BE CIVIL ENGINEERING
PROJECT REPORT

COST ANALYSES OF RESIDENTIAL HOME STRUCTURES

Project submitted in partial fulfilment of the requirements for the degree of
BE Civil Engineering

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This is to certify, that the

BE Civil Engineering Project entitled

COST ANALYSES OF RESIDENTIAL HOME STRUCTURES

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This research work is dedicated to

Our beloved Parents and Teachers, who have been a source of inspiration for us

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Abstract

The construction industry and services form an integral part of the economy of Pakistan. One of the big pillars of this economic tier is the residential construction. Due to the private and local nature of this sector coupled with the illiteracy, it faces a lot of problems during the planning and execution phases. These problems are related to the incorrect speculation of capital resources during the planning and their management during the execution phase. This research work makes an endeavour to streamline the capital management at this level. The work involves the cost estimation process at both preliminary and detailed levels and has tried to standardize the main elements of cost estimation applicable to the residential construction industry in Pakistan. Furthermore, it has focused on some standard and common house plans, modelled them in Autodesk Revit 2017 software to get the quantities of the construction elements which had earlier been standardized. These quantities were calculated to apply to the cost estimation process in order to speculate the estimations and to carry out cost analyses on the results. In these analyses, various elements have been compared vis-à-vis their costs as well as the trends in the variation of plan costs vis-à-vis variations in the plot areas. Basing on these analyses, digital cost models have been developed in MS-Excel which make the cost estimation process an easy task at the residential level. No technical specialities are needed to operate these models and the users just need to follow through the guidance by choosing some very useful options from the drop-down menus. The models are fully inter-linked and automated where the clients and contractors are at liberty to vary some elements/items as per their taste/requirement to come up with a more customized and accurate estimate on some standard plot areas within minimum time. Moreover, some helpful recommendations have also been proposed which can be of utter value to both the client and the contractor as regards cost management during the execution phase.

1 INTRODUCTION

1.1 Construction Engineering and Management

The application of science is ‘engineering’. The objective of engineering is providing comfort and convenience to man. The most basic comfort to a man is shelter on the head and from here on, ‘Civil Engineering’ in general and ‘Construction Engineering’ in particular come into play. The history of mankind validates its universality as the oldest form of Engineering, and stamps its current-ness forever. The post-modern industrial breakthrough has seen an exponential growth, causing all the disciplines of knowledge to overlap. Same is the case is with ‘Civil Engineering’ and ‘Management Science’, leading to the evolution of the field of 'Construction Engineering and Management’. The CE&M explores all the construction engineering works with a multi-dimensional approach towards their management, starting from the idea till the culmination while also taking into account the maintenance and rehab.

1.2 Residential Buildings

Residential buildings are the main dwellings of human beings, usually equipped with all the basic amenities of life including sleeping, cooking and washing. The concept of residential buildings is the main driving factor of the real estate sector, where the gross area of the dwellings slowly encroaches the adjacent natural terrain as new housing schemes are proposed by urban and town planners to meet the increasing population demands. These residential dwellings further encroach this adjacent natural terrain in the name of right of way, services and other basic installations in the public sector which are necessary for the efficient functioning of these dwellings. Thus to curtail this encroachment, the developed economies prefer more and more vertical construction instead of horizontal encroachments. This shift in urban planning has resulted in a switch from the concept of house to the concept of apartment, which is more ecologically sustainable.

In Pakistan, however, due to uncertain economic conditions and lack of long-term urban planning, the concept of a residential building has remained un-switched from house to apartment, and houses are still the mode of residence. Apartments are also being constructed and already in use in some urban areas, but the proportion of the overall population dwelling in them is still negligible. Therefore, houses of different types are to be considered in the following text as the main residential buildings.

1.3 Residential Construction in Pakistan

The system of residential construction is Pakistan remains haphazard as majority of the population is rural. Out the remaining urban population, only a small proportion actually owns land. So, this construction remains mainly an informal and less documented process. Local bylaws and regulations are present only in the prime housing societies and majority of the urban dwellings exist as slums. The process of construction meets no formal tiers and often is carried out without much planning. The client, from the feedback and hearsay judges his capital resources and when deems them sufficient, decides to go for it. When he sits with the contractor, an informal agreement of no legal value takes place in most of the cases. When such vague speculation of costs, aided by no legal measures is executed, many capital issues arise. Often a situation of mistrust builds up between the stakeholders when things don’t go the way as planned.

1.4 Cost Estimation for Residential Construction in Pakistan

As stated in the preceding paras, the planning of almost all the private residential construction is based on mainly just a speculation of the costs. Although the client relies on hearsay and feedback, the contractor offers him a rate based on an estimate. This estimate is still not sufficient as this is just a preliminary estimation, often basing on very blunt parameters such as areas and number of floors etc. The process of cost estimation is discussed in the succeeding paras.

1.5 Cost Estimation

Cost estimation is the most important preliminary process in any construction project. In the construction industry, cost estimation is the process of predicting the costs required to perform the work within the scope of the project. (Leonard Holm, John E. Schaufelberger, Dennis Griffin, Thomas Cole, 2004). Accurate cost estimation is crucial to ensure the successful completion of a construction project. Estimating construction cost is an example of a knowledge-intensive engineering task (Sheryl Staub-French, Martin Fischer, John Kunz, Boyd Paulson, 2003). There can be two approaches in cost estimation, hasty/preliminary estimation and deliberate estimation. In Pakistan, as stated above, much reliance is weighed upon preliminary estimation for residential construction purposes.

1.6 Importance of Preliminary Cost Estimation

The preliminary estimate of any residential construction project is taken when the project is being conceived and the feasibility is being assessed. Often the client will assess the expected costs on a blunt speculation of the total quantum of the work involved. Preliminary estimates help the client to adjust their needs and wants vis-à-vis their budget and should be considered during this conceptual phase of any residential project. After these adjustments, the client now has a better picture of the idea of the work he has in his mind.

Along with all their importance and necessity, preliminary estimates should only be used during the concept phase. Deliberate estimates should be worked out and used onwards when the client ticks the feasibility of the project to an affirmative. Moreover, preliminary estimates view the project as a whole, keeping the client unaware of the necessary work breakdown and the individual costs associated with it. So, till the time a cost analyses is not pondered upon a deliberate and customized cost estimate, the problems stated in the initial paras remain as they are during the subsequent planning and execution phases. This dilemma stands out in most of the residential construction projects particularly in Pakistan.

1.7 Problem Statement

The modern client in the construction industry faces the dilemma of managing his capital in an optimum way. This worsens in residential building projects where, often non-technical clients are involved. With many options available in the market, this clients stands confused in the choice of materials and the quality of execution desired.

1.8 Project Objective

To carry-out an in depth cost analysis of a number of residential building prototypes based on a systematic methodology and an agreed elemental structure, and to create a preliminary cost estimation tool to assist in the future cost planning by clients/contractors/consultants of residential projects.

1.9 Project Timeline

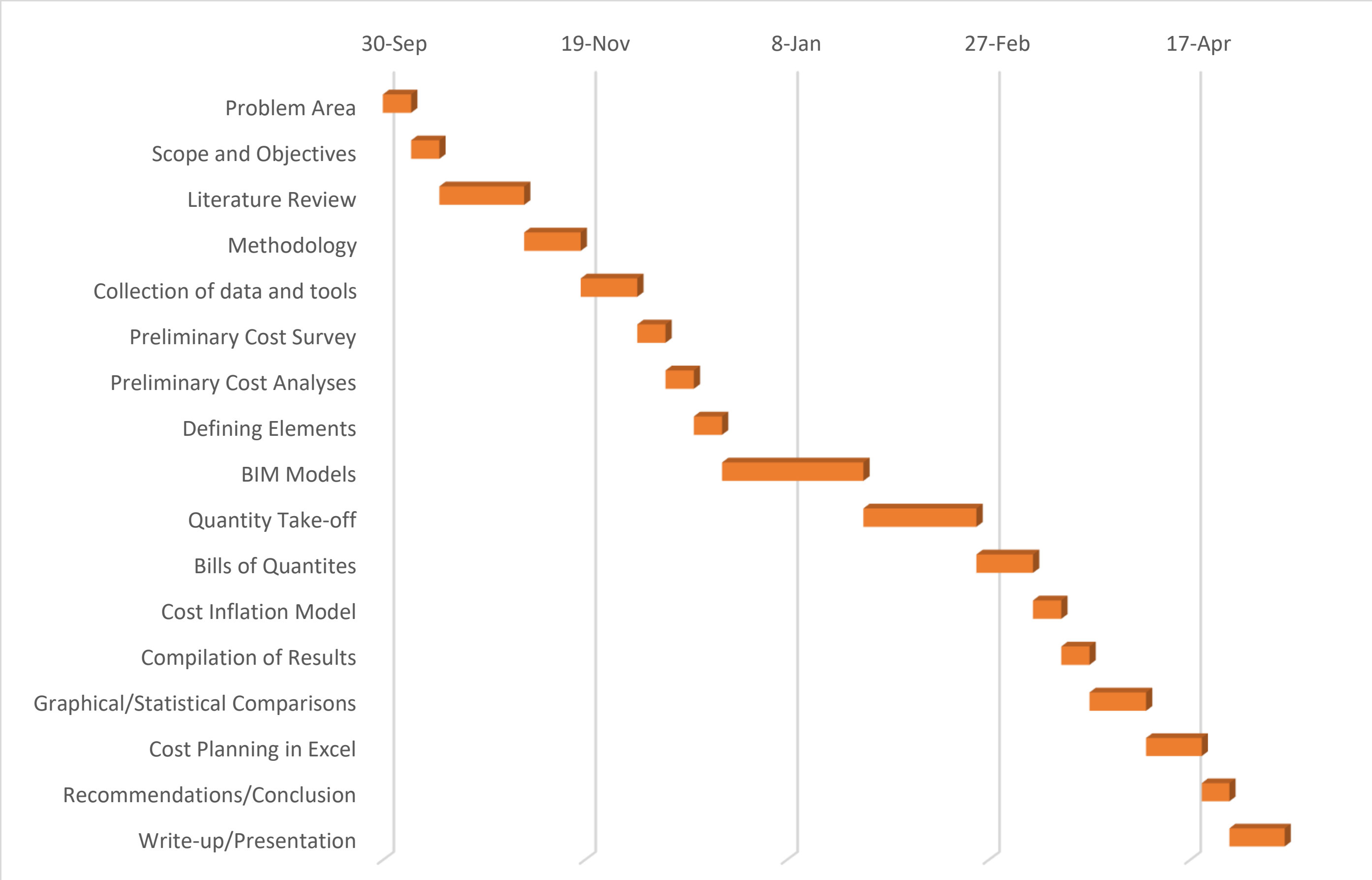

Figure 1-1: Project Timeline

2 LITERATURE REVIEW

2.1 History of Cost Estimation

The originators of building cost analysis were the then Ministry of Education (UK), who were trying to make some sense from building costs in the school building program of the late 1950s. They needed some technique whereby they could forecast and control the costs of building during the design stage. They published their findings in *Building Bulletin No. 4 – Cost Study*, which in the early 1960s was a very forward-looking document. It provided the first serious study undertaken on building costs. It was subsequently revised and published by the Department of Education and Science in 1972. (Ashworth, 2004)

2.2 Evolution of methods

The simplest form of cost analysis was to break down a construction project by trades and trade totals were considered. Later on, it was observed that the floor area plays a significant role in th variation of costs and the floor area analysis was evolved. However, the floor area could not give an accurate cost estimation as it paid no due consideration to the type and quality of materials used. It was only then, that a need for a comprehensive cost analysis system was felt.

A few other cost estimation techniques are also in practice, namely:

1. Assembly method
2. Per capita cost method
3. Percentage method

2.3 Standard Form of Cost Analysis (SFCA)

The first Standard Form of Cost Analysis (SFCA) was published by the then Building Cost Advisory Service of the RICS. It found widespread support from quantity surveyors employed in private practice and the public sector who were concerned with the forecasting of costs for building projects. The current form of cost analysis has been in use for almost 40 years with only minor modifications. (Ashworth, 2004)

Based on SFCA, a building project needs to be divided into well-defined elements. A standard criteria is to be set but the regulations for the same are dynamic and vary with the region as the costs of different materials and labour wages vary with the region. However, for any building project, the level of accuracy and details intended dictates the criteria for the elemental definition. For hasty estimates and guesstimates, only major elements with considerable costs need to be defined and quantified, whereas the no. of elements keeps on increasing with the increasing level of detail, increasing accuracy and increasing project risk management practice. For instance, a building structure maybe divided into a single element of sub-structure at the feasibility stage during planning, however it needs to be further divided into the sub-elements of earthwork, construction of foundations and termite treatment of the foundations vis-à-vis labour and material costs of the same for bidding of a more accurate contract. A few elements which can be defined in the light of SFCA are sub-structure, superstructure, frames, structural masonry, roofs, staircases, external walls, windows and doors, internal and external finishes, fittings and furniture, and engineering services etc.

Furthermore, an effective cost analysis facilitates the negotiations of the client with the contractor. It is preferable if in the first instance the bill of quantities can be prepared on an elemental basis. This will make the preparation of the cost analysis very straightforward, even if an addendum to the design is necessary at the tender stage. (Ashworth, 2004)

2.4 Cost Planning

Cost planning is generally seen as a method of providing cost advice which assists the designer in making design decision. It is a term used to describe any system of bringing cost advice to bear upon the design process. (Nwachukwu, 2003)

The modern trends in the construction industry dictate optimum use of capital to maximise its productivity. Generally in heavy civil works, many technical stakeholders and organizations are involved and such works are planned very deliberately so cost planning is just another dimension of the overall planning process. The planning dilemma however, occurs when in a small-scale residential project a non-technical client has to deal often with a non-technical builder. This dilemma worsens in third world countries where there are no set regulations and by-laws governing the land use in urban atmosphere to ensure a minimum quality of materials and execution. There is no set scale of costs of materials and labour which leaves a client with many options just to add to his confusion, also when there is no formal contract involved. Normally there can be three types of clients in such scenarios.

Table 2-1: Client Affordability VS Awareness

Scenario	Awareness of the cost implications/ Cost affordability	Awareness of the building requirements
Client 1	No	Yes
Client 2	Yes	No
Client 3	Limited	Yes

Cost planning aims to resolve all the scenarios tabulated above with an added emphasis on and scope in the third scenario where a client has a limited budget to make an optimum use of. Thus "cost planning today should more appropriately be renamed value planning, since although there is an emphasis on ensuring that tender sums equate with approximate estimates, the other intention is to provide a balanced design and value for money" (Ashworth, 2004).

2.5 Quantity Take-off

Quantity takeoff is one of the key tasks in the construction process since it is the foundation for several other tasks — the building elements are measured, and these quantities are then used to estimate their cost and the relevant workload. Quantity takeoff can be a measurement of the building's schematics or of the work done on site (Andre Monteiro, Joao Pocas Martins, 2013).

In the early stages, quantity takeoff provides the base for a preliminary cost estimate for the project; in the tendering stage it is used to assist in the estimation of the project's cost and duration of the construction activities; before the construction stage it is used to forecast and plan the construction activities; and during the construction stage it is used for the economic control of the project. An accurate quantity takeoff is decisive for the economic balance of the contractor's finances as it is the only way of achieving a thorough analysis of the productivity and of the different types of costs in a particular project. Traditionally, quantity takeoff is a manual process that involves measuring the different design elements, namely, floor plans, elevations, cross sections and other similar documents (Andre Monteiro, Joao Pocas Martins, 2013).

The taking-off of all the quantities forms the bases of a deliberate cost estimation, regardless of the technique. This reason makes this task to demand for clarity. The clear the client is in his demands and the precise the contractor in their execution, the more accurate the quantity take-off becomes. Therefore it is reasonable to say that a communication gap between the two parties leads to an inaccurate taking-off of the quantities and hence a vague estimate.

Another valid reason to contest this emphasis is that the prices in the market are always continuous and variable which leads to a linear inaccuracy of any analysis. If the quantities are not taken-off accurately, this further leads to an exponential inaccuracy of the 2^{nd} degree, when coupled with the discrepancies in the fluid market prices. The degree increases further when the demands and their execution are murky.

Currently to address this critical issue, many tools are available in the market which pave way for a reasonable quantity take-off, based on a fair judgement of the client further aided by consultants and contractors. In fact this is just a small link in the big chain of “Building Information Modelling” which gives a variety of universal solutions to the problems faced by the construction industry. With everything digitised starting from the planning and feasibility till the handing over of any completed project to the client, many BIM tools are available that provide fair and friendly tools for quantity take-off.

2.6 Building Information Modelling

Building Information Modelling (BIM) is a set of interacting policies, processes and technologies generating a "methodology to manage the essential building design and project data in digital format throughout the building's life-cycle" (Penttila, 2006).

Building Information modelling is a digitized approach towards the management of building construction projects. It integrates all the possible stakeholders and variables involved in the construction along with the available resources and gives a live approach to the modern-day project managers as they manage it during various stages from conception till completion. The capital and time resources are well integrated and it enables all the stakeholders to monitor the consumption of these resources as speculated during the planning stage. Moreover, it provides different planning aids, techniques and parameters to follow during various stages of the construction projects, particularly the planning phase, where, often one needs to have a fair assessment of the availability of all these resources. With this digitization, there are many software and BIM tools available in the market for Building Information Modeling.

These tools are very fluid and can be customized to fit and aid any ongoing construction project. Some of the aids these tools provide can be as follows:

1. Architectural design
2. Structural design
3. MEP design
4. Design integration
5. Quantity take-off and Budgeting
6. Scheduling
7. Project monitoring and maintenance

2.7 Autodesk Revit

Revit is Building Information Modeling (BIM) software offering a multi-disciplinary and collaborative approach to design and construction projects. Revit empowers architecture, engineering, and construction professionals to produce consistent, coordinated, and complete model-based designs for buildings and infrastructure. By unifying powerful tools for architecture, MEP, and structural engineering into a single interface, Revit helps project teams achieve better outcomes together (Autodesk Education, 2020).

2.8 Preliminary Cost Estimation

As the name suggests, are generally made during the initial stages of a project. It essentially helps reveal whether a project is economically feasible. Once a decision has been made then the estimates may be refined as we go further into the detailed design phases (Deshpande, 1999). These estimates, sometimes also called guesstimates are calculated when the proposal of a construction is to be presented, and its feasibility be defended. Some handy techniques are used and a roughly fair idea about the cost is conveyed. Key traits of preliminary cost estimation techniques are:

1. Consume less time
2. Less accurate
3. Do not cover contingencies/uncertainties
4. Need to be adjusted for inflation
5. Local conditions are not considered

Some of the preliminary guesstimating techniques are as follows:

2.8.1 Expert judgement

Expert judgment is sought when only a rough idea of the project scope is clear. This rough idea is conveyed to a practicing professional from the field and a rough expert opinion is asked. It is subjective in nature because, the analogies drawn by the different experts can be different based on their field experiences, and hence two opinions of the project based on the limited defined scope can be different. The greater the experience of the expert, the accurate will be his estimation. It is valid only for the concept screening of a brainchild.

2.8.2 Cost estimation w.r.t plinth area

The plinth area estimation method falls under the umbrella of analogous estimating methods. The plinth area rate of a project is calculated readily by dividing the total cost of a previously completed construction project of similar scope by the plinth area. This rate is then referred to for future estimations of projects of similar scope, provided the plinth area is defined. This makes clear that the technique is employed post-feasibility studies, when the project proposal has been approved, the scope is clear, the drawings have been drafted and the dimensions are clear. The method is still less deliberate but meets the requirements of the post-feasibility planning phase.

Another method similar to plinth area technique is floor area or covered area technique. It often comes under the same category as the plinth area, but is more accurate as regards scope of the work and is more flexible with the increasing number of floors or total covered floor areas. For this method to be employed, floor area / covered floor area rates are required to be defined instead of plinth areas.

2.8.3 Cost estimation w.r.t cost per capita/cost per unit

This method is involved when the complete cost of a building project is divided by total number of residents occupying the building or the total number of modular units in a building to reach a cost per capita rate or a cost per unit rate. For estimation of any similar project with a shared synonymous scope, the total number of occupants or total number of modular units is required to reach a rough idea of the project cost.

2.9 Detailed cost estimation

Once the conceptual design has been approved and most of the design work completed, approximate estimates are generally supplemented by detailed estimates. These will usually include a careful tabulation of the quantities for a project; this is called a "quantity takeoff'. These quantities are then multiplied by selected or developed unit cost which results in the direct costs for the facility. The two types of detailed estimates are the fair cost estimates and the contractor's-bid estimate in order of level of detail. These will not be explored further, but it may be important to note that proper evaluation of the effects of local practice, weather conditions, market competitiveness as well as the completeness of plans and specifications is extremely critical for the accuracy of such detailed estimates (Deshpande, 1999).

Detailed cost estimation techniques are employed during the deliberate planning phase of a construction building project. In this phase, the scope is well-defined, the drawings are available, the temporal dimensions are known, the technical specifications are agreed to and only the contractual award is left. This contractual award that follows the bidding process necessitates a detailed cost analysis to be done. The key traits of the detailed cost analyses are:

1. More deliberate and time consuming
2. More accurate
3. Uncertainties and contingencies are addressed
4. Address local conditions/bylaws
5. At par with current market rates/ inflation adjusted

Some of the detailed cost estimating techniques are as follows:

2.9.1 Parametric estimation method

This method is somewhat a more deliberate method of analogous estimation, with the definition of some added variables and considering their weightage in the overall estimation. These variables can be the current government policies, the difference in the market conditions, the local weather and ground conditions and other miscellaneous variables (Project Cost Estimating Tools & Techniques, 2020).

2.9.2 Trade totalling technique

The trade totalling technique breaks the project into different trades basing on the work breakdown, and the assembly costs of each trade is calculated to reach to a cumulative project cost. The assembly cost in itself is a net sum with respect to the trade, integrating both the material and the labour costs incurred till the completion of the respective trade/job. A possible trade/work breakdown can be for example, breaking a services sub-project into the respective electrical and mechanical installations to include their complete labour and material costs.

2.9.3 SFCA

The “Standard Form of Cost Analysis”, also called elemental cost analysis ensures the breakdown of a construction project more systematically and deliberately into well-defined elements of the overall construction. It is more flexible as regards trade totalling in the manner, that the accuracy desired can be pre-set, according to the number of elements defined. The greater number elements defined and their costs added deliberately will result in a more accurate project estimate. Moreover, it takes into account both the cost of materials and the cost of labour separately, which add to its accuracy in a sense but makes it a more complicated and time consuming technique to follow (Ashworth, 2004).

3 METHODOLGY

3.1 Collection of data

After the approval of the project proposal and the finalization of the scope and objective, a schematic of all the expected tasks and activities was drafted. All the required literature for study and data for execution of the work and the subsequent phases of the project was then seeked. Following data was retrieved from the library sources:

1. Books for literature review (prescribed by the worthy advisor)
2. ASCE Construction Engineering & Management Journals
3. SFCA publication (Royal Institute of Chartered Surveyors, 2009)
4. CDA by-laws
5. MES Schedule of Rates (Ministry of Defence, Military Engineering Services, 2014)

Following data was collected from digital sources, surveys and other miscellaneous sources:

1. Plans/drawings MES houses
2. Plans/drawings Bahria Town Islamabad houses
3. Elemental market rates and labour costs at par with current date
4. Autodesk Revit tool setup (along with tutorials)

3.2 Preliminary cost estimation

3.2.1 Method

The preliminary cost analysis technique employed is the covered floor area rate method. This method has an edge over the plinth area rate method because the plinth area rate fluctuates non-linearly with the increasing number of storeys/basements. Also as the unit building modules (apartments) are only defined in medium/high rise residential buildings with a considerable and stable number of building occupants, this technique supersedes the cost per capita/ cost per unit rate technique.

3.2.2 Execution

The plans of houses in following three categories will be considered being the most common plot areas in Pakistan:

1. 5 marla
2. 10 marla
3. 20 marla

These categories will be further divided into following types, being the most commonly followed in Pakistan:

1. Double storey
2. Double storey with basement

Following this division, a formal 2-D array classification mesh is formed as shown in the table:

Table 3-1: Classification of Plans

	5 Marla	10 Marla	20 Marla
Double storey	A1	B1	C1
Double storey with basement	A2	B2	C2

Covered floor area unit rates was obtained through a market survey. As the market practice is following the plinth area unit rate, the plinth area unit rate of a fully covered single story 10 marla house (with no covered area setbacks from the property line) was be obtained, assuming it to be a standard for asking quotations from contractor for the most general case. This rate was further obtained under following categories to reach a mean rate:

Table 3-2: Prevailing Plinth Area Rates per Floor

	Economic (PKR/sqf)	Medium (PKR/sqf)	High (PKR/sqf)
Without Basement	2200	2450	2600
With Basement	2400	2600	2750

Mean rate without basement = (2200 + 2450 + 2600)/3 = PKR. 2417 /sqf

Mean rate with basement = (2400 + 2600 + 2750)/3 = PKR. 2583 /sqf

3.2.3 Results

The mean rate as calculated above has been applied to the gross covered floor areas for each classification type. The market practices vary as regards consideration of areas. In common practice, where there are no limitations posed by the by-laws, the contractor considers the plot area while quoting a price per unit area. In more urban and sophisticated localities with more educated clients, the builder quotes the rate for the plinth areas because of the possibility of reduced areas due to the off-sets provided by local regulations and by-laws. Moreover, the common builder considers only the plinth area and increases the rate with the addition of stories, levels or basements. This practice leads to somewhat ambiguous estimates. As per the demand of the client, however, they can use a procedure to modify and accumulate the areas, while keeping the rate constant as per single storey value. For the sake of this work, this very procedure has been used for more accuracy. Here, the total constructed areas of all the floors/ basements are added to multiply with the quoted price per unit area of a single floor to reach the preliminary estimates.

Hence it is better to use the term "gross covered floor area" instead of merely the "plinth area", because the plinth area remains the same, regardless of the number of levels of construction and the quantum of work involved. The calculated gross covered floor areas of the same have been tabulated as follows.

Table 3-3: Category-wise Average Covered Areas, including all Floors

	5 Marla (sqf)	10 Marla (sqf)	20 Marla (sqf)
Double storey	(2155+1908)/2= *2032*	(3628+3068)/2= *3347*	(5232+5490)/2= *5361*
Double storey with basement	(2239+2734)/2= *2486*	(4424+4671)/2 = *4547*	(6803+6943)/2= *6873*

The results after applying the mean covered floor area rate to the gross covered floor areas in each category, the results obtained are tabulated as follows:

Table 3-4: Category-wise Preliminary Estimates

	5 Marla (PKR)	10 Marla (PKR)	20 Marla (PKR)
Double storey	4,911,000	8,090,000	12,957,000
Double storey with basement	6,422,000	11,744,000	17,753,000

3.3 Detailed Cost Estimation

3.3.1 Method

The detailed cost analyses will be done by the "Integrated Elemental Cost Analyses" method, a modified form of the "Standard Form of Cost Analysis". It comes with its inherent advantage of combining both the SFCA and trade totalling techniques which will lead to the convenience of computing both the material and labour costs simultaneously, but of well-defined elements as in the light of SFCA instead of poorly defined lump sum trades. A similar technique is currently in practice in many government departments like Military Engineering Services (Pakistan), where the estimation is based on defined elements, but the method of computing the costs is assembly, meaning thereby, that the costs of items are calculated after they have been assembled and put in the place they are meant to be (material + labour).

3.3.2 Defining areas and plans

The same model areas and plans as used above will be used for detailed cost estimation also and as depicted in Table 3-1. These plans were obtained and chosen out of many plans commonly available in the industry with real estate dealers and builders. The selection criteria was based solely on the commonality of the plans. Due to space restrictions, all the plans cannot be shown. A model plan for a 20 marla house, on which further quantity take-off and cost estimation will base is as shown below:

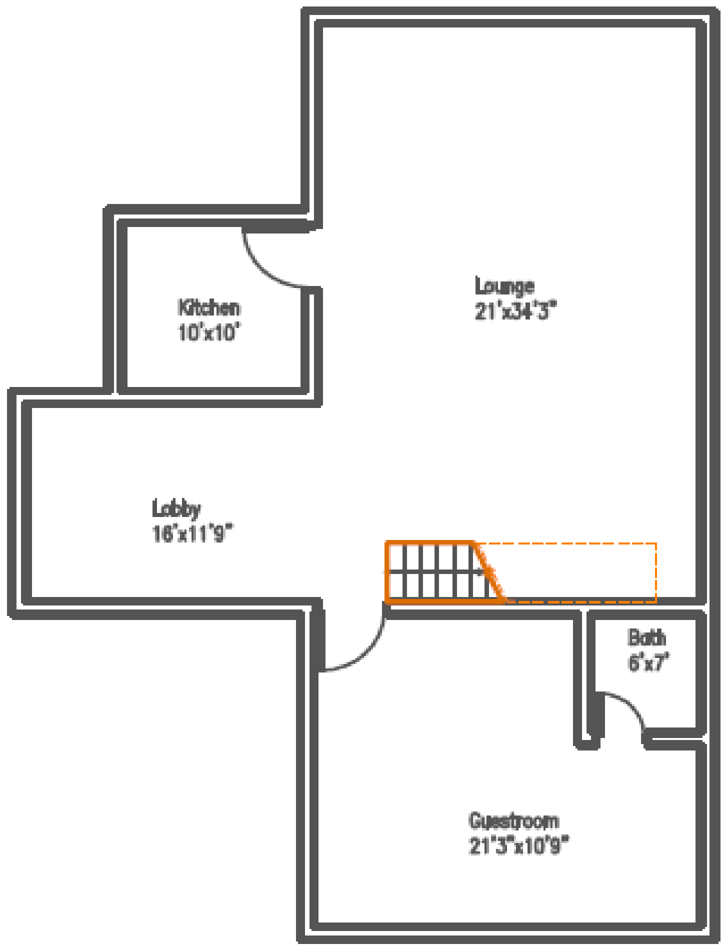

Figure 3-1: Model 20 Marla Plan - Basement

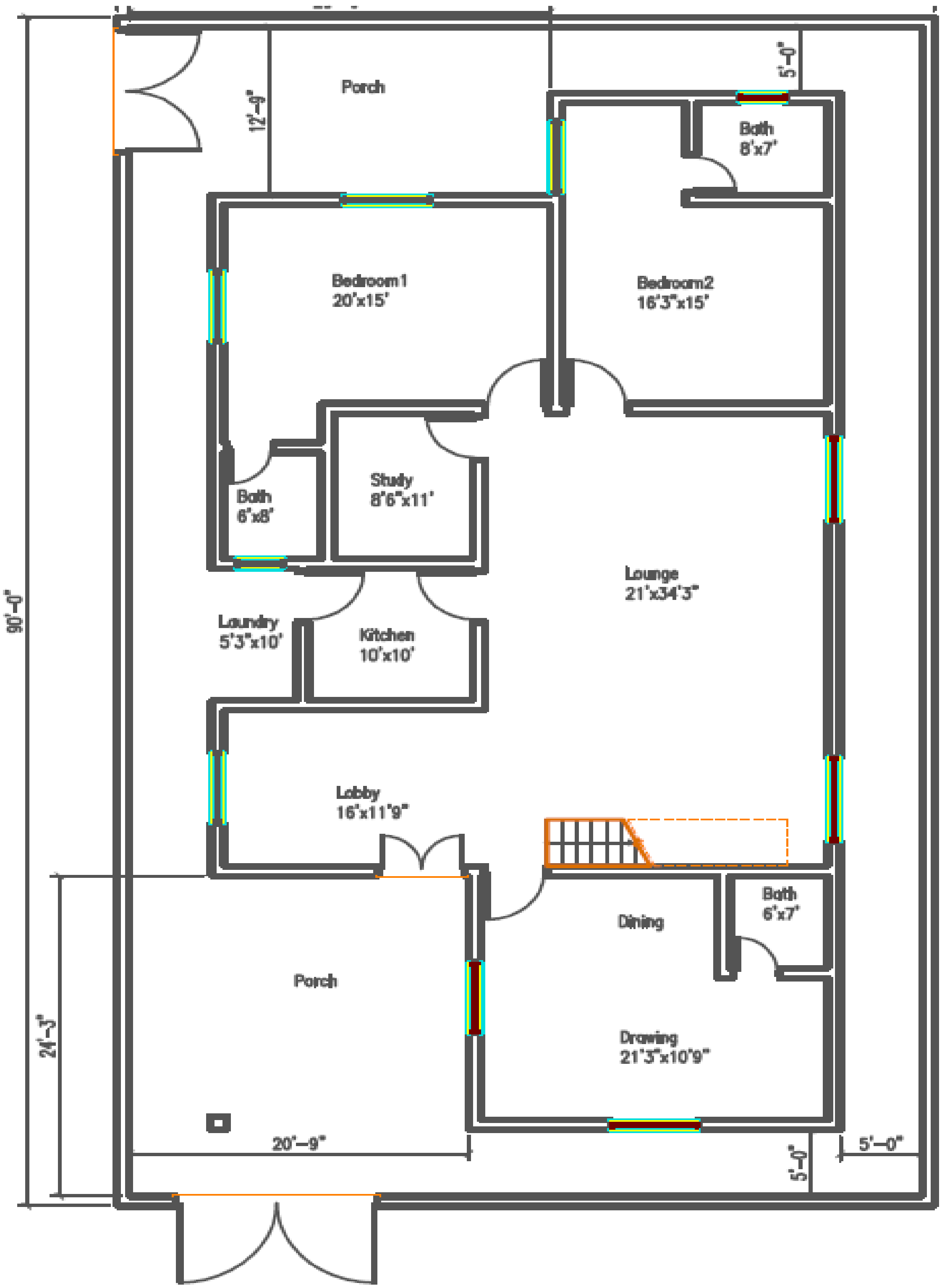

Figure 3-2: Model 20 Marla Plan - Ground Floor

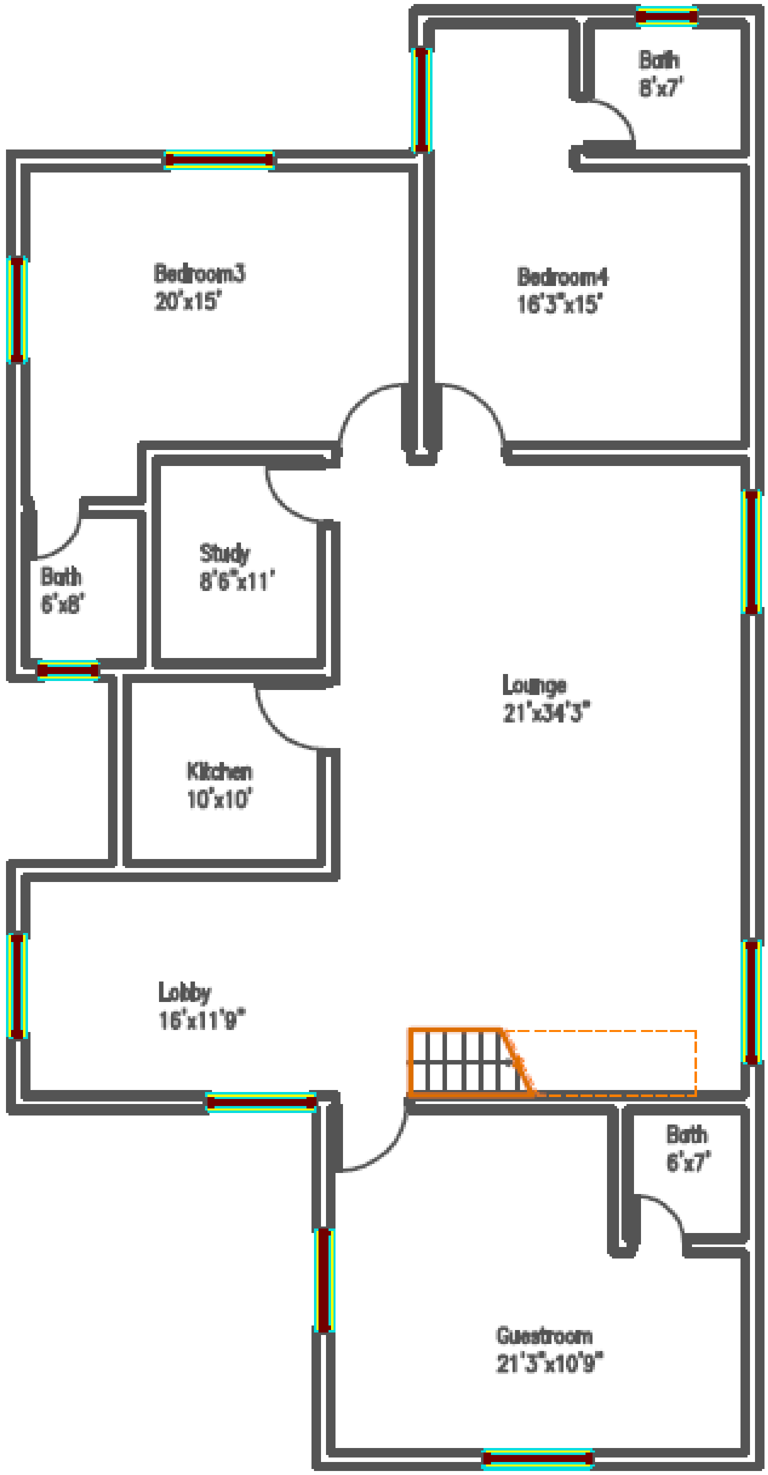

Figure 3-3: Model 20 Marla Plan - 1st Floor

3.3.3 Execution

The execution of the analyses is as follows:

3.3.3.1 Defining Building Elements

The building elements that will be considered in the detailed cost analyses will be as follows:

1. Substructure
    a. Earthwork (excavations, dumping and refilling)
    b. Foundations (lean concreting, brickwork and other foundation works)
    c. Basement (side-walls, roof slabs and other basement works)
2. Superstructure
    a. Masonry (brickworks and plaster)
    b. Concrete (roof-slabs and reinforcement detailing)
    c. Doors
    d. Windows
    e. Fittings (all kitchen and washroom accessories fittings not included in water supply or drainage services)
    f. Flooring (sand-bed, PCC and floor finishes)
    g. Misc (all items of superstructure not included in the categories above)
3. Services
    a. Electrical (both services and fittings)
    b. Water supply
    c. Sui gas
    d. Drainage
4. Finishing (all paints, weather shields and roof insulations etc.)

3.3.3.2 Quantity take-off

For this project, all the plans were modelled in Autodesk Revit 2017 with a 3-D approach, so as to obtain a fair picture of the quantities. The inherent advantage in Autodesk Revit is that many quantities can be accurately calculated and generated with an automated approach. These quantities can further be imported to MS Excel worksheets and can be interpreted in terms of a fair quantity take-off. For example, the volume of masonry can be generated by the automated generation of the volume of walls, the quantity of required distemper can be interpreted in terms of the cumulative walls' area, again generated automatically by the tool.

Autodesk Revit 2017 also gives a complete quantity take-off solution for MEPS, provided MEP plans are modelled in 3-D. The 3-D model of the 20 marla plan shown above was developed as follows:

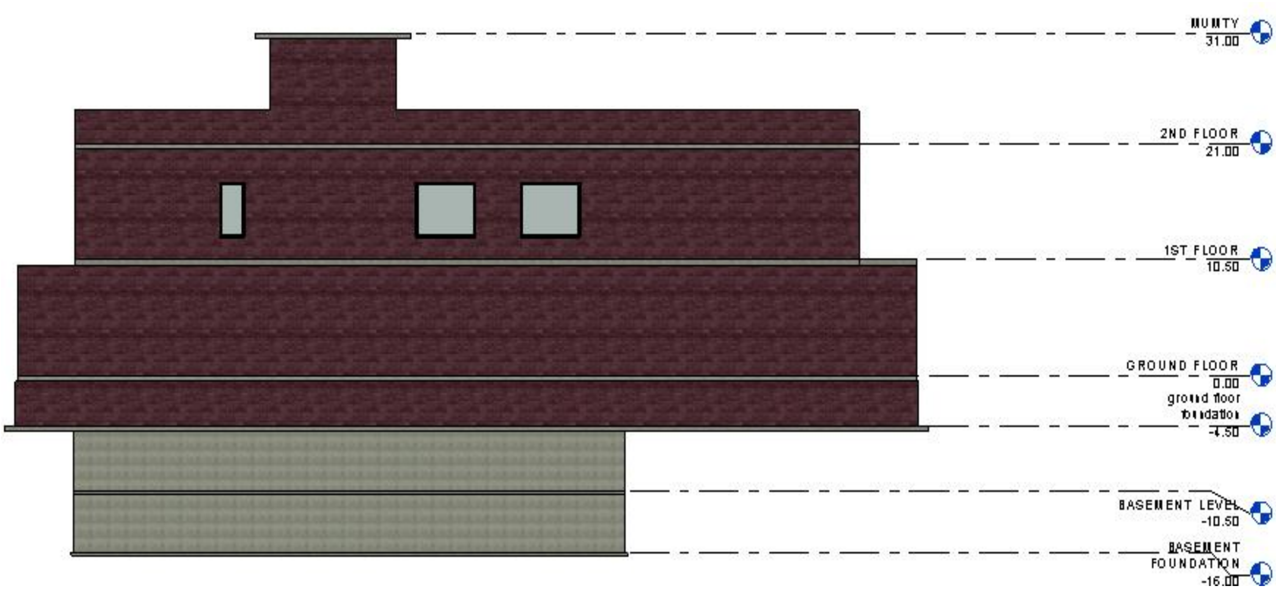

Figure 3-4: Revit 3D Model - Different Levels

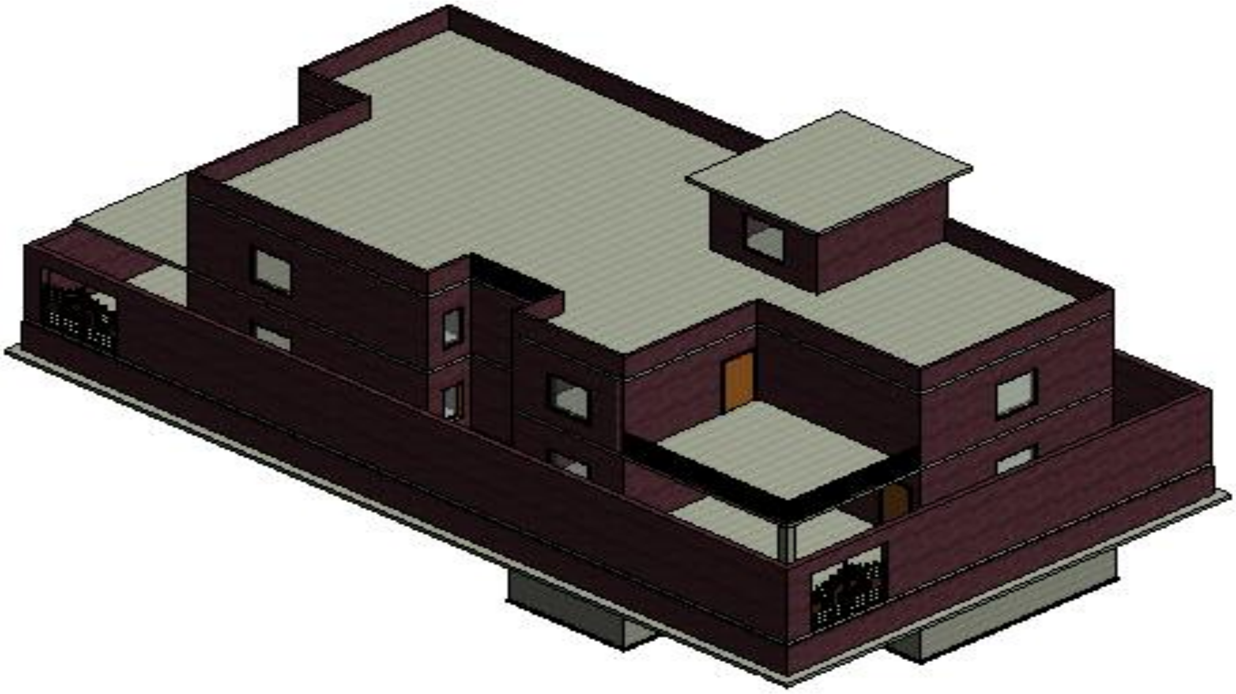

Figure 3-5: Revit 3D Model - Top Perspective View

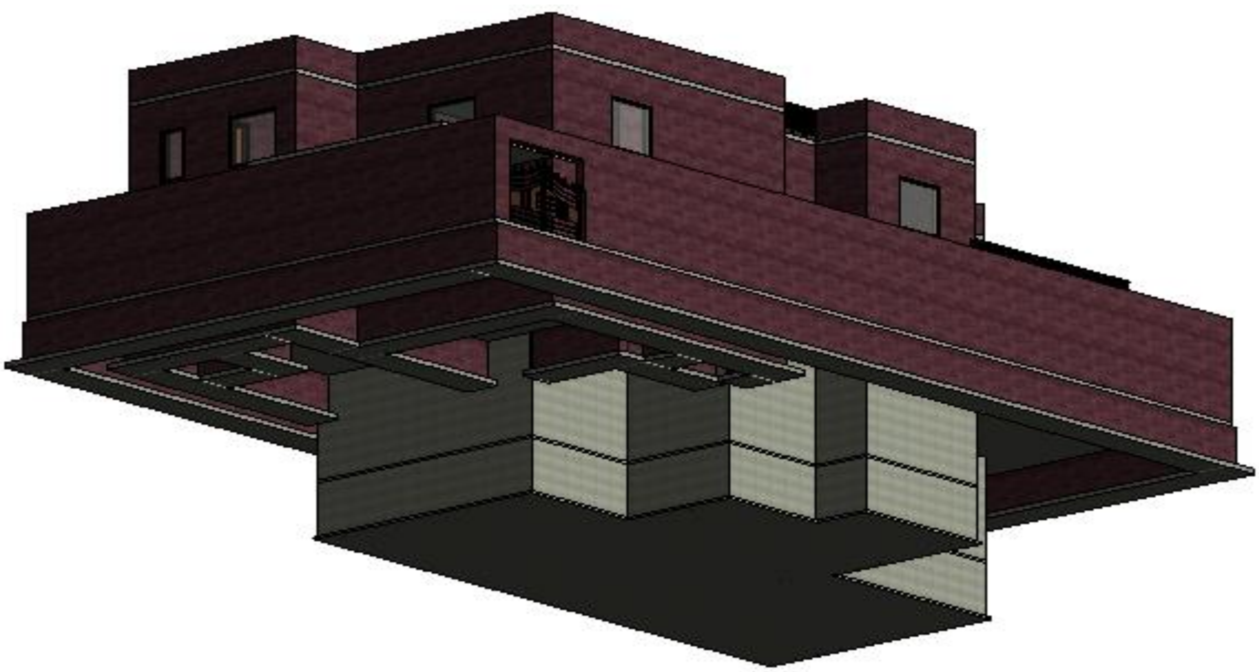

Figure 3-6: Revit 3D Model - Bottom Perspective View

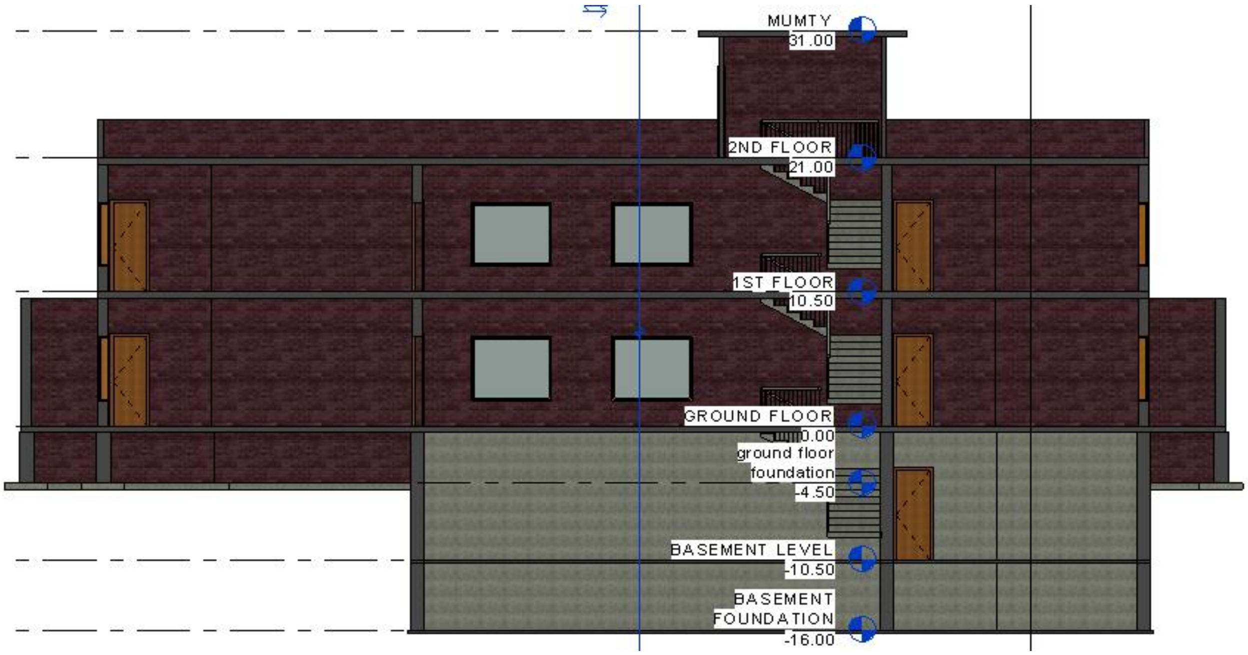

Figure 3-7: Revit 3D Model - Longitudinal Section View

Figure 3-8: Revit 3D Model – Lateral Section View

With the inherent complications combined with the temporal limitations, however, a manual approach was followed as the ultimate aim to use a tool was to save time, which it couldn't do so in this case. This doesn't curb down the tool's application as regards MEPS, because their modelling save a lot of time and effort with a universal project management approach, however it just wasn't efficient with a focused cost estimating approach. To cut short, the sheets of quantities generated as a result of this modelling are appended at the end of this write-up as:

1. Appendix A: The sheet shows the quantities generated from the walls i.e. wall surface areas and volumes for masonry and finishes.
2. Appendix B: The sheet shows the quantities generated from the doors i.e. door surface areas and volumes to include in finishes and exclude from masonry respectively.
3. Appendix C: The sheet shows the quantities generated from the windows i.e. window surface areas and volumes to include in finished and exclude from masonry respectively.
4. Appendix D: The sheet shows the quantities generated from the floors i.e. floor areas.
5. Appendix E: The sheet shows the quantities generated from stairs, surface areas and slab volumes for floorings and concrete respectively.
6. Appendix F: The sheet shows the quantities generated from the foundations and basements i.e. volumes for earthworks, backfills, foundations and basements.

However, all the manually calculated quantity take-off sheets are as follows:

Table 3-5: Manually-Generated Quantity Sheet - Bar Bending Schedule

Sr No.	Location / Steel Type		Shape	Sides/ Item	Nos. of bars each	Cut Length (ft)	Cut Length (inch)	Total Length of bars(ft) # 3	# 4	# 5	# 6	Remarks: Nos.	Cut Length	Misc
Col 1	Col 2		Col 3	Col 4	Col 5	Col 6	Col 7	Col 8 = Col 4 x Col 5 x (Col 6 + Col 7/12)	Col 9 = Col 4 x Col 5 x (Col 6 + Col 7/12)	Col 10 = Col 4 x Col 5 x (Col 6 + Col 7/12)	Col 11 = Col 4 x Col 5 x (Col 6 + Col 7/12)			
	Roof Slab													
1	Bottom Main Bars	Main bars #4 @ 6" C/C		1	178	49	10 1/2		8877.75			Nos of bars = Clear Span/bar spacing+1 88.5'/6"=177+1=178 say	48.5'+9"+9"-3/4"-3/4"=49.875'	Concrete Cover = 3/4" Wall bearing = 9"
2		Distribution Bars #3 @ 8" C/C		1	74	89	10 1/2	6650.75				48.5'/8"=72.75+1=73.75 say 74	88.5'+9"+9"-3/4"-3/4"=91.375'	Steel Grade G-40
3	Top Bars (-ve bars)	#4@12"c/c		1	89	24.5	5.25	0	4438.875			half of +ve bars	half of +ve bars	Steel Type Deformed Mild Steel
4		#3@16"c/c		1	37	44.5	5.25	3325.375	0					
5, 6	Chairs	#3 at 3 ft C/C under Top bars (A & B)		1	500	2	0	1000				4500 sf total slab area and 1 chair for 9 sf so total 500 chairs	4"+2"+2"+8"+2"+2"+4"=24"	spacing+ 2" extra on each side
				Total Steel (Rft) =				10976.13	13316.63	0.00	0.00	Sum of all above lengths		
				Weight in lbs per Rft =				0.376	0.668	1.043	1.502	# Density of steel = 490 lbs/cft		
				Total Weight (lbs) =				4127.02	8895.51	0.00	0.00	Total Weight in lbs = Total Steel in Rft x Weight in lbs per Rft of bars		
				Total Weight (kg) =				**1872.51**	**4036.07**	**0.00**	**0.00**	Total Weight in kg = Total Weight in lbs/2.204		
				Total Weight (Mton) =				1.87	4.04	0.00	0.00	Total Weight in Mton = Total Weight in kg/1000		
											TOTAL WEIGHT (KG)		**5908.59**	
											Per SF weight of reinforcement(kg)		**1.31**	
											Per Sqm weight of reinforcement(kg)		**14.1**	

The quantities of mainly MEPS which couldn't be modelled in Revit were calculated manually, basing on some fair visualizations. For example, the number of fan points in a floor can be left to the judgement of the client. Similarly, the length, depth, point of origin and end of the external drain can be left to the judgement of the contractor. The thing important here is that both the client and contractor should have a fair understanding of the plan. Following are the manual quantity taking-off sheets of the services:

Table 3-6: Manually-Generated Quantity Sheet - Services (Water Supply)

S#	Description	Quantity	Unit
1	S/F tubes water quality GI with all fittings (i.e. sockets, bends, tees, elbows where required) and laid complete in trenches (exclusive of excavation) or fixed to walls, ceiling and floors etc. including caps and plugs as required 25mm diameter (light).	40.84	Mtr
2	-do-but 50mm diameter	10.89	Mtr
3	S/F Union Socket GI, screwed BSP, 25mm diameter,	3.00	Each
4	S/F Union Socket GI, screwed BSP, 50mm diameter,	1.00	Each
5	S/F Valves peat pattern, strong gunmetal, high pressure, Full-way valves with iron wheel head screwed both ends for iron pipe, 25mm diameter	4.00	Each
6	-do-but 50mm diameter	1.00	Each
7	S/F non Return Valve 25mm diameter	2.00	Each
8	S/F non Return Valve 50mm diameter	1.00	Each
9	S/F Foot valve complete with Strainer 50mm diameter	1.00	Each
10	S/F Ball/Foot valve ,Brass (Corydon) other approved pattern with copper ball 50mm diameter	0.00	Each
11	S/F PE pipes (Polyethylene PE-100) 63mm diameter class PN-10/SDR-17	0.00	Each
12	Excavation up to 1.5m depth in to hard soil and making embankment of same	2.44	Mtr
13	S/F Water tank Polyethylene (PE) vertical 1360 litters (300 gallon capacity)	0.00	Each
14	S/F PPR Pipe (poly propylene random) with all fittings i.e. socket bend tee elbow where required 32mm diameter class PN-20(excluding excavation)	38.44	Mtr

S#	Description	Quantity	Unit
15	-do-but 63mm diameter	0.00	Mtr
16	S/F Bib cock, brass, CP, Fancy type Screwed down, BSP, 25mm diameter	4.00	Each
17	Double Bib Cock brass chromium plated fancy type screwed down B.S.P 25mm diameter, supply and fixing. (Toilet bib cock Double)	5.00	Each
18	S/F toilet shower best quality	6.00	Each
19	S/F Tee cocks, brass chromium plated, screw down, high pressure, fancy type, 15mm diameter but tee stop cock with CP pipe.	23.00	Each
20	S/F Ablution mixer chrome	0.00	Each
21	S/F Gas instant water Geyser 10 Litres capacity	3.00	Each
22	Water tank (Polyethylene) 500 gall	1.00	Each
23	S/F Centrifugal pumping set, AC, electric motor driven, 220/230v, SP, 50 cycles size 2"x2" (suction /delivery), mounted on a common channel base, similar rate as SI 19-3	1.00	Each

Table 3-7: Manual Quantity Sheet - Services (Sui Gas)

S#	Description	Total Quantity	Unit
1	S/F polyethylene (PE) Gas Pipe class MDPE-80 yellow pipe (SDR-11) 50mm diameter	1.53	Mtr
2	Excavation up to 1.5m depth in to hard soil and making embankment of same	0.83	Cum
3	S/F tubes water quality GI with all fittings (i.e. sockets, bends, tees, elbows where required) and laid complete in trenches (exclusive of excavation) or fixed to walls, ceiling and floors etc. including caps and plugs as required 15mm diameter (Medium).	15.68	Mtr
4	-do-but 20mm diameter	96.46	Mtr
5	-do-but 40mm diameter	8.08	Mtr
6	-do-but 50mm diameter	0.00	Mtr

7	S/F Brass valve ball type screwed both ends complete with steel handle 15mm diameter	13.00	Nos
8	-do-but 20mm diameter	3.00	Nos
9	-do-but 50mm diameter	0.00	Nos
10	S/F Union Socket GI, screwed BSP, 15mm diameter,	17.00	Nos
11	S/F Union Socket GI, screwed BSP, 20mm diameter,	14.00	Nos
12	S/F Union Socket GI, screwed BSP, 40mm diameter,	3.00	Nos
13	S/F Union Socket GI, screwed BSP, 50mm dia,	1.00	Nos
14	S/F Valves peat pattern, strong gun-metal, high pressure, Full-way valves with iron wheel head screwed both ends for iron pipe, 20 mm diameter,	19.00	Nos
15	-do-but 25 mm diameter	0.00	Nos
16	-do-but 40 mm diameter	3.00	Nos
17	-do-but 50 mm diameter	1.00	Nos
18	S/F non Return Valve 25 mm diameter	3.00	Nos
19	S/F Gas water heater complete with burner pilot ,thermostat and safety valve 136 Litre Capacity	2.00	Nos

Table 3-8: Manual Quantity Sheet - Services (Drainage)

Sr	Description	Qty	Unit
1	Supply and fix UPVC Soil and waste pipe 75mm bore (outside diameter) complete with plain end and solvent cement joint as specified.	32.96	Mtr
2	Supply and fix UPVC Soil and waste pipe 110mm bore (outside diameter) complete with plain end and solvent cement joint as specified.	24.34	Mtr
3	Supply and fix UPVC Soil and waste pipe 160mm bore (outside diameter) complete with plain end and solvent cement joint as specified.	3.96	Mtr
4	Supply and fix UPVC Vent pipe 50mm bore (outside diameter) complete with plain end and solvent cement joint as specified	13.41	Mtr
5	Supply and fix 75 mm dia. UPVC Elbow/bend 90^0 complete with solvent cement joint all as specified	7.00	Each
6	Supply and fix 110 mm dia. UPVC Elbow/bend 90^0 complete with solvent cement joint and rubber ring all as specified	2.00	Each

Sr	Description	Qty	Unit
7	Supply and fix Eccentric Reducer 50 mm x 110 mm dia. complete with solvent cement joint all as specified	4.00	Each
8	Supply and fix UPVC Access/door tee 75 mm dia. complete with solvent cement joint all as specified	5.00	Each
9	Supply and fix UPVC Access/door tee 110 mm dia. complete with solvent cement joint all as specified	5.00	Each
10	Supply and fix UPVC Vent Cowl 50 mm dia. on top of ventilating pipes	4.00	Each
11	Supply and fix UPVC Vent Cowl 75 mm dia. on top of ventilating pipes	0.00	Each
12	Excavate for, dispose of surplus spoil on site, make good surface distributed, supply (230mm x 230mm x 100mm out let) surface gullies and bed and surround in 100mm of cement concrete type 'C' provide 100mm x 125mm rounded cement concrete type 'C' curb or 900mm x 900mm x 100mm dished cement concrete type 'C' top and 250 x 250mm galvanised cast iron loose grating complete.	2.00	Each
13	Manholes complete rectangular or circular as described not exceeding 600mm deep form inverted to surface of cover, including main channel set in CM 1:1, 230mm thick brick walls.	0	Cum
14	Manhole complete rectangular or circular as described, exceeding 600mm but not exceeding 1800mm deep with iron steps (in angles 380mm centers), 230mm thick brick walls.	1.9	Cum
15	P/L RCC **type B** manhole cover (precast complete with angle iron frame embedded in concrete all as per information sheet No. Svcs-341 dated 10-11-99.	2.00	Each

Table 3-9: Manual Quantity Sheet - Services (Electrical)

Location	**Points**							**Fixtures**														
	Light point	Fan point	Bell Point	5 Amp Socket point	15 Amp point for power/light plug	15 Amp point for AC's	15 Amp points for circuits (W/O Conduit)	Bulk head fitting	LED 12 watt Light down light	LED 12 watt Light Surface light	Bath Light Fancey	Caset Type Fan 2'x2'	Ceilling Fan 140cm	Exhaust Fan size 25cm	Swetch 2 Gang	Swetch 6 Gang	Swetch 8 Gang	S/Socket 3 pin 5amp	TV Socket	Telephone socket	Special earth for MDB,S
Gr Floor																					
Porch 1	4	1	1	2	-	-	1	-	-	4	-	-	1	-	-	-	1	2	-	-	-
porch2	4	1	-	2			1			4	-	-	1	-	-	-	1	2	-	-	
lobby	4	-	-	-	-	-	1	-	-	4	-	-	-	-	-	1	-	1	-	-	-
drwng	4	2	-	3	-	1	1	-	4	-	-	2	-	-	-	1	1	2	-	-	-
lounge	8	4	1	4	2	-	1	-	8	-	-	-	4	-	-	2	2	2	1	1	-
Bed 1	4	2	-	3	-	1	1	-	4	-	-	2	-	-	1	1	1	2	-	-	-
Bed 2	4	2	-	3	-	-	1	-	4	-	-	-	2	-	1	1	1	2	-	-	-
bath1	2	1	-	1	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-
bath2	2	1	-	1	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-
bath3	2	1	-	1	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-
kitchn	2	2	-	2	-	-	1	-	2	-	-	1	-	1	2	-	-	-	-	-	-
store	1	1	-	1	-	-	-	-	-	2	-	-	1	-	-	1	-	-	-	-	-
Open	4	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	2
1st Floor																					
Lobby	4	-	-	-	-	-	1	-	-	4	-	-	-	-	-	1	-	1	-	-	-
Sitting area	8	4	1	4	2	-	1	-	8	-	-	-	4	-	-	2	2	2	1	1	-
Bed 1	4	2	-	3	-	1	1	-	4	-	-	2	-	-	1	1	1	2	-	-	-

Location	Points							Fixtures													
	Light point	Fan point	Bell Point	5 Amp Socket point	15 Amp point for power/light plug	15 Amp point for AC's	15 Amp points for circuits (W/O Conduit)	Bulk head fitting	LED 12 watt Light down light	LED 12 watt Light Surface light	Bath Light Fancey	Caset Type Fan 2'x2'	Ceilling Fan 140cm	Exhaust Fan size 25cm	Swetch 2 Gang	Swetch 6 Gang	Swetch 8 Gang	S/Socket 3 pin 5amp	TV Socket	Telephone socket	Special earth for MDB,S
Bed 2	4	2	-	3	-	-	1	-	4	-	-	-	2	-	1	1	1	2	-	-	-
Bed 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Study	4	2	-	3	-	-	1	-	4	-	-	2	-	-	-	1	1	2	-	-	-
Kitchn	2	2	-	2	-	-	1	-	2	-	-	1	-	1	2	-	-	-	-	-	-
bath1	2	1	-	1	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-
bath2	2	1	-	1	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-
bath3	2	1	-	1	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-
Store	1	1	-	1	-	-	-	-	-	2	-	-	1	-	-	1	-	-	-	-	-
2nd floor																					
mumti	2	1	-	2	-	-	1	-	2	-	-	1	-	-	2	-	-	1	-	-	-
basemnt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
lounge	8	4	1	4	2	-	1	-	8	-	-	-	4	-	-	2	2	2	1	1	-
staircase	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
guestroom	4	2	-	3	-	1	1	-	4	-	-	2	-	-	-	1	1	2	-	-	-
room2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
bath1	2	1	-	1	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-
bath2	2	1	-	1	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-
kitchn	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
misc1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	96	43	4	53	6	4	17	4	58	28	8	13	20	10	18	17	15	27	3	3	2

3.3.3.3 Detailed Bills of quantities

A priced quantity take-off sheet systematically rooted on the elemental breakdown structure is called the “bill of quantities”. Prior to drafting the bill of quantities, the prices of all the relevant materials and assemblies etc. should be obtained. These prices are to be entered against each quantity exclusively defined in units and the cumulative price be obtained thereafter. All the cumulative prices of respective sub-elements then accumulate to give the total cost of an element. For example, the prices of reinforcement and concrete accumulate to give the cost of basement, which is then coupled with the price of earthwork and foundations so that the total cost of the element namely sub-structure is obtained.

For this project, the prices have been obtained from the “MES Schedule of Rates 2014”. The Schedule is a fine manifestation of the market trends and although it is 5 years old, it cannot exactly be termed obsolete. The reasons for the effectiveness of this schedule are as follows:

1. All the feasibilities, formulations, biddings and awards of MES Contracts rely on this schedule in which the costs of assemblies and materials are set with the aim that this does not get outdated immediately within a timeframe of 2 to 3 fiscal budgets. Instead the formulators of this Schedule focus on setting the prices with such a mind-set that the schedule remains effective for at least 5 years (because the schedule is updated every 5 years and the preceding edition was released in 2009).
2. The prices of some items which vary by big margins are reset by releasing star rates, which are different for different areas and regions. Therefore, much reliance is also not being made on the star rates. However, with the guidance of staff available at MES School (MCE), some rates have been adjusted based on the current-ness of the personnel who are at par with the market trends.
3. The prices of items whose ranges vary to a great extent in the schedule e.g. openings, woodworks etc. are averaged to come to a more stable pricing regime for the purpose of this

project and to give the worthy client a sense of liberty of switching between different specifications of the same material with the estimates not distorting considerably.

The Bills of Quantities of all 11 plans (except the one shown above) have been summarized for the sake of reducing inconvenience. The Bills of quantities of the above shown plan, with respect to the above shown elemental breakdown have been included in this report and are as follows:

3.3.3.3.1 Substructure

Table 3-10: Bill of Quantities - Substructure

Sr	Description	Qty	Unit	Item No.	Rate	Amount
	EARTHWORK					
1	Excavation over areas as in Hard Soil up to 1.5 m depth in foundation/ to obtain earth for filling under floors / areas etc. Or for shafts, wells exceeding 30 sqm each, throw earth clear of edges of excavation within 10m	0	Cum	1-7	249.53	-
2	Excavation as in Hard Soil up to 1.5m depth, in foundation and pipe trenches up to 1.5 m wide in shafts, wells and independent holes up to 30 sqm each and throw earth clear of edges of excavation within 10 m. Timbering to be paid extra (Trench over 1.5 m width will be treated as areas).	139.59	Cum	1-2	299.66	41,829.54
3	Back filling earth obtain from excavation in trenches/over areas within 10m including watering and compaction in 150mm layer and dressing to required profile and shape.	71.57	Cum	1-15	160.33	11,474.82
	FOUNDATIONS					
4	P/L of sand cushion in layers as specified, under concrete roads, hard standings, landing ground etc.	14.31	Cum	2-91	972.02	13,909.61

Sr	Description	Qty	Unit	Item No.	Rate	Amount
5	P/L CC 1:4:8 using **Crushed or Broken Stone** graded as specified	19.7	Cum	3-8	5173.94	101,926.62
6	P/L CC **Type B** using crushed or broken stone in foundations, independent column footings, solid floors etc. including form work as specified. Reinforcement measured and paid separately	0	Cum	3-18	7350.07	-
7	P/L RCC **Type B** using crushed or broken stone in roof slabs, landings, walls, plinth beams and bands etc. as specified requiring shuttering. Reinforcement measured and paid separately	18.8	Cum	3-22	10205.81	191,869.23
8	Burnt brick work in wall over 115 mm thick laid and jointed in CM 1:6 straight or to curve with inner radius of 6 m and over up to 4.25 m depth	55.22	Cum	4-27	9491.08	524,097.44
9	S/F of water proof **building or insulating paper** weighing 3.92 Kg per 10 sqm and fix in any position with 50mm side and 150mm end laps and nailing as described for felt.	47.43	Sqm	10-99	89.75	4,256.84
10	Two coat of bitumen applied hot on roof at the rate of 0.75 Kg per sqm and blinding with sand at 0.012 Cum per sqm (including cleaning surface).	253.22	Sqm	2(10-100)	282.7	71,585.29
11	Two coat of water proofing compound using bitumen 10-20 applied hot at 14.68 Kg per 10 sqm.	47.43	Sqm	2(10-102)	434.7	20,617.82
12	**Termite proofing** of new buildings including wood-work therein with approved chemicals.	335.68	Sqm	11-01	71.38	23,960.84
	BASEMENT					
13	Providing and laying **RCC Type 'A'**, using crushed or broken stone as specified in roof slabs, landings, walls, plinth beams and bands, etc. requiring shuttering. Reinforcement measured and paid separately	165.79	Cum	3-26	11160	1,850,216.40

Sr	Description	Qty	Unit	Item No.	Rate	Amount
14	S/F bars round, using deformed bars **Grade - 60** including cutting, bending, binding and placing reinforcement in position.	10574.58	Kg	9-56	118.42	1,252,241.76
15	13mm thick **cement plaster 1:4** finished as specified.	485.96	Sqm	13-05	219.01	106,430.10
16	P/L **cement concrete 1:4:8** laid under floors using crushed or broken stone	11.28	Cum	12-03	4753.73	53,622.07
17	P/L CC **Type 'B"** using crushed or broken stone laid in floor slabs, as under layer for Terrazzo / stonolithic /tiles top finished.	11.61	Cum	12-19	5818.28	67,550.23
18	P/L of white / light colour/ glazed/non-skid tiles exceeding 400 sqcm but not exceeding 900 sqcm area each, on walls and floors, set in neat cement and joints grouted with white /colour cement complete all as specified.(Pak made).	31.66	Sqm	12-52	1527.13	48,348.94
19	P/L **10/12mm** thick white/colour marble tiles (except green and yellow) on walls and floors laid, jointed and grouted in white / coloured cement (1: 2) including rubbing and chemical polishing complete.	84.29	Sqm	12-80	949.12	80,001.32
20	P/L **20/22mm** thick white/colour marble slab (except green and yellow) exceeding 900 sqcm but n-exceeding 1.00 sqm each on walls and floors laid, jointed and grouted with white / coloured cement (1: 2) including rubbing and chemical polishing complete.	44.35	Sqm	12-76	2030.78	90,065.09
					Total RS.	**4,554,004.0**

3.3.3.3.2 Superstructure

Table 3-11: Bill of Quantities - Superstructure

Sr	Description	Qty	Unit	Item No.	Rate	Amount
	MASONRY					
1	Burnt brick work in wall 115 mm thick laid and jointed in cement mortar 1:4 straight or to curve with inner radius of 6 m and over up to G.F roof level	0	Cum	4-05	9992.70	-
2	BB work in wall over 115 mm thick laid and jointed in CM 1:6 straight or to curve with inner radius of 6 m and over up to G.F roof level.	129.64	Cum	4-09	9052.6	1,173,579.06
3	BB work in wall 115 mm thick laid and jointed in CM 1:6 straight or to curve with inner radius of 6 m and over up to 1st floor roof level	0.18	Cum	4-12	9851.13	1,773.20
4	Burnt brick work in walls over 115 mm thick laid and jointed in CM1:6 straight or to curve with inner radius of 6 m and over up to 1st floor roof level	75.57	Cum	4-15	9188.89	694,404.42
5	BB work in walls 115 mm thick laid and jointed in CM 1:6 straight or to curve with inner radius of 6 m and over up to 2nd floor roof level	12.02	Cum	4-18	10013.44	120,361.55
6	BB work in wall over 115 mm thick laid and jointed in CM 1:6 straight or to curve with inner radius of 6 m and over up to 2nd floor roof level	0.00	Cum	4-21	9317.2	-
7	13mm thick **cement plaster 1:4** finished as specified.	1004.52	Sqm	13-05	219.01	219,999.93
8	13mm thick **cement plaster 1:6** finished as specified.	1475.17	Sqm	13-07	200.27	295,432.30

Sr	Description	Qty	Unit	Item No.	Rate	Amount
9	Forming **V-grooves** 13mm wide and 10mm deep in new plaster.	0	Mtr	13-24	27.34	-
	CONCRETE					
10	P/L RCC **Type B** using crushed or broken stone in roof slabs, landings, walls, plinth beams and bands etc. as specified requiring shuttering. Reinforcement measured and paid separately	81.41	Cum	3-22	10205.81	830,854.99
11	P/L RCC **Type B** using crushed or broken stone in columns, beams, stairs, posts, struts, piers, lintels, and the like requiring shuttering, as specified. Reinforcement measured and paid separately	4.25	Cum	3-24	10459.74	44,453.90
12	S/F bars round, using deformed bars **Grade - 40** including cutting, bending, binding and placing reinforcement in position.	8513.16	Kg	9-54	112.58	958,412.03
13	S/F bars round, using deformed bars **Grade - 60** including cutting, bending, binding and placing reinforcement in position.	0.00	Kg	9-56	118.42	-
	DOORS					
14	S/F first class soft wood, framed and panelled doors, gates less S/F of chowkats	58.43	Sqm	J/R(PER Sqm)	6849.54	400,218.62
15	Two coat of Spirit polishing to new wood work.(complete rate)	95.58	Sqm	15-98	129.97	12,422.53
16	Three coat on new work, such as doors of any type and description with synthetic enamel paint as specified.	116.86	Sqm	15-43 15-44 15-45	318.72	37,245.62

Sr	Description	Qty	Unit	Item No.	Rate	Amount
17	S/F first class soft wood, **framed and panelled doors**, gates etc. (panelled filled in with MDF 16mm sheet) except hanging chowkats, hold-fast, and iron mongery as described, 38mm thick	0	Sqm	7-98 (-) 7-99	7037.18	-
18	Supply and fix first class soft wood, **framed and panelled doors**, gates etc. except hanging chowkats, hold-fast, and iron mongery as described, 38mm thick	0	Sqm	07-96 (-) 7-99	6707.63	-
19	S/F First Class soft **wood dolly frame chowkat**	58.43	Sqm	J/R (PER Sqm)	8174.93	477,661.16
20	S/F of First Class soft **wood dolly frame chowkat** using 57mm x 57mm fillets on edge side of wall and @ 381mm c/c cross fillets covered with 3mm **commercial** ply including architrave on both sides (Inside/Outside) not exc. 12.90 sqcm in any design/ shade, holdfast, bitumen coating on wall side of frame and wood, preservative on remaining side of frame, gapes filled with CC Type B for 115mm wall, complete all as specified (Single/ double rebate)	0	Sqm	Pro ½(7-234)	2137.05	-
21	S/F of **Steel door** using 22 gauge black sheet outer frame angle iron 1½" x 1½" x⅜" shutter frame and bracing 1¼" x 1¼" x ⅛" including laying and locking arrangement & Painting all as specified	-	Each	J/R	-	-
	<u>WINDOWS</u>					

Sr	Description	Qty	Unit	Item No.	Rate	Amount
22	S/F **first class soft wood** wrought sashes, and doors, glazed with moulded or chamfered bars, panels filled in with gauzed 9x9 mesh 24 GB except chowkats, hold fasts and hung with hinges or pivots including iron mongery as described, 38mm thick.	0	Sqm	7-14 7-15	4413.52	-
23	S/F of **Aluminium sliding window** (Economy Model & Premium Model) with all necessary fittings and frame.	45.98	Sqm	J/R(PER sqm)	7573.91	348,248.38
24	S/F of **Aluminium sliding window** (Economy Model) of Anodized Champagne extruded section up to height of 1524 mm as specified including fixing on concrete, wooden or steel frames complete with all necessary fittings including 5mm thick tinted glass all as specified.	0.00	Sqm	7-38 16-5	7315.05	-
25	S/F of **Aluminium fly/Insect screening** with imported mash (Economy Model & Premium Model) of Anodized Champagne extruded section as specified including fixing on concrete, wood or steel frames complete with all necessary fittings	45.98	Sqm	7-83	1824.41	83,886.37

Sr	Description	Qty	Unit	Item No.	Rate	Amount
26	S/F MDF (Medium Density Fibre Board) hollow flush door, 38mm thick with Malaysian Ply(Pak made) 3mm skin panel on both sides internal wood, second class soft wood frame, 75mm x 32mm hydraulically hot pressed with glue in any design, shape and pattern complete, including iron mongery all as specified except chowkats.	0	Sqm	07-119	2850.33	-
27	S/F kitchen floor/ sink floor cabinet/kitchen wall cabinet/kitchen Exhaust hood	8.53	Mtr	J/R(PER Mtr)	6146.09	52,426.15
28	S/F kitchen Exhaust hood made of teak veneered board with 22 BG PGI sheet fixed on inner side complete as per information sheet IS Arch No. 17, 18 and 19 including all fitting/fixture as specified	0	Mtr	7-216	4705.46	-
	FITTINGS					
29	Supply and fix chromium plated locks **rim or latch** 150 mm with two bolts and two levers, in any pattern/shape best quality with 2 keys.	14.19	Each	8-94	572.04	8,117.25
30	S/F 300 mm long Brass, **sliding and locking bolts** with staple (plate thickness 16 to 18 gauge).	27.00	Each	8-26	867.04	23,410.08
31	S/F of **fillets** not exceeding 12.90 sqcm section area of 1st class soft wood wrought and	0.00	Mtr	6-13	119.13	-

Sr	Description	Qty	Unit	Item No.	Rate	Amount
	fixed with screwed all as specified					
32	Supply and fix Stainless steel **kick plate** (16 to 18 gauge).	0	Sqm	8-270	7450.12	-
33	S/F General Steel work (Wall/Column Ties) all as specified	0.00	Kg	9-22	156.13	-
34	S/F of water proof **building or insulating paper** weighing 3.92 Kg per 10 sqm and fix in any position with 50mm side and 150mm end laps and nailing as described for felt.	0	Sqm	10-99	89.75	-
35	S/F **water closet Asiatic pattern** (light colour including foot rest, full Orrisa pattern or equivalent) 13 lit flushing cistern low down, plastic flush pipe, etc. fixed to concrete, brick, stone or wood work , best quality Pak made	2.00	Each	17-24	5951.33	11,902.66
36	S/F **water closet apparatus European pattern**, complete (Coupled Set) comprising closet, 13 litres flushing cistern glazed in light colour seat cover complete set (IFO Pattern or equivalent width not less than 380mm) fixed to concrete brick stone or wood work best quality Pak Made	6.00	Each	17-9	9205.08	55,230.48
37	S/F **sink scullery** of stainless steel with single drainage board complete, shallow or deep pattern up to 6000 sqcm, super, fixed to concrete, brick, stone or wood. (Pak Made) including fittings accessories etc. as required.	2.00	Each	17-58	11110.52	22,221.04

Sr	Description	Qty	Unit	Item No.	Rate	Amount
38	S/F vanity bowl glazed ware one hole complete with bottle trap waste coupling chain & plug etc. (except mixer) best quality fixed to concrete, brick, stone and marble slab in any size shape **Light** colour	2.00	Each	17-137	6377.38	12,754.76
39	S/F 25mm thick white / coloured marble slab around vanity bowl with brackets etc. including cutting in shape with machine rubbing, polishing, and making the joints water tight, fixed to concrete, brick, or stone work.	0	Sqm	17-139	4181.72	-
40	Supply and fix **mirror,** any shape and pattern, 5mm thick imported edges ground complete, fixed to concrete, brick, stone, or wood work.	3.9	Sqm	17-97	1625.87	6,340.89
41	Supply and fix **plastic shelf** complete in any size and shape, Pak Made with plugs and screws, fixed to concrete, brick or stone work.	2.00	Each	17-101	1055.35	2,110.70
42	Supply and fix **soap/sponge tray** any shape, pattern and size, Pak Made, complete with plugs and screws etc. fixed to concrete, brick, stone or wood work.	8.00	Each	17-108	407.69	3,261.52
43	Supply and fix **towel rail**, chromium plated, single rod, any pattern shape and size, Pak made, with plugs screws etc., fixed to concrete, brick, stone or wood work.	8.00	Each	17-112	1041.88	8,335.04
44	Supply of fix 100mm, **CI floor trap** including reducer etc., complete.	7.00	Each	17-121	1365.09	9,555.63
45	Supply and fix **casted grating**, chromium plated, 150mm x 150mm.	0.00	Each	17-123	970.87	-

Sr	Description	Qty	Unit	Item No.	Rate	Amount
46	S/F **Toilet shower** best quality (Pak made) 15mm dia.	6.00	Each	17-141	814.16	4,884.96
47	S/F of Sink Mixer (700) Victorian all as specified	2.00	Each	28-338 18-228	2335.28	4,670.56
48	S/F of **C.P mixer** 15mm diameter, fancy head any pattern and shape, screw down high pressure, lettered "HOT" and "COLD" with long screwed channels and fly nuts. Complete	6.00	Each	18-227	1106.33	6,637.98
49	S/F **toilet paper holder** any shape, pattern and size, Pak Made, complete with plugs and screws etc. fixed to concrete, brick, stone or wood work.	6.00	Each	17-107	505.64	3,033.84
50	S/F of **Bath Mixer** Bravo (4021) any type and colour Pak Made	6.00	Each	17-142 28-505	4640.99	27,845.94
51	Provision of **Grease Trap** Complete as per specified	2.00	Each	J/R	6,116.01	12,232.02
52	S/F of **Wardrobe** complete all as specified	3.00	Each	J/R	61,980.37	185,941.1 1
53	S/F of **Single chimney stack** as per IS Arch No. 16 for Flow Pipe all as specified	2.00	Each	J/R	2,921.35	5,842.69
	FLOORINGS					
54	P/L **cement concrete 1:4:8** laid under floors using crushed or broken stone	17.6	Cum	12-03	4753.73	83,665.65
55	P/L CC **Type 'B"** using crushed or broken stone laid in floor slabs, as under layer for Terrazzo / Stonolithic / tiles top finished.	17.6	Cum	12-19	5818.28	102,401.7 3
56	P/L of white / light colour/ glazed/non-skid tiles exceeding 400 Sq Cm but not exceeding 900 Sq Cm area each, on walls and floors, set in neat cement and joints grouted with white /colour cement complete all as specified.(Pak made).	196.28	Sqm	12-52	1527.13	299,745.0 8

Sr	Description	Qty	Unit	Item No.	Rate	Amount
57	P/L **10/12mm** thick white/colour marble tiles (except green and yellow) on walls and floors laid, jointed and grouted in white / coloured cement (1: 2) including rubbing and chemical polishing complete.	195.5	Sqm	12-80	949.12	185,552.96
58	P/L **20/22mm** thick white/colour marble slab (except green and yellow) exceeding 900 SqCm but not exceeding 1.00 Sqm each on walls and floors laid, jointed and grouted with white / coloured cement (1: 2) including rubbing and chemical polishing complete.	159.39	Sqm	12-76	2030.78	323,686.02
59	P/L of white / light colour/ glazed/non-skid tiles exceeding 900 Sqcm each, on walls and floors, set in neat cement and joints grouted with white /colour cement complete all as specified.(Pak made).	0	Sqm	12-54	1651.86	-
60	P/L 75mm thick CC Type 'C' as in **plinth protection**, surface finished and smoothed with neat cement and steel trowel, including form work, using crushed or broken stone.	41.39	Sqm	12-106	419.19	17,350.27
	MISC					
61	S/F of **MS stair railing** complete all as per drawing	17.93	Mtr	S/R	1262.63	22,638.89
62	S/F of **MS deck balcony utility railing** complete all as per drawing	24.89	Mtr	S/R	1167.93	29,069.76
					Total RS.	**7,229,820.00**

3.3.3.3.3 Electrical services

Table 3-12: Bill of Quantities - Services (Electrical)

S#	Description	Unit	This Bill Quantity	Sch Item	Rate (Rs)	Amount (Rs)
1	S/F wiring for one point light controlled by one Switch with S/core PVC 1.5mm2 Cable in PVC conduit conceal	Point	96	24-12	1707.47	163917.12
2	-Do-but fan points	Point	43	24-12	1707.47	73421.21
3	-Do-but Bell Point	Point	4	24-12	1707.47	6829.88
4	-Do-but 5 Amp Socket point controlled by 1 switch with s/core PVC 1.5mm² cable in PVC Conduit (rate including earth wire)	Point	53	24-150	2022.76	107206.28
5	-Do-but 15Amp socket point control by one Switch with single core PVC 2.5mm2 Cable in PVC conduit concealed (rates including earth wire) for power and light plugs	Point	6	24-167	2289.17	13735.02
6	-Do-but for ACs (cooling units)	Point	4	24-167	2289.17	9156.68
7	-Do-but for circuits (Without Conduit)	Point	17	24-182 -24-158	430.93	7325.81
8	S/F Bulk head fitting with guard	Each	4	27-277	730.05	2920.20
9	LED 12 watt ultra slim round Light (similar rate as SI 29-339)	Each	58	29-339 + 24-278	2200.90	127652.20
10	LED 12 watt Surface type	Each	28	prov star Rate	1800.00	50400.00
11	S/F Bath Light Fancy	Each	8	prov star Rate	4500.00	36000.00

S#	Description	Unit	This Bill Quantity	Sch Item	Rate (Rs)	Amount (Rs)
12	S/F Caset Type Fan 2'x2' (Pak fan)	Each	13	prov star Rate	7550.00	98150.00
13	S/F Fan Elect with blades canopy and rod, connection, provision of cables 140cm sweep including clamp hook box type concealed	Each	20	24-533 + 24-530	4391.75	87835.00
14	S/F Exhaust Fan size 20cm plastic body (Pak fan)	Each	10	24-703	2618.47	26184.70
15	S/F Switch 2 Gang	Each	18	24-764	321.00	5778.00
16	S/F Switch 6 Gang	Each	17	24-767	674.14	11460.38
17	S/F Switch 8 Gang	Each	15	24-768	772.08	11581.20
18	S/F S/Socket 3 pin 5Amp (imported)	Each	27	prov star Rate	450.00	12150.00
19	S/F Bell push single 10 amp 250v	Each	-	24-514	114.33	
20	S/F Bell Buzzer Bakelite case 200/250v	Each	1	24-520	188.92	188.92
21	S/F Distribution board steel sheet (16 BG) with hinged covered suitable for fixing of different capacities of MCCB Size 1/.3mx.3m	Sqm	0.09	24-753	20510.86	1845.98
22	-Do-but Size 3/.48mx.63m	Sqm	0.00	24-753	20510.86	0.00
23	-Do-but Size 2/.38mx.53m	Sqm	0.00	24-753	20510.86	0.00
24	-Do-but Size 1/.53mx.71m (MDB Lighting)	Sqm	0.00	24-753	20510.86	0.00
25	-Do-but Size 1/.58mx.83m (MDB HVAC)	Sqm	0.00	24-753	20510.86	0.00
26	S/F MCCB TP 20 Amp	Each	0	24-390	4388.36	0.00
27	S/F MCCB TP 30 Amp	Each	0	24-391	4588.79	0.00

S#	Description	Unit	This Bill Quantity	Sch Item	Rate (Rs)	Amount (Rs)
28	S/F MCCB TP 100 Amp	Each	1	24-393	8896.45	8896.45
29	S/F TV Antenna socket	Each	3.00	24-778	198.19	594.57
30	S/F Telephone socket	Each	3.00	24-778	198.19	594.57
31	S/F Special earth (For MDB's) having water table up to 3 m depth	Each	2.00	24-468	19609.41	39218.82
32	S/F PVC conduit 20mm diameter complete with all fitting for concealed wiring	Mtr	279.68	24-501	292.16	81711.31
33	S/F Co-axial Cable .8mm² sc 2v,75 ohm (for TV)	Mtr	35.23	24-811	83.86	2954.39
34	Telephone Cable 5 pair Copper conductor 0.6mm diameter PE insulated PVC Sheathed	Mtr	44.56	24-781	97.80	4357.97
35	S/F UPVC pressure pipe 50mm diameter class D complete with solvent socket (for elect cable)	Mtr	0.00	18-460	379.75	0.00
36	S/F wiring and conduit Concealed with s/core PVC insulated 6mm² (For ECC)	Mtr	0.00	24-665	124.76	0.00
37	S/F wiring and conduit Concealed with s/core PVC insulated 10mm² (For sub main cable)	Mtr	0.00	24-666	196.15	0.00
	Total Amount					992066.65

3.3.3.3.4 Sui Gas Services

Table 3-13: Bill of Quantites - Services (Sui Gas)

S#	**Description**	**Unit**	**Total Quantity**	**Sch Item**	**Rate (Rs.)**	**Amount (Rs.)**
1	S/F polyethylene (PE) Gas Pipe class MDPE-80 yellow pipe (SDR-11) 50mm diameter	Mtr	1.53	26-108	466.69	714.04
2	Excavation up to 1.5m depth in to hard soil and making embankment of same	Cum	0.83	01-2+01-15-01-23-01-24	403.34	333.24
3	S/F tubes water quality GI with all fittings (i.e. sockets, bends, tees, elbows where required) and laid complete in trenches (exclusive of excavation) or fixed to walls, ceiling and floors etc. including caps and plugs as required 15mm diameter (Medium).	Mtr	15.68	18-9	334.12	5239.00
4	-do-but 20mm diameter	Mtr	96.46	18-10	423.51	40851.77
5	-do-but 40mm diameter	Mtr	8.08	18-12	686.40	5546.11
6	-do-but 50mm diameter	Mtr	0.00	18-13	944.02	0.00
7	S/F Brass valve ball type screwed both ends complete with steel handle 15mm diameter	Nos	13.00	26-40	387.96	5043.48
8	-do-but 20mm diameter	Nos	3.00	26-41	759.37	2278.11
9	-do-but 50mm diameter	Nos	0.00	26-42+26-42	2016.74	0.00
10	S/F Union Socket GI, screwed BSP, 15mm diameter,	Nos	17.00	18-148	109.50	1861.50
11	S/F Union Socket GI, screwed BSP, 20mm diameter,	Nos	14.00	18-149	143.46	2008.44

S#	Description	Unit	Total Quantity	Sch Item	Rate (Rs.)	Amount (Rs.)
12	S/F Union Socket GI, screwed BSP, 40mm diameter,	Nos	3.00	18-151	341.79	1025.37
13	S/F Union Socket GI, screwed BSP, 50mm diameter,	Nos	1.00	18-152	476.79	476.79
14	S/F Valves peat pattern, strong gunmetal, high pressure, Full-way valves with iron wheel head screwed both ends for iron pipe,20mm diameter,	Nos	19.00	18-249	761.01	14459.19
15	-do-but 25mm diameter	Nos	0.00	18-250	1014.63	0.00
16	-do-but 40mm diameter	Nos	3.00	18-251	1576.52	4729.56
17	-do-but 50mm diameter	Nos	1.00	18-252	2380.58	2380.58
18	S/F non Return Valve 25mm diameter	Nos	3.00	18-271	586.12	1758.36
19	S/F Gas water heater complete with burner pilot ,thermostat and safety valve 136 Litre Capacity	Nos	2.00	26-56	23400.21	46800.42
	Total Amount					**135505.96**

3.3.3.3.5 Water supply services

Table 3-14: Bill of Quantities - Services (Water Supply)

S #	Description	Quantity	Unit	Sch Item	Rate (Rs.)	Amount (Rs.)
1	S/F tubes water quality GI with all fittings (i.e. sockets, bends, tees, elbows where required) and laid complete in trenches (exclusive of excavation) or fixed to walls, ceiling and floors etc. including caps and plugs as required 25mm diameter (light).	40.84	Mtr	18_3	415.77	16980.05
2	-do-but 50mm diameter	10.89	Mtr	18-5	832.43	9065.16
3	S/F Union Socket GI, screwed BSP, 25mm diameter	3.00	Each	18-150	174.07	522.21
4	S/F Union Socket GI, screwed BSP, 50mm diameter	1.00	Each	18-152	476.79	476.79
5	S/F Valves peats pattern, strong gunmetal, high pressure, Full-way valves with iron wheel head screwed both ends for iron pipe, 25mm diameter	4.00	Each	18-250	1014.63	4058.52
6	-do-but 50mm diameter	1.00	Each	18-252	2380.58	2380.58
7	S/F non Return Valve 25mm diameter	2.00	Each	18-271	586.12	1172.24
8	S/F non Return Valve 50mm diameter	1.00	Each	18-273	780.72	780.72
9	S/F Foot valve complete with Strainer 50mm diameter	1.00	Each	18-310	1883.49	1883.49
10	S/F Ball/Foot valve ,Brass (Corydon) other approved pattern with copper ball 50mm diameter	0.00	Each	18-307	6175.91	0.00
11	S/F PE pipes (Polyethylene PE-100) 63mm diameter class PN-10/SDR-17	0.00	Each	18-687	434.70	0.00
12	Excavation up to 1.5m depth in to hard soil and making embankment of same	2.44	Mtr	01-2+01-15-01-23-01-24	403.34	984.15

S #	Description	Quantity	Unit	Sch Item	Rate (Rs.)	Amount (Rs.)
13	S/F Water tank Polyethylene (PE) vertical 1360 litters (300 gallon capacity)	0.00	Each	18-393	23824.12	0.00
14	S/F PPR Pipe (poly propylene random) with all fittings i.e. socket bend tee elbow where required 32mm diameter class PN-20(excluding excavation)	38.44	Mtr	18-895	333.17	12807.05
15	-do-but 63mm diameter	0.00	Mtr	18-898	1253.23	0.00
16	S/F Bib cock, brass, CP, Fancy type Screwed down, BSP, 25 mm diameter	4.00	Each	18-215	819.49	3277.96
17	Double Bib Cock brass chromium plated fancy type screwed down B.S.P 25 mm diameter, supply and fixing. (Toilet bib cock Double)	5.00	Each	18-219	1493.40	7467.00
18	S/F toilet shower best quality	6.00	Each	17-141	814.16	4884.96
19	S/F Tee cocks, brass chromium plated, screw down, high pressure, fancy type, 15mm diameter but tee stop cock with CP pipe.	23.00	Each	18-235	304.77	7009.71
20	S/F Ablution mixer chrome	0.00	Each	28-448 + 18-228	6507.28	0.00
21	S/F Gas instant water Geyser 10 Litres capacity.	3.00	Each	Prov Star Rate	9500.00	28500.00
22	Water tank (Polyethylene) 500 gallon	1.00	Each	18-395	35000.00	35000.00
23	S/F Centrifugal pumping set, AC, electric motor driven, 220/230v, SP, 50 cycles size 2"x2" (suction /delivery), mounted on a common channel base, similar rate as SI 19-3	1.00	Each	19-3	31061.87	31061.87
	Total Amount					168312.46

3.3.3.3.6 Drainage services

Table 3-15: Bill of Quantities - Services (Drainage)

Sr	Description	Qty	Unit	Item No.	Rate	Amount
1	Supply and fix UPVC Soil and waste pipe 75mm bore (outside diameter) complete with plain end and solvent cement joint as specified.	32.96	Mtr	20-90	720.83	23,758.56
2	Supply and fix UPVC Soil and waste pipe 110mm bore (outside diameter) complete with plain end and solvent cement joint as specified.	24.34	Mtr	20-91	1045.3	25,442.60
3	Supply and fix UPVC Soil and waste pipe 160mm bore (outside diameter) complete with plain end and solvent cement joint as specified.	3.96	Mtr	20-92	2285.11	9,049.04
4	Supply and fix UPVC Vent pipe 50mm bore (outside diameter) complete with plain end and solvent cement joint as specified	13.41	Mtr	20-96	281.91	3,780.41
5	Supply and fix 75mm diameter UPVC Elbow/bend 90^0 complete with solvent cement joint all as specified	7.00	Each	20-116	382.92	2,680.44
6	Supply and fix 110mm diameter UPVC Elbow/bend 90^0 complete with solvent cement joint and rubber ring all as specified	2.00	Each	20-117	707.39	1,414.78
7	Supply and fix Eccentric Reducer 50mm x 110mm diameter complete with solvent cement joint all as specified	4.00	Each	20-132	367.03	1,468.12
8	Supply and fix PVC Access/door tee 75mm diameter complete with solvent cement joint all as specified	5.00	Each	20-146	628.71	3,143.55
9	Supply and fix PVC Access/door tee 110mm diameter complete	5.00	Each	20-147	3062.67	15,313.35

Sr	Description	Qty	Unit	Item No.	Rate	Amount
	with solvent cement joint all as specified					
10	Supply and fix PVC Vent Cowl 50 mm diameter on top of ventilating pipes	4.00	Each	20-176	97.18	388.72
11	Supply and fix UPVC Vent Cowl 75mm diameter on top of ventilating pipes	0.00	Each	20-177	120.45	-
12	Excavate for, dispose of surplus spoil on site, make good surface distributed, supply (230mm x 230mm x 100mm out let) surface gullies and bed and surround in 100mm of cement concrete type 'C' provide 100mm x 125mm rounded cement concrete type 'C' curb or 900mm x 900mm x 100mm dished cement concrete type 'C' top and 250 x 250mm galvanised cast iron loose grating complete.	2.00	Each	21-19	1570.84	3,141.68
13	Man-holes complete rectangular or circular as described not exceeding 600mm deep form inverted to surface of cover, including main channel set in CM 1:1, 230mm thick brick walls.	0	Cum	21-25	26180.2	-
14	Manhole complete rectangular or circular as described, exceeding 600mm but not exceeding 1800mm deep with iron steps (in angles 380mm centres), 230mm thick brick walls.	1.9	Cum	21-29	20528.47	39,004.09
15	P/L RCC **type B** manhole cover (precast complete with angle iron frame embedded in concrete all as per information sheet No. Svcs-341 dated 10-11-99.	2.00	Each	21-35	4454.27	8,908.54
					Total RS.	**137,493.88**

3.3.3.3.7 Finishes

Table 3-16: Bill of Quantities - Finishes

Sr	Description	Qty	Unit	Item No.	Rate	Amount
1	Three coat of **Distempering with POLYVINYL distemper** or equivalent, on new or old surface	2225.141001	Sqm	15-06 15-07 15-07	108.94	242,406.86
2	Three coat of **weather shield paint** on exterior wall on new surface.	1004.522915	Sqm	15-90 15-91 15-91	253.4	254,546.11
3	**Roof insulation** complete as per IS Arch 33 type all as specified	253.23	Sqm	C/R	1796.87	455,021.33
					Total RS.	**951,974.30**

3.3.3.3.8 Final Sheet

Table 3-17: Bill of Quantities - Final Summary Sheet

Sr	Element	Sub-element	Cost (PKR)	Total Elemental Cost (PKR)
1	Substructure			4463937
		Earthwork	53304	
		Foundations	952223	
		Basement	3458410	
2.	Superstructure			6903150
		Masonry	2505550	
		Concrete	1833720	
		Doors	600882	

Sr	Element	Sub-element	Cost (PKR)	Total Elemental Cost (PKR)
		Windows	484560	
		Fittings	414329	
		Floorings	1012401	
		Misc	51708	
3.	Services			1433378
		Electrical	992066	
		Sui Gas	135505	
		Water Supply	168312	
		Drainage	137493	
4.	Finishes			951974
			Total	*13752446*
			Unforeseen 5%	*687622*
			Contractor's margin 10%	*1375245*
5.			**GROSS TOTAL (Nearest 1k)**	**15816000**

3.3.3.4 Final Summary Sheets of Bills of Quantities

The tables above show the comprehensive cost estimation of a plan, derived systematically from the elemental breakdown, followed by the quantity take-offs and pricing of the quantities obtained from the taking-off. The detailed plans, quantity take-off sheets and bills of quantities will be available with the soft copy package of the project, however, final summary sheets of the detailed bills of quantities of all the plans have been included in this document. These are as follows:

3.3.3.4.1 Plan 1: 5 Marla double storey (A-1-a)

Table 3-18: BQ Final Summary Sheet - (A-1-a)

Sr	Element	Sub-element	Cost (PKR)	Total Elemental Cost (PKR)
1	Substructure			560870
		Earthwork	29224	
		Foundations	530946	
2.	Superstructure			3310395
		Masonry	1255227	
		Concrete	773701	
		Doors	482438	
		Windows	218690	
		Fittings	182288	
		Floorings	374501	
		Misc	27550	
3.	Services			785532
		Electrical	515555	
		Sui Gas	81382	
		Water Supply	115182	
		Drainage	73413	
4.	Finishes			422093
			Total	*5078895*
			Unforeseen 5%	*253944*
			Contractor's margin 10%	*507889*
5.			**GROSS TOTAL (Nearest 1000)**	**5841000** @ 2710 /sf

3.3.3.4.2 Plan 2: 5 Marla double storey (A-1-b)

Table 3-19: BQ Final Summary Sheet - (A-1-b)

Sr	**Element**	**Sub-element**	**Cost (PKR)**	**Total Elemental Cost (PKR)**
1	Substructure			522692
		Earthwork	29598	
		Foundations	493094	
2.	Superstructure			2536380
		Masonry	862675	
		Concrete	610008	
		Doors	358050	
		Windows	237665	
		Fittings	148169	
		Floorings	296702	
		Misc	23111	
3.	Services			673163
		Electrical	424772	
		Sui Gas	72563	
		Water Supply	108350	
		Drainage	67478	
4.	Finishes			303270
			Total	*4035511*
			Unforeseen 5%	*201775*
			Contractor's margin 10%	*403551*
5.			**GROSS TOTAL (Nearest 1000)**	**4641000** @ 2433 /sf

3.3.3.4.3 Plan 3: 5 Marla double storey with basement (A-2-a)

Table 3-20: BQ Final Summary Sheet - (A-2-a)

Sr	**Element**	**Sub-element**	**Cost (PKR)**	**Total Elemental Cost (PKR)**
1	Substructure			1809794
		Earthwork	10624	
		Foundations	224190	
		Basement	1574980	
2.	Superstructure			3104871
		Masonry	1172259	
		Concrete	664234	
		Doors	390888	
		Windows	277182	
		Fittings	267754	
		Floorings	304067	
		Misc	28487	
3.	Services			876102
		Electrical	620613	
		Sui Gas	78432	
		Water Supply	108762	
		Drainage	68295	
4.	Finishes			355449
			Total	*6146224*
			Unforeseen 5%	*307311*
			Contractor's margin 10%	*614622*
5.			**GROSS TOTAL (Nearest 1000)**	**7069000** @ 3149 /sf

3.3.3.4.4 Plan 4: 5 Marla double storey with basement (A-2-b)

Table 3-21: BQ Final Summary Sheet - (A-2-b)

Sr	**Element**	**Sub-element**	**Cost (PKR)**	**Total Elemental Cost (PKR)**
1	Substructure			1807121
		Earthwork	8136	
		Foundations	401731	
		Basement	1397254	
2.	Superstructure			2970895
		Masonry	1018362	
		Concrete	708575	
		Doors	410997	
		Windows	252724	
		Fittings	203936	
		Floorings	341379	
		Misc	34922	
3.	Services			837017
		Electrical	579746	
		Sui Gas	76843	
		Water Supply	108993	
		Drainage	71435	
4.	Finishes			347217
			Total	*5962258*
			Unforeseen 5%	*298112*
			Contractor's margin 10%	*596225*
5.			**GROSS TOTAL (Nearest 1000)**	**6857000** @ 2503 /sf

3.3.3.4.5 Plan 5: 10 Marla double storey (B-1-a)

Table 3-22: BQ Final Summary Sheet - (B-1-a)

Sr	**Element**	**Sub-element**	**Cost (PKR)**	**Total Elemental Cost (PKR)**
1	Substructure			904738
		Earthwork	51412	
		Foundations	853326	
2.	Superstructure			4640878
		Masonry	1670855	
		Concrete	1125440	
		Doors	575839	
		Windows	265689	
		Fittings	294434	
		Floorings	670537	
		Misc	38084	
3.	Services			957317
		Electrical	630854	
		Sui Gas	91350	
		Water Supply	135356	
		Drainage	99757	
4.	Finishes			575225
			Total	*7078164*
			Unforeseen 5%	*353908*
			Contractor's margin 10%	*707816*
5.			**GROSS TOTAL (Nearest 1000)**	**8140000** @ 2242 /sf

3.3.3.4.6 Plan 6: 10 Marla double storey (B-1-b)

Table 3-23: BQ Final Summary Sheet - (B-1-b)

Sr	**Element**	**Sub-element**	**Cost (PKR)**	**Total Elemental Cost (PKR)**
1	Substructure			939637
		Earthwork	52447	
		Foundations	887190	
2.	Superstructure			4107556
		Masonry	1317921	
		Concrete	1021506	
		Doors	454437	
		Windows	396676	
		Fittings	288365	
		Floorings	594107	
		Misc	34544	
3.	Services			921730
		Electrical	605959	
		Sui Gas	92328	
		Water Supply	124942	
		Drainage	98501	
4.	Finishes			524751
			Total	*6493679*
			Unforeseen 5%	*324683*
			Contractor's margin 10%	*649368*
5.			**GROSS TOTAL (Nearest 1000)**	**7468000** @ 2430 /sf

3.3.3.4.7 Plan 7: 10 Marla double storey with basement (B-2-a)

Table 3-24: BQ Final Summary Sheet - (B-2-a)

Sr	**Element**	**Sub-element**	**Cost (PKR)**	**Total Elemental Cost (PKR)**
1	Substructure			2881877
		Earthwork	17819	
		Foundations	390542	
		Basement	2473516	
2.	Superstructure			4668030
		Masonry	1743195	
		Concrete	1089451	
		Doors	587537	
		Windows	366190	
		Fittings	284901	
		Floorings	551851	
		Misc	44905	
3.	Services			1099836
		Electrical	772534	
		Sui Gas	96480	
		Water Supply	134753	
		Drainage	96069	
4.	Finishes			565551
			Total	*9215300*
			Unforeseen 5%	*460765*
			Contractor's margin 10%	*921530*
5.			**GROSS TOTAL (Nearest 1000)**	**10598000** @ 2392 /sf

3.3.3.4.8 Plan 8: 10 Marla double storey with basement (B-2-b)

Table 3-25: BQ Final Summary Sheet - (B-2-b)

Sr	**Element**	**Sub-element**	**Cost (PKR)**	**Total Elemental Cost (PKR)**
1	Substructure			2810487
		Earthwork	13775	
		Foundations	647566	
		Basement	2149146	
2.	Superstructure			4661767
		Masonry	1349661	
		Concrete	1373868	
		Doors	531870	
		Windows	376918	
		Fittings	283011	
		Floorings	680422	
		Misc	66017	
3.	Services			1154328
		Electrical	797522	
		Sui Gas	117469	
		Water Supply	137082	
		Drainage	102255	
4.	Finishes			702425
			Total	*9329015*
			Unforeseen 5%	*466450*
			Contractor's margin 10%	*932901*
5.			**GROSS TOTAL (Nearest 1000)**	**10729000** @ 2292 /sf

3.3.3.4.9 Plan 9: 20 Marla double storey (C-1-a)

Table 3-26: BQ Final Summary Sheet - (C-1-a)

Sr	**Element**	**Sub-element**	**Cost (PKR)**	**Total Elemental Cost (PKR)**
1	Substructure			1488163
		Earthwork	86666	
		Foundations	1401497	
2.	Superstructure			6948601
		Masonry	2586438	
		Concrete	1670637	
		Doors	667545	
		Windows	627171	
		Fittings	319902	
		Floorings	1030705	
		Misc	46203	
3.	Services			1222888
		Electrical	776253	
		Sui Gas	131014	
		Water Supply	166581	
		Drainage	149040	
4.	Finishes			853210
			Total	*10512869*
			Unforeseen 5%	*525643*
			Contractor's margin 10%	*1051287*
5.			**GROSS TOTAL (Nearest 1000)**	**12090000** @ 2306 /sf

3.3.3.4.10 Plan 10: 20 Marla double storey (C-1-b)

Table 3-27: BQ Final Summary Sheet - (C-1-b)

Sr	**Element**	**Sub-element**	**Cost (PKR)**	**Total Elemental Cost (PKR)**
1	Substructure			1478614
		Earthwork	86423	
		Foundations	1392191	
2.	Superstructure			6291059
		Masonry	2416891	
		Concrete	1634655	
		Doors	584767	
		Windows	426423	
		Fittings	288535	
		Floorings	878799	
		Misc	60989	
3.	Services			1117793
		Electrical	697582	
		Sui Gas	134583	
		Water Supply	164873	
		Drainage	120755	
4.	Finishes			829851
			Total	*9717323*
			Unforeseen 5%	*485866*
			Contractor's margin 10%	*911732*
5.			**GROSS TOTAL (Nearest 1000)**	**11175000** @ 2032 /sf

3.3.3.4.11 Plan 11: 20 Marla double storey with basement (C-2-a)

Table 3-28: BQ Final Summary Sheet - (C-2-a)

Sr	**Element**	**Sub-element**	**Cost (PKR)**	**Total Elemental Cost (PKR)**
1	Substructure			4463937
		Earthwork	53304	
		Foundations	952223	
		Basement	3458410	
2.	Superstructure			6903150
		Masonry	2505550	
		Concrete	1833720	
		Doors	600882	
		Windows	484560	
		Fittings	414329	
		Floorings	1012401	
		Misc	51708	
3.	Services			1433376
		Electrical	992066	
		Sui Gas	135505	
		Water Supply	168312	
		Drainage	137493	
4.	Finishes			951974
			Total	*13752446*
			Unforeseen 5%	*687622*
			Contractor's margin 10%	*1375245*
5.			**GROSS TOTAL (Nearest 1k)**	**15816000** @ 2323 /sf

3.3.3.4.12 Plan 12: 20 Marla double storey with basement (C-2-b)

Table 3-29: BQ Final Summary Sheet - (C-2-b)

Sr	**Element**	**Sub-element**	**Cost (PKR)**	**Total Elemental Cost (PKR)**
1	Substructure			4252742
		Earthwork	59395	
		Foundations	1219758	
		Basement	2973589	
2.	Superstructure			7288275
		Masonry	2525375	
		Concrete	1993057	
		Doors	710372	
		Windows	637239	
		Fittings	428619	
		Floorings	941981	
		Misc	51632	
3.	Services			1638148
		Electrical	1161049	
		Sui Gas	152470	
		Water Supply	176606	
		Drainage	148023	
4.	Finishes			974202
			Total	*14153375*
			Unforeseen 5%	*707668*
			Contractor's margin 10%	*1415337*
5.			**GROSS TOTAL (Nearest 1k)**	**16277000** @ 2340 /sf

4 COST ANALYSES

Cost analysis can be defined as 'the systematic breakdown of cost data to facilitate examination and comparison. Cost analysis should provide information for any immediate problem and can be performed in a number of ways. It can, for example, permit detailed comparisons to be made between different projects and isolate the causes of differences. These may arise from a variety of causes, such as differences in basic design or details of design; differences in regional pricing or differences in contracting conditions. Indeed, they could arise from a whole range of factors which tend to make every scheme unique in one respect or another. Cost analysis forms the basis of cost control. (Seeley, 1996)

The above quoted text efficiently elaborates the scope and utility of cost analyses. It dictates that the analyses is always relative and comparable. These comparisons are always statistically based on a sample set. It has been taken care of that the plans constituting the sample set are the most common and random plans which appeal to the average client and do not distort the objective of the analyses. The area sizes and the number of stories are also the most common in practice. A total of 12 plans should constitute a fair sample size to base the analyses on.

The analysis forms the brain of any research endeavor. It is just like the transmission system of a vehicle, where it harnesses the mechanical energy already produced by the internal combustion and paves a mechanism forward for its application. Similarly, the analyses for this partial fulfillment will try to make an earnest endeavor to extract the ripest of the already processed information with an aim to brew the finest wine of utility for the future clients and builders. Since these stakeholders are often worried about optimizing the value of their capital, they are always interested in trading-off within different options at the elemental and sub-elemental level. For example, a client may analyze and get to know the extra costs incurred with the basement and prefer to have an extra story instead of basement (provided the local by-laws permit it). Or he may find that the proportion of foundation work involved decreases in terms of capital, as the area of construction increases. All these financial aspects need to be identified and known to the client/contractor/consultant prior to the construction and come under the umbrella of cost planning.

The ultimate aim of cost analyses is to facilitate this process of cost-planning by identifying niches in the execution phase whereby client can save his capital by trading-off between such aspects, but without jeopardizing the functionality and efficiency. The applications of cost analyses as regards proposing a way forward to the cost planning/modelling of residential houses implies the following:

4.1 Comparison of preliminary and detailed estimates

To compare both the estimating approaches, they must be converted to the same units. For this reason, the estimated final costs in the detailed estimates have been converted to covered area rate. These covered area rates have also been mentioned along with their final costs in the final summary sheets of the respective bills of quantities in the preceding section. Moreover, as there had been two separate rates for both the “with” and “without” basement categories in the preliminary estimates, separate comparisons have been made for both the categories. Following is a graphical comparison of preliminary and detailed estimates.

4.1.1 Plans without basement

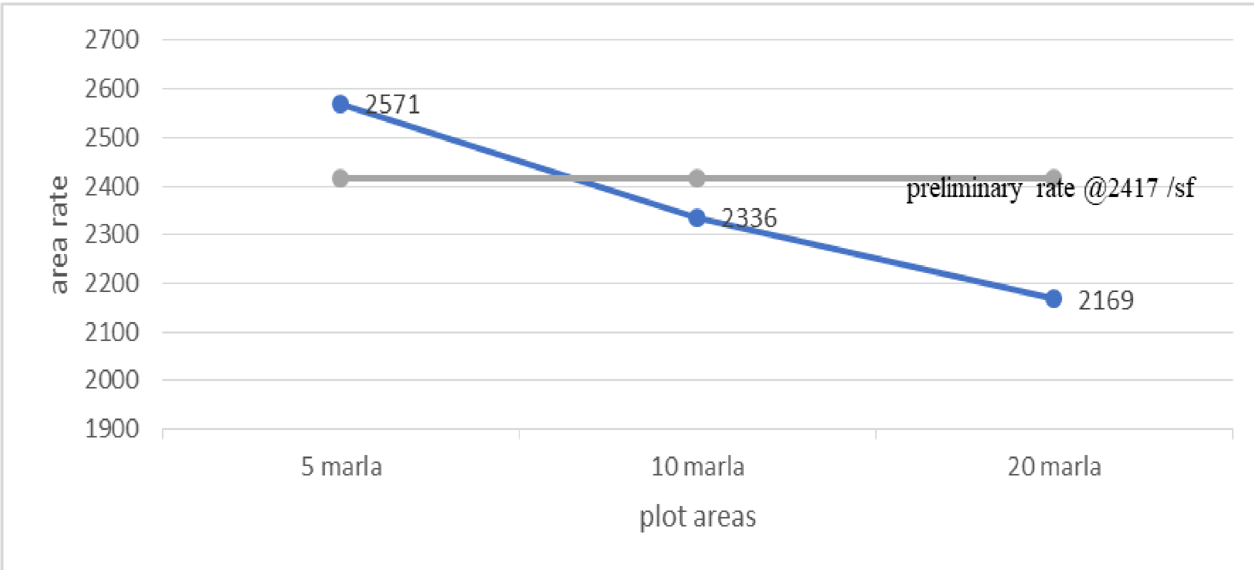

Figure 4-1: Preliminary VS Detailed Area Rate (Without Basement Category)

4.1.2 Plans with basement

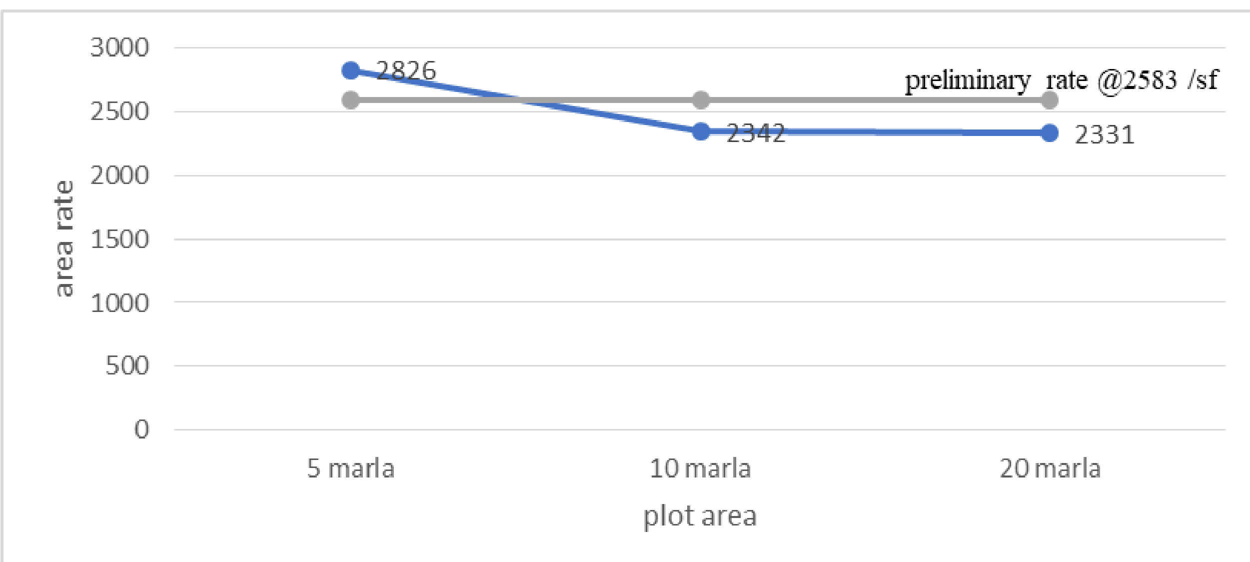

Figure 4-2: Preliminary VS Detailed Area Rate (With Basement Category)

4.2 Elemental cost proportion as part of the total cost

This section show the proportion of different elements in the total cost. This is deemed helpful to the stakeholders to assess the estimated proportion of an element in the total cost incurred. Many a times a scenario emerges when a client runs over-budget and chooses to trade-off between items in terms of quality and necessity. This pie chart analyses can provide such clients/stake holders with insights so as to readjust the prices of elements more efficiently in the estimating phase. This would serve to save them from any inconveniences and mishaps as regards cost management in the execution phase.

For this pie chart analyses, the plans were sorted category-wise and the charts generated after averaging the elemental costs and total costs in the same category. This has resulted in more random, stable and justified values when calculating proportion of that element in the total cost of one category e.g., the proportion of basement in the "10 marla with basement" category. Following are the charts:

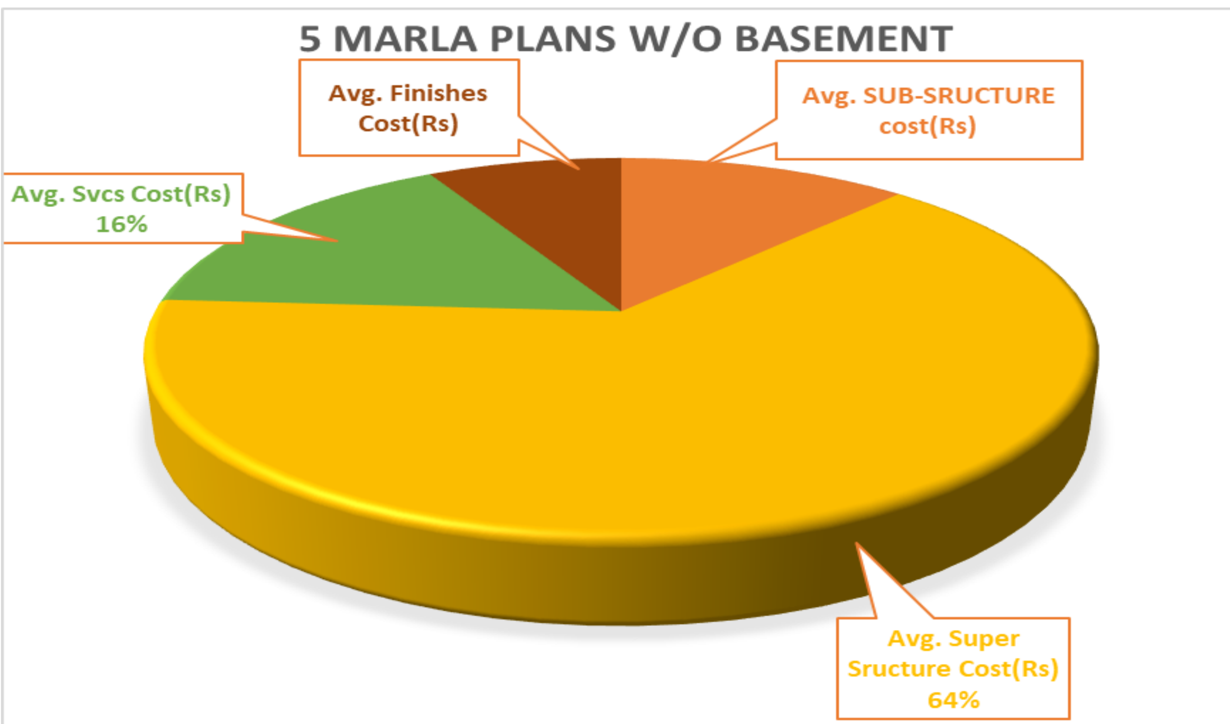

Figure 4-3: Cost Proportions - 5 Marla w/o Basement

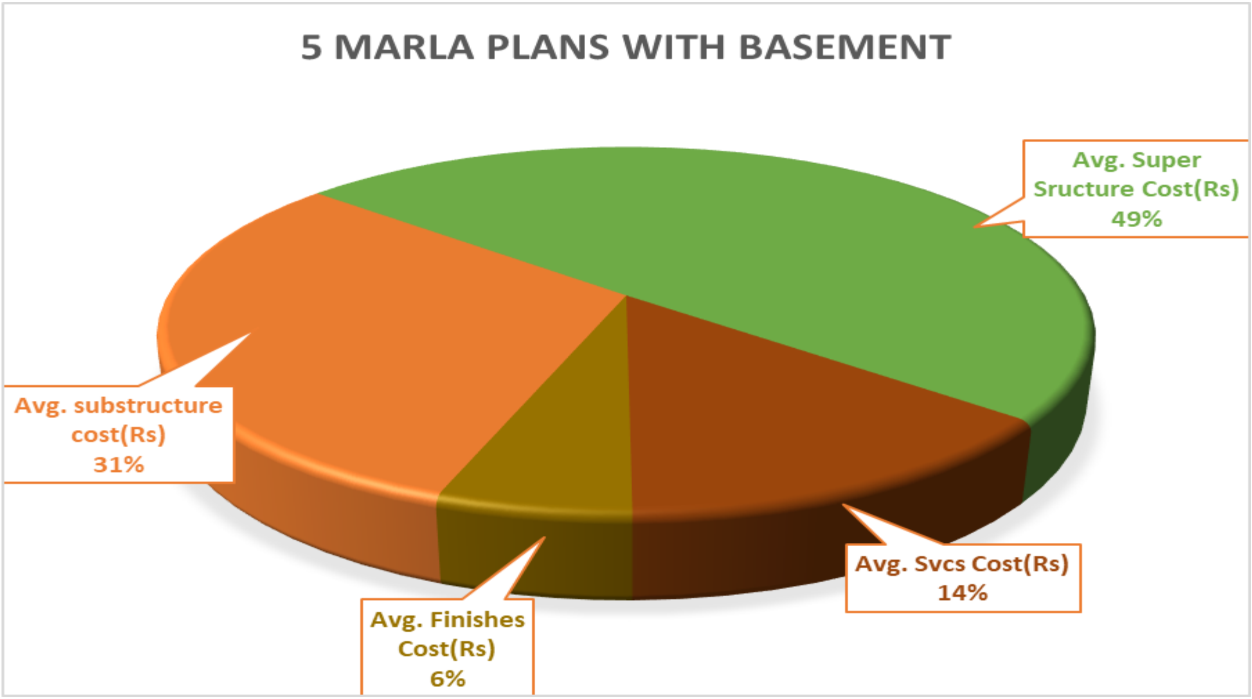

Figure 4-4: Cost Proportions - 5 Marla with Basement

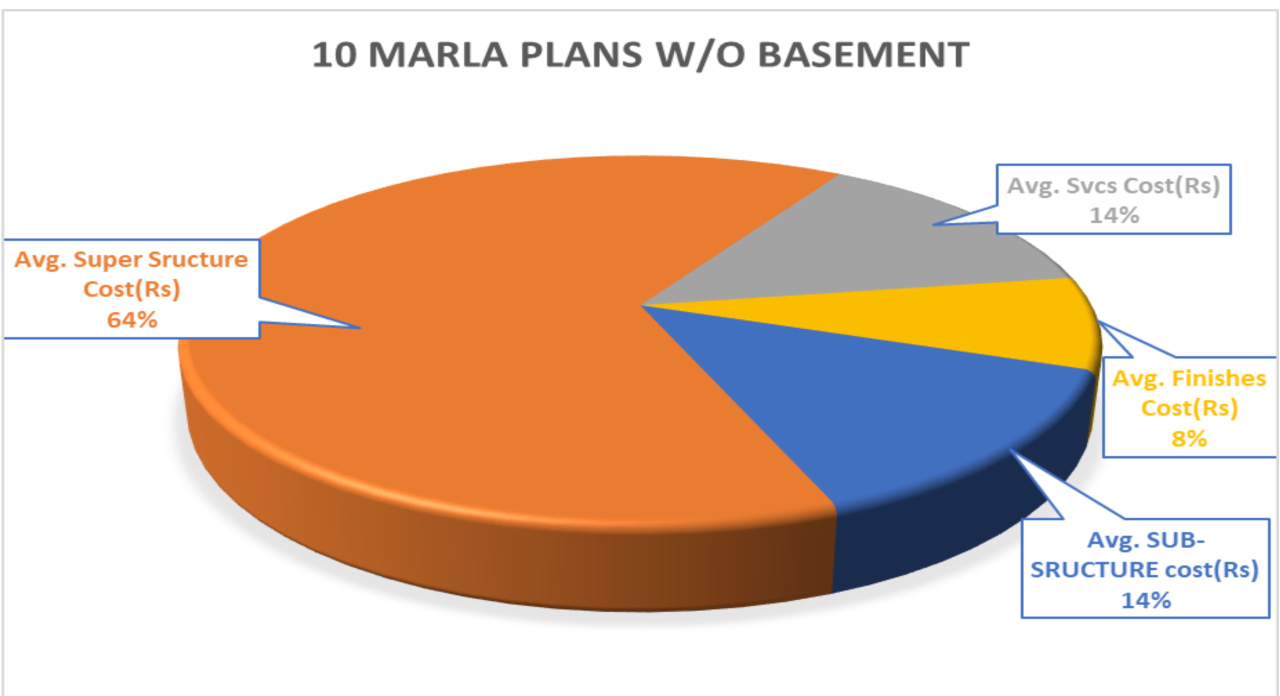

Figure 4-5: Cost Proportions - 10 Marla w/o Basement

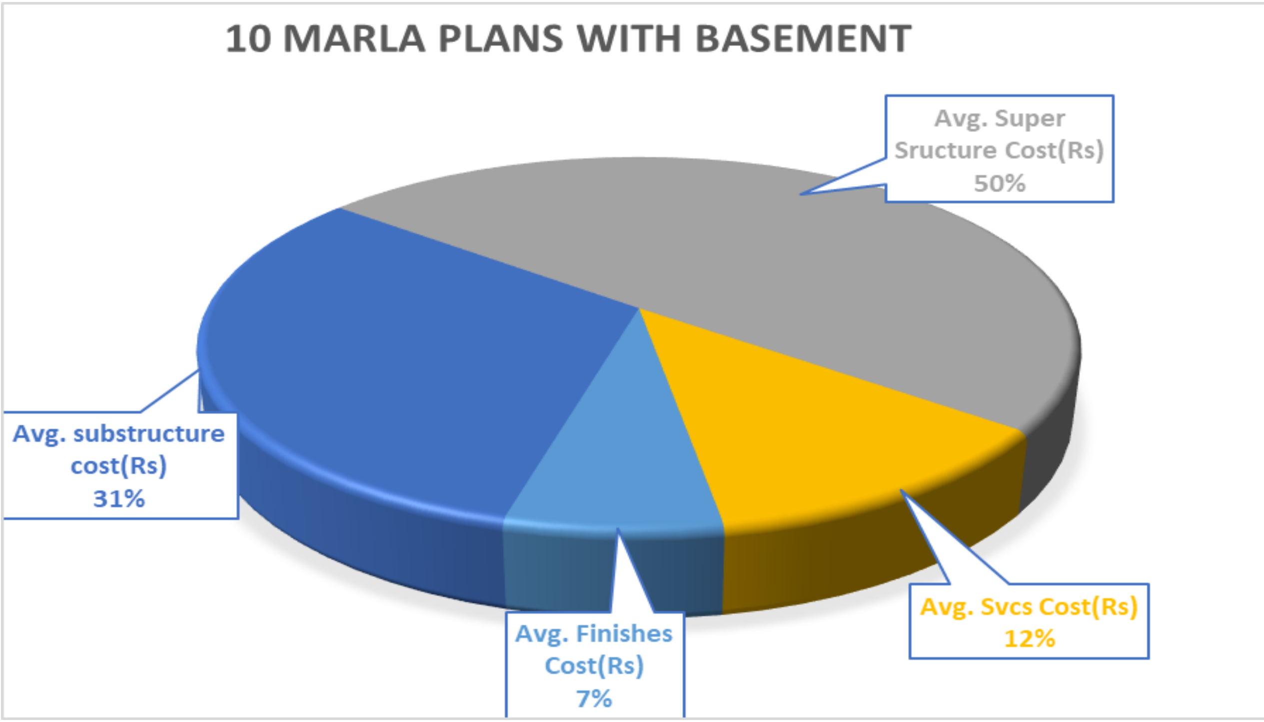

Figure 4-6: Cost Proportions - 10 Marla with Basement

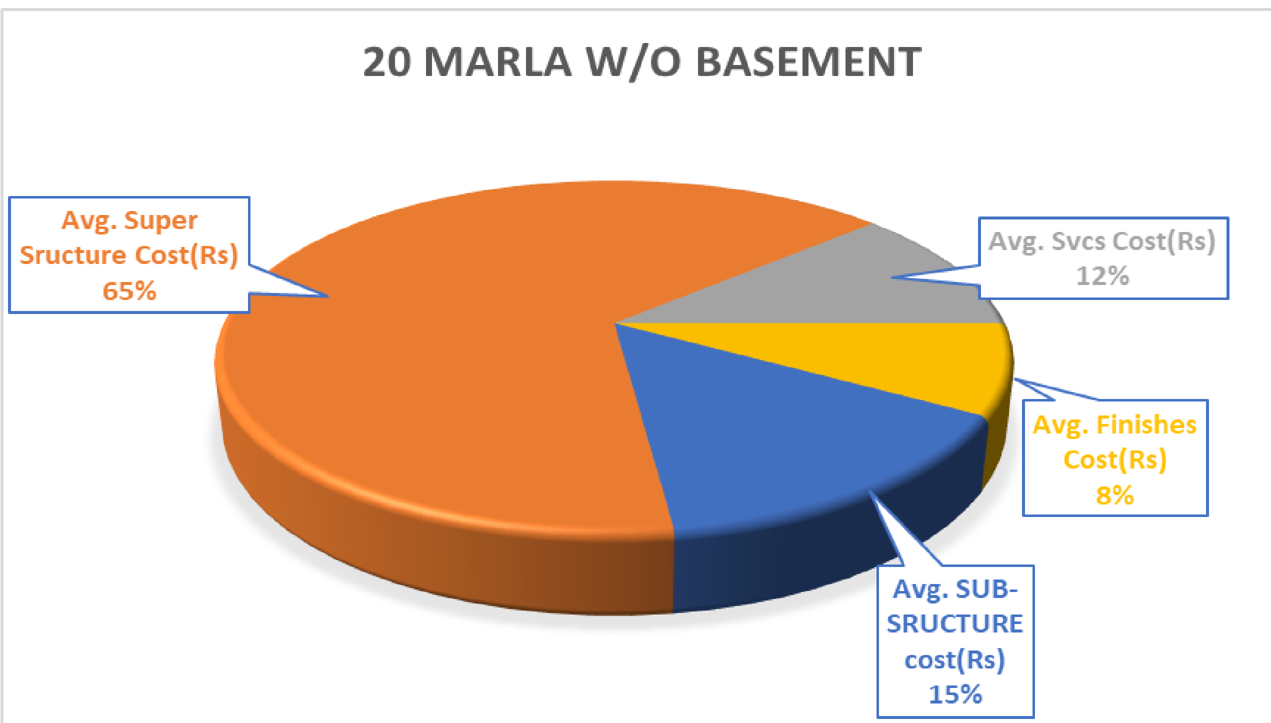

Figure 4-7: Cost Proportions - 20 Marla w/o Basement

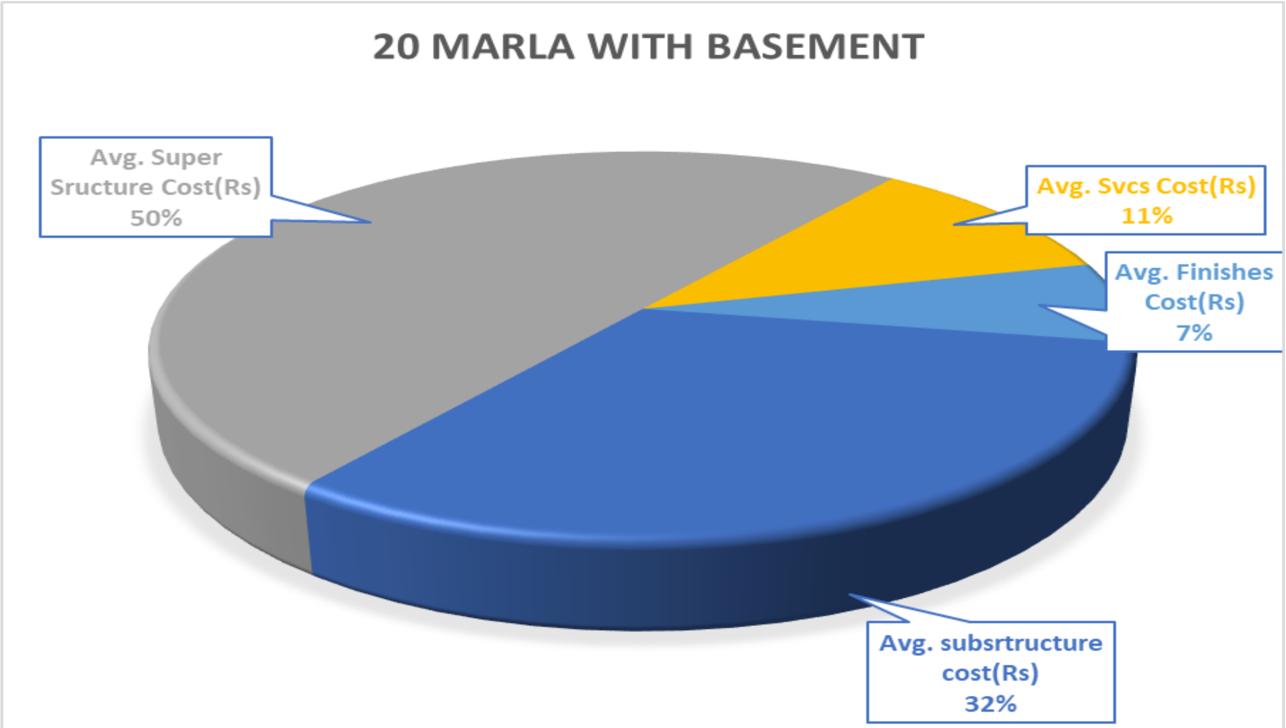

Figure 4-8: Cost Proportions - 20 Marla with Basement

4.3 Variation of elemental cost proportions in different area sizes

This part of the analyses shows, how the proportions of different elements in the total cost vary with increasing area sizes. For example, a graphical analyses may paint a picture of how the proportion of services varies as the area size increases. This may provide an insight to the client, where to save capital in order to utilize it elsewhere to increase the cost-effectiveness of the house. These insights will be suggested in the recommendations/cost modelling portion.

For this to materialize, all the key elements/sub-elements are identified which interest the most to the client in terms of assessing the cost-effectiveness of the whole residential construction. These areas of consideration are namely, "basement", "earthwork + foundation" (since these sub-elements go side-by-side), "masonry", "services", "concrete", "doors and windows", "floorings", and "finishes". For the same category of plans e.g., 5 marla with basement, the elemental costs and total costs have been averaged to come up to a more random, stable and justified value when calculating proportion of that element in the total cost. Following are some of these elemental evaluations:

4.3.1 Variation of basement proportion with increasing area

Figure 4-9: Variation of Basement Cost Proportion with Area

4.3.2 Variation of earthwork + foundation with increasing area

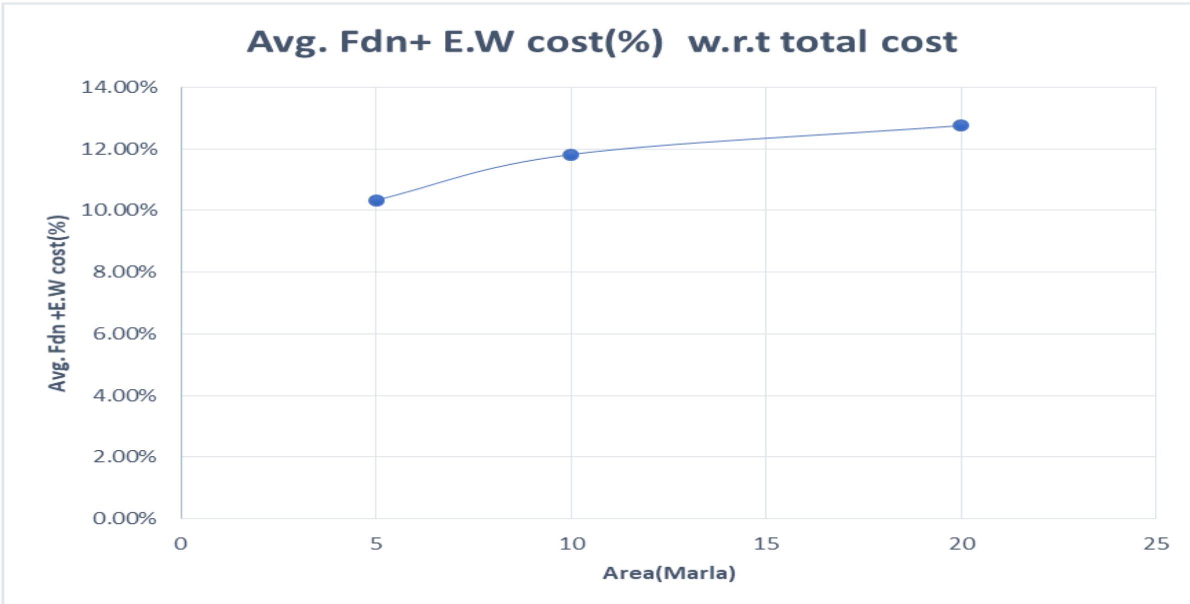

Figure 4-10: Variation of Earthwork + Foundation Proportion with Area

4.3.3 Variation of masonry with increasing area

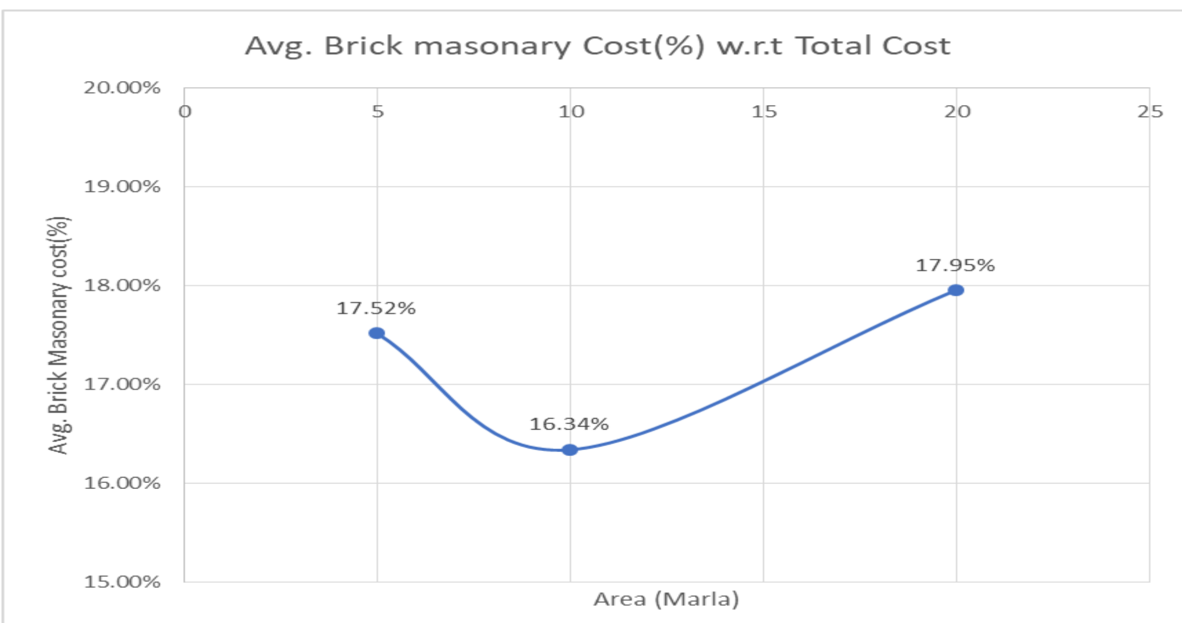

Figure 4-11: Variation of Masonry Proportion with Area

4.3.4 Variation of concrete with increasing area

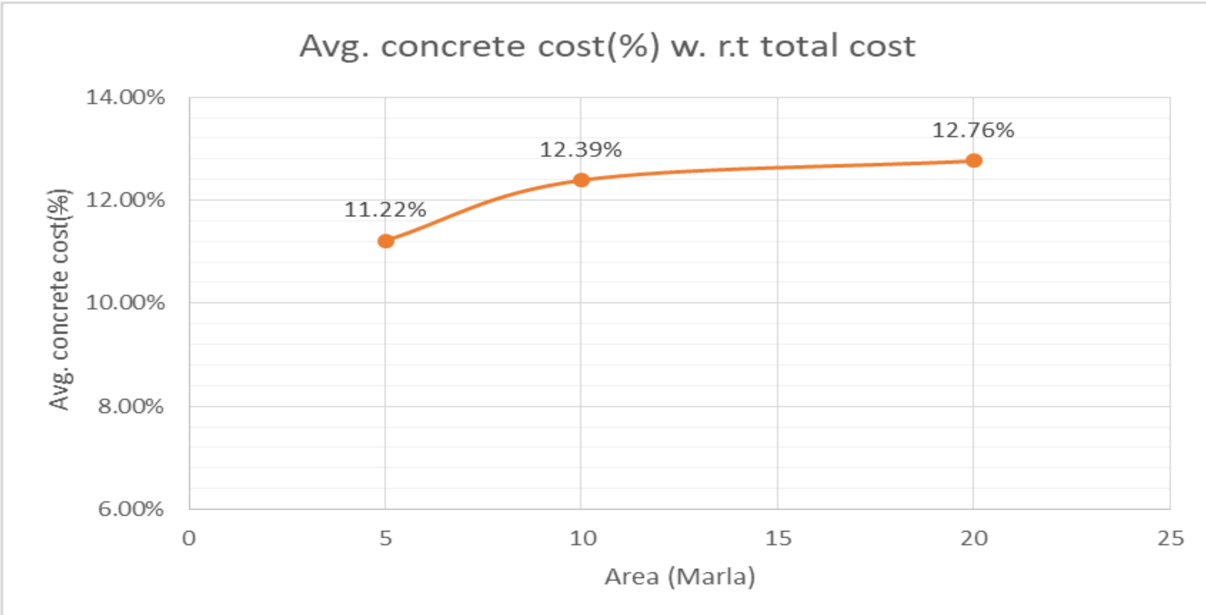

Figure 4-12: Variation of Concrete Proportion with Area

4.3.5 Variation of doors + windows with increasing area

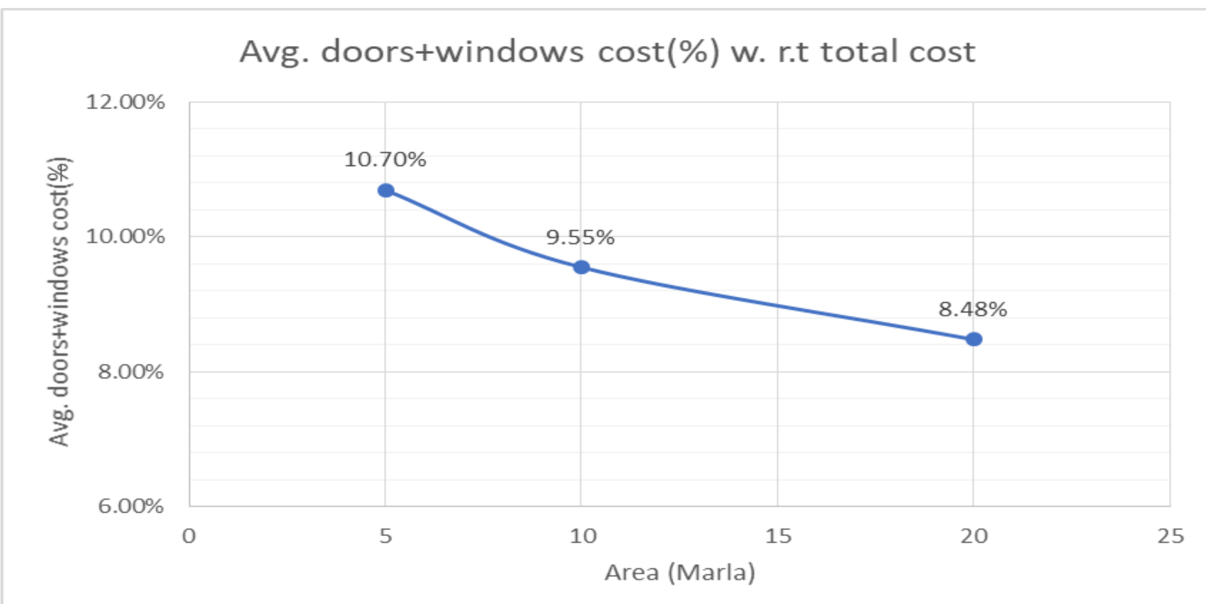

Figure 4-13: Variation of Doors & Windows Proportion with Area

4.3.6 Variation of floorings with increasing area

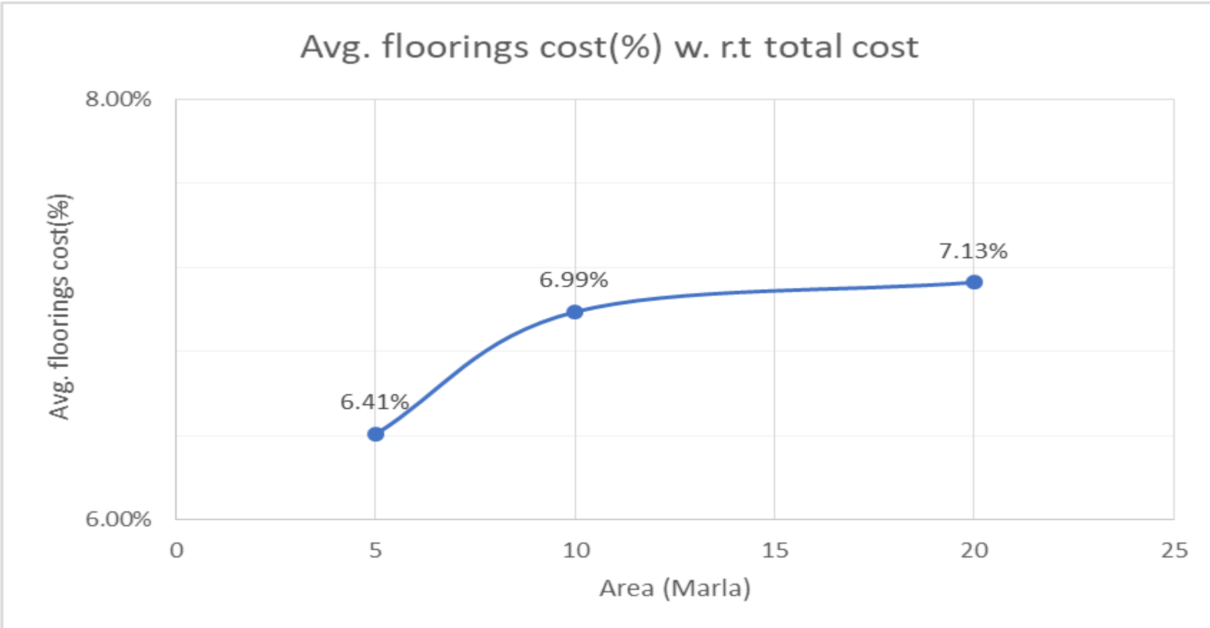

Figure 4-14: Variation of Floorings Proportion with Area

4.3.7 Variation of finishes with increasing area

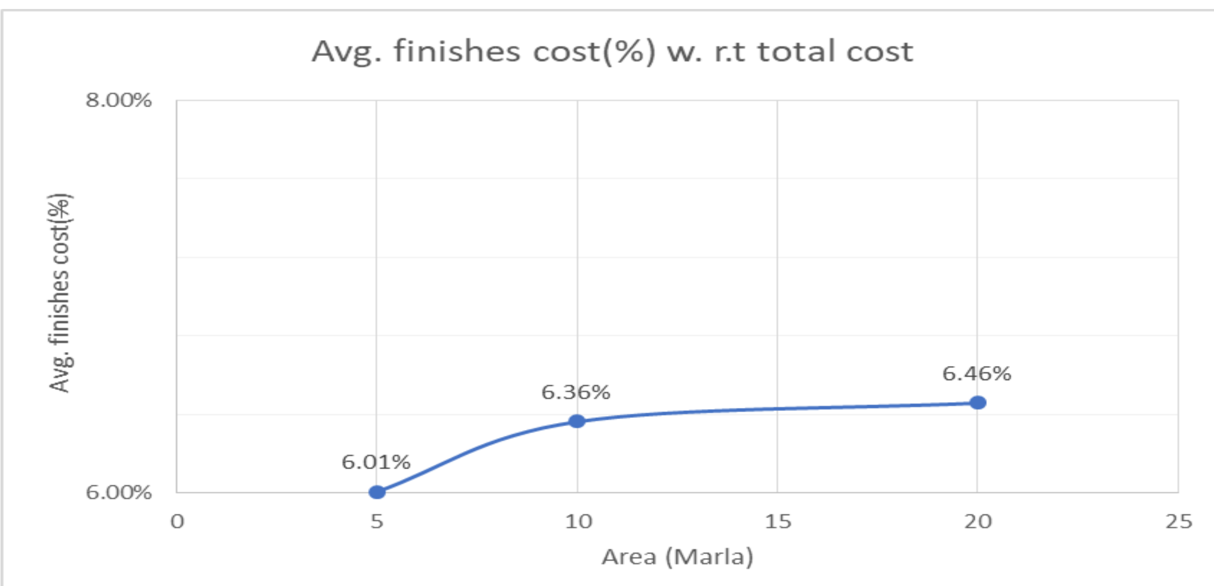

Figure 4-15: Variation of Finishes Proportion with Area

4.3.8 Variation of services with increasing area

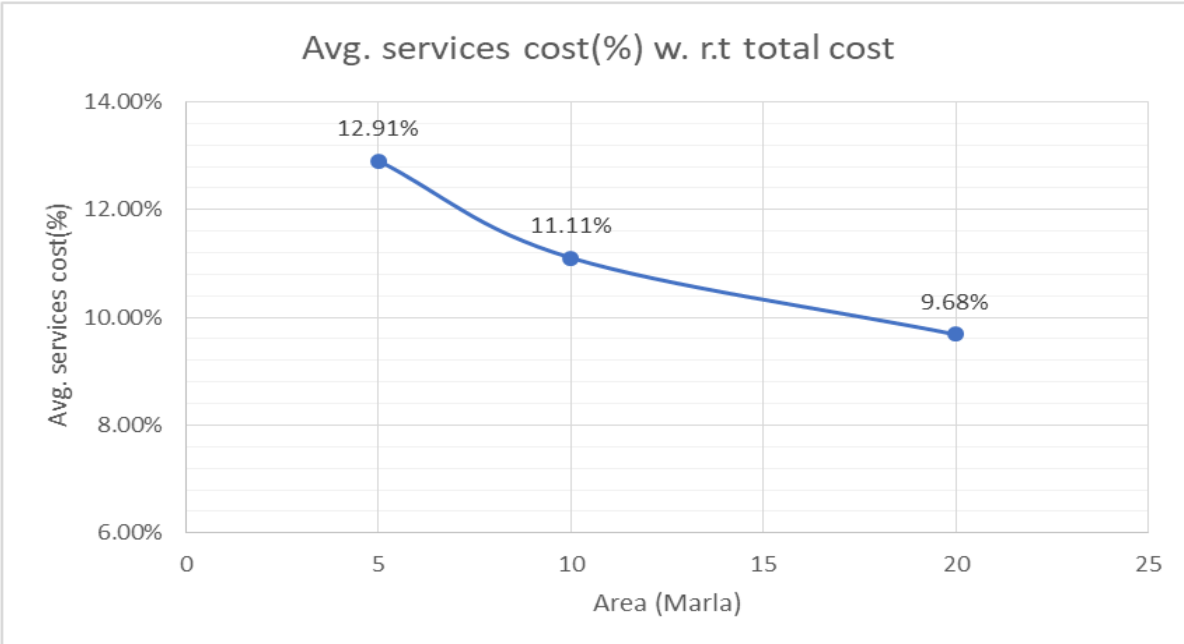

Figure 4-16: Variation of Services Proportion with Area

4.4 Discussion

1. The comparison of both the preliminary and the detailed area rates shown in Fig 4-1 and Fig 4-2 speaks for itself . The detailed rates show a declining trend as the area increases. Moreover, the preliminary rates, tend to underestimate the total cost at smaller plot sizes, and tend to overestimate the total costs at larger plot sizes. This declining trend is visible in both the "with basement" and "without basement" categories". Moreover, the rate of decrease in the detailed estimates, also decreases with increasing the areas.
2. The major portion of the total costs is gulped by the super-structure as shown in Fig 4-3 to Fig 4-8, which decreases if the client goes for the option of basement. Other elemental costs do not decrease considerably with the addition of basement.
3. The extra-earthwork related to the construction of basement (as shown in Fig 4-9 and Fig 4-10) had been separated from the earthwork required for foundations during the quantity

take-off stage, which gives a more realistic picture of the cost of basement and the proportion of basement costs in the total costs.

4. The proportion of “finishes” in all the plans as shown in the pie chart analysis (Fig 4-3 to Fig 4-8) and Fig 4-15 does not exceed 8%, means some clients who fear being over-budget during the execution phase can postpone finishes. Here, it is necessary to mention that finishes are not a necessity from the functionality point of view (especially external finishes), and can be postponed and executed in the operational stage of any residential project.
5. The proportion of foundation cost and the cost of earthwork related to the foundations as shown in Fig 4-10, increases minutely when areas (plot sizes) are increased, but remains with the range of 10-14 %.
6. Since a major portion of the total cost is the super-structure and the major portion of super-structure is the cost incurred in masonry (Fig 4-3 to Fig 4-8), it is the most stable proportion when area sizes are increased.
7. The cost of services however, decreases somewhat considerably with increasing area size (Fig 4-16). It is because as the plot size increases, the quantum of other elements like foundations and masonry increases in terms of effort and capital more remarkably as compared to the quantum of services provided. Moreover services are somewhat more discrete and fixed as compared to the fluid nature of other elements e.g., every house will have only 1 main circuit-board, 1 pumping motor and 1 water-tank, regardless of the area size.
8. The proportion of basement cost as shown in Fig 4-9, does not vary considerably with increasing area as opposed to the common misconception in the industry and ranges from 21-23 % in all the area sizes. It may also be due to the following reasons:
   a. Variation of basement areas in the same area plots
   b. The sample size is small.
   c. The quantum of earthwork and concreting involved in basements increases linearly with increasing areas.

5 RECOMMENDATIONS/COST MODELING

Owing to all the work done above, it is imperative that solutions be proposed which address all the relevant stake-holders in the residential construction industry. Therefore some recommendations are being proposed with the same intent of addressing already identified shortcomings.

5.1 Mutual understanding between stakeholders

The clients need to be more certain of their requirements both in terms of necessity and luxury, as well as their affordability in terms of fulfilling these necessities and luxuries. At the other end, the contractors need to be more certain of their capabilities in the light of the fulfilment of above-mentioned necessities and luxuries and the cost they consume while executing these capabilities. This results in more efficient cost-planning by the client aided by effective cost-management of the contractor/builder.

5.2 Comparison of preliminary and detailed estimations

The detailed cost analyses shows that the rate increase in the costs with increasing area sizes is not at par with the increase in area. The preliminary analyses which increases almost linearly by virtue of being a multiplicative cost in nature verifies this claim. It is therefore suggested that the more the area size, the less the actual plinth area rate (calculated backwards).

Based on this deduction, it is highly recommended that the clients should procure the material themselves and negotiate the contract with labour rate only. This can result in an increasing percentage of saving as the area increases, and the client can save up to 15 percent of the original cost as per the preliminary analyses calculated on the area rate basis.

Unfortunately, due to the scale and local nature of residential projects, the application of cost analyses has not been fully implemented in Pakistan. The trio of three main stake-holders i.e., client, contractor and consultant need to be more certain of their capital estimates during the planning and feasibility stage of any residential construction project.

5.3 Trade-off between elements

It has been shown in the analyses that the clients with less affordability always have the option of compromising on one option with less necessity to optimize another with more necessity. This optimizes the already available budget and adds value to the capital being expended. For example:

1. The client can demand to reduce the quantum of work in finishes and capitalize elsewhere for example on services to finish a project under a given budget threshold.
2. The client can also reduce the quantum of work involved in masonry, e.g. by reducing wall widths in the upper storey and by reducing the amount of steel in the top-most slab (in consultation with the experienced builder) to finish the project under a capital threshold.

5.4 Cost Modelling / Trade-off between Quality

Different cost models, one each for each area size are recommended, modelled and discussed in detail in the next section. These models will effectively help the stakeholders, particularly the clients to streamline their priorities and make capital/quality trade-offs basing on these priorities.

5.5 Cost Inflation Adjustment

An inherent limitation of this work is that, with time the costs will become obsolete gradually due to the inflation in the market. Inflation is a big phenomenon and a demands a separate research in order to adjust it. However, to propose a way forward to this work a minor approach is recommended for inflation adjustment. The formula to this is simple. We can convert any estimate/cost calculated in this project from “PKR” to “International Dollar” whose current value in this paper is being declared equal to [PKR 150.00]. Since the “International Dollar” can be conceptualized as the value of a USD in PKR at any given point in time, we can convert any cost to current value of International Dollar by dividing it by 150 and then convert it in PKR at any given point in future by multiplying it with the then value of USD in PKR. This will somewhat adjust the inflation for any estimate at any given point in future automatically.

6 COST MODELING

6.1 Approach

Different cost models, one each for each area size have been modelled at a basic and elementary level in MS-Excel. These models give the stake-holders a sense of choice and liberty in choosing between various qualities of the single construction item. These models are priced with the following approach:

1. The prices of all items/elements/sub-elements whose qualities don't matter/vary much are kept constant and are obtained from the averaged estimated costs of the detailed elemental estimates.
2. The prices of all the items whose qualities are of concern by the clients are kept variable and defined exclusively in terms of their specifications along with the range of prices they bring with them.

6.2 Formulation

Based on the above mentioned approach, the salient of the formulation process are as follows:

1. All the final summary bills of quantities were compiled in a single MS-Excel file.
2. The categories were sorted out first area-wise and then basement and without-basement wise. That makes 3 categories area-wise and further two sub-categories depending on the basement component.
3. The quantities decided to be fixed were averaged.
4. The quantities decided to be variable and chosen by the client were further divided mostly into 3 to 5 qualities with varying prices.
5. Firstly a sheet asks the client if they want a basement using a dropdown menu. The clients choose using the desired option.

6. A separate sheet was developed as the cost model after the summary sheets of every final BQ. Consequently it takes to the relevant model and then the client inputs his desired qualities for the variable quantities.
7. The estimates are summed up automatically for both the constants and variables and the final estimated cost is shown to the client.

6.3 Discussion

The client will have the liberty to choose the desired item for a particular element/sub-element from the latter with its price that will be from the range already set. In this manner, by choosing between different qualities and specifications of different variable items, the client will be able to mould a standard prototype estimate to reach a customized estimate. This estimate will paint to the client a better picture of his affordability and budget vis-à-vis his choices and requirements. For example, windows can be an item where clients want to have more choice along with an insight of their affordability of the very choice they want to make. In the model, a dropdown list has been made that includes different options for windows along with their prices and the client will have the choice to select one up to his taste. Since the model is interlinked and costs are accumulated with an automated approach, the cost of the client’s choice will automatically be included in the total cost. This way client will be able to make a live trade-off between different items as regards their qualities.

7 CONCLUSION

The modern theory of economy is defined in the terms of optimizing the value of capital at every point in the value-chain. The construction industry is not exempted from this. In this work an endeavour has been made to identify and rectify many snags in the chain of residential construction industry. This will ultimately pave a way forward to adding value to the client's capital while facilitating other stakeholders at the same time in terms of effective cost management.

A comprehensive approach was employed in the project starting from the very base of identifying the elements and sub-elements and finishing with recommendations to cover the main issues faced during the cost planning and management. The project has shown that the efficiency of quantity survey and estimating can be enhanced by using different BIM tools, which paint a satisfying picture of what the client needs to visualise. Moreover with the proposed cost model, sufficient time and effort can be saved during the planning and feasibility stages while facilitating the contract negotiations. It is now left to the judgement of the reader to analyse the universality and effectiveness of this endeavour, while at the same time think of and propose better solutions to carry the baton forward in this never-ending race of cost-optimization.

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Appendices

Appendix A: Auto-Generated Revit Quantity Sheet - Walls

Family and Type	L	Ht	W	Mat: Area (Sqm)	Material : Vol (CF)	Wall Sfc Area	Plinth beam volume (cf)	BB at diff levels(CF)
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	21.8	16'0"	1' - 0"	33	353	705.25 SF		
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	54.3	16' - 0"	1' - 0"	78	841	1681.75 SF		
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	22	16' - 0"	1' - 0"	32	341	682.00 SF		
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	19.3	16' - 0"	1' - 0"	26	283	565.75 SF		
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	37.8	16' - 0"	1' - 0"	52	561	1121.25 SF		
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	12.5	16' - 0"	1' - 0"	18	194	387.50 SF		
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	16	16' - 0"	1' - 0"	23	248	496.00 SF		
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	22.5	16' - 0"	1' - 0"	29	309	617.50 SF		

Family and Type	L	Ht	W	Mat: Area (Sqm)	Material : Vol (CF)	Wall Sfc Area	Plinth beam volume (cf)	BB at diff levels(CF)
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	10.8	16' - 0"	1' - 0"	15	167	333.25 SF		
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	10.8	16' - 0"	1' - 0"	14	151	302.25 SF		
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	6.75	16' - 0"	1' - 0"	10	105	209.25 SF		
Basic Wall: BASEMENT AND B.FOUNDATION- 12" Concrete	7.75	16' - 0"	1' - 0"	8	87.1	174.25 SF		
Basic Wall: BRICK 4.5" 1ST FLOOR	15	0' - 6"	0' - 4 1/2"	1	2.95	15.75 SF		2.95
Basic Wall: BRICK 4.5" 1ST FLOOR	12.1	0' - 6"	0' - 4 1/2"	1	3.54	18.88 SF		3.54
Basic Wall: BRICK 4.5" MUMTY	15	10' - 0"	0' - 4 1/2"	14	54.8	292.13 SF	2.81	54.77
Basic Wall: BRICK 4.5" MUMTY	12.1	10' - 0"	0' - 4 1/2"	8	33.8	180.38 SF	2.27	33.82
Basic Wall: BRICK 4.5" MUMTY	20.8	10' - 0"	0' - 4 1/2"	11	44.3	236.00 SF	3.89	44.25
Basic Wall: BRICK 4.5" MUMTY	7.75	10' - 0"	0' - 4 1/2"	10	41.9	223.25 SF	1.45	41.86
Basic Wall: BRICK 4.5" MUMTY	17.4	3' - 0"	0' - 4 1/2"	6	23.8	126.75 SF		23.77
Basic Wall: BRICK 4.5" MUMTY	46.4	3' - 0"	0' - 4 1/2"	2	8.72	46.50 SF		8.72
Basic Wall: BRICK 4.5" MUMTY	19.6	3' - 0"	0' - 4 1/2"	5	19.6	104.25 SF		19.55

Family and Type	L	Ht	W	Mat: Area (Sqm)	Material : Vol (CF)	Wall Sfc Area	Plinth beam volume (cf)	BB at diff levels(CF)
Basic Wall: BRICK 4.5" MUMTY	22.4	3' - 0"	0' - 4 1/2"	13	51.8	276.00 SF		51.75
Basic Wall: BRICK 4.5" MUMTY	19.3	3' - 0"	0' - 4 1/2"	5	22.1	117.75 SF		22.08
Basic Wall: BRICK 4.5" MUMTY	15.8	3' - 0"	0' - 4 1/2"	6	25.2	134.25 SF		25.17
Basic Wall: BRICK 4.5" MUMTY	12.9	3' - 0"	0' - 4 1/2"	5	21.7	115.50 SF		21.66
Basic Wall: BRICK 4.5" MUMTY	5.25	3' - 0"	0' - 4 1/2"	4	17.7	94.50 SF		17.72
Basic Wall: BRICK 4.5" MUMTY	0.25	3' - 0"	0' - 4 1/2"	4	14.5	77.25 SF		14.48
Basic Wall: BRICK 4.5" MUMTY	5.25	3' - 0"	0' - 4 1/2"	1	5.91	31.50 SF		5.91
Basic Wall: BRICK 4.5" MUMTY	27.9	3' - 0"	0' - 4 1/2"	0	0.07	0.38 SF		0.07
Basic Wall: BRICK 4.5" MUMTY	0.17	3' - 0"	0' - 4 1/2"	1	5.91	31.50 SF		5.91
Basic Wall: BRICK 4.5" MUMTY	9.96	3' - 0"	0' - 4 1/2"	8	30.9	165.00 SF		30.94
Basic Wall: BRICK 4.5" MUMTY	20.8	3' - 0"	0' - 4 1/2"	0	0.4	2.13 SF		0.4
Basic Wall: BRICK 4.5" MUMTY	23.5	0' - 6"	0' - 4 1/2"	0	1.86	9.94 SF		1.86
Basic Wall: BRICK 9" 1ST FLOOR	17	10' - 6"	0' - 9"	17	137	365.00 SF	9.56	136.87
Basic Wall: BRICK 9" 1ST FLOOR	77.8	10' - 6"	0' - 9"	22	176	470.00 SF	43.73	176.25
Basic Wall: BRICK 9" 1ST FLOOR	22	10' - 6"	0' - 9"	12	99.4	265.00 SF	12.38	99.37
Basic Wall: BRICK 9" 1ST FLOOR	19.3	10' - 6"	0' - 9"	65	529	1410.00 SF	10.83	528.75

Family and Type	**L**	**Ht**	**W**	**Mat: Area (Sqm)**	**Material : Vol (CF)**	**Wall Sfc Area**	**Plinth beam volume (cf)**	**BB at diff levels(CF)**
Basic Wall: BRICK 9" 1ST FLOOR	37.8	10' - 6"	0' - 9"	18	146	390.00 SF	21.23	146.25
Basic Wall: BRICK 9" 1ST FLOOR	12.5	10' - 6"	0' - 9"	17	139	370.00 SF	7.03	138.75
Basic Wall: BRICK 9" 1ST FLOOR	16	10' - 6"	0' - 9"	31	246	657.00 SF	9	246.37
Basic Wall: BRICK 9" 1ST FLOOR	22.5	10' - 6"	0' - 9"	9	75	200.00 SF	12.66	75
Basic Wall: BRICK 9" 1ST FLOOR	14	10' - 6"	0' - 9"	15	120	320.00 SF	7.88	120
Basic Wall: BRICK 9" 1ST FLOOR	17	10' - 6"	0' - 9"	16	129	344.00 SF	9.56	129
Basic Wall: BRICK 9" 1ST FLOOR	8.75	10' - 6"	0' - 9"	11	86.6	231.00 SF	4.92	86.62
Basic Wall: BRICK 9" 1ST FLOOR	7.75	10' - 6"	0' - 9"	13	104	276.00 SF	4.36	103.5
Basic Wall: BRICK 9" 1ST FLOOR	10.3	10' - 6"	0' - 9"	8	65.6	175.00 SF	5.81	65.62
Basic Wall: BRICK 9" 1ST FLOOR	16	10' - 6"	0' - 9"	5	39.4	105.00 SF	9	39.37
Basic Wall: BRICK 9" 1ST FLOOR	27.5	10' - 6"	0' - 9"	9	74.7	199.17 SF	15.47	74.69
Basic Wall: BRICK 9" 1ST FLOOR	11.8	10' - 6"	0' - 9"	14	111	295.00 SF	6.61	110.62
Basic Wall: BRICK 9" 1ST FLOOR	6.75	10' - 6"	0' - 9"	23	182	485.00 SF	3.8	181.87
Basic Wall: BRICK 9" 1ST FLOOR	6.75	10' - 6"	0' - 9"	11	88.1	235.00 SF	3.8	88.13
Basic Wall: BRICK 9" 1ST FLOOR	7.75	10' - 6"	0' - 9"	4	31.9	85.00 SF	4.36	31.88
Basic Wall: BRICK 9" 1ST FLOOR	0.42	10' - 6"	0' - 9"	6	50.6	135.00 SF	0.24	50.63

Family and Type	L	Ht	W	Mat: Area (Sqm)	Material : Vol (CF)	Wall Sfc Area	Plinth beam volume (cf)	BB at diff levels(CF)
Basic Wall: BRICK 9" 1ST FLOOR	49.3	10' - 6"	0' - 9"	5	39.4	105.00 SF	27.7	39.37
Basic Wall: BRICK 9" 1ST FLOOR	89.3	10' - 6"	0' - 9"	0	0.31	0.83 SF	50.2	0.31
Basic Wall: BRICK 9" GROUND FLOOR	49.3	10' - 6"	0' - 9"	46	375	1000.00 SF	27.7	375
Basic Wall: BRICK 9" GROUND FLOOR	89.3	10' - 0"	0' - 9"	83	669	1785.00 SF	50.2	669.38
Basic Wall: BRICK 9" GROUND FLOOR	20.8	10' - 0"	0' - 9"	39	316	841.66 SF	11.67	315.62
Basic Wall: BRICK 9" GROUND FLOOR	7.75	10' - 0"	0' - 9"	76	610	1627.01 SF	4.36	610.13
Basic Wall: BRICK 9" GROUND FLOOR	17	10' - 6"	0' - 9"	18	143	380.00 SF	9.56	142.5
Basic Wall: BRICK 9" GROUND FLOOR	77.8	10' - 6"	0' - 9"	7	58.1	155.00 SF	43.73	58.13
Basic Wall: BRICK 9" GROUND FLOOR	19.3	10' - 6"	0' - 9"	12	99.4	265.00 SF	10.83	99.38
Basic Wall: BRICK 9" GROUND FLOOR	22	10' - 6"	0' - 9"	65	529	1410.00 SF	12.38	528.75
Basic Wall: BRICK 9" GROUND FLOOR	37.8	10' - 6"	0' - 9"	13	107	286.00 SF	21.23	107.25
Basic Wall: BRICK 9" GROUND FLOOR	12.5	10' - 6"	0' - 9"	17	141	375.00 SF	7.03	140.63
Basic Wall: BRICK 9"	16	10' - 6"	0' - 9"	30	241	643.00 SF	9	241.13

Family and Type	L	Ht	W	Mat: Area (Sqm)	Material : Vol (CF)	Wall Sfc Area	Plinth beam volume (cf)	BB at diff levels(CF)
GROUND FLOOR								
Basic Wall: BRICK 9" GROUND FLOOR	10.8	10' - 6"	0' - 9"	9	75	200.00 SF	6.05	75
Basic Wall: BRICK 9" GROUND FLOOR	16	10' - 6"	0' - 9"	15	120	320.00 SF	9	120
Basic Wall: BRICK 9" GROUND FLOOR	27.5	10' - 6"	0' - 9"	8	62.3	166.00 SF	15.47	62.25
Basic Wall: BRICK 9" GROUND FLOOR	15.8	10' - 6"	0' - 9"	14	111	295.00 SF	8.86	110.63
Basic Wall: BRICK 9" GROUND FLOOR	31	10' - 6"	0' - 9"	23	182	485.00 SF	17.44	181.88
Basic Wall: BRICK 9" GROUND FLOOR	8.75	10' - 6"	0' - 9"	14	113	300.00 SF	4.92	112.5
Basic Wall: BRICK 9" GROUND FLOOR	7.75	10' - 6"	0' - 9"	24	190	507.00 SF	4.36	190.13
Basic Wall: BRICK 9" GROUND FLOOR	6.75	10' - 6"	0' - 9"	8	65.6	175.00 SF	3.8	65.63
Basic Wall: BRICK 9" GROUND FLOOR	7.75	10' - 6"	0' - 9"	5	39.4	105.00 SF	4.36	39.38
Basic Wall: BRICK 9" GROUND FLOOR	10.8	10' - 6"	0' - 9"	6	50.6	135.00 SF	6.05	50.63
Basic Wall: BRICK 9" GROUND FLOOR	11.8	10' - 6"	0' - 9"	5	39.4	105.00 SF	6.61	39.38
Basic Wall: BRICK 9"	11.8	10' - 6"	0' - 9"	7	56.6	151.00 SF	6.61	56.63

Family and Type	L	Ht	W	Mat: Area (Sqm)	Material : Vol (CF)	Wall Sfc Area	Plinth beam volume (cf)	BB at diff levels(CF)
GROUND FLOOR								
Basic Wall: BRICK 9" GROUND FLOOR	6.75	10' - 6"	0' - 9"	11	88.1	235.00 SF	3.8	88.13
Basic Wall: BRICK 9" GROUND FLOOR	49.3	10' - 6"	0' - 9"	8	66.8	178.00 SF	27.7	66.75
Basic Wall: BRICK 9" GROUND FLOOR	89.3	10' - 6"	0' - 9"	4	31.9	85.00 SF	50.2	31.88
Basic Wall: FOUNDATION WALL 13.5"	49.3	4' - 6"	1' - 1 1/2"	19	227	403.00 SF		226.69
Basic Wall: FOUNDATION WALL 13.5"	89.3	4' - 6"	1' - 1 1/2"	33	402	714.00 SF		401.63
Basic Wall: FOUNDATION WALL 13.5"	20.8	4' - 6"	1' - 1 1/2"	18	222	394.00 SF		221.63
Basic Wall: FOUNDATION WALL 13.5"	23.5	4' - 6"	1' - 1 1/2"	33	397	705.00 SF		396.56
Basic Wall: FOUNDATION WALL 13.5"	17	4' - 6"	1' - 1 1/2"	8	93.4	166.00 SF		93.38
Basic Wall: FOUNDATION WALL 13.5"	23.5	4' - 6"	1' - 1 1/2"	9	106	188.50 SF		106.03
Basic Wall: FOUNDATION WALL 13.5"	8.75	4' - 6"	1' - 1 1/2"	6	76.5	136.00 SF		76.5
Basic Wall: FOUNDATION WALL 13.5"	7.75	4' - 6"	1' - 1 1/2"	8	101	179.50 SF		100.97
Basic Wall: FOUNDATION WALL 13.5"	9.25	4' - 6"	1' - 1 1/2"	3	39.4	70.00 SF		39.38
Basic Wall: FOUNDATION WALL 13.5"	11.8	4' - 6"	1' - 1 1/2"	2	29.8	53.00 SF		29.81
Basic Wall: FOUNDATION WALL 13.5"	6.75	4' - 6"	1' - 1 1/2"	3	41.9	74.50 SF		41.91

Family and Type	L	Ht	W	Mat: Area (Sqm)	Material : Vol (CF)	Wall Sfc Area	Plinth beam volume (cf)	BB at diff levels(CF)
Basic Wall: FOUNDATION WALL 13.5"	5.25	4' - 6"	1' - 1 1/2"	4	48.1	85.50 SF		48.09
Basic Wall: FOUNDATION WALL 13.5"	27.5	4' - 6"	1' - 1 1/2"	2	25.3	45.00 SF		25.31
Basic Wall: FOUNDATION WALL 13.5"	5.25	4' - 6"	1' - 1 1/2"	2	23.9	42.50 SF		23.91
Basic Wall: FOUNDATION WALL 13.5"	27.5	4' - 6"	1' - 1 1/2"	10	119	211.00 SF		118.69
		Area	**32370.73 SF**	**663.91 Sqm**				
						Vol	**18.8**	**CUM**

Appendix B: Auto-Generated Revit Quantity Sheet – Doors

Family and Type	No	Level	Height	Width	Thickness	OPENING AREA FOR DOORS(SF)
Doors Ext Double Louvre with Transom: DOOR 4.5' EXT DOUBLE	2	GR FLOOR	7' - 0"	4' - 6"	0' - 2"	31.5
GATE- converted from door family 8513.0001: MAIN GATE	1	GR FLOOR	5' - 0"	9' - 0"	0' - 2"	45
GATE- converted from door family 8513.0001: MAIN GATE	1	GR FLOOR	5' - 0"	9' - 0"	0' - 2"	45
Single-Flush: DOOR 2.5'	1	GR FLOOR	7' - 0"	2' - 6"	0' - 2"	17.5
Single-Flush: DOOR 2.5'	1	GR FLOOR	7' - 0"	2' - 6"	0' - 2"	17.5
Single-Flush: DOOR 2.5'	1	GR FLOOR	7' - 0"	2' - 6"	0' - 2"	17.5
Single-Flush: DOOR 2.5'	1	1ST FLOOR	7' - 0"	2' - 6"	0' - 2"	17.5
Single-Flush: DOOR 2.5'	1	1ST FLOOR	7' - 0"	2' - 6"	0' - 2"	17.5
Single-Flush: DOOR 2.5'	1	1ST FLOOR	7' - 0"	2' - 6"	0' - 2"	17.5
Single-Flush: DOOR 2.5'	1	BASEMENT LEVEL	7' - 0"	2' - 6"	0' - 2"	17.5
Single-Flush: DOOR 3'	1	GROUND FLOOR	7' - 0"	3' - 0"	0' - 2"	21
Single-Flush: DOOR 3'	1	1ST FLOOR	7' - 0"	3' - 0"	0' - 2"	21
Single-Flush: DOOR 3.5' SNGL	1	GROUND FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	GROUND FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	GROUND FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	GROUND FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	GROUND FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	GROUND FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	1ST FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	1ST FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	1ST FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	1ST FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	1ST FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	2ND FLOOR	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	BASEMENT LEVEL	7' - 0"	3' - 6"	0' - 2"	24.5
Single-Flush: DOOR 3.5' SNGL	1	BASEMENT LEVEL	7' - 0"	3' - 6"	0' - 2"	24.5
Grand total: 26						**629**
						58.43 SQM

Appendix C: Auto-Generated Revit Quantity Sheet – Windows

Family and Type	Level	Sill Height	Head Height	Height	Width	OPENING AREA
Fixed: WINDOW 2.5'	GROUND FLOOR	2' - 0"	7' - 0"	5' - 0"	2' - 6"	12.50 SF
Fixed: WINDOW 2.5'	GROUND FLOOR	2' - 0"	7' - 0"	5' - 0"	2' - 6"	12.50 SF
Fixed: WINDOW 2.5'	1ST FLOOR	2' - 0"	7' - 0"	5' - 0"	2' - 6"	12.50 SF
Fixed: WINDOW 2.5'	1ST FLOOR	2' - 0"	7' - 0"	5' - 0"	2' - 6"	12.50 SF
Fixed: WINDOW 2.5'	1ST FLOOR	2' - 0"	7' - 0"	5' - 0"	2' - 6"	12.50 SF
Fixed: WINDOW 2.5'	GROUND FLOOR	2' - 0"	7' - 0"	5' - 0"	2' - 6"	12.50 SF
Fixed: WINDOW 5'	GROUND FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 5'	GROUND FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 5'	GROUND FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 5'	GROUND FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 5'	GROUND FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 5'	GROUND FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 5'	1ST FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 5'	1ST FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 5'	1ST FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 5'	1ST FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 5'	1ST FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 5'	2ND FLOOR	2' - 0"	7' - 0"	5' - 0"	5' - 0"	25.00 SF
Fixed: WINDOW 6'	GROUND FLOOR	2' - 0"	7' - 0"	5' - 0"	6' - 0"	30.00 SF
Fixed: WINDOW 6'	GROUND FLOOR	2' - 0"	7' - 0"	5' - 0"	6' - 0"	30.00 SF
Fixed: WINDOW 6'	1ST FLOOR	2' - 0"	7' - 0"	5' - 0"	6' - 0"	30.00 SF
Fixed: WINDOW 6'	1ST FLOOR	2' - 0"	7' - 0"	5' - 0"	6' - 0"	30.00 SF

		495 SFT	**45.9 SQM**

Appendix D: Auto-Generated Revit Quantity Sheet – Floors

Family and Type	**Material: Description**	**Default Thickness**	**Material: Area(SF)**	**AREA (Sqm)**	**Material: Vol(CF)**	**Material: Volume(CUM)**	**Reinforcement(kg)**
Floor: BASEMENT FLOOR 3"	Lightweight concrete	0' - 3"	1593.31	148.01	398.33	11.28	
Floor: BASEMENT FLOOR 3"	Lightweight concrete	0' - 3"	1640.56	152.4	410.14	11.61	
Floor: FLOOR 6" 1ST FLOOR	Cast-in-place concrete	0' - 6"	3024.44	280.95	1512.22	42.82	3961.4
Floor: FLOOR 6" 2ND FLOOR	Cast-in-place concrete	0' - 6"	2441.12	226.77	1220.56	34.56	3197.46
Floor: FLOOR 6" MUMTY FLOOR	Cast-in-place concrete	0' - 6"	284.81	26.46	142.41	4.03	373.09
Floor: GROUND FLOOR 6"	Cast-in-place concrete	0' - 6"	4435.37	412.02	2217.69	62.79	5809.48
				1246.61	**5901.34**	**167.09**	**13341.43**

Appendix E: Auto-Generated Revit Quantity Sheet – Stairs

Family and Type	**No of Risers**	**Riser Height**	**Actual Tread Depth**	**Count**	**Material: Volume(CF)**	**Material: Area(SF)**
Cast-In-Place Stair: Monolithic Stair	19	0' - 6 5/8"	1' - 0"	1	45.05	249.71
Cast-In-Place Stair: Monolithic Stair	19	0' - 6 5/8"	1' - 0"	1	45.05	249.71
Cast-In-Place Stair: Monolithic Stair	19	0' - 6 5/8"	1' - 0"	1	45.05	249.71
					Total 135.14 cf	Total 749.13 sf
					3.83 cum	**69.58 sqm**

Appendix F: Auto-Generated Revit Quantity Sheet – Earthwork

AREA (Sqm)	**Material: Volume(CF)**	**EXCAVATION(CF)**	**3.5 feet high and 13.5'' thick brick work volume(CF)**
15.85	85.31 CF	560.22	193.92
26.94	145.03 CF	1002.42	347.01
14.87	80.03 CF	573.02	198.37
25.96	139.75 CF	1015.22	351.42
7.25	39.00 CF	236.03	81.7
8.3	44.69 CF	300.02	103.87
3.13	16.86 CF	105.93	36.66
2.91	15.64 CF	121.57	42.09
1.06	5.69 CF	63.98	22.17
0.94	5.08 CF	60.43	20.91
6.45	34.73 CF	268.02	92.77
5.13	27.63 CF	193.38	66.94
2.34	12.59 CF	75.36	26.11
1.66	8.94 CF	99.53	34.45
6.45	34.73 CF	255.23	88.36
129.24	**695.7**	**4930.35**	**1706.75**
			139.59 cum