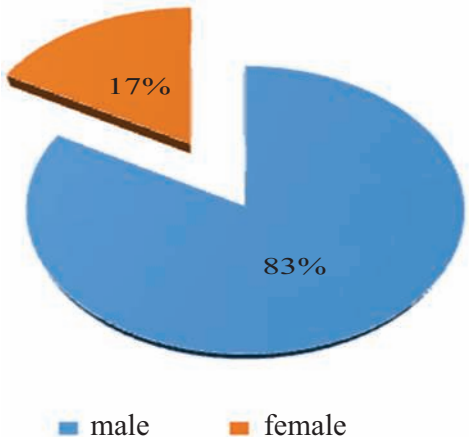


Fig. 1. Gender Ratio

Occupation of each respondent was also asked in this survey. Housewives, farmers and workers were interviewed randomly to have a variety of information in this survey. Fig. 2 highlighted that more than 50% respondents were farmers in this survey. It shows that most of the people in this village are dependent on agriculture profession for their livelihoods.

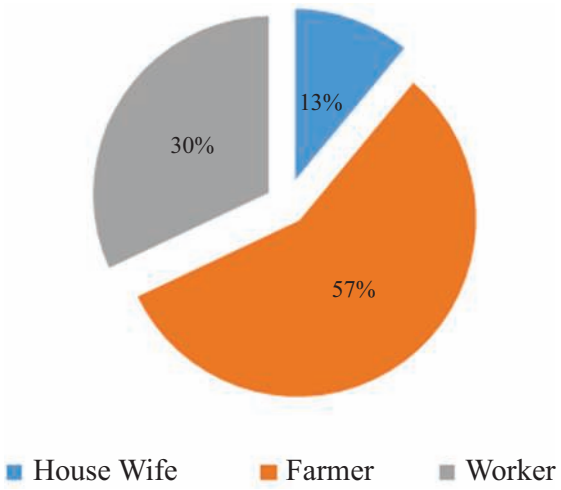


Fig. 2. Occupational Distribution

Further it was asked from the respondents what they were doing when the flood hit their village. This question indirectly unwrap the level of awareness people were having about the flood forecast. Analyses disclosed that majority of villagers were busy in their daily routine, working in fields and factories or on their shops (see Fig 3). This analysis revealed that most of the people were not aware or prepared for the upcoming flood in their area.

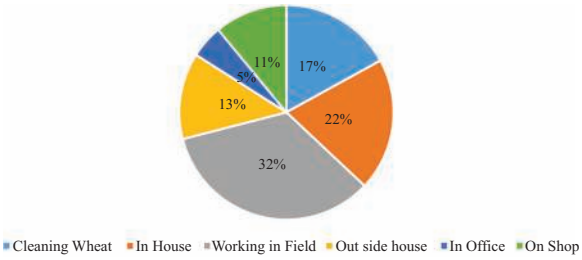


Fig. 3. Activities at the Time of Flood

Moreover, villagers were directly asked about any early warning about past floods they had experienced. The unexpected response was received from villagers. Fig. 4 shows that three-fourth (75%) of the respondents received warning for flood while remaining 25% villagers did not receive any kind of information about upcoming floods in their village. It shows some positive role of Government of Pakistan in providing early warning to the residents of flood-prone areas.

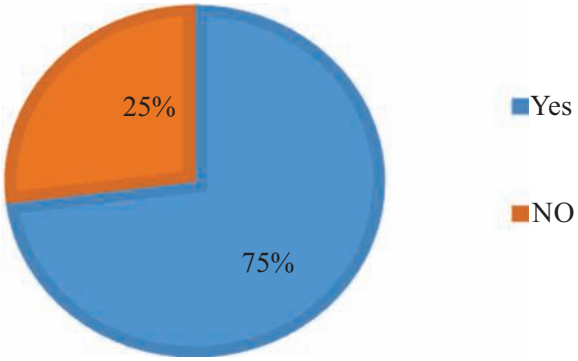


Fig. 4. Warning Received

The next interesting question was that how earlier the communities get informed about the upcoming floods. The purpose of this question was to find out that had community members got enough time to respond properly to the warning and evacuate the area? Analysis revealed that almost half of the respondents (54%) got information only 4 to 7 hours before the flood hit their area (see Fig 5).Only 18% villagers received flood warning four days before the flood hit their area. This analysis shows that majority of villagers did not receive flood warning earlier to respond before the flood hit their area.

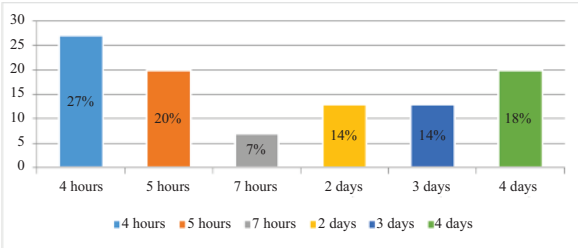


Fig. 5. Timing of Warning Received

The source of early warning system for the flood is an important indicator to find out the response of community at the time of floods. According to Figure 6, the majority of respondents (60%) had received the warning from Government announcements. Flood warning was announced in the local mosque of case study area. It was also announced that the upcoming flood will be very dangerous and soon can hit the village. Only 20% respondents received information from their friends, family and neighbors. It shows that Government is disseminating the information of upcoming floods to the local residents.

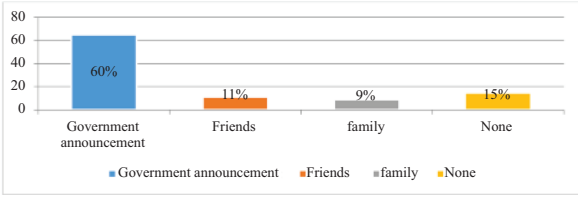


Fig. 6. Source of Warning

After disseminating the warning about the hazard, next responsibility of the Government is to suggest the safe place to the communities at the time of evacuation due to floods. Almost all respondents said that there was no single place suggested to the villagers by the Government where they could move with their necessary luggage and take their cattle with them. It shows that villagers were told to evacuate the area before the flood but no emergency shelter was provided for them to move to.

When the people were only asked for the evacuation without any safer place suggested, what could they do to avoid flood or minimize damage on their own behalf? Analysis showed that a small proportion of respondents(6%) took refuge at their relatives or friends and only 10 % respondents had evacuated the flooded area on self-help. On the other hand, a large part of the respondents (84%) did not do anything until flood trapped them.

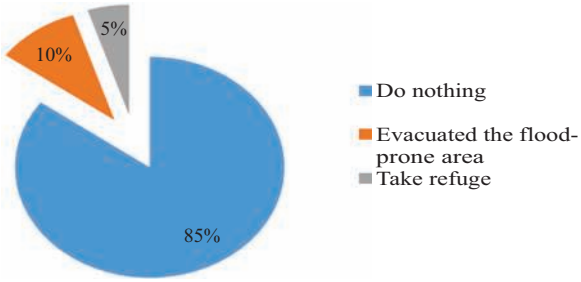


Fig. 7. Action Taken by Residents

When villagers were asked about why they did not take any step to avoid flood, variety of answers were received which unpacked one of the large gaps in the prevailing flood early warning system. Analysis revealed that two-fifths of the total respondents(40%) were not willing to leave their places because they did not believe on Government announcements about floods. A considerable portion (10%) considered the warning as false based on their previous experience of believing on the warning and evacuating the area but actually warning proved false and their area remained safe from the flood(see Fig 8). It shows the lack of trust of people on Government announcements about flood warnings.

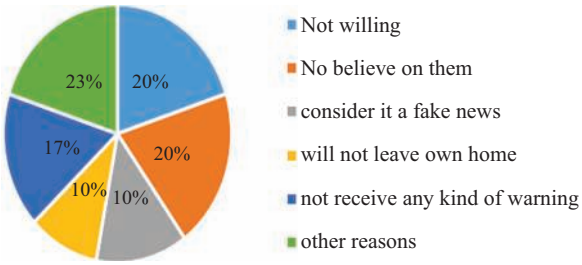


Fig. 8. Reasons behind not taking any Action

The Government of Pakistan claimed that they had prepared very detailed Flood Fighting Plan (FFP) for every district in Punjab [xvii]. But when villagers were asked whether they had been advised of any flood management plan? Almost all respondents' said that they do not know about any flood management plan. Analysis revealed that the plan had been prepared but it is not discussed or disseminated with the local community.

Further community's views were sought on strengthening flood early warning system in their area. The majority of the respondents (80%) were of the view that there is dire need of flood early warning system in their area as part of disaster management.

Suggestions were also sought from community members about how they would like to be informed in future when an early warning system is developed by Government? Respondents gave suggestions according to their local environment and available resources. According to Fig. 9, nearly half of the respondents (45%) showed their willingness to be informed on the radio as they were the regular listener of radio. Secondly, more than one-third respondents (36%) were willing to be informed on television. In addition to this, a small proportion of respondents (19%) were comfortable in receiving the text message of flood warning on their mobiles and considered this mode as most safe, applicable and credible warning mode.

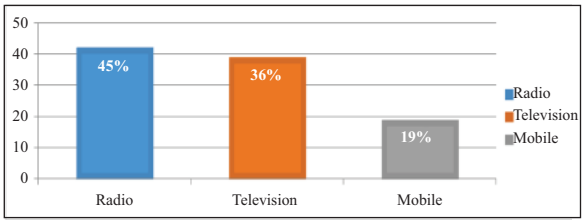


Fig. 9. Mode of Early Warning System

It can be learnt from the experience of the developed countries that there must be the restriction on the construction in hazard-prone areas (xviii). Worldwide research suggested that countries which coped well with the floods had applied effective disaster management strategies [x]. When the residents in this survey were asked that after the occurrence of floods, did government impose any restriction on the development in flood-prone areas, all of the respondents said that no restriction had been imposed on the construction in flood prone areas. It shows that Government is not efficiently working to reduce the damages of people due to floods.

Moreover, residents were asked regarding the strengthening of river embankments. The majority of the respondents(90%) said that no steps had been taken by Government to strengthen river embankment to save the village from flooding. Very few respondents (10%) said that river embankment was done at few places in

their village (see Fig 10). It shows that no effective and efficient pre-flood management strategy was adopted in the case study area.

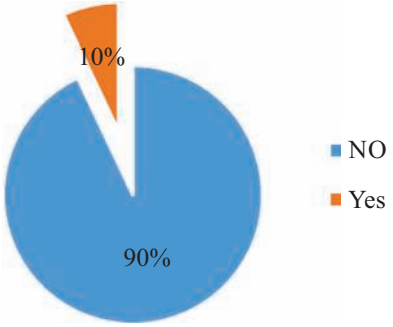


Fig. 10. Strengthening of River Embankments

V. Conclusions and Recommendations

More focused and well-tested disaster management approaches have been used in developed and developing countries to reduce causalities from floods (xix). Early warning system is internationally considered as the basis of disaster management which gives birth to properly structured safety system intended to save lives and their belongings. Community-based early warning system is becoming more common in all developed and developing countries including Pakistan because of its effectiveness and strong roots well absorbed in the local community [xx].

Pakistan lacks in the implementation of proper and well-functioning flood early warning system. Pakistan has poor dissemination and communication of flood early warning system in flood prone areas. Last but not the least; flood response capability among community members is very weak in Pakistan. Communities are unable to understand flood warning messages and its implementation.

The Government of Pakistan should give priority to improve and implement flood early warning system involving the local community and their capacity building. Flood maps can be displayed in the areas showing the location of flood prone areas and safer sites. River embankments should be improved so that these can bear the extreme flow of water during monsoon season.

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Characterizing the Subgrade Soil Using Local Modifiers

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Abstract-Sub-grade layer perform important role in a pavement service life. Inadequate strength of subgrade soil may cause premature failure of pavement, especially if the pavement is subjected to heavy loading and the subgrade is under moist condition. Providing the thicker pavement over a weaker subgrade soil may increase per length cost. The study aims to improve the stiffness properties of three types of soils using the commonly available modifiers like lime, sand and marble (pulverized). Improvement in the soil with modifiers have been suggested based on triaxial and clegg impact hammer tests. Statistical analysis using the Local Linear Regression and Artificial Neural Networking techniques has been performed to ascertain the influence of modifiers on subgrade soil properties. The relationships developed were smooth and statistically efficient. It was evident from the test results that Local Linear Regression precisely assessed the relationship with significant values of statistical parameters as compared to other techniques. This study recommends using locally available modifiers to improve the soil properties and hence to reduce the overall pavement cost.

Keywords-Subgrade; Soil; Pavement; Stiffness; Clegg Impact Value

I. Introduction

A typical flexible pavement comprised of different layers of materials that transfers the wheel load to sub-grade layer through multi elastic layer system and derive support from the underlying sub-grade. Sub-grade layer supports the pavement as foundation [i]. The strength of sub-grade soil is defined as pavement ability to accommodate load induced compressive stresses and relatively lower compressive strains [ii]. However, in case of a weak sub-grade, soil properties may be improved. Soil stabilization techniques that may economize the highway projects by reducing the thicknesses of upper pavement layers. Pavement engineers considered increasing the strength and durability of pavement sub-grade soil by mixing a cementitious material during construction [iii]. Adding commonly available additives and modifiers is a common practice. Utilizing waste materials in soil stabilization save depleting landfill space [iv]. Stabilization of soils with conglomerate materials is another alternatives from economic point of view [v].

California Bearing Ratio (CBR) test was used in the past to estimate stiffness of pavement sub-grade soil. But with the advancement in research, the focus is shifted to more promising methods like using resilient modulus as it simulates with the in-situ conditions [vi]. The clegg impact value test has been used to augment the resilient modulus results in the research. In the past, extensive research was carried out to correlate CBR with MR; however, there has been a little work to establish relationship between the CIV and MR.

It has been established that CBR failed to assess actual dynamic loading on the pavement. Several research studies [vii-viii] presented similar findings. CBR has been used as a criterion for characterization of sub-grade for many years, but the advancement in research has shifted it towards the resilient modulus. Calculating the resilient modulus in the laboratory is a complex and time consuming procedure. Thus, many researcher studies have correlated the CBR and soil index properties to obtained resilient modulus. In this research, impact value and modified proctor test findings were correlated with the resilient modulus using linear and nonlinear regression techniques. Soil stabilization using different additives is a common practice in the world, which minimizes the wastage of the natural resources and contributes towards safer environment. Many researcher studies have suggested different materials like stone powder, lime, marble, marble slurry and Portland cement for improvement of soil. The effect of nontraditional additives on engineering characteristics of Laterite soil. Microstructural characteristics were also considered parallel in this study [ix].

Reference [x] suggested techniques to improve road subgrade soils using marble dust. The effect of modifier was studied red tropical soils. [xi] Proposed a method to improve sub grade for rural road soils using rice husk and lime. [xii] Further investigated the effect of marble dust and rice husk on strength and durability of expansive soil. [xiii] Utilized the stabilized dune sand in road engineering. [xiv] Studied the improvement of

calcareous marl using lime and cement. The CBR and clegg Impact Hammer tests were performed for strength evaluation. According to this study cement modified soils yielded more strength and durability than lime treated soils. [xv] Stabilized the weak tropical organic soil by using cement sodium silicate grout. [xvi] Studied the utilization of marble slurry to enhance soil properties and protect environment. [xvii] Studied the effect of lime on the soil improvement and recommended an optimum percentage for soil improvement. [xviii] Improved the weak peat ground by using cement and silica fume treated columns. [xix] Reviewed the characterization of sub-grade material in ME-Design Guide 2002 and applied it to Minnesota fine-grained soils. [xx] Addressed calibration of laboratory resilient modulus measurements using field data of modulus of elasticity for sub-grade layer determined through plate load test. [xxi] Proposed resilient modulus of sub grade as an important parameter in the pavement design. [xxii] Studied the use of fly ash (FA) or ground granulated blast slag (GGBS) and reactive lime blends for cement-stabilized Nanjing clay, comparing them with Portland cement (PC) for enhanced technical performance. [xiii] Studied the effect of lime sludge on strength and compaction characteristics of soil. Several research studies in the past suggested different correlations among different soil properties. Table I shows a brief history of the models developed to correlate the resilient modulus with CBR, index properties and material properties. Table I discusses some of the earlier studies to predict resilient modulus from other parameters including soil index properties.

TABLE I
HISTORY OF MODEL DEVELOPMENT ON RESILIENT MODULUS

Author	Equation	Variables
Uzan (1985)	$M_R = a(3p_{max})^b$	a, b= parameter showing material properties P_{max}= maximum atm. pressure
Elhannani (1991)	$\varepsilon_v = pa^{(1-b)}p^b[(1/a)-((1-b)/6c)*(q/p)2 - (b/d)(q/p)]$ $\varepsilon_s = pa^{(1-b)}p^b$ [(1/3c)*(q/p) - 1/d]	Where a, c, d are the constant parameters with stress units
Boateng-Poku and Drumm (1990)	$M_R = (A + B*\sigma_d) / \sigma_d$	A, B= material constants
Uzan (1992)	$M_R = k_1P_a (\theta/P_a)^{k2} * (\sigma_d / P_a)^{k3}$	k_1,k_2,k_3 are considered as parameters showing material properties
Matthew Witczak (2003)	$M_R = k_1 P_a \left(\frac{\sigma_b}{P_a}\right)^{k_2} \left(\frac{\tau_{oct}}{P_a}+1\right)^{k_3}$	Where, σ_b is the bulk stress and τ_{oct} is the octahedral stress on sample

Providing a thicker pavement structure over a weaker subgrade soil may leads premature pavement failure, especially when the soil comes in contact with water. Also, it may increase the unit length cost of the pavement. It would be more viable way to improve weaker subgrade soils and provide relatively thinner pavement section. Present study focused on sub-grade soil improvement using different modifiers.

The results of the improved soil were then compared with the stiffness of the granular (A-2-4) and silt clayey (A-4) soil, which are generally considered appropriate for the sub-grade layer of a pavement. A weaker soil (A-6 soil as per AASHTO Soil Classification System) was chosen in this study, which is commonly available in most of part of the country. Commonly available cheap modifiers including marble waste, lime and sand in six different percentages each for improving the stiffness properties of the soil have been used.

The improvement in sub-grade strength were evaluated by different methods including CBR and M_R value. Triaxial test and clegg Impact Hammer test have been conducted to determine resilient modulus (M_R) and clegg impact value (CIV), respectively. Also, relationship has been developed between the laboratory and field data. Resilient modulus of sub-grade soil is an important parameter that has been used in the mechanistic-empirical pavement design methodology. It characterizes stress-strain behavior of sub-grades subjected to repeated traffic loadings [ii, iv]. Highway design agencies suggested relatively better soil in the pavement design methodology for sub-grade layers. Present study predicts resilient modulus from Triaxial and clegg impact testing data. Such relationship has been statistically analyzed using different techniques.

II. OBJECTIVES AND RESEARCH METHODOLOGY

Followings are the objectives of this research study; to improve the stiffness properties of weak sub grade soil by using different modifiers by optimizing percentage of each modifier in the soils. Evaluating the effect of modification on the resilient modulus and clegg impact values of soil and proposing a regression model within an acceptable significance level. To correlate resilient modulus with clegg impact value and assessing the sensitivity of relationship using different approaches artificial neural networking techniques.

A two phase study was planned to accomplish the study objectives. Phase I comprised of laboratory testing using the soil classification. Modified proctor test was run to determine the optimum moisture content

and maximum dry density of different soils and their mixtures with different types of modifiers. Triaxial test for resilient modulus of weak sub-grade soil and clegg impact value to evaluate the stiffness behavior of the soil were utilized.

Phase II involved statistical analysis to predict the resilient modulus from different test results primarily; optimum moisture content, maximum dry density and clegg impact value. Local linear regression and artificial neural networking techniques were used for statistical analysis. Fig. 1 illustrates the methodology adopted for the research study.

Three soil types were selected in this research study including granular, silty and clayey soils. These soils covers the major area of the whole country and true representative of typical available soil for subgrade formation. Soil and modifiers samples were collected from the local areas near the testing laboratory. Classification of different soils was performed at initial.

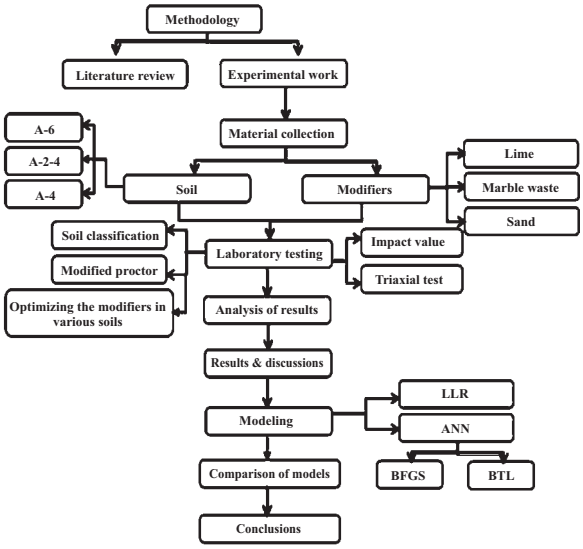

Fig. 1. Scope and methodology of the work

Soil index properties like liquid limit, plastic limit, difference of liquid and plastic limit (Plasticity index) and grain size distribution through sieve analysis and hydrometer analysis were determined. Specific gravity test were also performed on all soil samples. The test result for soil index properties have been shown in Table II.

TABLE II
SOIL INDEX PROPERTIES

Liquid Limit (%)	Plasticity Index (%)	Passing # 200 sieve	Passing # 40 sieve	Clay content (%)	Silt Content (%)	AASHTO Classification
20.5	1.0	28.0	N/A	3.2	25.4	A-2-4
24.4	4.9	42.0	N/A	9.0	33.1	A-4
37.2	13.1	96.0	99	19.3	78.7	A-6

Different percentages of modifiers like lime; marble (pulverized) and sand were mixed in the soil to improve the physical and mechanical properties. The modified proctor test was performed on all soil samples mixed with six different percentages of each of the three modifiers to get the maximum dry density and optimum moisture content. A total of 54 modified proctor test were performed on the selected soil samples.

An optimized value of different modifiers for different soils were determined using the typical plots between the moisture-density relationships. It was observed that maximum dry density of soil samples decreases with an increase in lime and marble percentages while, it increases with an increase in sand percentage. Similarly, it was also observed that the moisture content decreases with an increase in sand and marble percentage, while it increases when lime percentage increased.

Triaxial test was performed using NU-14 in replicates on soil samples in accordance with AASHTO T 307 [xiv]. The specimens of 100 mm diameter and 200 mm height were fabricated using the superpave gyratory molds at an optimum moisture content. The loading sequence involved 500 conditioning repetitions and 1500 load repetitions at different stress levels. A load stress with a rest period of 0.9 sec and load period of 0.1 sec was applied and the results were recorded using two linear variable differential transformers (LVDTs). The clegg impact test was performed using clegg impact hammer in accordance with ASTM D 5874 [xv]. The molds for impact value test were prepared in a CBR mold having 200mmdiameter. Tests were performed in replicates and the data obtained from different test was screened and results with higher standard deviation were discarded.

III. RESULTS AND DISCUSSION

Soil samples prepared at an optimum moisture content at each modifier percentage were tested at both triaxial machine and clegg impact tester. Results obtained from a triaxial test have been shown in Fig. 2.

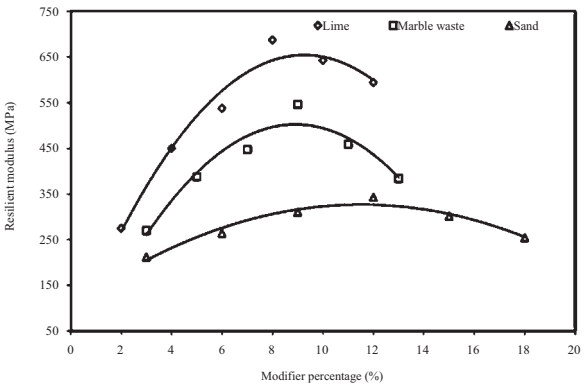

Fig. 2. Influence of modifier percentage on M_R Value

It may be noted from the Fig. II that resilient modulus value increases with an increase in the modifier percentage, but up to a certain limit. A further increase in modifiers percentage decreases the resilient modulus value. The peak value yields an optimum percentage of a modifier against for different soil types. Fig. 3 shows the results obtained from a clegg impact test.

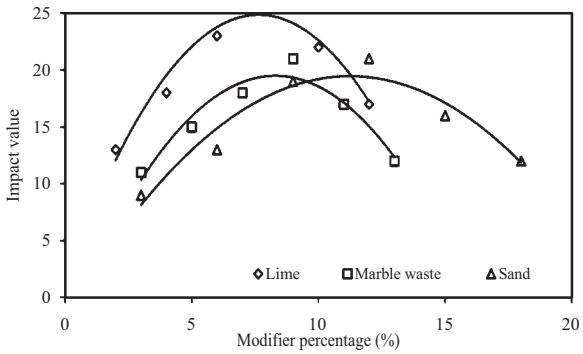

Fig. 3. Influence of modifier percentage on clegg impact value

The trends obtained from a clegg impact test were in line with the resilient modulus test. Fig. 4 shows optimum values of both moisture content and modifier percentages. Statistical modeling was then performed on the testing data for augmenting the test results.

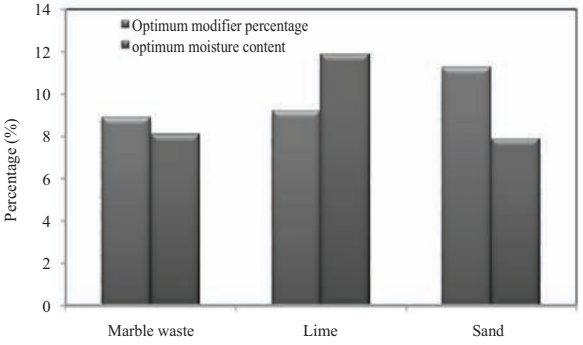

Fig. 4. Optimum modifier and moisture content values

Local linear regression and Artificial Neural Networking (ANN) techniques were adopted for modeling the test results. Both triaxial and clegg impact tests data was iterated using the statistical package and Following relationship was found between the clegg impact value and resilient modulus test values.

$$M_R = 0.62(CIV) + 182.37 \quad (1)$$

A coefficient of determination (R^2) of 0.70 was found for the equation I. The frequency distribution curves indicates that about 70% of the model computed values remains near to the estimated median value.

B. Artificial Neural Networks (ANN)

Artificial Neural Network is a computational technique to analyze the test data like neuron system in the brain. It processes the data using testing and training algorithms and develops a link between past and future events [xxvi]. The training part, also called as learning part comprises of supervised and unsupervised. In the artificial neuron model, n input signals $_iX$ are being sent through links, which are further multiplied with their corresponding synoptic weights, $_iW$, $i = 1, 2, 3, \ldots, n$. A linear combiner added up all the signals through this link like a junction. This combiner is therefore called as activation function $f(.)$. In this algorithm, the main purpose of combined is to limit the amplitude of the output and gives its nonlinearity. Mathematically; this function can be shown as [xxvii].

$$\sigma = \sum_{i-1}^{n} X_i W_i \quad (2)$$

There are several techniques to interlink different neurons for the performance of a specific task. A single neuron cannot complete a task, rather interlinked neurons, mostly in shape of layers work together to complete a computational task. Such layers are usually called as input layer, intermediate layer and output layer [xxviii]. An important aspect of model development using ANNs is training (learning) phase.

Typical ANN algorithms are Back propagation (BP), conjugate gradient (CG), Broyden Fletcher Goldfarb Shanno (BFGS), quasi Newton and Levenberg-Marquardt (LM). The suitability of each algorithm to fit the testing data depends purely on the nature of data. The conjugate gradient algorithm works on the concept of conjugate directions using the following relationship;

$$g_{j+1} = \nabla E(w_j + a_j d_j) = 0 \quad (3)$$

Where α_j is calculated using a line search algorithm technique, H = Hessian matrix evaluated at point w_{j+1}, d_{j+1} = new direction, d_j = Existing search direction. Broyden-Fletcher-Goldfarb-Shanno (BFGS) algorithm is a quasi-newton method that is used to find out either zeroes or local maxima and minima of a function using the following relationship;

$$w_{j+1} = w_j - \alpha_j G_j g_j \quad (4)$$

Where α_j = line search constant, G_j = inverse Hessian matrix, g_j = gradient vectors, w_j = estimated weight, w_{j+1} = upgraded weight.

Present study aims at predicting the resilient modulus of soil from engineering characteristics of soil using different ANN techniques. Data was trained in

two hidden layers and simple trial and error method was used to define number of nodes per each layer. The basic aim of selecting double hidden layer process was to avoid complexity in the results. Under such situation, ANN model might be unable to predict the desired results for a complex nonlinear conditions [xxix]. A local linear regression has also been utilized to confirm the results and to assess the variability in the computed results.

C. ANN based modeling

The normalization process, by scaling between 0 and 1, has been adopted in order to make all the variables dimensionless. The calculation of normalized values was performed using following standard formula:

$$(Normalized)\ P_i = \frac{P_i - P_{min}}{P_{max} - P_{min}} \quad (5)$$

Where;

P_i = ith value of variable P

P_{min} = the minimum value for variable P

P_{max} = the maximum value for variable P

Then, Gamma test was adopted to determine the best input combinations. Gamma test is a novel mathematical tool which is performed to check the noise in the data and also to choose the best combinations between the input parameters. The best combination of input parameters is prerequisite for a smooth and efficient model. The test is capable of calculating the variance of noise, Gamma Statistics or Best Mean Square Error, on our desired output.

Gamma test separates x/y relationship into smooth and noisy. Such process is known as disintegration the relationship between x and y, while the initial data set. $\{(x_i, y_i), 1 \le i \le M\}$ defines the relationship between both the variables. Following relationship shows *f* as a part of smooth and *r* as a part of noise [xxvii].

$$Y = f(x) + r \quad (6)$$

The function *f* is known as unknown function and can be shown with a constant bias in case of zero noise (*r*) value. Even with an unknown value, noise can be calculated using this tool. With an increase in the test data size, the variance of a noise also increases and a stage reached when the gamma value becomes equal to an asymptotic value.

Table III describes the variables which are involved in model development. Tests to find out these variables and observation lengths are also mentioned. Output and input variables were selected for model development.

TABLE III
VARIABLES INVOLVED IN STATISTICAL MODELING

Dataset	Test performed	Status	Observation Length
Resilient modulus	Triaxial	Output	18
Impact value	Impact value test	Input	
Optimum moisture content	Modified proctor		
Maximum dry density			

Table IV explains the different experiments carried out to find gamma statistic by performing Gamma test in Win Gamma environment.

TABLE IV
SELECTION OF THE BEST SUITED EXPERIMENTS FOR MODEL FORMATION

Experiment No.	Mask	Gamma Statistics	Training Length	Testing Length
1	111	0.0179	10	8
2	011	0.0092	10	8
3	101	0.0201	10	8
4	110	0.0199	10	8
5	100	0.0269	10	8
6	010	0.0161	10	8
7	001	0.0184	10	8

It is obvious from the values that experiment no. 2 (mask 011) outperformed the other experiments with a higher degree of accuracy. Experiments 6 and 1 were also selected due to their higher accuracy as compared to the rest of the combinations for model development. Hit and trial method was used for choosing the best possible combination of training and testing lengths.

Table V explains the statistical parameters like R^2, mean bias error (MBE) and root mean square error (RMSE) calculated during the modeling for evaluation of the models developed. The bold values in the table represent the best values in each column e.g. BFGS model 3 would be considered the best of all the above models with respect to RMSE in training phase with the least value of 26.899. The best model for each technique is declared based on the more accurate statistical parameters.

TABLE V
STATISTICAL PARAMETERS FOR THE DEVELOPED MODELS

Technique	Model No						
		R-square	MBE	RMSE	R-square	MBE	RMSE
LLR	1	0.921	0	40.09	0.965	-91.09	94.87
	2	0.641	0	85.18	0.657	-63.93	117.9
	3	0.923	0	39.35	0.904	-96.1	103.1
BFGS	1	0.961	1.42	28.26	0.893	-94.7	102.6
	2	0.729	-2.29	75.28	0.631	-65.06	120.96
	3	0.965	4.02	26.90	0.747	-90.42	117.62
BTL	1	0.910	-1.81	42.65	0.841	-124.7	134.8
	2	0.824	-1.71	59.86	0.599	-51.86	141.9
	3	0.960	-0.49	28.38	0.643	-106.3	130.6

D. Broyden Fletcher Goldfrab Shanno Neural Networking

The prediction of resilient modulus based on BFGS models was also satisfactory with the second model being the least accurate based on parameters. Of the other two, model one was selected as the best model as it had the least mean bias error (1.422) in training and negative MBE in testing phase. R-square was highest (0.893) in testing phase and almost equal to highest (0.961) in training. RMSE value was least in training as compared to a bit high value in testing. Fig. 5 and 6 represents the predicted resilient modulus using BFGS technique and the difference between the actual and predicted values for the observation length.

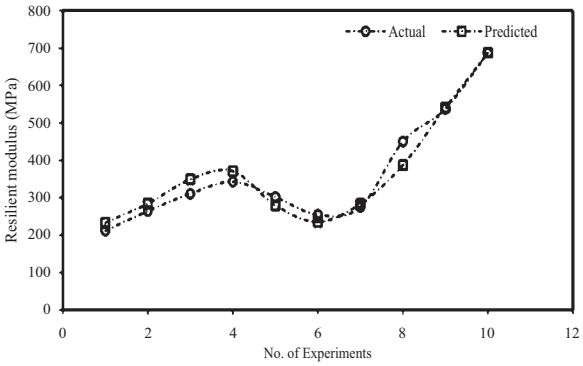

Fig. 5. Scatter and time series plots for training series data for BFGS

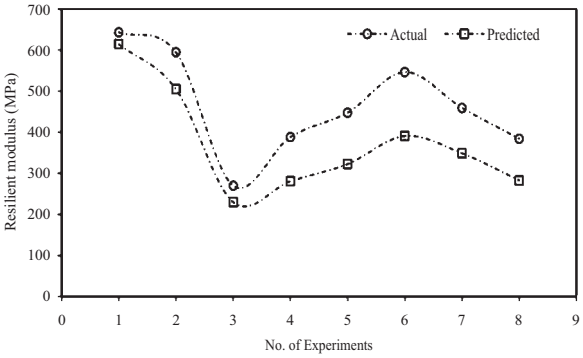

Fig. 6. Scatter and time series plots for testin series for BFGS

E. Backpropagation Two Layer Neural Networking

The third technique used in model development was back propagation two layer neural network. Similar to first two techniques, three models were developed for three combinations of inputs already specified. Of these three, most suitable model (R^2 of 0.96) was selected and drawn here based on statistical parameters. Other parameters like MBE and RMSE among different models were also compared. The model yielding higher R^2 value and lower RMSE and MBE was selected for BTL techniques. Fig. 7 and 8 show the scatter plot relationship between actual and predicted resilient modulus values for first model of BTL.

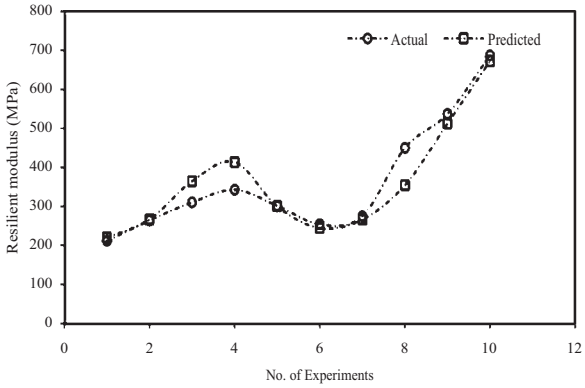

Fig. 7. Scatter and time series plots for training series data for BTL

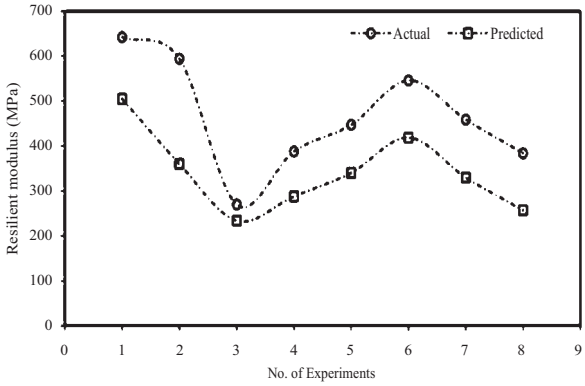

Fig. 8. scatter and time series plots for testing series data for BTL

This model also shows the relation between the actual and predicted values of resilient modulus for the observation lengths. It is obvious from the above discussion and statistical data that Local Linear Regression was more precise as compared BFGS and BTL Neural Networking techniques. The models developed using LLR technique for resilient modulus prediction are statistically more reliable and predicted values are more accurate as compared the models developed by using the other techniques.

E. Local Linear Regression (LLR)

Local linear regression is one of the reliable techniques that assess the relationship among different factors with relatively higher degree of accuracy. That is why this technique has widely been used for low dimensional forecasting. Solution of a linear matrix as basic requirement of the model can be obtained using p_{max} points under the influence of statistics. For a given neighborhood, following relationship is commonly used to solve a linear matrix;

$$Xm = y \qquad (7)$$

Where, X, m and y are *d* matrix, column vector of parameters and column vector of length p_{max},

respectively. The X is always in d dimension and is a d matrix of p_{max} input points, and $xi(1 \leq i \leq pmax)$ are the nearest neighbor points. These parameters are determined to provide the optimal mapping from X to y so that:

$$\begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1d} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2d} \\ x_{31} & x_{32} & x_{33} & \cdots & x_{3d} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{xpmax1} & x_{xpmax2} & x_{xpmax3} & \cdots & x_{xpmaxd} \end{bmatrix} \begin{bmatrix} m_1 \\ m_2 \\ m_3 \\ \vdots \\ m_d \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \vdots \\ y_{max} \end{bmatrix} \quad (6)$$

The rank r of a matrix X shows its number of linearly independent rows. This number of rank is representative of existence or uniqueness of the solution for m. Assuming that matrix X is a nonsingular square matrix, following relationship works for the solution;

$$m = X^{-1}y \quad (8)$$

in case of non-square and non-singular X value, following relationship can be used to find a vector m;

$$|Xm - y|2 \quad (9)$$

It may be observed from Table V that the first model by using LLR techniques is the most reliable based on the statistical parameters out of three models. Mean biased error was zero in testing for all the models of LLR, which clearly shows the zero systematic error; whereas it was negative (-91.091) for testing, showing the under estimation of trends of the model. Standard efficiency, R^2 value was also highest for first model in testing (0.97) and it was almost equal to the highest in training phase (0.92) of the same model. First model also has the least value of RMSE in testing and almost equal to the lowest in training. From the above discussion, it was crystal clear that for local linear regression, first model was the most smooth and efficient one. Fig. 9 and 10 show the comparison between the actual and predicted resilient modulus by the first model in both training as well as testing.

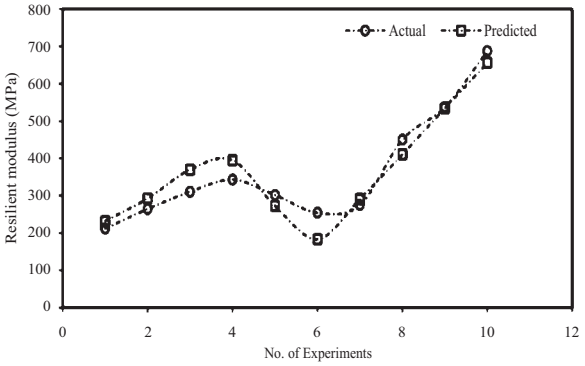

Fig. 9. Scatter and time series plots for training series data for LLR

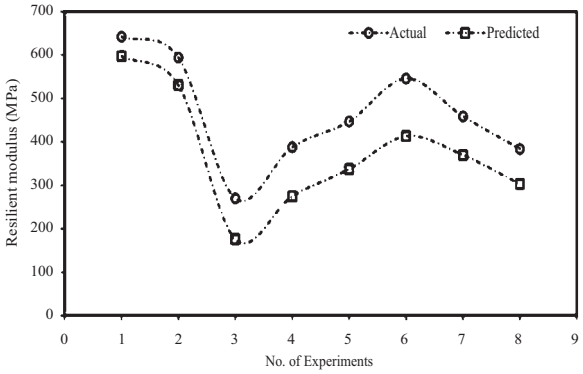

Fig. 10. Scatter and time series plots for testing series data for LLR

The study thus recommends utilizing the local available modifiers in the weak subgrade soil to improve the stiffness properties and to adopt statistical methods and artificial neural network approach for the selection of appropriate relationship. The effect of modifiers was significant in case of clayey soils rather granular soils. The study thus recommends utilizing the modifiers for the improvement of clayey soils. An improved subgrade can reduce the pavement structural thickness for the same traffic load and hence the construction cost

IV. Acknowledgment

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V. Conclusion

This research study was initiated with an objective of improving the weak sub-grade soil by adding different modifiers like lime, marble and sand. The modifiers were used in six different percentages of each. Soil classification, modified proctor, triaxial and clegg impact value tests were performed to achieve the study objectives. Further, statistical analysis was performed to predict the resilient modulus from dry density, moisture content and impact value using local linear regression and artificial neural networking techniques. The following outcomes were achieved by the research study;

A significant improvement in stiffness properties in all the soils was observed during the study. All the three modifiers improved the stiffness of the soils. But it was observed that the lime had the most significant effect to improve the stiffness of the soil samples. It was also observed that the clayey soil showed improvement in stiffness properties than the other soils used in the

study.

It has been observed that an increase in lime and marble waste percentage causes a decrease in the dry density of the soil samples, where as an increase in percentage of sand has improved the dry density of the soils. Similarly, percentage increment in lime has increased the optimum moisture content of the samples; whereas increments in percentage of sand and marble waste has decreased the optimum moisture content. The basic reason behind this increase in moisture content for lime is attributed to its fineness.

The significant relationships were developed to predict the resilient modulus by dry density, moisture content and impact value by using local linear regression and artificial neural networking techniques including BFGS and BTL techniques.

All the prediction techniques predict the resilient modulus from other test parameters with a reasonable accuracy, but Local linear regression (LLR) better predict the results.

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Laboratory Study of Head loss for Trapezoidal Weirs with Vegetation Elements

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Abstract-Rivers, the natural drainage, are the most important water resource in the world but it is difficult to measure accurate value of discharge of river during floods, due to change in bed formation of river. Accurate measurement of river during flood is very important because underestimation of flow may cause more disaster and overestimation may lead to wastage of resources. Embankment weirs, in this regard, e.g. railway embankment or highway embankment may be used for the measurement of discharge during flood. In this research paper, Embankment weirs with symmetrical side slope in open channel flow were investigated. Three different discharges were used in this study and graphs were plotted against each discharge to observe the effects of discharge on head loss. Moreover, embankment weirs with different side slopes were also investigated. This research will help to understand the effects of discharge on head loss in Laboratory and also in the field. Recommendations for future work have also been provided at the end.

Keywords-Embankment Weirs, Head Loss, Open Channel Flow, Sharp Crested Weir, Vegetation Rods

I. Introduction

Rivers, also the beauty of nature, are important for life. These are the most important source of water for domestic, industrial and commercial use. The discharge of river is always point of interest for hydraulic engineers to make maximum use of it and to keep people safe from its adverse effects. The unpredictable behavior of water makes it very difficult to measure the discharge accurately. However, studies in this topic convinced hydraulic engineers for the construction of big structures like weirs, barrages and even dams for storage of water and production of power. Regardless of all the benefits of river, these are responsible for destructions of a society, humans, animals, agriculture etc. It has been reported that sixty six million people a year were victimized during 1973 to 1997. Therefore it is the most challenging job for hydraulic engineers to safeguard the damages cause by floods. The development of hydraulic structures gave some solution to the problem but how to estimate the flow of river once flood came. Accurate measurement of flow during flood in flood plain is important to know for making some concrete decision to avoid damages in future. In this regard, embankment weirs e.g. railway embankment or highway embankment may be used for the estimation of flow. In this research paper, Laboratory investigations were carried out on embankment weir with symmetrical side slopes using different discharges. Weirs are the simplest arrangement in open channel due to the simple design, easy construction and accurate measurement. They may be classified into two categories i.e. sharp crested weirs and weirs of finite crest length [i]. Weirs of finite crest length may be divided into three categories i.e. long crested, broad crested and narrow crested weirs depends upon the ratio between head over the weir and crest length measured in direction perpendicular to the flow. If one considers head over the weir as "h" and crest length as "L" then ratio h/L shows long crested weir in the range 0 to 0.1 while ratio shows broad crested weir in the range 0.1 to 0.4. The ratio represents narrow crested weir in the range 0.4 to 2 whereas sharp crested weir in indicated by the ratio greater than 2. Different studies have been carried out for circular type or sharp edge of upstream weir end. Broad crested weirs were investigated by different researchers using ramps at upstream or downstream or at both ends. Broad crested weir with ramps at both upstream and downstream end may be called as trapezoidal weir.

The weirs in this research were kept fully submerged i.e. downstream water level higher than crest level of weir. Data was then found and using the data different calculations were performed and graphs were plotted with different parameters. The detailed work on different embankment weirs is presented in the paper.

II. Literature Review

The broad crested weir without ramps at upstream and downstream end i.e. vertical ends is known as standard trapezoidal weir. In this type of weir,

cavitation occurs in downstream end and deposition of sediment may occur in upstream end. In this situation significant head loss will occur and it will be difficult to operate the hydraulic structure.

Reference [ii] showed that if vertical end of broad crested weir is changed to rounded end, the coefficient of discharge will increase. Reference [iii] showed that if vertical ends of weir are replaced with ramps, the deposition of sediments at upstream and scouring at downstream may be avoided. Trapezoidal weirs are of interest by the researchers in recent years and some experimental work was performed to develop discharge-head relationship. The importance of trapezoidal weirs lies in the fact that these represents embankment weir e.g. road or railway embankment and discharge during floods may be estimated using road or railway embankment without construction of some new hydraulic structure. Different studies were made but no general relation was developed yet. However, Reference [iv], developed an equation presenting discharge depth relation for finite crest length weir as

$$Q = Cd\,B\,x\,(\sqrt{}(8/27)\,x\,g)\;h^{3/2} \qquad (1)$$

Where Q = discharge, Cd = Co-efficient of discharge, B = width of channel, g = acceleration due to gravity. In case of broad crested weir, the flow layers are smooth and hydrostatic conditions are achieved approximately [v]. If the edge corner of broad crested weir is rounded, the coefficient of discharge increases up to 8% [vi] (Woodburn). Experimental study was carried out by [vii] to highlight the effects of surface tension and viscosity on coefficient of discharge. The author of [viii] performed different experiments to investigate the effects of geometry of weir. They investigate the square edge and circular type edge weir. Different studies were carried out to find the inflow geometry of weir and pattern of discharge. The author of [ix] carried out embankment study based on experiments by considering embankment slopes of 2H: 1V. The author of [x] investigated the characteristics of discharge of Broad crested weirs. References [xi-xii] studied the hydraulic resistance offered by vegetation weir like structure during high stage.

III. Experimental Setup

A smooth re-circulating rectangular-flume was used for the experimentation located in Hydraulics Laboratory, Department of Civil Engineering, University of Engineering and Technology, Taxila. The dimensions of flumes were 12.5 m length, 0.30 m width and 0.40 m depth and attached with the computer as shown in Fig. 1. The channel was kept horizontal throughout the experiments. Water entered the channel at the upstream end while the discharge was measured using sharp crested weir installed at the downstream end. Weirs were also used to control the depth of flow in the channel. Point gauges were used to measure the depth of flow. Water level was measured 1 m upstream from crest of trapezoidal weir and 2 m downstream from the crest of trapezoidal weir. Three different discharges were used for each weir and different depths were measured using point gauge for each discharge. The weir was kept fully submerged during whole experimentation.

Fig. 1. Channel used for experimentation

Trapezoidal weir, made of wood, was selected for this research. The crest height of model is 12cm, crest width is 6cm and side slopes are 1V:3H, 1V:5H and 1V:10H. Side slopes are symmetrical in upstream and downstream. Weirs were made by joining upstream and downstream faces with the rectangular crest as shown in Fig 2. Fig. 3 shows provision for vegetation elements. Fig. 4 represents installed vegetation elements over the weir crest while Fig. 5 shows the vegetated weir installed in the channel with water flowing in the channel. Vegetation in the form of circular rods was provided over the weir crest. Experiments were performed in three manners for each weir which includes experiment over (i) smooth weir (ii) weir with sparse vegetation and (iii) weir with dense vegetation. Vegetation was kept partially submerged during experimentation. Sparse vegetation contains five circular rods of 12cm height, 2cm dia. and offers 33% blockage while dense vegetation contains nine circular rods of same dimensions and offers 60% blockage.

Fig. 2. Trapezoidal weir used

Fig. 3. Holes for installing vegetation elements

IV. Results and Discussions

The experiments were conducted using trapezoidal weirs with three different slopes and three different discharges including vegetation for each weir. Different depths were measured at upstream i.e. 1m from crest of weir and 2m downstream from crest of weir. The discharge coefficient was measured using eq.

$$qo = \frac{2}{3} C \sqrt{\frac{2}{3} g} Ho^{3/2} \qquad (2)$$

Where "qo" is discharge per unit width, "C" is discharge coefficient for fully submerged weir, "g" is acceleration due to gravity and "Ho" is the upstream energy head. Graphs were plotted between downstream water depth and head loss for weirs with three different slopes i.e. 1:3 1:5 and 1:10. For each weir, three different discharge values were used. Vegetation condition over the crest also varies in the above mentioned cases i.e. for 1:3 slope weir, there is no vegetation whereas sparse vegetation exists in case of 1:5 slope and it becomes dense for 1:10 slope weirs. Results have been shown in Fig. 6-8 below. It can be concluded from these graphs that the head loss reduces as the downstream water depth increases. Also, the curves depart from the origin when the discharge increases with all other parameters remaining constant. It is also clear from these graphs that head loss increases with increasing discharge. Graphs were also plotted again between downstream water depth and head loss for different slopes by maintaining the discharge as constant to observe the effect of slope on head loss. Results have been shown in Fig. 9-11. It was observed that with the increase in slope of weir the curve moves away from the origin which indicates that the head loss increases with increasing slope values for the same downstream depths of flow. Head loss vs d/s water depth for a weir with side slopes of 1:10 and discharge intensity of 9.23 l/sec with varying vegetation conditions have been shown in Fig. 12.

Fig. 4. Vegetation elements installed over the weir crest

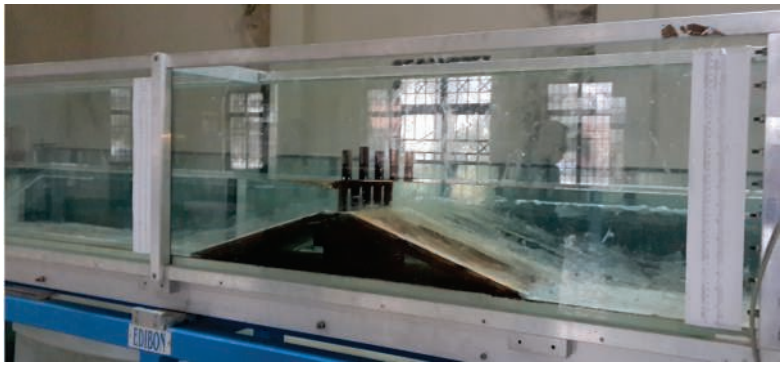

Fig. 5. Channel flow with partially submerged vegetation

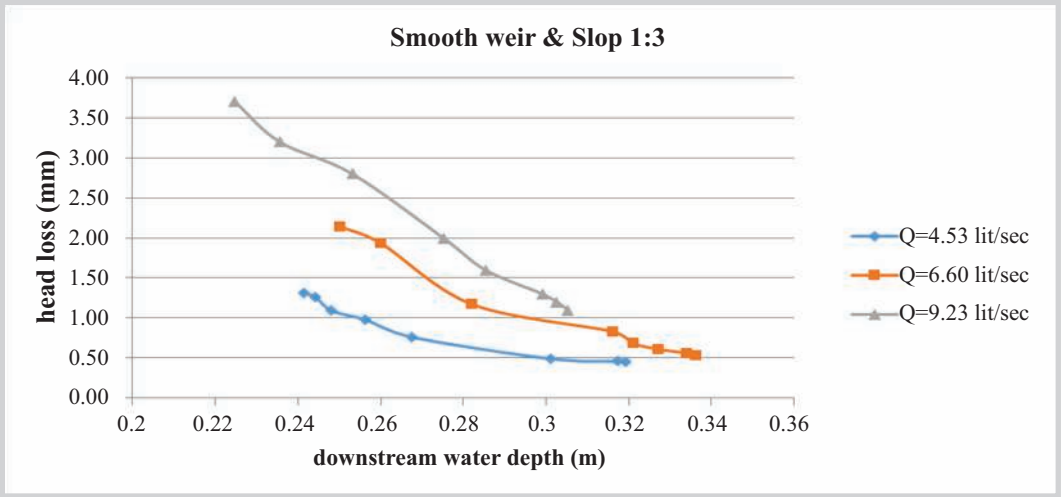

Fig. 6. Head loss vs d/s water depth for slope 1:3

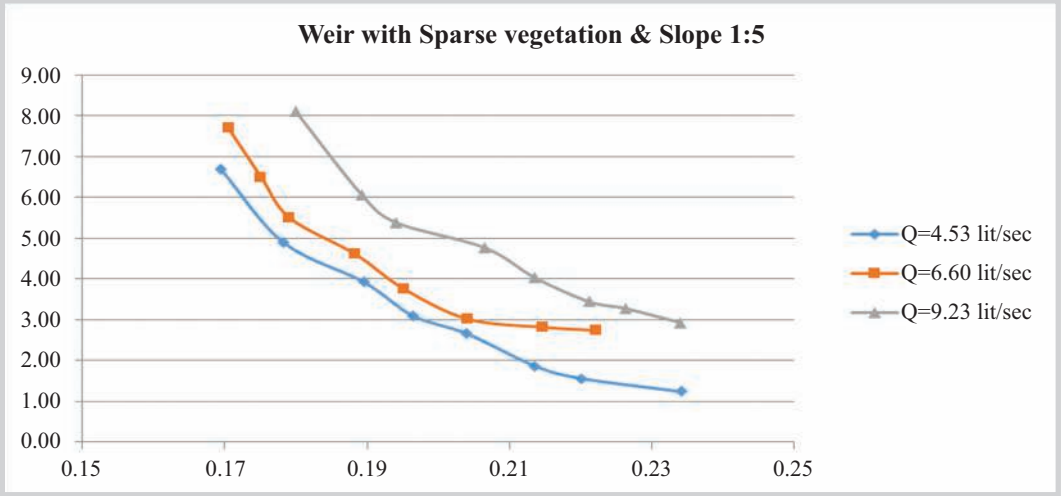

Fig. 7. Head loss vs d/s water depth for slope 1:5

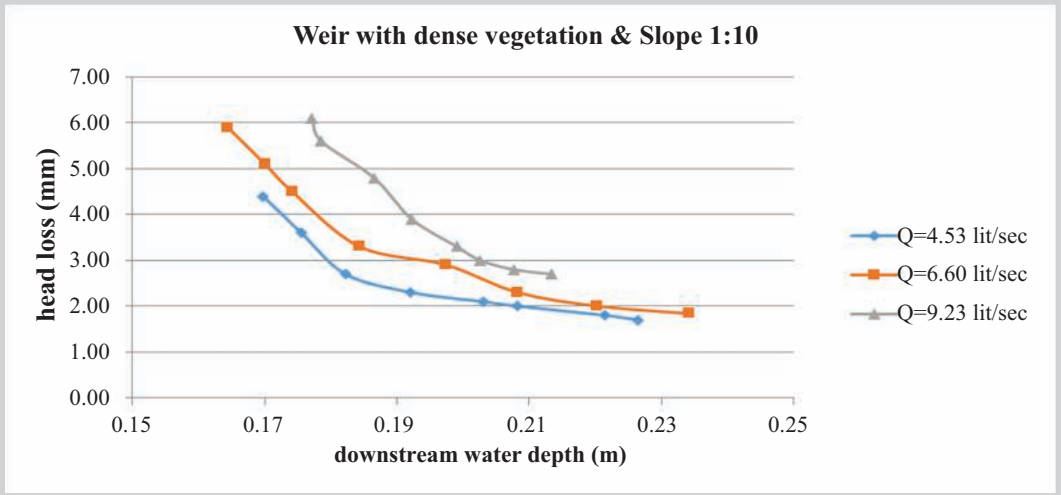

Fig. 8. Head loss vs d/s water depth for slope 1:10

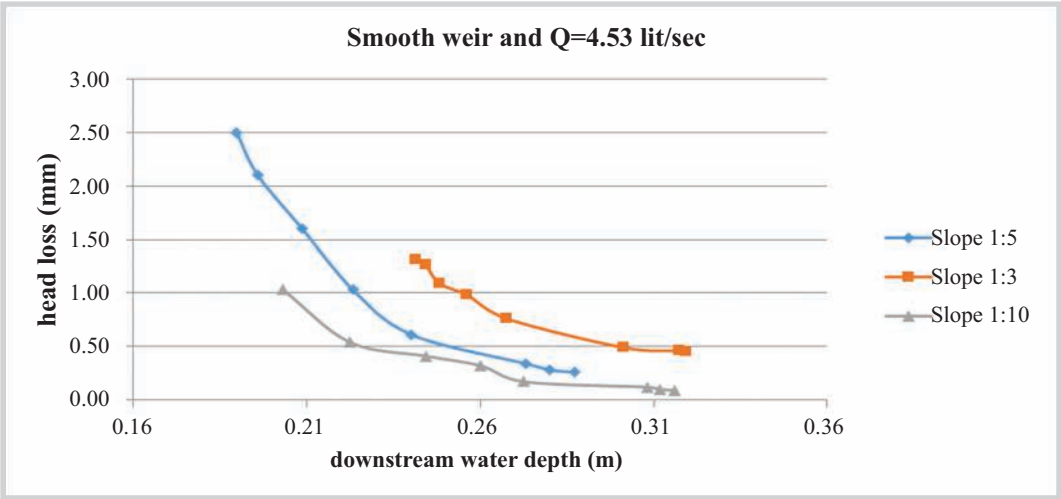

Fig. 9. Head loss vs d/s water depth for discharge 4.53 l/sec and different slopes

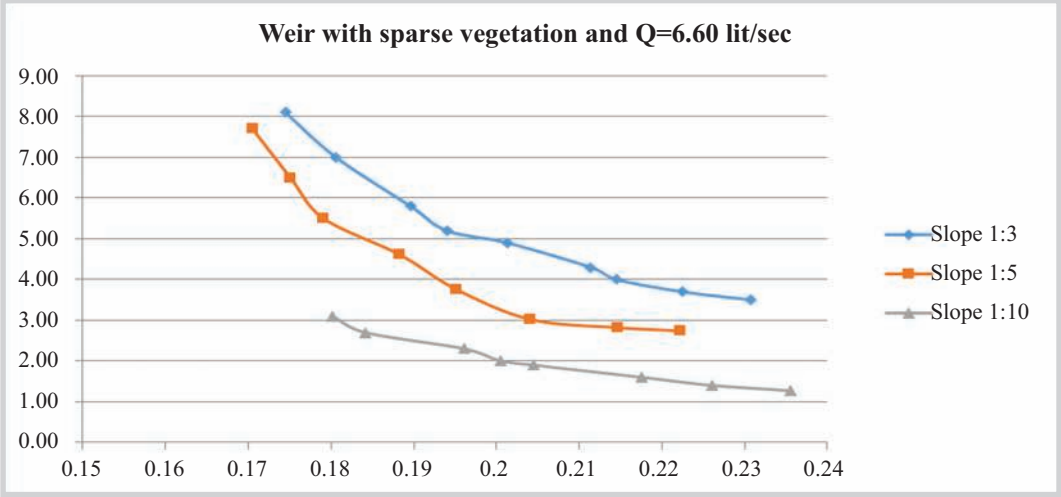

Fig. 10. Head loss vs d/s water depth for discharge 6.60 l/sec and different slopes

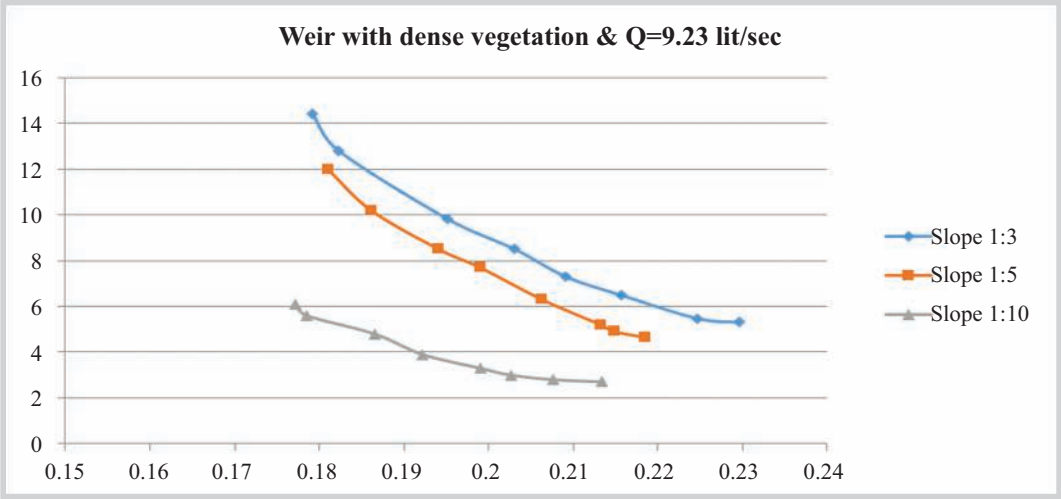

Fig. 11. Head loss vs d/s water depth for discharge 9.23 l/sec and different slopes

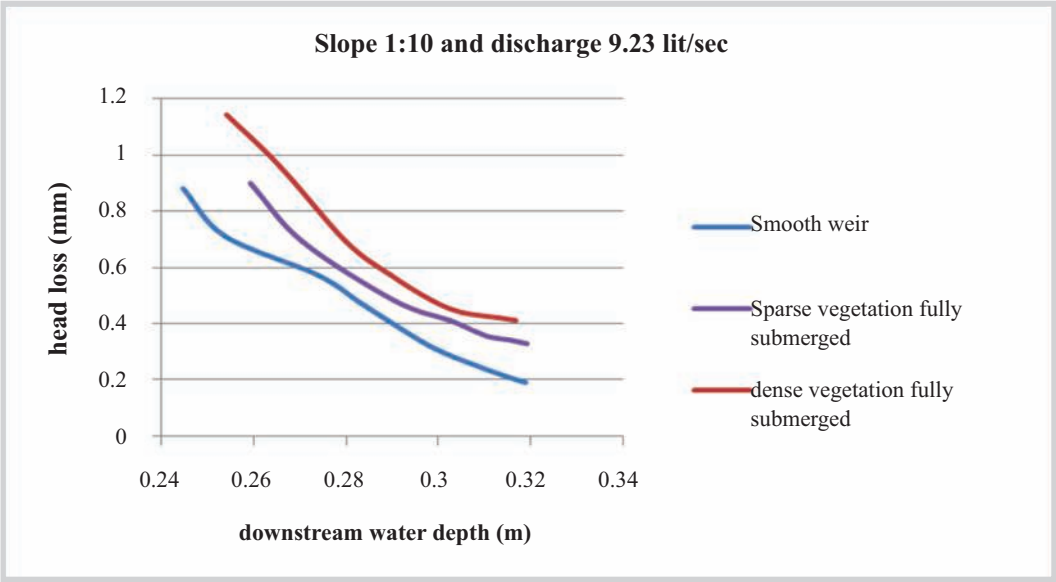

Fig. 12. Head loss vs d/s water depth for discharge 9.23 l/sec and different vegetation conditions

V. Recommendations

Experimental investigations of embankment weir were made on laboratory scale and it gives reliable results therefore, these results may be used to incorporate the flow resistance caused by weir like structure in flood plain for design discharge during flood protection measures. However, following recommendations may be considered for future work;

Usually, the channel section is not uniform but comprises of different sections e.g. flood plain, dikes etc. and flume used for this experimental work was smooth and prismatic. Therefore, it is recommended that more experimental work may be performed using compound channel to find the effects of different components in laboratory.

Weirs used in this case were not possessing any type of gravel or other rough surfaces but vegetation elements alone. Hence rough weirs with different types of vegetation may be used to find the effects of roughness on flow characteristics.

The discharge intensities utilized in this experimental work were small. High discharges may be considered for future work. Vegetation considered in this work was in the form of circular rods. More experiments may be performed using flexible vegetation.

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A Treatise of Civil Engineering in Pakistan

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Abstract-The paper set up from a glance of civil engineering through the ancient ages to the twenty first century world. Nurturing of civil engineering all the way through the construction of pyramids in Egypt (2700-2500 BC) to the modern world civil engineering marvels. On its itinerary it passes through the different historic ages and it has detailed look on the civil engineering in perspective to Pakistan. Growth of Civil engineering education, employment of civil engineers, mega projects, civil engineering establishments, societies and civil engineering statistics are the major spotlights of this voyage. The field of civil engineering is being remodeled drastically to meet the challenges of public safety, health and welfare. With such evolvement there is a definite need to improve the high standards of civil mobility engineering e.g., sureness of presence of experts to ensure the distribution of knowledge and approach to the technology. Civil engineers are present on every level starting from public sector, municipal and national government to private sector, and individual home town firms through international companies. Pakistan is facing severe energy crises and new dams and energy resources are required to overcome this shortage of energy and the civil engineers are the one, who can contribute to achieve this goal. Civil engineering skills to optimize performance and efficiency of community systems are helping to balance safety standards. Despite of all its achievements, civil engineer is notorious for its rare failures as compared to usual brilliant success.

Keywords-Civil Engineering History, Civil Engineering Services, Mega Projects, Civil Marvels

I. Introduction

History of Civil Engineering is as old as the human life itself and that can be explained by looking at ancient structures. It can be assumed that the very early practices took place somewhere around 4000 and 2000 BC in ancient Egypt & Mesopotamia (ancient Iraq) [i]. The first large structures that were ever constructed are pyramids of Egypt (circa 2700-2500 BC). Imhotep is the first documented engineer; he is renowned for constructing a stepped pyramid located at Saqqara Necropolis for the king Djoser. He is supposed to be a courtier so he might have designed and then supervised the program of work. Some people call it engineer's high privilege when a civil engineer transforms his ideas from a brain wave to a plan on paper. Then this plan is turned into an actual non-abstract structure which provides shelter to people and elevates the standard of living & comforts of life.

II. Ancient Historic Civil Engineering Constructions

Some of the ancient marvels of Civil Engineering include Qanat water management system in Iran that is 1400 years old with a length of 71 Km [ii]. Some other outstanding reminders of Civil Engineering from the part of the world are;

One of the major reasons of the elevation of Roman civilization was the infrastructures they built. Romans built building, roads, bridges, aqueducts, harbours, dams etc. throughout their reign. Machu Picchu, Peru, was constructed in 1450 during the Inca Empire. It is one of the miracles of Civil Engineering. Some of the outstanding water resources engineers contributed in its construction in the Andes Mountains. Resident of Machu Picchu were highly advanced in using engineering techniques as their constructed structures, drainage system and food production sustained for more than 500 years.

If we look at engineering education, a book named Vitruvirus De archiectura was published in 1 AD in Rome. This book is an exportation on architectures that gives readers glimpses of the part. It is assumed that it was written by the Roman architect Vitruvirus. Somewhere around 15 BC he dedicated the book to his ruler, Caesar Augustus.

III. Civil Engineering History

A. Mega Projects

In the territory of the present Pakistan; the first Civil Engineering Project of its nature was the railway line built during 1847 from Karachi to Kotri. The Scinde Railway succeeded to connect Karachi and Kotri through railway line on May 13, 1861, just after 6 years of its creation, and it was the first railway line to handle public trains. The total length of track between these two cities was 108 miles (174 km). By the end of 1887 Railway lines to the Bolan Pass, Ruk to Sibi and Quetta had been completed. On March 25, 1889 the Lansdowne Bridge over the Indus was inaugurated to

connect Sukkur and Rohri and making the route for Railway connection between Peshawar and Karachi.

Sukkur Barrage was another mega project of Civil Engineering, built during 1923 to 1932 named Lloyd Barrage during the British Raj. The construction of this barrage opened new horizons for the civil engineering professionals by establishing the first institution in Pakistan for training of graduate Civil Engineers.

The construction of Karakoram Highway (KKH) was started in 1959 and the project reached to its completion in 1979. It is at the highest (Elevation of 4693 meters) paved road in the world. The construction of this project took the lives of about 1010 workers, including 200 Chinese. On its route from Pakistan to China it passes through Khunjerab Pass and is also referred as the "Eighth Wonder of the World".

Mangla Dam is a multipurpose dam constructed during 1961-1967. At the time, it was the 9th largest dam in the world. Another dam named Tarbela is the earth and rock filled Dam and was completed in 1976. It is one of the world's largest of its kind [iii]. Civil works contract of Tarbela Dam, amounting to $ 623 Million, was the world's largest single contract at that time. It was a Joint Venture comprised a group of three Italian and three French contractors.

B. Educational & Institutional History of Civil Engineering

The term 'Civil Engineering' has an interesting origin and it was used in the beginning to cover all terms that apposed military engineering. The National School of Bridges and Highways in France was the first engineering school, established in 1747. John Smeaton constructed Eddystone Lighthouse in 1759 and called himself for the first time a civil engineer.

In 1819, Captain Alden Partridge established first private college to teach civil engineering, it was named Norwich University in Vermont, USA. In 1835, Rensselaer Polytechnic Institute awarded the first degree in Civil Engineering, whereas in 1905, Nora Stanton Blatch Barney a woman was awarded first civil engineering degree by Cornell University.

In Pakistan, Mughalpura Technical College at Lahore was the first technical institute; established on November 9, 1921. Later in 1923, it became the 'Maclagan Engineering College'. In the year 1932, the classes of bachelor degree in engineering was started in affiliation with the University of the Punjab. At the time of Pakistan's independence (1947), the institution was offering well-established B.Sc. degree courses in Civil, Electrical and Mechanical Engineering [iv].

The Nadirshaw Eduljee Dinshaw (NED) University of Engineering and Technology was founded in 1922, as a technical project to train civil engineers working on the building of Sukkur Barrage [v], it was the institution for post graduate education in engineering in Pakistan although the bachelor degree program of the institution was started in succession to the University of Punjab. After British rule, it became the part of Sindh government management and it remained affiliated with University of Bombay, University of Sindh and University of Karachi respectively.

School of Military Engineering (SME) was established at Sialkot in April 1948. Organization was comprised of Administration Wing, Civil Engineering Wing, Field Engineering Wing and Combat Wing and. the institution was upgraded to Military College of Engineering (MCE), [vi] in 1952 and shifted to Risalpur.

North West Frontier Province (NWFP) University of Engineering and Technology Peshawar started Civil Engineering Department during 1953-54. It is the pioneer in Civil Engineering education in the province of Khyber Pakhton Khaw (KPK) and has produced thousands of engineers.

Civil Engineering department at Mehran University of Engineering & Technology initially established as constituent college of the University of Sindh in 1963. The Institutions offering the Degree in Civil Engineering in Pakistan have been enlisted in Table I, below;

TABLE I
INSTITUTION, OFFERING CIVIL ENGINEERING DEGREE

Sr. No	Name of University/Institutions	Civil Department Established
1	NED University of Engineering & Technology, Karachi	1923
2	University of Engineering & Technology, Lahore	1932
3	Military College of Engineering, Risalpur	1948
4	NWFP University of Engineering & Technology, Peshawar [5]	1953
5	Mehran University of Engineering & Technology, Jamshoro [5]	1963
6	Baluchistan University of Engineering & Technology, Khuzdar	1987
7	University of Engineering & Technology, Taxila (University College of Engineering and Technology was established in 1975 in Sahiwal and moved to Taxila in 1977)	1993
8	University College of Engineering and Technology, BZU, Multan	1994
9	Sir Syed University of Engineering & Technology, Karachi	1995
10	Quaide e Awam University of Engineering and Technology, Nawab Shah	1996
11	Gandhara Institute of Science & Technology, PGS Engineering College, Peshawar	2001
12	CECOS University of Information Technology and Emerging Sciences, Peshawar	2002
13	University of South Asia, Lahore	2006
14	Sarhad University of Science and Information Technology, Peshawar	2007

15	National University of Science & Technology (NUST), Islamabad	2008
16	Balochistan University of Information technology, Engineering and Management Science, Quetta	2008
17	University of Lahore	2009
18	Mirpur University of Science & Technology, AJ&K	2009
19	Wah Engineering College, Wah Cantt.	2010
20	National University of Computer and Emerging Sciences, Lahore Campus	2012
21	MNS University of Engineering & Technology, Multan	2012
22	The University of Central Punjab, Lahore	2013
23	COMSATS Institute of Information Technology, Wah & Abbotabad	2013
24	NFC Institute of Engineering & Technology, Multan	2013
25	University of Sargodha	2013

C. *Civil Engineering Societies*

ICE (Institution of Civil Engineering) is the first engineering society that was formed in 1818 in London. It got royal charter in 1828 that recognized civil engineering as an independent profession. According to the charter, the definition of civil engineering goes as: *"Civil engineering is the application of physical and scientific principles, and its history is intricately linked to advances in understanding of physics and mathematics throughout history. Because civil engineering is a wide ranging profession, including several separate specialized sub-disciplines, its history is linked to knowledge of structures, material science, geography, geology, soil, hydrology, environment, mechanics and other fields."* [vii]

Mechanical engineering came thirty years later after the creation of ICE. First professionals institute was established in 1847 under the name (IMechE). It was mainly a break away from the civil engineering (ICE) by George Stephenson who is termed as 'Father of Railways' and creator of the 'Rocket'.

Quaid-e-Azam took special interest in establishing Institution of Engineers, Pakistan (IEP) which was inaugurated on May 07, 1948. The institution was in succession to its predecessor that was Institution of Engineers. India, established by Royal Charter of 1937 and provides a forum for the professional, through a wide range of activities and programs. It covers majority of engineering discipline and has 14 major divisions to date.

The IEP members are round about 50,000 but interesting fact is that 20,000 numbers out of these are from corporate sector.

Pakistan Engineering Council (PEC) was established in 1976, as a body to regulate engineering education and profession in Pakistan. It is a federal government organization to grant accreditation to engineering institutions, enlistment of professional engineers, grant of license to contractors and consultants and provide services as a think tank to the government of Pakistan.

D. *Civil Engineering Statistics*

Civil engineers make up a significant proportion, about 50 per cent, of all engineers in the world [viii]. In Pakistan the proportion of Civil Engineers as compared to other branches of engineering has been shown graphically in Fig. 1.

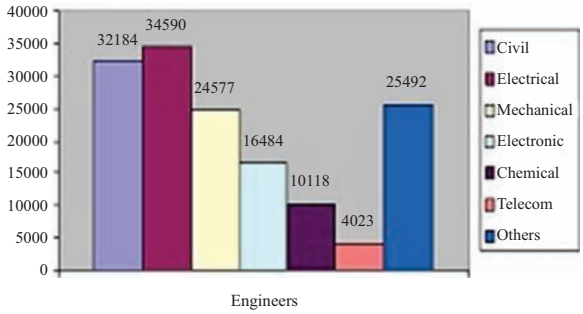

Fig. 1. Comparison with Other Engineering

At the time of independence there were only few civil engineers in Pakistan and the number has been grown to 32,184 as registered Civil Engineers with Pakistan Engineering Council out of 160,225 total engineers registered with it in various disciplines at the end of year 2013. Trend of increasing numbers of civil engineers since 1976 and their comparison with other disciplines have been shown in Fig. 2, 3, 4 & 5.

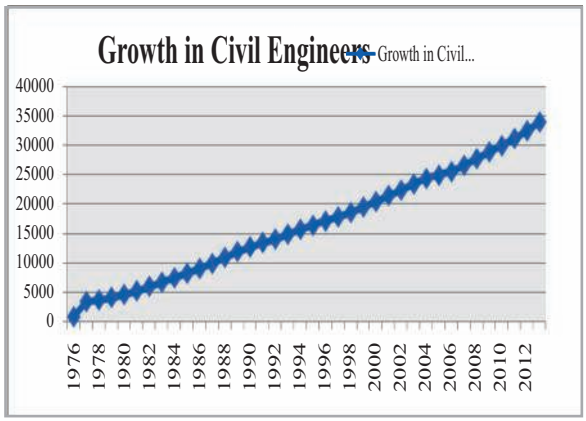

Fig. 2. Trend In Increase of Civil Engineers (1976-2013)

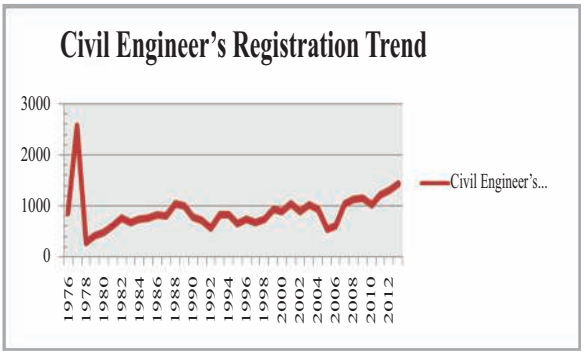

Fig. 3. Yearly Flux Of Civil Engineer's Registration (1976-2013)

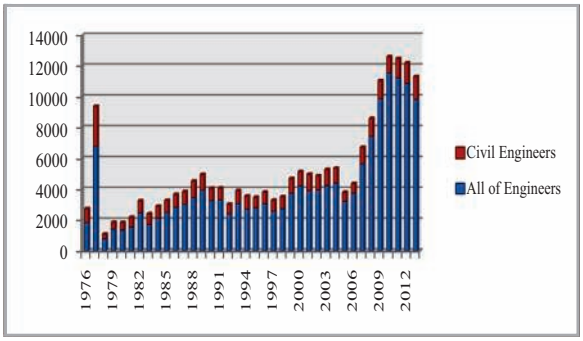

Fig. 4. Civil Engineers Boost As Compared To All Other Engineers (1976-2013)

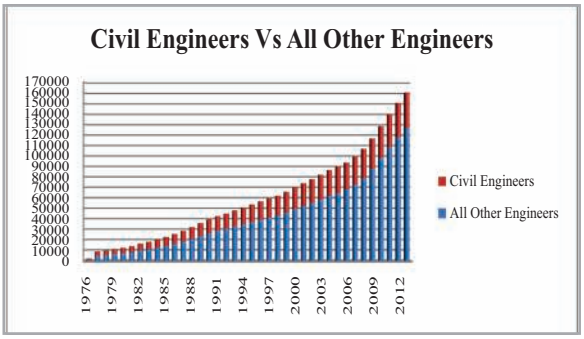

Fig. 5. Trend of Increase In Civil Engineer Vs All Other Engineers (1976-2013

Pakistan Engineering Council was established in 1976 to regulate the engineering profession and Mr. A.M. Akhoond was the first person who registered with PEC as a civil engineer while Mrs. Farzana Ali became the first female civil engineer getting PEC Registration, during 1976.

E. Civil Engineering Establishments

In 1849, British Government founded a Military Board to manage all basic infrastructures in the area of Punjab, North-West Frontier Province and the adjoining areas. Mr. Robert Napier was the head of the board. Later in 1854, civil, military and public engineering works were combined as a one department and Lord Robert Napier was selected as chief engineer. To address issues of irrigation, a separate directorate was formed. After some duration, PWD (Public Works Department) was formed at provincial levels and was under the central control. Due to increasing demand and burden, following three branches were established in 1866;

- Military Works Branch
- Civil Works Branch i.e. Irrigation etc.
- Railways Branch

In 1869, an improvisation was made to the administration and a separate Building and Roads (B&R) branch was founded. Achievements of PWD increased and many canal circles, sanitation and water supply, public health circles and divisions were formed in consideration with requirement and necessity of civil works. Later after independence, the B & R was given under the control of chief engineer and a secretary to manage all concerned matters. The matters were mainly focused on communication, building, sanitation, water works and electrification of government places. Administrative reorganization of government department during May 1962 altered this system as well. Old ways, suspended in 1955, were revived and communication and works (C & W) department was formed under West Pakistan government. Department of B & R and Town Planning were given under the administration of C & W department.

The previous post of provincial chief engineer was cancelled and a new order was formed with a team of five chief engineers. All of them were assigned full technical power, as each of them was in-charge of the relevant region. In 1972, the West Pakistan Housing and Settlement Agency was replaced by Housing and Physical Planning Department (H & PP) with a single attached department the "Directorate General Housing & Physical Planning" Lahore. Afterwards in 1973 H & PP was given control of Improvement Trust at Faisalabad, Gujranwala, Multan, Rawalpindi, Sargodha and Murree. Improvement trusts were transformed into development authorities except Sargodha & Murree.

One of the renowned and reliable construction firm FWO (Frontier Works Organization) was created on 31 October 1966. Purpose behind its creation was to build something that seemed an impossible project. The firm was supposed to make a way out of the highest mountain ranges of the world, the Karakoram Highway.

Near the completion of KKH, the authorities weighed the talent and potential of FWO in completing such projects full of ordeals. So government decided to keep FWO not only for civil engineering projects but expand it throughout the premises of country.

National Engineering Services Pakistan (NESPAK) is government owned private limited company. It was established in 1973 to achieve indigenous pool of competent consultant engineers to

minimize the dependence on the foreign consultants. NESPAK has not only achieved this but it has also gained recognition in the international market of engineering consultancy services by getting registered with a number of international funding agencies such as Asian Development Bank (ADB), International Bank for Reconstruction and Development (IBRD), and Islamic Development Bank (IDB), and it is providing services in as many as (37) countries of the world including Azerbaijan, Afghanistan Bangladesh, Chad, Comoros Island, Cameroon, Ethiopia, Ghana, Iran, Kazakhstan, Libya, Nigeria, Qatar, Kingdom of Saudi Arabia, Senegal, Somalia, Syria, Tanzania, Turkey, Turkmenistan, United Arb Emirates, Uzbekistan, and Yemen.

F. Civil Engineering History: Employment

Total number of civil engineers registered with Pakistan Engineering Council at the end of year 2013 is 33,986 being 21.21 % of the total engineers of 23 disciplines. Ministry of Defense is the largest employer of civil engineers in Pakistan, having approximately 2400 civil engineers; National Highway Authority is the second largest employer having 1500 engineers and Water & Power Development Authority has employed 901 civil engineers. The other major employers of Civil engineers have been shown in the Table II:

TABLE II
MAJOR EMPLOYERS OF CIVIL ENGINEERS

Sr. No	Employer	No. of Civil Engineers
1	Communication & Works Departments	1485
2	Irrigation, P & D, Housing, Urban Development & Public Health Engineering Departments	1165
3	National Engineering Services Pvt. Ltd	715
4	Ministry of Railways	171
5	Others	16250

G. Famous Civil Engineers of the World

Among many following are the prominent Civil Engineers,

Yasser Arafat	Former Palestinian President
Mahmoud Ahmadinejad	Ex-President of Iran
Leopoldo Calvo Sotelo	Spanish Prime Minister
H.D. Deve Gowda	Former Indian Prime Minister
Hu Jintao	Ex Chinese President
Gabriel Narutowicz	The 1st President of the Second Polish Republic.
Fidel V. Romas	Ex President of Philippines

IV. CIVIL ENGINEERING CHALLENGES

With rapid increase in population, responsibilities have increased as well. The discipline of engineering has to fulfill higher standards. The field of civil engineering is being remodeled drastically to meet the challenges of public safety, health and welfare. With such evolvement there is a definite need to improve the high standards of civil mobility engineering e.g., sureness of presence of experts to ensure the distribution of knowledge and approach to the technology.

World Council of Civil Engineers (WCCE) was established in July 2006, to communicate with engineers on a global level. Usually the engineering graduates are tempted at well earning jobs in sector like management sciences, computer sciences, information technology, financial services and civil services. However, much of the ambitious young civil engineers are lured into medium sized construction firms. Two to three decades ago, bright and talented engineers went to foreign countries in pursuit of high income. Over this gigantic "brain drain", the president of Federation of Indian Chamber of Commerce and Industry (FICCI) commented, "Talent has to be compensated."

V. CIVIL ENGINEERING MARVELS

The Civil Engineering remained ahead of all the branches of engineering throughout the historic age and it is a matter of pride for civil engineers that almost all of the Seven Wonders of ancient ages [ix] belong to civil engineers. Their writings have not survived, except as references. The classic seven wonders are:[x]

1. Great Pyramid of Giza
2. Colossus of Rhodes
3. Lighthouse of Alexandria
4. Statue of Zeus at Olympia
5. Hanging Gardens of Babylon
6. Mausoleum at Halicarnassus
7. Temple of Artemis at Ephesus

To meet the challenges of their work, Designers rely less on formulas learned in graduate school than on the kind of improvisation learned in practice [x]. As per American Society of Civil Engineers, wonders of the modern world have been shown in Table III.

TABLE III
THE WONDERS OF THE MODERN WORLD [xi]

Sr. No	Wonder	Location
1	Channel Tunnel	Between France and the UK
2	CN Tower surpassed by Burj Al-Khalifa	Toronto, Ontario, Canada
3	Empire State Building	New York, U.S.A
4	Golden Gate Bridge	North of San Francisco, California, U.S.A
5	Itaipu Dam	Between Brazil and Paraguay (Paraná River)
6	Delta Works/Zuiderzee Works	Netherlands
7	Panama Canal	Isthmus of Panama

Following is the brief description of the modern world wonders.

It was an old dream to link Britain with rest of the Europe. The thirty one-mile channel tunnel made that dream come true. It is a splendid marvel of civil engineering that unites infrastructure and machinery to form an underwater passage of unmatchable innovation.

Fig. 6. Channel Tunnel

Fig. 7. Burj Al Khalifa

Burj Khalifa (Arabic: برج خليفة, "Khalifa Tower"), is the tallest man-made structure in the world[5]. The building is a blend of diversity. About over 828 meters (2,716.5 feet) and more than 160 stories, Burj Khalifa holds the following World Record:[xii]

- Tallest building in the world
- Highest number of stories in the world
- Highest outdoor observation deck in the world
- Tallest free-standing structure in the world
- Highest occupied floor in the world
- Tallest service elevator in the world

Before Construction of Burj Khalifa, CN Tower was the highest building at 1,815 feet above the sidewalks of Toronto. The CN Tower was erected at an incredible rate of 18 feet per day.

The Empire State building is one of the best-known skyscrapers in the world. It held the record of being the tallest building ever constructed for more than four decades. The distinguished feature of this 1,250 feet high building is that it was constructed in a year and 45 days, without any overtime.

Fig. 8. CN Tower

Fig. 9. Empire State Building

The Golden Gate Bridge in San Francisco was declared by ASCE as a movement of millennium and is considered to be a land mark in civil engineering, completed in just four years. A number of ordeals were faced by the crew during its construction including intense cold weather, 70-mph gusts and dizzying heights during the brief span of four years of its construction.

Fig. 10. Golden Gate Bridge

Itaipu Dam, five miles wide was constructed by shifting the course of the seventh largest river in the world; 1.3 mile by pass was dug to accomplish this goal.

Fig. 11. Itaipu Dam

The hollow concrete segments are used to construct the main dam removing approximately 50 million tons of earth and rock; flanking wings of the dam comprise of earth and rock fill. The quantity of steel and iron used in the construction of Itaipu dam is enough to construct as many as 300 Eiffel Towers. The power house of Itaipu dam is another marvel of engineering, it measures one half mile in length and it is partially submerged. It has 18 hydroelectric generators producing 12,600 megawatts of power that is enough for the most of California [xiii]. This power is more than 60 % of total power demand of Pakistan

Fig. 12. Netherlands North Sea Protection Works

Inhabitants of Netherland made a number of attempts to protect themselves from flooding but could not succeed. Netherland North sea protection works, unique vast and complex system of dams, floodgates, and storm surge barrier are the literal reasons behind Netherland existence.

Fig. 13. Panama Canal

Panama Canal opened in 1914 and still functional is a miraculous combination of geotechnical, hydraulic, structural, and sanitary engineers. The canal has reduced the maritime distances by 13,000 km between the American East and West coasts [xiv]. Panama Canal has been declared as the Monument of the Millennium and an International Historic Civil Engineering Landmark by the ASCE [xv].

The world's largest flood prevention projects named as Tide Barrier Project, constructed in Venice, Italy, to protect the Venetian lagoon from the sea water during high tides and storms. It consists of 78 rotating gates, blocking the sea from the lagoon.

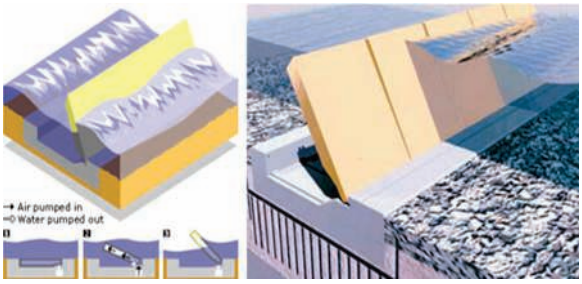

Fig. 14. The Venice Tide Barrier Project

A massive irrigation system in Egypt “The New Valley Project” conceived to reclaim a half-a-million acres of desert is one of the five most outstanding civil engineering achievements of the year by the American Society of Civil Engineers. The First phase was completed and opened for operation in year 2005, second Phase is scheduled to be completed in 2017. It will provide about 3 million jobs, a foremost contribution to help manage the increasing growth of Egypt's inhabitants.

Fig. 15. The New Valley Project

The Three Gorges Dam is one of China's largest construction projects since the Great Wall. It is almost 400 miles long, over 600 feet wide and produce electricity equal to 18 nuclear power plants.

Fig. 16. Three Gorges Dam

Fig. 17. Palm Islands

The Palm Islands, located off the coast of the United Arab Emirates in the Persian Gulf near Dubai, are outstanding examples of engineering achievement. The islands, formed by filling the seabed with sand, in the shape of a palm tree with a crescent-shaped rock encircling the top of each island as shown in Figure 17, are the largest man made islands.

VI. Conclusions

American Society of Civil Engineers define Civil Engineers as "Civil Engineers serve competently, collaboratively, and ethically as: constructors, planners, designers and operators of society's economic and social engine; the built environment; stewards of the natural environment and its resources; integrators of ideas and technology across the academic, public and private sectors; innovators and managers of risk and uncertainty caused by accidents, natural events and other threats [xv]. Civil engineer is present on every level starting from public sector, municipal and national government to private sector, individual home town companies to international companies.

- Civil engineers carry the responsibility as they influence the lives of people around them, as professionals they are managing the built environment.
- To ensure human life safety and prosperity, reliable, safe and high quality measures need to be ensured. A flaw on part of a civil engineer can result into disruption and many other dire consequences like sickness, injury and potentially death of a large number of people.
- Civil engineers bring unique services to society – services that involve creative skills and personal decisions that carry substantial responsibility.
- In the early ages of Pakistan, civil engineering rose to high altitudes. Projects like Karakorum Highway, Mangla & Tarbela Dams and Irrigation networks showed new horizons to Pakistani civil engineers. Interaction with world fame civil engineers enhanced their capabilities, and civil engineering remained on highest merit in the engineering institutions of the country. The statistics shows that registration of Civil Engineers at the time of creation of PEC in 1976 was more than 50 % as compared to all other disciplines. Civil engineering faced a downfall in the early nineties, consequently graduating civil engineers in that era faced problems to find suitable jobs and many of them switched their professions due to lack of opportunities. After 2003, civil engineering profession in Pakistan started resurgence and it is striving to get back to the past glory. Today's statistics of opportunities for civil engineering graduates are very encouraging.
- An interesting fact is that despite of all its achievement, a civil engineer is notorious for his/her rare failures as compared to usual brilliant success.

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Section B

ELECTRICAL AND ELECTRONICS ENGINEERING

Design of Fourth Order Active Band-Pass Filter With Sallen and Key Topology

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Abstract-Analog active filters can be found in most of the electronic circuits. One major application of active filters involve an important class of sharp cutoff filter used to condition analog input signals that are being sampled and converted to digital signal as real-time to the modern computers. In this paper, we present the design of active filter with the second and the fourth order Butterworth responses in the category of Sallen and Key filter architecture. This type of filter has voltage controlled voltage source topology that uses a unity-gain amplifier. The complex transfer function of the filter is obtained and the capacitor/ resistor values are calculated. The filter is simulated with the Multisim program and compared with the Matlab tool. The results of the frequency responses are very similar to each other.

Keywords-Active Filters, Sallen and Key Topology, Butterworth Response, Frequency Response, Power Estimation

I. INTRODUCTION

Analog active filters can be found in most of the electronic circuits. In communication system, filters are generally used for the elimination of noise and tuning in specific frequencies of range (0 KHz to 20 KHz). In digital signal processing system, filters are implemented for interference and noise prevention. All input signals are composed of sinusoidal components of various frequencies, amplitudes and phases. If we are interested in a certain range of frequencies, we can design filters to eliminate frequency elements outside the range. Active filters can be made to be part of adaptive signal-processing systems. Here the filter's poles, zeros or gain can be altered electronically in response to some criterion. A tracking active filter can be made to follow the frequency of a coherent input to preserve maximum signal-to-noise ratio at the filter's output. One major application of active filters involves an important class of sharp cutoff low-pass filter used to condition analog input signals that are being periodically sampled and converted to digital form as real-time inputs to digital computers. Anti-aliasing filters remove all significant signal spectral energy at and above one-half the sampling frequency. Active filters can also be made to be part of adaptive signal-processing systems. A tracking active filter can be made to follow the frequency of a coherent input signal to preserve maximum signal-to-noise ratio at the filter's output.

Numerous types of filter designs have evolved in the past twenty years. Most of them are non-standard and less precise values of resistors and capacitors to achieve design goals. Among those active filters are most effective filters. Active filter uses operational amplifier (op-amp) as active component in the circuit. Op-amp-based active filters do not require the use of inductances in their designs. It is far easier to build a nearly ideal resistor or capacitor than an ideal inductor. Also, inductors are bulky and heavy. Thus modern active filter use only resistors, capacitors and op-amps that can make compact and inexpensive relative to RLC networks with the same pole-zero platforms. This is especially true when we consider filters designed to work in the subsonic spectral region. Also, design procedures for high-order, passive RLC filter are very complex, whereas the modular approach used in the synthesis of high-order active filters makes design more straightforward.

Some types of filters have no independent control of mid-band gain, damping factor, or break frequency. The most popular types of active filter responses are the Tschebyscheff, Chebyshev, Bessel and Butterworth. Among these, Butterworth is most effective topology for the implementation of the maximum flat response. It exhibits a nearly no ripples with flat pass. The roll-off is more monotonic and smooth with high-pass and low-pass roll of 20 dB/decade for each pole. Thus, the implementation of filter with fourth order would have attenuation rate of +40 dB/decade and -40 dB/decade. The filter responses can be demonstrated with band-pass, band-stop, low-pass, and high-pass filter configuration setups.

The paper is organized as follows. In Section II and III, the background of Butterworth filter and Sallen and Key filter is discussed. In Section IV and V, the analysis of the active low-pass and band-pass filters are described. The implementation of the fourth order active band-pass filter using Sallen and Key topology is given in section VI. The power estimation method for filter and the results are discussed in Section VII and VIII. Finally, the Section IX summarizes the work.

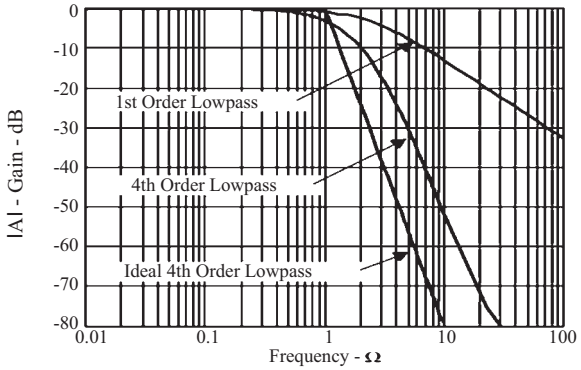
II. Butterworth Filters

Fig. 1 plots the amplitude and phase responses of Butterworth low-pass first order, and fourth order active filters [I, v]. The Butterworth filter has the maximum pass-band flatness as illustrated in the figure. Due to the flatness, it uses as anti aliasing filter in data conversion applications with preciseness in the signal across the entire pass-band. Many low-pass filters are designed to construct with a Butterworth transfer function with following magnitude response:

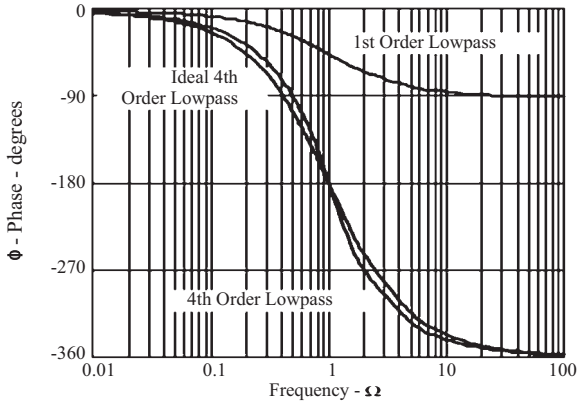
$$|H(f)| = \frac{H_o}{\sqrt{1+f/f_b{}^{2n}}} \quad (1)$$

where n is the order of the filter and f_b the 3 dB cutoff frequency and H_O is the gain magnitude at dc voltage.

Active low-pass Butterworth filter response can be implemented by cascading modified Sallen and Key circuits. In this class of active filter, an op-amp is used to provide voltage-controlled voltage-source (VCVS) with a low inverting or non-inverting voltage gain, and along with various resistors and capacitors, to realize quadratic low-pass, band-pass and high-pass filters. This class includes the well-known Sallen and Key designs, which are described in the next sections.



(a)



(b)

Fig. 1. Frequency responses of 1st and 4th order active low pass filters with (a) magnitudes and (b) phases [I]

III. Sallen and Key VCVS Filters

The second-order Sallen and Key electronic filters are the degenerated form of a VCVS filter topology. A VCVS filters generally uses a unity gain voltage amplifier with the high input impedance, zero output impedance, and the infinite impedance of input to implement a two-pole (12 dB/octave) low-pass, band-pass or high-pass responses. This unity-gain amplifier (i.e., a pure buffer amplifier with 0 dB gain) permits for high Q-factor and pass-band gain without the use of inductors in the analog circuits. However, source or emitter followers are different choices for the buffer amplifier. Voltage-controlled voltage-source filters are comparatively resilient to certain level of the component tolerance. Due to the consideration of high Q-factor may need extreme individual component value or high gain [ii, v]. Higher order filters can be constructed by cascading two or more stages as shown in figure 7. The filter cascaded order may be increases up to 10th order by cascading first and second order type. However, identical stages are not recommended and rarely can be used due to very poor frequency response for different applications.

A. *Characterizations of Sallen and Key filter*

- Positive gain or non-inverting amplifier
- Components replication
- Simplicity in analog designs

B. *Limitations of the filter*

- The gain and Q-factor are related to each other
- Q-factor > 0.5, since $A_v > 1$

IV. Low-Pass Filters

A Sallen and Key quadratic low-pass filter with non-inverting VCVS can easily be made with an op-amp and two resistors/capacitors (RC) as illustrated in Fig. 2. The frequency response of the ideal low-pass filter is shown in Fig. 3. Analysis of the behavior of active filter design proceeds by noting:

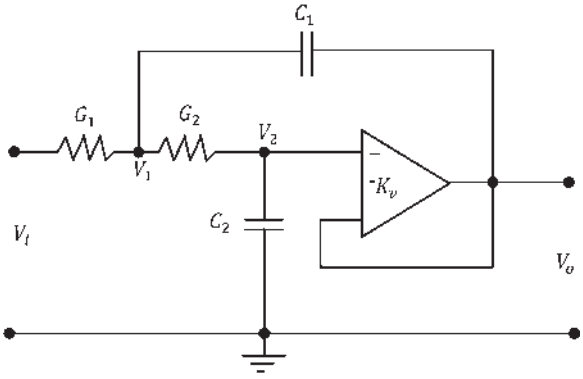


Fig. 2. Unity gain Sallen and Key VCVS low-pass active filter

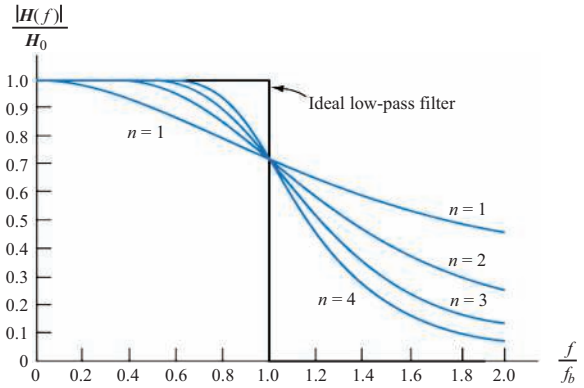


Fig. 3. The frequency response of low-pass Sallen and Key VCVS filter [iii]

Consider the low-pass filter design in Fig. 2, that $V_O = K_v V_2$ and

$$V_2 = \frac{V_1(1/sC_2)}{R_2 + 1/sC_2} = \frac{V_1}{1+sR_2C_2} \quad (2)$$

Using Kirchoff's current law in (3):

$$V_1\left(G_1 + \frac{1}{R_2+1/sC_2} + sC_1\right) - sC_1V_o = V_iG_1 \quad (3)$$

To solve (2) for V_1 and substitute into (3), we find (4):

$$(sR_2C_2 + 1)\left(\frac{V_o}{K_v}\right)\left(G_1 + \frac{sC_2}{1+sR_2C_2} + sC_1\right) - sC_1V_o = V_iG_1 \quad (4)$$

Then we can write the low-pass active filter's transfer function in time-constant format in (5):

$$\frac{V_o}{V_i} = \frac{K_v}{s^2C_1C_2R_1R_2 + s[C_2(R_1+R_2) + R_1C_1(1-K_v)] + 1} \quad (5)$$

To solve it in Sallen and Key format, K_v = 1, so the filter's transfer function reduce to

$$\frac{V_o}{V_i} = \frac{1}{s^2C_1C_2R_1R_2 + s[C_2(R_1+R_2)] + 1} \quad (6)$$

This filter's break frequency can be written in (7):

$$w_n = \sqrt{\frac{1}{C_1C_2R_1R_2}} \quad (7)$$

and the damping frequency can be expressed in (8):

$$\xi = \frac{C_2(R_1+R_2)}{2}\sqrt{\frac{1}{C_1C_2R_1R_2}} \quad (8)$$

If $R_1 = R_2$, so that $R_1 = R_2 = R$ then damping frequency reduces in (9):

$$\xi = \sqrt{\frac{C_2}{C_1}} \quad (9)$$

Hence the ratio C_2/C_1 sets the Sallen and Key low-pass filter' damping factor, and simultaneous adjustment of R_1 and R_2 with a ganged, dual-variable resistor can set ω_n independently of ξ. The dc gain of this low-pass filter is unity. During design, the value of the capacitance can be chosen first after resistance values. As K_v increases from 0 to 3, the transfer function shows more peak values. In case of $K_v > 3$, then the circuit is not stable. The empirical values for filter can be determined with the combination of different orders.

A. The Butterworth Approximation

The general form of the non-zero transfer function of nth-order low-pass filter is shown in (10) [iv]:

$$A(s) = K\frac{1}{1+\mu_1(s/\omega_c)+\mu_2(s/\omega_c)^2+\ldots+\mu_n(s/\omega_c)^n} \quad (10)$$

where K is the dc gain constant, ω_c is a normalization frequency, and the μ_i are the positive constants.

B. High-Pass Filter

Fig. 4 illustrates a Sallen and Key high-pass filter. Following a nodal analysis similar to just used on the low-pass filter, we obtain the following transfer function, where we assume K_v and $C_1 = C_2 = C$ in (11):

$$\frac{V_o}{V_i} = \frac{s^2C_1C_2R_1R_2}{s^2C_1C_2R_1R_2 + s(C_1R_1 + C_2R_1) + 1} \quad (11)$$

Here again, the undamped natural frequency of the filter is expressed in (12):

$$w_n = \sqrt{\frac{1}{C_1C_2R_1R_2}} \quad (12)$$

and the damping frequency is in (13):

$$\xi = \frac{R_1(2C)}{2}\sqrt{\frac{1}{CR_1R_2}} = \sqrt{\frac{R_1}{R_2}} \quad (13)$$

The high-frequency $(\omega \gg \omega_n)$ gain for this filter is also unity.

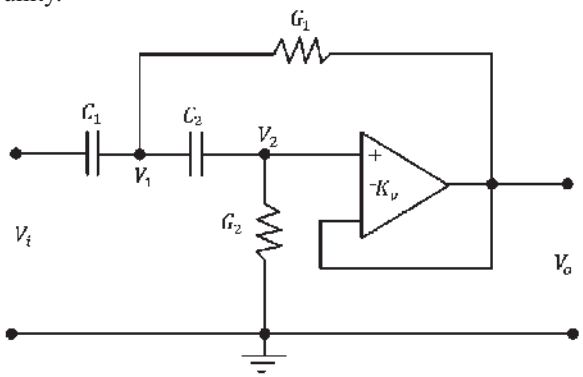


Fig. 4. Unity gain Sallen and Key VCVS high-pass active filter

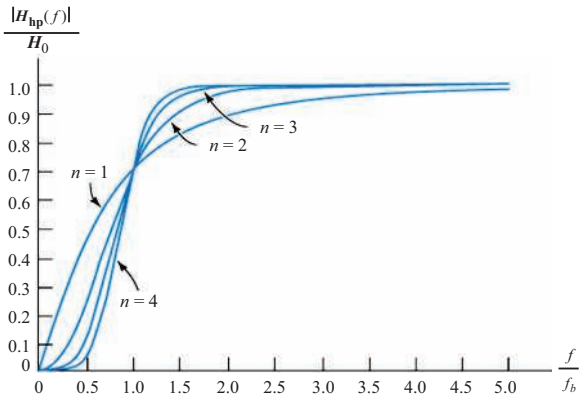


Fig. 5. The frequency response of low-pass Sallen and Key VCVS filter [3].

V. Band-Pass Active Filter

The unity gain Sallen and Key VCVS band-pass active filter is shown in Fig. 6.

By solving the circuit of Fig. 6, the node equation for V_1 and V_2, noting that $V_O = K_v V_2$, we find in (14):

$$\frac{V_o}{V_i} = \frac{s\left[\frac{K_v C_1 G_1}{G_2(G_1+G_3)}\right]}{s^2\left[\frac{C_1 C_2}{G_2(G_1+G_3)}\right] + s\left[\frac{C_1 G_2 + (C_1+C_2)(G_1+G_3) - K_v C_1 G_3}{G_2(G_1+G_3)}\right] + 1} \quad (14)$$

where we assume $K_v = 2$ and $C_1 = C_2 = C$ in (15):

$$w_n = \frac{1}{C}\sqrt{G_2(G_1+G_3)} \quad (15)$$

$$A_v = \frac{2G_1}{G_2 + 2G_1} \quad (16)$$

and the damping frequency is (17):

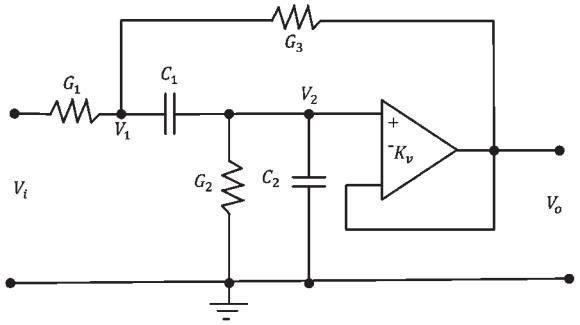


Fig. 6. Unity gain Sallen and Key VCVS band-pass

$$Q = \frac{G_2(G_1+G_3)}{\sqrt{G_2(G_1+G_3)(G_2+2G_1)}} \quad (17)$$

Note that the peak response A_v and Q are independent of C; $C_1 = C_2 = C$ can be used to set w_n at A_v and Q.

VI. Implementation of 4th Order Active Band-Pass Filter Circuit Using Sallen-Key Topology

The filter cascaded order may be increases up to 10th order by cascading first and second order type. However, identical stages are not recommended and rarely can be used due to very poor frequency response for different applications. The design of 4th order filter is very complex, it may be designed by the cascading two second-order filters as shown in figure 7. The attenuation at the cutoff frequency of individual filter should be -3dB then the attenuation for two stage filter will be at -6dB.

TABLE I
Specifications of Band-Pass Filter

Specifications	Values
Pass-band frequency	10-20 Khz
Pass-band ripples	0.5 dB
Stop-band attenuation	60 dB
Center frequency	17 kHz
Overall Mid frequency	15 kHz

The design of 4th order active band-pass filter of Sallen and Key topology is implemented in this paper due to its simplicity of the design. The Butterworth filter response is adopted for more flat gain. These types of filter response have wider range during the lower order with low-power dissipation and good linearity. The filter response is insensitive to parasitic capacitances. The second order Sallen and Key band-pass filter is illustrated in Fig. 6. The specifications of desired filter are shown in Table I.

The transfer function of 4th order active band-pass filter is determined in (18):

$$A_v = \frac{\frac{A_{mid}}{Q_p}\sigma.s}{\left[\frac{1}{Q_p}\left(\frac{s}{\sigma}\right) + \left(\frac{s}{\sigma}\right)^2 + 1\right]} \cdot \frac{\frac{A_{mid}}{Q_p}\sigma.s}{\left[\frac{\sigma.s}{Q_p} + (\sigma.s)^2 + 1\right]} \quad (18)$$

where A_{mid} is the gain of mid frequency f_{mid} of individual filter, Q_p is the quality of pole for each filter, σ and $1/\sigma$ are the mid frequency factors of individual filters $f_{mid\text{-}1}$ and $f_{mid\text{-}2}$ extracted from the f_{mid} of the overall band-pass filter.

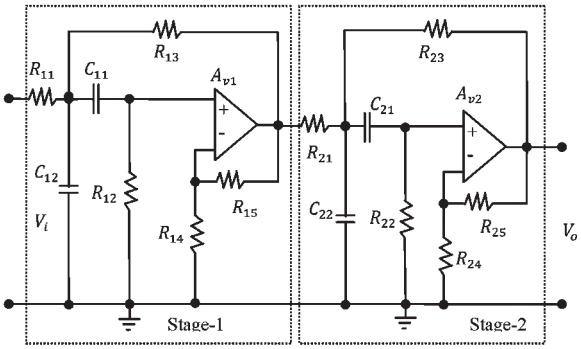


Fig. 7. Sallen and Key VCVS 4th order band-pass active filter

Using successive approximation method, factor σ is derived in (19):

$$\sigma^2 + \frac{1}{\sigma^2} + \left[\frac{\sigma \cdot \alpha_1 \cdot \Delta\varphi}{\beta_1(1+\sigma^2)}\right]^2 - \frac{(\Delta\varphi)^2}{\beta_1} - 2 = 0 \qquad (19)$$

where $\Delta\varphi$ is the normalized bandwidth defined as $\Delta\varphi = (Q_{all})^{-1}, (Q_{all} = 1.5)$ is the overall filter's quality), α_1 and β_1 are the second order low-pass coefficients of the specific desired filter type. In this case Butter worth filter has $\alpha_1 = 1.4142$ and $\beta_1 = 1$. The overall filter's quality in (20):

$$Q_{all} = \frac{f_{mid}}{B} \qquad (20)$$

The quality of each filter can presented in (21):

$$Q_p = Q_{all} \cdot \frac{\beta_1(1+\sigma^2)}{\sigma \cdot \alpha_1} \qquad (21)$$

The individual gain of the mid frequencies $f_{mid\text{-}1} = f_{mid\text{-}2} = f_{mid}$ is same for both filters, so

$$A_{mid} = \frac{Q_p}{Q_{all}} \cdot \left(\sqrt{\frac{A_m}{\beta_1}}\right) \qquad (22)$$

where A_m is the overall gain at mid frequency taken as 2 value.

By using Table I, $\sigma = 1.27$, $Q_p = 2.28$, $A_{mid} = 4.12$. In Fig. 7, the RC values are calculated for both stages of 4th order band-pass active filter as:

$$C_{11} = C_{12} = C_{21} = C_{22} = 10\,nF$$

$$R_{11} = R_{13} = 1.45k\Omega,\ R_{12} = 3.12k\Omega, R_{14} = 10k\Omega, R_{15} = 12.38k\Omega$$

$$R_{21} = R_{23} = 755.10k\Omega,\ R_{22} = 1.90k\Omega, R_{24} = 10k\Omega, R_{25} = 12.38k\Omega$$

The transfer function of 4th order Butterworth band-pass filter was derived as:

$$A_v = \frac{s^2-1}{s^2-0.6325s+0.6597} \cdot \frac{s^2-1}{s^2-0.1155s+0.6314} \qquad (23)$$

Hence, by the use of transfer function in (23), the frequency response of the filter is plotted in Matlab tool as shown in Figure.

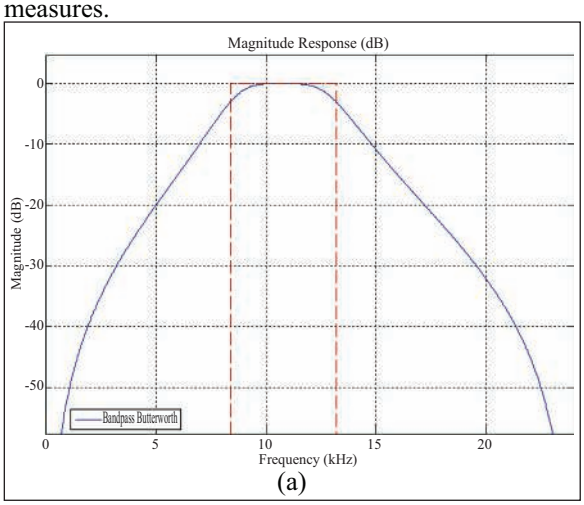
VII. Power Estimation for Filter

In this section, we present the power estimation procedure for Sallen and Key filter. Recently we have presented a macro-model for different intellectual property (IP) blocks and IP-based digital systems in [vi, vii, viii]. We used the same approach for the power estimation of the DSP applications such as Sallen and Key filter. In this method the statistical variables such as signal probability (*SP*), transition density (*TD*), spatio-temporal correlation (*ST_C*), are used for the generation of input signals of the filter. Using functional simulations and power estimator, the output signal sequences are observed and the average power dissipation of the filter is estimated. The results of the filter are given in section VIII.

VIII. Experimental Results

This section demonstrates the results of 4th order band-pass Sallen and Key architecture with Butterworth response. The Butterworth filter response is adopted due to its flatter gain. The filter response has wider range during the lower order with low-power dissipation, good linearity and insensitive to the parasitic capacitances. The circuit of the band-pass filter is shown in figure 7. The filter consists of two stages of cascaded band-pass filters. It is designed with careful considerations for the adjustable values of the resistors/capacitors and constructed its transfer function in (23). The specification of the filter is shown in Table I. The result of the transfer function is illustrated in terms of the different plots of: magnitude, phase, step response and delay response as shown in figure 8. The filter is simulated in Multisim software and the transfer function is implemented in Matlab tool. The filter has band-pass frequencies 10KHz and 20 KHz, The band-pass gain is kept greater than one and roll-off rates of ±40 dB/dec. The experimental result shows that the responses of the complex filter are very similar with the commercial software plots and shows accurate results in terms of flat gain.

We have implemented the statistical power estimation method of the filter as discussed in section VII. We have generated several randomly input signals of (*SP*), (*TD*), and (*ST_C*) of range between [0-1]. In experiments the average error of filter is found 11.34%. One important source of error is due to the power consumption of interconnects and the fixed coefficients used in the filter. The experiment demonstrates that the transition density is more significant in the estimation of power dissipation and relatively linear to the power measures.



(a)

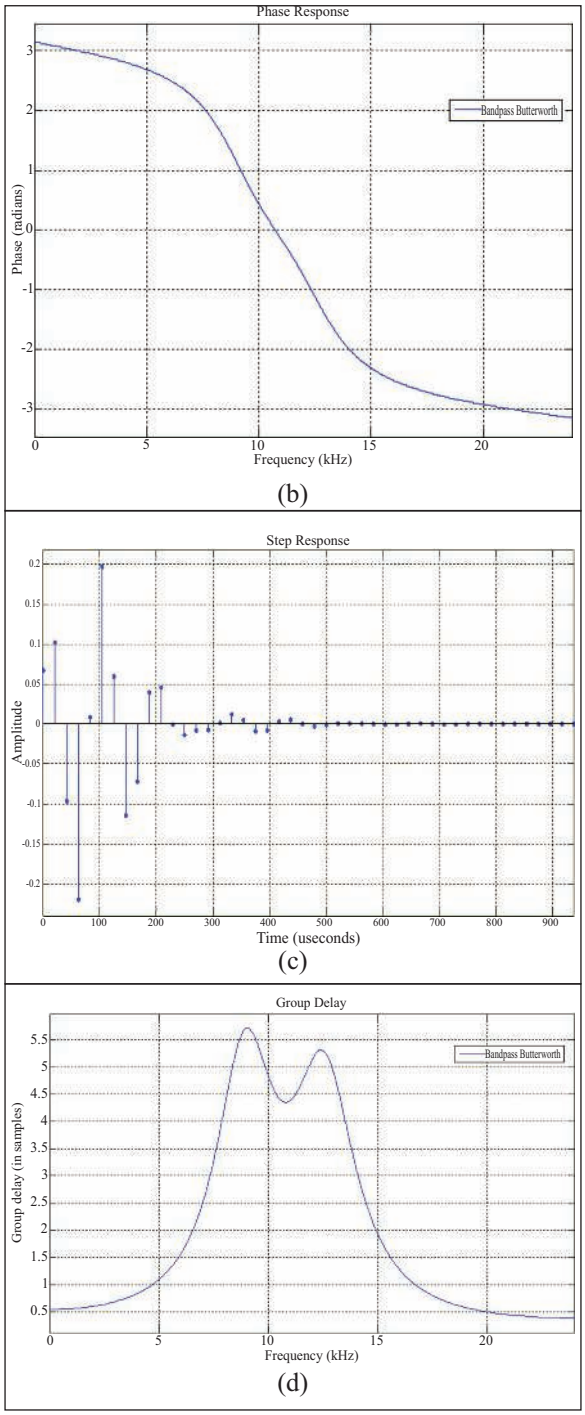


Fig. 8. Frequency responses of 4th order active band-pass filters with (a) magnitudes (b) phases (c) step response and (d) delay responses.

IX. Conclusion

The 4th order band-pass filter is designed and simulated in this paper. The circuit of the filter is composed of two operational amplifiers, ten resistors, and four capacitors. The magnitude and phase responses of the filter are very similar to the Multisim software. If more-accurate frequency response is required, more stages must be used. Power estimation of the filter is dependent on the digital input signals and greatly influence on the average power. The power estimation of the DSP applications is not only the transition activity at the inputs and outputs, but also the input arrival times and the spatio-temporal correlation of the input data.

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Throughput Maximization for Cellular Communication Underlay Device to Device Network

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Abstract-This paper aims at designing a cellular system underlay device-to-device (D2D) system through Rate Proportional allocation (RPA) algorithm and Reuse allocation (RUA) algorithm. System throughput has been maintained between cellular users (CUEs) and D2D users (DUEs) through proposed schemes. Further, we analyzed our proposed schemes with Random Allocation (RA) algorithm. Simulation results have verified the increased gains in system throughput with proposed schemes.

Keywords-Cellular Networks, Resource Management, Resource Blocks, Wireless Networks, OFDM

I. INTRODUCTION

With the exponential growth in the number of users and their escalating demands, telecom operators are in no doubt battling for increasing their data demands with existing spectrum. Device-to-Device (D2D) communication is a propitious answer to the firing question of data demands. Third Generation Partnership Project (3GPP), and Long Term Evolution (LTE) are focusing on deployment of D2D [i]. Fifth Generation (5G) with deployment of D2D is no more far behind because large propagation loss with minimum multi-user interference is ideal for underlay which causes different types of interferences within and out of the network.5G is brainy network because it uses Millimeter Waves (mm Wave) which has highly directional antenna for small distances.D2D is a direct link, infrastructure less communication i.e. without or less involvement of the base station (BS). It is ideal for catastrophic conditions where requirement of a framework is really a big hurdle. For example, the tsunami and the earthquake occur in the last few years. On the basis of coverage of networks two classes are defined. Class A and Class B. Class A are for those networks which cover small distances. This class includes Bluetooth, ZigBee, Wi-Fi and many others like these. Some of them are unlicensed devices like Bluetooth which causes high interferences. Moreover, these devices are non-transparent to users. While Class B involves long distance covering networks like cellular networks and Worldwide Interoperability for Microwave Access .In [ii] it is described that a brainy algorithm is required for clever communication. So, different routing protocols have been defined. Moreover, the estimation in increment of number of user with time is given. Resource allocation and power control still remains a problem over many advantages of hop gain, proximity and spatial reuse. In [iii] every aspect of D2D has been discussed including in-band, out-band, overlay and underlay and controlled and autonomous approaches are reviewed. In [iv] resource allocation schemes are purposed to alleviate interferences. Moreover, the perspective of unlicensed band is discussed. Uplink resources can be reused efficiently while keeping cellular user in its high preference with maximum interference avoidance in D2D is discussed in [v]. In addition downlink user (DU) which is an exacerbate deals through interference alignment schemes for high throughput is focused in [vi]. Illustration of D2D is shown in Fig. 1.

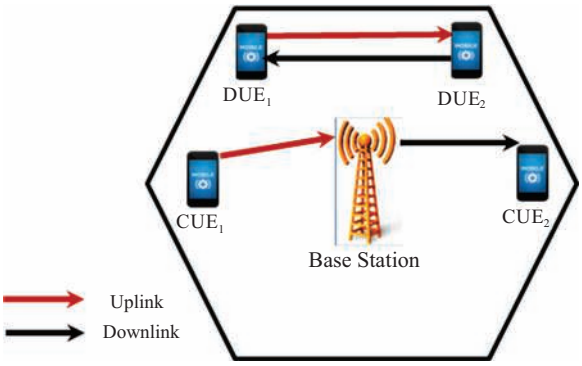

Fig. 1. Illustration of cellular system with D2D communication: Two types of users in the hexagonal cell: CUEs link through BS while DUEs links directly.

A. *Related work:*

Demands comes with generations. To cope with the increasing demands of data utilization, D2D is suggested as a promising solution. Interference management, resource allocation and power control are hurdles to be overcome and need more work to be done on them. The authors in [vii] have viewed underlay i.e.

both D2D and cellular user (CUE) use the same spectrum which in turn causes homogenous and heterogeneous interferences. Hence to alleviate this problem, it is critically analyzed in isolated and connected community network. While its solutions given through social aware resource allocation algorithm to give optimal allocation scheme.

In [viii] a cooperative multicast scheme is proposed instead of one stage multicast scheme. A near center protocol is suggested where successful users act as relays to resend data to the rest of unsuccessful users. While time allocation problem is solved by Sequential Quadratic Programming (SQP). A comparative study of single stage and dual stage multicast is done with briefing the pros and removing the obstacle through SQP in line allocation and data acknowledgment to the user. In addition [ix] has dealt with interference between two different broadcast groups of D2D. Inter broadcast group interference is depreciated with graph based algorithm.

To mitigate the effects of inter cell and intra cell interference when it is an underlay network, the authors in [x] purpose a solution through graph coloring based scheme. It took three steps to complete. First, a feedback strategy is introduced. Second, algorithm is specified. Third, resource allocation scheme is used on the basis of second step. Simulation is carried out to prove the excellence of proposed scheme. Fractal frequency reuse (FCR) based ICIC (Inter Cell Interference Coordination) is used in [xi] to relief heterogeneous inference and homogenous interference palliated by OFDMA-LTE system. FFR improves better performance with optimal spatial reuse. Major core of this paper is dedicated towards discussion at cell brink.

Sequential second price auction mechanism is used for the effective system sum rate over the sharing of spectrum of both D2D and CU. Spectrum is divided into expedient blocks and auctioned off the highest bid charges and cost the second highest bid. Process of auction continues until the last leave is reached. Number of D2D users and expedient blocks are not limited. Hence, spectrum utilization and efficiency are its resulting rewards and are discussed in [xii]. Issue of power control also has addressed through different and novel aspects in many research papers. In [xiii] two approaches i.e. Pricing Based Power Control and Two Layer Power Control Algorithm are used on uplink resource units to increase throughput and provide near to null interference. Moreover, these two mechanisms are critically analyzed and compared on performance basis. In [xiv], authors have gone through centralized and decentralized methods. Former is gifted with reliability and efficiency and lateral is defeated on reliability.

Weakening of signals at the edge of cells is mitigated in [xv] through introduction of mirror frequency concept. I/Q imbalance have studied in respect to near far effects and other impairments. In [xvi] and [xvii] iteration process is used but in different context. In former paper it is used as a bridge between scheduling problem and transmits power while in later power is controlled through setting it to zero or maximum value not in between it and consist of repetitive steps of power at start and modification of power level. In [xviii] a comparative study on iterative and binary power control scheme is done which is limited to small number of D2D and UE.

B. Motivations and Contribution

Theoretically, work has been done for single transmitter and single receiver system. While practically, multiple transmitters and antennas are deployed, this causes interferences. In order to mitigate the effect of interferences and cope with the problem of resource allocation different schemes are proposed which are Inband and Outband. We are focusing toward underlay (type of inband). Mostly overlay is purposed for interference mitigation but it is not spectrum efficient because underlay on the other hand uses same spectrum for both cellular user and D2D users. So, maximum throughput and sum-rate is gained by using underlay.

C. Organization

The remaining paper moves around following sections. Section II describes system model and mathematical description. In section III, problem formulation is provided to mitigate interference, while in section IV simulation parameters and simulation results are discussed. While Section V presents a conclusion.

II. System Design and Mathematical Description

A. System Design

In this paper, an Orthogonal Frequency Division Multiplexing (OFDM) cellular system is considered with BS at its core. In the given system model, *N* cellular users, known as CUEs and *M D2D* users, known as DUEs are considered. CUEs users communicate via BS while D2D users communicate via BS as well a scan communicate directly to each other but still these are considered under the control of BS when assuming them as underlay cellular system. All entities have single antenna systems.

A. Mathematical Description

For convenience, uplink transmission is only measured. Since Z_{bs} is the received signal via BS from n^{th} CUE in the uplink is given by

$$Z_{bs,m} = \sqrt{P_{cu,n}} H_{cu,n} D_{cu,n} + \sqrt{P_{dtx,m}}, H_{dtx,m} D_{dtx,m} + ¥_{bs} \quad (1)$$

where

$P_{cu,n}$: Power of n^{th} CUE to transmit in uplink

$H_{cu,n}$: n^{th} CUE and BS are separated by channel vector

$D_{cu,n}$: Symbolof n^{th} CUE data

$P_{dtx,m}$: m^{th} DUE_T power to transmit

$H_{dtx,m}$: m^{th} DUE_T and BS are separated by channel vector

$D_{dtx,m}$: Symbol of m^{th} $DUE_{T\ data}$

$¥_{bs}$: BS AWGN distortion

In the uplink, m^{th} DUE_T is the transmitting signal tom^{th} DUE_R is given as

$$Z_{drx,n} = \sqrt{P_{dtx,m}}L_{dtx,m}D_{dtx,m} + \sqrt{P_{cu,n}}L_{cu,m}D_{cu,n} + ¥_{drx} \quad (2)$$

where

$p_{dtx,m}$: Power of m^{th} DUE_T to transmit in uplink

$L_{dtx,m}$: m^{th} DUE pair separated by channel vector

$D_{dtx,m}$: m^{th} DUE_T Data symbol

$L_{cu,n}$: n^{th} CUE and m^{th} DUE_R separated by channel vector

D_{dtxm}: m^{th} DUE_T Data symbol

Interference signal, data signal and distortion has been represented in (1) and (2). $\Psi_{cu,n}$ and $\Psi_{dtx,m}$ are the received signal to Interference-noise ratio (SINR) at BS and at m^{th} DUE_R and can be expressed by

$$\Psi_{cu,n} = \frac{P_{cu,n}|H_{cu,n}|^2}{P_{dtx,m}|H_{dtxm}|^2 + n_0} \quad (3)$$

$$\Psi_{dtx,m} = \frac{P_{dtx,m}|L_{dtx,m}|^2}{P_{cu,n}|L_{cu},n|^2 + n_0} \quad (4)$$

Uplink transmission throughput as a sum rate is given by

$$C_{n,m}^{rpa} = log_2(1 + \Psi_{cu,n}) + log_2(1 + \Psi_{dtx,m}) \quad (5)$$

III. Problem Formulation

A. Rate Proportional Allocation (RPA)

In order to maximize the sum-rate of system, both cellular and D2D users have supposed same goal rates. A number of RBs are considered with OFDM system and devised through Binary Linear Programming (BILP) method which is defined as

Maximize:

$$\sum_{n=1}^{N}\sum_{m=1}^{M} \delta_{n,m}^{x} C_{n,m}^{x} \quad (6)$$

Where$X$ indicates the x^{th} term of RBs. RB allocation index is indicated by binary integer $\delta_{n,m}^{x}$

Subject to:

$$\sum_{n=1}^{N}\sum_{m=1}^{M} \delta_{n,m}^{x} \leq 1, \forall x, \quad \delta_{n,m}^{x} \in \{0,1\}, \forall(n,m,x) \quad (6\text{-a})$$

These limitations provide a result that there is only one CUE or DUE per RB. The homogenous interference is mitigated by this limitation

$$\sum_{x=1}^{X} log_2 \frac{P_{cu,n}|H_{cu,n}|^2}{P_{dtx,m}|H_{dtxm}|^2 + n_o} \geq C_{cu} \quad (6\text{-b})$$

$$\sum_{x=1}^{X} log_2 \frac{P_{dtx,m}|L_{dtx,m}|^2}{P_{cu.n}|L_{cu,n}|^2 + n_o} \geq C_{dxt} \quad (6\text{-c})$$

Where C_{cu} and C_{dxt}: minimum rate requirements for CUE and DUE, respectively.

B. Reuse Mode Allocation (RUA)

For reuse mode selection it is assumed that there are no dedicated resources available for DUEs or CUEs. In Reuse mode interference between a DUE and CUE plays a vital role in the allocation of resources. DUEs are assumed to work in the same uplink band as CUEs and can reuse RBs of CUEs with least interference. With known channel conditions, BS can assign RBs to certain DUEs by keeping the interference level for CUEs to such extent that it is not harmful for CUEs links. The individual threshold SINRs are set for DUEs and CUEs to keep interference at control level.

Uplink transmission throughput as a sum rate in reuse mode can be given as:

$$C_{n,m}^{rua} = log_2\left(1 + \frac{P_{cu,n}|H_{cu,n}|^2}{I_{du,m}+n_0}\right) + log_2\left(1 + \frac{P_{dtx,m}|L_{dtx,m}|^2}{I_{cu,m}+n_0}\right) \quad (7)$$

where $I_{du,m}$ and $I_{cu,m}$ shows the maximum interference introduce by DUE to CUE and from CUE to DUE, respectively in reuse mode. To limit the level of the interference on CUE and DUE, the SINR at both selected DUE and CUE must be higher than some threshold value of SINR.

$$\frac{P_{cu,n}|H_{cu,n}|^2}{I_{du,m}+n_0} \geq SINR_{cu}^{th} \quad (8\text{-a})$$

$$\frac{P_{dtx,m}|L_{dtx,m}|^2}{I_{cu,m}+n_0} \geq SINR_{du}^{th} \quad (8\text{-b})$$

The problem formulation for reuse mode is same as earlier except the constraint in (6-a) is replaced with (8-a) and (8-b).

C. Proposed Scheme

The intended RB-allocation algorithm is primarily

based on three rules, Precedence, Ampleness, and Maximization.

1. **Precedence**: In D2D underlay communication, cellular and D2D users share the same resources. While in this algorithm, resources are assigned by keeping commensurate precedence between CUEs and DUEs. Moreover, precedence is provided to CUEs and it is checked by analyzing the Signal to Noise Ratio (SNR) on all given RBs. It is advantageous to use this process because every single CUE achieves equivalent opportunity to utilize its channel excellence unless it reaches to require minimum rate (MR). When this process of MR completes for all CUEs then it happens again for DUEs.
2. **Ampleness:** It is the process of allocation of RBs or demand requirements i.e. MR of all CUEs and DUEs. This step took place for those CUEs and DUEs which don't have precedence until now. So, CUEs and DUEs which reach up to mark level of MR are impermanent removed from this process. Hence it gives opportunity to others to achieve its ampleness.
3. **Maximization:** For convenience, if some RBs are still not allocated then they follow the precedence rule and only allocated to CUEs. Actually it is the maximization of end throughput.

The proposed algorithm is shown in algorithm-1:

D. Power Allocation

In this paper we focus only on the allocation of subcarriers and it is assumed that power is fixed.

MATLAB optimization toolbox can also be used efficiently to optimize the power in such problems. An optimization tool "FMINCON" which is designed to find the minimum of a given constrained nonlinear multivariable function is applied.

Algorithm-1

1: Initialize all RBs, CUEs and DUEs
2: for rounds =1: X
3: $(n', x') = \arg\max\left(\Psi^{x}_{cu,n}\right) \forall n, \forall x$
4: DO

$$\delta^{x}_{n} = 1, \{RBs\} = \{RBs\} - \{RB\ x'\}$$

5:if
For RPA:

$$\sum_{x=1}^{X} log_2\left(1 + \frac{P_{cu,n|H_{cu,n}|^2}}{P_{dtx,m|H_{dtxm}|^2 + n_o}}\right) \geq C_{cu}$$

For RUA:

$$\frac{P_{cu,n}\left|H_{cu,n}\right|^2}{I_{du,m} + n_0} \geq SINR^{th}_{cu}$$

6: Do

$$\{CUEs\} = \{CUEs\} - \{CUE\ n'\}$$

7: end if
8: if $\{CUEs\} = \varnothing$,
9: go to 12
10: end if
11: end for
12: $(m', x') = \arg\max\left(\Psi^{x}_{dtx,m}\right) \forall m, \forall x$
13: DO

$$\delta^{x}_{m} = 1, \{RBs\} = \{RBs\} - \{RB\ x'\}$$

14:if
For RPA:

$$\sum_{x=1}^{X} log_2 \frac{P_{dtx,m|L_{dtx,m}|^2}}{P_{cu,n|L_{cu,n}|^2 + n_o}} \geq C_{dxl}$$

For RUA:

$$\frac{P_{dtx,m}\left|L_{dtx,m}\right|^2}{I_{cu,m} + n_0} \geq SINR^{th}_{du}$$

15: Do$\{DUEs\} = \{DUEs\} - \{DUE\ m'\}$
16: end if
17: if $\{DUEs\} = \varnothing$
18: go to 21
19: end if
20: end for
21: Do for all waiting RBs
22: for rounds= 1: waiting RBs length
23:
$(n'/m', x') = \arg\max\left(\Psi^{x}_{cu,n}/\left(\Psi^{x}_{dtx,m}\right)\right) \forall n, \forall m, \forall x$
24: $\delta^{x}_{n/m} = 1, \{RBs\} = \{RBs\} - \{RB\ x'\}$
25: end for
26: exit

Maximization is achieved by multiplying the objective function with -1 before applying this optimization command. FMINCON is a gradient-based method that is designed to work on problems where the objective and constraint functions are both continuous and have continuous first derivatives. When the problem is infeasible, FMINCON attempts to minimize the maximum constraint value. This built-in function is flexible since it includes both equality and inequality constraints[xix].

IV. Numerical Results and Discussion

This section estimates the excellence of intended algorithms. The simulations are performed in MATLAB to prove the results. BS is considered as core in a single cell to serve CUEs and DUEs. All nodes are supposed to be familiar with Channel state estimation (CSI). Then, its estimation is done for individual and overall throughput of CUEs and DUEs. Other simulation variables are depicted in Table I.

TABLE I
SIMULATION VARIABLES

Variables	Values
Nominal SNR	20 dB
Available Channel Realization	1000
Channel Scheme	Rayleigh
Available CUEs	3
Available DUE Pairs	3

The results of the proposed rate proportional allocation (RPA) algorithm and Reuse allocation (RUA) algorithm are compared with the Random Allocation (RA) algorithm. Moreover the excellence of intended commensurate allocation algorithm is used in contrast with fixed RB allocation scheme. In random allocation RB scheme we divide fixed resources between DUEs and CUEs. In Random allocation, both CUEs and DUES have equal number of available resources and resources are allocated in Round Robin techniques. In all cases we fix the minimum rate requirement of 1 Mb/S for all CUEs and DUEs.

Fig. 2 is depicted between overall throughput and diverse number of given Rbs. Analysis has shown that proposed scheme RPA gives near optimal throughput. This is happening because CUEs and DUEs have assigned the excellent channel gains. A noticeable gain is achieved by applying RPA and RUA as compared to RA with increasing number of Rbs.

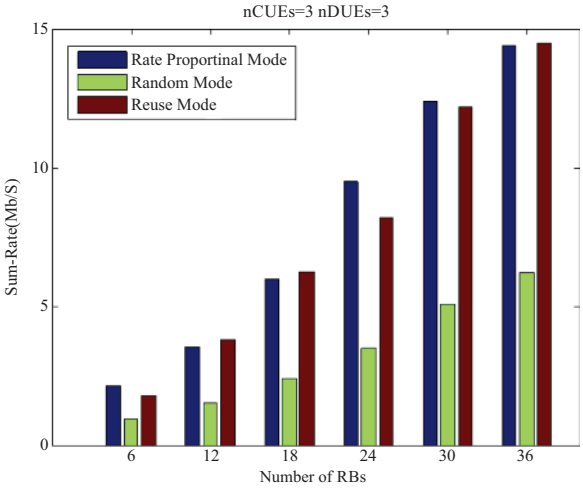

Fig. 2. Throughput of a system versus number of Rbs

Fig. 3 and Fig. 4 show the individual throughputs achieved by DUEs and CUEs, respectively in all scenarios. We can easily observe that when numbers of available resources are increased for DUEs, the CUEs are unable to meet minimum rate requirement as shown in Fig. 4. While in the proposed RPA algorithm and RUA, both CUEs and DUEs are able to meet this requirement in any scenario and the overall throughput is also enhanced as already shown in Fig. 2. The simulation results show nearly optimum throughput when intended commensurate allocation is made in whole scenarios i.e. in cellular network underlay D2D communication with fixed allocation.

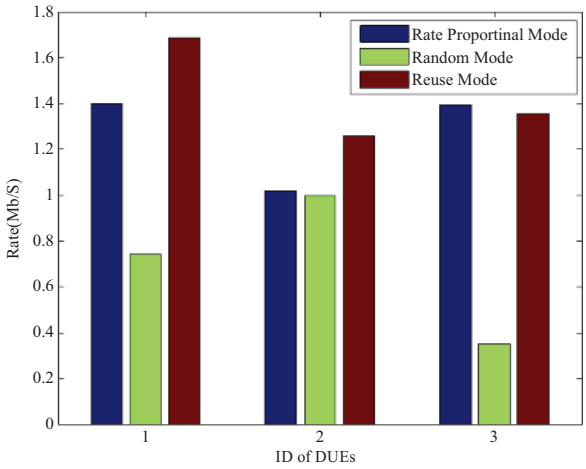

Fig. 3. Individual Throughput for Each DUE

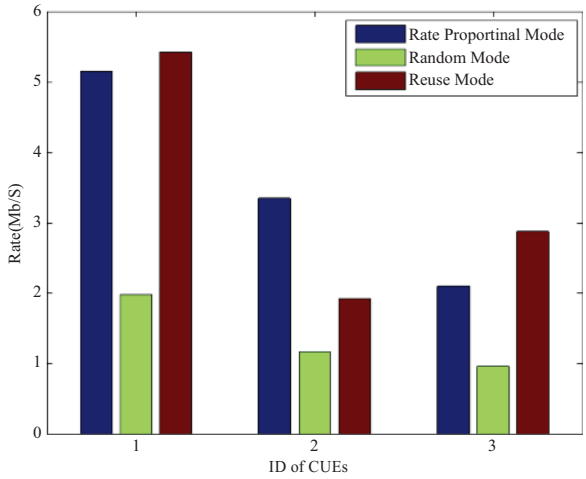

Fig. 4. Individual Throughput for Each CUE

V. CONCLUSION

D2D communication is a key feature of all future technologies. It provides high spatial efficiency and advantageous for catastrophe condition. This paper copes with problem of interference through maximum throughput algorithm in multi-user environment. RB utilization increases through this method. Moreover, the optimization problem for maximum throughput is explored for a Multi-user Cellular system underlay D2D system. A rate proportional resource allocation scheme is analyzed in correspondence with RUA and RA allocation. Simulation results verified the increased gain of the proposed algorithms in terms of proportional fairness between CUEs and DUEs. Simulation results have validated its effectiveness.

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Section C

MECHANICAL, INDUSTRIAL, MATERIAL, ENERGY ENGINEERING AND ENGINEERING MANAGEMENT

Detection of Lateral Motion Noise and Error Ratio for Rail Wheelset Based Upon Creep

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Abstract-The knowledge about lateral motion is very crucial parameter for railway wheelset dynamics for the smooth running of railway vehicle wheels over rail track to avoid the adhesion ratio by balancing creep application. The lateral motion is caused by critical speed and high forward velocity of railway vehicle wheels. This lateral movement may be perturbed on running system on track by certain noise and disturbances, which may be necessary to be estimated to avoid accidents. In this paper, the essential dynamics of lateral motion is modeled and kalman filter is used to estimate for detection of noise to reduce disturbance and slip. The controller for Kalman estimator scheme is proposed to analyze error percentage to for controlling slippage. This slip causes the destruction of vehicle and lives. Since lateral motion is dependent upon the longitudinal speeds variations. If forward speed is higher, then the lateral speed extends due to adhesion deficiency on creepage force.

Keywords-Adhesion, Creep co-efficient, Lateral Speed, Kalman Filter, Error Estimation

I. INTRODUCTION

The carter and kalker are considered as former pioneers of railway wheelset dynamics. The carter has done sufficient work on railroad vehicles while kalker paved path for dry friction procured by sliding of steel wheels on track and his concerned theories are just guide for researchers [i-ii]. The Davies has elaborated upon lateral oscillations by performing some practical on it and proved that lateral motion is affected by linear speed [iii]. The correlation between creep force and creepage is complicated for solving the rolling contact problem and effect of lateral movement for railway wheels on creepage of rail-wheel contacting surface. The concerned research in the lateral motion shows that discrimination between longitudinal creepage is smaller and possible error is lower than twenty percent. The lateral creepage on left wheel contact is more than right wheel surface as well as spin creepage of left wheel lower in lateral movement for railway wheelset. The motion of a railway wheelset move at a constant forward speed is studied that lateral motion is fixed by flanges and the rail tracks have sinusoidal lateral deviations by wheels. The lateral motion of the wheelset can be stationary, chaotic or periodic. There are two major types of motion, [iv] one in flange contact occurs at rail and other in range of contact occurs at both rail and wheels.

The two wheels of railway wheelset are rigidly connected by an axle. The wheelset rolls on the railway contacts are considered as arc and radius of a circle. The restored force of the wheel flanges are approximated on the rail wheelset connected by strong straight springs with a dead band and without damping material. Thus lateral motion is limited by these springs without any damper. The wheelset and the axle are conceived as rigid bodies. Figure-1 shows the geometry of the railway wheelset having two degrees of freedom by movement. The rolling of a rail wheels without slipping is considered by the creep analysis. The wheels are assumed by two cones having commonly based and the rails by two circle cylinders with parallel planes [v]. The dynamics of the undisturbed rolling movement of the wheelset happens when the centre of mass moves along with a straight path. The disturbed movement describes a sinusoidal trajectory on the central mass of the wheelset.

The artificial noise does not exist on the rail-wheelset attitude at several speeds under the condition of present fluctuation noise. The lateral and yawing movements develop small amplitudes, and if the present velocity is more than the critical speed, the lateral and yawing motions arise with existing timing factor. The developing amplitude is controlled by wheel flanged contact of the wheelset to the rolling rig under the condition of the present speed. The Lateral displacements happen due to imperfections on the rail road generating uninvited movements in X,Y Z axes. The Lateral motion procures in the rail wheel contact due to their connection. These generated contact forces are discriminated as creepage forces depending upon varied creep coefficients for railroad wheelset steadiness [vi]. The creep coefficients comprise rail-wheel structure, constants and normal load.

The conventional Kalman filtering algorithm is usually application for stochastic and dynamic modeling. The dynamically model defines the nature of

modeling the errors that grow upon time while the stochastically [vii] model explains the noise of the concerned properties and new measurements of the processing to be modeled for railway wheelset.

The model was framed by using real time system for verifying validity of rail wheel contact factors for estimation of slip and sliding [xvi].

Author of this article has enumerated identification of adhesion influenced by contamination on rail track to affect the lateral phenomenon based upon creep forces associated with forward speed to cause slip [xvii].

In this paper, the railway wheelset dynamics with reference to its lateral motion is discussed to model system. The kalman filter scheme is used to estimate the noise based upon various creep co-efficient and thus error percentage is described to detect information about slippage. This kalman filter scheme is used as algorithm to differentiate the actual and estimated with their error ratio by making code on mat lab and simulink blocks as chart for implementation of mathematical relations.

II. Dynamics for Lateral Motion of Rail-Wheels

The attitude of a single railway wheels can be considered at a constantly moving speed *v* on a straight track. The mathematically model for rail wheel contain two degrees of freedom on lateral '*y*' and yawing 'ψ' motions. The running direction is *x*, as shown in Figure 1. It is assumed that the creep force in each direction is linearly proportional to the creepage, respectively. Details of the model for the contact conditions and of the experimental derivation for the related parameters are shown in eq-5.

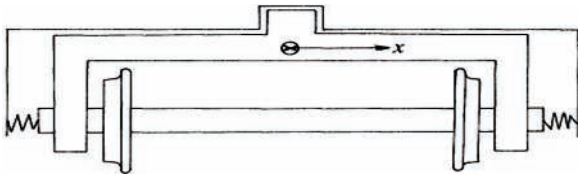

Fig.1. Railway wheelset model with lateral motion

The Creep is referred to velocity of the railway wheelset on rails. The Creep is concerned to wheels disposed laterally by left or right wheels respectively follow as under.

$$\lambda_y = \frac{\dot{y}_w - \dot{y}_v}{\dot{y}_v} \quad (1)$$

Where $\dot{y}_w = \omega_w . r = v_w$ (2)

Where λ_y is lateral creep, $\dot{y}$ is lateral speed and y_w is wheel speed for railway wheels as

$$v_{wL} = \omega_{wL} . [r_o + \gamma (y - y_t)] \quad (3)$$

$$v_{wR} = \omega_{wR} . [r_o - \gamma (y - y_t)] \quad (4)$$

Let 'F' be the horizontal force at the wheel-tread tangent to the axis, then railway wheelset is in the [viii-ix] direction for applied force divided by its distance, runs into own axis, that is "lateral creepage (λ_y)".

$$(\lambda_y + \psi).v = \frac{d}{dt}(y) \quad (5)$$

$$dy = \int (\lambda_{yR} + \psi).v.dt \quad (6)$$

Above is lateral motion for right wheel of vehicle

$$\frac{d}{dt}(y) = (\lambda_{yL} + \psi).v \quad (7)$$

$$dy_L = \int (\lambda_{yL} + \psi).v.dt \quad (8)$$

Above is lateral motion for left wheel of railway vehicle

Here (λ_{yR}) and (λ_{yL}) are lateral creepages of right and left wheels. If the friction coefficient is highly slip confined to a diminishing thinner zone of the rail wheel contact patch at the trailing edge. The creep forces for right and left railway wheels can be expressed using linear creep equations as under.

$$F_{yR} = f_{22} \lambda_{yR} \quad (9)$$

$$F_{yL} = f_{22} \lambda_{yL} \quad (10)$$

Where f_{22} is lateral creep force coefficients for right and left wheels respectively.

The dynamics of lateral motion is assessed by the entire creep force of railway wheelset in lateral movement way. The lateral displacement of the railway wheels is implemented by below equation.

Thus putting values of lateral creepages from equations 9 and 10 into equations 6 and 8 we get

$$dy_R = \int [(F_{yR} / f_{22}) + \psi).v] dt \quad (11)$$

$$dy_L = \int [(F_{yL} / f_{22}) + \psi).v] dt \quad (12)$$

Here ψ denotes the yaw motion between two wheels

III. Kalman Filter Control Scheme

Kalman filter is interesting subject for extraordinary research and applications particularly in autonomous and assisted navigation fields. It is [x] combination of mathematical formulae providing an active recursive and computational sources to filter the process states to minimize the mean of the coupled errors.

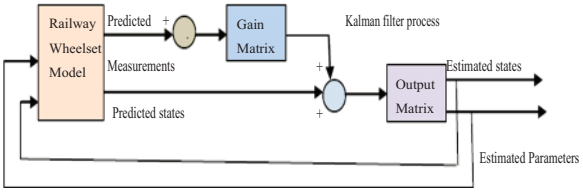

Fig. 2. Block diagram of kalman filter process for railway wheelset model

Above Fig. 2 is shown for Kalman filter processing by block diagram is conceived by author. It is observed that model is utilised to predict the systematic states and sensing inputs by measuring controlled inputs for railway system. The system study is comprised by dynamic model, provides the dynamical parts of the railway system to be filtered by kalman estimator [xi].

Kalman filters are usually depending upon the hidden Markov model system and linear algebra. The premising system modeled as a Markov chain is framed disturbed by Gaussian noises on linear operators. The railway system states can be described by vector of real numbers as Kalman filter behaves as recursive filter [xii-xiii]. It defines only the estimated states from the former time step and present measurements are required to calculate the estimation for next state of railway wheelset.

IV. Environment for Simulation

Here, the lateral motion of railway wheelset is simulated for estimating the noise through measurements by using the kalamn filter [xiv-xv] as well as detecting the error ratio for analyzing the adhesion based upon the creep. The results are enumerated as under.

A. Behaviour of Lateral motion of railway wheel on variation of creep co-efficient

The aforesaid lateral motion of the wheels on the rail road is displayed in the figure-3 to 5 where lateral motion of the wheels is checked by three dissimilar creep co-efficient to observe the efficiency of the railroad wheels.

The Fig. 3 reflects creep co-efficient on having value as 10^7, the lateral motion of the steel wheels moves with movement of $3.2x10^{-3}$ meters at first to $8x10^{-3}$ meters within time of 0.5 seconds in zigzag way with time spans from 0.5 sec to 5 sec with increase of 0.5 seconds containing upon simulated and estimated parameters. The simulated sizes denoted by 'blue colour' moves parallel to the estimated values are marked by 'green colour' in disorder mode. Here maximum height of peak is at 8e-3 meters in 4.4 seconds and minimum downward height of peak of curve is 2.1e-3 meters in 4.7 seconds.

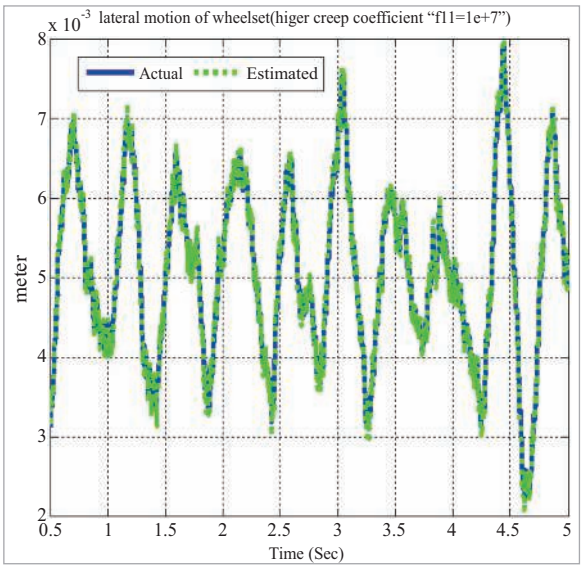

Fig. 3. lateral motion for railway wheelset on creep coefficient of 10^7

In Fig. 4, the creep co-efficient is projected as 10^6 then the lateral motion of the rail wheels vary from the 0.01 meters up to 0.03 meters for the estimated parameter in the smaller zigzag manner in time of 5 seconds. Whereas the estimated indication with tiles on time from 0.5 sec to 5 seconds with the smaller turbulence starts from -0.01 meters descending to near11 meters. Both simulated and estimated values differ and sprint at some detachment from each other.

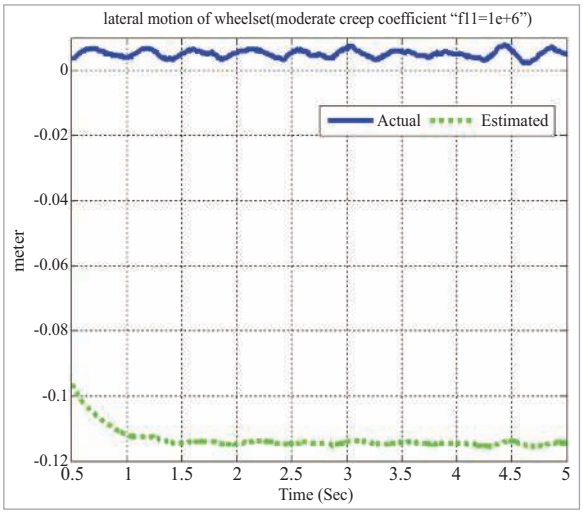

Fig. 4. Lateral motion of railway wheels on creep co-efficient of 10^6 for wheelset

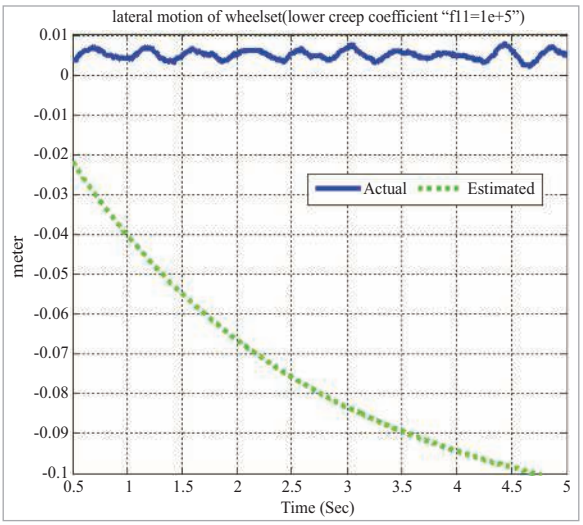

Fig. 5. Lateral motion of wheelset at creep co-efficient of 10^5 for wheelset

In Fig. 5, the creep co-efficient is assumed as 10^5 then lateral motion of the wheels changes from the 0.001 meters to 0.005 meters for the estimated signal in small zigzag way in 5 seconds. While the estimated signal with flooring of time from 0.5 sec to 5 seconds with the smaller conflict starts from -0.02 meters downward lower than it to -0.11 meters with lower zigzag manner in 4.8 sec of time. Both simulated and estimated values alter and tune at a large displacement from one another.

The results obtained from both Fig. 4 and Fig. 5, resemble with each other except the image of the Fig. 3. The 1st part denotes that when the co-efficient of creep is superior, then both simulated and estimated signals partly cover each other, but when the creep co-efficient is decreased then both the simulated and estimated parameters graph lines are divorced from each other by important at smaller displacement from one another.

B. Error judgment for lateral motion of rail wheels

The railway vehicle dynamic signals are computed to examine the error % ratio through higher creep coefficient by blue curve and lower creep coefficient by green curve. The higher creep co-efficient is preferred as 10^7 and lower creep coefficient is gained as 10^6 for estimation of errors.

The parameters of the higher and lower creep coefficient obviously are applied to estimate the error % ratio for lateral motion of rail wheels of the vehicle in Fig. 6 as under. The black line represents higher co-efficient of creep moves in directly direction with little disturbance from zero error measured on scale. This conceives that there is none error in adhesion to cause slip denotes utmost adhesion by straight curve. Whereas low creep coefficient displyed by blue curve goes through -0.01 lower than 0 to 0.11 in arched vertical scale of error signal in upward direction while in straight way with negligible disturbances denotes rude lack of the adhesion.

In Fig. 6, higher parameter for the error estimation is displayed by 'e1' by coefficient of creep and 'e2' is denoted by the lower error estimation based upon the creep coefficient with time in seconds horizontally plane.

The curve denoting error 'e2' by blue that line travels linearly upward shows the stability of system at 0.1 in 0.5 seconds. Then this line is converted into straight horizontal line to end at 0.108 in one second shows maximum creep.

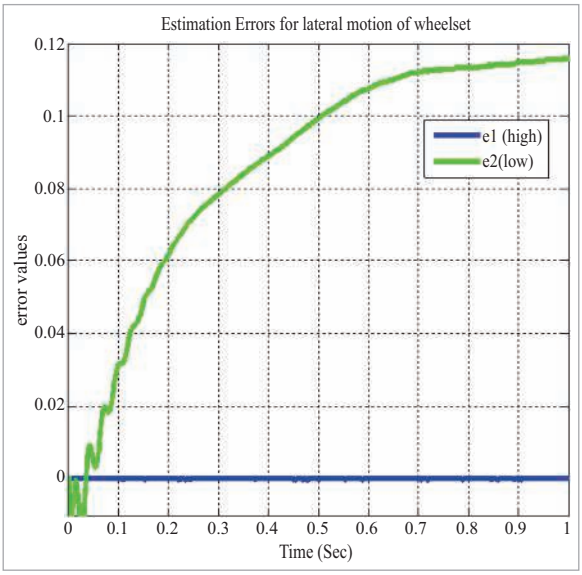

Fig. 6. Error estimation for lateral motion of wheelset

V. Conclusion

In this paper, the lateral motion of the railway wheelset is discussed and verified by its simulation results to observe their behaviour on application of three different partitions of creep co-efficient. Watching these results it can be concluded that on applying higher value of co-efficient of creep, both actual and estimated quantitative parameters travel overlapping each other in chaos zigzag manner. On average creep coefficient, both actual and estimated parameters run in zigzag way at a part distance from each other in their zones with smaller different nature. While on decreasing the ratio of creep coefficient the estimated parameter falls curved down with span of time, this conceives the idea that on decreasing creep coefficient the estimated signal provided by kalman estimator lowers away from actual line. Finally the attitude of lateral motion by error ratio is analysed to observe that creep becomes constant on higher value making slip zero, while on lower error percentage, adhesion becomes higher linearly then curves to travel in horizontal straight path.

Thus it can be concluded that lateral motion is affected by forward speed slip due to decrease in adhesion based upon creep forces to cause errors and

disturbance. So kalman filter is used to actual and estimated difference. This research on lateral analysis paves the path to develop an intelligent algorithm to control the lateral motion of railway vehicle based creep by identification of adhesion level. The error ratio also helps to monitor the adhesion information to avoid accidents due to high speed.

NOMENCLATURE

ω_L, ω_R	Left and right wheel angular velocities
v	Forward Speed of Vehicle
M_v, m_w	Mass of vehicle and mass of wheelset
I_R, I_L	Moment of inertia of right wheel, left wheel
I_w	Yaw moment of inertia
ψ	Yaw Movement
y	Lateral Motion
λ_L, λ_R	Left and right wheel Creepages
$\lambda_{xL}, \lambda_{xR}$	Left and right wheel creepage in longitudinal direction
$\lambda_{yL}, \lambda_{yR}$	Left and right wheel creepage in lateral direction
γ	Conicity of wheel
L_g	Half Gauge
r_L, r_R	Left and right wheel radius
r_o	Radius of each wheel when wheelset is centred
f_{11}, f_{22}	Longitudinal and lateral Creep force coefficients
y_l	Lateral Disturbance Caused by Track irregularities
T_s, T_t	Torsional Torque, Driving Torque
T_L, T_R	Tractive torque Left wheel and Right Wheel respectively

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Investigation of Endurance Limits and Analysis of Electric Discharge Machined Surface of Aluminum Alloy 2024 T6

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Abstract-Electric discharge machining (EDM) removes the workpiece material by the electro-thermal energy followed by flushing of the molten pool. A portion of this molten material is not removed but resolidifies on the surface of base material and alters the mechanical properties of the material. In this study the endurance limits are investigated for the electric dischrage machined (EDMed) aerospace grade Aluminum alloy 2024T6 for the discharge currents of 3 and 12 amperes. The fatigue tests were performed on 4-point rotating bending machine at the frequency of 50Hz and ambient temperature. These tests were carried out according to the modified stair case method. It is found that the obtained endurance limit for the EDMed specimens at 3 ampere discharge current level is 21% greater than that of 12 ampere. Some surface and subsurface defects are highlighted that can cause high stress concentration.

Keywords-Electric Discharge Machining, Endurance Limit, Scanning Electron Microscopy

I. INTRODUCTION

The electric discharge machining is a non-traditional machining process that generates high localized thermal energy by discrete electric sparks between workpiece and tool immersed in the dielectric liquid. EDM produces tool face negative geometry on the surface of the workpiece and is mostly used for machining of hard to cut materials in the industry [i]. The generation of the intricate shapes is the advantage of the EDM due to its noncontact machining. The tool side loads and vibrations are not produced in EDM as compared to the conventional machining processes like milling and turning. EDM has got acceptance in the manufacturing industry dealing with soft metals like aluminum alloy in the aerospace and automobile sector due to its high precision and accuracy [ii].

The molten material is rapidly cooled by the dielectric liquid after each discharge, where a portion of molten material is not removed and sticks on the surface of the base metal [iii]. The resolidified surface on the substrate after EDM has different characteristics than the parent material [iv]. This surface is generally recognized as white layer in the literature [v-viii]. Many sub layers of different microstructure and phases are formed in the white layer [v]. Pulse ON-time and discharge current are the important parameters that influence the formation of the white later on the surface of the material [vi]. whereas, it was determined by [ix] that white layer thickness of Al 6061-T6 increases with the current initially but after some certain value, white layer thickness starts to decrease because of intense crack formation that are easily flushed away by kerosene as dielectric liquid. It was reported by [x] that EDM effect is observed only in upper three layers in tool steel, i.e. white layer, heat affected layer and transition layer. Micro-structure of bulk material remained totally unaffected.

Thickness of the white layer and cracks density in it are inversely proportional to the thermal conductivity of the material and directly related to the thickness of workpiece [xi]. The material having high thermal conductivity permits the produced thermal energy to dissipate into surrounding bulk material, due to which the temperature falls in the localized area. The white layer in Ni, Ti and Fe based alloys is brittle and hard [xii]. White layer has micro cracks that often terminate at the junction of the white layer and the base material. These cracks can be avoided by increasing pulse current value and reducing pulse on time value [xii]. The thickness of white layer also depends on the type of dielectric fluid, electrode size and machining parameters [xiii]. It was studied by [xiv] that a thermally affected layer below the white layer that has tempered microstructure and is enriched by the carbon contents that may be absorbed from dielectric liquid or tool electrode. Lower layer has slightly lower hardness than the hardness of WL.

The endurance limit is the fatigue strength of the material at which it can bear infinite number of cycles. Many studies are available for the determination of endurance limit of the hard material but limited work had been performed for soft metal alloys. In the current study, the endurance limit of the Al 2024 T6 alloy

has been investigated for the current levels of 3 and 12 ampere. Alongside, the surface conditions are also incorporated with the endurance limit.

II. Material and Experimentation

The materials used in this study is Aluminum 2024 T6 in the form of rods. Initially the specimens are prepared by turning operation on the lathe machine. Then the specimens are further machined by the electric discharge machine at the selected conditions. Dog-bone shape specimen of gauge length 96 with 12mm diameter are prepared on numerical control lathe machine with a centered peripheral notch of 10mm diameter and 0.8mm depth Fig. 1. A Carbide tip Cutting tool has been used for lathe machining. Initially rough and then finish cut is performed with the machining parameters as described in Table I.

TABLE I
NC-Lathe Machining Parameters

Type of cut	RPM	Feed *mm/s*	Depth of Cut *mm*	Tool nose radius *mm*
rough	1000	0.12	1	0.5
finish	1200	0.08	0.2	0.2

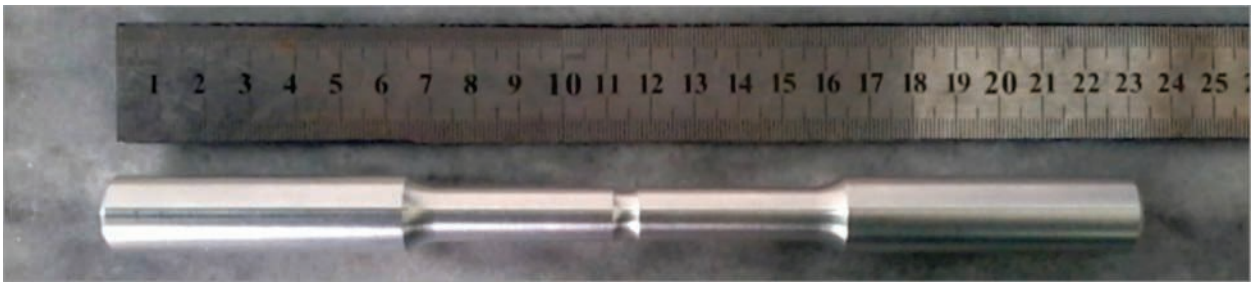


Fig. 1. Picture of the specimen prepared by turning operation.

The surface is generated in the notch of the specimen by the Die-sink Electric discharge machine (NEUAR) and the depth of the notch is increased to 1 mm as described in Fig. 2. The machining is performed at 3 ampere and 12 ampere by keeping all other parameters same. In current study, only two levels of discharge current are investigated which are usually used for finish machining. The industrial grade pure copper is used for the tool electrode. The kerosene oil is used as dielectric liquid. The dielectric pump of EDM can generate a pressure of impingement equal to 0.9 kg/cm^2 on the surface of the workpiece. But in present work this option is not adopted. Instead, the flushing is occurs by the rotation of the workpiece.

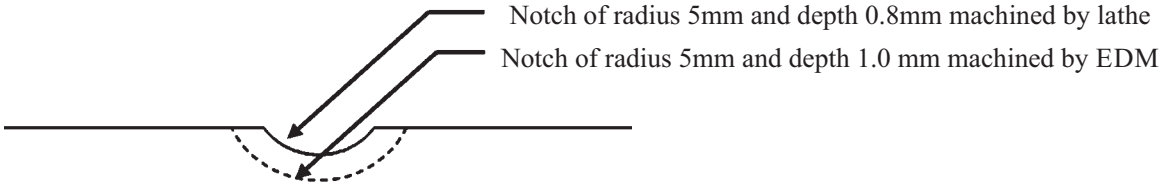


Fig. 2. Machining of Notch

The typical surface of the EDMed specimen is shown at three different magnifications (1x,3x and 10x) as shown in Figure 3. The surface is composed to hemispherical cavities that are termed as crater in the literature. The size of the crater is directly proportional to the discharge energy which reveals the dependence of the surface roughness on it.

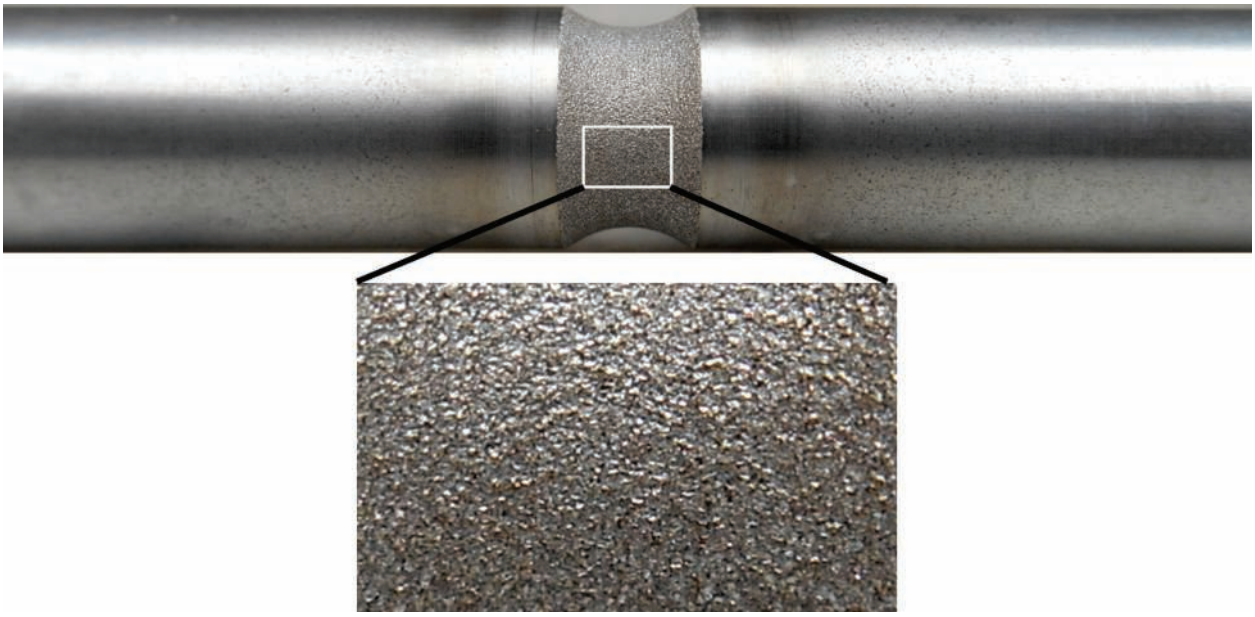


Fig. 3. Typical surface appearance of the EDMed surface of the specimen.

The procedure for preparation of specimens for microscopic examination is shown in Figure 4. After EDM machining specimen are cut at the middle of the notch so that each part contains half notch. Again 12mm length is cut from the side of half notch. EDM surface have free carbon particles and oil contents that need cleaning by placing samples in acetone liquid in ultrasonic chamber for five to ten minutes. Then each piece is placed in the center of small portion of pipe. Araldite® LY 5052/Aradur® 5052 is used with the ratio of 70:30 is poured into the gap between specimen and pipe. This solution is allowed to dry completely in sunshine or open air. After epoxy gets hardened, grinding is performed by emery paper with grit sizes # 350, 600, 1000, 1200, and 2000. Then further mirror like polishing is achieved by using abrasive paste of 1 micron on buffing paper. To avoid reflection of light during microscopy these polished specimens are etched by HF solution for 40 seconds. Immediately after etching, specimens are rinsed with running water and dried in open air.

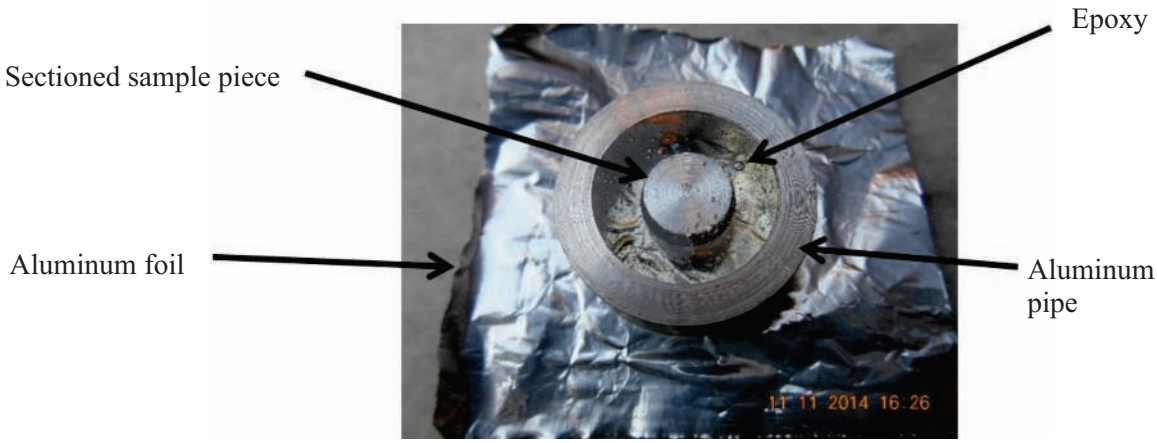


Fig. 4. sample preparation for optical microscopy and micro-hardness test

III. Determination of Endurance Limits

The Modified Staircase Method was used since it needs only six experiments and is recommended by Japan Society of Mechanical Engineers (JSME) standard for its results being very close to that of conventional Staircase method [xv]. Fatigue tests were performed for the run-out of 1E7. Load step of 10 N was applied for 3 A and 5 N for 12 A. The mean endurance limit 'μy' was obtained by

$$\mu_y = \frac{\sum_{i=2}^{n+1} S_i}{n} \qquad (3)$$

Where,

S = Magnitude of alternating stress (MPa)

I = Experiment no.

n = total no. of experiment

IV. Results and Discussions

A. Endurance Limits

The results obtained by the fatigue tests according to modified-stair-case method are presented in the form of experiment suspended and specimen broken for 3 ampere and 12 ampere as shown in Table 2 and Table 3 respectively. Endurance limits for 3 ampere and 12 ampere has been found equal to 89.1 MPa and 73.6 MPa respectively. If machining is performed at 3 ampere then the endurance limit is improved by 21% as compared to 12 ampere.

TABLE II
Stair-Case Test Data for 3 Ampere

Load (N)	S#1	S#2	S#3	S#4	S#5	S#6	S#7
160			x				
150		o		x		x	
140	o				o		estimated

o = Suspended, x = Broke

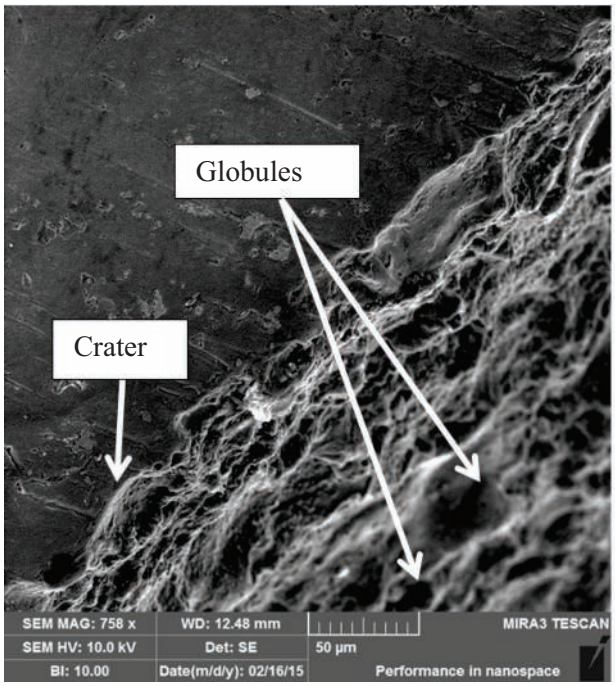
TABLE III
Stair-Case Test Data for 12 Ampere

Load (N)	S#1	S#2	S#3	S#4	S#5	S#6	S#7
130			x				
125		o		x			
120	o				x		Estimated
115						o	

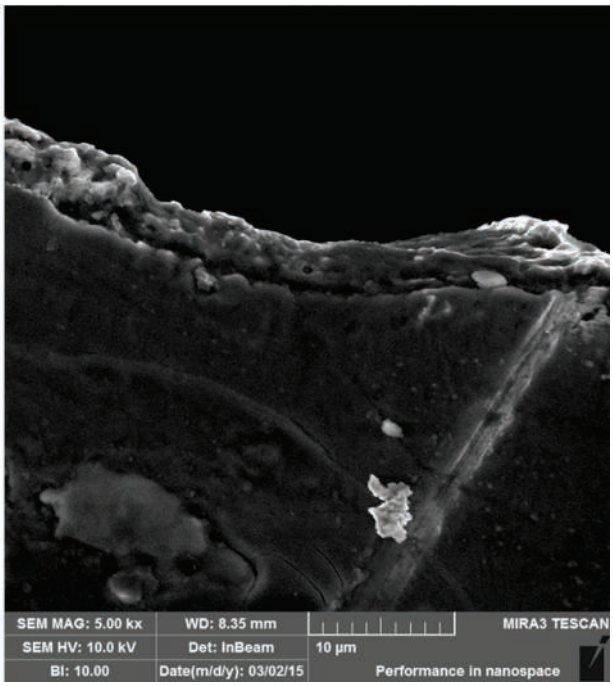
o = Suspended, x = Broke

B. Microscopy

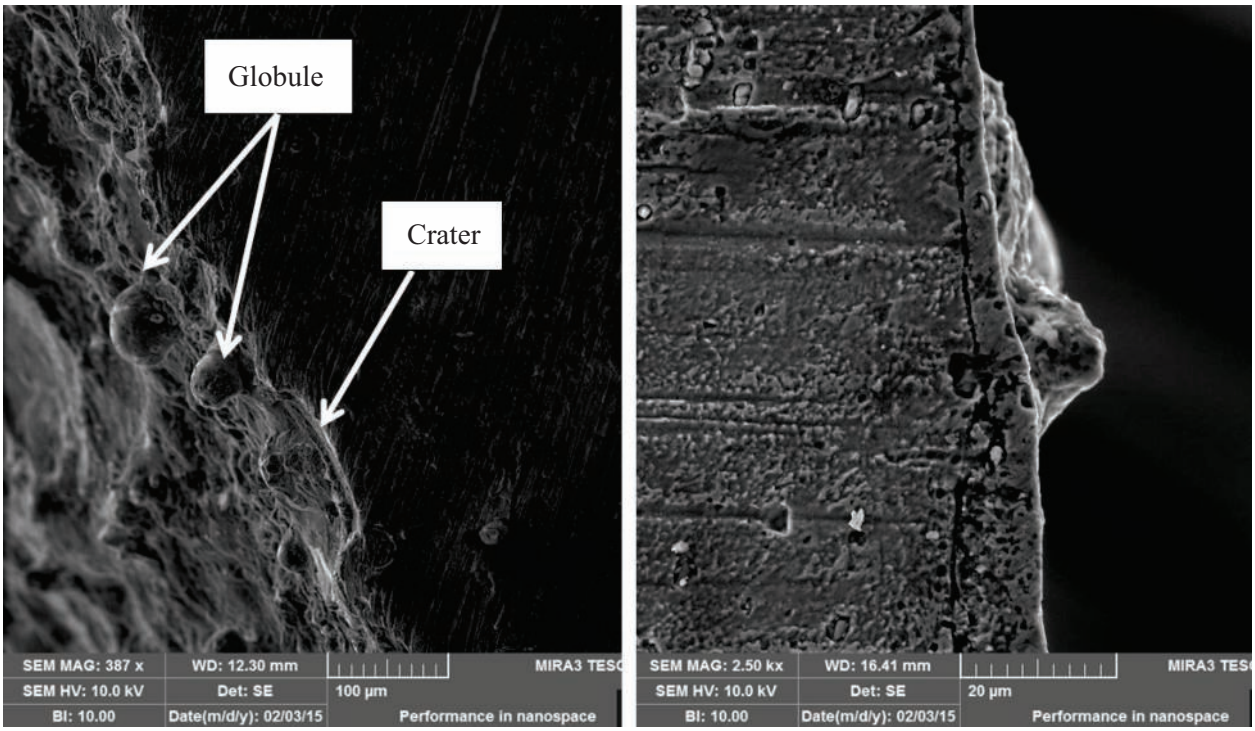
The tangential observations of the white layer are investigated by the scanning electron microscope and metallurgical microscope. In Fig. 5, comparison between 3 and 12 amperes discharge current level is performed by the images of the scanning electron microscope. It is seen that the craters and globules are produced on the surface and the size of these features is small at 3 ampere as compared to 12 ampere. The white layer at 3 ampere discharge current level is relatively uniform as compared to the 12 ampere discharge current level, where the white layer thickness is increasing from top side of image to the lower side of the image.



(a) 3A



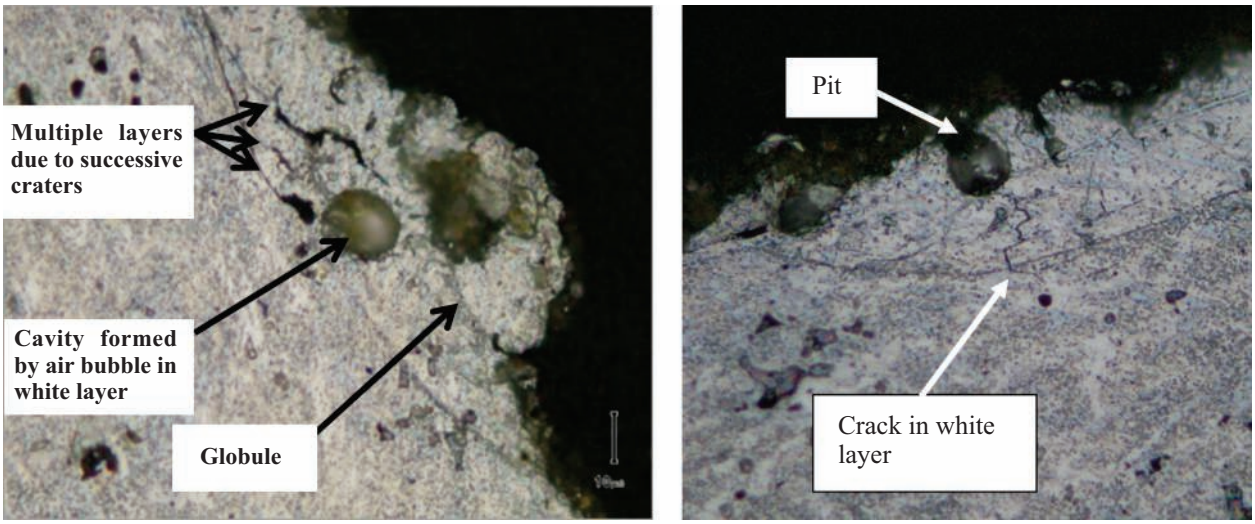
(b) 3A



(c) 12A (d) 12A

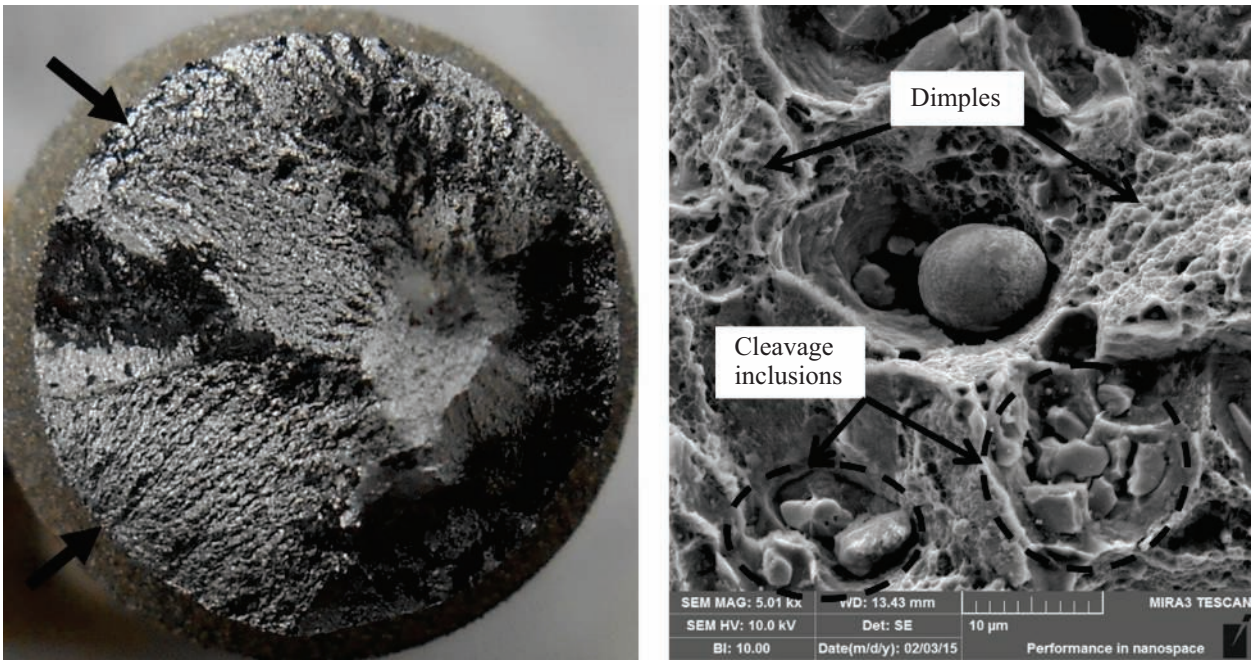
Fig. 5. SEM cross-sectional image of the white layer by at 3A and 12A

A white layer is shown in Fig. 6(a), three overlapping layers are seen due to formation of successive crater after each discharge. A spherical cavity is observed which is possibly due to entrapped gas bubbles during EDM. A globule of approximately 25 µm diameter is seen. In Fig. 6(b), a pit or pockmark is formed on the surface of white layer and below this pit a crack is formed due to stress concentration at this area. Near to this pit a very sharp discontinuity in the white layer is also observed that may become a stress raiser.



(a) (b)

Fig. 6. (a) Defects in white layer, (b) crack propagation from white layer to base material; (1000X)



(a) (b)

Fig. 7. Fractrographs (a) Multi-cite crack initiating from white layer (10x), (b) Nature of fracture (5000x)

In Fig. 7, Fractographic observations of the fractured surface at the lowest stress level are shown. Multiple crack initiation cites are observed from the EDMed surface and cracks are propagating radially inward as shown in Figure 7(a). Figure 7(b) conforms the nature of fracture in the crack propagation region. Round and rectangular cleavage facets of the intermetallic inclusions are observed at the bottom of cavities. These inclusions are comprised of secondary phase particles such as silicon, ferrous and magnesium, which show weak bonding with the matrix. Micro-voids appear from these inclusions and the size of micro-voids keeps on increasing by the repeated stresses and finally merge to form a crack that ultimately caused rupture of the material. Many dimples are seen on the surface which reveals inter-granular ductile fracture.

V. Conclusions

In Electric Discharge Machining, amount of molten material is directly proportional to discharge current. Rapid cooling thereafter in hydrocarbon oil, changes the characteristics of machined surface. Effect on fatigue strength is investigated in this study for different surface conditions generated by two discharge current levels conventionally used in EDM. Knowledge of fatigue strength for different surface conditions generated by EDM will necessarily help design engineer when designing components exposed to repeated loading.

The conclusions of the investigation are

1. The electric discharge machining at 3A discharge current level resulted an improvement of 21% in the endurance limit as compared to that of 12 ampere discharge current.
2. The surface generated at 12 ampere discharge current produced craters and globules of larger size than that of 3 ampere discharge current
3. The resolidified surface layer contains overlapping sub-layers which have gaps at the junction of these layer. Also the entrapped air bubbles and surface pits are possible stress raisers that can cause early crack initiation.
4. Multi-site cracks are initiated from the electric discharge machined surface which radiate radially inward.

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Reverse Logistics A Tool for Organizational Excellence; A Pakistani Perspective

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Abstract-Due to intense competition and globalization, the challenges associated with providing products and services at the right time and place as well as at the lowest possible costs have increased. The practicing of Supply Chain Management (SCM) has now become an essential requirement for staying competitive in international market. The importance of returns is obvious due to growing environmental concerns, sustainable competitiveness and corporate social responsibility. This is only possible with effective management of returns. In this article, the basic emphasis has been made towards the realization for implementation of reverse logistics in manufacturing industries of Pakistan. In this context, the current state of reverse logistics trends is studied in manufacturing industries of Pakistan. Performance index of developed and under developed countries are analyzed and efforts have been made to provide basic guidelines for improving organization performance through improving supply chain index by incorporating reverse logistics as a tool.

Keywords-Reverse Logistics, Logistics Performance Index, Sustainable Development, Challenges for Reverse Logistics, Customer Delight and Loyalty.

I. INTRODUCTION

he Council of Logistics Management (CLM) has defined reverse logistics as "The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal" [i]. Generally speaking reverse logistics is the process of moving goods from their typical final destination to the manufacturer for the purpose of repair, refurbishment, remanufacturing and recycling (recapturing value), or proper disposal [ii].

A reverse logistics system incorporates a supply chain that has been redesigned to manage the flow of products or parts destined for remanufacturing, repairing, or disposal and to effectively use the resources and recovered products after repair and remanufacturing [iii]. Reverse logistics consists of almost 1% of the total U.S. gross domestic product [iii]. However it is not surprising that the process initially defined as "The return, exchange, repair, refurbishment, remarketing, and disposition of products" is now quickly emerging as an integral component in leading global organizations [iv]. Prominent OEMs in multiple industries are focusing on developing the reverse logistics process in order not only to sustain the existing customers by acquiring their confidence and trust level but also to enhance the business activity by increasing the number of loyal customers. Moreover it is a useful methodology for earning more profits by converting the defective returns into more useful product [iv]. Nevertheless it is a step forward to comply with environmental regulations, reducing operating costs and improving product uptime and quality at most. The graphical representation of reverse logistics is presented in Fig.1, where a closed loop supply chain system is shown with a clear distinction of forward and reverse logistics activities in detail.

This is an exploratory and descriptive study with the purpose to introduce basic and general concepts of RL in perspective with Pakistani manufacturing industries and persuade the local industry to accept RL as a mandatory business driver because authors believe that local industries are reluctant to adopt and implement this useful management. Focus has been made to present the benefits of RL implementation to increase customer satisfaction and loyalty.

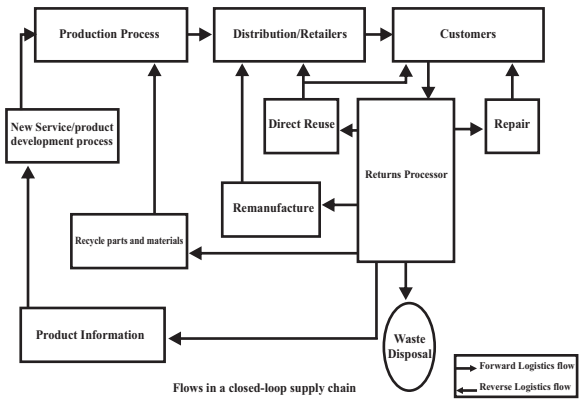

Fig. 1. closed loop supply Chain System

A. Reverse Logistics: Scope and Reasons

During the last few decades the reverse logistics have acquired sufficient attention as engineering field in academia and industry. The authors and practitioners have focused on numerous matters at strategic, tactical and operational level for effective implementation of reverse logistics. At the strategic level, the recovery network design has been studied in details [v]. At the tactical level, the focus has been made for establishing connections with partners and stake holders of network [vi]. At the operational level, inventories have to be managed and controlled [vii]. Significant literature is available for the implementation of reverse logistics in developed countries while there are few (if any) studies about the subject.

The paper exclusively discusses the manufacturing industry of Pakistan with the purpose of RL implementation. In manufacturing industry, different types of manufacturing returns occur including scrap, defectives, rework, planned waste, production left-overs etc. [viii]. While the customers returns which is the focus of this paper, may include excess quantities, rejected materials, service returns (spare parts, repair), B2C commercial returns, reimbursements, warranty claims, end of lease returns, end of life returns etc. [viii].

B. Logistics Performance Index

During the last few decades, logistics and SCM concepts remained the focus of most of the organizations and researchers around the world for sustainable and continual growth of the companies. The logistics performance of companies is determined by an index called, Logistics Performance Index (LPI). The logistics performance index of the entire world came out to be 2.8 in year 2012 [ix]. The value of this index for USA in the same year was 4.0. Logistics Performance Index reflects overall score for perceptions of country's logistics, based on efficiency of customs clearance process, quality of trade, transport related infrastructure, ease of arranging competitive priced shipments, quality of logistics services, ability to track and trace consignments, and the frequency for shipments reach the consignee within the scheduled time [iii]. The index ranges from 1 to 5, with a higher score representing better performance [ix]. It can be seen that although the logistics performance index vary from country to country as per the business conditions and cultural constraints of the countries, however, even the most developed countries still not even touched the highest rating of the specified performance index. Table-1.1, presents the regional LPI derived from Logistics Performance Index Group, a team of World Bank.

TABLE I
REGIONAL LOGISTICS PERFORMANCE INDEX
(WORLD BANK REPORT 2012)

S #	Country	Logistics performance index 1-5 (worst to best) 2012
1	World	2.87
2	Low income zone	2.36
3	Middle income zone	2.69
4	Lower middle income zone	2.58
5	Upper middle income	2.78
6	Low and middle income	2.6
7	East Asia and Pacific	2.77
8	Europe and Central Asia	2.73
9	Latin America and Caribbean	2.67
10	Middle East and North Africa	2.58
11	South Asia	2.58
12	Sub-Saharan Africa	2.46
13	High income zone	3.48
14	Euro area	3.56

C. Causes of low LPI

There could be a number of reasons behind the low logistic performance index (LPI) of different companies around the world. But in the logistics scenario, micro analysis revealed the following most important factors:-

1. Companies usually emphasize on having an effective logistic system. Still forgetting to pay attention to a most important element of this chain: the management of returns.
2. Even though, few companies tried to compensate or adopt this specific area of handling returns, still the process they adopted was so mismanaged and complex that instead of increasing efficiency of their business activities, it actually brought chaos to the entire system.
3. Moreover due to the complexity of various processes involved in handling of the returns, unwanted worms like warranty conflicts, confusion and delay relating to segregation, decision regarding disposition, cost implications etc. make it even difficult to embrace the true essence of the return flow and the organization suffer huge loss rather than any benefit.
4. Overall the ratio of the return to overall company's production is very low as evident from the data given in Table 1.2 relating to the USA industry. Most of the companies' do not bother to even think of handling these returns rather than expensing their useful energies in transforming the catastrophe into opportunity. However such thinking on the long run creates a shortfall in the confidence level of the customers due to unavailability of the necessary after sales support.

An international survey carried out by a group of researchers in 2010 showed that the loyalty level of the customer was directly related to the assurance of after sales services, a company provides at the time of selling a product [iv]. Moreover the same survey showed that the growth in the number of customers was also an exponential function of availability of the after sale services along with other parameters.

TABLE II
RETURN % BY SECTOR
(COURTESY OF UNIVERSITY OF NEVADA, RENO CENTER FOR LOGISTICS MANAGEMENT, 2007)

S #	Industry	%
1	Magazine Publishing	50%
2	Book Publishers	20-30%
3	Book Distributors	10-20%
4	Greeting Cards	20-30%
5	Catalog Retailers	18-35%
6	Electronic Distributors	10-12%
7	Computer Manufacturers	10-20%
8	CD-ROMs	18-25%
9	Printers	4-8%
10	Mail Order Computer Manufacturers	2-5%
11	Mass Merchandisers	4-15%
12	Auto Industry (Parts)	4-6%
13	Consumer Electronics	4-5%
14	Household Chemicals	2-3%

5. On the other hand the nature of fluctuation in the return received by any company also makes it very difficult for the planners to accurately forecast the types of inventory required for the purpose of managing the different scenarios of the returns [x]. Moreover, accumulation of the huge unexpected return in the companies' junkyard sometimes makes the less storage capacity available for the forward production than the received defective / unwanted products. The management of these unwanted junk requires the utilization of useful revenue / resources that a company may utilize for further growth and the same is being expended on the value addition of the considered unwanted junk.
6. Most of the companies involved in the consumer related products often offer their customers the after sales service / maintenance facility. In this regard they usually receive appreciable amount of returns from their customers at all levels and from different destinations. Most of the time a centralize repair / maintenance facility is established. However, centralized repair and maintenance facility is the solution for slow response due to excessive work load of diverse nature on the facility. Although it also results in the development of expertise of handling different problems but at the same time too much diversification of work may result in the inappropriate and inefficient response by the overburdened employees and management.
7. Inventory management plays a vital role in supply chain and reverse supply chain management. The service provided to the customer eventually gets enhanced once the efficient and effective management of inventory is carried out throughout the supply chain network [xi]. Thus keeping the optimum inventory level in reverse supply chain is critical to reduce costs. Minimizing the total cost is meant for minimizing holding and shortage cost in the entire reverse supply chain. The minimization of the total cost can only be achieved when optimization of the base stock level is carried out at each member of the supply chain [xii]. However each part or function of the supply chain lacks in the in-depth coordination among different functions. Hence the result is the accumulation or shortage of the necessary inventory required for the effective management of the above mentioned scenario.

From the above discussion it is evident that there can be a number of reasons due to which the companies fail to excel in the supply chain management field. The failure to comply with the ultimate requirements of the supply chain management can drastically reduce the profitability of the organization and the company can fail to compete in the growing global market. To address these issues the current research is be focused on the return flows of the supply chain system with the aim to develop a conceptual frame work for efficient, effective, collaborative, optimal and customer focused reverse logistics methodology.

D. Companies with Successful Reverse Logistics Processes

Reverse logistics is an emerging area of importance in supply chain management field and many companies are practicing it. Every company, irrespective of industry, can adopt a reverse logistics process that can save money and generate profits. A company can also evaluate the potential to recycle its products to help improve environmentally friendly practices.

Bosch, an automotive and industrial technology company, builds sensors into its power tools that indicate if the motor is worth reconditioning. The sensors reduce inspection and disposition costs, allowing the company to realize profits on the remanufactured power tools [xiii]. General Motors simplified its process for returning automotive parts by allowing parts to be returned to a single facility using GM's pre-printed shipping labels. This less costly process enhanced GM's relationships with its customers and supply chain partners [xiv]. Volvo, a Swedish car manufacturer, anticipated the Swedish

government passing a resolution holding auto manufactures accountable for disposal of vehicles. Volvo implemented a reverse logistics process of salvaging and dismantling cars. The company generated revenues by selling the used metal, plastics and car parts [viii].

E. Manufacturing Industry of Pakistan

Pakistan is one of the developing nations of the world, striving to move forward with the world growing economies. However the pathway, Pakistani government and its people followed, for attaining the desired goals, was giving the desired results till late 80s. After the involvement of Pakistani government in Afghan war against USSR the main focus of the government was shifted from the economic growth towards the strengthening the country defense [xiv]. After retrieval of the foreign troops from the neighboring country and the aggressive progression of India and other south Asian countries in economic sector it has been realized by Pakistani government to step forward and take concrete measures in economic growth and sustenance. The policies and infrastructure is being established in cooperation with multinational alliances. However no significant growth in the manufacturing industrial sector of Pakistan can be seen till date [x].

F. Basis of Pakistani Manufacturing Industry Downfall

1. In late 20th century while the rest of the world was focusing in achieving business excelling through adaptation of modern tools, techniques and methodologies, Pakistani industry were striving for the sustenance of obsolete machinery and techniques. The result was, as obvious, very high cost, high defect rate and late deliveries. All the factors outclassed manufacturing industry of Pakistan in global market creating a total loss-loss situation for the manufacturing firms [xv].
2. In a modern economy it is very essential to transform scientific research into competitive advantages. In the US, extensive collaboration between universities and industry and the ensuing transfer of scientific knowledge has been viewed as one of the main contributors to the successful technological innovation and economic growth of the past three decades [xvi]. At the same time, the insufficient interaction between universities and firms in the EU is, according to a report of the European Commission (1995) itself, one of the main factors for the poor commercial and technological performance of the EU in high-tech sectors [xvi].

   It can be understandable that even the European Union, which third world countries rate highly advance, still shortfall of the desirable technological excellence due to a slight less collaboration between the industries and academia than the USA [xvii]. One can imagine the condition of the technological growth of a society which has never thought of existence of such collaboration like developing nations. Unfortunately the current worst condition of Pakistani manufacturing industry is the best example of such non collaborative environment. This ultimately resulted in decline of the technological improvement in the industrial sector. The government and the private sector both are responsible in one way or another for the occurrence of such condition. Under the non-collaborative environment neither the government has the proper visibility of the technological needs of manufacturing sector (in terms of education as well as machines or equipment) nor does the industrial sector has the opportunity to get benefited from the enriched and concentrated technological hubs. In this scenario the suffering is of the nation as a whole rather than of a specific sector.
3. Non-collaborative attitude, unwillingness to acquire new knowledge and techniques and lack of required expertise ultimately results in the inefficiency of the people and process at all level of the business activities and does not remain limited to the specific manufacturing setups only. It grew like a cancer and damaged one organ after another. It is understood by even a small business owner as well that all the business activities are interlinked. One ineffective, inefficient One ineffective, inefficient process or person will subsequently affect the entire business portfolio if not taken care of.
4. Moreover the entire business moves around the end user or customer. Customers drive all the business across the globe. For any organization, customers are the resource upon which the success of the business depends. When thinking about the road map of success, the importance of customers cannot be ignored. Following are the proven guidelines for achieving business success :-
   a. Repeat business is the pillar of successful marketing strategy. It helps to provide recurrence and revenue for the business.
   b. Organizations are reliant upon their customers. If they do not nurture customer satisfaction and loyalty then they could lose their customers and ultimately the entire business will vanish from existence. Without customers the organization could not even think of survival.
   c. As per the modern terminologies the "organization is an entity build for customers, run for customers and co-existence with customers by bringing their desires in to reality".

If we look into a broader prospective of the business activities then it can be easily visualized that the business is run for the customers. It is obvious that all the organizations around the world are striving for extending their customer satisfaction level. The extension in the number of customers is merely dependent upon the quality of product and services one offer to ones customers. This offered attribute is sometimes not enough to retain the existing customers rather to expect an increase.

G. Suggestion for Sustenance and Development of Pakistani Industrial Sector

From the previous discussion on subject, the technological advancement by the use of collaborative strategy and to become a customer focused organization are the two building blocks of attaining the competitive advantages and sustenance development among a specific business portfolio specially for the reverse logistics applications.

The technological advancement comprises of the two main areas:-

1. Technological advancement in the area of enhancement and improving products, its related processes specially logistics movement by use of state of the art equipment / machinery etc.
2. Enhancement and improving different management processes for the purpose of increasing efficiency and effectiveness of different business activities particularly forward and reverse logistics.

Technological advancement in the area of enhancement and improving production and relating processes specially logistics movement by the use of state of the art equipment / machinery etc. can be attained by the collaborative efforts of the government / private sector with the academia [xvii]. Efforts are required to be put in by the government agencies, private consortiums as well as by the universities to create an understanding and harmonization between the industrial current and future requirements and the syllabus being taught at different universities and research centers [xviii].

Moreover incentives in the form of tax rebates etc. are required to be offered by the government to those industries / universities / research centers who regularly collaborate with each other for the purpose of searching solutions of various practical problems and try to develop new technologies for current and future use. In this regard it should be made mandatory for the industries as well as for the universities / research centers that the research project assigned to the different caliber of students should be taken from the practical problems / needs of different industrial sectors. Moreover the industries should be made bound to financially assist all such research projects. The result of research than can be utilized by the different industries to enhance their capacity and capabilities.Most of the work relating to the technological advancement of management process for the purpose of increasing the efficiency and effectiveness of different business activities relates to incorporate the essence of the emerging philosophies into the corporate function for identification and removal of the inefficient process (creating wastes) and for adaptation of the techniques useful for creating harmonization, stability and swift decision making ability relating to the changing stimuli across the different function of an organization. It means to study the existing process of the entire organization then map them to sufficient detail and investigate the areas creating hindrance to achieve the desired performance levels in perspective of implementing latest management philosophies.

After removing the inefficient / undesirable process (wastes) from the system, elements of different philosophies having similar or interactive behavior may be implemented together or one after another to ascertain the results. In most of the cases the achieved performance results when integrated with the technological advancement set the path way to success for an organization.

II. Points of Ponder in Reverse Logistics

The most important aspect of becoming the customer focused organization is to establish a close link between the customer and all other business facets in order to create a better understanding between the customer and organization. In the current world scenario the most important element of the business which is directly related to the customer in acquiring their needs / expectations and to remain in direct contact with the customers is the Supply Chain System. However conventional supply chain management techniques do not fulfill the results which are being expected by this state of the art management philosophy.

Hence it is now realized by most of the management executives that there is a missing link that is creating the inefficiency of the supply chain system [xix]. In the supply chain system the goods move from the OEM toward the customer / end user. During this movement a number of stake holders are involved which participate in enhancing the efficiency of the total system.

However, when a scenario arises where the movement of a product from the customer towards the OEM is desirable than considerable hindrances are posed by different stakeholders at each and every step of transformation including the OEM itself [xx]. Although this hindrance is not intentionally posed by all stakeholders but due to non-clarity of different scenarios mentioned below, barriers are automatically invoked:-

a. Is the product defective?
b. Is it under warranty?
c. Does it require repair or needs to be replaced?
d. Is it out of date or expired?
e. Is the manufacturing fault induced due to violation of user guidelines or occurred due to transportation etc.?
f. Will company accept the product?
g. Is it worth repair?
h. Can it be utilized otherwise?
I. Can recycling be done?
j. Is refurbishment possible?
k. Does regulation impose to recycle it?
l. Will it be helpful to earn name for the organization in reused / recycled etc.?
m. Will it enhance the customer satisfaction?
n. Is the return product needed by the organization?
o. Is cost of repair, refurbishment, recycling etc is feasible?

The answer to all the above or some of the question if unknown creates a total confusion situation in which final destiny of the return product is never decided and the return products eventually become junk. Most of the companies consider it satisfactory due to their shortsightedness of the worst consequences that the undecided return product will brought not only onto their fame but will also result in the loss of a huge chunk of loyal customer. The business essences will be lost and eventually a steady decline in the growth of the organization will occur. Such non customer focused organization will never be able to identify the causes of their business failure even though the reasons are most obvious one.

Hence it is call of the day to stream line and harmonize the various processes and steps involved in the management of return flows to get the full benefit of the supply chain system. If the missing link of the supply chain system is properly and efficiently addressed then the motive of the all organizational effort to become the business leaders will be finally attained. The management of the specified return flow in supply chain management system is usually referred to as "REVERSE LOGISTICS".

III. Challenges Involved to Improve Reverse Logistics

As previously discussed reverse logistics is a key ingredient of attaining the loyalty of the customers which ultimately results in the enhancement of the business portfolio [xviii]. Moreover if the reverse logistic activities are properly planned, executed, monitored and controlled then the same will become the assurance for the success of any business activity. However due to chaos and ambiguity of different scenarios involved in the execution of reverse logistics process companies fail to avail strategic benefits associated with RL system [xix]. Hence before proceeding it will be very beneficial to have an understanding of the main challenges involved in the implementation of reverse logistics.

a. Lack of awareness reading the importance of reverse logistics activities in business success.
b. Lake of understanding of the interrelationship between various steps / elements of reverse logistics.
c. Lack of awareness relating to the possibility of the high assert recovery ratio to the total product return or produced.
d. Poor policy relating to the warranty claims
e. Very stringent gate keeping policy
f. Poor planning relating to different elements / process of reverse logistics
g. Centralize recovery / disposition facility
h. Poor inventory management methodology
I. Slow response to the customer queries.
j. High time from recovery to final resubmission of the return product
k. Unavailability of the appropriate performance measure for evaluating the efficiency and effectiveness of different processes of reverse logistics.
l. Poor or insufficient data generation and collection.

IV. Benefits of RL Implementation

The following benefits at different stakeholders' level can be obtained [i]. A brief of such advantages are listed below:

A. Stakeholders' Gains
a. Stakeholders have win-win situation
b. Everyone earns benefits
c. Everyone love economic activity as it enhances the quality of life
d. Stakeholder's gain provides business opportunity
e. Stakeholder's gain drives value chain among all stakeholders and associated partners like transporter

B. Social Gains
a. Employability
b. Moral compensation
c. Job Opportunities
d. Encouraging entrepreneurial spirit
e. Media Fear
f. Entrepreneurial Spirit
g. Social Corporate Responsibility

C. Economic Gains
a. Creating impact at company productivity
b. Wealth creation
c. Cost Reduction
d. Monetary value addition
e. Enhancing profit margins

D. Environmental Gains

a. Environmental care
b. Environmental awareness
c. Green Image and Clean environment
d. Saving environment for future generations
e. Avoiding Pollution Charge
f. Enforcement of Environmental Laws

V. Results and Findings

Reverse logistics is one of the most emerging concepts both in the academia and in the industry. From the last few decades, logistics and supply chain management concepts remained the focus of most of the companies and researchers around the world for sustainable and continual growth of business activities. The concept of managing return flows from the market place back to the manufacturer destination for rework, refurbishment, reuse, recycle is not new. Examples can be given of reuse of products, materials and spares, waste paper recycling, deposit systems for soft drink bottles, metal scrap brokers and reusing of different automobile parts. However, reverse logistics as a research field is relatively a new area.

As a matter of fact, reverse logistics is usually considered as a nuisance because of existence of many inbuilt constraints offered by the various business sectors specially by the top ranking companies of that sector. Many of the companies alleged the efforts on RL as wasting the useful resources. Moreover due to unsupportive companies polices the RL efforts are usually failed to be fruitful. Nevertheless financial implications, lack of necessary knowledge, less technological exposure, non-customer focused approach, unclear company polices and least environmental concerns are few of the aspects creating the disinclination of the third world countries to adopt the proven advantage of the Reverse logistics system.

This paper promotes strategic managers to focus this overlooked dimension and pushing the tactical managers for exploring sustainable competitive advantages.

Failure to comply with the growing needs of integrated supply management system will definitely pose a reversing effect of the RL opportunities / benefits. The current scenario of business activities in Pakistan are a true reflection of the losses being incurred due to the misconception of this idea. A few companies like beverage industry, automobile manufacturer and some of pharmaceutical companies have adopted the concepts of reverse logistics in a smaller prospective [xxi]. However, due to their limited and inefficient implementation approach, they are unable to capture the real benefits of RL system. In this paper an effort has been placed to realize the manufacturing industries of Pakistan to adopt this useful aspect of supply chain management. It will definitely bring effectiveness in terms of sustainable, environmental perspectives and customer satisfaction and delight. In future efforts can be made to derive a workable, efficient and cost effective framework suitable for Pakistani environment.

VI. Conclusion

The implications of this study for Pakistan's manufacturing industry are plentiful. There is nothing for denying the fact that RL is a necessity for regulatory and customer service objectives. Reverse logistics has not received the attention it deserves and little or no attempt is being made to manage RL for managing costs and efficiency especially in manufacturing industry of Pakistan. Delayed responses, long return processing times, poor control of returned products create potential problems for the manufacturing companies. In the manufacturing industries of Pakistan, employing reverse logistics will lead to cost effective business enhancements and sustainable logistics operations. Mathematical modeling & simulation and the system dynamics modeling are open areas for research in future.

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Section D

COMPUTER, SOFTWARE, TELECOMMUNICATION ENGINEERING AND COMPUTER SCIENCE

Assessment Model to Measure the Performance and Behavior in eLearning based Universities

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Abstract-Electronic learning provides the opportunity for students to learn anytime and anywhere. The eLearning based universities provide an online discussion of students and teachers on the Moderated Discussion Board. Students do not have direct interaction with the teacher, so they use some discussion board to discuss their problems with the teachers. Online discussion has built-in property to save the text, which can be analyzed later, and smart learning management systems have the ability to process the video. The principal area of analysis in this paper is whether the students' discussion about their teachers on MDBsare useful to measure teaching performance. The present research endeavors shove the MDB text based dialogs to drill down through experiments. The sample size was 246 and 80 in experiment 1 and experiment 2 respectively. The first experiment clarifies the learners' trust on emotional reflection of assessment evidence of learning management system by selecting courses without verifying its rationality. There were other factors, which arguably counted for more. At the same time, it could be argued that how it is different from traditional or classroom based learning and teaching. It can be contrasted them as traditional, or classroom based learning provides instant feedback to teach while in electronic learning teacher is not present in the class and students are at a distance.

Keywords-eLearning, Moderated Discussion Board, Teaching Performance, Learning Behavior, Electronic Feedback

I. INTRODUCTION

Students do not have direct interaction with the teacher, so they use some discussion board to discuss their problems with the teachers. A type of discussion board, which is running under the administration of the teachers, is called Moderated Discussion Board (MDB). The effect of MDB on higher education is analyzed from alternate points of view gave by the online university. The central issue communicated about in the present writing is whether learner assessments of their educators on MDB are genuine. A few researchers have addressed the legitimacy of MDB, as the website has no impact on critical problems, e.g. who is posting an assessment.A learner who has taken that course or never enrolled for that particular course. In any case, he is being allowed to evaluate the teacher, or when an assessment is posted e.g. an understudy to allow to assess the teacher without imposing any time limit, regardless it is tenyears' post-graduation or the very first day of class.While the greater part of confirmation focuses at an absence of legitimacy in learner assessments on MDB, a few researchers had contended that these assessments without a doubt are substantial, as confirm when they were discovered to correspond fundamentally with things on a percentage of the authority assessments managed by foundations.

Dissimilar to former research, the momentum experiment is not centered on the open deliberation of MDB legitimacy. Rather, this experiment endeavors to drill down the exchange to a study in depth by representing, in which students' assessments on MDB or comparable sites may prompt predisposition choice making, free of legitimacy. As saw by [i], MDB and other comparable sites have incited a lot of debate among instructors and scientists as to their legitimacy; then again, inquire about that measures potential results of MDB site utilization are extremely restricted. This experiment looks at how online assessments, impact students' mentality to their teachers and their subsequent course selection conduct in two analyses, concentrating on two basic variables: a review about the attractiveness of the teacher and review about feedback size. The subtle elements of both investigations are introduced after a writing survey. General examinations of the trial discoveries are given at the end of the article.

Teaching performance and student learning behavior in electronic learning have not been evaluated before in the effective and distant way [ii]. Our current effort is to measure them in an eLearning environment. There were other factors, which arguably counted for more. At the same time, it could be argued that how it is different from traditional or classroom based learning

and teaching. We can contrast them as traditional, or classroom based learning provides instant feedback to teach while in electronic learning teacher is not present in the class and students are at a distance [iii]. Therefore, both setups are different in nature. Hence, the crucial question that how to measure it effectively and accurately. Our strategy for the measurement is very intuitive. We have conducted surveys of the students of eLearning in different universities and to support and strengthen the hypothesis; we further conducted a survey of college level students with the lesser population as well. Different statistical tests are performed to make the results more reliable.

The next section is *Related Work.* After the related work section, the next section is proposed a model, i.e., *Student-Teacher Interaction Assessment Model*. Methodology section is extended by its *Mathematical Formalization* section. The hypothesis from null hypothesis i.e. H0 to H3 are presented. After the hypothesis, experiments are presented. Experiment One with has the following sub-headings: Outline, Methodology, Collection of Experimental Data, Statistical Variables, Outcomes of the experiment, Description of statistical results, Statistical relationships relating dependence, Analysis of unobserved variables, The prism of mediation model, Discussion about the experiment. Then the next experiment is presented. The sub-headings are Experiment Two Outline, Experimental procedure, Pilot test, Questionnaire after the experiment, Manipulation checks, Course registration objective, Student Behavior towards the Teacher, Discussion about the experiment. At the end and before references section Conclusion is presented.

II. Related Work

Electronic Feedback and Evaluation (EFV) has long been an imperative wellspring of data that influences choice making. It is normally characterized as casual correspondence about items or administrations between two or more people, none of whom speaks to a promoting source. The basic idea of EFV demonstrates that data, and, specifically, proposals, pass by verbal means in a casual, individual-to-individual way, instead of by broad communications or conventional promoting. As a result, one EFV message can arrive at and possibly impact numerous individuals through different trades[iv-viii].

With the development of the new Web standards period and the development of on-line social networking investment, the EFV is seen to be more compelling today than at any other time. Web dialogs posted on sites, talk gatherings, social networking, and notion sites are frequently seen as a machine-processed-text (MPT) and video analysis[ix]. Individuals can get item and administration, data from loved one part, as well as from a mixture of obscure individuals through numerous virtual assumption stages. From diversion venues and restaurants to relax destinations and machines, on-line audits are accessible for very nearly anything including universities and school teachers. The learner assessments on MDB and other comparison sites can be viewed as a manifestation of MPT [x].

As a shopper commanded the channel of correspondence that essentially infers from individual impact, the EFV is regularly seen as more solid, sound, and dependable than organization launched, the amount individuals frequently control showcasing data, and its belongings believe the data source. The force of MPT is clear in the experiment. More than 4000 Web clients were reviewed on the effect of client produced substance from web journals, rating/survey sites, discussions, exchange sheets, and interpersonal interaction sites on their buying choices [xi]. It was discovered that give or take 9% of the respondents interfaced no less than one MPT source straightforwardly to a late buy choice[xii-xiii].

Given the expanding ubiquity of MPT, a developing collection of re-inquiry has concentrated on how it influences people's choice making in diverse item classifications. Review about attractiveness and review about feedback size are two discriminating variables inspected in numerous former studies, despite the fact that these experiment discoveries are blended. In the abstract, simplified view of most former re-look, intrinsic attractiveness or averseness speaks to the way of data as either negative or positive, though quantity alludes to the aggregate sum of data scattered. The author has analyzed the effect of online video audits on film industry income and found that the quantity of MPT data gave critical illustrative force to both total and week after week film industry incomes. Then again, its intrinsic attractiveness or averseness, as measured by the rates of negative and positive messages, demonstrated no critical impact. Authors took a gander at the relationship between film audits and film industry deals and found that the quantity of motion picture appraisals pushed more noteworthy impact on film industry deals than intrinsic attractiveness or averseness [xiv].

Different studies, nevertheless, discovered MPT intrinsic attractiveness or averseness to be a critical indicator of buyer conduct. Case in point uncovered that positive client audits had the best effect on purchasers repurchase aims while the aggregate number of re-perspectives demonstrated no noteworthy impact. It was discovered that positive on-line surveys were more inclined to produce higher deals development. The author examined online deals and demonstrated that positive online surveys and fundamentally expanded the number of bookings, although negative audits influenced the bookings antagonistically[xv-xxi].

Different studies recommended that both reviews aboutthe feedback size and review about attractiveness have huge impacts in affecting their choice making. Authors found that both quantity and intrinsic attractiveness or averseness of online audits affected book deals. The writers reasoned that "the expansion of new, positive surveys at one site brings about a build offers on that site of a book on the next website [xxii]. Pro-represented a dispersion model utilizing measurements from computer-based client audits throughout the opening weekend of a motion picture with other conventional measurements, for example, theater film accessibility. It was demonstrated that both the quantity and intrinsic attractiveness or averseness of online motion picture audits had a positive and huge measurable effects on future film industry deals [xxiii-xxvii].

The possible motivation behind why discoveries of MPT impacts in the writing are to some degree blended is that analysts inspected the altogether different item and administration classifications in their studies, some of which by nature may be more helpless to the impacts of MPT, than others. Individuals may be impacted by MPT messages more when they are taking a gander at the administration, situated items, e.g., lodgings, restaurants, and motion pictures [vii,xxv]. What's more, MPT may assume a more noteworthy part when buying new items that purchasers don't know well and for which more data is required before buy [xxviii].

A few earlier studies have inspected elements that prompt MPT conduct, including individuals' longing for social communication, financial motivations, sympathy toward other individuals, and the possibility to upgrade their particular self-esteem. Key inquiry in regards to the present experiment is the reason school learners post assessments of their educators online, and what finished result, they are attempting to accomplish recommended that as opposed to prevalent thinking, students don't make ratings of their educators on the Internet for the purpose of "requital."Indeed, they have a tendency to give online evaluations to all their teachers as opposed to picking those whom they truly like or aversion[29]. Be that as it may, a noteworthy bit of learners may be "prowlers" that energetically gather survey data from others however seldom help their substance[xxx-xxxiv].

Despite the fact that the MPT framework for higher instruction (MDB or other comparable sites) may be seen as wrong and scrutinized for making a hostile to scholarly tone. Learners think that it's extremely valuable for course determination purposes [xxxv-xxxvi]. As demonstrated in the paper, the intrinsic attractiveness or averseness of MDB audits has a huge effect on learners' observations. Learners who viewed positive audits about an educator were more prone to report expand in anticipating the class, foresee acquiring "A"grade and propose the class to a companion. In an alternate experiment, Authors' found that apparent teacher performance, e.g., energy, the association has a tendency to produce more online learner audits, whichever negative or positive[xxxvii].

III. Student-Teacher Interaction Assessment Model

Unlike previous researchers, this study does not focus on students' input in the form of a survey or feedback form data only, but also focuses on the text data filled by students and video analysis data. Video analysis tool has been developed to conduct the experiments described later in the manuscript. This text data is collected and processed using natural language processing and machine learning techniques which can be explored by the tools e.g. IBM SPSS Text Analytics. We have proposed the Assessment Model for Student-Teacher Interaction in eLearning, which shows the inputs and outputs as shown in Fig. 1.

A. Mathematical Formalization

As depicted by the author, distinctive commercial ventures and item/benefits classifications are affected by MPT in diverse ways. The ebb and flow research enhances the MPT writing by concentrating on an exceptional administration industry where students and their teachers are viewed as stakeholders. Compared to substantial items, they may be more responsive to MPT with their buys of administrations. Albeit online evaluations and surveys of educators may be wrong or uncalled for, they are in any case a vital variable to consider when taking a gander at course enlistment in higher education.

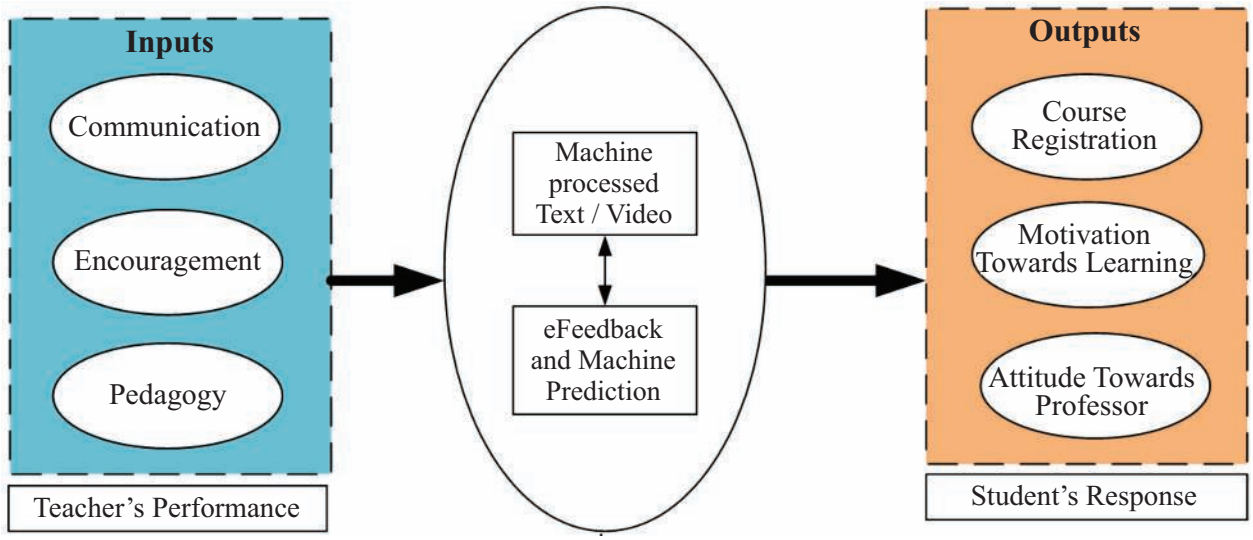

Fig. 1. Assessment Model for Student-Teacher Interaction in eLearning

The assessment model (as portrayed in Fig. 1) gives us the mathematical formation which can be further used for assessing teaching performance, students' responses and their relationship based on any number of parameters [xxviii,xxxviii]. In this case, we had used three parameters on both sides. Experiments performed in this research clearly exhibit that teacher's performance and students' responses are directly proportional.

$$TP \propto SR \tag{1}$$

Teaching performance has some parameters so:

$$TP\sum_{i=1}^{n}(TPP)_i \propto SR \tag{2}$$

Hence, SR is measured by some parameters as well so:

$$TP\sum_{i=1}^{n}(TPP)_i \propto SR\sum_{j=1}^{m}(SR)_j \tag{3}$$

In case, multiple students' responses:

$$TP\sum_{i=1}^{n}(TPP)_i \propto SRs\sum_{p=1}^{k}\left(\sum_{j=1}^{m}(SR)_j\right)_p \tag{4}$$

Where TP is Teaching Performance, SR is Student's Response, TPP is Teaching Performance Parameters, and SRs is multiple students' responses. Here n, m, and k are sets of natural numbers.

Therefore, the proper and comprehensive input is taken from the students. As a result, a deeper analysis is possible other than relying on pre-available options to the students in the survey. Automatic text processing and attribute extraction are very import and necessary for solid results. Virtual University of Pakistan (VU) and Virtual COMSATS University have been taken as case study institutes. Total enrolled students are above 200,000 at VU and VCOMSATS from different cities of Pakistan as well as international students. Therefore, we have a diverse population of students to conduct experiments. More than 40,000 active students are surveyed for the purpose of their course websites and general surveys for online education. The students of these institutes carry out the present study because these are suitable universities for the purpose where massive online students are studying various courses using electronic learning. Experiments are conducted in two phases. In the first phase, the data of the students of VU are analyzed and in a second phase, the data from VCOMSATS is analyzed. Many other universities are also providing such education so that this study can be enhanced.

B. Hypothesis

Based on earlier studies, the present experiment expects that better educator performance, and it prompts more positive online assessments influences course selection. Null hypothesis to prove results accuracy is as follow:

H0. Teaching performance is not directly proportional to student learning experience.

As it were, we expect an intervention impact of MPT intrinsic attractiveness or averseness between seeing teacher performance and genuine course selection. The accompanying theory is therefore produced:

H1. The high performance of the teacher prompts higher course selection rate, intervened by the intrinsic attractiveness or averseness of online learner assessments of the educator.

It is noteworthy that if assessments of 2 different teachers were comparative trendy intrinsic attractiveness or averseness yet distinctive in quantity then what will be the outcome. No known experiment has given an agreeable reply to this inquiry. This inquiry is hypothetically critical, as the cooperation impacts between review about attractiveness and review about size inside the MPT connection look blended and indistinct in the present collection of writing. Subsequently, the present experiment plans to reveal novel insight in noting the present inquiry, in light of the simplicity of impact recovery skeleton.

Individuals frequently structure their judgment of recurrence, probability, and normality on the premise of the straightforwardness with which models might be inferred. The sensation that individuals utilize their knowledge of the particular subject of review as an investigative effort in making the choice procedure is characterized simplicity of recovery impact. In one of their excellent analyses, it is watched that members overrated the number of words starting with "*r*". Be littled some words, those are having "r" as a3rd letter, on the grounds, we can say that words that starting with a particular letter are simpler for review that holds that similar letters in the 3rd location in the word. Since Narayan et al. presented their arrangement of probes the simplicity of recovery impact, there has been an enormous measure of resulting examination, all of which has given joined conclusions. Given the simplicity of recovery impact, subjective knowledge of straightforwardness or trouble influences people's surmising about the measure of data accessible, which like this serves as a judgmental heuristic. Trouble in creating encouragement capable models, for instance, is expected to demonstrate that those models are few, and in this way, the position they help may be flawed. The accomplished simplicity, then again, apparently recommends that many people such models exist, and consequently, the position they are backing is a persuading one.

Double process models of influence, for example, the Expansion Likelihood Method (ELM) help to clarify the simplicity of recovery impact. As indicated by the ELM, while individuals are not included in the high embellishment of a message, it is sure that they have a tendency to create basic derivations focused around different fringe signs, for example, some contentions in that particular message. Without lifting a finger off-recovery impact, people's subjective accomplished simplicity or trouble works as a fringe prompt. Accomplished simplicity of recovery improves message legitimacy while accomplished trouble of recovering debilitates it. Applying this method of reasoning to the present experiment, while the quantity of computer-based assessments of a teacher is more in measuring units. Learners are required to encounter straightforwardness when in the future they will recover important models of that educator, accordingly upgrading the review about attractiveness impacts that are dignified behaviorally and effectively [xxxix]. Conversely, they will encounter trouble recovering models when the online assessment quantity is low, prompting debilitated review about attractiveness impacts. Likewise, the accompanying two philosophies are created:

H2. It is noted that there will be a cooperation impact concerning online assessment quantity and intrinsic attractiveness or averseness on students' course selection propositions. At the point when the quantity is high, the review about the attractiveness impact on the course enlistment aim will be fortified. At the point when the quantity is low, the intrinsic attractiveness or averseness impact on the course selection is debilitated.

H3. Cooperation impact will be there concerning online assessment quantity and intrinsic attractiveness or averseness on students' demeanor to their teachers. At the point when the quantity is high, the review about the attractiveness impact on mentality will be fortified. At the point when the quantity is low, the intrinsic attractiveness or averseness impact on disposition can be debilitated.

C. Experiment One

Electronic learning is different from traditional learning, and we have constructed and evaluated the teacher. The experiment is based on the student learning experience in eLearning arrangements. Moreover, traditional learning can be taken under the consideration of the experiments if the blend of electronic learning is there in the experiment. So both type of learning arrangements can be examined, but the presence of electronic based methodology is essential.

D. Outline

The essential goal of experiment one is to investigate H1. So it remained intended a real field test. Arbitrarily tested statistical evaluations & composed educators' audits extracted from MDB. Students' course determinations were analyzed focused on the impact of these evaluations and surveys.

E. Methodology

The methodology for the experiment is straightforward. Data from the students' learning experience and behavior is examined to determine the teacher's performance. Different parameters for the teacher performance and student learning experience are taken to make the study more reliable and reproducible.

F. Collection of Experimental Data

Using MDB, students assess their teachers on three qualities, i.e. teaching style, encouragement, and communication; on a 1-to-5 scale, with five are clear,

useful,& simple. The site likewise gives space for learners to post composed audits of their teachers. With a specific end goal in measurably a possible perplexing variable, i.e. course selection: whether a course is elective or compulsory; in information investigation, Virtual University of Pakistan was chosen as the example university. There was an aggregate of 1451 teachers recorded as a feature of the example university on MDB. Taking into account in order request and the beginning of the first teacher, each fifth educator was efficiently chosen. This inspecting technique yielded a specimen size of 277 teachers, coating a sum of 245 courses around then. The course enlistment information; most extreme enlistment number considered each one course and real selection number; were gathered after passing the last date to unregister a course from the example university's site[xl].

G. Statistical Variables

Subsequently, educators were assessed focused around three traits on MDB, the normal popularity of each one property was saved in the database for each one-specimen educator. All the three properties structured premise of free statistical variation: saw educator performance. What's more, all composed audits of the specimen educators were recorded. The intrinsic attractiveness or averseness of the audits (positive or negative, unbiased) was later substance broke down by two codes. Among codes, unwavering performance was 0.88. It is noticed that the inconsistencies of coding were determined via talk. Each of the specimen educator, the rate of positive audits was ascertained as a middle person. Selection percentage of each course, which was computed as the rate of genuine enlistment number against the greatest selection number, permitted. The control variable, i. e. course selection; information was taken from the example university's learning management system's website related to that particular course[xli].

H. Outcomes of the experiment

Experiments revealed that the students and teachers in the electronic learning are different connected and concerned about each other. This setup supports the distance based teacher and learning, but the concern is connected to each other. Next sections of the paper explain the statistical outcomes of the experiment.

IV. Description of Statistical Results

Each one specimen teacher got assessments from marginally more than 11 learners on normal (MEAN = 11.03, STANDARD DEVIATION = 14.98). Students evaluated their teachers a normal of 3.15 on pedagogy (STANDARD DEVIATION = 0.91), 3.88atthe encouragement (STANDARD DEVIATION = 1.04), and 3.77incommunication style (STANDARD DEVIATION = 0.94). The mean number of audits every teacher got was 28.97 (STANDARD DEVIATION = 38.77). After analyzing the data fromsurveys, we conclude that 25% as negative, and 8% as impartial and 68% were coded as positive. From 246 specimen courses, 48% were required, and 52% were elective. The mean, obviously enlistment rate was 80.96% (STANDARD DEVIATION = 0.24) (see a

TABLE I
Summary of Description of Statistical Results in Experiment 1

	Min	Max	Mean	SD
Students who evaluated each teacher	6.00	246.00	11.3	14.98
Perceived pedagogy of each teacher	2.00	6.00	3.15	0.91
Perceived encouragement of each teacher	2.00	6.00	3.88	1.03
Perceived communication style of each teacher	1.39	6.00	3.77	0.94
Reviews of each teacher	1.00	230.00	28.97	38.77
Course registration percentage per each course	0.00	1.00	0.80	0.24

A. Statistical relationships relating dependence

A connection examination uncovered that course enlistment percentage was altogether associated with saw teaching style (Pearson's r = 0.22, p <0.01), communication (Pearson's r = 0.17, p <0.05), and positive re-view rate (Pearson's r = 0.26, p <0.001). Additionally, saw effortlessness, encouragement, and communication were all decidedly corresponded with one another ((Pearson's r extended from 0.50 to 0.85, p <0.001) (see a rundown of correspondence investigation in Table II).

TABLE II
STATISTICAL RELATIONSHIPS RELATING DEPENDENCE IN EXPERIMENT-1

	Apparent pedagogy	Apparent encouragement	Apparent communication style	Percent reviews	Percent of course registration
Apparent pedagogy	-	0.51	0.53	0.51	0.22
Apparent encouragement		-	0.85	0.83	0.13
Apparent communication style			-	0.78	0.17
Percent reviews				-	0.26
Percent of course registration					-

B. Analysis of unobserved variables

Since seeing effectiveness, encouragement, and communication was exceedingly connected, an exploratory component dissection was performed to look at whether these three things could structure a variety of saw teacher performance. The greatest probability extraction technique was embraced. The results of the study recommended one-element result, with an Eigenvalue of 2.26. It is because the variable loadings of the three things were 0.57, 0.91, and 0.92, and each of the three things together clarified 75.11% change. Subsequently, the three things were found the middle value of to structure a solitary saw teacher performance list (MEAN = 3.60, STANDARD DEVIATION = 0.84).

C. The prism of mediation model

To test H1, the three-stage intercession examination [xxii-xxiii] was directed. The analysis revealed that apparent educator performance was a noteworthy indicator that the audit rate for positive ways ($B = 0.27$, $b = 0.81$, $t = 20.04$, $p < 0.001$). Further analysis exhibits that the word variable required to be relapsed on the autonomous variable. It is clear that con-establishing variables are, course selection and some surveys that required being controlled. It is necessary that a course was elective or required may influence students' selection. Along these lines, a sham variable was made for course selection, with one coding to obligatory and 0 coding to elective.

Further, the number of composing surveys for every teacher likewise required to be controlled, because data quantity is a potential fringe prompt for data transforming (as indicated by the ELM). Along these lines, the embedded variables were 2 into the relapse comparison as the first piece. To make the result sound and error-free, the free variable saw educator performance, was then further part of the mathematical statement. By means of analysis, it was discovered that apparent educator performance was a critical indicator obviously enlistment rate ($B = 0.07$, $b = 0.21$, $t = 2.98$, $p < 0.01$). At long last, then go between was added to the mathematical statement. It was discovered that the noteworthy impact of seeinga teacher performance in the second step vanished (from $p < 0.01$ to $p > 0.1$). Then, positive survey rate represented a critical impact on the course enlistment rate ($B = 0.17$, $b = 0.23$, $t = 1.97$, $p < 0.05$) (see an outline of the intercession examination in Table 3). It was inferred that the huge impact of seeing teacher performance on course enlistment rate completely interceded. At the end of the day, "fantastic" educators have a tendency to get extra positive surveys & consequently, see a higher selectionof their courses,so it is concluded that it supports H1.

TABLE III
RELATIONSHIP BETWEEN INDEPENDENT VARIABLES AND DEPENDENT VARIABLES IN EXPERIMENT-1

Variables		B	SE B	B
Step 1				
	DV = Percent positive reviews			
	Apparent teaching performance	0.30	0.02	0.79
Step 2				
	DV = Percent course registration			
	Course selection	0.05	0.04	0.09
	Number of reviews	0.01	0.01	0.03
	Apparent teaching performance	0.07	0.03	0.21

Step 3				
	DV = Percent course registration			
	Course selection	0.05	0.04	0.11
	Number of reviews	0.01	0.01	0.03
	Perceived teaching performance	0.03	0.04	0.07
	Positive review percentage	0.19	0.10	0.23

D. Discussion about the experiment

Experiment 1 imitated a few discoveries in the writing furthermore made special commitments. Initially, steady with the learner audits on MDB were discovered to be moreover negative or positive, with minimal in the middle. It is also necessary on the other hand, predictable with earlier research, saw teaching style, encouragement, and communication were all discovered to be noteworthy ascribes that learner's utilization to judge an educator's general performance. At last, it was delineated that students do use MDB to settle on course determination choices. Unlike former studies whose conclusions were focused around learner overviews and center gatherings, the present experiment utilized genuine course selection information.

Despite the fact that the realistic setting gave more outside legitimacy for experiment one, there was an absence of mechanism on some possible con-establishing variables (other than the number of audits and course selection). For instance, learners' course selection may be influenced by other outer elements, for example, the accessibility of option courses. Likewise, the information gathered from MDB did exclude full of feeling measures. In this manner, the relationship between online assessment intrinsic attractiveness or averseness and students' state of mind to their educators could not be tried. Also, the MPT quantity (number of learner re-sees for every educator) was controlled in experiment 1 instead of being controlled [xlii]. Finally, the example, university in experiment one was placed in the Pakistan, and its learners were principally Pakistani. It is necessary to build the generaliz ability of the experimental discoveries; other understudy populace gatherings are likewise required. Experiment 2 was outlined and directed to conquer these limits.

E. Experiment Two Outline

Experiment 1 uncovered a critical review about attractiveness impact, demonstrating that positive teacher audits expanded course enlistment. The basic role of experiment 2 is to investigate that this impact is directed by the review about size, as it was anticipated in our previous hypothesis i.e. H2 and H3. Components controlled were two to review about attractiveness (negative vs. positive) and review about the size (low vs. high).

F. Experimental Procedure

Totally 80 agreed students from COMSATS, Pakistan students (Age: MEAN = 21.11, STANDARD DEVIATION = 2.60; and the gender of the participants were 75% female) examining students took an interest in the analysis. They were haphazard as marked to 1 of 4 testing conditions, and 21 members performed this for every condition. It is clear from the analysis that it was directed in a machine lab where a specula- tive experiment-abroad situation was reproduced. Members were advised to envision that they had a chance to go to an outside university to experiment throughout the approaching summer i.e. summer 2014. The students were directed to the interpretation of an assigned site that held some data about the university and afterward, address a survey. To take out potential slant related with the institution is standing. Each site held 6 pages, giving a presentation of the site itself, and short diagrams of the Institute, correspondence division at the University, a correspondence course "Android Developers" learner lodging, and the univer-sity exercise center.

The arrangement and messages were the same over each of the four locales, excluding the course “Android Development”. This course was elective, it was about media processing and software development for Android based devices. Two locales gave 25 reviews in total, and the other two destinations offered five studies in total. They were asked to put a review, which held control measures and checks of control variables.

G. Pilot Test

The reviews about the teacher encompassed on the test destinations were pilot-attempted with fifteen students. They did not take an enthusiasm toward the trial. 20 positives and 20 negative reviews were attempted. Both types of review were expressed in a backward way of clearly contrasting about course material. The fifteen learners were needed to survey the inherent appeal or averseness from each advertisement on a Likertscale (7 = positive and 1 = negative). This technique for 21 positive reviews went from 5.08 to 6.34.The strategy for the 21 negative reviews has been reached out from 1.21 to 3.26. A matched t-test (two-tailed)discovered that positive reviews (MEAN = 5.83, STANDARD DEVIATION = 0.72) on ordinary were seen as more positive ones (MEAN = 1.83, STANDARD DEVIATION = 0.55), $t(14) = 13.51$, $p < 0.001$.

H. Questionnaire after the experiment

Members were asked to assess two announcements on a Likert scale (7 = determinedly concur and 1 = firmly differ). The post - test survey

was "I discovered the remarks about the teacher on this site to be a lot of people" and "most of the remarks about him on this site were sure" to check the free variable controls. Additionally, they were asked to report their probability of enlisting in the "Android Development" course on the scale. Their state of mind to the teacher was measured with four sets of modifiers i.e. exhausting and intriguing, unfavorable and good, aversion/like, terrible and great; on a 1 to 7 scale with one speaking of awful, disdain, unfavorable, exhausting, and seven speaking to the universe. Since members' characteristic enthusiasm toward the zone of correspondence, may advance conceivably influence their selection propositions for the course? They were likewise encouraged to record the response enthusiastically toward the subjects identified with correspondence innovations as a rule on a scale (7 = extremely intrigued and 1 = not intrigued).

I. Manipulation Checks

Taking into account members' reactions to the post-test survey it was observed that those in the low-quantity, the check did not see the surveys to be the same number of as (MEAN = 4.10) and those in the high-quantity, condition where $p < 0.001$ (two-tailed), (MEAN = 5.77), $t (77) = 6.74$.It likewise was discovered that the individuals who saw the sites with for the most part positive surveys (80% positive).They were more positive (MEAN = 5.24) as compared to individuals who saw sites with generally negative audits where $t (79) = 10.93$, $p < 0.001$ (two-tailed) and (80% negative, MEAN = 2.14).Results affirmed the accomplishment of free variable controls in the investigation.

J. Course Registration Objective

A noteworthy connection impact was identified, where $p < 0.05$ and $F (177) = 6.83$, supporting H2. Particularly, when the survey introduced five audits, members indicated higher plans of enlisting in the course when most surveys were certain (MEAN = 4.21) as an op-postured to when most surveys were negative (MEAN = 2.26). At the point when the survey gave 25 audits, members uncovered much higher aims of selecting in the course when maximum surveys were certain (MEAN = 5.51) & significantly lesser propositions negative reviews (MEAN = 1.96).

One possible perplexing variable, which is required to be controlled, was members' innate enthusiasm toward the point of correspondence innovations. Subsequently, an extra ANCOVA test was performed with members' enthusiasm toward correspondence innovations being the covariate. The communication impact between review about thesize and intrinsic attractiveness or averseness on the course selection plan was again noteworthy, where $p <0.05$ and $F (176) = 6.60$. The bearing of the cooperation impact was like that of the ANOVA test (5 basically/surveys, positive: MEAN = 4.31; five generally/audits negative: MEAN = 2.34; 26 audits for the most part positive: MEAN = 5.39; 26 basically/audits negative: MEAN = 1.90).

V. Student Behavior Towards the Teacher

Members' mentalities around the educator were measured with four sets of modifiers in the post-test survey. The four things were found the middle value of to structure a solitary record, with an acceptable dependability (a = 0.94). A critical association's impact was uncovered, where $p < 0.001$ and $F (177) = 15.45$. Members demonstrated a bigger distinction in their state of mind around the teacher when the survey displayed 26 audits (basically positive: MEAN = 5.72; for the most part negative: MEAN = 2.74), Contrasted with when the site exhibited five surveys (generally negative: MEAN = 3.54; positive: MEAN = 4.94).

Since members' enthusiasm for the theme of correspondence innovations may influence their state of mind around a teacher who is teaching them, another ANCOVA test was executed with enthusiasm toward correspondence advances as the covariate. The communication impact between review about the size and intrinsic attractiveness or averseness on demeanor around the educator stayed critical, where $p < 0.001$ and $F (176) = 15.33$. The course of the communication impact again was like what was uncovered in ANOVA test (5 surveys/basically positive: MEAN = 4.93; five audits/for the most part negative: MEAN = 3.53; 26 audits/generally positive: MEAN = 5.73; 26 surveys/for the most part negative: MEAN = 2.74).

A. Discussion about the experiment

Based on the discoveries of Experiment 1, Experiment 2 further showed that its quantity directs the impacts of MPT intrinsic attractiveness or averseness. Given the same intrinsic attractiveness or averseness, the quantity of online audits of an educator may serve as a heuristic signal and delude learners to structure predisposition state of mind and behavioral plans. Predisposition is prone to happen throughout this procedure. Case in point, it appeared less demanding for members who saw 20 positive and five negative surveys to think of positive models, rather than the individuals who saw just four positive and one negative audit, despite the fact that the extent of positive audits was the same in both cases.

Inputs from the students for the attributes of teacher's communication style, encouragement to the students and pedagogical skills determine the teacher's quality of teaching which we call teaching performance. The outputs of the model result in student learning behavior are called students' response. The students' response is reflected by the students in the form of course registration, motivation towards

teachers, and learning motivation. The e-feedback performs the evaluation in the form of survey and text analysis. Statistical tools process survey data and text data is processed with text analytics tool, i.e. IBM SPSS text analytics that made the task easier, efficient, accurate, and video analysis is done with the help of the tool developed by us.

VI. CONCLUSION

Learners today are existing in the new Web standards time, and they anticipate that the Internet will give replies to the majority of their inquiries. When they have an inquiry regarding whether they ought to bring a course with a specific educator, they normally go to MDB or comparative sites for the response [24]. In this manner, the methodology of deciding the "performance" of a teacher is advantageous, yet it is prone to be inclined. Experiment 1 showed that students use MDB to settle on their course enlistment choices without considering legitimacy. Experiment 2 then demonstrated that students' choice making procedure mightbe predisposed focused around the impact of MPT quantity. Regardless of the fact that it is accepted that all surveys on MDB are composed in "accordance with some basic honesty" by students who have really taken the courses, diverse amounts of audits may even now lead learners to accept a few teachers are "better" or "more awful" than others because of straightforwardness or trouble of pertinent model recovery.

Mostly, this experiment upholds the idea that MPT intrinsic attractiveness or averseness completely intercedes the causal relationship between saw educator performance and learners' course selection, and that quantity directs this impact. No known earlier experiment has tried these impacts together. Accordingly, these discoveries will be development teachers and establishments' general understanding of how MDB or comparative site impact students' choice is making methodology concerning their course determination. Joining discoveries from both experiment 1 and experiment 2, it is clear that apparent effectiveness, supportiveness, and communication focus saw educator performance. This impact, nonetheless, is directed by some understudy surveys. At the point when some surveys are bigger, significant models (either negative or positive) of the teacher are simpler to recover, so that the intrinsic attractiveness or averseness of audits is reinforced. Conversely, when some audits are more diminutive, pertinent models are harder to recover, and the intrinsic attractiveness or averseness impact is debilitated.

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3G/ 4G Telecom Technology; User Acceptance Among Educated Youth of Pakistan

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Abstract-State of the art telecom technologies i.e. 3rd Generation/ 4th Generation (3G/ 4G) have been launched in Pakistan since 23rd April, 2014. Pakistan is one of the late adopters of these technologies. Research is needed to explore various factors influencing user acceptance of these technologies. This study makes use of a popular leading model i.e. Technology Acceptance Model (TAM)and validates it in the scenario of Pakistan. This research predicts user acceptance for 3G/ 4G mobile services and behavioral intention associated with it among educated youth in Pakistan (Islamabad/ Rawalpindi/ Wah regions due to richness of educational opportunities for youth.) not only because youth forms major portion of users of these services in Pakistan but also service providers have focused to attract educated youth through their advertising campaigns

Young generation in Pakistan uses telecom devices much more than any other age group as 77% of users lie in 21-30 age bracket, while 12% in 31-40, 9% in 10-20 and 1% in 41 and above aged people. Accordingly, young generation in Pakistan is the focus of mobile telecom operators with regards to customer base, hence the main focus of this study is also the educated youth. The research explores and analyses usage of 3G/ 4G services by educated youth to establish whether Perceived Ease of Use and Perceived Usefulness which are the key constructs of TAM are useful in predicting Behavioral Intention among educated youth for 3G/ 4G services?

Survey strategy is employed in this research by taking into account simple random sampling. A structured questionnaire has been adopted for this study with due concentrations for reliability and validity. Through statistical analysis, it was found that perceived usefulness and perceived ease of use have a positive direct relationship with Behavioral Intention to use 3G/ 4G technology. The research will be helpful for telecom service providers in Pakistan to contrive strategies for increasing the adoption trend of 3G/ 4G technologies.

Keywords-3G, 4G, User Acceptance, Perceived Usefulness, Perceived Ease of Use, Behavioral Intention, Technology Acceptance Model.

I. INTRODUCTION

3G/ 4G are generic names for description in advancement of mobile communication in terms of "generations" [i]. It can also be regarded as the advanced and latest infrastructure networks, telephones and other similar technologies to equip mobile consumers' with fast speed Internet, video calls, messaging and streaming services. These applications are recently made possible in Pakistan with increased data rates due to the 2-8MBPS bandwidth availabilities [ii].

The Technology Acceptance Model (TAM) is a highly recognized model which has been used by many researchers in their work. This model is based on different relationships given by the Theory of Reasoned Action (TRA) [iii]. TAM is the most widely used model for forecasting and clarifying user behavior on their attitudes and intentions. The TAM is used for determining user acceptability of various kinds of technologies e.g. TAM is also used to determine user acceptability of 3G services in Botswana, Taiwan, China and many other countries. The technology acceptance model is the best suitable model for understanding Behavioral Intention and showing the acceptance of 3G/ 4G mobile service.

Various researches have been seen such as: in Taiwan, Botswana and China, where user acceptance trend for 3G services was analyzed using TAM and its core constructs were found to be significant predictors of Behavioral Intention. As results can vary from one country to another, TAM model will be validated in this research paper considering the scenario of intention to use 3G/ 4G services in Pakistan (Islamabad/ Rawalpindi/ Wah). 3G/ 4G services have recently been launched in Pakistan in April 2014 and it is one of the late adopters of these technologies. This research aims to predict the Behavioral Intentions for 3G/ 4G technology among educated young generation as they possess the highest ratio of latest mobile telecom services usage. This research paper focuses on identifying the factors which influence user adoption of 3G/ 4G services among educated youth of Pakistan.

II. Rationale & Significance

Acceptance of any technology in a society is an important factor which should be considered in detail to check the success of any technology [iv]. 3G/ 4G services are recently launched in Pakistan and are of utmost importance for the development of telecommunication sector. To make these services successful in Pakistan, we need to study in detail and learn how these services are contributing towards the betterment of our society and how are people responding towards them. A lot of research has been done in different countries to understand behavioral intention of 3G/ 4G technologies and it needed to be conducted in Pakistan as well because the results obtained for one country cannot be considered for another one due to different cultural and moral values.

The total number of mobile phone owners in Pakistan are 136.4 million in January, 2015 [v]. According to ITU, there are 20 million internet users in Pakistan and 50% of them access internet through their mobile devices. Mobile operators face a huge problem as the majority of smartphone users use Wi-Fi to access internet, 25% only access the internet while on the go and 12% don't use internet. Young generation of Pakistan uses cell phone much more than any other age group as 77% of cell phone users lie in 21-30 age bracket, while 12% in 31 to 40, 9% in 10-20 and 1% in 41 above aged people [vi]. Therefore the main focus of this research paper is also on the educated youth of Pakistan with the most cell usage.

This research paper will help us identify various factors which are influencing acceptance of this technology among educated young generation thus affecting users' Behavioral Intention. This research will pave way for the speedy adoption of 3G/ 4G services which will contribute towards progress of Pakistan. The factors affecting the 3G/ 4G adoption can be handled by mobile telecom service providers to successfully implement them by devising a strategic plan. Rapid adoption of 3G/ 4G services will open doors for various other technologies to be efficiently introduced in Pakistan. Pakistan will be able to face the global competition efficiently by adopting 3G/ 4G technology.

III. Review of the Literature

Wireless Communication initiated the age of communication without any wires. Cellular systems have gone through an exponential increase over the last decade.. Its adaption has been increased even more due to the introduction of laptops, palmtop computers and mobile phones as it helps and guarantees online access anywhere and anytime [vii]. The most popular use of wireless communication is through mobiles which can also be termed as mobile communication [viii]. Mobile is a remarkable technical advancement which offer various services which fits all in your pocket and mobile communication will be the main focus of our research paper [ix].

A. Advancement in Mobile Communication

Mobile telecommunication has truly brought a revolution as it has not only brought efficient communication but also brought mobility due to which people can communicate with each other anywhere anytime [x]. Cell phones are no longer considered a luxury but a necessity and a lifeline in the time of an emergency [xi]. A fixed amount of spectrum is allocated to mobile communications and this spectrum must be re-used by re-using frequencies to accommodate massive demand of users [xii].

Zero generation (OG) can be regarded as the pre cellular systems or predecessor of first generation of cellular systems but do not support the handover and data transfer feature [xiii, xiv]. In 1st Generation (1G) analog mobile radio systems were introduced, and in 2nd Generation (2G) digital mobile systems were employed whereas in 3rd Generation (3G) broadband data handling was introduced for the first time [xv].Ever increasing demand for internet usage also came during the popularity phase of 2G and 3G, thus leading to introduction of mobile broadband. To provide the same quality of services people were utilizing with fixed broadband was a huge task and a driving force for Long Term Evolution (LTE). LTE introduces less delay, high spectrum efficiency and huge data rate [xvi].

B. 3G/ 4G Mobile Communication

3G stands for the third generation of mobile communication standard and it evolved as the demand for better and faster services increased. It is also termed as International Mobile Telecommunications-2000 (IMT-2000) and regarded as the standards for 3G introduced by International Telecommunication Union (ITU). 3G allows for simultaneous use of data services and speech and high data rates with improved spectral efficiency [xvii]. These technologies require specialized equipment and handsets for their efficient working [xviii]. 3G standard was basically created to help support the effective delivery of a range of multimedia services [xix]. It provided high quality multimedia services and enabled global roaming [xvii]. It also brought a revolution in device technology and the era of smartphones started [ix].

4G stands for the fourth generation of mobile communication standard and the main difference between 4G and its predecessor was of speed and capacity. It is also regarded as Long Term Evolution (LTE) In 2008, International Mobile Telecommunications Advanced (IMT-Advanced) has been specified by ITU-R which are the requirements of 4G standard. It supports wider channels with Orthogonal Frequency Division Multiple Access

(OFDMA) and create spatially separated paths by employing Multiple Input Multiple Output (MIMO) antennas [ix]. IMT-Advanced has specified a peak data rate of 1 Gbps for downlink and 500 Mbps for uplink in case of 4G [x]. Users will be offered to fully avail these multimedia services with this high data rate which is about 260 times greater than 3G wireless networks [xx].

C. Comparison among Generations of Mobile Communication

Mobile communication has undergone many generations involving change in fundamental nature of technology as well as service like higher peak data rates, new frequency bands, wider channel bandwidth. The main difference between them is of throughput data rate. The data rates of important standards introduced in these generations are shown in Table I. The download (to the user) and upload (to the Internet) data rates given below are peak or maximum rates and end users will typically experience lower data rates.

TABLE I
DATA RATES OF MOBILE COMMUNICATION [xxi].

Generation	Standards	Data Rates
2G	Global System of Mobiles	22.8 Kbps
2.5G	General Packet Radio Service	56-114 Kbps
2.75G	Enhanced Data Rate for Global Evolution	384 Kbps
3G	Universal Mobile Telecom System	2 Mbps
3G	High Speed Packet Access	HSUPA(5.76 Mbps) HSDPA(14 Mbps)
4G	Long Term Evolution	100 Mbps or 1Gbps

D. Technology Acceptance Model

It is very crucial to understand why people reject/ accept technologies and which factors are considered important for predicting user intentions. It plays a very significant role in making any technology a success and it helps in improving processes and systems thus improving user acceptability [xxii].Technology acceptance model (TAM) was first introduced by Davis in 1989 which is actually based on the Theory of Reasoned Action (TRA) [xxiii]. The two of the main core determinants of TAM are Perceived Ease of Use and Perceived Usefulness. Later modifications were made in TAM to further investigate the determinants of Perceived Usefulness and Perceived Ease of Use in TAM2 or Extended TAM [xxiv] and TAM3 [xxv]. It is used to study the acceptance of various technologies and basically investigates the behavior of users regarding technology acceptance.

TAM is best for those scenarios in which the main focus is on the customers' intention to adopt or reject a technology. TAM focuses on customers feelings and how they perceive things. It is used to check intentions of customers' to adopt/ reject a technology when it has been recently launched so that effective measures can be taken to ensure its success. TAM basically focuses on predicting future user behavior after interaction with a system on trial basis or for a short period of time. This model is best for scenarios where systems are evaluated in the early stages of their development and extensive user experience cannot be achieved [xxvi]. A substantial amount of researchers have supported TAM and found that it describes a substantial part of variance in usage intentions typically about 40% [xxiv]. TAM model will be validated in our research keeping the scenario 3G/ 4G user acceptance among educated youth of Pakistan (Islamabad/ Rawalpindi/ Wah).

E. 3G/ 4G Mobile operators in Pakistan

Wireless telecommunication has evolved to a great deal in Pakistan and there are currently five mobile operators in Pakistan. All of them have been able to function smoothly and efficiently despite the increased atmosphere of competition among them. On April 23, 2014 Pakistan gained $1.13 billion in an auction of 3G/ 4G licenses. 3G license were given to four existing operators of Pakistan namely The Pakistan unit of China Mobile Ltd. Zong, Pakistan Mobile Communications Ltd. Mobilink, Telenor ASA (TEL)'s local subsidiary and Ufone of Pakistan Telecommunication Co. China mobile. 4G license was acquired by only Zong at the auction but Warid has also started to provide 4G services.Significantresearch is lacking in Pakistan to study the behavior intention of users after 3G/ 4G implementation using TAM. The main focus of the mobile operators in Pakistan for 3G/ 4G success is upon the youth as they form the largest portion of customer base. This research paper will focus on understanding the behavior intention of young users of 3G/ 4G which will further aid the mobile operators in reaching their goal and will improve the economy of Pakistan.

IV. RESEARCH FRAMEWORK AND DESIGN

The basic TAM forms theoretical framework for this research as shown in Fig. 1. The TAM consists of two basic constructs i.e. Perceived Usefulness and Perceived Ease of Use which are affecting the Behavioral Intention of users.

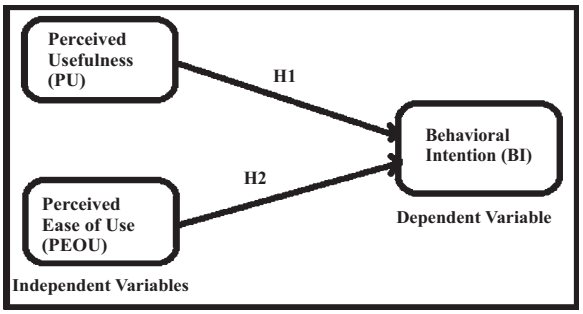

Fig. 1. Basic TAM - Theoretical Framework.

The corresponding research question drawn out is:

"How does the core determinants of technological acceptance model stimulate user acceptance of 3G/ 4G technologies among educated youth in Pakistan (Islamabad/ Rawalpindi/ Wah)?"

A. Operational Definitions and Research Hypotheses

Operational definitions for various constructs in the proposed theoretical framework are as follows:

1) Behavioral Intention (BI)

Behavioral Intention can be regarded as the degree of a person's intention to perform a specific behavior. BI plays a vital role in determining the success of any technology so great emphasis is made to determine it for emerging technology. Determining BI, enable managers to make effective decisions and take efficient measures for greater adoption rate of concerned technology.

2) Perceived Usefulness (PU)

Perceived Usefulness is regarded as the degree to which a person believes that using a particular technology will be beneficial for him and will increase his/ her job performance [xxvii]. This characteristic may differ from one individual to another depending on their nature of work and understanding. Perceived Usefulness was found to have a positive relationship with BI when it offered any form of advantage to the user. Similarly if it didn't offer any form of advantage it affected BI negatively and in turn technology adoption rate [xxvi, xxvii, xxiv, xxv]. So, formulate hypotheses are as follows:

- **Ho1:** *"No relationship exists between Perceived Usefulness and Behavioral Intention to use 3G/ 4G technology".*
- **H1:** *"Perceived Usefulness has a positive direct effect on Behavioral Intention to use 3G/ 4G technology".*

3) Perceived Ease of Use (PEOU)

Perceived Ease of Use is regarded as the degree to which a person believes that using a particular system or technology will be free of effort [xxvii]. Any technology which helps an individual to achieve his target in a timely manner without much mental and physical effort is perceived to be easy to use. This characteristic of a technology may also differ from one individual to another. A technology which is perceived to be more useful than another technology is more likely to achieve a better adoption rate [xxvii]. Perceived Ease of Use was found to have a positive relationship with BI when the user was able to use the technology without any difficulty or much mental and physical effort. Similarly if it offered any form of difficulty in usage then BI is affected negatively which in turn technology adoption rate [xxvi, xxvii, xxiv, xxv]. So, formulated hypotheses are as follows:

- **Ho2:** *"No relationship exists between Perceived Ease of Use and Behavioral Intention to use 3G/ 4G technology".*
- **H2:** *"Perceived Ease of Use has positive direct effect on Behavioral Intention to use 3G/ 4G technology".*

B. Research Design

1) Research Strategies and Choice

Survey strategy has been used for this research with deductive approach chosen as the theory already existed has been validated for local scenario. Research Choice is quantitative as it involve tabulation of data and different statistical tests performed on numerical data to extract useful results [xxviii]. Moreover, quantitative research comprises of specifying precisely both dependent and independent variables under study, making the interpretations and results more reliable [xxix].

2) Research Settings and Time Horizon

Research setting is non-contrived as natural setting is used. The data has been collected at a single point of time making the study cross-sectional [xxx]. This type of study is more useful when the research has to be finished in a limited time frame, making it convenient to identify and analyze the relationships between the various determinants involved [xxxi].

3) Population

The population considered for this research is educated youth of Pakistan. Due to budget and time constraints, population has been limited to educated youth in Rawalpindi, Islamabad and Wah considering abundant educational facilities and high literacy index.

4) Sampling Technique, Frame and Size

Probabilistic sampling is normally linked with survey based strategies to make deductions for population. Simple random type probabilistic sampling is used in this study to investigate the research hypotheses. The sample frame consists of students of Higher Educational Institutes of Pakistanin Rawalpindi, Islamabad and Wah. The Higher Educational Institutes have been selected through random number generator. A confidence level of 95% with 5% error margin, the minimum size of sample should be 384 to achieve reliable results [xxxi]. In order to achieve true results, the questionnaires were distributed among 700 students, among ten universities. Around 433 questionnaires were filled and

received back, from which 41 were ineligible. Therefore an overall response rate of 61.8 % was achieved.

5) Questionnaire Development

The questionnaire used for survey comprises of two main parts, with the opening section comprising five questions related to the demographic details of respondent while the second part containing fifteen questions measuring the respondent's acceptance level of 3G/ 4G technologies. The questionnaire for constructs PU and PEOU has been adopted from [xxvii, xxvi] and for BI from [xxxii, xxxiii]. A five point Likert scale used with (1) corresponding to "Strongly agree", (2) "Agree", (3) "Neutral", (4) "Disagree" and (5) to "Strongly Disagree".

6) Validity and Reliability

The questionnaire was verified by experts to validate language and comprehensiveness and then it was followed by a pilot study though reliability was ensured by calculating Cronbach alpha as in Table II.

TABLE II
CRONBACH ALPHA FOR PILOT TESTING

Constructs	Cronbach's Alpha	No. of items
Perceived Usefulness	0.833	6
Perceived Ease of Use	0.818	6
Behavioral Intentions	0.751	3

The items were considered highly reliable and consistent as the results of the pilot tests showed the reliability being greater than 0.8 except for Behavioral Intentions with 0.751 which is again adequately reliable and acceptable for further continuing the research. Therefore the questionnaire was further distributed to respondents to gain more results.

V. DATA ANALYSIS

In order to extract useful inferences, data analysis is necessary which is now much easier to perform with the help of latest software such as Statistical Package for the Social Sciences (SPSS).

1) Descriptive Analysis-Basic TAM Dimensions

The Table III relates to the descriptive statistics and these results demonstrate minimum and maximum value, the average value measured by mean, the dispersion in the series measured by standard deviation and the value of skewness to check whether the series are positively or negatively skewed within the range +1 to -1 to be considered as normal distribution. The values of kurtosis have also been mentioned, which depicts the peak of the curves, of the series of values used in the study. The primary descriptive statistics concerning basic TAM have been shown in Table III.

TABLE III
DESCRIPTIVE STATISTICS-BASIC TAM

	Min	Max	Mean	Std Dev.	Skewness	Kurtosis
PU	1	4	2.17	718	.530	.199
PEoU	1	4	2.03	.646	.298	.197
BI	1	5	2.24	.747	.685	.842

2) Inferential Analysis

Inferential data analysis using various statistical techniques to test the hypothesis mainly comprises of two parts. The first part encompasses the assessment of association among the variable whether the relationship exists or not. The second part is more deliberate over the predictability of the dependent variable by the independent variables.

• *Correlation Analysis*

Statistical Correlation is the measure of association among different constructs, identifying whether the relationship is weak or strong and positive or negative. At this point in the research the null hypothesis will be accepted or rejected based upon the R values and sig levels.

Table IV illustrates the relationship between the variables. All the independent variables are showing moderate strength of positive relationships with the criterion variable i.e. BI and also showing moderate positive association amongst each other with $0.7 > r > 0.3$ and sig < 0.05 resulting in rejection of null hypotheses.

TABLE IV
CORRELATION ANALYSIS- TAM CONSTRUCTS

		PU	PEOU	BI
PU	Pearson Correlation			
	Sig. (2-tailed)			
PEOU	Pearson Correlation	.540**		
	Sig. (2-tailed)	.000		
BI	Pearson Correlation	**.455****	**.612****	
	Sig. (2-tailed)	.000	.000	

• *Regression Analysis*

Simple Linear Regression uses only one independent variable whereas Multiple Regression Analysis is a statistical technique that involves the prediction of an unknown value of dependent variable through two or more independent variables and analyzes the linear relationship between a dependent and two or more independent variable. It can also be used to infer cause and effect between independent and dependent variables.

In Table V, the model summary of the core constructs of TAM shows the value of R, known as the multiple correlation coefficient, which is the square

root of R Square and can be defined as the correlation between the predicted and observed values of the dependent variable, which is Behavioral Intentions in our case. The value of R > 0.7 which indicates a moderate positive association of the predictors with the criterion variable. Moreover the value of R Square=0.396 which is coefficient of determination indicates that almost 40% of the variance in Behavioral Intention measured outcome can be accounted for by the model used for this research. The adjusted R Square narrates the predictive loss in R square value if the same model is applied to other similar samples.

TABLE V
MODEL SUMMARY- CORE CONSTRUCTS OF TAM

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	.629[a]	.396	.393	.59748
a. Predictors: (Constant), PU, PEOU				

In Table VI shows the F = 127.915 with sig = 0.000 which means that the model has sufficient explanatory power with regards to variance in Behavioral Intention explained and accounted for by the predictors i.e. Perceived Usefulness and Perceived Ease of Use in 3G/ 4G mobile telecommunication technology. At this point in the research, it is validated that the model is fit enough to proceed further with the results of regression analysis and conclude the hypothesis testing process.

TABLE VI
ANALYSIS OF VARIANCE

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	91.328	2	45.66	127.9	.000[b]
	Residual	139.225	390	.357		
	Total	230.553	392			
a. Dependent Variable: BI						
b. Predictors: (Constant), PU, PEOU						

Table VII illustrates that Perceived Usefulness and Perceived Ease of Use are significant predictors of Behavioral Intention for using 3G/ 4G telecom tech by educated youth in Pakistan. It also verifies that multicollinearity does not exist among the predictors as **Tolerance > 0.1** or vice-versa Variance Inflation Factor (**VIF < 10**).

TABLE VII
COEFFICIENT ANALYSIS-TEST OF SIGNIFICANCE

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std Err	Beta		
1	(Constant)	.081	.116		.701	.484
	PU	.222	.059	.175	3.75	.000
	PEOU	.687	.062	.517	11.06	.000
a. Dependent Variable: BI						

• *Summary of Inferential Analysis*

TABLE IX
SUMMARY OF INFERENTIAL ANALYSIS

Hypotheses	Results
Ho1: No relationship exists between Perceived Usefulness and Behavioral Intention to use 3G/ 4G technology.	**Not Supported**
H1: Perceived Usefulness will have a positive direct effect on Behavioral Intention to use 3G/ 4G technology.	**Supported**
Ho2: No relationship exists between Perceived Ease of Use and Behavioral Intention to use 3G/ 4G technology.	**Not Supported**
H2: Perceived Ease of Use will have a positive direct effect on Behavioral Intention to use 3G/ 4G technology.	**Supported**

VI. RESULTS AND DISCUSSION

In order to investigate the users' intentions to adopt 3G/ 4G technology, this study was conducted using the basic TAM model to validate it considering scenario of Pakistan (Islamabad/ Rawapindi/Wah). This study encompassed to analyze the user acceptance of 3G/4G services among educated youth of Pakistan. According to the results achieved, Perceived Usefulness and Perceived Ease of Usehave beenfound positively related to Behavioral intention to adopt 3G/ 4G technology.The results acquired from this study revealed R-square to be almost 40% which confirms validation of TAM as TAM describes a substantial part of variance in usage intentions typically about 40% [xxiv].

It can be deduced that the youth with greater level of perceived ease of use and perceived usefulness are more expected to rapidly and efficiently adopt 3G/ 4G technology. Thus youth are ready to accept and adopt 3G/ 4G technology as they believe that it is beneficial to them, convenient and easy to use.It has been found that PU and PEOU are significant predictors of BI and TAM is validated in the scenario of Pakistan considering 3G/ 4G technology usage among educated youth which is consistent with the findings of [xxxiv, xxxv, xxxvi, iii, xxxvii, xxxviii, xxxix, xxvi, xxxx] for

Basic TAM model consisting two core determinants i.e. PU, and PEOU has been used for this research which predicts BI to use 3G/ 4G technology among educated youth of Pakistan. TAM is a leading model for predicting usage intentions and no known research was found in Pakistan concerning validation of this basic model in 3G/ 4G user acceptance among educated youth. This model explained 40% of variance in usage intentions [xxiv]. This research focuses upon the users behavior intentions with regards to adoption of state of the art telecom technology i.e. 3G/ 4G mobile communication which is the backbone and founding platform for many other modern Communication and Information Technology based systems e.g. M-Learning, E-Government, online shopping/ banking, etc being researched currently for analyzing adoption/ diffusion trends not only in Pakistan but also other developing and technology savvy countries where these systems are considered to be new trends as compared to technologically and socially developed countries. As the user acceptance for 3G/ 4G technologies will increase, it will also pave way for the success of various other emerging technological systems in Pakistan e.g electronic government (E-Government) and mobile learning (M-learning) being extensively studied to enhance its adoption and further diffusion but it cannot be accomplished without proper adoption of 3G/ 4G services as it is the main stay.

VII. Conclusions

This study was conducted to analyze the Behavioral intentions of educated youth to accept 3G/ 4G technology in Pakistan, based on the basic TAM model and the previous literature. According to the results, 40% of variance in Behavioral intention to adopt 3G/ 4G telecom services measured outcome can be accounted for by the model used for research and data collected resulting in validation of TAM model in Pakistani scenario. The core determinants which are perceived usefulness and perceived ease of use were found to be positively associated with the Behavioral intention to adopt 3G/ 4G technology. As 3G/ 4G services are still in initial phase and has been launched in Pakistan two years back, so mobile operators should devise efficient ways of its efficient adoption. This research paper focuses on the factors which affect the adoption of 3G/ 4G technology and it will prove to be very useful for the mobile operators, leading Pakistan to a successful nation.

VIII. Recommendations and Future Work

Based on the statistical inferences and hypothesis testing carried out, the following recommendations can be made to promote successful employment of 3G/ 4G among the educated youth of Pakistan. Media should play an important role by highlighting the advantages offered by 3G/ 4G technology and should create awareness among users' by conducting different seminars and workshops. As 3G/ 4G technology is the backbone for many other latest technologies such as m-learning, e-government etc. so the mobile operators should clear its usefulness to the users' so that they can also reap benefits from other technologies as well. Once the 3G/4G technology is implemented successfully, it is important for mobile operators to continuously monitor their quality of service, and evaluate their usability and performance to increase the efficiency of the applications introduced.

This research can also contribute to various other researches so many future work can be carried out based on this research. The scope of this study has been limited to universities in the twin universities of Rawalpindi and Islamabad and Wah. Therefore future researchers can include universities from different cities, other than the twin cities and Wah, to get more generalized results. The future research can include longitudinal study in which researchers will be able to identify changes and improvements in the behavior of the educated youth instead of assessing at a single instant of time. This basic TAM model can also be used for validation in other technology contexts and this research can be further expanded to include additional different types of variables which affects intention behavior. Additional research work can be carried out to by taking uneducated youth into account and users' of different age groups. The study can be extended to include the higher education institutes of other countries as well as the acceptance level of 3G/ 4G technology varies from culture to culture and country to country.

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Optical Character Recognition (OCR) System For Saraiki Language Using Neural Networks

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***Abstract*-**Saraiki language is one of the local languages of Pakistan. It is spoken and understood over a large geographical part of Pakistan. Little work has been done to develop Optical Character Recognition systems for local languages due to the complex writing system. The OCR system for Saraiki language can help to digitize the language literature. This work presents an OCR system that uses the Neural Network to recognize the printed text images of Saraiki (Urdu/Arabic/Punjabi) language generated in MS Word. Neural Network is trained with the segmented and isolated character set. At first, characters are extracted from the text image using segmentation approach. These segmented characters are then fed to the Neural Network in order to be recognized. MATLAB is used for the implementation of the OCR system that at present shows about 85% accuracy.

***Keywords*-**Saraiki OCR (SOCR), Feed Forward Neural Networks (FFNN), Machine Learning, Pattern Recognition.

I. INTRODUCTION

Saraiki language belongs to the Indo-Aryan (Indic) languages. Saraiki is majorly spoken in Pakistan but it is also spoken in some areas of India and Britain.

A. Saraiki Language

The areas of "Saraiki belt" includes Southern Punjab, Indus Valley, Northern Sindh, Bannu, Tank, Jampur, Dera Ghazi Khan and Dera Ismail Khan [i] . It is transliterated as "Sirāikī".Saraiki language was recognized at the national level of Pakistan for the first time in the 1981 Census. This is the fourth most spoken local language in Pakistan after Punjabi, Pashto, and Sindhi. It is in the 61st number as a world's largest language [ii]. Saraiki is usedas a medium of expression by more than 18 million people of southern Pakistani Punjab, adjacent border regions of Khyber Pakhtunkhwa (KPK) and northern Sindh, and nearly by some 70,000 emigrants and their descendent in India [iii].

B. Saraiki Writing System

Saraiki language is written from right to left using Arabic and Urdu language scripts as the majority of alphabets of Saraiki language are present in both the languages[iv]. Saraiki language has some special characters that are additional to the Urdu language. These special characters are ﺏ (ḇë), ﺝ (ĵë), ڈ (ḍäl), گ (ğäf) and ڻ(ṇŭn). Figure 2 shows a detailed character set for the Saraiki language with symbolic representation and hexadecimal Unicode for each character.

II. LITERATURE REVIEW

Saraiki script has a cursive nature. Alphabets change their shape when combined with other alphabets to form differentwords.Figure 1 shows the shapes of a letterع('ain) at different positions in a word when used in combination with some other letters [v].

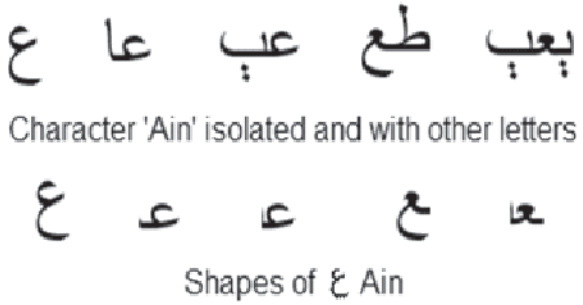

Fig. 1. Shapes of ع "Ain" in formation of Saraiki words.

Reference [vi] suggested there should be some centralized repository of words, usually known as a lexical database for cross-lingual processing. Natural language processing or natural language engineering has many tasks such as word sense disambiguation, machine translation, part of speech tagging [vii]. All these tasks also need large-scale lexical databases. NLP is a theory-motivated range of computational techniques for the automatic analysis and representation of human language. NLP research has evolved from the era of punch cards and batch processing (in which the analysis of a sentence could take up to 7 minutes) to the era of Google and the likes of it in which millions of webpages can be processed in less than a second [viii]. Saraiki is also written using different font styles like Urdu. Most popular fonts used are Nastalique style and Naskh style [ix] .

The efficiency of an OCR system is highly dependent on the writing style used for the particular language. An OCR system designed for one writing style might not work for the other writing styles due to thedifferent cursive structure.Despite a large character set Saraiki/Urdu has a small set of character classes which are easily distinguishable from one another.The characters belonging to a class are similar in shape but differ from each other due to the use of dots or symbols above or below these shapes [x].

III. METHODOLOGY

In this work, the methodology used for the development of the OCR system is word segmentation based. Characters from the words or ligatures of the language are extracted and then fed to the neural network in order to get recognized. Saraiki language has forty-four basic characters and a special character'Do-Čashmī Hë'. Many characters take multiple shapes based on their position in the ligatures. Each character is assigned a unique bit sequence for representation. The SOCR system also works well for some other languages like Urdu, Arabic, Persian and Punjabi [xi].This system has been designed to work with the Arial writing style used in the Microsoft Word, but it can be used for some other writing styles like Shamsheer, Aasaar, Batool, Unwan and Bombay Black used in Inpage Urdu as shown in Table I.

Table. I: Character For Saraiki Language for Symbolic Representation and Unicode [iii]

تھ	ٹ	پھ	پ	ٻ	بھ	ب	آ	ا
تھے	ٹے	پھے	پے	ٻے	بھے	بے		الف
thë	të	phë	pë	b̲ë	bhë	bë		Alif
th	t	ph	p	b̲	bh	b	ã	Ă
	062A		067E	067B		0628	0622	0627
ح	چھ	چ	ڃ	ڄ	ج	ث	ٹھ	ٹ
وڈی حے	چھے	چے	ڃے	ڄے	جیم	ثے	ٹھے	ٹے
vaḍḍī ḥë	čhë	Čë	ĵë	jhë	jīm	t̲ë	ṭhë	ṭë
ḥ	čh	Č	ĵ	jh	j	t̲	ṭh	ṭ
062D		0686	0684		062C	062B		0679
رھ	ر	ڑ	ڈ	ڈھ	ڈ	دھ	د	خ
رھے	رے	ڑال	ڈال	ڈھے	ڈال	دھے	دال	خے
rhë	rë	ṛäl	ḍäl	ḍhë	ḍäl	dhë	däl	ẖë
rh	r	ṛ	ḍ	ḍh	ḍ	dh	d	ẖ
	0631	0630	0759		0688		062F	062E

ط	ض	ص	ش	س	ژ	ز	ڑھ	ڑ
طوے	ضاد	صاد	شین	سین	ژے	زے	ڑھے	ڑے
ṭ̈ë	żuäd	ṣuäd	shīn	sīn	ẑë	zë	ṛhë	ṛë
ṭ̈	ż	ṣ	sh	s	ẑ	z	ṛ	ṛ
0637	0636	0635	0634	0633	0698	0632		0691
گھ	گ	کھ	ک	ق	ف	غ	ع	ظ
گھے	گاف	کھے	کاف	قاف	فے	غین	عین	ظوے
ghë	gäf	Khë	käf	qäf	fë	ġain	'ain	ẓ̈ë
gh	g	Kh	k	q	f	ġ	'	ẓ̈
	06AF		0643	0642	0641	063A	0639	0638
ڻ	ں	نھ	ن	مھ	م	لھ	ل	پ
ون	نونغنہ		نون		میم		لام	ناف
n̆ün	nün ġunna	Nh	nün	mh	mīm	lh	läm	Ğäf
n̤		Nh	n	mh		lh	l	G
0768	06BA		0646		0645		0644	06B3

ے	ی	ء	ھ	ہ	و
بڑی یے	چھوٹی یے	ہمزا	دو چشمیے ھ	چھوٹی ھے	واؤ
vaḍḍī yë	čhöṭī yë	hamza	dö-čhashmī hë	čhöṭī hë	Väö
e	y	ʻ	h	h	v
06D2	0649	0621	06BE	0647	0648

The character segmentation approach used in this system works for any font size, but in this work, the system has been trained to work with “24” font size of Arial writing style used in Microsoft Word documents. A detailed architecture of the Saraiki OCR system is given in Fig. 3. The system is divided mainly into three modules.

A. Preprocessing
B. Segmentation
C. Recognition

A. Pre-processing

Pre-processing phase involves the procedures like skewing the text image, noise removal and extracting the individual lines of text. Microsoft Word is used for the generation of input Saraiki text to be used in the system as input image files. For the Saraiki OCR system, individual text lines are provided as input (bitmap image files) to the system which is assumed to

be noise-free and skewed. The extra white area above and below the text image is removed, and the image is then converted to the binary bitmap image of pure black and white pixels. This pre-processed image text is used in the later stage for character segmentation.

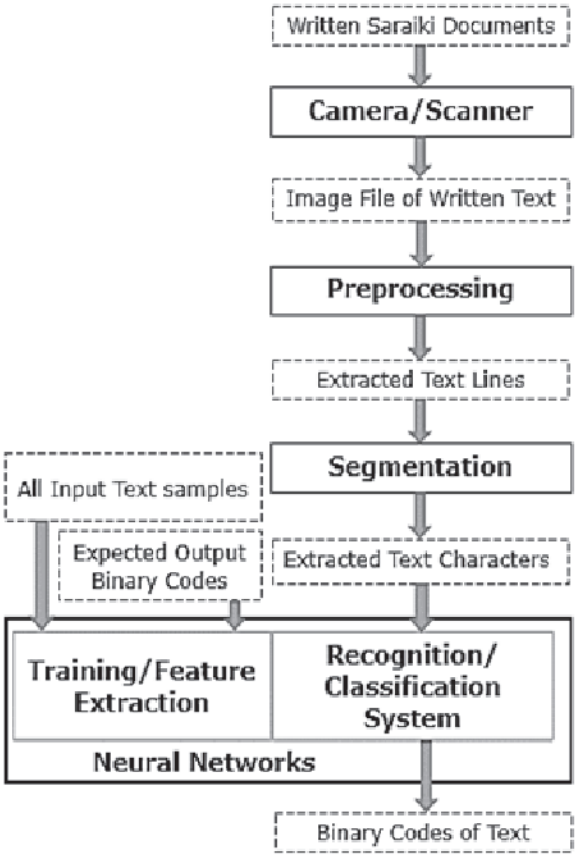

Fig. 2. Saraiki OCR (SOCR) System architecture.

B. Segmentation

In this phase, the pre-processed text image is used to extract each possible character constituting this text. In Arabic like languages, words are formed by the combination of one or more ligatures [xii] .Each ligature is an isolated letter or a combination of multiple letters. For the used font, characters join each other on the baseline to form a ligature. Segmentation algorithm exploits the nature of the font.

It works on the principle of measuring the vertical and horizontal pixel strength variations above and below the baseline of the text image while traversing the image horizontally. Figure 4 shows the text structure of Saraiki language using different ligatures and characters.

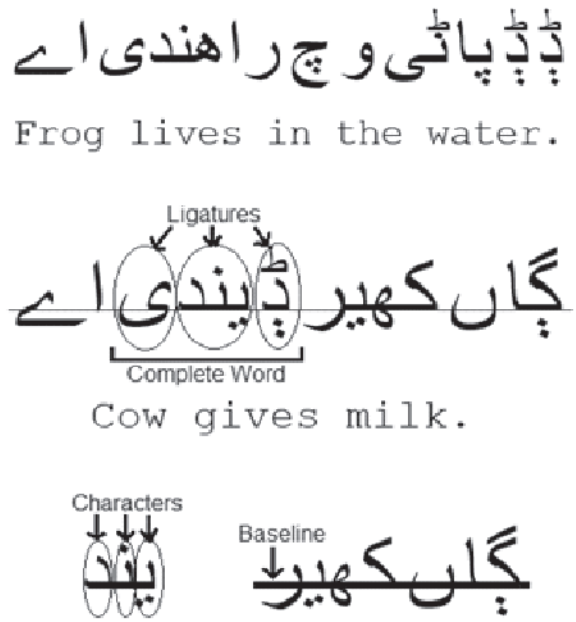

Fig. 3. Saraiki text formation using Ligature and Characters

In segmentation, firstly, the ligature words are isolated by exploiting the vertical gap present between the ligatures which results in the zero-pixel strength of black pixels. Secondly, segmentation algorithm finds the minimum vertical pixel strength which is mostly consistent throughout the ligature. This minimum vertical pixel strength is actually the height of the baseline on which joining of characters takes place for the used writing style. This minimum vertical pixel strength is found between every two joined characters in order to isolate the possible characters forming the ligature.

The result ofsegmentation module is the text image with isolated characters constituting the text which are fed to the Feed Forward Neural Network (FFNN) in order to get recognized. Figure 4 shows the segmented text image window of MATLAB after the segmentation process.

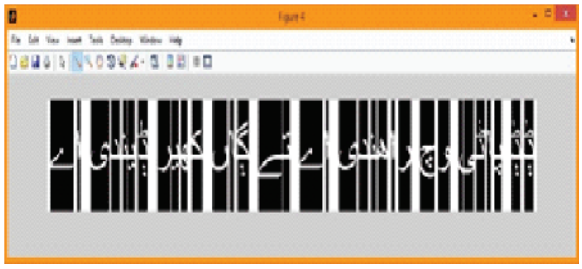

Fig. 4. MATLAB window showing segmented Saraiki text

C. *Recognition*

A three-layer (Input, Hidden and Output) Feed Forward Neural Network is made usingMATLABtools to train and simulate character recognition. A total number of sixty-one charactersand shapes are identified and generated for the Saraiki OCR system. A hundred samples of all the character shapes are extracted from training the network. Each input (training and simulation) sample is resized to 30x21 dimension to match the input layer of the Neural network which consist of 630 (30x21) neurons. The output layer of the network consists of six neurons which constitute the 6-bit target number for every possible input character shape. This target sequence is then converted to the 16-bit Unicode used in Microsoft Office for every character.

The Hidden layer of the neural network consists of 4000 neurons which are chosen based on the different trial results. Transfer functions used for supervised learning are 'Tansig' for the second layer (Hidden) and 'Logsig' for the third layer (Output). 'Trainscg' is the training function used to generate bias values and weights for the network.FFNN is generated with above settings that are trained with sixty-one hundred training samples for the SOCR system.

All the segmented characters generated in the segmentation phase are resized to 30x21 dimensions to match input layer of FFNN. These resized characters are fed to the Neural Network using the simulation 'sim' function of MATLAB which results in the 6-bit code for each character. This code is then converted to the hexadecimal code (Unicode) of each character used in MS Office. If the character is not recognized, then “Character Not Matched” message is displayed. Otherwise, each character and its recognized Unicode is displayed as output.

IV. Conclusion

The research aims to provided that SOCR System has been tested with different text samples, and it gives about 85% accurate recognition. Segmentation procedure shows above 90% accurate results. In this improved segmentation approach, garbage characters are minimized by considering the character joins over the baseline only. Characters like س, ش, ص and ض produce a character ں as garbage when occurring at the end of a ligature or in isolated form. Otherwise, the garbage produced in the other scenarios is left unrecognized and can be controlled in the recognition phase. In future, this system will be enhanced for the recognition of the other regional as well as international languages.

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A Review on Extrinsic Registration Methods for Medical Images

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Abstract-In medical image analysis, image registration is the process of mapping the features or coordinate space of one image with the features or coordinate space of another image. The main aim of medical image registration is to obtain detail, precise and complementary information from two or more images. Image registration plays an important role in image-guided surgery and radiotherapy. Currently, several types of registration methods are available for the precise registration of medical images. In this paper, the available methods for extrinsic registration are analysed and their pros and cons are discussed in a comprehensive manner. The detail investigation and assessment of each registration method is performed according to various parameters. The aim of this paper is to provide detail knowledge on extrinsic registration methods that has been developed for medical images. This review is a suitable reference for those who are looking for registration methods for a specific application.

Keywords-Medical Image Registration, Extrinsic Registration, Image Guided Surgery, Radiotherapy

I. INTRODUCTION

Image-guided surgery has advanced with the introduction and developments in image processing techniques and imaging modalities. Image registration is one of the important techniques in image guided-surgery and radiotherapy in which one to one geometric correspondence between two or more images are established. In medical image registration, images of the same organ may be taken either from same or different viewpoints, times and scanners. The basic purpose of registration is to properly map the corresponding features and geometric coordinates in each image dimensions[i]. The mapping of two or more images (in which one is called source image and another is called target image) is performed by features or coordinate space comparison, analysis and transformation [ii-vii]. Fig. 1 shows the registration of source image obtained via MRI scanner with target image obtained with PET scanner. In the Fig., the registered image of MRI and PET on the right side is obtained through features comparison, analysis and transformation. The registered image shows more useful information and the differences and visibility of different head organs and tissues can also be observed in the registered image.

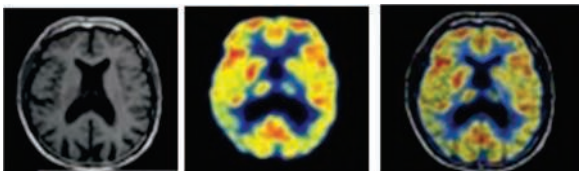

Fig. 1. Multi-modal registration of brain images. Image on the left side is brain MRI while the image in center is PET image of the same patient. Image on the right side is the registered PET image with MRI image

Image-guided surgeries and radiotherapies greatly depend on the accurate registration of medical images. Therefore, medical image registration is widely used in practices and clinics. Image registration also plays a vital role in imaging modalities such as magnetic resonance imaging (MRI), computed tomography (CT), ultrasound (US), Single-photon emission computed tomography (SPECT) and positron emission tomography (PET). Different types of anatomical and functional information in 3D form are precisely obtained with the help of these modalities. [viii]. Therefore, the detection of symptoms and treatment planning is done easily, precisely and with high accuracy.

Extrinsic registration rely on the external objects attached to the patient and these objects are called external markers or frames[ix]. In extrinsic registration methods, external objects are more visible and are therefore, easily distinguished from any other region in the image. Furthermore, the computation speed of extrinsic registration methods is also fast because it does not need complex algorithms for implementation. The registration of complex problems such as the registration of 3D and 4D shapes is easily performed with extrinsic registration methods. Several state-of-the-art survey papers [i], [vii] & [x-xvii] are available which evaluate and discuss the importance of extrinsic registration methods in image-guided surgery and

radiotherapy.

Despite the popularity of extrinsic registration methods, there is lack of comprehensive knowledge on this area of research in the literature. This paper aims to present a review on extrinsic registration methods for medical images. Although, extrinsic registration methods are presented in several state-of-the-art survey papers but the available knowledge is very brief in them. Furthermore, there is also lack of comprehensive evaluation on each method according to different parameters. In this review paper, the available knowledge about extrinsic registration methods is presented in a systematic manner. We have evaluated each registration method based on twelve important parameters that includes accuracy, efficiency, reliability, robustness/ stability, optimization procedure, transformation, error detection, target localization, computation/automation, clinical use/applications, modality and the support/availability of software tools.

The main contributions of this review are as follows.

- Extrinsic registration methods, which include stereotactic frame, fiducials (screw markers), mould, frame, dental adapter, and skin markers are described concisely.
- The use and performance of each extrinsic registration method on the basis of important parameters are shown.
- Some of the important merits and challenges of each registration method are discussed.
- The paper provides a theoretical foundation for new researchers in the field, which will eventually improve their knowledge on this challenging area of research.

The remainder of this paper is organized as follows: Section II briefly describe the general concept about medical image registration while section III presents detail knowledge on each registration method belongs to extrinsic criteria. Evaluation methodology is discussed in section IV while section V provides analysis and discussion on extrinsic registration methods. Section VI summarizes this paper.

II. Medical Image Registration Methods

Medical image registration is a highly vibrant area due to its broad range applicability and significance in human anatomy. Registration methods relate corresponding significant points in each image, extract similar features, perform optimal transformation and compute similarity measures [xi]. Integrating multiple types of information from more than one modalities such as from MRI and PET into a single one is essential which is only possible by using the appropriate method of medical image registration. The registration of PET and MRI brain images are shown in Fig. 1. In the Fig., the image on the left side is obtained from MRI while the middle one is taken from PET. The differences and visibility of different head organs and tissues are shown in the registered image of PET and MRI on the right side. Therefore, combining information from multiple modalities greatly helps surgeons in the precise identification and separation of tumor from normal tissues during image-guided surgery.

Medical image registration methods are classified on the bases of different criteria by the researchers from time to time and several review articles are available on this challenging area of research. These review articles are listed in Table II, together with the publication years and topics. Most of the classifications briefly cover each method and user cannot get detail knowledge along with their pros and cons. In this review paper, we have narrowed down the classification of medical image registration into extrinsic types. The main aim is to evaluate these methods, cover a comprehensive literature review about them and describe their use and importance in research and clinical practices. Diagrammatic representation of the classification is shown in Fig. 2 and the detail of each method is described in section III.

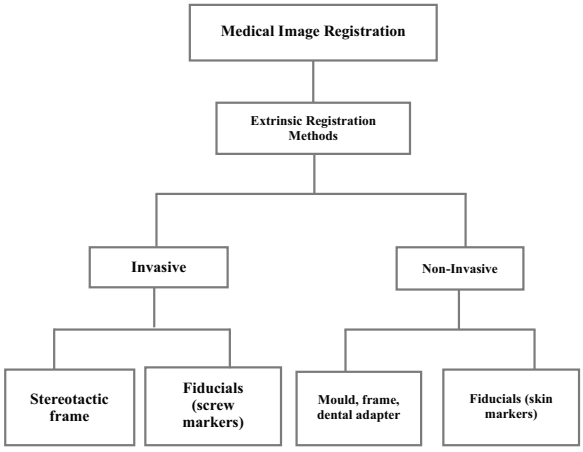

Fig. 2. Extrinsic registration methods for medical images

III. Extrinsic Registration Methods

Extrinsic registration methods are based on external artificial objects attached to patient's body. These registration methods always remain the best option in image-guided surgery. In the last two decades, extrinsic registration methods for medical images have been extensively studied in image-guided surgery and radiotherapy [xi-xii]. The aim is to acquire more efficiency, accuracy and reliability by analysing their corresponding features. Feature detection, feature extraction/ matching [xviii], transformation and optimization are the main steps for mapping source image to target image during registration process. Image features include edges, lines, curves and points

and these features are determined during feature detection step. On the other hand, in feature matching steps, a cost function is used to find the similarity measure in both source and target images. Image translation, rotation and scaling are performed during transformation phase while the optimizer finds the degree of similarity in transformation. Multi-modal images of the same organs containing both anatomical and functional information are effectively integrated using image registration. These different types of information are more reliable and can assist the clinicians and surgeons to take accurate decisions about patient tumor. A number of methods are now available to registered medical images using different types of procedures [xix-xxiii]. Extrinsic registration methods are the popular among them for the successful registration of medical images and are widely used in several clinical applications. Registration methods belong to extrinsic category rely on external objects i.e. artificial markers and frames attached to the patient's body[xxiv-xxv].

Extrinsic methods are categorized into invasive and non-invasive registration, which are further divided into stereotactic frame, fiducials (screw markers), mould, frame, dental adapter and skin markers. Invasive registration methods integrate and transform information obtained from multiple sources into a single image containing more information. Functional and anatomical information from human organs are obtained with minimum incisions, low pain and rapid recovery using the methods of invasive registration. On the other hand, non-invasive registration methods obtain the same types of information from internal organs without any incisions. In these methods, instruments are passed into internal organs and their images are shown on monitors during image-guided surgery with fast operating mechanism and without any collateral damage to the skin and normal tissues. The two categories of extrinsic registration methods i.e. invasive and non-invasive are discussed in the sub-sections below.

A. Invasive Registration Methods

Invasive image registration methods have been widely accepted as a treatment options because of the availability of realistic information related to patient's anatomy. In image-guided surgery, minimal invasive methods play a vital role by providing significant information about the organs under observation [xxvi]. Minimal invasive surgery provides several types of benefits to both surgeons and patients i.e. for surgeons the manipulation of surgical devices is performed in a best possible way and for patients, small incisions are made in the skin leading to less pain and fast recovery.

The development and availability of different types of imaging modalities result their wide spread use in the medical field. It is because of these developments that clinicians now uses minimal invasive techniques to get functional and structural information from human body. Furthermore, it is also now necessary for clinicians to learn increased amount of skill for the proper operation of the available techniques. Clinicians usually face some problems during image-guided surgery such as poor tactile feedback, eye-hand coordination and low visual feedback as compared to physical surgery [xxvi]. The solution for such problems is to take 3-D images of the organ using different modalities such as CT, MRI, PET and SPECT, integrate common features in them and presenting more informative image to the surgeons. Such type of integration and transformation of multi-modality images into single more informative image is performed with the help of invasive image registration methods. The importance of invasive methods of medical image registration is obvious due to the availability of specific information i.e. functional or structural. Stereotactic frame and fiducials markers are the two types of invasive techniques, discussed in the sub-sections below.

1) Stereotactic Frame Registration

Stereotactic frame is one of the earliest invasive registration techniques for multimodality images in the field of image-guided surgery. Stereotactic frame is directly fixed on the patient's head and the images of human organs are displayed on computer monitor. This process is performed simultaneously with the help of different imaging modalities in different orientations. Images obtained from multiple modalities are aligned in order to share and transform similar information [xxvii]. Stereotactic frame registration is also called image-to-physical coordinate space registration. In Stereotactic frame registration, image space is related to physical space occupied by the patient i.e. the mapping of MRI or CT coordinate system with the stereotactic frame coordinate system [xxviii]. Clinicians uses stereotactic frame devices for the proper navigation of mechanical apparatus such as probes, electrodes and biopsy cannulas with the help of image guidance in three dimensional spaces. They can perform effective surgery with freedom and flexibility by linking invasive frames to the patient's skulls through screws before pre-operative scan of CT and MRI. Stereotactic systems consist of stereotactic reference frames, a technique for stereotactic image acquisition and a mechanism for the proper direction of surgical devices. It is due to these features that target points are defined and the fixation of rigid body skull becomes possible using pins or screws which create a stereotactic coordinate system in physical space as shown in Fig. 3. Stereotactic frame registration is used for the proper management of general surgery as well as specific surgical problems such as orthopedic, neurosurgical, craniofacial and otolaryngology. These surgical procedures are performed with highest accuracy, safety, efficiency, highest probability of tumor removal and less surgical exposure. Applications

of stereotactic frame registration in image-guided surgery include biopsies, catheter insertions, gamma knife surgery, injections and aspirations. Despite several advantages of stereotactic frame registration it is invasive and uncomfortable.

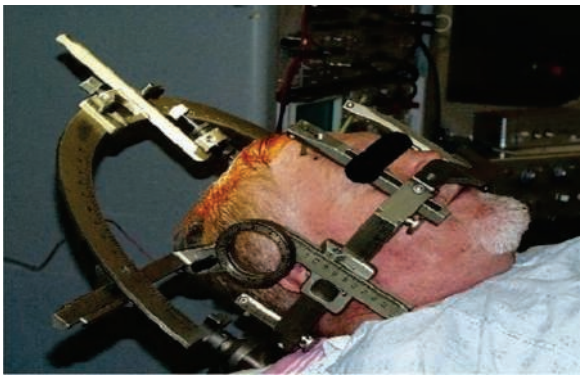

Fig. 3. Stereotactic frame is rigidly attached to the patient skull during image-guided surgery

2) Fiducials (Screw Markers) Image Registration

Fiducial markers are artificial objects attached to human organs, which provide transformation between image space and physical space. These objects are composed of different shapes and material such as plastics, ceramics, passive reflective, liquid-filled and steel [xxx]. The registration of medical images using fiducial screw markers is commonly used methods in invasive image-guided surgery where predefined fiducials i.e. screw markers are specifically applied on the preoperative images of different modalities such as X-rays, CT, SPECT and MRI. Furthermore, correlation is established between the preoperative images obtained from different modalities and intra-operative physical anatomy of patients. In other words, objects are positioned in the visible field of different imaging system for measurement and as a reference point in fiducial based image-guided surgery. In this invasive image guided surgery, surgeon put screw markers on patient's skin without rupturing under local anesthesia. Surgeon uses fiducial screw markers is an easy tracking tool for treatment of several image-guided surgeries such as bone treatments, prostate, orthopedic and brain surgeries. Fiducial screw markers are flexible objects and used with different types of imaging modalities and are easily used with X-ray, CT and MRI due to the availability of multimodal screw markers. These markers can also check errors for co-registration. Fig. 4 [xxxi] shows invasive screw markers over the anterior facial skeleton in which the green markers were used for registration while the blue markers are used for finding the target registration error.

Image registration with extrinsic fiducials screw markers is simple and automatic. Due to which it is used for the registration of both mono-modal and multi-modal images [xxxii]. In fiducial screw marker based registration, there is no need to apply complex computation parameters and algorithms. However, un-comparability, patient movement and invasiveness are the major limitations of it. Furthermore, high skill and planning is required for the clinicians to place screw

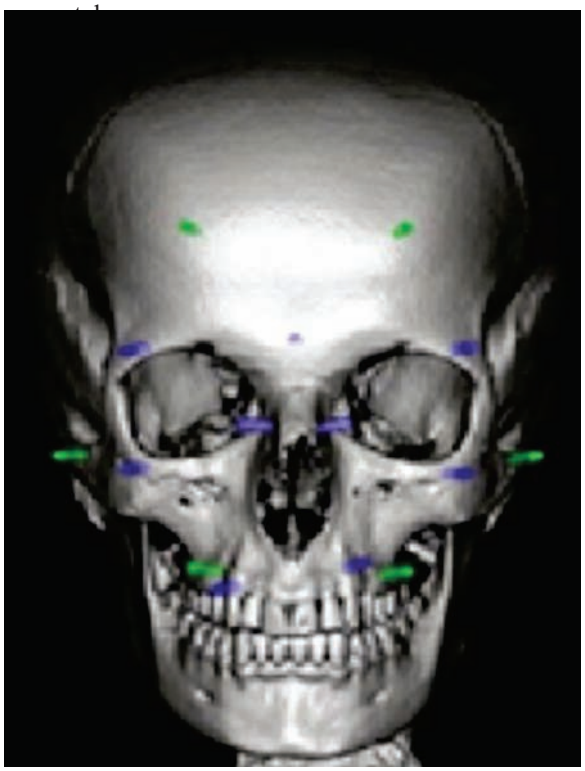

Fig. 4. Invasive fiducial markers placed in each skull

B. Non-Invasive Registration Methods

The techniques of minimally invasive image-guided surgery dramatically changed the way operation is performed and the patient's recovery in a minimum possible time. However, minimal invasive surgery still requires incisions and penetration into the body. On the other hand, in non-invasive image guided surgery, the concept of cutting the skin or tissue has been entirely eliminated. This type of surgery is done through endoscopy, in which an instrument is penetrated through natural human orifices such as mouth, the vagina, and the anus[xxxiii].

Non-invasive surgery requires image registration methods which combines and translates the images obtained from internal organs through penetrated instruments and displays them on the monitors for guidance. Non-invasive image registration methods are used in several image-guided procedures such as laser treatment, dermatological procedures and skin treatment surgery, in gastrointestinal issues and vision problems. These types of image registration methods have changed the way operation is performed. Their main features include fast operating mechanism, complete resection of infected tissues and no cut and

However, despite major improvements and success in these methods, non-invasive surgery is limited in scope and several challenges are still faced by the clinicians. One of the major challenges is the provision of proper interactive image guidance during surgery. Because high utilization of related information in the real time images obtained from different modalities is only possible due to interactive image guidance paradigm [xxxiv]. Using interactive image guidance paradigm during surgery, surgeon can utilized both 2D and 3D patient data properly i.e. 3D MR data for therapy arrangement and target demarcation while 2D real-time ultrasound for visualization of the eliminated region. Therefore, the proper registration of medical images obtained from multiple modalities with changing nature due to tissue motion and deformation is vital for the successes of non-invasive image guided-surgery in the future. Non-invasive medical image registration techniques are further categorized into Mould, Frame, Dental Adapter and Fiducials (Skin Markers), discussed in the sub-sections below.

1) Mould, Frame and Dental Adapter Registration

Despite its accuracy and usefulness, invasive registration methods such as stereotactic frame and fiducials screw markers are not suitable for the registration of non-malignant cases. In non-malignant surgery such as otologic the scale of accuracy is very high using fiducial systems [xxxv]. Non-invasive markers or landmarks such as moulds, frames and dental adapters are appropriate for these types of surgical cases. Moulds, head holder frames and dental adapters are tightly attached to the patient skin during otologic image guided surgery. During image-guided surgery, the frame encloses the subject area with non-invasive fiducial markers. Moreover, fiducial markers when localized in the physical and image space, provides transformation of interested image data between physical space and image space as shown in the Fig. 5.

Registration based on extrinsic non-invasive frame and dental adapter is applicable for both mono and multimodal image registration. Detection of the subject markers in multimodal images is easy due to which it can register two images automatically [xxxii]. Non-invasive image registration methods based on these landmarks is suitable choice for efficient image-guided surgery with accuracy because it can perform registration without any need for complex optimization and computation of image registration parameters. On the other hand, patient movement and dislocation of markers glued to the patient skin greatly affect the accuracy of registration.

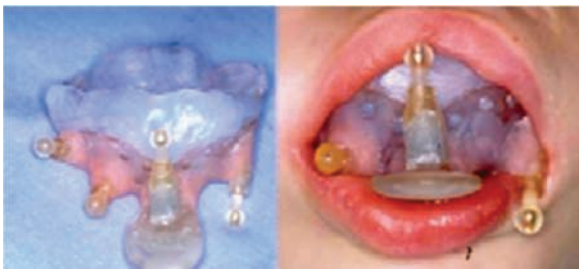

Fig. 5. Image registration using non-invasive dental adapter

2) Fiducials (Skin Markers) Registration

Image registration based on skin markers is non-invasive method used in image-guided surgery. In this method, artificial external markers are placed on the patient's skin before MR or CT imaging which uniquely identify and show particular reference points [xxxvi]. It is widely used in image-guided surgery because surgeon can clearly see the reference points on both the surface of the patient's body and on the image under observation. The proper attachment of the markers is essential until the completion of operation [xxxvii]. Fig. 6 [xxxviii] shows image-to-patient registration based on fiducial skin markers. It is shown in the Fig. that the registration is performed between image space i.e. left side and physical space i.e. right side using set of corresponding points.

The placing and removal of fiducial skin markers are easy as compare to invasive screw markers and frames during image-guided surgery. Although the accuracy of fiducial skin markers is good and range up-to 2 mm but sometimes unpredictable errors are generated at the time of data acquisition and during surgery due to natural skin movement. Registration based on skin markers is suitable for nasal sinus surgery and neuro-navigation. However, this registration method is not suitable for the revision and operations of recurrent disease due to the unavailability, inaccessibility and displacement of reference structure. Furthermore, consistency in the size and shape of the skin markers is also an important factor to be considered during image- guided surgery.

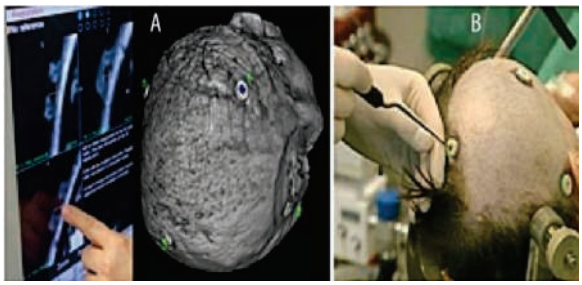

Fig. 6. Image registration using fiducial skin markers

IV. Evaluation Methodology

This paper evaluate extrinsic registration methods on the bases of twelve parameters which includes accuracy, efficiency, reliability, robustness/stability, optimization procedure, transformation, error detection and calculation, target localization, computation/automation, clinical use/applications, modalities involved and software tools availability. The purpose is to give insight knowledge and understanding of the available extrinsic registration methods. In order to evaluate the different registration methods according to the above mentioned parameters, they are presented in Table I. The Table provides state-of-the-art information to the users and researchers in the image registration field. The categorization of extrinsic registration methods is also shown graphically in Fig. 2 and the important parameters for evaluation are as follows.

- Accuracy: Accurate image registration is essential for useful clinical applications and in improved health care [xxxix-xl]. The registration method is called inaccurate if errors either actual or timely occurred at any time during registration. Therefore, it is necessary to modify and replace weak and inaccurate registration methods with more advanced and sophisticated methods [xli]. Two types of accuracy is achieved with medical image registration i.e. quantitative and qualitative. The former requires a ground truth that is consistent in clinical applications while the later type of accuracy is obtained using simple visualization tools and spectrum. Accuracy of registration methods is improved with several types of techniques such as non-rigid deformation and composite warping.
- Efficiency: Speed and computational efficiency are very important for the registration of medical images during image-guided surgery and radiotherapy. Efficiency is now become more important with the development of complex algorithms, which always reduce the speed and efficiency of registration process. Moreover, efficiency with reliability is required for successful registration. Therefore, several types of registration methods with high efficiency and reliability are developed which play an important role in image guided surgery and radiotherapy [xlii]. High efficiency is achieved with the optimization of interpolation and transformation parameters, reduction in number of similarity measures and with the development of fast template based tracking approaches.
- Reliability: Reliability is one of the important parameters in medical image registration because expected results are always required in the range of possible clinical input. The testing of registration method on several combinations of input images providing the same results as expected shows high reliability of that registration method.
- Robustness: The natural behavior of continuous organ movements and instability in human anatomy greatly affect the robustness and consistency of registration. Registration method is more robust if a small amount of change in the source image results the same amount of change in the target image [xliii]. On the other hand, registration method is less robust if a small amount of change in the source image results more change in the target image.
- Optimization Procedure: Some of the important parameters for registration methods such as accuracy, preciseness and robustness are measured with optimization procedures [xliv]. These procedures are applied iteratively until the merger of similarity measures obtained from the source and target images during registration. Several types of optimization techniques are available for the enhancement of registration process such as gradient decent, nonlinear conjugate gradient, multi resolution techniques, evolution strategy and simultaneous perturbation.
- Transformation: The mapping of points in one image space with another image space during registration is called transformation. Proper transformation of points in target image space to the points in the source image space is essential for successful registration[xxxi].
- Error Detection: Errors in image registration mostly occur due to the variations and movements in medical images which also effect accuracy [xlv]. Although error detection was a major problem in the early registration methods but it is now an easy job with the introduction of advanced methods. Several types of testing techniques have been developed which can easily and automatically detect errors in image registration.
- Target Localization: The division of tumor from normal tissues is called target localization. Target localization allows more local control of tumor volume in image guided surgery and radiotherapy. In modern radiotherapy, target localization is performed by the use of advanced registration methods and image fusion [xxx]. The registration and fusion of different modalities such as CT-MRI now clearly separate tumor from normal tissues and provide better target localization.
- Computation/Automation: Several types of automatic and semi-automatic registration methods are available which need less or no interaction from the users. These methods increase the speed and accuracy of registration process when there is high number of images to be registered. Automatic registration methods have also the capability to integrate both functional and

anatomical features from images belong to different modalities. Therefore, such types of automatic techniques are now a suitable choice for researchers and clinician due to their precise and fast mapping mechanism.

- Clinical use/Applications: Excessive adaptation of image registration methods in clinical practices shows their strength and usefulness. In this regard, the use of rigid registration in clinics is more than non-rigid registration methods. However, accuracy validation is essential for any registration methods to be useful in clinical practices.
- Modality: CT, PET, MRI and SPECT are the popular imaging modalities used by the registration methods to integrate different types of information. The accuracy and quality of registration depends on these modalities. Registration of multimodal images such as CT-MRI and PET-CT are widely used in medical diagnoses such as tumor localization, segmentation of organs and prostate localization.
- Software Tools support/availability: Clinicians and other technical users always demand the availability and support of software tools for a registration method. Because a software tool provides an environment for users to create, store, edit, maintain, and visualize image information in registration process. Therefore, the popularity and widespread use of a registration method require the availability of popular and easy to use software.

V. Analysis and Discussion

Researchers contributed high efforts in developing powerful methods for extrinsic registration. These methods are applicable for several types of registration problems. In this review article, the available extrinsic registration methods are highlighted in extreme. To further refine the subject and enhance the strength of understanding, the available methods are evaluated using a criteria described in section II. A detail analysis of the main features of the extrinsic registration methods are presented in Table I. It is found out that both invasive and non-invasive registration methods provide their own facilities and potentials to registered medical images in different formats effectively. However, non-invasive registration methods are more appropriate to represent medical images. The superiority of non-invasive registration methods including moulds, frames, dental adapters and fiducial skin markers over its companions is attributed due to some of its prominent features including: (1) their high efficiency compared to invasive techniques (2) simple optimization procedure (3) easy errors detection (4) easy target localization (5) manual and automatic mechanism to detect coordinates (6) widely used clinical applications and software tool availability.

After thorough analysis, it is found that both types of methods can be used to successfully register medical images. Although the two sets of registration methods have some degree of differences but have majority ratio of similarities. Therefore, can be used for any type of medical registration problems subject to the introduction of sophisticated technology and algorithms in the field. The list of similarities among the methods includes efficiency, reliability, robustness, simple optimization procedures, wide spread clinical applications, applicability to mono and multi-modalities, open source software tool availability and easy and quick transformation mechanism. The restriction of extrinsic registration to only rigid transformation greatly affects its flexibility. However, more transformations such as shearing and scaling are possible with the introduction and implementation of more sophisticated frames and fiducial markers. Low accuracy of extrinsic registration methods is also a big problem which need the development of more advanced tools and algorithms.

The current registration methods are mostly developed for specific problems and situation. The available methods are based on either single or multi-modality, based on either point based or surface based, rigid based or non-rigid based, subject based or object based and or dependent on image dimensions. Therefore, we came up with a conclusion that due to the diverse scenes, applications and several kinds of objects with different behaviors, generic and powerful registration methods are need to be developed. These generic and powerful methods should have the capability to precisely and efficiently register medical images of any kind and in any situation.

VI. Conclusion

The importance and need of image registration in the medical field is obvious because obtaining accurate information from sets of images is always required for successful image guided surgery. Therefore, researchers developed a number of registration methods in the past several years due to which clinician and patient now takes lot of benefits in medical diagnoses and surgeries. In this review article, we have presented a detail overview of the extrinsic registration methods for medical images and described their use and importance in image-guided surgery. These registration methods provide efficiency, accuracy and automation by integrating information from multiple sources in image-guided surgeries and radiotherapies. The leading factors affecting the efficiency, reliability and accuracy of medical image registration are complex physical associations between source and target images, complex optimization procedures, intensive computation, transformation mechanisms, invasiveness, compatibility issues, missing or partial

data and difficult target localization. Therefore, for the reliable, efficient and precise registration of medical images, more advanced and sophisticated methods are needed to be developed in near future. Nevertheless, the introduction of such advanced technologies and their use in clinics is difficult and still needs a massive amount of research contributions from the research communities.

TABLE I
ANALYSIS OF EXTRINSIC REGISTRATION METHODS USING A SET OF EVALUATION PARAMETERS

Parameters	Extrinsic Registration Methods			
	Invasive Registration		Non-Invasive Registration	
	Stereotactic Frames	Fiducials (Screw Markers)	Mould, Frame, Dental Adapter	Fiducials (Skin Markers)
Accuracy	Very High, because registration cues can be taken from a device that is built expressively to provide such cue	Perform accurate registration, but requires high skill from surgeons	Less accurate then invasive registration	Less accurate due to motion of the skin during surgery
Efficiency	Less efficient in head frame placement	Efficient, because there is no need for complex optimization algorithms	Quick and fast then invasive	Quick and fast then invasive
Reliability	More reliable because neither the anatomy nor the pathology are involved in registration	Reliable but small surgical risk associated with their use	Reliable	Not reliable due to elasticity in human skin
Robustness/ Stability	Provide robust basis for registration	Mechanically stable	More stable and robust	Less robust due to the independent motion of the markers on the skin
Optimization Procedure	Not complex but inconvenient	Simple and no need for complex optimization procedures, since the registration parameters can often be computed explicitly	Simple, because registration parameters are mostly computed explicitly	Simple, because registration parameters are mostly computed explicitly
Transformation	Relationship between skull and brain remain rigid during surgery	Often restricted to rigid (Translation and Rotation)	Often restricted to rigid (Translation and Rotation)	Often restricted to rigid (Translation and Rotation)
Error Detection	Can easily detect errors introduced as a result of the mathematical operations	Can check and detect errors for co-registration	Can detect target registration errors and fiducial localization errors	Easily detect fiducial localization errors
Target Localization	Requires high spatial Accuracy	Sophisticated markers and algorithms are available which can quickly and accurately localize targets	Provide precise target localization and patient setup	subject to localization errors
Computation/Automation	Automatic and explicit	Automatic and explicit	Automatic and explicit	Automatic and explicit
Clinical use/Applications	General surgery, orthopedic, neurosurgical, craniofacial and otolaryngology	Biopsies , Catheter Insertions, Gamma Knife Surgery, Injections and Aspirations, Orthopedic and facial surgery	Biopsy, thermal ablation, endoscopy, and laparoscopy	Orthopedic and facial surgery nasal sinus surgery and neuronavigation
Modality	Well visible and accurately detectable in all of the modalities	Visible and can be detected in both mono and multimodal	Visible and can be detected in both mono and multimodal	Well visible and accurately detectable in all of the modalities
Software Tools Availability	Nero surgical planning software tools are available	Available	Available	Available

TABLE II
REVIEW ARTICLES ON MEDICAL IMAGE REGISTRATION METHODS

Year	Reference	Topic
1992	[xi]	A Survey of Image Registration Techniques
1998	[x]	A Survey of Medical Image Registration,
2010	[xx]	Non rigid Registration of Medical Images: Theory, Methods, and Applications
2012	[xiii]	A review of 3D/2D registration methods for image-guided interventions
2013	[xiv]	Survey of Medical Image Registration
2003	[xv]	Image registration methods: a survey
2013	[xvii]	Medical image registration: a review
2014	[xii]	Image Registration Concept and Techniques: A Review
2015	[1]	Current trends in medical image registration and fusion
2016	[ii]	Evaluation of Medical Image Registration Techniques Based on Nature and Domain of the Transformation
2016	[xlvi]	INTRINSIC REGISTRATION TECHNIQUES FOR MEDICAL IMAGES
2016	[xlvii]	Deformable Registration Methods for Medical Images: A Review Based on Performance Comparison

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