Achieving Optimal Residential Unit for Low Cost Mass Housing in Developing Countries

by

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DEDICATED

TO

MY LOVING PARENTS, BROTHER, SISTERS, TEACHERS,

FRIENDS and MY COLLEAGUES

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ABSTRACT

Low cost housing is a concept which deals with effective budgeting and following of techniques which help reducing construction cost using locally available materials along with improved skills and technologies without sacrificing the strength, performance, and life of the structure. In this study we identity the factors affecting the cost of optimal residential unit for low cost mass housing. To achieve optimal residential unit, it consists of several steps starting with the selection of size of residential unit, standard design, wall thickness, structure type and energy efficiency strategy used for optimal residential unit. After complete designing, calculation of the estimated cost of optimal residential unit for low cost mass housing through Revit model and manual estimation. After estimation 4 installment plans are established for 5 years, 10 years, 15 years, and 20 years. For validation the designed layout and installment plans are shown to low income group of society and collect their valuable input. Survey shows that 3 Marla size is suitable for low income group and people are interested in 10 year installment plan.

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Chapter 1

INTRODUCTION

1.1 INTRODUCTION

In developing countries providing shelter to the masses is surfacing as a brewing issue in the modern age. It is a well-known fact that housing is the third most essential need after food and clothing (Oyebanji, Liyanage and Akintoye, 2017). Over the years with tremendous increase in population the housing crisis is escalating unrestricted and the development authorities can be blamed for not coming up with sustainable housing plans for the increasing population (Mueller and Tighe, 2007).

A low cost housing meets all or some of affordability creation, that encompasses family size, income, or the relationship between the price of house and annual income. Affordable housing is a glaring issue that most of the countries across the globe are taking seriously. Affordable housing is correlated with better health care, education, quality life and perceived control (Rohe and Stegman, 1994). Reducing the unemployment in society, Affordable Housing (AH) significantly reduces crime rate (Gopalan and Venkataraman, 2015), and drastically elevates the living standards of residents.

Constructing houses at low cost is turning out to be one of the greatest challenges in urban Pakistan, today. It is a panacea to the proliferation of slums, unorganized real estate development, unplanned growth, and transit congestion. To mainstream low-cost or affordable housing certain critical issues need to be addressed urgently. Identifying the appropriate clientele, multiplying reach through micro mortgage financing, identifying self-help groups and structuring flexible payment mechanism to generate variable income flows are a few critical issues (Rohe and Stewart, 1996).

1.2 PROBLEM STATEMENT

Due to surge in population, Pakistan is at verge of urban transformation. The total population explosion of Pakistan might reach to 380 million by the year 2050 if contemporary rate of population increases is considered which is 3% annually. (Kugelman et al., 2014). To guarantee sufficient resources of housing, education, health, infrastructure, and food for this exponentially increasing population is necessity. Presently, 78% of the country's gross domestic product (GDP) is made through urban areas making it economic base of Pakistan (Karrar et. al., 2013). The half of the total population of the country will be reckoned as urban by 2025 as estimated by United Nations Population Division (Jabeen et al., 2017). The demand for housing in Pakistan, especially in the major metropolitan areas, is growing increasingly because of rapid urbanization. Seventy percent (70%) of the annual incremental demand for housing is constituted by low-income households (Yuen et al., 2012). Currently, there is a backlog of housing of more than 10 million units in Pakistan, and existing affordable housing has substandard living and poor infrastructure (Jabeena et al., 2015 & World Bank, 2018). This deficit of housing establishes the dire need to form a proper housing policy / rule to assist in handling the demand and supply gap of housing through provision of adequate quality in public and private sectors/institutions (Chohan et al., 2015).

AH initiatives are part of two dynamic strategic approaches: universal approach and targeted approach. The more common one is the targeted approach, usually countries like USA, Canada, Malaysia, and EU countries follow this approach. Whereas Singapore, Denmark, Netherlands, and Sweden follow universal approach. In universal approach, countries tend to focus on providing affordable housing to the whole population. On the other hand targeted approach lay focus on vulnerable section of society , so that they should be the beneficiaries of affordable housing(Gopalan and Venkataraman, 2015).

In 1991, the government of China introduced the Housing Provident Fund (HPF) Scheme. Under this scheme all the employees were bound to contribute a portion of their salaries to the provident fund. Similarly, employers also need to contribute the same amount to the fund. The construction bank of China assumed the responsibility of setting up accounts for each employee. When workers retire, they

withdraw their savings in HPF. Also they can use these savings to buy a private home in the private housing market(Yeung and Howes, 2006).

Currently, the practical application of low-cost housing revolves around multiple subsidies and financing alternatives (Holmans, Whitehead and Scanlon, 2010),creating optimal supply side levers along with favorable revenue measures.(Gan and Hill, 2009) based on repayment plans and repayment affordability housing seems affordable while purchasing but as the time lingers on owing to fluctuating market interest rates housing often become unaffordable. (Aziz and Ahmad, 2012). Purchase affordability is the measure of the capacity of a household to buy a house. Whereas repayment affordability is the measure of repaying capacity of a household to bear the burden of mortgages.

It is the responsibility of the state to provide conducive environment for AH developers, not only through subsidies but by providing robust approval processes. , delineating land laws, reconstructing the financing and land assembling processes, and through earmarking areas for development, opening up avenues for public private partnerships, and rethinking floor space index (FSI) limits (Berry, 2003).

The acceptability of the building in the eyes of the client is a key issue. In low cost housing, cost is reduced by utilizing new and innovative materials and techniques. So, the acceptance of the innovation over conventional methodology must be kept in mind while employing any new techniques or material in construction (Jaiyeoba and Amole, 2013; Ugochukwu and Chioma, 2015). Efficient management can reduce the cost of the building significantly, by keeping the labor productive, accurate estimation and purchase of the materials and reduce the material being wasted at the site (Tam, 2011).

The market mechanism is having speculation, and mismanagement. Pakistan had a backlog of approximately 10 million housing units due to an explosion of population and urbanization (Shah et al., 2018). The initiation of private housing schemes has contributed to address this deficit in Pakistan (Rahman et al., 2016), but the low income families are most vulnerable part of the society in terms of the availability of affordable housing. The private and government sectors have not been able to cater for the need of housing of the low income families in their independent capacity.

The government is already overburdened in terms of financial and human resources. The private developers have started business in the real estate and property market, but their major motive is maximum profit. Furthermore, the private party in its independent capacity cannot address this housing deficit issue and have not considered the low income segment as their potential customers. (Nadeem et.al. 2020).

Numerous studies have already been conducted on low cost housing, for example (Chowdhury & Roy 2013, Ugochukwu and Chioma 2015, Jaiyeoba and Amole, 2013, Nadeem et.al. 2020). But the major focus was to compare the different type of material used in low cost housing, analysis to identify the level of satisfaction for different socio economic factors on already developed low cost housing projects and different type of delivery methods used for low cost mass housing. As evident from the above discussion none of the above studies have provided the layout plan for low cost residential unit and installment plans accordingly.

So, an optimal residential unit is required which is affordable as well as acceptable to the weaker section of society. Can we develop an affordable optimal residential unit for low cost housing which have suitable living condition and different financing options available?

1.3 RESEARCH OBJECTIVES

- To determine the factors affecting cost of optimal residential unit for low cost mass housing in a developing country.
- To develop the optimal residential unit using existing construction techniques for mass housing.
- To calculate an installment plans, principal amount, and payback period for affordable housing.

1.4 SCOPE OF THE STUDY

This research aims to determine the factors affecting cost of optimal residential unit for a low to medium income household in a developing country through surveys and validation of data through different statistics available and semi structural interviews. Moreover, it proposes a technique for the low cost

construction based on collected data and develops a financial model accordingly. This research also focuses on improving living condition and quality of life of a low- and middle-income people of society from unsuitable conditions to acceptable as well as affordable condition, size of housing unit may not be much bigger, but it must have all basic living necessities.

1.5 THESIS OVERVIEW

In this thesis, Chapter 1 includes the introduction in detail, the problem statement with the research gap, the objectives of this research, and the scope of work in this thesis. Chapter 2 consists of the theory behind the proposed methodology. It includes all the details of the theory involved in this thesis and the enlisted factors affecting the cost of optimal residential unit for low cost mass housing. Chapter 3 involves the methodology adopted to acquire the data involving the experimental paradigm and development of layout plan for optimal residential unit, its principal amount and different installment plans. Chapter 4 consists of the evaluation and results and the analysis of results obtained, and a discussion in detail. Chapter 5 consists of a conclusion and briefly explains the future work.

Chapter 2

LITERATURE REVIEW

2.1. GENERAL

Pakistan is facing the deficit in housing units like other developing countries and this shortage of housing units is increasing day by day. The housing which is being built by the developers is too expensive for the poor segment of the society and the prices are increasing exponentially. The poorest and financially under-served segment is the one who is suffering the shortage of the houses due to unreachable prices of houses. The financing of the houses is a major issue in Pakistan.

The government in its independent capacity is unable to provide the housing units to its people. The housing schemes initiated by the government of Pakistan in past majorly resulted in failure because of lack of financing and delay disbursement of funds by government (Riazul Haq et al., 2016). The private housing sector is also not considering the need of low cost housing because of profit oriented approach. The housing deficit issue has been the main point of contention for low income families. One of the causes of this deficit is that how markets were perceived by them (Ghaus et al., 1990).

2.2. CAUSES OF HOUSING CRISIS IN PAKISTAN

A lot of researchers have worked to determine the reasons for shortage of housing in Pakistan. Sana et al., (2019) found that in Pakistan variety of housing institution with overlapping roles and responsibilities, intricate institutional framework with no clear distinction of regulatory or executing body, inadequate policy vision with no understanding of collaborative engagement. Nuzhat Ahmad et al., (2002) found unemployment, less per capita income of household and excessive taxation on real estate as main causes for shortage of housing in Pakistan.

Likewise, (Shah et al., 2007) and (Hina et al., 2014) found out monopoly of real estate tycoon, weak urban planning & management, and flawed system of approvals as the major shortcomings for availability of housing. Furthermore, they

pointed out that miserable economic growth, rapid urbanization, and rising population have resulted in an augmented demand for housing. It was argued that with passing time as population is increasing, housing poverty will become more critical aspect of overall poverty. Furthermore, (Arif Hassan et al. 2018) highlighted that no legislation of land acquisition for low - cost housing, irregular informal housing, inappropriate housing standards and land speculation are major reasons for housing crisis in Pakistan.

(Masoom Ilyas et al., 2018) concluded in the research that the problems of housing deficit do exist in the real-estate market of Pakistan. The major cause of housing deficit crisis was found to be rampant speculation by investors and information asymmetry, as most of the investors and developers were reluctant to share critical information with the market.

2.3. OPTIMAL RESIDENTIAL UNIT FOR LOW COST MASS HOUSING

The target segments for low cost housing are lower and middle income families and if people can afford a residential unit (owned or rented) for an amount approximately 30 percent of its total monthly gross income then low cost house will be considered affordable (Miles, 2000).

Furthermore, selecting an appropriate method of construction is critical as it has significant consequences on the performance of a housing unit, and it determine the life span of a mass housing project (Harelimana 2017). Studies suggest that incorporating cost effective and alternative construction technologies techniques significantly reduces the cost of construction and it is environments-friendly. However, it must be noted that resorting to cost effective means of construction does not mean compromising on safety and sustainability of buildings as it follows building codes, meticulously (Suhaimi et al. 2020).

The new tend of using concrete blocks and slabs had become popular in the industrial period. This trend had placed the traditional construction methods on the back burner. Furthermore, it had set forth the norm to use modern building material in housing and construction. (Ugochukwu and Chioma, 2015).

Numerous administrative and land related issues increase the cost as well as the delivery time of a project under construction. Major administrative and land related issues that construction industry today is facing are lack of master planning, poor governance, administrative inefficacies at local and national level, delayed administrative procedures, adherence to building codes, faulty utility connections and problematic zoning (Mohit et al. 2010).

An accurate design provides you the value for the money in terms of cost and life span. Things that should be the topmost priority of designer and the client must be energy and maintenance equations. Additionally, the front elevation and the efficient use of space are the other considerations (Latham, 1994).

The cost of construction depends on various variables. In the light of the literature review the more time consuming is the project more will be the construction cost (Hussain et al 2012). Cement Concrete Block is considered a perfect material in constructing masonry unit of concrete. Working on the principal of densification of a lean concrete mix, it helps to extract unwanted material such as excessive water from the structure (Tam 2011). Thus, it increases the life span of a structure while minimizing cost.as concreter blocks are relatively larger in size compared to ordinary clay brick, therefore the mortar required Is less. So, the construction is fast paced and cost effective. Furthermore, the strength of the concrete blocks can be changed based on desired specifications (Chowdhury and Roy 2013).

Standard texts on building economics and cost planning (for example, Ashworth, 2004; Feryal., 1999; Jagger et al., 2002) focuses on the cost of a project and the implications of various design elements. These include the building's dimensions; the plane's shape; and the roofing structure, such as its construction, covering, and size. Ferry et al. (1999) explores the many cost-effectiveness measurements of a building shape, including the wall/floor ratio, ratio, length breadth index, and plan/shape index. Examining the literature on construction cost modelling can provide more evidence of the impact of building attributes on construction costs. Because cost is one of the most important elements influencing project success, it's vital to investigate those factors that can influence it, so that by regulating those

factors according to their impact, more successful projects can be achieved (Tam 2011).

Achieving value for money can be understood as a balance between satisfying requirements and expectations of user and the resources required to meet them. Competent project management will enable the project to be completed on time, to the requisite standard and quality, and at a cost that is affordable according to Chartered Institute of Building which is a professional body dedicated to the construction industry (Memon et al. 2011).

The cost of a structure is significantly influenced by its geometry. Building morphology is concerned with the building's size, shape, and complexity. Larger structures with simple, rectangular, regular floor plans and elevations will, on average, cost less per square foot of floor area than smaller, complicated shaped, curved, or angular ones. The materials chosen and the intended construction elements will have a major impact on the project's cost (Ishak et al.2016).

2.4. FACTORS AFFECTING COST OF OPTIMAL RESIDENTIAL UNIT FOR LOW COST MASS HOUSING

Low-cost housing is a relative notion that has more to do with budgeting and aims to lower construction costs by improved management, suitable use of local resources, skills, and technology while maintaining performance and structural life (Tiwari et al., 1999). It should be mentioned that low-cost housings are not those built using low-quality building materials. In terms of foundation, structure, and strength, a low-cost house is designed and built the same as any other house. Because cost is one of the most important variables influencing a project's performance, it's necessary to investigate the aspects that can influence it. Considering these factors can lead to a more acceptable layout for an optimal residential unit (Tam 2011).

The cost savings are obtained by making good use of locally accessible building materials and procedures that are durable, cost-effective, user-accepted, and do not require costly maintenance (Miles, 2000). The ideal of owning a home is becoming increasingly challenging for low- and middle-income families. For

construction, it is vital to use cost-effective, innovative, and environmentally friendly housing technologies.

Some of the factors affecting cost of optimal residential unit for low cost mass housing pointed out from literature are illustrated below:

Table 1 Factors affecting cost of optimal residential unit for low cost mass housing.

Factors Affecting Cost of Optimal Residential Unit	**Authors**
Size of Residential Unit	Jaiyeoba, Amole (2013), Mohit et al. (2010), Bashari (2019), Suhaimi et al. (2020), Mathews et al. (1994) , Chowdhury and Roy (2013) , Bredenoord (2016) , Nadeem et al. (2020) , Otti (2012), Nguyen & Reiter (2012) , Gan & Hill (2009)
Standard Design and Specification	Hussain et al. (2012), Mohit et al. (2010), Bashari (2019) , Suhaimi et al. (2020) , Mathews et al. (1994) ,Jaiganesh et al. (2016), Chowdhury and Roy (2013) ,Hutcheson (2011), Bredenoord (2016) , Nadeem et al. (2020) , Otti (2012), NGUYEN & REITER (2012) , Harelimana (2017), Ishak et al. (2016)
Availability of material	Jaiyeoba, Amole (2013), Jaiganesh et al. (2016), Tiwari et al. (1999), Bredenoord (2016),

	Ugochukwu and Chioma (2015), Fadairo (2013).
Type of Structure and Foundation	Mohit et al. (2010), Bashari (2019), Suhaimi et al. (2020), Jaiganesh et al. (2016), Tiwari et al. (1999), Tam (2011), Ganiron et al (2014), Chowdhury and Roy (2013), Ugochukwu and Chioma (2015),Fadairo (2013), Otti (2012).
Thickness of Walls	Hussain et al. (2012), Suhaimi et al. (2020), Tam (2011), Tiwari et al. (1999), Ganiron et al (2014), Chowdhury and Roy (2013) , Ugochukwu and Chioma (2015),Harelimana (2017), Fadairo (2013),Gan & Hill (2009), Harelimana (2017).
Construction Technology	Jaiyeoba, Amole (2013) , Suhaimi et al. (2020), Tiwari et al. (1999),Tam (2011), Ganiron et al (2014), NGUYEN & REITER (2012) , Harelimana (2017), Ishak et al. (2016)
Energy Efficiency Strategies	Mohit et al. (2010) Bashari (2019) , Suhaimi et al. (2020), Mathews et al. (1994), Jaiganesh et al. (2016),

	Bredenoord (2016) ,Ugochukwu and Chioma (2015), ,Fadairo (2013),, Otti (2012), NGUYEN & REITER (2012) ,Gan & Hill (2009), Harelimana (2017), Ishak et al. (2016)
Inadequate Planning & Scheduling	Jaiganesh et al. (2016),Tiwari et al. (1999),Hutcheson (2011), Hashim et al. 2012 Ishak et al. (2016)
Construction Time	Jaiyeoba, Amole (2013), Hussain et al. (2012),Tam (2011), Ganiron et al (2014), ,Ugochukwu and Chioma (2015),Memon et al. (2011)
Communication issues between Stakeholders	Hussain et al. (2012), Jaiganesh et al. (2016), Hutcheson (2011), Nadeem et al. (2020) ,
Delays in decision making and change orders	Hussain et al. (2012), Hutcheson (2011), Nadeem et al. (2020) ,Memon et al. (2011)
Labor Availability	Hussain et al. (2012),Mathews et al. (1994),,Tiwari et al. (1999), Bredenoord (2016) ,Memon et al. (2011), Hashim et al. 2012

2.5. INSTALLEMENT PLANS IN LITERATURE

Possibility of borrowing a huge sum of money. The mortgage loan is intended for real estate purchases. As a result, more financial resources are available. Consequently, interest rates are low, because the mortgage is included in the targeted lending program and is designed for people with an average income. Most mortgage programs require an advance payment of 10-15% of the total cost. (Kudryavtseva 2019).

Several criteria must be thoroughly studied if the dynamic instalment or progressive annuity method of financing is considered as an alternative to the fixed instalment way of financing a property. Both kinds of financing have aspects in common, such as the length of the bond's repayment period and the controlling interest rate, However, the dynamic instalment technique has its own set of parameters, such as the installment's growth rate and the time span over which it might increase. The progressive annuity has smaller starting instalments than the fixed annuity, but larger subsequent instalments. (Apgar &Allegra Calder, 2005).

Almost every form of fiscal instrument, and indeed legislation, may be found all over the world, including depreciation allowances, tax credits, preferential treatment of housing-related savings, and interest-rate subsidies and grants for home acquisition, new construction, and restoration. (Kearl 1979)

During the 1970s, in Canda every resident non-homeowner may contribute $1000 per year to a registered home-ownership savings plan, up to a total of $10,000. Contributions were tax deductible, and income earned in the plan was not taxed. If the money and interest were utilized to purchase an owner-occupied home, no tax was due.

2.6. SIMILAR STUDIES

Prefabricated elements, the use of locally accessible materials, and the use of innovative techniques to increase the endurance of conventional low-cost materials, making them appropriate for today's housing demands were all examined by Rinku Taur and Vidya Devi T. (2009). Their research looked on the use, advantages, and disadvantages of prefabricated materials in a range of applications.

Exponential rise in population, ageing housing stock, overcrowding, slum development, supply shortages, Katchi Abadis, and a lack of financial resources have all increased Pakistan's housing problem, according to (Azra Jabeena et al., 2015). Due to increasing regional urbanization the availability of low - cost housing near public transportation or mass transit has become disproportionate. Rising property prices and housing costs, massive informal settlements, insufficient housing investment, and a lack of official mortgage institutions all lead to significant potential distortions (Ishak et.al. 2016). Furthermore, plenty of barriers such as a lack of housing laws, unstable property rights with ineffective enforcement, high-cost construction, ineffective subdivision regulations, ineffective town planning regulations and rules, limited budgets for property acquisition and development, distortive taxation mechanisms, and rent controls are all contributing to the housing shortage.

Shanghai was the first Chinese city to use the HPF Scheme as a financial tool for housing reform, which included a kind of mandatory employee saving (Shanghai Housing Provident Fund Management Centre (ed.), 1999). All employers and workers in Shanghai were expected to deposit a proportion of their monthly salary to the HPF's "employees" account. The proportion was initially set at 5% but was later increased to 7% in 1999. The People’s Bank of of China determines HPF rates and is responsible for monitoring the Scheme at the strategic and national levels, while the Ministry of Construction and Ministry of Finance. On the local level, housing committees establish policies for the day-to-day operations of the HPF in collaboration with management centers and approved banks. HPF loan interest rates were lower than commercial banks' mortgage rate. Potential house purchasers therefore favored using HPF financing. The city of Shanghai is presently approving the adjustment of the HPF housing interest rates to encourage people in other commercial banks to borrow loans.

"In the United Kingdom, the programmed provides sufficient incentives to guarantee the provision of low-income housing by the provision of tax credits to owners of eligible houses for occupation by low- and moderate-income households. While the subsidy is supplied fully under the federal tax code, it is managed by state authorities, typically the state housing finance agency.

Low-income households in the Netherlands are excluded from the payment of 40% tax received from the home user (the other 60 percent is paid by the owner). Based on a unique domestic savings contract, the German contract savings and lending system offers lending under which borrowers must make regular deposits in advance, until a specified savings objective is met, when they become eligible for a mortgage. In the subsidy to low-income households, the government pays 10% of their yearly savings.

Chapter 3

RESEARCH METHODOLOGY

This chapter describes the methodology for achieving the objectives described in chapter 1. The research is designed in compliance with detailed research process (including literature review, development of layout plan for optimal residential unit, 4 different installment plans and its validation).

3.1. RESEARCH DESIGN

For the first objective of our research, a detailed literature review has been carried out from several research articles to identify the factors affecting cost of optimal residential unit for low cost mass housing. A preliminary survey has also been carried out among the professionals in our construction industry, to validate the existence of factors identified from literature and ranked the factors based on 60-40 percent values.

To achieve second objective, The determinants are identified. To identify the values for determinants the survey is conducted among field experts. These values will be used to develop layout plan for optimal residential unit using existing construction techniques. To achieve optimal residential unit several steps are necessary, starting with the selection of size of residential unit, standard design, wall thickness, structure type and energy efficiency strategy used for optimal residential unit.

To achieve last objective after complete designing, calculation of the estimated cost of optimal residential unit for low cost mass housing through Revit model and manual estimation. After estimation 4 installment plans are established for 5 years, 10 years, 15 years and 20 years using adjustable rate mortgage calculator and validated by conducting semi structural interviews to low income group of society for low cost mass housing.

Following chart shows the methodology of this research.

The workflow of this research has been designed and shown the Flow chart illustrated as below:

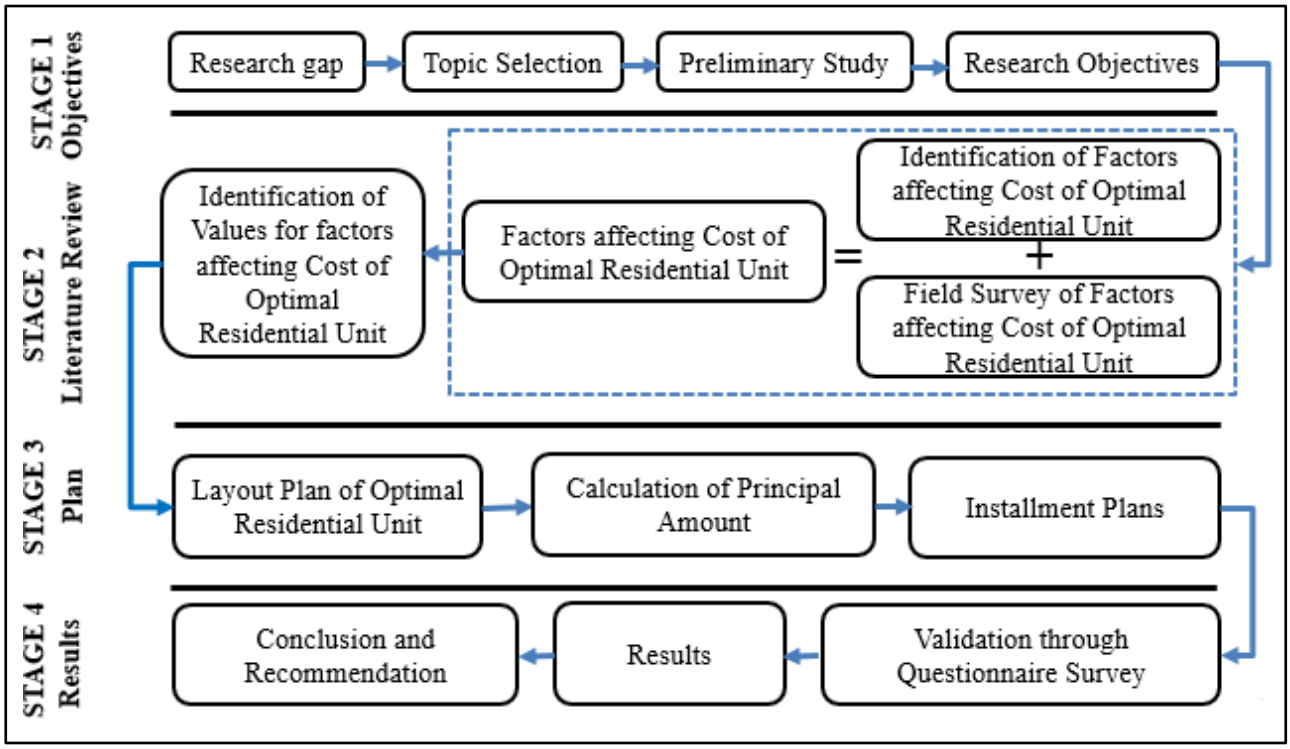

Figure 1 Research Methodology Flow Chart

3.2 LITERATURE SCORE

The above table of factors was scrutinized and analyzed for their literature score and following results were obtained are given in Table 2. The table shows the 12 most significant factors affecting the cost of optimal residential unit through literature.

Table 2 Literature analysis of factors affecting cost of optimal residential unit

S. No	Factors	Literature Score	L.S/ Sum	Cumulative Score
1	Size of Residential unit	0.55	0.1134	0.1134
2	Standard Design and Specification	0.70	0.1443	0.2577
3	Availability of material	0.30	0.0618	0.3195
4	Type of Structure and Foundation	0.50	0.1030	0.4226
5	Inadequate Planning & Scheduling	0.25	0.0515	0.4742
6	Construction Time	0.30	0.0618	0.5360
7	Thickness of Walls	0.55	0.1134	0.6494
8	Delays in decision making and change orders	0.20	0.0412	0.6907
9	Communication issues between Stakeholders	0.20	0.0412	0.7319
10	Energy Efficiency Strategies	0.60	0.1237	0.8556
11	Construction Technology	0.40	0.0824	0.9381
12	Labor Availability	0.30	0.0618	1

3.3 FIELD SCORE

A preliminary survey was conducted among the professionals working in the field related to construction industry showed in Annex 1. Total 30 experts were targeted by using distinct platforms having expertise in construction related activities pertaining to construction industry in Pakistan. As here, the case was related to highlight the relevancy of identified factors affecting cost of optimal residential unit for low cost mass housing. The responders were required to rate the relevancy of each factor regarding cost of optimal residential unit on a 5-point Likert scale (1= Not Relevant, 2= Slightly Relevant, 3= Relevant, 4= Very Relevant and 5= Extremely Relevant). Due to unavailability of proper data a sample size of 30 was assumed and in total 33 responses were recorded. Out of these 33 responses 3 were discarded as manifested to be improperly filled.

Table 3 illustrates the analysis of all the factors based on field survey.

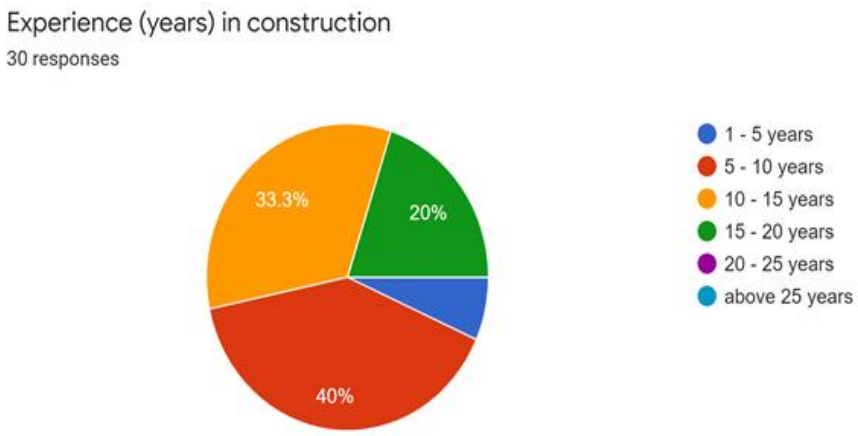

Figure 2 Experience of Respondents

Among 30 respondents, 2 have the experience between 1-5 years, 12 have 5-10 years' experience, 10 have 10-15 years' experience and 6 have 15-20 years' experience in construction industry.

These factors are ranked based on relative importance index calculated from the field survey. The relative importance index (R.I.I) has been calculated by using the following formula as used by Rooshdi (2018) in his study:

$$R.I = \sum \frac{R}{Hx\ T} \quad \text{……. Equation No.1}$$

where R is the weightage assigned by respondents on a scale of one to five, with a minimum of one and a top of five. H is the largest and T is the total sample number. Akadiri's report (2011), five important levels are transformed from RI values: high (0.8 to 1), high to medium (0.6 to 0.8), medium (0.4 to 0.6), medium to low (0.2 to 0.4) and low (0 to 0.2). The factors are ranked in their respective order based on relative index.

Table 3 Field analysis of Factors affecting Cost of Optimal Residential Unit

Factors	**Mean**	**RII**
Type of Structure and Foundation	4.78	0.956
Size of Residential unit	4.48	0.896
Thickness of Walls	4.38	0.876
Energy Efficiency Strategies	3.91	0.782
Standard Design and Specification	3.75	0.75
Communication issues between Stakeholders	2.83	0.566
Inadequate Planning & Scheduling	2.66	0.532
Construction Time	2.08	0.416
Delays in decision making and change orders	2	0.4
Labor Availability	2	0.4
Availability of material	2	0.4
Construction Technology	1.9	0.38

After obtaining the field score, emergence of field and literature score was done. They were added in a proportion of 60 to 40, 60% weightage is given to field score and 40% weightage is given to literature score and rank accordingly. Table 4 shows the ranking of factors.

Table 4Mergence of Field Score and Literature Score

Factors affecting Cost of Optimal Residential Unit	**F.S**	**L.S**	**60-40**	**Rank**
Type of Structure and Foundation	0.956	0.5	0.773	1
Size of Residential unit	0.896	0.55	0.757	2
Thickness of Walls	0.876	0.55	0.745	3
Standard Design and Specification	0.75	0.70	0.730	4
Energy Efficiency Strategies	0.782	0.60	0.709	5
Communication issues between Stakeholders	0.566	0.20	0.419	6
Inadequate Planning & Scheduling	0.532	0.25	0.419	7
Construction Technology	0.38	0.40	0.388	8
Construction Time	0.416	0.30	0.369	9
Labor Availability	0.400	0.30	0.360	10
Availability of material	0.400	0.30	0.360	11
Delays in decision making and change orders	0.400	0.20	0.320	12

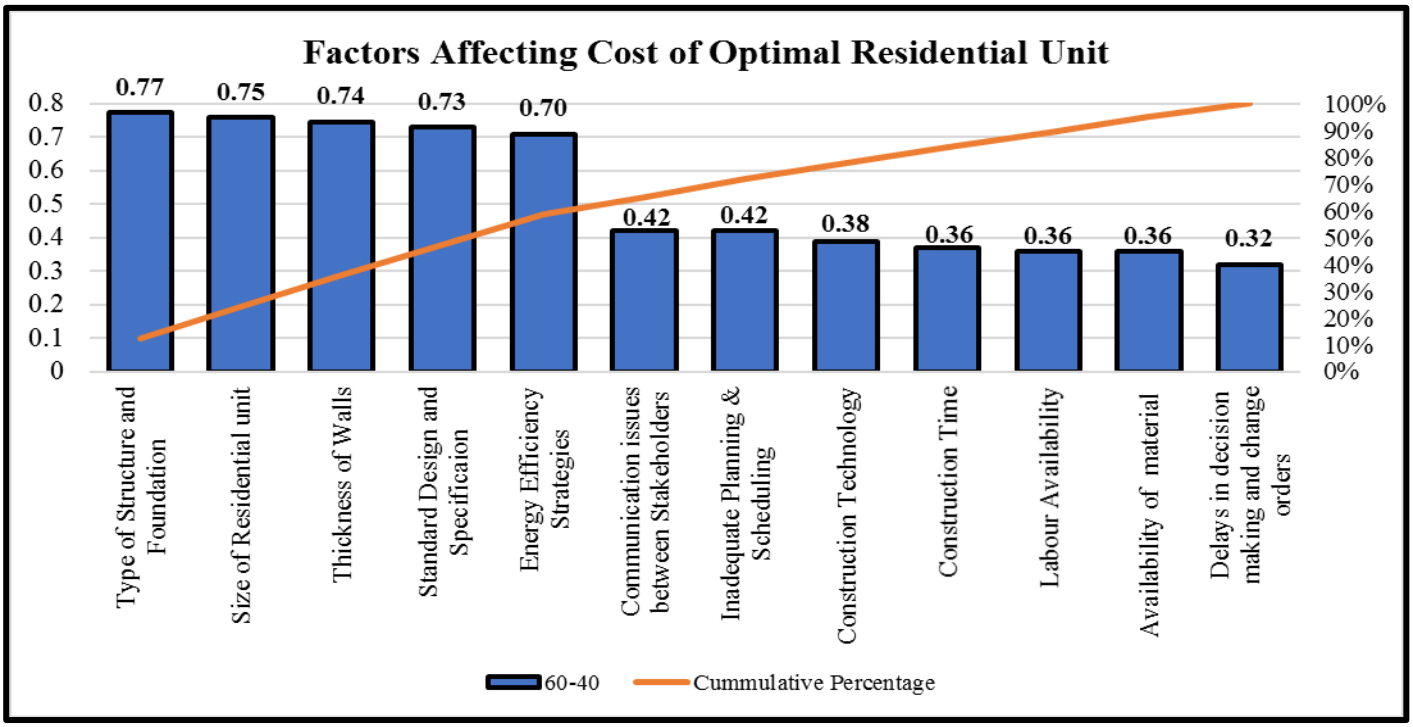

Figure 3 Ranking of Factors

After merging the field score and literature score, factors are ranked showed in on the basis of their values, figure 3 shows that type of structure and foundation is most significant and common factor affecting cost of optimal residential unit for low cost mass housing at rank 1, size of residential unit ranked 2nd, thickness of walls is 3rd most significant factor, standard design and specification ranked at 4th place while energy efficiency strategies is 5th more important factor affecting cost of optimal residential unit. For designing of layout plan for optimal residential unit factors having values above 60% is used.

Previous research conducted on low cost housing identified four different sizes of residential unit as (i) 3 Marla (ii) 5 Marla (iii) 7 Marla and (iv) 10 Marla (Gopalan and Venkataraman, 2015 Mohit et al. 2010 Nadeem et. al 2020), common types of structure and foundation used in low cost housing were identified through literature are (i) frame structure and isolated footing (ii) frame structure and combined footing (iii) load bearing wall and isolated footing and (iv) load bearing wall and combined footing. (Vivian W.Y.Tam 2011, Ugochukwua & Chioma 2015, Harelimana 2017, Otti 2012), thickness of walls is third most important factor affecting cost of residential unit, literature indicated that (i) 6" Cement Block (ii) 9" Brick Masonry (iii) 9" Fly ash brick and (iv) Precast Partition walls can be used for

low cost mass housing. (Vivian W.Y.Tam 2011,Chowdhury & Roy 2013, E.H. Mathews et. al 1996, Bredenoord, J 2016). Literature predicted the standard design of residential unit for low cost mass housing is consist of different layout plans (i) one room, one living area, one kitchen, and one bath, (ii) two rooms, one living area, one kitchen and two bath (iii) two rooms, one living, one kitchen and one bath (iv) one room, one living area, one kitchen and two bath. (Eindhoven 2011, Mohit et al. 2010, Nadeem et. al, otti 2012). Both active and passive energy efficiency strategies were used in previous studies for residential unit (E.H. Mathews et. al 1996, Bredenoord, J 2016).

Table 5 Shortlisted Factors

Sr.No	Factors affecting Cost of Optimal Residential Unit
1	Size of Residential unit
2	Type of Structure and Foundation
3	Thickness of Walls
4	Standard Design and Specificaion
5	Energy Efficiency Strategies

3.4 PARAMETER / VARIABLES FOR FACTORS AFFECTING COST OF OPTIMAL RESIDENTIAL UNIT

For identification of values for factors shown in Table 5 semi-structured survey composed of two sections – part A & B has been created. Part A comprised of the personally identifiable information of the responder and Part B of 5 questions and 4 options available for each option. To select the optimal size of residential unit, standard design, foundation type, thickness of wall and energy efficiency strategy the interview was conducted among 36 field experts of construction industry. A combination of semi structural interviews and questionnaire was filled. Amoung interviewers 55.2% are working as consultant while 48.3 are working as contractor and 20.7% are client in construction industry.

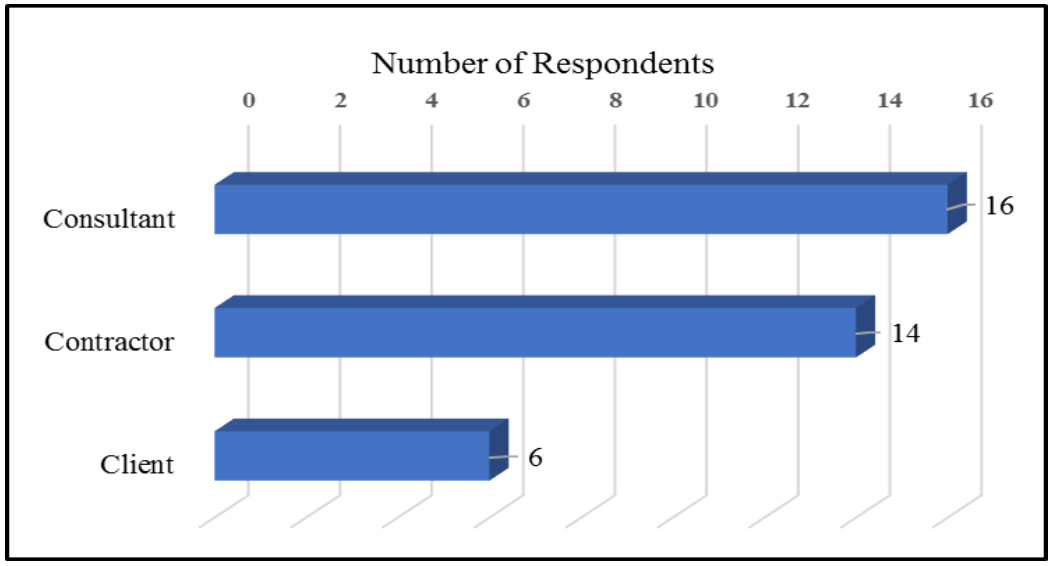

Figure 5 Demographic of Respondents

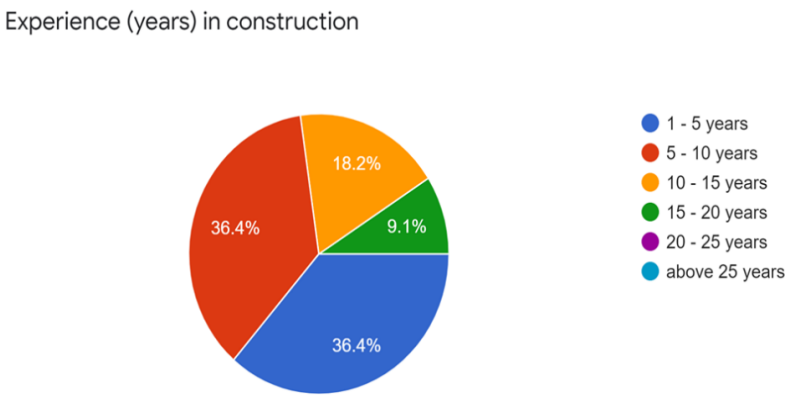

Figure 4 Experience of Field Professionals

Among 36 respondents, 13 have the experience between 1-5 years, 13 have 5-10 years' experience, 7 have 10-15 years' experience and 3 have 15-20 years' experience in construction industry. Experts were required to select the variable from options which were mentioned above regarding cost of optimal residential unit for low cost mass housing. Table 6 shows the result of survey. 73% of the experts select 3 Marla size for optimal residential unit, 85% of the experts suggested to use load bearing wall and isolated footing for low cost house because of cheaper cost and less steel requirement, 93% of the respondents recommended to use 6 inch thick cement block for construction of walls because of its thermal property and cheaper rate as compared to conventional brick and precast partition walls. For internal design of

optimal residential unit 77% of the experts choose two rooms, one living area , one kitchen and one bath the main reason of choosing two rooms is because of privacy propose, also previous studies shows that The design of low-cost housing with one bedroom isn't adequate for the resident, because there is nothing like privacy, the design of the housing unit is one bedroom and, if we can link the housing unit to the culture of the country, the design is for one person alone. Bashari et. al. (2019).

For energy efficiency strategy 97% of the experts recommended to use passive strategy, because active strategy needs extra cost to achieve energy efficiency while passive strategy utilize what nature provides for free to keep buildings comfortable without the need for purchased energy. Passive design takes advantage of a building's site, orientation, climate, reduction of direct sunlight and materials to minimize energy use. A carefully engineered passive house decreases the energy efficiency demand by heating and cooling. Important factors considered during design of optimal residential unit were orientation of building, building shape, buffer spaces, high-performance windows (clear, low-e), window to wall area ratio and external shading.

These parameter / variables are used to design the layout plan of optimal residential unit for low cost mass housing.

Table 6 Selection of Parameter for Optimal Residential Unit

Factor	Options	Result
Standard Size	**3 Marla✓**	**73%**
	5 Marla	23%
	7 Marla	4%
	10 Marla	0%
Type of structure and foundation	Frame Structure and Isolated Footing	15%
	Frame Structure and Combined Footing	0%
	Load Bearing Wall and Isolated Footing ✓	**85%**
	Load Bearing Wall and CombinedFooting	0%
Thickness of Wall	**6" Cement Block ✓**	**93%**
	9" Brick Masonary	7%
	9" Fly ash brick	0%
	Precast Partition wall	0%
Standard Design	1 Room + 1 Living + 1 Kitchen + 1 Bath	0%
	2 Rooms + 1 Living + 1 Kitchen + 2 Bath	23%
	2 Rooms + 1 Living + 1 Kitchen + 1 Bath ✓	**77%**
	1 Room + 1 Living + 1 Kitchen + 2 Bath	0%
Energy Efficiency	Active	3%
	Passive✓	**97%**

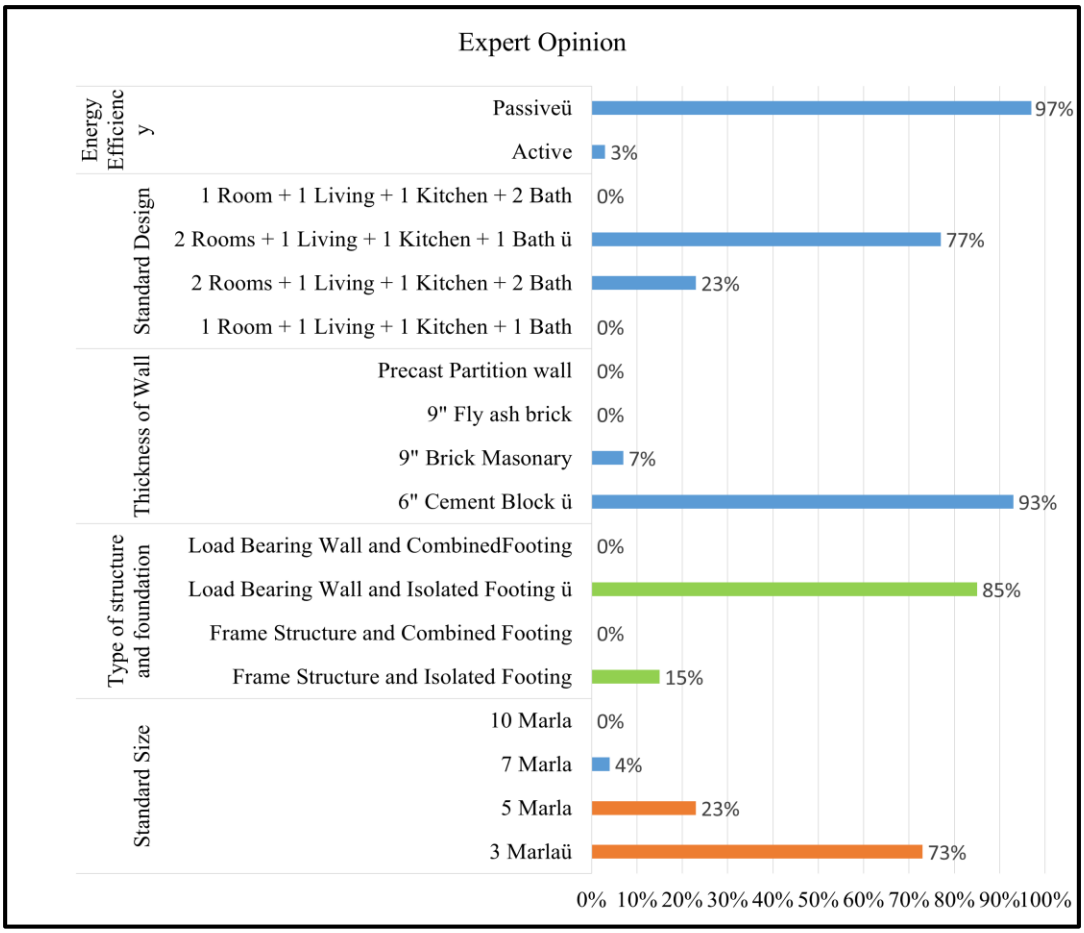

Figure 6 Characteristics of Optimal Residential Unit for Low Cost Mass Housing

3.5 LAYOUT PLAN OF OPTIMAL RESIDENTIAL UNIT

For designing of layout plan of optimal residential unit parameters are selected based on survey conducted by field expert. Optimal size of 3 Marla size selected for low cost house design, the smaller the size the lesser will be construction cost, two rooms, one living, one bath and one kitchen is designed on 3 Marla size.

Experts suggested two bed unit because of privacy propose, also previous research shows the design of low-cost housing having one bedroom is not satisfactory for the resident because there is nothing like privacy (Ishak et.al 2016). In Pakistani culture, wherever the people work, the family (wife/husband) tends to work together; as time goes by, the family will grow (having children), so that Muslims need privacy. The design that has only one bedroom cannot fulfill their requirement. Figure 8 shows the designed layout plan of optimal residential unit.

Cement Block is a concrete masonry unit. It is used to create a regular shaped, homogeneous high quality masonry unit using the densification principle of a lean concrete mix (Harelimana 2017). Because of good durability, fire resistance, partial sound resistance, thermal insullation, minimal dead load and rapid building speed, these are cost-effective and superior alternatives to burnt clay bricks. And because they are bigger than a normal clay brick, fewer mortar is needed, and the cost of building is therefore reduced (Chowdhury & Roy 2013). The main benefit of concrete blocks is that they may be developed according to required strength. Concrete blocks have a very good thermal property because of their cavities. It is also insulated from fire and sound.

For Passive energy efficiency strategy important factors considered during design of optimal residential unit were orientation of building, building shape, buffer spaces, high-power windows (clear, low-e) and window to wall ratios were regarded essential considerations in the construction of an optimal residential unit. Passive approach uses the nature to maintain buildings pleasant without the need for energy. In order to decrease the consumption of energy, passive structure takes use of the building site, its orientation, climate and direct sunlight reduction.. (Mathews et. al.1994).

A building's geometry has a huge cost influence. The size, form and complexity of the building are of interest to building morphology. In general, it is believed that larger buildings with simple design are less expensive per sq-ft of floor space than smaller, complicated structures with complex, rectangular and curved design. (Ishak et.al 2016).

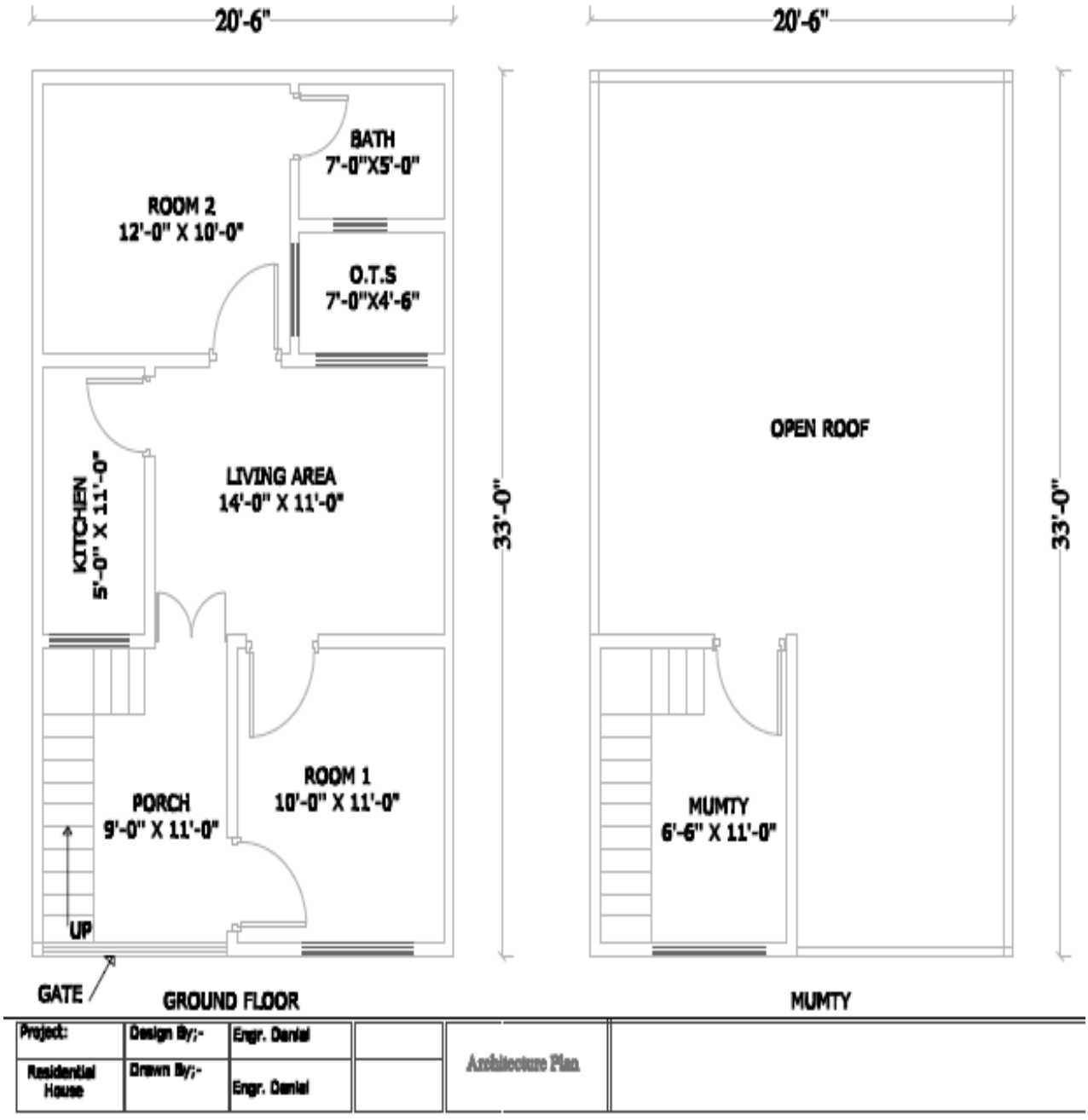

Figure 7 Layout Plan of Optimal Residential Unit

3.6 COST ESTIMATION OF OPTIMAL RESIDENTIAL UNIT

To calculate the total cost of designed optimal residential unit, Revit model is designed. A thorough estimate of construction cost including soft expenses may be used by Revit. Construction costs can in large part be described as work, material, equipment, financing, services, utilities etc. incurred by a contractor plus overheads and profit for the contractor. Costs like land, design, consultant, and engineer fee are not construction costs. Table 7 shows the BOQ of designed optimal residential unit. For cost estimation traditional construction method is assumed, cost of labor, material and other work like formwork, steel fixing etc. are considered accordingly.

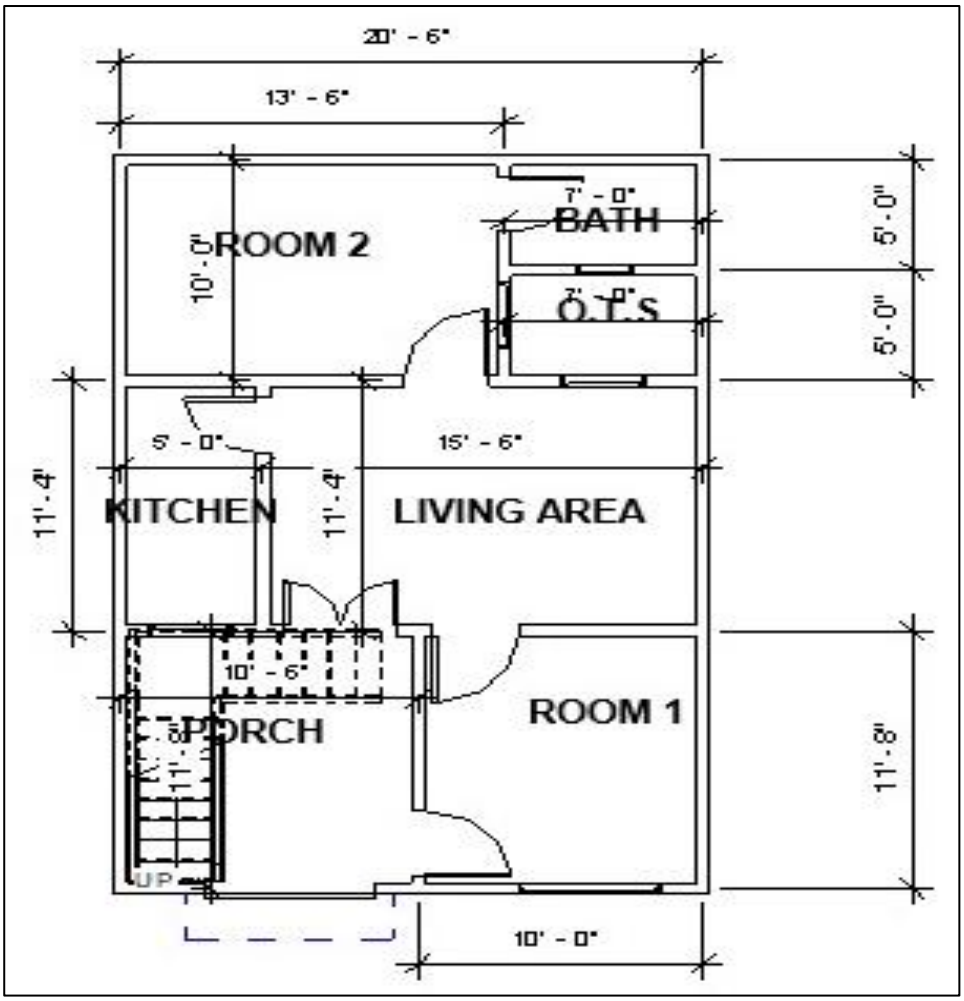

Figure 8 Revit Model for Cost Estimation

Project management deals with cost estimates are the method for predicting the financial and other resources required to accomplish a project in a given scope. The cost estimate accounts for each work item and labor cost and calculates the overall budget of the project.

In this study traditional construction method is used for cost estimation. For the case study the detailed processes for each stage are as follows:

Foundation:

The foundation is the lowest section of the building to transfer building loads to the ground and worked as base for the superstructure. Cost of excavation in all types of soil for columns / brick wall foundation i/c cost of dressing, back filling in 6" layers and disposal of excavated soil including curing.

Cement concrete:

Laying plain cement concrete (1:4:8) machine mix for foundation of columns, walls, etc. With 40 mm coarse aggregate including ramming, consolidating, and curing etc. with a 6" thick layer for masonry foundation and column footings is used.

Wall construction:

6" size cement block for all outer and internal walls. Providing and laying 6" Block in walls in 1:5 cement sand mortar including racking out joint and curing etc. Complete in all respects as per drawing.

Reinforced cement concrete slab and beam:

Providing and laying reinforced cement concrete (1:2:4) (cement: sand: aggregate) with minimum cylindrical strength of 3000 psi at 28 days, using Portland cement, clean sand (lawrancepur sand) and Margala crush of specified grading including placing, rodding, vibrating, leveling, compacting, and curing i/c the cost of supply, fabricate and fix formwork & its subsequent removal etc. is also included in cost estimation.

Steel Reinforcement:

Cost of providing laying, and fixing steel of minimum yield strength 40000 Psi deformed bars and confirming standards of ASTM A-615 (A) in cement concrete including fabrication i.e., cutting, annealed wire, bending, binding is included in cost estimation.

Plastering:

Plaster of all walls, roof including inner and outer walls using Portland cement and clean sand (ghazi) in 1:5 (cement: sand) ratio, before plastering, joints are scraped, and complete curing is achieved and complete in all aspect.

Flooring:

Before laying marble, soil is compacted and laying of PCC (1:4:8) is provided, then Marble (1’ x 2’) provided with 1:3 cement, sand mortar, using Lawrancpur sand and Portland cement including labor and material.

Electrical & Plumbing:

Distribution panelboards, panelboards, lighting installations and wiring accessories, PVC Pipes, and fittings of good quality and cost of transportation and labor is included.

Doors & Windows:

Doors imported kale with petrel wood including frames and accessories complete in all aspect. Windows of aluminum alloy, including frames, hardware sets, accessories and fixings.

Painting and finishing:

Acrylic emulsion paint to concrete, masonry, and plaster. Surface is prepared with putty and primer and cost of already-made paint is calculated.

Table 7 Cost Estimation of Designed Optimal Residential Unit

Sr. No	Description of Work	Quantity	Unit	Rate	Cost
1	Excavation in all types of soil for columns / brick wall foundation i/c cost of dressing, back filling in layers not and disposal of excavated soil else where outside the site.	1500	Cft	15	22500
2	Providing and laying 6" Block in walls in 1:5 cement sand mortar including racking out joint and curing etc. Complete in all respects as per drawing.	2360	Sft	115	271400
3	Laying plain cement concrete (1:4:8) machine mix for foundation of columns, walls, etc. With 40 mm coarse aggregate including ramming , consolidating, and curing etc.	875	Cft	52.6	46025
4	Providing and laying reinforced cement concrete (1:2:4) with minimum cylindrical strength of 3000 psi at 28 days, using Portland cement, clean sand (lawrancepur sand) and margalla crush of specified grading including placing, rodding, vibrating, leveling, compacting and curing i/c the cost of	1341	Cft	98	131418
5	Plaster of walls using Portland cement and clean sand (ghazi) in 1:5 ratio including curing and complete in all aspect.	5500	Sft	23	126500
6	Providing laying, and fixing steel of minimum yield strength 40000 Psi deformed bars and confirming standards of ASTM A-615 (A) in cement concrete including fabrication i.e. cutting, annealed wire, bending, binding and such overlaps are not shown in position, in all kinds of RCC Works.	2.6	Ton	1,60,000	416000
7	Doors imported kale with pertal wood including frames, sub frames, hardware sets, accessories and fixings.Windows, extruded aluminum alloy, clear anodized finish; including frames, sub frames, fly screens, hardware sets, accessories glazing beads and fixings.	14	Complete Job		131000
8	Marble (1' x 2') Flooring with 1:3 cement, sand mortor, using Lawrancpur sand and Portland cement including labor and material.	800	Sft	100	80000
9	Distribution panelboards, panelboards, lighting installations and wiring accessories, PVC Pipes and fittings.	Complete		Job	165000
10	Acrylic emulsion paint to concrete, masonry and plaster.	6000		Sft	210000
				Cost	1599843
		Development Charges 15%			239976.5
		Contingency Amount 10%			159984.3
		Total Cost in Rs.			**1999804**

Chapter 4

RESULTS AND ANALYSIS

Analysis performed on the collected data is covered in this chapter. It also covers the detailed results and discussions on the findings of the study.

4.1 INSTALLMENT PLANS

After calculation of principal amount of designed optimal residential unit, for calculation of 4 different installment plans for 5 Years, 10 Years, 15 Years and 20 Years, **Adjustable Rate Mortgage (ARM)** calculator is used. Adjustable rate mortgages can provide attractive interest rates, but payment is not fixed. This calculator helps to calculate monthly payments. The rate and payment adjustment at the given frequency after any fixed interest rate term has ended. A fully amortising ARM also has a maximum rate not exceeding it. The most frequent forms of Fully Amortized ARMs are presented in Table 8.

Table 8 Adjustable Rate Mortgage

Common Adjustable Rate Mortgages	
Types	**Months Fixed**
10/1 ARM	Fixed for 120 months, adjusts accordingly
7/1 ARM	Fixed for 84 months, adjusts accordingly
5/1 ARM	**Fixed for 60 months, Adjust accordingly**
3/1 ARM	Fixed for 36 months, adjusts accordingly

For calculation of installment plans 5/1 ARM is used because data collected through NAPHDA shows their interest rate changed after 5 year term. Initial annual interest rate for mortgage, which is taken as 3% in NAPHDA. In this study 4 different terms are calculated 5 Years, 10 Years, 15 years, and 20 years. The interest rate will

be subject to rate adjustments. In this study after every 60 months/ 5 Years interest rate is increased by 2% like NAPHDA.

Mortgage Amount: Total amount / Principal amount for mortgage.
Starting Interest Rate: It can be defined as initial interest rate for first five year term.
Term In Years: The total length of loan in years is defined as term in years, the most common terms which are used are 5,10,15 and 20 years.
*Interest Rate Cap***:** The maximum increase in interest rate allowed by mortgage after adjustments.
Months Before First Adjustment: Number of months after this which interest rate will increase according to rate adjustment. In our study we follow NAPHDA, after every 60 months/ 5 years installments are subjected to rate adjustment.
Starting Monthly Payment: Starting monthly payments are monthly installment for 1st year, it depends upon principal amount, initial interest rate and duration / length of loan
Total Payments: Total payment is sum of principal amount and total interest amount payed by the user, or we can say that sum of all monthly payments till the end of the mortgage

Table 9. ***Five*** *Years Installment Plan*

Loan information	**Tenure 5 Years**
Loan amount	18,00,000
Starting Interest Rate	3%
Monthly Installment	32,343
Total Payment	1,940,618
Total Interest	1,40,618
Rate Adjustment	None

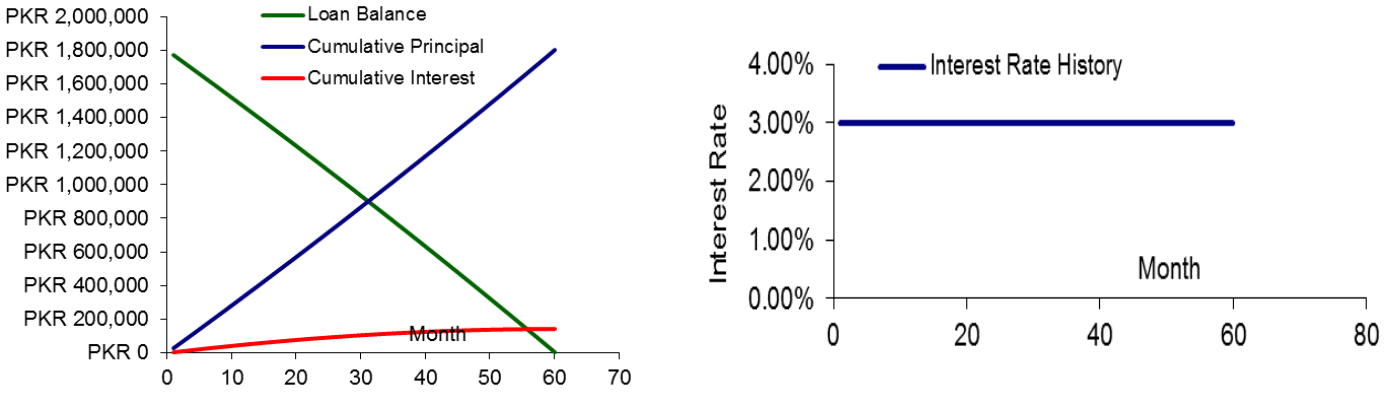

Figure 9 Five Year Installment Plan

In 5 years, installment plan, initial down payment is 10% of total mortgage which is Rs.2,00,000 remaining Rs.18,00,000 is financed through subsidized interest rate used in NAPHDA, ARM provided the details shown in Table 9, monthly installment will be Rs.32,343 throughout 5 years and total payment will be Rs. 19,40,610 at the end of 5 year. Buyer will pay total interest amount of around Rs. 1,40,618.

*Table 10. **Ten** Years Installment Plan*

Loan information	**Tenure 10 Years**
Loan amount	18,00,000
Starting Interest Rate	3%
Monthly Installment First 5 Years	17,380
Monthly Installment 5-10 Years	18,253
Total Payment	2,138,093
Total Interest	338,093
Rate Adjustment	5% after 5 years

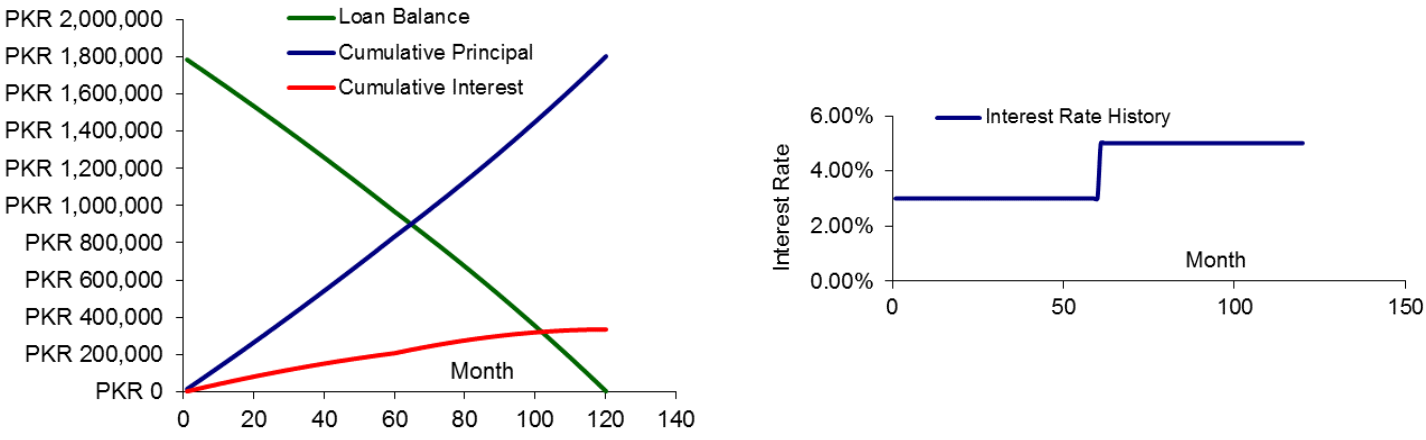

Figure 10 Ten Years Installment Plan

In 10 years, installment plan, initial down payment is 10% of total mortgage which is Rs.2,00,000 remaining Rs.18,00,000 is financed through subsidized interest rate used in NAPHDA, ARM provided the details shown in Table 10, monthly installment will be Rs.17,380 for first 5 years and Rs. 18,253 for next five years, total payment paid by the buyer at the end of the mortgage will be Rs. 2,138,093. Buyer will pay total interest amount of around Rs. 3,38,093.

*Table 11. **Fifteen** Years Installment Plan*

Loan information	**Tenure 15 Years**
Loan amount	18,00,000
Starting Interest Rate	3%
Monthly Installment First 5 Years	12,430
Monthly Installment 6-10 Years	13,654
Monthly Installment 11-15 Years	14,326
Total Payment	2,424,684
Total Interest	624,684
Rate Adjustment	2% Increase after every 5 Years

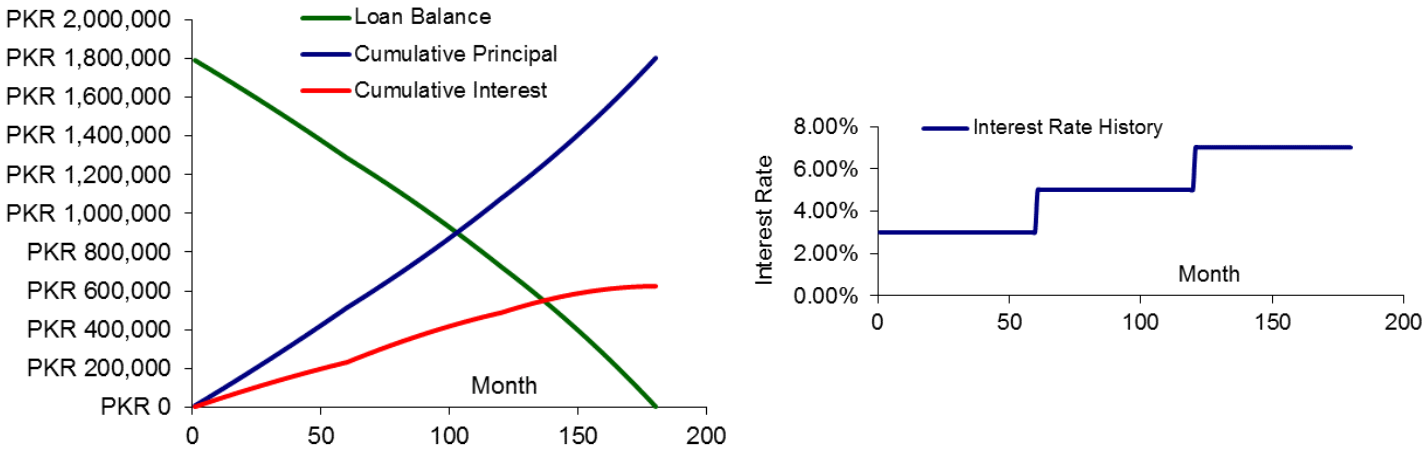

Figure 11 Fifteen Years Installment Plan

In 15 years, installment plan, initial down payment is 10% of total mortgage which is Rs.2,00,000 remaining Rs.18,00,000 is financed through subsidized interest rate used in NAPHDA, ARM provided the details shown in Table 11, monthly

installment will be Rs. 12,430 for first 5 years, Rs. 13,654 for next five years and Rs. 14,326 for last five years, total payment paid by the buyer at the end of the mortgage will be Rs. 24,24,684. Buyer will pay total interest amount of around Rs. 6,24,684. The change in monthly installment after every 5 years is because of increase in interest rate.

*Table 12. **Twenty** Years Installment Plan*

Loan information	**Tenure 15 Years**
Loan amount	18,00,000
Starting Interest Rate	3%
Monthly Installment First 5 Years	9,982
Monthly Installment 6-10 Years	11,431
Monthly Installment 11-15 Years	12,513
Monthly Installment 16-20 Years	13,118
Total Payment	2,822,794
Total Interest	1,022,794
Rate Adjustment	2% Increase after every 5 Years

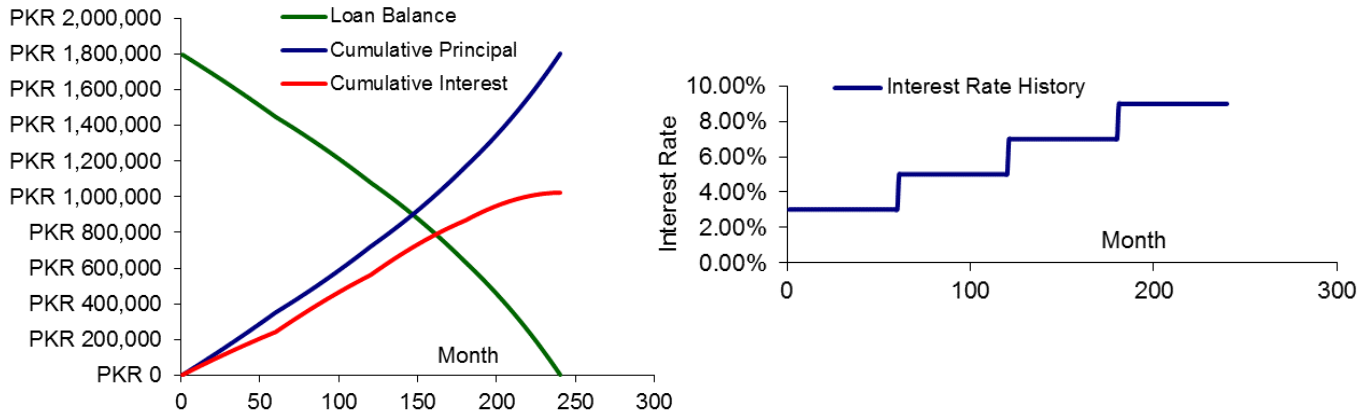

Figure 12 Twenty Years Installment Plan

In 20 years, installment plan, initial down payment is 10% of total mortgage which is Rs.2,00,000 remaining Rs.18,00,000 is financed through subsidized interest rate used in NAPHDA, ARM provided the details shown in Table 12, monthly installment will be Rs. 9,982 for first 5 years, Rs. 11,431 for next five years, Rs. 12,513 for 11 to 15 years and Rs. 13,118 for last five years, total payment paid by the buyer at the end of the mortgage will be Rs. 28,22,794. Buyer will pay total

interest amount of around Rs. 1,022,794. The change in monthly installment after every 5 years is because of increase in interest rate.

4.2 ANALYSIS OF OPTIMAL RESIDENTIAL UNIT

To analyze the characteristics of optimal residential unit and installment plan, interview based questionnaire survey was conducted among end-users. The detailed layout plan and four different installment plans were explained to the end-user and asked them to rate according to their suitability. The demographics of survey in figure 13 shows the highest percentage of people are living in rented house and having monthly income between 40 thousand to 70 thousand.

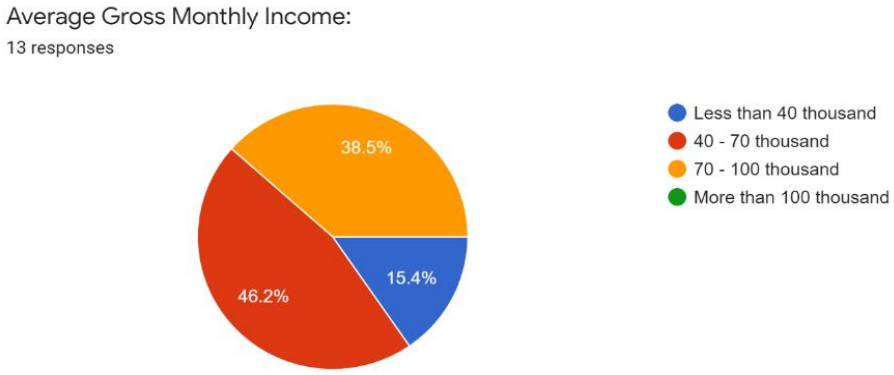

Figure 14. Gross Monthly Income

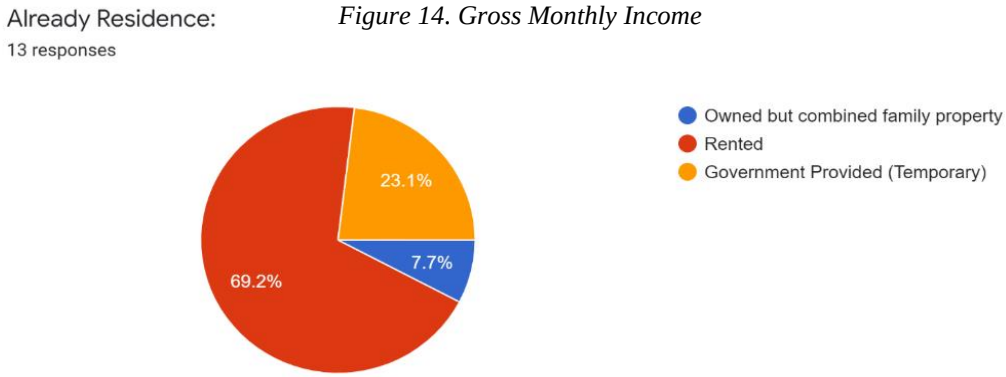

Figure 13. Demographic of Survey

4.3 FIELD VALIDATION

The survey results in Table 13 shows that the people are satisfied with the 3 Marla size for low cost mass housing because more than 3 Marla size is not affordable for low income group, consumers are also satisfied with the standard design of low cost house (2 Rooms, 1 living, 1 bath and 1 kitchen). The Passive energy strategy is used to reduce the construction cost, consumers are also satisfied with the energy efficiency passive strategy.

Table 13. Respondents Score for Optimal Residential Unit

Sr. No.	Factors Identified	Values Identified	Respondents Score out of 3
1	Size of Unit	3 Marla's	2.461
2	Standard Design	2 Rooms + 1 Living + 1 Kitchen + 1 Bath	2.461
3	Energy Efficiency	Passive	2.307

5 Years installment plan is not suitable for low income group because of very high monthly installment and consumers are also not interested in 15 and 20 years plan because of very long tenure and high interest rate. **10 Years** installment plan is most suitable for end-user because of its moderate monthly installment as well as suitable tenure.

Table 14. Respondents Score for Installment Plan

Sr. No.	Instalment Plan Identified	Respondents Score on a Likert scale of 3
1	5 years	1.230
2	10 years	**2.692**
3	15 years	2.000
4	20 years	1.923

Chapter 5

CONCLUSION AND RECOMMENDATION

The study is concluded in this chapter by covering & summarizing the research results & findings and stating the recommendations for future research. The insight will help the reader to understand the crux of the study and parting ways for future endeavors related to this area of research.

5.1 CONCLUSIONS

This research identifies the factors affecting the cost of optimal residential unit for low cost mass housing. The results predicted the characteristics and layout plan of optimal residential unit for low cost mass housing. It is evident that people are more concerned about having their own home, even its 3 Marla size. In Pakistan mostly people of low income group are living in rented houses. The research findings helped in selection of optimal size and design of residential unit for low cost mass housing.

Overall design of optimal residential unit is acceptable for low income group, privacy is major factor for people in Pakistan that's why they preferred residential unit having two room instead of one room residential unit. The design of low-cost housing having one bedroom is not satisfactory for the low income group.

It is also found out that people of low income group are more concerned about construction cost that's why they preferred passive energy efficiency strategy because passive strategy utilize what nature provides for free to keep buildings comfortable without the need for purchased energy. Passive design takes advantage of a building's site, orientation, climate, reduction of direct sunlight and materials to minimize energy use.

It is also concluded that people are not interested in long term mortgage because of high interest rate, 10 year installment plan is most suitable for low income group. In 5 year, installment plan monthly installment is very high which is not affordable to low income group. People are also not interested in 15 years installment plan.

5.2 RECOMMENDATION

i. Future research investigates the way to select the location for low cost mass housing.

ii. Further research can include other socio economic factors.

iii. Further investigation can be carried out on the prefabricated construction for low cost mass housing.

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Annex – I

Identifying Factors Affecting Cost of Optimal Residential Unit:

Dear Sir/Madam,

A survey is in process at Construction Engineering & Management department of National University of Sciences and Technology (NUST), H-12, Islamabad, Pakistan.

The purpose of this exercise of conducting interviews is to validate the factors that affect the cost of optimal residential unit, identified through the literature review of past studies carried out in different regions of the world.

Thank you for your cooperation.

PRIVACY NOTE: Any personal data entered will be kept confidential and only be used for research purposes only.

1) **Email: _____**

2) **Experience (years) in construction Industry:**

   a) 1 - 5 years
   b) 5 - 10 years
   c) 10 - 15 years
   d) 15 - 20 years
   e) 20 - 25 years
   f) above 25 years

3) **Experience in Industry as:**

   a) Consultant
   b) Contractor
   c) Client

4) **Choose the magnitude of severity of factors that affect the cost of optimal residential unit:**

	Not Serious	Slightly Serious	Normal	Serious	Very Serious
Size of Residential Unit	☐	☐	☐	☐	☐
Time for Construction	☐	☐	☐	☐	☐
Material Locally Available	☐	☐	☐	☐	☐
Standard Design and Specification	☐	☐	☐	☐	☐
Adequate Planning and Scheduling	☐	☐	☐	☐	☐
Type of Structure and Foundation	☐	☐	☐	☐	☐
Issues in Communication between Stakeholders	☐	☐	☐	☐	☐
Thickness of Walls	☐	☐	☐	☐	☐
Delays in Decision Making	☐	☐	☐	☐	☐
Energy Efficiency	☐	☐	☐	☐	☐

5) Please mention any other factors, which you think in your expert opinion, are not listed above: _____

Annex – II

Dear Sir/Madam,

A survey is in process at Construction Engineering & Management department of National University of Sciences and Technology (NUST), H-12, Islamabad, Pakistan.

The purpose of this exercise of conducting interviews is to validate the factors that affect the cost of optimal residential unit, identified through the literature review of past studies carried out in different regions of the world.

Thank you for your cooperation.

PRIVACY NOTE: Any personal data entered will be kept confidential and only be used for research purposes only.

1) **Email: _____**

2) **Experience (years) in construction Industry:**

   a) 1 - 5 years
   b) 5 - 10 years
   c) 10 - 15 years
   d) 15 - 20 years
   e) 20 - 25 years
   f) above 25 years

3) **Experience in Industry as:**

   a) Consultant
   b) Contractor
   c) Client

Choose The Optimal Values for Factors That Affect The Cost Of Optimal Residential Unit:

1) What would be the optimal size in Marla's of residential unit for low cost mass housing?
   a) 3
   b) 5
   c) 7
   d) 10

2) What would be the optimal type of structure and foundation of residential unit for low cost mass housing?
   a) Frame Structure and Isolated Footing
   b) Frame Structure and Combined Footing
   c) Load Bearing Wall and Isolated Footing
   d) Load Bearing Wall and Combined Footing

3) What would be the optimal Thickness wall for residential unit for low cost mass housing?
   a) 6" Cement Block
   b) 9" Brick Masonary
   c) 9" Fly ash brick
   d) Precast Partition wall

4) What would be the optimal standard design for residential unit for low cost mass housing?
   a) 1 Room + 1 Living + 1 Kitchen + 1 Bath
   b) 2 Rooms + 1 Living + 1 Kitchen + 2 Bath
   c) 2 Rooms + 1 Living + 1 Kitchen + 1 Bath
   d) 1 Room + 1 Living + 1 Kitchen + 2 Bath

5) What would be the optimal Energy Efficiency for residential unit for low cost mass housing?
    a) Active
    b) Passive

Annex – III

Dear Sir/Madam,

A survey is in process at Construction Engineering & Management department of National University of Sciences and Technology (NUST), H-12, Islamabad, Pakistan.

PRIVACY NOTE: Any personal data entered will be kept confidential and only be used for research purposes only.

Evaluation of Optimal Residential Unit Instalment Plan Model:

1) **Job: _____**

2) **Average Gross Monthly Income:**
   a) Less than 40 thousand
   b) 40 - 70 thousand
   c) 70 - 100 thousand
   d) More than 100 thousand

3) **Family Size: _____**

4) **Already Residence:**
   a) Owned but combined family property
   b) Rented
   c) Government Provided (Temporary)

1. How much is the optimal "size of a low cost housing unit" identified by the experts as "3 Marlas" practically feasible for you?

a. Not Feasible
b. Feasible
c. Extremely Feasible

2. What is your level of satisfaction with the "standard design of a low cost housing unit" identified by the experts?

a. Not Feasible
b. Feasible
c. Extremely Feasible

3. What is your level of need for the Energy strategy (Passive) identified by experts?

a. Not Feasible
b. Feasible
c. Extremely Feasible

4. How much is "5 year Instalment Plan" feasible for you?

a. Not Feasible
b. Feasible
c. Extremely Feasible

5. How much is "10 year Instalment Plan" feasible for you?

a. Not Feasible
b. Feasible
c. Extremely Feasible

6. How much is "15 year Instalment Plan" feasible for you?

a. Not Feasible
b. Feasible
c. Extremely Feasible

7.How much is "20 year Instalment Plan" feasible for you?

a. Not Feasible

b. Feasible

c. Extremely Feasible