“GREEN BUILDINGS – COST BENEFIT ANALYSIS”

A PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree

of

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Under the supervision of

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by

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to

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WAKNAGHAT, SOLAN – 173 234

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CERTIFICATE

This is to acknowledge that the work presented in this project report titled **"GREEN BUILDING – COST BENEFIT ANALYSIS"** is done as a part of the award of the degree of Bachelor of Technology, presented to Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is a genuine record of assessment done by **Ashutosh Abrol** throughout a period from July 19, 2017 to May 7, 2018 under the supervision of **Dr. Saurav,** Assistant Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

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ABSTRACT

As the global population continues to rise and developing countries begin to utilize their share of the resources, it is required to observe how we, as the citizens, use our scarce resources judiciously. India accounts nearly for about 5.3% of the global energy to feed 18.72% of the World's population. Nearly, one third of this energy is taken up by the building sector. This does not take into consideration the amount of embodied energy utilized in the manufacture of building materials or the scarce finite resources used in product segment.

During ongoing construction activities and at the termination of the useful building life, construction materials and components are discarded irresponsibly with construction debris accounting for around 28 percent of landfill waste in our nation. Irresponsible usage of building materials emitting chemicals can degrade the indoor environment quality with some newer building chemicals concentrations up to 100 times greater than the outside levels. While Indians spend nearly 70% of their time indoors, it is interesting to note that the World Health Organization (WHO) estimates around 30% of all the buildings will have Indoor Air Quality (IAQ) concerns during the facility's occupancy. In this regard, Green or environmentally friendly materials help to create more sustainable, helpful and ecologically sensitive buildings. This is easily achieved through environmental materials assessment and green building specifications. As more and more companies and clients are becoming environmentally aware and request for the specification of green building materials in their proximity and with the consequent minimization of the natural resources, manufacturers now have to respond to the increased demand and the necessity to make greener materials.

The environmental criterion depends upon many factors. Criterion also vary depending upon the phase of the project, whether it is a newly constructed, a renovated up gradation of an existing structure or whether some eco sensitive site work is associated with the building. Lesser toxicity, reduced emissions, recycled content, efficiency of resources and recyclability of the materials are some of the recommended environmental considerations for use in green building product or system assessment and evaluation.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION OF GREEN BUILDINGS

1.1 OVERVIEW

With India's rise as a rapid progressive economy and an enlightened outlook towards infrastructure needs have enhanced an environment of positivity among industry leaders that a highly efficient Green Building poses as a solution to the building sector requirements requiring enormous development but taking into consideration environment and costing perspective.

Indian Green Building Council (IGBC) defines a Green Building as a building that uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building. These structures incorporate the principles of Sustainable Development and caters to the needs of the present time. They also ensure environmental safeguards, ensure economic gains, minimize waste reduction as well as promote healthy environment and enhanced efficiency in comparison to conventional buildings.

1.2 NEED FOR STUDY

The pace of growth and progression of development of any nation is a foundational reform to its financial advancement. With increasing economic growth, the dangers to the ecological needs are a matter of concern. In India, building sector utilizes around 35% of the available energy and thus act as a major cause for efforts towards Greenhouse gas emissions. Taking into consideration the above scenario, it's necessary to promote Green buildings in our surroundings so as to ensure the sanctity of our environment and enforce the legal obligations ratified by our nation at international scale.

Green Building uses many practices and technologies to minimize and ultimately phase out the repercussions of Conventional buildings on the ecology and human beings.

1.3 BENEFITS OF GREEN BUILDING

A green building possess many benefits over and above the Conventional Building Environmental Benefits includes minimization of wastage of water, conservation of natural resources, improvement in air quality and water quality, protection of biodiversity and ecosystems. Economic Benefits of Green Building includes reduced operating cost, improved occupant productivity and a vast market for newer green products and services. Social Benefits include improved quality of life, minimized strain on local infrastructure and improved occupant health and comfort.

1.4 OBJECTIVES

i. To identify, explore and validate the significance of Green Buildings.

ii. To layout a 3 dimensional house on AUTO CAD and evaluate its costing with CostMiner and manual methods and compare the results.

iii. To determine the payback period of additional price encountered during the Construction of Green Building.

1.5 SCOPE OF THE PROJECT

The scope of this project is to model a 3 dimensional Green Building showing all the factors used suitable to the climatic aspects of New Delhi using AutoCAD Software. Juxtaposition would be analyzed between Conventional Building and Green Building on economic grounds using manual methods and software CostMiner.

CHAPTER 2

LITERATURE REVIEW

2.1 DISCUSSION OF RESEARCH PAPERS

Singh, P., Sharma, K. (2017) [1]

The study was conducted regarding the use of organic building materials in residential construction in 2016 and stated that wood is the mostly used organic building material. Also, the level of fatigue was less in wooden houses as compared to non-wooden houses.

Mayer, S., et al. (2017) [2]

The study was conducted to perform a payback period analysis and recommended the use of low e-glass with Argon, cellulose wall and cellulose insulation in the ceiling. The study also recommended that photovoltaic is not economical in the short run.

Gibler, M. R. (2016) [3]

Green roof presents the environmental, social and economic benefit along with sustainability. The author's findings present the direct link between the evaporative cooling potential of green roofs, capable of enhancing the cooling benefits of green ceiling, when incorporated into a climate-based model.

Wong, P., et al (2016) [4]

The review carried out a research on eight different vertical greenery systems in 2015 and stated that the surface temperature of building facades in the tropical climate is directly proportional to the cooling load and energy costs.

Singh, H., et al (2015) [5]

The reviews investigated the effects of improved Indoor Environmental Quality (IEQ) and concluded that improved IEQ leads to reduction in the absenteeism and have an impact on work hours as a result of betterment in health and well-being.

Denzer, A.,Heimbuck, K. (2015) [6]

Based on the work, the authors concluded that making a robust freshman course for architects and engineers is a need of the hour. This should consist of kinesthetic and inductive learning activities on a variety of Green Building topics.

O'mara, S., Bates, W., (2014) [7]

The study asserted on the need to reduce climate change and suggested that provision of smart grids should be incorporated in green buildings to allow two-way energy flow between the grid and building thereby, distributing energy wisely across the region so that load could be managed better.

Nguyen, H.T., Gray, M. (2014) [8]

The study was conducted in Vietnam and concluded that various middle income countries are adopting the idea of green building. Increased energy demand, scarce resources, huge infrastructure requirements due to growing population and urbanization is making way for the widespread acceptance of Green Buildings.

Khosla, J., Singh H., (2013) [9]

The authors conducted a study to assess the potential and capacity of Green Buildings to save energy and stated that behavioral, organizational and financial factors are some of the hindering factors for the construction of green buildings.

Xing, A.M., et al. (2012) [10]

Based on a study conducted on designing of vertical garden for Beijing city in 2010, the review revealed that the homeowners and interior designers possessed more awareness regarding vertical garden than architects.

Kanika, P., et al. (2011) [11]

The study carried out a research on interior environmental assessment of Green Buildings in Gurgaon and Panchkula in 2011 and stated that Indoor Environment Quality (IEQ) data of Green Buildings were far better than those of conventional buildings in all the IEQ aspects except the humidity level.

Kaplow, J. (2011) [12]

This archive demonstrates that green building fetches lesser value in contrast to a traditional building. When compared, Leadership in Energy and Environmental Design(LEED) buildings with non LEED buildings, the LEED buildings came out to be potentially 33% more energy efficient.

Kalidas, S.K., Christopher, L.(2010) [13]

The reviews investigated the effects of improved Indoor Environmental Quality (IEQ) and concluded that improved IEQ leads to reduction in the absenteeism and have an impact on work hours as a result of betterment in health and well-being.

Chaturvedi, S., (2009) [14]

The study concluded the remarks on the adoption of efficient energy innovations. With the effective rise in energy consumption, degradation of the environment is on rise which is urging the demand for green design. The construction of conventional building leads to destruction of natural habitats and bio-diversity, air and water pollution, more water consumption, waste generation and decreased user productivity.

Chunduri, S., Yimin, Z., Bayraktar, M. E. (2008) [15]

This study undertook an experimental analysis on 24 post graduates in the field of construction management and noted some results with regard to the impact of altering the content of presentation on the basis of learning styles while instructing green building concepts. The results depicted that by customizing a student's grasping way enhances results in understanding of green building concepts. Learning style was based on the concept maps mind maps, ontology.

Ionescu, C., et al. (2008) [16]

The study revealed the historical evolution of the energy efficient building in about 5500 BC in Romania (Carpathian region) where houses were totally constructed on the ground in order to keep a constant indoor temperature during the year. Since then, evolution has only increased over time and today's world is adapting to more prominent ideas continuingly.

Sajjadian, S. M., et al. (2007) [17]

The study corresponds to the different climatic regions and stated that low and high thermal mass do not contribute to the thermal balance. The author performed simulations in existing buildings of London and Manchester using Design Built Software (calculation engine ENERGY PLUS) considering the weather data of 2010, 2025, 2050 with five high performance construction and concluded that climatic change solely do not impact the decision of choosing among builders.

Sorell, S. (2007) [18]

Complex economic system, increased energy demand with the increased economic growth, not considering the feasible solutions to climatic changes are some emerging issues as a barrier for reducing energy demands which can be encountered by accepting new energy efficient technologies and growing literature on sociotechnical transitions.

Sun, S., et al.(2006) [19]

Building industrialization has changed the world's perspective toward the improvement in building components to achieve the optimum energy efficiency. Study included the HS-EPS core column structure system. For the construction in the tropical area, building industrialization can save 40% of the working time, 50% saving in labor as compared to the traditional construction. For the pre-fabricated components building industrialization can save 7% of concrete, 2% of Steel, 40% of water consumption, 70% of plasterer materials..

Chan, A. P. C., et al. (2006) [20]

The study aims to examine the criticality of various barriers which are preventing the adoption of green building technologies. Author categorized the barriers from the Factor analysis results that are technological risks and difficulties; stakeholders' attitudes, knowledge limitations; market limitations; and higher cost and information. To improve the barrier there is much need of integrated designs and strategies.

Charalambides, J., Wright, J. (2006) [21]

The author concluded the effect of building orientation which isadvantageous for solar gain and building heat losses and gains, it allows designer to optimize the building orientation to an extent. He considered the building shape and a limited range of UV values, he further observed that optimal orientation of a building is significantly affected by the latitude and climate of the particular region.

Chokor, A.,Asmar, M. E. (2006) [22]

The study investigates the impact of LEED certification on the buildings energy consumption. The study covered the novel LEED performance assessment method by analyzing the case study of 18 Green Buildings located in climate zone 2B, which is developed after the predictive models of the energy consumption for the investigated buildings. Author noted the heating/cooling and electricity energy consumption every 15 minutes increments over a 7-years period and aim at specific type of facilities in one geographical location in order to limit the variation in the dataset. The results shows the superiority of the Gradient Boosting Regression over other regression models in predicting energy consumption for this dataset of research buildings. The study shows the differences between the benchmark addressed in the literature and the one proposed in this study in order to assess the performanceof LEED buildings.

Kannan, N., et al.(2005) [23]

The authors stated that the applications of solar energy is widespread and are generally used in various field areas for the purpose of heating and cooling of building, roof mounted systems, solar energy for drying and green houses, refrigeration, lighting, water pumping, charging of electronic devices, removal of salinity, treatment of wastewater and space application.

Kolokotroni, M., et al.(2005) [24]

The authors findings revealed that Green roofs leads to the reductions for heating and cooling energy loads, whereas the cool roofs leads to reductions only for the cooling energy loads because of higher surface reflectance which reject the significant amount of solar heat gains.

Wong, N., H. (2005) [25]

The author concluded that the provision of naturally ventilated buildings in tropical climates have lower thermal comfort and better indoor air quality. In order to rectify the shortcomings in thermal comfort assessment, provision of naturally ventilated industrial buildings should be applied.

2.2 SUMMARY OF LITERATURE REVIEW

From the analysis of vast number of studies conducted by the researchers across the globe, the Green Buildings have come out to be the potent solution for the repercussions of the climate change. The findings reveal that eco-friendly buildings, green design and energy efficient buildings in construction industry are some of the innovative ideas taking place from past era till present time. Its need is recognized due to the rapid rate of exhaustion of energy resources, unequal distribution of the resources, out of date technologies and less significant materials. There is an urgent requirement to correct the issues and communicate with the designers for advanced approaches to reduce the energy utilization and ecological loss that is directly impacting the environment. Usually, the energy optimization in infrastructure is attained by reducing the use of load by the usage of the solar technology, considering eco- friendly techniques and using the non-conventional energy. Moreover by spreading awareness regarding the green and efficient technologies, a lot can be achieved to see the world in its natural habitat. The initial cost for the construction of green building are found to be 6-10% more than that the conventional building. This initial increase is balanced by the long term benefits in terms of saving in energy and water costs. Also, Green Buildings enable a healthier indoor environment, thus enhancing its productiveness.

CHAPTER 3

PROJECT OUTLINE

3.1 CRITERIA FOR SELECTION OF GREEN BUILDING MATERIALS

Materials are the backbone of the buildings construction. Before using them, their chemical, physical and mechanical properties as well as an appropriate design are accountable for the building mechanical strength. Thus, the green buildings design begins with the appropriate selection of eco-friendly materials having an upper edge over traditional building materials. Their selection range on the basis of utility and financial factors. However, due to the widespread awareness campaign done in the past regarding climate change, a change has emerged for the welfare of all. The major task now lies in finding out a new material that is recyclable and reusable, sustainable production of materials or the incorporation of green resources, careful selection of eco-friendly sustainable building materials may be the fastest way for builders to start integrating sustainable design concepts in buildings. Generally, financial perspective has always been the primary consideration when thinking over switching to the newer technology. But this thing must be kept in mind that the price of a building material only reflects the manufacturing and transportation costs and not take into consideration their social or environmental costs. Embracing green building materials is a good alternative to meet to this objective.

3.2 STUDY OF NEW DELHI’s CLIMATE

The total population of Delhi as per the census of 2011 conducted by National Sample Survey Organisation (NSSO) under Ministry of Commerce and Industry is 1,67,87,941 comprising 89,87,326 males and 78,00,615 females. The climatic aspects of the city over a period of last 5 decades is given below

i. Maximum mean temperature for the city is recorded during the month of May and is 40.9°C while Minimum mean temperature is recorded during the month of January and is 8.2°C.

ii. Maximum Humidity is recorded during the month of January and is 93% and Minimum Humidity is recorded during the month of May and is 46 %.

iii. Total average annual rainfall is 656.1 mm. Maximum rainy days are usually in the month of July and are mostly 10.

3.3 AUTOCAD

AutoCAD is a 2 dimensional and 3 dimensional computer-aided drafting software application used in the fields of architecture, construction and manufacturing as it helps to assist in the preparation of blueprints and other engineering plans. Professionals using AutoCAD are usually referred to as drafters. The software application is developed and marketed by Autodesk. AutoCAD has its origin from a program called Interact, which was written in a proprietary language. The first release of the application used only primitive figures such as polygons, circles, lines, arcs and text to further program complex objects. Later, it was transformed and came to support custom objects through a C++ application programming interface. The modern version of the software application provides the provision of full set of tools for solid modeling and 3 dimensional. AutoCAD also supports numerous application program interfaces for automation and customization. The native file format for the application is DWG (Drawing). The application also provides support for Design Web Format (DWF), a format developed by Autodesk for publishing CAD data.

3.4 COSTMINER

CostMiner is an estimation and project management software application for architects, builders, contractors and engineers. This provides the provision of various cost estimates and rate analysis of buildings. It classifies the categories into sub heads and provides the provisions for editing rates and specifications for individual headings. It also analysis rates as per material, labour and machinery requirements for each heading. It also gives the approximate idea about the materials required for each activity in the project. At the end, it provides the split up of cost into materials, labour, machines, etc.

CHAPTER 4

CLIMATE AND GREEN BUILDING IN NEW DELHI

4.1 BUILDING IN SUB-TROPICAL REGION

The city of New Delhi has a subtropical climate The temperature ranges from around 46 °C (115 °F) in summer season to around 0 °C (32 °F) in winter season. The area has a characteristic feature of long and hot summer season ranging to relatively mild winters, a small monsoonal period of 3-4 months and occasional dust storms. Summer seasons are long, extending over 7 months starting from early April and ends upto October. The monsoon season occurs in the middle of the summer from mid-June to the end of September. Winter season starts in the month of November and has its peaks in the month of January. The annual mean temperature of the city is around 25 °C (77 °F) and the monthly daily mean temperatures range over 14°C to 34 °C (57°F to 93 °F). New Delhi recorded its highest ever temperature of 48.4 °C (119.1 °F) on June 28, 1883 while −2.2 °C (28.0 °F) is the lowest temperature on January 11, 1967. The average annual rainfall of the city is 714 millimeters (28.1 in)having its peak in the month of July and August.

4.2 CLIMATOLOGY IN NEW DELHI

The climate data for New Delhi from 1971 to 1990 is depicted through Fig 4.1. City's average temperature and precipitation are shown in the Fig 4.2. Fig 4.3 gives the number of cloudy, sunny and precipitation days. On an average, the city has nearly 20 sunny days except the monsoon duration. Fig 4.4 gives the range of maximum temperatures in a year. May and June are the two months with most number of hot days having temperatures in the range of 30°C to 45°C. Fig 4.5 gives the precipitation amount. July and August receives the majority of the precipitation. Its average annual rainfall is 714 millimeters. Fig 4.6 depicts the wind speed for the city. Fig 4.7 represents the Wind Rose diagram.

Climate data for Delhi (Safdarjung) 1971–1990													[hide]
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	30.0 (86)	34.1 (93.4)	40.6 (105.1)	45.6 (114.1)	47.2 (117)	46.7 (116.1)	45.0 (113)	42.0 (107.6)	40.6 (105.1)	39.4 (102.9)	36.1 (97)	29.3 (84.7)	47.2 (117)
Average high °C (°F)	21.0 (69.8)	23.5 (74.3)	29.2 (84.6)	36.0 (96.8)	39.2 (102.6)	38.8 (101.8)	34.7 (94.5)	33.6 (92.5)	34.2 (93.6)	33.0 (91.4)	28.3 (82.9)	22.9 (73.2)	31.2 (88.2)
Daily mean °C (°F)	14.3 (57.7)	16.8 (62.2)	22.3 (72.1)	28.8 (83.8)	32.5 (90.5)	33.4 (92.1)	30.8 (87.4)	30.0 (86)	29.5 (85.1)	26.3 (79.3)	20.8 (69.4)	15.7 (60.3)	25.1 (77.2)
Average low °C (°F)	7.6 (45.7)	10.1 (50.2)	15.3 (59.5)	21.6 (70.9)	25.9 (78.6)	27.8 (82)	26.8 (80.2)	26.3 (79.3)	24.7 (76.5)	19.6 (67.3)	13.2 (55.8)	8.5 (47.3)	19.0 (66.2)
Record low °C (°F)	−0.6 (30.9)	1.6 (34.9)	4.4 (39.9)	10.7 (51.3)	15.2 (59.4)	18.9 (66)	20.3 (68.5)	20.7 (69.3)	17.3 (63.1)	9.4 (48.9)	3.9 (39)	1.1 (34)	−0.6 (30.9)
Average precipitation mm (inches)	19 (0.75)	20 (0.79)	15 (0.59)	21 (0.83)	25 (0.98)	70 (2.76)	237 (9.33)	235 (9.25)	113 (4.45)	17 (0.67)	9 (0.35)	9 (0.35)	790 (31.1)
Average precipitation days (≥ 1.0 mm)	1.7	2.5	2.5	2.0	2.8	5.5	13.0	12.1	5.7	1.7	0.6	1.6	51.7
Average relative humidity (%)	63	55	47	34	33	46	70	73	62	52	55	62	54
Mean monthly sunshine hours	214.6	216.1	239.1	261.0	263.1	196.5	165.9	177.0	219.0	269.3	247.2	215.8	2,684.6
Source #1: NOAA[29]													
Source #2: Indian Meteorological Department (record high and low up to 2010)[30]													

Fig 4.1 Climate data of New Delhi [26]

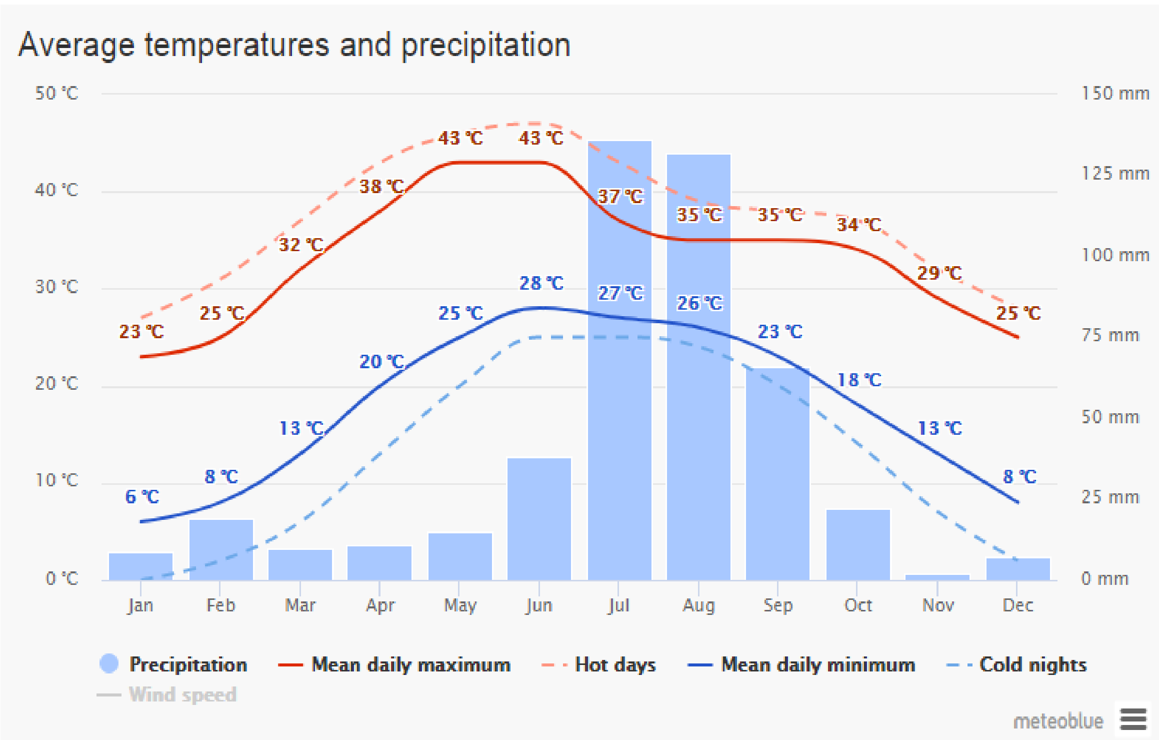


Fig 4.2 Average Temperature and Precipitation [26]

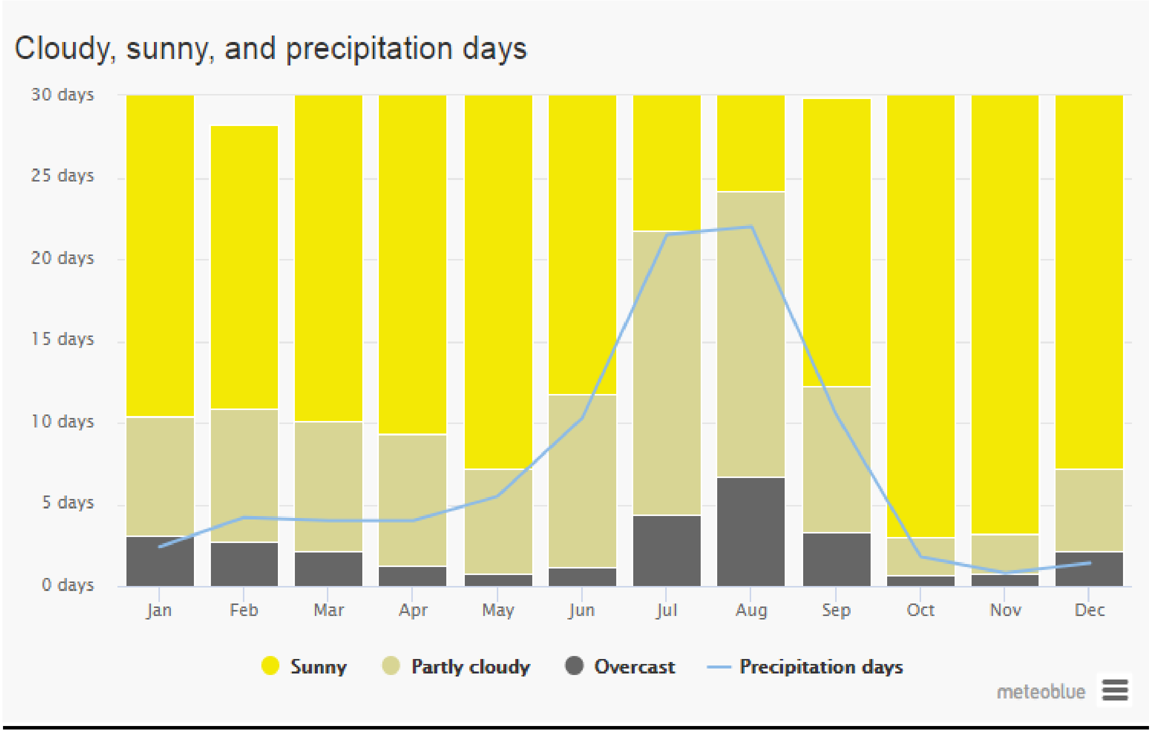


Fig 4.3 Cloudy, sunny and precipitation days [26]

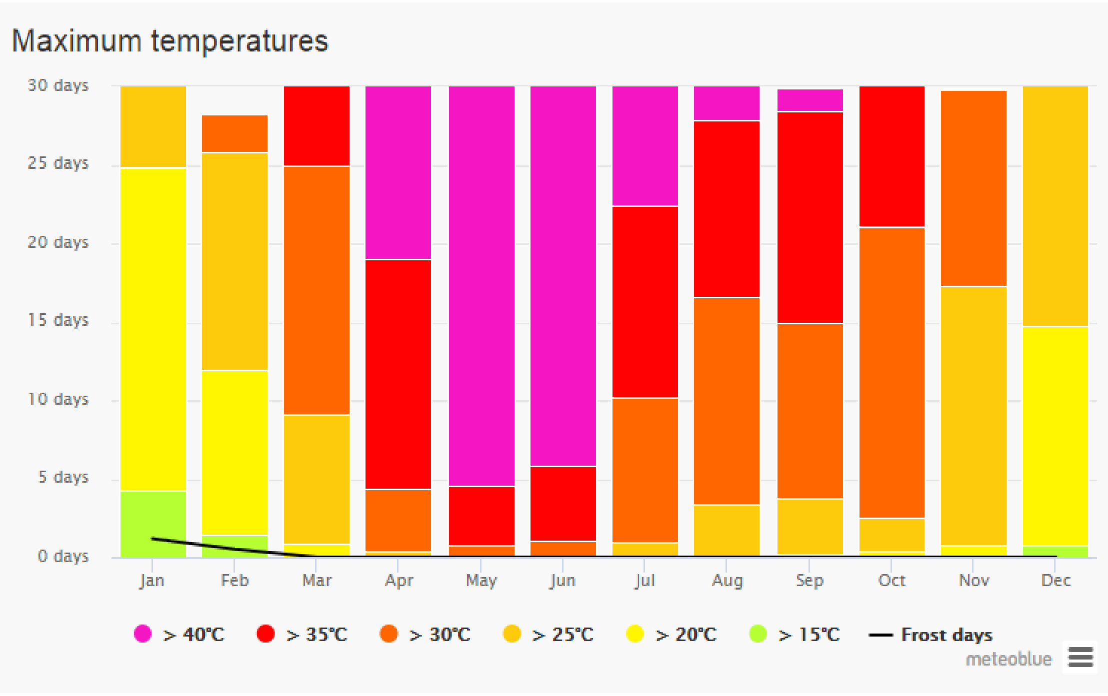


Fig 4.4 Maximum Temperatures in a year [26]

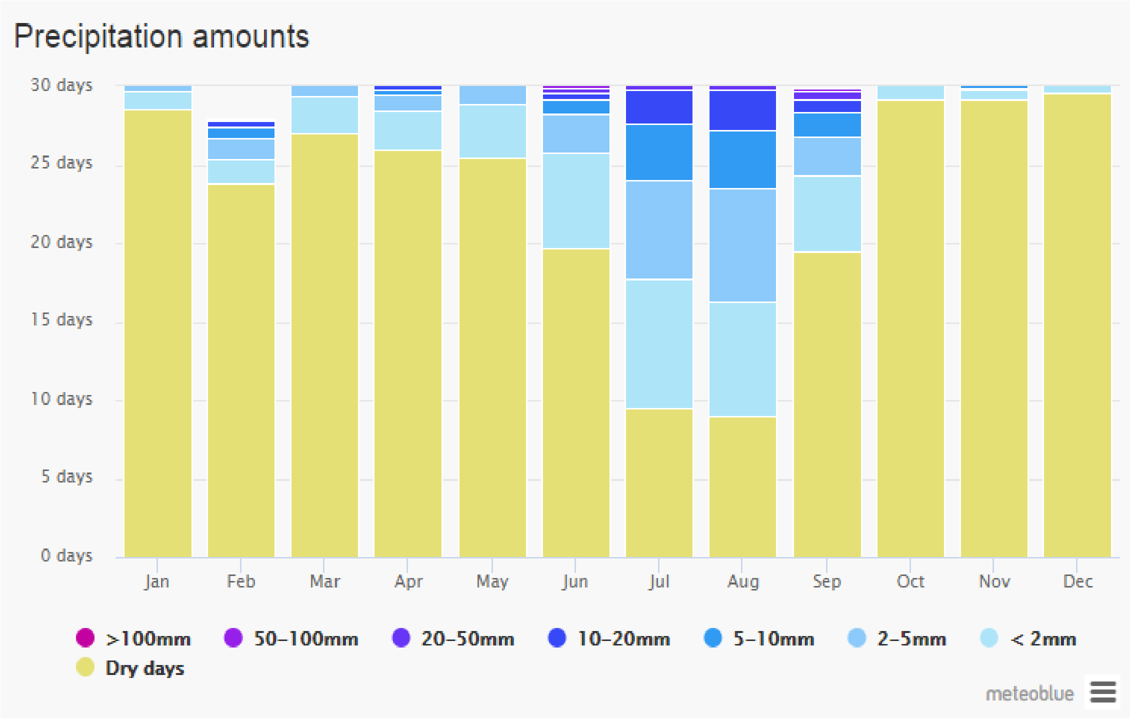


Fig 4.5 Precipitation amounts [26]

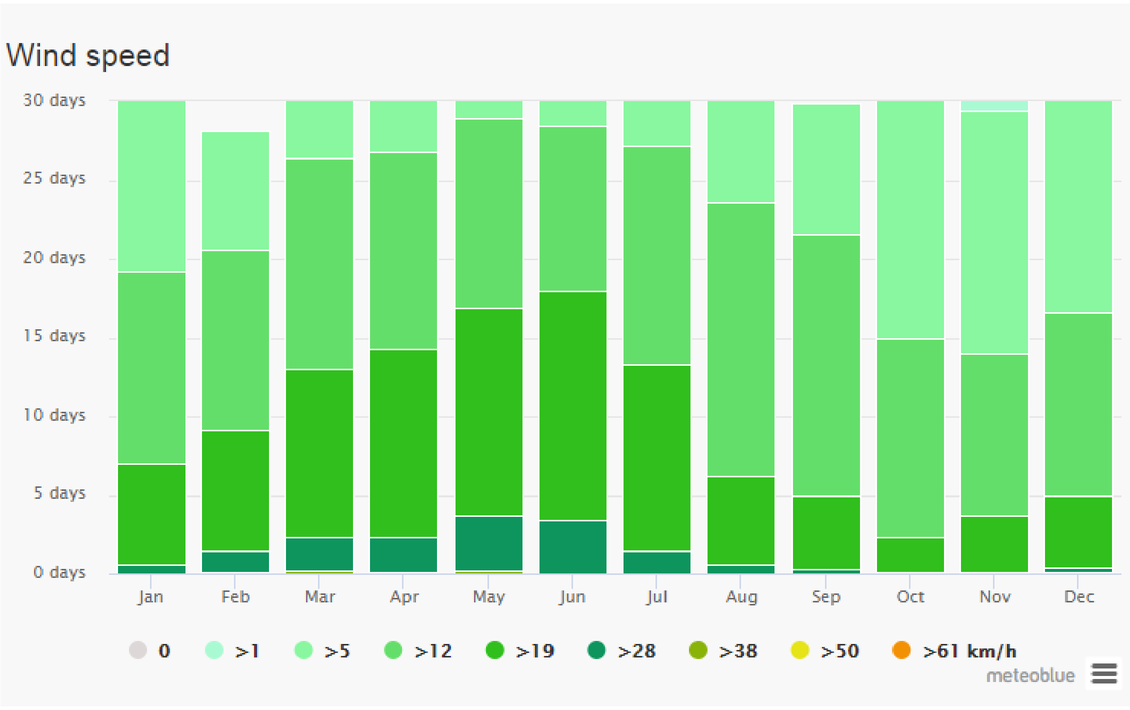


Fig 4.6 Wind Speed [26]

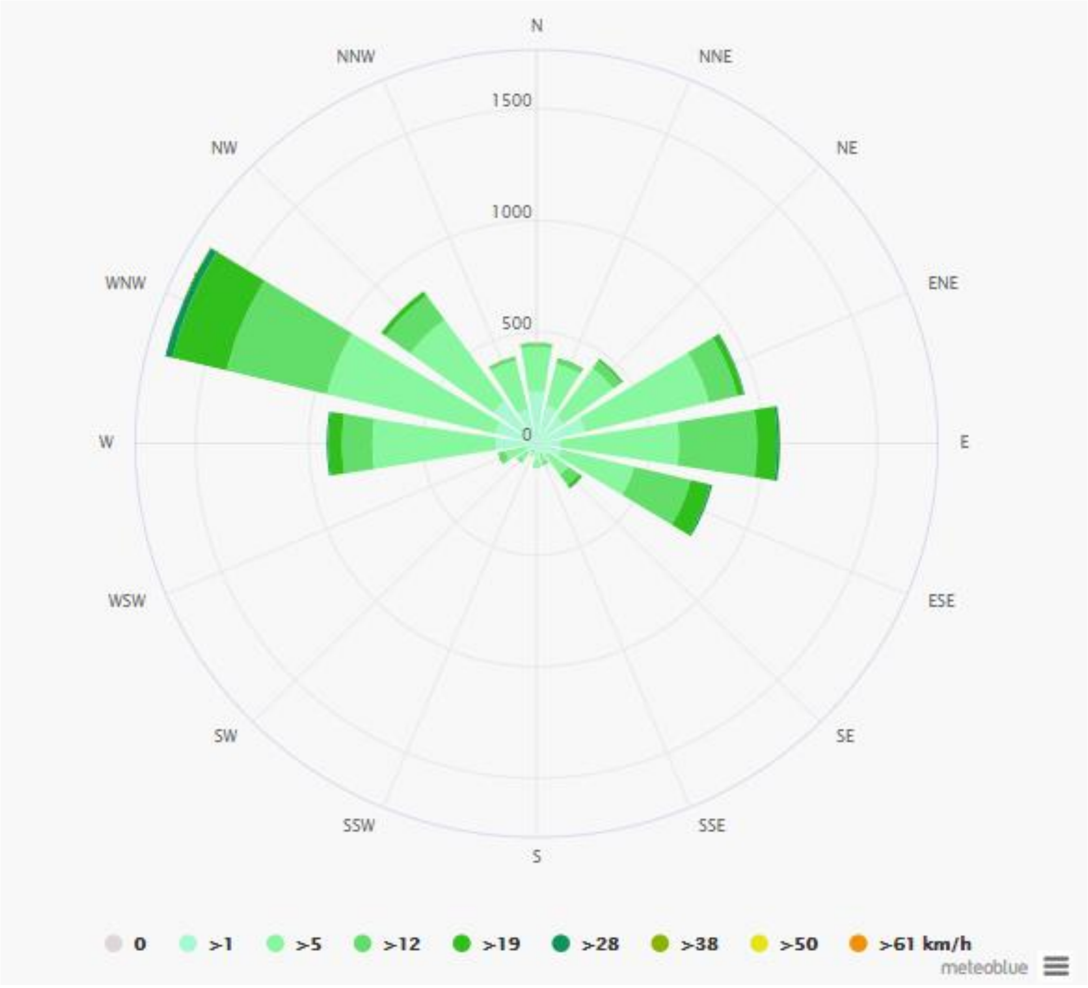


Fig 4.7 Wind Rose Diagram [26]

CHAPTER 5

DESIGN FEATURES OF THE GREEN BUILDING

5.1 PLAN OF THE DESIGNED BUILDING

The plan consists of a single storey 10.0 m x 7.0 m rectangular building constructed for monsoon influenced humid sub-tropical climate of New Delhi. The front elevation phasing south guides entry into the house that leads to the Hall (6.0 m x 1.45 m) adjoining Bedroom (6.0 m x 5.0 m) towards West and Kitchen (4.0 m x 3.45 m) towards North. Provision of single Bathroom (3.45 m x 2.45 m) is made adjoining the Bedroom and Kitchen. The plan of the designed building is illustrated in the Fig 5.1.

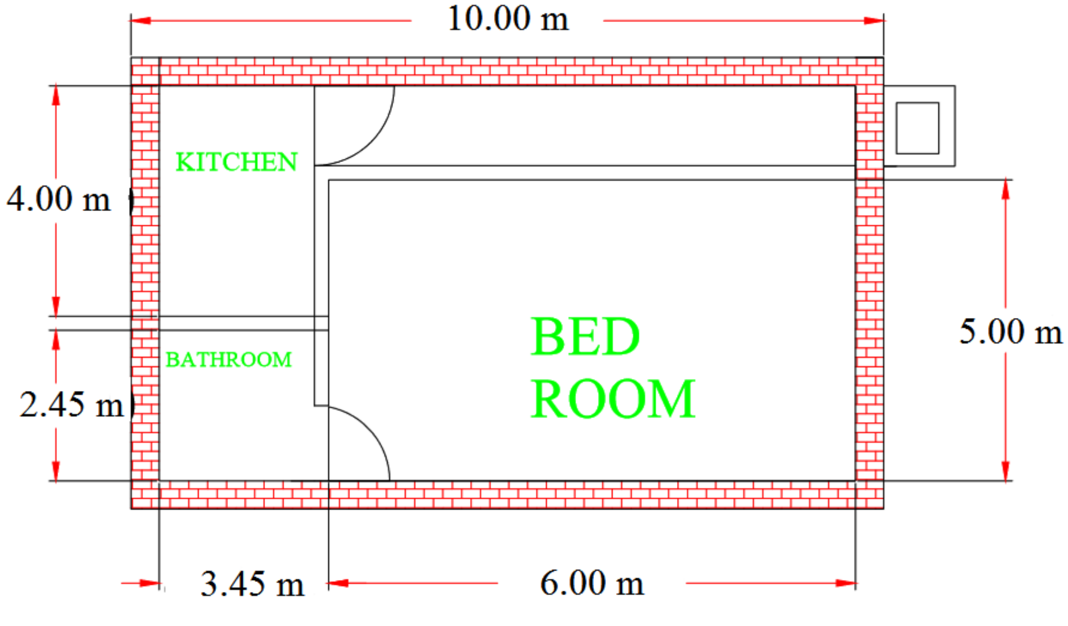


Fig 5.1 Plan of the building

5.2 3-D VIEW OF THE DESIGNED BUILDING

The 3-D Frame of the designed building is as shown in the Fig 5.

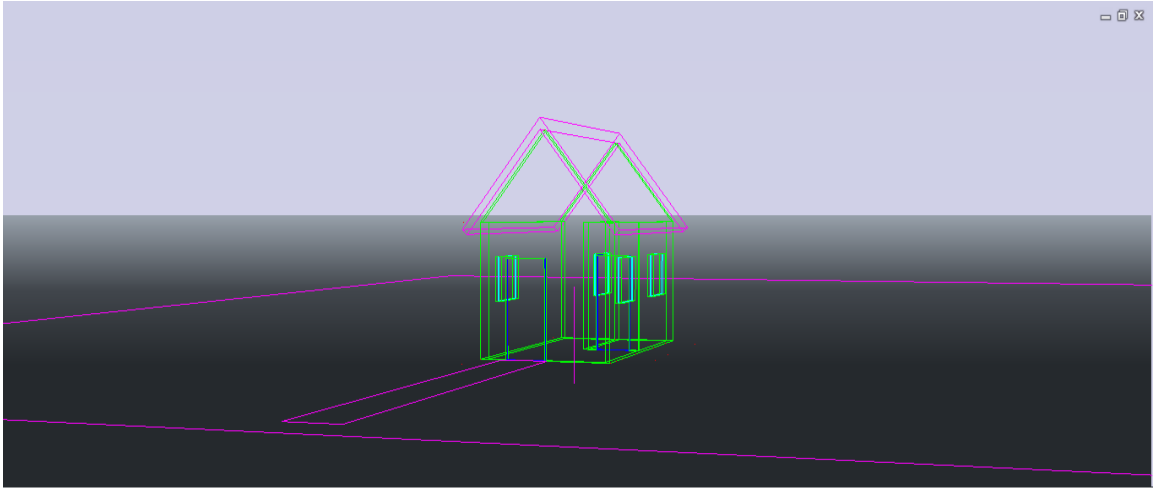


Fig 5.2 3-D Frame of the building

Fig 5.3 Building in AutoCAD

The building in its 3-D format is depicted through Fig 5.4

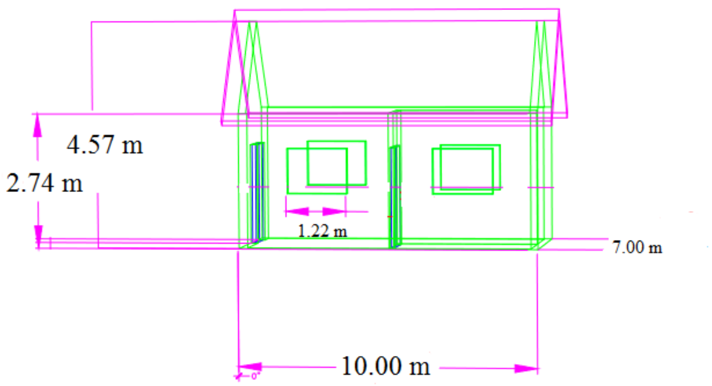


Fig 5.4 Dimension of the Building

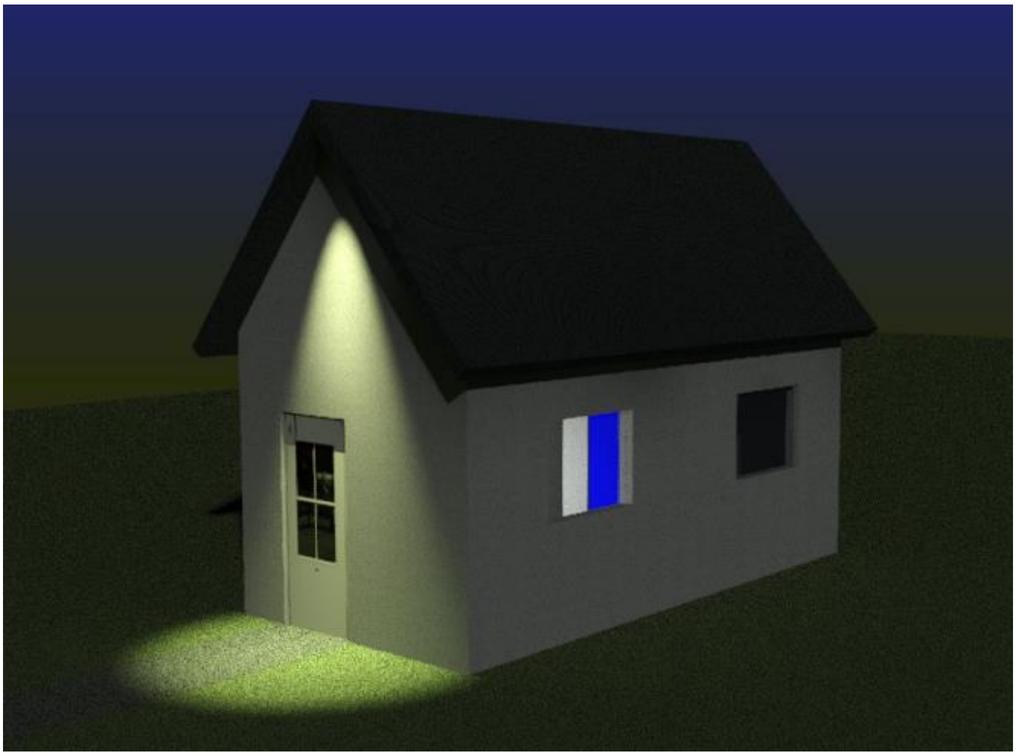


Fig 5.5 Building in AutoCAD

5.3 ORIENTATION

For a city in the sub-tropical climate, the building should be oriented in such a way that it gets optimum sun rays in winters, while phasing out the cooler winds in the same season. The shorter axis of the building should be arranged along East to West so that the longer axis of Building is receives large amount of sunlight. Orientation done in such a manner as shown in Fig 5.6 would lead to occupant comfort conditions in the building.

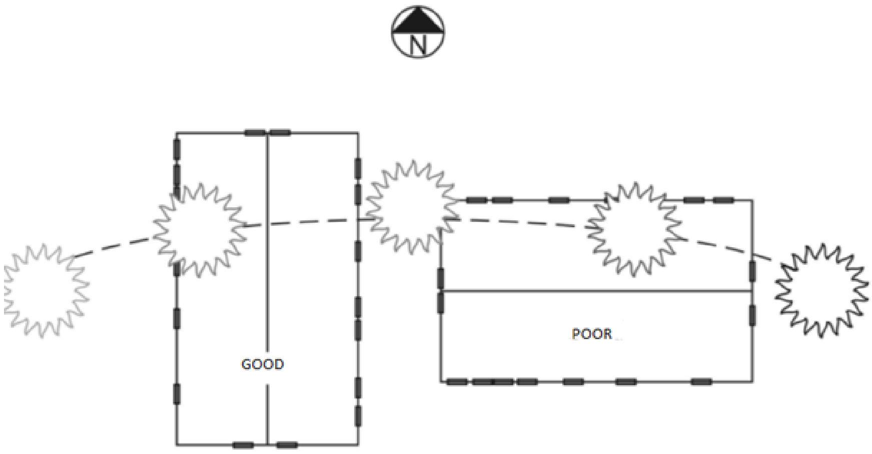


Fig 5.6 Orientation of the Building [27]

5.4 LIME

Lime should replace the cement in the building construction owing to its eco friendly nature. Lime absorbs the carbon and emits oxygen in the atmosphere, thus giving good air quality. The longevity of lime on the basis of quality can be checked against its usage in the ancient structures and its life gets strengthened over a period of time. The cost of lime ₹ 7.5/kg while that of cement is ₹ 6/Kg. Experimental analysis suggests that the durability of lime building is greater than cement building. The usage of lime as plaster in building segment minimizes its internal temperature by 4°C to 5°C over cement's incapacity to alter the temperature. On one hand, lime reduces the carbon footprint in the environment whereas, on the other hand, cement contributes to the increase in carbon. The manufacturing of lime utilizes lower energy as shown through Fig 5.7 when contrasted against cement production, hence it, thereby, minimizes the carbon emission in the atmosphere.

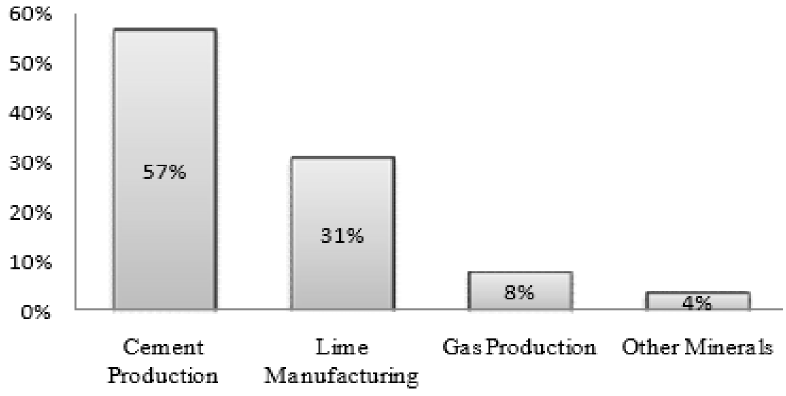


Fig 5.7 Energy used in production of materials [28]

5.5 SAND LIME BRICKS

Provision of Sand Lime bricks is termed as the replacement for the conventional bricks in the field of construction industry owing to the strength parameter as shown through Table 5.1 . Sand lime bricks costitutes sand, lime, fly ash and water. Sand has an added advantage to bind the particles together. Its brittleness helps us to recycle it and reuse in other works.Cost of conventional brick is ₹ 3.3/ brick and that of sand lime brick is ₹ 4.0/ brick. Experimental data suggests that the longevity of sand lime brick is greater than conventional brick. Compressive Strength of Sand Lime Brick is shown in the Table 5.1

Table 5.1 Compressive Strength of Sand Lime Bricks [28]

CLASS	MINIMUM MEAN COMPRESSIVE STRENGTH (WET) OF TEN BRICKS N/MM^2	MINIMUM PREDICTED LOWER LIMIT OF COMPRESSIVE STRENGTH N/MM^2
7	48.5	40.5
6	41.5	34.5
5	34.5	28
4	27.5	21.5
3	20.5	15.5

5.6 ECO -FRIENDLY TILES

Provision of Eco-friendly tile as shown in Fig 5.8 is termed as the replacement for the conventional flooring and utilizes lower energy in their making. It is economical over conventional tile. They also enhances the effectiveness of Indoor Environment Quality, thus possessing health and occupant comfort benefits. Eco – friendly tiles have more longevity than ceramic tiles and are manufactured from locally available materials. They are prone to water and laid directly on floor. They utilizes lesser energy. Eco-friendly tiles are economical and are made at the construction site, thus possessing lesser transportation charges. Price of normal tiles (Ceramic) is ₹ 40 while that of eco-friendly tiles is ₹ 35.

Fig 5.8 Eco Friendly Tiles [28]

5.7 COLOURED LIME PLASTER

Although lower VOC (Volatile Organic Compounds) paints are easily accessible but by utilizing coloured lime plaster in place of paint, it minimizes the painting maintainenance throughout its lifecycle. It has least maintenance, easily washable and prone to water. Its shine and glossiness increases as the time passes. It possesses better aesthetics looks. It is less expensive and more durable over normal paints. Price of normal paint is ₹ 10/sq. ft. and price of coloured lime plaster is ₹ 35/sq. ft. It has lesser maintenance associated over cement plastering and paint work. It is initially expensive but turns out to be economical over a period of time. It possesses better indoor quality and it is odourless.

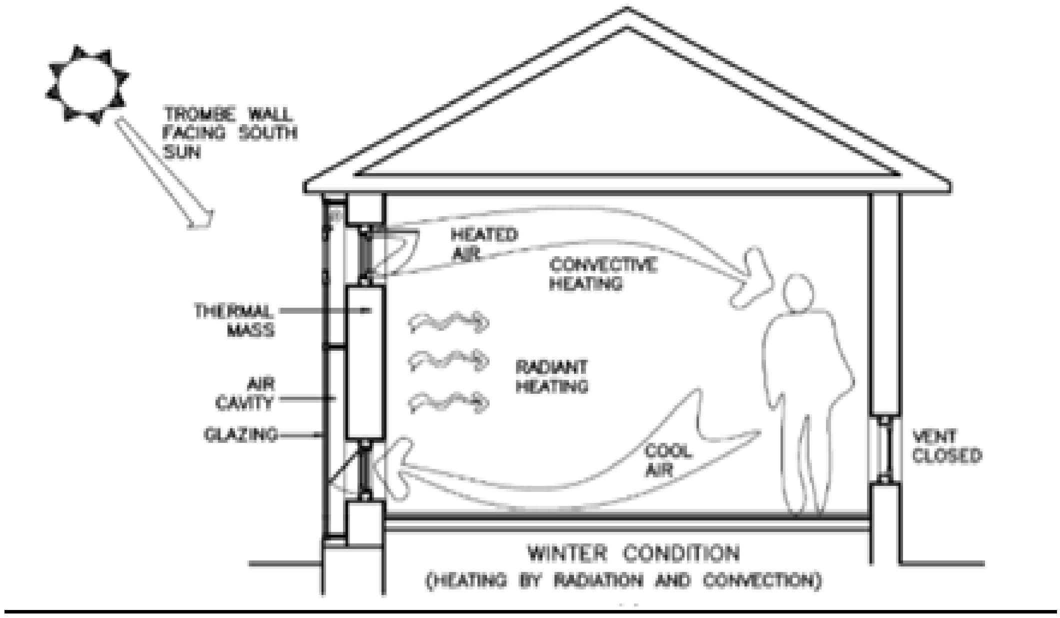
Fig 5.9 Colored Lime Plaster [28]

5.8 INSULATION

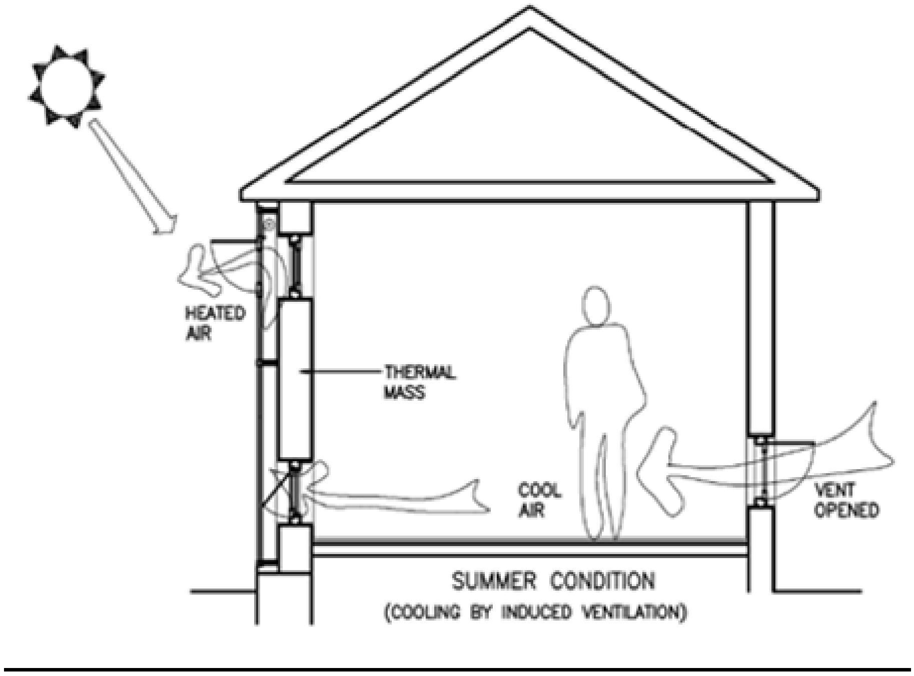
Insulation is useful in order to avoid unwanted heat losses. So insulation is provided on floors, roofs and walls. Puffed insulation are used in Roofs. They possess low thermal conductivity and are not easily ignitable and has negligible water permeability. Rigid Polyisocyanurate foam has a higher hot surface performance of 150°C compared with only 110°C of normal Polyurethane Foam. This purpose makes it suitable for use directly over steam or electrical tracing. They may be applied externally or internally depending upon the requirement.

5.9 TROMBE WALL

A Trombe wall as shown in the Fig 5.10 (a) and (b) receives the heat from the outside region and store it in between the glass and walls. Provision of Vents is also done in order to utilize this heat in the winter season. The inside sides of the Trombe walls are generally coated with black colour or some other dark colour in order to receive maximum amount of solar radiations.



(a)



(b)

Fig 5.10 Trombe Wall [28]

5.10 CAVITY WALL

Cavity walls are very beneficial for the regions receiving higher moisture content. Its representation is illustrated as shown in Fig 5.11. In this case, the inner wall is immune to protection because the consequence of moisture is observed on the outer side only. This mechanism is provided corresponding to the portion prone to the winter winds.

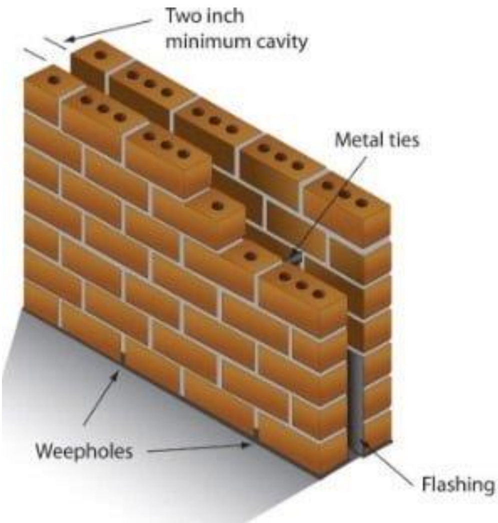


Fig 5.11 Cavity Wall [28]

5.11 DAY - LIGHTING

Glazing roof on sloping sides and windows facing to the Sun let the entrapping of sunrays and solar light into the home. This provision is made mostly in winter season when the position of the sun is at lower horizon, thus raising the inside temperature. In order to retain the heat, the inner surface should be painted with some dark color.

Fig 5.12 Day Lighting [28]

5.12 SOLAR PANELS

Provision of Solar panels as shown in the Fig 5.13 is used in order to absorb the solar radiations which are then transformed to electricity. These are beneficial on economic grounds as they tend to minimize the electricity cost by nearly 28%. Whenever the solar radiations strike the electrode, they get charged that leads to the generation of electricity. The electricity generated from such solar panels are utilized for various electrical appliances.

Figure 5.13 Solar Panels [28]

5.13 GLAZED WINDOWS GLASS

The window glasses used are doubled glazed glass. They have varying SHGC (Solar Heat Gain Coefficient) depending on whichever side, a window is placed. These windows are completely weather resistant and 100% water proof. They offer excellent insulation, thus making it a cost effective option as they keep the house cooler in summer and warmer in winter. A Glazed window is shown in the Fig 5.14.

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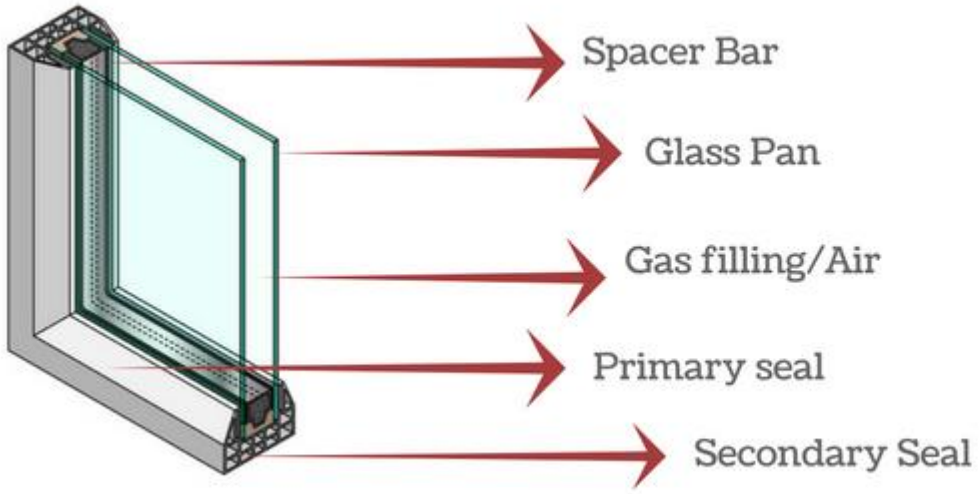

Fig 5.14 Glazed Glass Window [28]

5.14 DECIDUOUS TREES

Provision of Deciduous trees leads to the protection of the building during summer against the highly temperature solar radiations. When incorporated such trees in practice, the solar radiations does not directly fall on the walls. Rather, they are absorbed by these trees. This has its significance in the fact that in the peak summer, the inside temperature of the room won't be at its peak, thus avoiding the occupant comfort. In the season of winter, these trees let their trees to shedding as per the prevailing environmental condition that leads to maximum striking of solar radiations on the external walls, thus providing sufficient heat.

5.15 REDUCE WATER USE

The Green Building is equipped with the water efficient appliances including shower, taps, etc in order to minimize the indoor water use. For Gardening purpose, sprinkler system and drip irrigation should be promoted.

5.16 ENERGY EFFICIENT APPLIANCES

Electrical appliances used should be energy efficient in order to minimize energy use.

Fig 5.16 Energy Efficient Appliances Logo [29]

CHAPTER 6

COSTING AND ESTIMATION

6.1 PURPOSE

The prime aim of costing and estimation is to get an insight regarding the cost of the intended building before its actual construction begins. Cost estimate is prepared for various construction activities done at various stages on the basis of the approximate inputs accessible. An early estimation of the building on economical grounds helps the owner to take an advanced decision whether the activity is affordable within the available budget, while fulfilling the intended requirements. It also prepares the owner and the builder psychologically to keep the money and resources ready to meet some urgent need.

6.2 AIM OF COST ESTIMATION

i. To evaluate the most economical way to achieve the objective.

ii. To make wise decisions at an early stage.

iii. To recommend the alternate designs.

iv. To determine the total budget.

v. To optimize the cost savings in existing facilities.

The cost of construction of the Conventional Building including all the construction activities is summarized in Table 6.1

Table 6.1 Total Cost of construction of the Conventional Building

S.No	Activity	Quantity	Unit	Rate	Cost (₹)
1	Excavation	37.68	m^3	278.93	10509.80
2	Lime Concreting	11.19	m^3	3706.23	41472.70
3	Brick Work in Foundation	55.89	m^3	3183.25	177911.10
4	Earthwork in filling plinth	46.32	m^3	110.75	5129.94
5	DPC-	9.06	m^2	390.70	3539.83
8	Brick Work in Superstructure	115449.00	m^3	3183.25	115449.00
10	Wood Work	1.96	m^3	47446.10	93252.00
11	Glass Work	3.14	m^2	2241.28	7036.50
12	Lintel	0.26	m^3	4918.00	1277.10
13	Floor Finishing				
	Material	1.23	m^3	3944.14	4867.10
	Tiles and Labour	61.70	m^2	417.53	25762.20
14	Cement Plaster				
	Material	4.43	m^3	3944.15	17464.67
	Labour	369.03	m^2	81.40	30042.00
15	Painting	396.68	m^2	114.57	45499.00
	Total Cost				**579212.94**

For Calculations Refer to **ANNEXURE 1**

Total cost of construction of the Green Building including all the construction activities is summarized in Table 6.2

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Table 6.2 Total Construction Cost Of Green Building

S.No	Activity	Quantity	Unit	Rate	Cost (₹)
1	Excavation	40.69		278.93	11349.38
2	Lime Concreting	12.69	m^3	3706.23	47022.80
3	Brick Work in Foundation	62.05	m^3	3183.25	197520.66
4	Earthwork in filling plinth	46.32	m^3	110.75	5129.94
5	DPC	10.26	m^2	390.70	3987.10
8	Brick Work in Superstructure	41.59	m^3	3108.25	135520.90
10	Wood Work	1.96	m^3	47446.10	93252.00
11	Glass Work	3.14	m^2	2650.28	9381.10
12	Lintel	0.26	m^3	4918.00	1277.10
13	Floor Finishing				
	Material	1.23	m^3	3944.14	4867.10
	Tiles and Labour	61.70	m^2	417.53	25762.20
14	Cement Plaster				
	Material	4.42	m^3	3944.15	17464.67
	Labour	369.03	m^2	81.40	30042.00
15	Painting	430.68	m^2	122.68	52835.80
	Total Cost				**635411.94**

Calculation Refer to **ANNEXURE 2**

6.3 MANUAL ENERGY COSTING

There are generally two primary reasons for doing calculations on building thermal performance. They are obtained to size and accordingly choose mechanical equipment or to guess the annual energy requirements of the building. The following steps would lead to the manual energy costing.

Step I : Calculate the number of thermal appliances:

The number of thermal appliances to be used depends upon a number of factors such as the use, size, shape and the number of occupants in the building.

Step II : Determine load for every appliance

The requirement of load is done on an hourly basis for heat escape in the season of summer or provision of heat in the season of winter required to keep the building's inner atmosphere comfortable. In step II, load rates on annual basis, peak hourly basis, heating and cooling rates are calculated.

Step III: Selection of Heating, Ventilation and Air Conditioning (HVAC) systems

Based on the above mentioned peak loads evaluated in Step II, size and selection of the building mechanical equipment should be done now.

Step IV: Calculation of hourly energy consumption

Determine the loads placed on the selected mechanical equipment on hourly basis of a recent
meteorological year and calculate the amount of energy required by the equipment.

Step V: Input Electric Utility

Determine the input energy rate information including peak demand of electricity charges for the selected building site.

Step VI : Evaluating energy costs

Determine the energy utilized on hourly basis of the year and then find the annual requirement on hourly basis of the year.

Table 6.3 Units of electricity (kWh) utilized of Conventional Building

Month	Appliances	No. of Appliances	No. of days	No. of hours	kWh	kWh per month
January	Heater	1	31	4	1.50	186.00
	Fan	2	0	0	0.08	0
	Refrigerator	1	31	24	0.18	133.92
	WashingMachine	1	4	2	0.50	4.00
	Lights	6	31	6	0.03	27.90
	Electric Geyser	1	31	0.5	4.00	62.00
	Air Conditioner	1	0	0	3.50	0
					Total	**413.82**
February	Heater	1	20	4	1.50	120.00
	Fan	2	0	0	0.08	0
	Refrigerator	1	28	24	0.18	120.96
	Washing Machine	1	4	2	0.50	4.00
	Lights	6	28	6	0.025	25.20
	Electric Geyser	1	28	0.5	4.00	56.00
	Air Conditioner	1	0	0	3.50	0
					Total	**326.16**
March	Heater	1	0	0	1.50	0
	Fan	2	21	6	0.08	20.16
	Refrigerator	1	31	24	0.18	133.92
	Washing Machine	1	4	2	0.50	4.00
	Lights	6	31	6	0.03	27.90
	Electric Geyser	1	10	0.5	4.00	20.00
	Air Conditioner	1	0	0	3.50	0
					Total	**205.98**
April	Heater	1	0	0	1.50	0
	Fan	2	30	7	0.08	33.60

	Refrigerator	1	30	24	0.18	129.60
	Washing Machine	1	4	2	0.50	4.00
	Lights	6	30	5.5	0.03	24.75
	Electric Geyser	1	0	0	4.00	0
	Air Conditioner	1	10	3	3.50	105.00
					Total	**296.95**
May	Heater	1	0	0	1.50	0
	Fan	2	31	8	0.08	39.68
	Refrigerator	1	31	24	0.18	133.92
	Washing Machine	1	4	2	0.50	4.00
	Lights	6	31	5.5	0.03	25.58
	Electric Geyser	1	0	0	4.00	0
	Air Conditioner	1	31	3	3.50	325.30
					Total	**528.48**
June	Heater	1	0	0	1.50	0
	Fan	2	30	8	0.08	38.40
	Refrigerator	1	30	24	0.18	129.60
	Washing Machine	1	4	2	0.50	4.00
	Lights	6	30	5.5	0.03	24.75
	Electric Geyser	1	0	0	4.00	0
	Air Conditioner	1	30	4	3.50	420.00
					Total	**616.75**
July	Heater	1	0	0	1.50	0
	Fan	2	31	8	0.08	39.68
	Refrigerator	1	31	24	0.18	133.92
	Washing Machine	1	4	2	0.50	4.00
	Lights	6	31	5.5	0.03	25.58
	Electric Geyser	1	0	0	4.00	0
	Air Conditioner	1	31	4	3.50	434.00
					Total	**637.18**

August	Heater	1	0	0	1.50	0
	Fan	2	31	8	0.08	39.68
	Refrigerator	1	31	24	0.18	133.92
	Washing Machine	1	4	2	0.50	4.00
	Lights	6	31	5.5	0.03	25.58
	Electric Geyser	1	0	0	4.00	0
	Air Conditioner	1	31	3.5	3.50	379.75
					Total	**582.93**
September	Heater	1	0	0	1.50	0
	Fan	2	30	7	0.08	33.60
	Refrigerator	1	30	24	0.18	129.60
	Washing Machine	1	4	2	0.50	4.00
	Lights	6	30	6	0.03	27.00
	Electric Geyser	1	0	0	4.00	0
	Air Conditioner	1	15	3	3.50	157.50
					Total	**351.70**
October	Heater	1	0	0	1.50	0
	Fan	2	20	5	0.08	16.00
	Refrigerator	1	31	24	0.18	133.92
	Washing Machine	1	4	2	0.50	4.00
	Lights	6	31	6.5	0.03	30.23
	Electric Geyser	1	0	0	4.00	0
	Air Conditioner	1	0	0	3.50	0
					Total	**184.15**
November	Heater	1	0	0	1.50	0
	Fan	2	10	4	0.08	6.40
	Refrigerator	1	30	24	0.18	129.60
	Washing Machine	1	4	2	0.50	4.00
	Lights	6	30	7	0.025	31.50
	Electric Geyser	1	0	0	4.00	0

	Air Conditioner	1	0	0	3.50 Total	0 **171.50**
December	Heater Fan Refrigerator Washing Machine Lights Electric Geyser Air Conditioner	1 2 1 1 6 1 1	15 0 31 4 31 21 0	4 0 24 2 7.5 0.5 0	1.50 0.08 0.18 0.50 0.03 4.00 3.50 Total	90.00 0 133.92 4.00 34.88 42.00 0 **304.79**

Total units utilized - **4620.40 kWH**

Table 6.4 Units of electricity (kWh) utilized of Green Building

Month	Appliances	No. of Appliances	No. of days	No. of hours	kWh	kWh per month	Energy saved using Solar Panels	Total Energy required
January	Heater	1	31	4	1.50	186.00	55.85	130.15
	Fan	2	0	0	0.08	0	0	0
	Refrigerator	1	31	24	0.18	133.92	40.20	93.72
	Washing	1	4	2	0.50	4.00	1.20	2.80
	Machine	6	31	6	0.03	27.90	0	27.90
	Lights	1	31	0.5	4.00	62.00	18.62	43.38
	Electric Geyser	1	0	0	3.50	0	0	0
	Air Conditioner						Total	**297.95**
February	Heater	1	20	4	1.50	120.00	36.04	83.96
	Fan	2	0	0	0.08	0	0	0
	Refrigerator	1	28	24	0.18	120.96	36.32	84.64
	Washing	1	4	2	0.50	4.00	1.20	2.80
	Machine	6	28	6	0.03	25.20	0	25.20
	Lights	1	28	0.5	4.00	56.00	16.82	39.18
	Electric Geyser	1	0	0	3.50	0	0	0
	Air Conditioner						Total	**235.78**
March	Heater	1	0	0	1.50	0	0	0
	Fan	2	21	6	0.08	20.16	6.72	13.44
	Refrigerator	1	31	24	0.18	133.92	40.22	93.70
	Washing	1	4	2	0.50	4.00	1.20	2.80
	Machine	6	31	6	0.03	27.90	0	27.90
	Lights	1	10	0.5	4.00	20.00	6.66	13.44

	Electric Geyser	1	0	0	3.50	0	0	0
	Air Conditioner						Total	**151.28**
April	Heater	1	0	0	1.50	0	0	0
	Fan	2	30	7	0.08	33.60	10.10	23.50
	Refrigerator	1	30	24	0.18	129.60	38.92	90.68
	Washing	1	4	2	0.50	4.00	1.20	2.80
	Machine	6	30	5.5	0.03	24.75	0	24.75
	Lights	1	0	0	4.00	0	0	0
	Electric Geyser	1	10	3	3.50	105.00	31.50	73.50
	Air Conditioner						Total	**215.23**
May	Heater	1	0	0	1.50	0	0	0
	Fan	2	31	8	0.08	39.68	11.92	27.76
	Refrigerator	1	31	24	0.18	133.92	40.18	93.74
	Washing	1	4	2	0.50	4.00	1.20	2.80
	Machine	6	31	5.5	0.03	25.58	0	25.58
	Lights	1	0	0	4.00	0	0	0
	Electric Geyser	1	31	3	3.50	325.30	97.60	227.70
	Air Conditioner						Total	**377.57**
June	Heater	1	0	0	1.50	0	0	0
	Fan	2	30	8	0.08	38.40	11.53	26.87
	Refrigerator	1	30	24	0.18	129.60	38.80	90.80
	Washing	1	4	2	0.50	4.00	1.20	2.80
	Machine	6	30	5.5	0.03	24.75	0	24.75
	Lights	1	0	0	4.00	0	0	0
	Electric Geyser	1	30	4	3.50	420.00	126.13	293.87
	Air Conditioner						Total	**439.10**
July	Heater	1	0	0	1.50	0	0	0
	Fan	2	31	8	0.08	39.68	11.92	27.76
	Refrigerator	1	31	24	0.18	133.92	40.21	93.71

	Washing	1	4	2	0.50	4.00	1.20	2.8
	Machine	6	31	5.5	0.03	25.58	0	25.58
	Lights	1	0	0	4.00	0	0	0
	Electric Geyser	1	31	4	3.50	434.00	130.33	303.67
	Air Conditioner						Total	**453.50**
August	Heater	1	0	0	1.50	0	0	0
	Fan	2	31	8	0.08	39.68	11.92	27.76
	Refrigerator	1	31	24	0.18	133.92	40.21	93.71
	Washing	1	4	2	0.50	4.00	1.20	2.80
	Machine	6	31	5.5	0.03	25.58	0	25.58
	Lights	1	0	0	4.00	0	0	0
	Electric Geyser	1	31	3.5	3.50	379.75	114.04	265.71
	Air Conditioner						Total	**415.55**
September	Heater	1	0	0	1.50	0	0	0
	Fan	2	30	7	0.08	33.60	10.09	23.51
	Refrigerator	1	30	24	0.18	129.60	38.92	90.68
	Washing	1	4	2	0.50	4.00	1.20	2.80
	Machine	6	30	6	0.03	27.00	0	27.00
	Lights	1	0	0	4.00	0	0	0
	Electric Geyser	1	15	3	3.50	157.50	47.30	110.20
	Air Conditioner						Total	**254.19**
October	Heater	1	0	0	1.50	0	0	0
	Fan	2	20	5	0.08	16.00	4.80	11.20
	Refrigerator	1	31	24	0.18	133.92	40.22	93.70
	Washing	1	4	2	0.50	4.00	1.20	2.80
	Machine	6	31	6.5	0.03	30.23	0	30.23
	Lights	1	0	0	4.00	0	0	0
	Electric Geyser	1	0	0	3.50	0	0	0
	Air Conditioner						Total	**137.93**
November	Heater	1	0	0	1.50	0	0	0

	Fan	2	10	4	0.08	6.40	1.92	4.48
	Refrigerator	1	30	24	0.18	129.60	38.92	90.68
	Washing	1	4	2	0.50	4.00	1.20	2.80
	Machine	6	30	7	0.03	31.50	0	31.50
	Lights	1	0	0	4.00	0	0	0
	Electric Geyser	1	0	0	3.50	0	0	0
	Air Conditioner						Total	**129.46**
December	Heater	1	15	4	1.50	90.00	27.00	63.00
	Fan	2	0	0	0.08	0	0	0
	Refrigerator	1	31	24	0.18	133.92	40.22	93.70
	Washing	1	4	2	0.50	4.00	1.20	2.80
	Machine	6	31	7.5	0.03	34.88	0	34.88
	Lights	1	21	0.5	4.00	42.00	12.60	29.40
	Electric Geyser	1	0	0	3.50	0	0	0
	Air Conditioner						Total	**223.78**

Total units utilized – **3331.118 kWh**

Table 6.5 Monthly comparison between Conventional Building and Green Building

Month	Conventional Building (kWh)	Green Building (kWh)
JANUARY	413.82	297.95
FEBRUARY	326.16	235.78
MARCH	205.98	151.28
APRIL	296.95	215.23
MAY	528.48	377.57
JUNE	616.75	439.10
JULY	637.18	453.50
AUGUST	582.93	415.55
SEPTEMBER	351.70	254.19
OCTOBER	184.15	137.93
NOVEMBER	171.50	129.46
DECEMBER	304.79	223.78

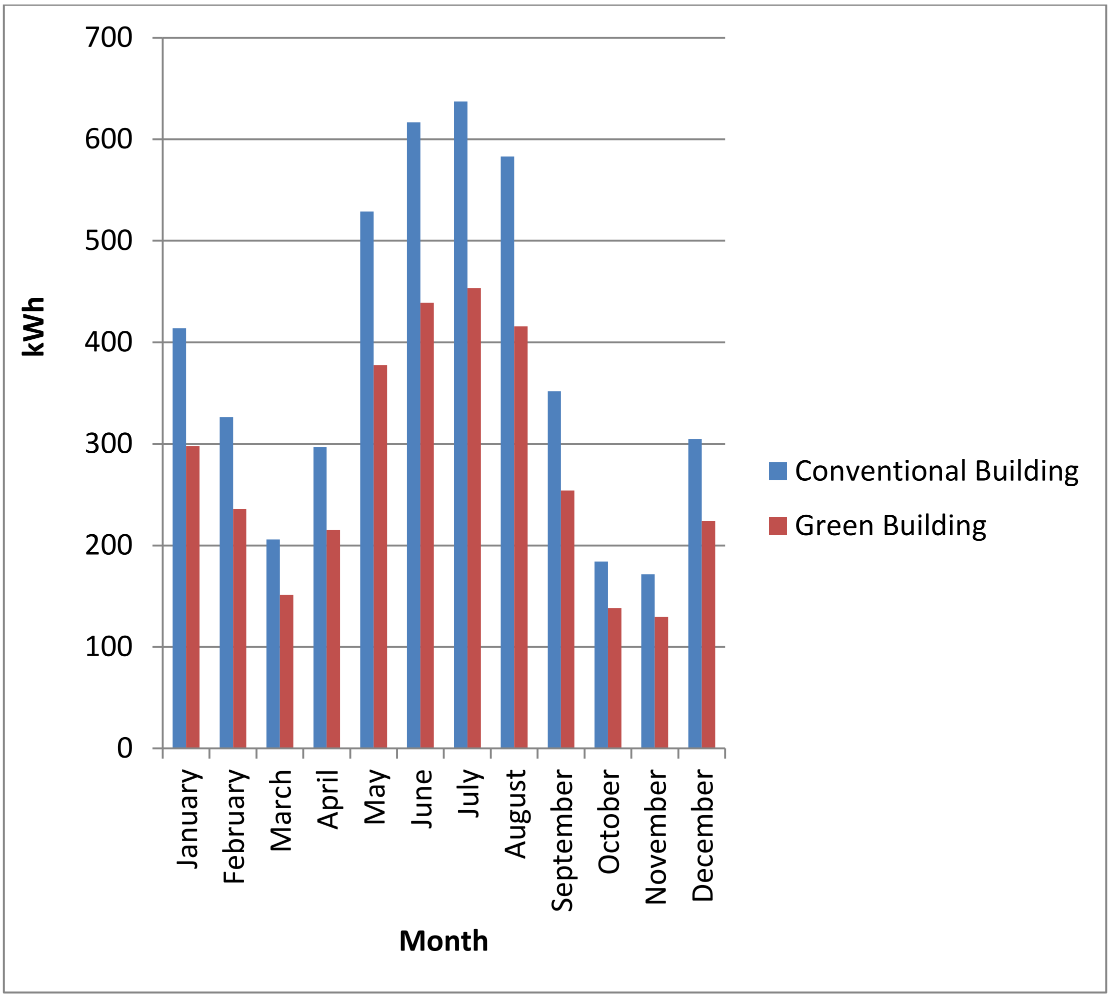

Fig 6.1 Graphical Representation of Monthly Comparison of Energy of Conventional and Green Building

Table 6.6 Annual Electricity consumption of Conventional and Green Building

Building	kWh Per Year
Conventional Building	4620.40
Green Building	3331.12

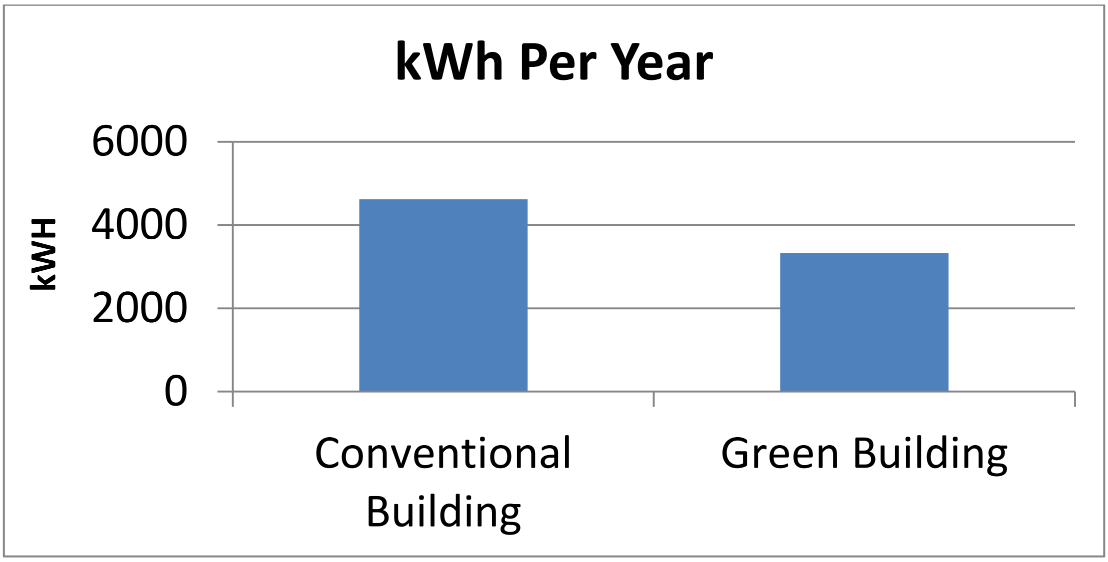

Fig – 6.2 Graphical representation of Energy Consumption on annual basis of Conventional and Green Building

Total cost of construction of the Conventional Building = **₹. 579212.94**

Total cost of construction of the Green Building = **₹. 635411.94**

Cost of Solar Panels = ₹58/Watt
[Su-Kam]

1kWh capacity of solar panel produces 5kWh units of electricity

Units of electricity we've saved by switching to the use of Solar Panels
= (3331.118 – 4620.4) / 5 = 197.85 kWh

Cost of 2 Solar Panels with 200 Watt power = 58*200 = ₹ 11600

Cost of battery required for the Solar Panels = ₹2000/200 Watt [Su-Kam]

Cost of Solar DC to AC Converter = ₹ 8000

Cost of Green Building including Solar Panels = 635411.94+11600+2000+8000= **₹657011**

Extra cost incurred to construct Green Building = ₹657011 - ₹ 579212 =**₹77799**

6.4 DETERMINATION OF PAYBACK PERIOD

The payback period is estimated by computing the number of years it will take to recover the initial investment. Payback period of the Green Building incurring extra initial cost of ₹56200 is 16 years while computing it on Net Present Value with an inflation rate of 3.8% and interest rate of 10.5%. Figure 6.3 illustrates the year wise returns of the green building from the year of switching.

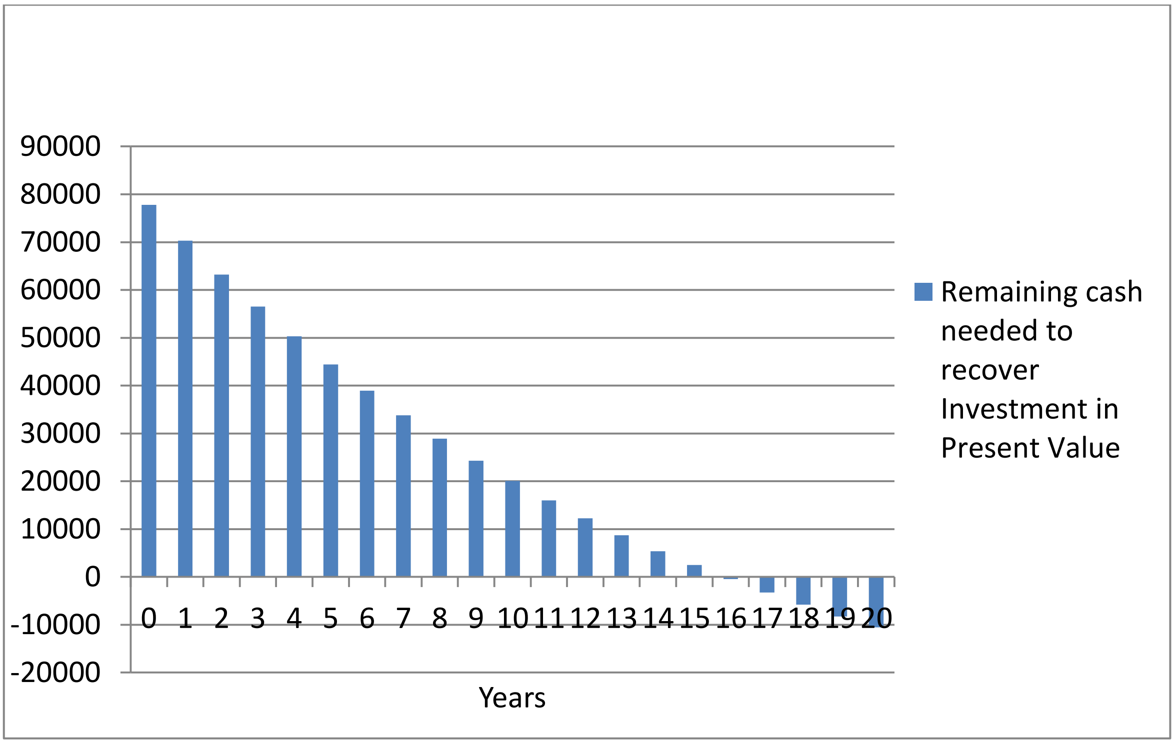

Fig 6.3 Graphical representation of Payback period of Green Buildings

For Calculation Refer to **ANNEXURE 3**

CHAPTER 7

CONCLUSION

7.1 ECONOMIC SAVINGS

The green technology is economical as a lot of savings are accrued from the electricity and water recycling. Nearly 38.7% of electricity is generated from the solar panels and water is recycled from the rainwater harvesting mechanism. The banking system can promote the sector by investing more, thus elevating the economy. The government should also intervene and provide subsidies in order to achieve its Nationally Determined Contribution and objectives of Paris Climate Agreement. The relationship between working surroundings and employee efficiency has a direct influence on the organization's profit. The major elements of the work environment depend upon the physical layout, comfort level and environmental condition such as artificial lighting, ventilation system and natural lighting. They subsequently reduce the employee absentia and increase the employee productivity and company's profit.

7.2 SOCIAL AND COMMUNITY BENEFITS

The principles of Green Building recommend the use of locally available materials. They lessen the impact on the environment by subsequently reducing the excess pollution owing due to the transportation of materials. The segment also boosts employment in the region catering from managerial rank to grass root laborers. Since the green building is a new journey, lots of new door would be open in this industry. This will also promote entrepreneurship amongst the younger generation.

7.3 ENVIRONMENTAL HARMONY

The Green Building is so designed in order to optimize the daylight utilization and reduce the subsequent heat gain. The provision of atrium permits passive solar shading. The water supply is recycled through rain water harvesting. Energy demand is met by Photovoltaic solar panels.

7.4 GOVERNMENT ASPECT

With the boost in the job creation and entrepreneurial opportunities coupled with the increased investment from the banking sector and subsequent following by the booming economy, the government would be able to realize more tax revenues. The government should use these extra resources in Research and Development in order to access cheaper and viable technology so that India would become a global leader to promote sustainable development and fight climate change.

REFERENCES

01. Singh, P., Sharma, K. (2017)“Green Building Construction for Sustainable Fututre”. Indian Journal of Research Paripex volume : 2, Issue : 3, March 2016
02. Mayer, S., Stephen, A. (2016) “Payback Period for Green Building Materials” – Civil and Environmental Research www.iiste.org ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) Vol.3, No.6, 2016
03. Gibler, M. R. (2016) “Vertical Greenery System” - International Journal of Scientific & Engineering Research, Volume 3, Issue 6, June -2016
04. Wong, P., Rein, W. (2015) “Effects of Green Building materials on Interior Environmental Assessment”- Journal of Engineering, Science and Management Education/Vol. 4, 2015
05. Singh, H., Sharma, A. (2015) “Buildings and Climate Change” - Indian journal of public health, 2015.
06. Singh, H., Sharma, A. (2014) Green Buildings – Need of the century. The Engineering Economist, 2014.
07. O’mara, S., Bates, W., (2014) “Vertical Garden – Green Building Design” Sustainable Development, 2014.
08. Nguyen, H.T., Gray, M. (2013) “Interior Environmental Assessment on Green buildings”. Journal of Infrastructure Systems, 2013.
09. Khosla, J., Singh H., (2013) Bamboo as reinforcement in structural concrete elements Lightweight Concrete Beams, Pontificia Universida de Catolica, Rio de Janeiro,
10. Xing, A.M., Rein, A. (2012) “Identifying the critical factors for green construction- An empirical study in China.
11. Kanika, P., Singh, P. (2011) Investigating the awareness and the application of sustainable construction concept.
12. Kaplow, J. (2011) The Cost and Financial Benefits of Green Buildings, November 3rd, 2011.

13. Kalidas, S.K., Christopher, L. (2010) The Cost of Green Revisited Publication. 2010.
14. Chaturvedi, S., (2009) Green Buildings – Need of the century. The Engineering Economist, 2009.
15. Chunduri, S., Yimin, Z., Bayraktar, M. E. (2008) “Vertical Garden – Green Building Design” Sustainable Development.
16. Ionescu, C., Xing, A. (2008) “Interior Environmental Assessment on Green buildings”. Journal of Infrastructure Systems, 2008.
17. Kannan, N., Sharma, A. (2007) Bamboo as reinforcement in structural concrete elements Lightweight Concrete Beams, Pontificia Universida de Catolica, Rio de Janeiro,
18. Sorell, S. (2007) “Effects of Green Building materials on Interior Environmental Assessment”- Journal of Engineering, Science and Management Education/Vol. 4, 2007
19. Sun, S. (2006) “Buildings and Climate Change” - Indian journal of public health
20. Chan, A. P. C., Xien, A. (2006) Green Buildings – Need of the century. The Engineering Economist, 2006.
21. Charalambides, J., Wright, J. (2006) “Vertical Garden – Green Building Design” Sustainable Development, 2006.
22. Chokor, A.,Asmar, M. E. (2006) “Interior Environmental Assessment on Green buildings”. Journal of Infrastructure Systems, 2006.
23. Kannan, N., Chaturvedi, A. (2005) Bamboo as reinforcement in structural concrete elements Lightweight Concrete Beams, Pontificia Universidade Catolica, Chicago.
24. Kolokotroni, M., John, F. (2005) “Identifying the critical factors for green construction-An empirical study in Mexico.
25. Wong, N., H. (2005) Investigating the awareness and the application of sustainable construction concept.
26. Climate of New Delhi from 1965 to 2015. Retrieved from http://www.meteoblue.org.newdelhi/climate/. Accessed on 15 April 2018
27. Raussaeu, D., “Sustainable Built Environment-vol.1, Environmentally friendly building materials”.

28. Parashar, A.K.,Parashar, R.K., “Construction of an Eco-Friendly Building using Green Building Approach” - International Journal of Scientific & Engineering Research, Volume 3, Issue 6, June -2004
29. Energy Efficient Appliances Logo. Retrieved from Google Images.
30. Garg, A.K., “Financial aspects of Green Buildings”- Journal of Engineering, Science and Management Education/Vol. 4, 2003

LIST OF PUBLICATIONS

Journal Publication

1. Saurav, Abrol, A. (2018). " A Comprehensive Cost Benefit Analysis of Green Buildings". *Journal of Civil Engineering and Environment Technology,* 5(4), 171-176. **[UGC approved]**

APPENDIX

ANNEXURE I

Cost of Construction of Conventional Building

Table - 8.1 Volume required for Excavation

Item No.	Excavation	Dimensions			No. of Units	Quantity(m^3)	Explanatory Notes
		Length (m)	Breadth (m)	Depth (m)			
1	Main Wall	33.1	0.9	1	1	29.79	10-0.225/2; 7-0.225/2
	Partition Wall	16.1	0.7	0.7	1	7.889	6+0.1/2;3.45+0.1/2
	Total					37.679	

Table - 8.2 Cost of Excavation

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material		0	0	0.00	
2	Labour					
2.1	Mate	Mandays	0.06	365	22.88	For 1 m^3
2.2	Mazdoor	Mandays	0.62	365	226.08	For 1 m^3
3	Plant and Machinery		0	0	0.00	
	Total				246.84	For 1 m^3
4	Water Charges				0.00	
5	Tools		3% of total cost		7.41	
6	Profit		10% of total cost		24.68	
	Cost of Excavation for 1 Cum				278.93	
	Cost of Excavation for 37.68 Cum				10509.8	

Table – 8.3 Volume required for Lime Concrete Foundation

Item No.	Lime Concrete Foundation	Dimensions			No of Units	Quantity(m^3)
		Length (m)	Breadth (m)	Height (m)		
2	Main Wall	33.1	0.9	0.3	1	8.937
	Partition Wall	16.1	0.7	0.2	1	2.254
	Total					11.191

Table - 8.4 Material required for Lime Concreting

Lime Concreting In Foundation with 40 mm gauge Brick Ballast	
White Lime : Surkhi : Brick Ballast = 1 : 2 : 6	
Wet Volume = 1 Cum	
Dry Volume = 1.4* W V	1.4 m^3
Vol Including Wastage = 1.1* D V	1.54 m^3
White Lime (Cum)	0.17
Surkhi (Cum)	0.34
Brick Ballast (Cum)	1.03

Table - 8.5 Cost of Lime Concrete Foundation

Sr No.	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material					
1.1	White Lime (dry hydrated lime)	m^3	0.17	5086.4	871.15	1 m^3 = 2210 Kg = 22.10Quintal
					0.00	1 m^3 = 22.10*230 = ₹ 5086.0
1.2	Carraige of Lime	m^3	0.17	107.50	19.22	Distance = 3 to 4 km
1.3	Surkhi	m^3	0.34	699	240.56	
1.4	Carraige of Surkhi	m^3	0.34	107.50	35.44	Distance = 3 to 4 km
1.5	Brick Ballast	m^3	1.03	649	668.33	
1.6	Carriage Of Brick Ballast	m^3	1.03	107.00	110.33	Distance = 3 to 4 km
2	Labour				0.00	
2.1	Mason	Mandays	0.1	436	44.50	For 1 m^3
2.2	Mazdoor	Mandays	2.65	365	962.95	For 1 m^3
2.3	Bhisti	Mandays	0.8	365	291.40	For 1 m^3
3	Plant and Machinery		0	0	0.00	
	Total				3237.88	For 1 m^3
4	Water Charges		1.5% of total cost		49.55	
5	Tools		3% of total cost		98.11	
6	Profit		10% of total cost		324.69	
	Cost of Lime Concreting for 1 Cum				3708.23	
	Cost of Lime Concreting for 11.19 Cum				41472.7	

Table - 8.6 Volume required for Brickwork in Foundation

Item No.	Brickwork in Foundation	Dimensions			No. of Units	Quantity(Cum)	Explanatory Notes
		Length (m)	Breadth (m)	Depth (m)			
3	Main wall						
	60cm thick	33.1	0.6	0.20	1	9.12	
	50cm thick	33.1	0.5	0.20	1	7.65	
	40cm thick	33.1	0.4	1.06	1	32.71	
	Partition wall						
	40cm thick	16.1	0.4	0.20	1	1.29	
	30cm thick	16.1	0.3	1.06	1	5.12	
	Total					55.89	

Table - 8.7 Material required for Brickwork in Foundation

Volume	1 m^3				
Nominal size of bricks	200*100*100	2000000 mm^3			
Brick size(without mortar)	190*90*90	1538000 mm^3			
Mortar volume for 1 Brick		461000 mm^3			
Total no of bricks		500			
Mortar volume		23050000 mm^3	0.231	(m^3)	(Wet volume)
Dry volume			0.288	(m^3)	D.V = 1.25* W.V
Volume inc .wastage			0.316	(m^3)	Wastage = 1.1 * D.V
Cement volume			0.053	(m^3)	
Sand volume			0.264	(m^3)	Cement:Sand for brick work=1:6
Cement weight	1 m^3=1.44 Tons		0.076	(Tons)	First Class Brick

Table -8.8 Cost of Brickwork in Foundation

S No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Bricks	per brick	500	3.4	1660	Rate 1000 bricks = 3400
1.2	Cement	m^3	0.053	9073	488.18	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = ₹9072
1.3	Sand	m^3	0.264	690	185.49	
1.3	Carraige of Bricks	per brick	500	0.284	142.95	
1.4	Carraige of Cement	m^3	0.053	138.39	6.9	
1.5	Carraige of Sand	m^3	0.264	106.49	29.06	Distance = 3 to 4 km
2	Labour					
	Mason	Mandays	0.250	435	109.85	1 m^3
	Mazdoor	Mandays	0.400	363	146.3	1 m^3
	Bhisti	Mandays	0.100	363	37.0	1 m^3
3	Plant and Machinery		0	0	0	
	Total				2781.14	1 m^3
4	Water Charges		1.5% of total cost		42.80	
5	Tools		3% of total cost		82.50	
6	Profit		10% of total cost		279.00	
	Cost of Brick work in Foundationt for 1 Cum				3184.25	
	Cost of Brick work in Foundation for 55.89 Cum				177911.60	

Table - 8.9 Volume required for Earthwork in Filling Plinth

Item No.	Earthwork in Filling Plinth	Dimensions			No. of Units	Quantity(Cum)
		Length (m)	Breadth (m)	Depth (m)		
4	Bedroom	6.00	5.00	0.76	1	22.8
	Toilet	3.45	2.45	0.76	1	6.42
	Kitchen	4.00	3.45	0.76	1	10.49
	Lobby	6.00	1.45	0.76	1	6.61
	Total					46.32

Table - 8.10 Cost of Earthwork in Filling Plinth

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material		0	0	0	
2	Labour					
2.1	Mate	Mandays	0.02	363	6.9	1 m^3
2.2	Mazdoor	Mandays	0.25	363	90.75	1 m^3
3	Plant and Machinery		0	0	0	
	Total				99.00	1 m^3
4	Water Charges				0	
5	Tools		3% of total cost		3.00	
6	Profit		10% of total cost		10.00	
	Total Earth Work in Filling Plinth Cost for 1 Cum				111.76	
	Total Earth Work in Filling Plinth Cost for 46.32 Cum				5129.94	

Table - 8.11 Area required for 2.5cm thick DPC

Item No.	2.5cm thick DPC	Dimensions			No. of Units	Quantity(m^2)	Explanatory Notes
		Length (m)	Breadth (m)				
5	Main Wall	33.1	0.225		1	7.45	
	Partition Wall	16.1	0.1		1	1.61	
	Total					9.06	

Table - 8.12 Cost of DPC

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material		0	0	0	
1.1	DPC	Sqm	1	258.9	258.9	
2	Labour					
2.1	Mason	Mandays	0.1	445	44.5	1 m^2
2.2	Mazdoor	Mandays	0.1	365	36.5	1 m^2
2.3	Bhisti	Mandays	0.01	365	36.5	1 m^2
3	Plant and Machinery		0.0	0.0	0.0	
	Total				342.24	1 m^2
4	Water Charges		1.5% of total cost		4.95	
5	Tools		3% of total cost		9.75	
6	Profit		10% of total cost		35.20	
	Cost of DPC for 1 m^2				389.71	
	Cost of DPC for 9.06 m^2				3539.83	

Table - 8.13 Volume required for Superstructure Brickwork

Item No.	Superstructure Brickwork	Dimensions			No. of Units	Quantity(Cum)	Explanatory Notes
		Length (m)	Breadth (m)	Height (m)			
6	Main Wall	33.1	0.225	2.74	1	20.41	
		7	0.225	1.82	2	2.8665	Triangle area
	Slanting wall	10.0	0.225	2.65	2	11.925	8.48ft ~ 9ft
	Partition Wall	6.0	0.1	3.92	1	2.352	1.18+2.7432
		5.0	0.1	2.7432	1	1.3716	
		5.0	0.1	1.82	1	0.455	Triangle area
		3.45	0.1	1.48	1	0.5106	
	Deductions						
	D (room)	1.45	0.1	2.13	2	-0.6177	
	D (main)	1.45	0.225	2.13	1	-0.695	
	D (kitchen)	1.45	0.1	2.13	1	-0.3088	
	W (room)	1.2192	0.225	0.92	2	-0.5017	
	W (toilet)	0.6	0.225	0.92	1	-0.1228	
	W (kitchen)	1.2192	0.225	0.92	1	-0.2508	
	Lintels						
	D (room)	1.45	0.1	0.15	2	-0.0435	
	D (main)	1.45	0.225	0.15	1	-0.0489	
	D (kitchen)	1.45	0.1	0.15	1	-0.02175	
	W (room)	1.2192	0.225	0.15	2	-0.0822	
	W (toilet)	0.6	0.225	0.15	1	-0.02025	
	W (kitchen)	1.2192	0.225	0.15	1	-0.04114	
	Total					37.13616	

Table - 8.14 Material required for Superstructure brickwork

Volume	1 Cum				
Nominal size of bricks	200*100*100	200000 mm^3			
Brick size(without mortar)	190*90*90	153900 mm^3			
Mortar volume for 1 Brick		461000 mm^3			
Total no of bricks		500			
Mortar volume		23050000 mm^3	0.231	(m^3)	(Wet volume)
Dry volume			0.288	(m^3)	D.V = 1.25* W.V
Volume inc .wastage			0.316	(m^3)	Wastage = 1.1 * D.V
Cement volume			0.045	(m^3)	
Sand volume			0.271	(m^3)	Cement:Sand for brick work=1:6
Cement weight	1Cum=1.44 Tons		0.0648	(Tons)	First Class Brick

Table - 8.15 Cost of Brickwork in Superstructure

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Bricks	per brick	500.0	3.35	1660	Rate 1000 bricks = 3300
1.2	Cement	m^3	0.045	9073.00	408.24	1 Cum = 1.44 tonnes
						1 Cum = 1.44*6300 = 9073 Rs
1.3	Sand	m^3	0.271	700	189.7	
1.3	Carraige of Bricks	per brick	500.0	0.29	142.00	Rates 1000 bricks = 284.95 for distance 3 to 4 km
1.4	Carraige of Cement	m^3	0.045	137.4	6.15	Rate 1 Cum=1.44*94.65=136.3 Rs for Distance = 3 to 4 km
1.5	Carraige of Sand	m^3	0.271	105.50	29.86	Distance = 3 to 4 km
2	Labour					
	Mason	Mandays	0.25	445	109.80	1 m^3
	Mazdoor	Mandays	0.4	365	146.3	1 m^3
	Bhisti	Mandays	0.1	365	37.4	1 m^3
3	Plant and Machinery		0	0	0	
	Total				2715.16	1 m^3
4	Water Charges		1.5% of total cost		40.70	
5	Tools		3% of total cost		81.45	
6	Profit		10% of total cost		271.51	
	Cost of Brick work in Superstructure for 1 Cum				3108.82	
	Cost of Brick work in Superstructure for 37.13 Cum				115449	

Table-8.16 Volume required for Wood Work

Item No.	Wood work	Dimensions			No. of Units	Quantity(Cum)
		Length (m)	Breadth (m)	Height (m)		
7						
	D (room)	1.45	0.1	2.13	2	0.6177
	D (main)	1.45	0.225	2.13	1	0.6949
	D (kitchen)	1.45	0.1	2.13	1	0.30885
	Frames					
	D (room)	0.1	0.1	2.13	4	0.0852
		1.45	0.1	0.1	2	0.029
	D (main+kitchen)	0.1	0.1	2.13	4	0.0852
		1.45	0.1	0.1	2	0.029
	W (room)	0.1	0.1	0.9144	2	0.0183
		1.2192	0.1	0.1	2	0.0244
	W (toilet)	0.1	0.1	0.91	2	0.0182
		0.6	0.1	0.1	2	0.012
	W (kitchen)	0.1	0.1	0.9144	2	0.0183
		1.2192	0.1	0.1	2	0.0244
	Total					1.96545

Table -8.17 Cost of Wood Work

S.No	Description	Unit	Quantity	Rate	Amount(Rs.)	Remarks
1	Material					
1.1	Sal wood	m^3	1	33180	33180	
1.2	Carriage Of Timber	m^3	1	122.8	122.8	Distance = 3 to 4 km
2	Labour					
2.1	Carpenter	Mandays	20	400	7990	1 m^3
2.2	Mazdoor	Mandays	2	365	728	1 m^3
3	Plant and Machinery		0	0	0	
	Total				41988.8	1 m^3
	Water Charges		0	0	0	
	Tools		3% of total cost		1260.8	
	Profit		10% of total cost		4199.79	
	Cost of Wood Work for 1 m^3				47448.20	
	Cost of Wood Work for 1. 96545 m^3				93252.93	

Table-8.18 Area required for Glass Work

Item No.	Glass work	Dimensions		No. of Units	Quantity(Sqm)
		Length (m)	Height (m)		
8					
	W (room)	1.1192	0.8144	2	1.823
	W (toilet)	0.5	0.81	1	0.405
	W (kitchen)	1.1192	0.8144	1	0.9115
	Total				3.1395

Table - 8.19 Cost of Glass Work

S.No	Description	Unit	Quantity	Rate	Amount (Rs.)	Remarks
1	Material					
1.1	Glass (Single Glazed)	Sqm	1	1850	1850	
2	Labour					
2.1	Glazier	Mandays	0.2	400	78.9	1 m^3
2.2	Mazdoor	Mandays	0.01	365	4.05	1 m^3
3	Plant and Machinery		0	0	0	
	Total				1984.50	1 m^3
	Water Charges		0	0	0	
	Tools		3% of total cost		58.60	
	Profit		10% of total cost		199.44	
	Cost of Glass Work for 1 m^2				2242.28	
	Cost of Glass Work for 3.1395 m^2				7036.5	

Table – 8.20 Volume required for Lintel over Doors and Windows

Item No.	Lintel over doors and windows	Dimensions			No. of Units	Quantity(m^3)
9	D (room)	1.45	0.1	0.15	2	0.0435
	D (main)	1.45	0.225	0.15	1	0.04894
	D (kitchen)	1.45	0.1	0.15	1	0.02175
	W (room)	1.2192	0.225	0.15	2	0.0833
	W (toilet)	0.6	0.225	0.15	1	0.02052
	W (kitchen)	1.2192	0.225	0.15	1	0.0417
	Total					0.25917

Table – 8.21 Material required for Lintel over Doors and Windows

Volume	1 m^3
Dry Volume = 1.25*Volume	1.25 m^3
Volume including wastage = 1.1*D V	1.375 m^3
Cement : Sand = 1:3	
Cement (Cum)	0.34375
Sand (Cum)	1.03125

Table - 8.22 Cost of Lintel required over Doors and Windows

S.No	Description	Unit	Quantity	Rate	Amount (Rs	Remarks
1	Material					
1.1	Cement	m^3	0.35	9075	3120.6	1 m^3 = 1.44 tonnes
						1 m^3 = 1.44*6300 = ₹ 9072
1.2	Sand	m^3	1.035	700	722.88	For 1 m^3
1.3	Carriage Of Cement	m^3	0.35	136.3	48.85	Rate 1 m^3=1.44*94.65= ₹136.3 for Distance = 3 to 4
1.4	Carriage Of Sand	m^3	1.035	106.49	110.82	Distance = 3 to 4 km
2	Labour					
2.1	Mazdoor	Mandays	0.80	365	273.30	For 1 m^3
2.2	Bhisti	Mandays	0.1	365	36.5	For 1 m^3
3	Plant and Machinery		0	0	0	
	Total				4295.75	For 1 m^3
	Water Charges		1.5% of total cost		65.60	
	Tools		3% of total cost		129.90	
	Profit		10% of total cost		430.5	
	Cost of Lintel for 1 m^3				4920.45	
	Cost of Lintel for 0.25917 m^3				1277.1	

Table – 8.23 Area required of Floor Finishing

Item No.	Floor Finishing	Dimensions		No. of Units	Quantity(Sqm)
		Length (m)	Breadth (m)		
10	Bedroom	6.0	5	1	30.00
	Toilet	3.45	2.45	1	8.4525
	Kitchen	4.00	3.45	1	13.8
	Lobby	6.0	1.45	1	8.7
	Doors (Room)	1.45	0.1	2	0.29
	Doors (main)	1.45	0.225	1	0.326
	Door (kitchen)	1.45	0.1	1	0.145
	Total				61.7

Table – 8.24 Material required for Floor Finishing

22mm Thick Tile flooring on 20mm thick cement mortar(1:4)	
Volume of Mortar (61.7*0.020)cum	1.234
Taking Volume	1 m^3
Dry Volume = 1.25*Volume	1.25 m^3
Volume including wastage = 1.1*D V	1.375 m^3
Cement : Sand = 1:4	
Cement (Cum)	0.275
Sand (Cum)	1.1

Table - 8.25 Cost of Floor Finishing

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material					
1.1	Cement	m^3	0.278	9075.00	2495.9	1 m^3 = 1.44 tonnes
						1 m^3 = 1.44*6300 = ₹ 9072
1.2	Sand	m^3	1.2	700.00	840	For 1 m^3
1.3	Carriage Of Cement	m^3	0.278	229.2	63.75	
1.4	Carriage Of Sand	m^3	1.2	107.50	118.14	Distance = 3 to 4 km
1.5	Tiles	m^2	1.0	240.00	240.00	
2	Labour					
2.1	Mason	Mandays	0.08	445	35.2	1 m^3
2.2	Mazdoor	Mandays	0.12	365	44.80	1 m^3
2.3	Bhisti	Mandays	0.1	365	35.9	1 m^3
3	Plant and Machinery		0	0	0	
	Total Cost of Mortar Material				3445.80	1 m^3
	Water Charges		1.5% of total cost		52.68	
	Tools		3% of total cost		104.50	
	Profit		10% of total cost		345.50	
	Cost of Material required for 1 Cum				3945.15	
	Cost of Material required for 1.23 Cum				4867.10	
	Total Cost of Tiles and Labour				365.80	1 m^2
	Water Charges		1.5% of total cost		6.40	
	Tools		3% of total cost		12.80	
	Profit		10% of total cost		38.55	
	Cost of tiles and Labour for 1 Sqm				420.54	
	Cost of tiles and Labour for 61.7 Sqm				30629.32	
	Total Floor Finish Cost				30629.32	

Table – 8.26 Area required for Cement Plastering

Item No.	Cement Plastering	Dimensions		No. of Units	Quantity (m^2)	Explanatory Notes
		Length (m)	Height (m)			
11	Outer Walls					
	North	10.0	2.7432	1	27.432	
	South	10.0	2.7432	1	27.432	
	East	7.0	2.7432	1	19.2024	
		7.0	1.8288	1	12.8016	Triangle area
	West	7.0	2.7432	1	19.2024	
		7.0	1.8288	1	12.8106	Triangle area
	Bedroom	6.00	2.7432	1	16.4592	
		5.00	2.7432	1	13.716	
		6.00	3.92	1	23.52	

		2.45	2.7432	1	6.72	
		2.45	1.28	1	1.568	Triangle area
		2.55	2.7432	1	6.995	
		2.55	(1.8288+1.1768)	1	6.1638	Trapezium area
	Toilet	3.45	2.7432	1	9.464	
		2.45	2.7432	2	13.44	
		2.45	1.28	2	3.136	Triangle area
		3.45	4.141	1	14.286	
	Kitchen	3.45	2.734	1	9.4323	
		3.275	2.734	2	17.907	
		3.275	1.8288	2	5.9893	Triangle area
		0.725	(1.8288+1.14499)	2	2.155	Trapezium area
		0.725	2.734	2	3.9643	
		3.45	4.141	1	14.2865	
	Lobby	6.00	2.7432	1	16.4592	
		6.00	3.5	1	21.0	
		1.45	2.7432	2	7.955	
		1.45	0.875	2	1.26875	Triangle area
	Ceiling	10.00	3.9489	2	78.978	
	Total				400.92	
	Deductions					Deduction should be from sides , so quantity = length * breadth * unit * 2 Add 0.1 due to woodwork
	D (room)	1.55	2.23	4	-13.826	
	D (main)	1.55	2.23	2	-6.913	
	D (kitchen)	1.55	2.23	2	-6.913	
	W (room)	1.3192	1.0144	2	-2.676	
	W (toilet)	0.7	0.325	1	-0.2275	
	W (kitchen)	1.3192	1.0144	1	-1.3382	
	Total				369.03	

Table – 8.27 Materials required for Cement Plastering

Area	m^2	369.03
Thickness	m	0.013
Volume of Mortar = Area*Thickness	m^3	4.428
Taking Volume =	m^3	1
Dry Volume = 1.25*Volume	m^3	1.25
Volume including wastage = 1.1*D V	m^3	1.378
Cement : Sand = 1:4		
Cement	m^3	0.278
Sand	m^3	1.2

Table – 8.28 Cost of Cement Plastering

S.No	Description	Unit	Quantity	Rate	Amount (₹.)	Remarks
1	Material					
1.1	Cement	m^3	0.278	9075	2495.9	1 m^3 = 1.44 tonnes
						1 m^3 = 1.44*6300 = ₹ 9072
1.2	Sand	m^3	1.2	690.00	690	1 m^3
1.3	Carriage Of Cement	m^3	0.278	229.107	63.80	
1.4	Carriage Of Sand	m^3	1.2	107.50	118.2	Distance = 3 to 4 km
2	Labour					
2.1	Mason	Mandays	0.085	445	35.6	1 m^2
2.2	Mazdoor	Mandays	0.11	365	35.8	1 m^2
3	Plant and Machinery		0.0	0	0	
	Total Cost of Material				3445.668	For 1 Cum
	Water Charges		1.5% of total cost		52.670	
	Tools		3% of total cost		104.340	
	Profit		10% of total cost		345.467	
	Total Cost of Material for 1 Cum				3945.145	
	Total Cost of Material for 4.428 Cum				17464.67	
	Total Cost of Labour				72.2	For 1 m^2
	Water Charges		1.5% of total cost		0.95	
	Tools		3% of total cost		1.95	
	Profit		10% of total cost		7.22	
	Cost of Labour for 1 Sqm				82.50	
	Cost of Labour for 369.03 Sqm				30045	
	Total Cement Plastering Cost				47689.4	

Table – 8.29 Area required for Painting and Polishing

Item No.	Painting and Polishing	Dimensions		No. of Units	Quantity (Sqm)	Explanatory Notes
		Length (m)	Height (m)			
12	Outer Walls					
	North	10.0	2.7432	1	27.432	
	South	10.0	2.7432	1	27.432	
	East	7.0	2.7432	1	19.2024	
		7.0	1.8288	1	12.8016	Triangle area
	West	7.0	2.7432	1	19.2024	
		7.0	1.8288	1	12.8106	Triangle area
	Bedroom	6.00	2.7432	1	16.4592	
		5.00	2.7432	1	13.716	
		6.00	3.92	1	23.52	
		2.45	2.7432	1	6.72	
		2.45	1.28	1	1.568	Triangle area
		2.55	2.7432	1	6.995	

		2.55	(1.8288+1.1768)	1	6.1638	Trapezium area
	Toilet	3.45	2.7432	1	9.464	
		2.45	2.7432	2	13.44	
		2.45	1.28	2	3.136	Triangle area
		3.45	4.141	1	14.286	
	Kitchen	3.45	2.734	1	9.4323	
		3.275	2.734	2	17.907	
		3.275	1.8288	2	5.9893	Triangle area
		0.725	(1.8288+1.14499)	2	2.155	Trapezium area
		0.725	2.734	2	3.9643	
		3.45	4.141	1	14.2865	
	Lobby	6.00	2.7432	1	16.4592	
		6.00	3.5	1	21.0	
		1.45	2.7432	2	7.955	
		1.45	0.875	2	1.26875	Triangle area
	Ceiling	10.00	3.9489	2	78.978	
	Total				400.92	
	Deductions					
	W (room)	1.3192	1.0144	2	-2.676	Add 0.1 due to woodwork
	W (toilet)	0.7	0.325	1	-0.2275	Deduction should be from
	W (kitchen)	1.3192	1.0144	1	-1.3382	sides , so quantity = length
	Total				396.678	* breadth * unit * 2

Table – 8.30 Cost of Painting and polishing

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material					
1.1	Primer	Sqm	1	8.7	8.7	1 m^2 = 0.75 litre = 0.75*115 = ₹8.70
1.2	Paint	Sqm	1	23.1	22.500	1 m^2 = 0.125 litre = 0.125*180 = ₹22.5
2	Labour					
2.1	Painter	Mandays	0.08	400.0	31.920	m^2
2.2	Mazdoor	Mandays	0.04	365.0	14.520	m^2
3	Plant and Machinery		0	0.0	0.000	
	Total				99.6	m^2 and 2 coat of paint
	Water Charges		1.5% of total cost		1.40	
	Tools		3% of total cost		2.80	
	Profit		10% of total cost		9.996	
	Cost of Painting for 1 m^2				115.574	
	Cost of Painting Cost for 396.6783 m^2				45449	

ANNEXURE II

Cost of Construction of Green Building

Table - 9.1 Volume required for Excavation

Item No.	Excavation	Dimensions			No. of Units	Quantity(m^3)	Explanatory Notes
		Length (m)	Breadth (m)	Depth (m)			
1	For Main Wall	16.55	0.9	1	1	14.895	10-0.225/2; 7-0.225/2
	For Partition Wall	16.1	0.7	0.7	1	7.889	6+0.1/2;3.45+0.1/2
	For Trombe Wall	9.775	1	1	1	9.775	
	For Cavity Wall	6.775	1.2	1	1	8.13	
	Total					40.689	

Table - 9.2 Cost of Excavation

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material		0	0	0.00	
2	Labour					
2.1	Mate	Mandays	0.06	365	22.80	1 m^3
2.2	Mazdoor	Mandays	0.62	365	226.80	1 m^3
3	Plant and Machinery		0	0	0.00	Manual Excavation
	Total				247.72	1 m^3
4	Water Charges				0.00	
5	Tools		3% of total cost		8.05	
6	Profit		10% of total cost		25.10	
	Total Excavation Cost for 1 Cum				280.93	
	Total Excavation Cost for 40.689 Cum				11349.38	

Table - 9.3 Volume required for Lime Concrete Foundation

Item No.	Lime Concrete Foundation	Dimensions			No of Units	Quantity(Cum)
		Length (m)	Breadth (m)	Height (m)		
2	For Main Wall	16.55	0.9	0.3	1	4.4685
	For Partition Wall	16.1	0.7	0.2	1	2.254
	For Cavity Wall	6.775	1	0.3	1	2.0325
	For Cavity Wall	9.775	1	0.3	1	2.9325
	Total					12.6875

Table - 9.4 Material required in Lime Concreting

Lime Concreting In Foundation with 40 mm gauge Brick Ballast	
White Lime : Surkhi : Brick Ballast = 1 : 2 : 6	
Wet Volume = 1 Cum	
Dry Volume = 1.4* W V	1.4 m^3
Vol Including Wastage = 1.1* D V	1.54 m^3
White Lime (Cum)	0.17
Surkhi (Cum)	0.34
Brick Ballast (Cum)	1.03

Table - 9.5 Cost of Lime Concrete Foundation

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material					
1.1	White Lime (dry hydrated lime)	m^3	0.17	5086.4	868.15	1 m^3 = 2211 Kg = 22.11Quintal
					0.00	1 m^3 = 22.11*230 = ₹ 5085.3
1.2	Carraige of Lime	m^3	0.17	107.50	17.90	Distance = 3 to 4 km
1.3	Surkhi	m^3	0.34	690	240.50	
1.4	Carraige of Surkhi	m^3	0.34	107.50	37.20	Distance = 3 to 4 km
1.5	Brick Ballast	m^3	0.95	690	668.50	
1.6	Carriage Of Brick Ballast	m^3	0.95	107.50	110.35	Distance = 3 to 4 km
2	Labour				0.00	
2.1	Mason	Mandays	0.1	435	43.50	1 m^3
2.2	Mazdoor	Mandays	2.65	363	962.90	1 m^3
2.3	Bhisti	Mandays	0.8	363	295.40	1 m^3
3	Plant and Machinery		0	0	0.00	
	Total				3237.90	1 m^3
4	Water Charges		1.5% of total cost		49.20	
5	Tools		3% of total cost		98.20	
6	Profit		10% of total cost		324.40	
	Total Lime Concreting Cost for 1 m^3				3708.40	
	Total Lime Concreting Cost for 12.6875 m^3				47024.8	

Table - 9.6 Volume required for Brickwork in Foundation

Item No.	Brickwork in Foundation	Dimensions			No. of Units	Quantity(Cum)	Explanatory Notes
		Length (m)	Breadth (m)	Depth (m)			
3	Main wall						
	60cm thick	16.55	0.6	0.20	1	4.56	
	50cm thick	16.55	0.5	0.20	1	3.825	
	40cm thick	16.55	0.4	1.06	1	16.355	
	Partition wall						
	40cm thick	16.1	0.4	0.20	1	1.29	
	30cm thick	16.1	0.3	1.06	1	5.12	
	Trombe Wall						
	60 cm thick	9.775	0.6	0.2	1	4.692	

	50 cm thick	9.775	0.5	0.2	1	3.91	
	40 cm thick	9.775	0.4	1.06	1	3.128	
	Cavity Wall						
	60 cm thick	6.775	0.6	0.2	1	3.252	
	50 cm thick	6.775	0.5	0.2	1	2.71	
	40 cm thick	6.775	0.4	1.06	1	2.168	
	Total					62.05	

Table - 9.7 Material required for Brickwork in Foundation

Volume	1 Cum				
Nominal size of bricks	200*100*100	200000 mm^3			
Brick size(without mortar)	190*90*90	153900 mm^3			
Mortar volume for 1 Brick		461000 mm^3			
Total no of bricks		500.00			
Mortar volume		23050000 mm^3	0.231	(m^3)	(Wet volume)
Dry volume			0.288	(m^3)	D.V = 1.25* W.V
Volume inc .wastage			0.316	(m^3)	Wastage = 1.1 * D.V
Cement volume			0.053	(m^3)	
Sand volume			0.264	(m^3)	Cement:Sand for brick work=1:6
Cement weight	1Cum=1.44 Tons		0.076	(Tons)	First Class Brick

Table -9.8 Cost of Brickwork in Foundation

S No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material					
1.1	Bricks	per brick	500	4	1650	Rate 1000 bricks = 4000
1.2	Cement	Cum	0.054	9075	479.20	1 m^3= 1.44 tonnes
						1 m^3 = 1.44*6300 = ₹ 9072
1.3	Sand	Cum	0.265	690	185.50	
1.3	Carraige of Bricks	per brick	500	0.285	142.90	Rates 1000 bricks = 283.96 for distance 3 to 4 km
1.4	Carraige of Cement	Cum	0.054	137.30	6.90	
1.5	Carraige of Sand	Cum	0.265	107.50	27.05	Distance = 3 to 4 km
2	Labour					
	Mason	Mandays	0.250	445	109.80	1 m^3
	Mazdoor	Mandays	0.400	365	146.8	1 m^3
	Bhisti	Mandays	0.100	365	36.5	1 m^3
3	Plant and Machinery		0	0	0	
	Total				2782.13	1 m^3
4	Water Charges		1.5% of total cost		42.25	
5	Tools		3% of total cost		84.50	
6	Profit		10% of total cost		279.01	
	Total Brick work in Foundation Cost for 1 Cum				3184.25	
	Total Brick work in Foundation Cost for 62.05 Cum				197520.66	

Table - 9.9 Volume required for Earthwork in Filling Plinth

Item No.	Earthwork in Filling Plinth	Dimensions			No. of Units	Quantity(m^3)
		Length (m)	Breadth (m)	Depth (m)		
4	Bedroom	6.00	5.00	0.76	1	22.8
	Toilet	3.45	2.45	0.76	1	6.42
	Kitchen	4.00	3.45	0.76	1	10.49
	Lobby	6.00	1.45	0.76	1	6.61
	Total					46.32

Table - 9.10 Cost of Earthwork in Filling Plinth

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material		0	0	0	
2	Labour					
2.1	Mate	Mandays	0.02	365	6.95	1 m^3
2.2	Mazdoor	Mandays	0.25	365	89.90	1 m^3
3	Plant and Machinery		0	0	0	
	Total				96.85	1 m^3
4	Water Charges				0	
5	Tools		3% of total cost		3.95	
6	Profit		10% of total cost		10.10	
	Total Earth Work in Filling Plinth Cost for 1 Cum				115.75	
	Total Earth Work in Filling Plinth Cost for 46.32 Cum				5129.94	

Table - 9.11 Area required for 2.5cm thick DPC

Item No.	2.5cm thick DPC	Dimensions			No. of Units	Quantity(Sqm)	Explanatory Notes
		Length (m)	Breadth (m)				
5	Main Wall	16.55	0.225		1	3.725	
	Partition Wall	16.1	0.1		1	1.61	
	Trombe Wall	9.775	0.225		1	2.55	
	Cavity Wall	6.775	0.225		1	1.82	
	Total					10.205	

Table - 9.12 Cost of DPC

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material		0	0	0	
1.1	DPC	Sqm	1	258.5	258.5	
2	Labour					
2.1	Mason	Mandays	0.1	445	44.5	1 m^3
2.2	Mazdoor	Mandays	0.1	365	36.5	1 m^3
2.3	Bhisti	Mandays	0.01	365	3.65	1 m^2
3	Plant and Machinery		0	0	0	
	Total				342.40	1 m^2
4	Water Charges		1.5% of total cost		4.95	
5	Tools		3% of total cost		9.9	
6	Profit		10% of total cost		34.24	
	Total DPC Cost for 1 m^2				391.70	
	Total DPC Cost for 10.205 m^2				39871.1	

Table - 9.13 Volume required for Superstructure Brickwork

Item No.	Superstructure Brickwork	Dimensions			No. of Units	Quantity(m^3)	Explanatory Notes
		Length (m)	Breadth (m)	Height (m)			
6	Main Wall	16.55	0.225	2.74	1	10.205	
		7	0.225	1.82	2	2.8665	Triangle area
	Trombe Wall	9.775	0.225	2.74	1	6.026	
	Cavity Wall	6.775	0.225	2.74	1	4.176	
	Slanting wall	10.0	0.225	2.65	2	11.925	8.48ft ~ 9ft
	Partition Wall	6.0	0.1	3.92	1	2.352	1.18+2.7432
		5.0	0.1	2.7432	1	1.3716	
		5.0	0.1	1.82	1	0.455	Triangle
		3.45	0.1	1.48	1	0.5106	
	Deductions						
	D (room)	1.45	0.1	2.13	2	-0.6177	
	D (main)	1.45	0.225	2.13	1	-0.695	
	D (kitchen)	1.45	0.1	2.13	1	-0.3088	
	W (room)	1.2192	0.225	0.92	2	-0.5017	
	W (toilet)	0.6	0.225	0.92	1	-0.1228	
	W (kitchen)	1.2192	0.225	0.92	1	-0.2508	
	Lintels						
	D (room)	1.45	0.1	0.15	2	-0.0435	
	D (main)	1.45	0.225	0.15	1	-0.0489	
	D (kitchen)	1.45	0.1	0.15	1	-0.02175	
	W (room)	1.2192	0.225	0.15	2	-0.0822	
	W (toilet)	0.6	0.225	0.15	1	-0.02025	
	W (kitchen)	1.2192	0.225	0.15	1	-0.04114	
	Total					43.5924	

Table - 9.14 Material required for Superstructure brickwork

Volume	1 m^3				
Nominal size of bricks	200*100*100	200000 mm^3			
Brick size(without mortar)	190*90*90	153900 mm^3			
Mortar volume for 1 Brick		46100 mm^3			
Total no of bricks		500			
Mortar volume		23050000 mm^3	0.231	(m^3)	(Wet volume)
Dry volume			0.288	(m^3)	D.V = 1.25* W.V
Volume inc .wastage			0.316	(m^3)	Wastage = 1.1 * D.V
Cement volume			0.045	(m^3)	
Sand volume			0.271	(m^3)	Cement:Sand for brick work=1:6
Cement weight	1 m^3=1.44 Tons		0.0648	(Tons)	First Class Brick

Table - 9.15 Cost of Brickwork in Superstructure

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material					
1.1	Bricks	per brick	500.00	4.0	1650	Rate 1000 bricks = 4000
1.2	Cement	m^3	0.046	9075	408.24	1 m^3 = 1.44 tonnes
						1 m^3 = 1.44*6300 = ₹ 9072
1.3	Sand	m^3	0.272	700	189.7	
1.3	Carraige of Bricks	per brick	500	0.284	142.05	
1.4	Carraige of Cement	m^3	0.046	135.30	6.12	
1.5	Carraige of Sand	m^3	0.272	108.50	29.05	Distance = 3 to 4 km
2	Labour					
	Mason	Mandays	0.25	445	109.80	1 m^3
	Mazdoor	Mandays	0.4	365	146.4	1 m^3
	Bhisti	Mandays	0.1	365	36.5	1 m^3
3	Plant and Machinery		0	0	0	
	Total				2715.16	1 m^3
4	Water Charges		1.5% of total cost		41.65	
5	Tools		3% of total cost		83.30	
6	Profit		10% of total cost		272.60	
	Total Brick work in Superstructure Cost for 1 m^3				3108.82	
	Total Brick work in Superstructure Cost for 43.5924 m^3				135520.9	

Table-9.16 Volume required for Wood Work

Item No.	Wood work	Dimensions			No. of Units	Quantity(m^3)
		Length (m)	Breadth (m)	Height (m)		
	D (room)	1.45	0.1	2.13	2	0.6177
	D (main)	1.45	0.225	2.13	1	0.6949
	D (kitchen)	1.45	0.1	2.13	1	0.30885
	Frames					
	D (room)	0.1	0.1	2.13	4	0.0852
		1.45	0.1	0.1	2	0.029
7	D (main+kitchen)	0.1	0.1	2.13	4	0.0852
		1.45	0.1	0.1	2	0.029
	W (room)	0.1	0.1	0.9144	2	0.0183
		1.2192	0.1	0.1	2	0.0244
	W (toilet)	0.1	0.1	0.91	2	0.0182
		0.6	0.1	0.1	2	0.012
	W (kitchen)	0.1	0.1	0.9144	2	0.0183
		1.2192	0.1	0.1	2	0.0244
	Total					1.96545

Table -9.17 Cost of Wood Work

S.No	Description	Unit	Quantity	Rate	Amount(₹)	Remarks
1	Material					
1.1	Sal wood	Cum	1	33180	33180	
1.2	Carriage Of Timber	Cum	1	122.1	122.1	Distance = 3 to 4 km
2	Labour					
2.1	Carpenter	Mandays	20	400	8000	1 m^3
2.2	Mazdoor	Mandays	2	365	730	1 m^3
3	Plant and Machinery		0	0	0	
	Total				41988.6	1 m^3
	Water Charges		0	0	0	
	Tools		3% of total cost		1260.42	
	Profit		10% of total cost		4199.78	
	Total Wood Work Cost for 1 m^3				47448.101	
	Total Wood Work Cost For 1. 96545 m^3				93252.93	

Table-9.18 Area required for Glass Work

Item No.	Glass work	Dimensions		No. of Units	Quantity(m^2)
		Length (m)	Height (m)		
	W (room)	1.1192	0.8144	2	1.823
8	W (toilet)	0.5	0.81	1	0.805
	W (kitchen)	1.1192	0.8144	1	1.1115
	Total				3.5395

Table - 9.19 Cost of Glass Work

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material					
1.1	Glass (Double Glazed)	Sqm	1	2350	2350	
2	Labour					
2.1	Glazier	Mandays	0.2	400	80.0	1 m^3
2.2	Mazdoor	Mandays	0.01	365	3.65	1 m^3
3	Plant and Machinery		0	0	0	
	Total				1984.45	1 m^3
	Water Charges		0	0	0	
	Tools		3% of total cost		59.50	
	Profit		10% of total cost		198.34	
	Total Glass Work for 1 m^2				2650.4	
	Total Glass Work Cost For 3.5395 m^2				9381.1	

Table – 9.20 Volume of Lintel over Doors and Windows

Item No.	Lintel over doors and windows	Dimensions			No. of Units	Quantity(m^3)
9	D (room)	1.45	0.1	0.15	2	0.0435
	D (main)	1.45	0.225	0.15	1	0.04894
	D (kitchen)	1.45	0.1	0.15	1	0.02175
	W (room)	1.2192	0.225	0.15	2	0.0833
	W (toilet)	0.6	0.225	0.15	1	0.02052
	W (kitchen)	1.2192	0.225	0.15	1	0.0417
	Total					0.25917

Table – 9.21 Material required for Lintel over Doors and Windows

Volume	1 m^3
Dry Volume = 1.25*Volume	1.25 m^3
Volume including wastage = 1.1*D V	1.376 m^3
Cement : Sand = 1:3	
Cement (Cum)	0.35
Sand (Cum)	1.05

Table - 9.22 Cost of Lintel over Doors and Windows

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material					
1.1	Cement	Cum	0.35	9075	3119.2	1 m^3 = 1.44 tonnes
						1 m^3 = 1.44*6300 = ₹9072
1.2	Sand	Cum	1.05	690	705.90	For 1 m^3
1.3	Carriage Of Cement	Cum	0.35	137.8	47.80	
1.4	Carriage Of Sand	Cum	1.05	105.8	110.5	Distance = 3 to 4 km
2	Labour					
2.1	Mazdoor	Mandays	0.75	365	273.30	1 m^3
2.2	Bhisti	Mandays	0.07	365	26.10	1 m^3
3	Plant and Machinery		0	0	0	
	Total				4295.71	1 m^3
	Water Charges		1.5% of total cost		65.68	
	Tools		3% of total cost		130.44	
	Profit		10% of total cost		429.57	
	Total Lintel Cost for 1 m^3				4920.05	
	Total Lintel Cost for 0.25917 m^3				1278.2	

Table – 9.23 Area required for Floor Finishing

Item No.	Floor Finishing	Dimensions		No. of Units	Quantity(m^2)
		Length (m)	Breadth (m)		
10	Bedroom	6.0	5	1	30.00
	Toilet	3.45	2.45	1	8.4525
	Kitchen	4.00	3.45	1	13.8
	Lobby	6.0	1.45	1	8.7
	Doors (Room)	1.45	0.1	2	0.29
	Doors (main)	1.45	0.225	1	0.326
	Door (kitchen)	1.45	0.1	1	0.145
	Total				61.7

Table – 9.24 Material required for Floor Finishing

22mm Thick Tile flooring on 20mm thick cement mortar(1:4)	
Volume of Mortar (61.7*0.020)cum	1.234
Taking Volume	1 m^3
Dry Volume = 1.25*Volume	1.25 m^3
Volume including wastage = 1.1*D V	1.375 m^3
Cement : Sand = 1:4	
Cement (Cum)	0.275
Sand (Cum)	1.1

Table - 9.25 Cost of Floor Finishing

S No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material					
1.1	Cement	m^3	0.278	9075	2495.6	1 m^3 = 1.44 tonnes
						1 m^3 = 1.44*6300 = ₹ 9072
1.2	Sand	m^3	1.12	690	772.15	1 m^3
1.3	Carriage Of Cement	m^3	0.278	229.05	63.84	
1.4	Carriage Of Sand	m^3	1.12	107.50	120.11	Distance = 3 to 4 km
1.5	Tiles	m^2	1.0	280	280	Eco – friendly tiles
2	Labour					
2.1	Mason	Mandays	0.08	445	35.6	1 m^2
2.2	Mazdoor	Mandays	0.12	365	42.80	1 m^2
2.3	Bhisti	Mandays	0.1	365	36.5	1 m^2
3	Plant and Machinery		0	0	0	
	Total Cost of Mortar Material				3445.68	1 m^3
	Water Charges		1.5% of total cost		52.10	
	Tools		3% of total cost		104.20	
	Profit		10% of total cost		345.60	
	Total Cost of Material for 1 m^3				3945.20	
	Total Cost For Material for 1.23 m^3				4867.1	
	Total Cost of Tiles and Labour				365.80	1 m^2
	Water Charges		1.5% of total cost		5.50	
	Tools		3% of total cost		11.05	
	Profit		10% of total cost		37.10	
	Total Cost of tiles and Labour for 1 m^2				424.40	
	Total Cost of tiles and Labour for 61.7 m^2				25764.20	
	Total Floor Finish Cost				30630.30	

Table – 9.26 Area required for Cement Plastering

Item No.	Cement Plastering	Dimensions		No. of Units	Quantity (m^2)	Explanatory Notes
		Length (m)	Height (m)			
11	Outer Walls					
	North	10.0	2.7432	1	27.432	
	South	10.0	2.7432	1	27.432	
	East	7.0	2.7432	1	19.2024	
		7.0	1.8288	1	12.8016	Triangle area
	West	7.0	2.7432	1	19.2024	
		7.0	1.8288	1	12.8106	Triangle area
	Bedroom	6.00	2.7432	1	16.4592	
		5.00	2.7432	1	13.716	
		6.00	3.92	1	23.52	
		2.45	2.7432	1	6.72	

		2.45	1.28	1	1.568	Triangle area
		2.55	2.7432	1	6.995	
		2.55	(1.8288+1.1768)	1	6.1638	Trapezium area
	Toilet	3.45	2.7432	1	9.464	
		2.45	2.7432	2	13.44	
		2.45	1.28	2	3.136	Triangle area
		3.45	4.141	1	14.286	
	Kitchen	3.45	2.734	1	9.4323	
		3.275	2.734	2	17.907	
		3.275	1.8288	2	5.9893	Triangle area
		0.725	(1.8288+1.14499)	2	2.155	Trapezium area
		0.725	2.734	2	3.9643	
		3.45	4.141	1	14.2865	
	Lobby	6.00	2.7432	1	16.4592	
		6.00	3.5	1	21.0	
		1.45	2.7432	2	7.955	
		1.45	0.875	2	1.26875	Triangle area
	Ceiling	10.00	3.9489	2	78.978	
	Total				400.92	
	Deductions					
	D (room)	1.55	2.23	4	-13.826	Deduction should be from sides , so quantity = length * breadth * unit * 2 Add 0.1 due to woodwork
	D (main)	1.55	2.23	2	-6.913	
	D (kitchen)	1.55	2.23	2	-6.913	
	W (room)	1.3192	1.0144	2	-2.676	
	W (toilet)	0.7	0.325	1	-0.2275	
	W (kitchen)	1.3192	1.0144	1	-1.3382	
	Total				369.03	

Table – 9.27 Materials required for Cement Plastering

Area	m^2	369.03
Thickness	m	0.012
Volume of Mortar = Area*Thickness	m^3	4.428
Taking Volume =	m^3	1
Dry Volume = 1.25*Volume	m^3	1.25
Volume including wastage = 1.1*D V	m^3	1.375
Cement : Sand = 1:4		
Cement	m^3	0.275
Sand	m^3	1.1

Table – 9.28 Cost of Cement Plastering

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material					
1.1	Cement	Cum	0.275	9075	2495.6	1 m^3 = 1.44 tonnes
						1 m^3 = 1.44*6300 = ₹ 9072
1.2	Sand	Cum	1.1	690	771.50	For 1 m^3
1.3	Carriage Of Cement	Cum	0.275	229.20	61.90	Rate 1 Cum=1.44*94.65= ₹ 136.3 for Distance = 3 to 4 km
1.4	Carriage Of Sand	Cum	1.1	107.50	118.20	Distance = 3 to 4 km
2	Labour					
2.1	Mason	Mandays	0.08	445	35.2	1 m^2
2.2	Mazdoor	Mandays	0.1	365	35.90	1 m^2
3	Plant and Machinery		0	0	0	
	Total Cost of Material				3445.80	1 m^3
	Water Charges		1.5% of total cost		52.10	
	Tools		3% of total cost		104.20	
	Profit		10% of total cost		344.58	
	Total Cost of Material for 1 Cum				3945.12	
	Total Cost of Material for 4.428 Cum				17465.68	
	Total Cost of Labour				70.2	1 m^2
	Water Charges		1.5% of total cost		0.995	
	Tools		3% of total cost		1.99	
	Profit		10% of total cost		7.12	
	Total Cost of Labour for 1 Sqm				80.1	
	Total Cost of Labour for 369.03 Sqm				30045	
	Total Cement Plastering Cost				47690.2	

Table – 9.29 Area required for Painting and Polishing

Item No.	Painting and Polishing	Dimensions		No. of Units	Quantity (m^2)	Explanatory Notes
		Length (m)	Height (m)			
12	Outer Walls					
	North	10.0	2.7432	1	27.432	
	South	10.0	2.7432	1	27.432	
	East	7.0	2.7432	1	19.2024	
		7.0	1.8288	1	12.8016	Triangle area
	West	7.0	2.7432	1	19.2024	
		7.0	1.8288	1	12.8106	Triangle area
	Bedroom	6.00	2.7432	1	16.4592	
		5.00	2.7432	1	13.716	
		6.00	3.92	1	23.52	
		2.45	2.7432	1	6.72	
		2.45	1.28	1	1.568	Triangle area
		2.55	2.7432	1	6.995	

		2.55	(1.8288+1.1768)	1	6.1638	Trapezium area
	Toilet	3.45	2.7432	1	9.464	
		2.45	2.7432	2	13.44	
		2.45	1.28	2	3.136	Triangle area
		3.45	4.141	1	14.286	
	Kitchen	3.45	2.734	1	9.4323	
		3.275	2.734	2	17.907	
		3.275	1.8288	2	5.9893	Triangle area
		0.725	(1.8288+1.14499)	2	2.155	Trapezium area
		0.725	2.734	2	3.9643	
		3.45	4.141	1	14.2865	
	Lobby	6.00	2.7432	1	16.4592	
		6.00	3.5	1	21.0	
		1.45	2.7432	2	7.955	
		1.45	0.875	2	1.26875	Triangle area
	Ceiling	10.00	3.9489	2	78.978	
	Total				400.92	
	Deductions					
	W (room)	1.3192	1.0144	2	-2.676	Add 0.1 due to woodwork
	W (toilet)	0.7	0.325	1	-0.2275	Deduction should be from
	W (kitchen)	1.3192	1.0144	1	-1.3382	sides , so quantity = length
	Total				396.678	* breadth * unit * 2

Table – 9.30 Cost of Painting and polishing

S.No	Description	Unit	Quantity	Rate	Amount (₹)	Remarks
1	Material					
1.1	Primer	m^2	1	9.05	9.05	1 m^2 = 0.75 litre = 0.75*115 = ₹ 8.625
1.2	Paint	m^2	1	35.0	35.00	1 m^2 = 0.125 litre = 0.125*180 = 22.5
2	Labour					
2.1	Painter	Mandays	0.08	400	32.00	m^2
2.2	Mazdoor	Mandays	0.04	365	15.200	m^2
3	Plant and Machinery		0	0	0.00	
	Total				99.20	m^2 and 2 coat of paint
	Water Charges		1.5% of total cost		1.49	
	Tools		3% of total cost		2.98	
	Profit		10% of total cost		9.92	
	Total Painting Cost for 1 m^2				122.68	
	Total Painting Cost for 430.6783 m^2				48664.5	

ANNEXURE III

DETERMINATION OF PAYBACK PERIOD USING PRESENT VALUE CONCEPT

$$Modified\ Interest\ Rate = \left(\frac{1+\text{interest rate}}{1+\text{inflation rate}} - 1\right)*100$$

$$Net\ Present\ Value = \frac{\text{Savings per year}}{(1 + \text{modified interest rate})^{nth\ year}}$$

Extra cost incurred = ₹ 77800

Inflation rate = 3.8 %

Interest rate = 10.5 %

Modified interest rate = 6.45 %

Table 10.1 Determination of Payback Period

Year	Net Savings (₹)	Net Present Value (₹)	Cummulative Net Present Value (₹)	Remaining Cash need to recover Investment in Present Value
0	0	0	0	77800.00
1	8013.00	7527.50	7527.50	70272.50
2	8013.00	7071.00	14598.50	63201.50
3	8013.00	6643.00	21241.50	56558.50
4	8013.00	6240.00	27481.50	50318.50
5	8013.00	5862.00	33343.50	44456.50
6	8013.00	5507.00	38850.50	38949.50
7	8013.00	5173.00	44023.50	33776.50
8	8013.00	4860.00	48883.50	28916.50
9	8013.00	4565.00	53448.50	24315.50
10	8013.00	4289.00	57737.50	20062.50
11	8013.00	4029.00	61767.00	16033.50

12	8013.00	3784.00	65550.00	12249.50
13	8013.00	3555.00	69105.50	8694.50
14	8013.00	3340.00	72445.50	5354.50
15	8013.00	3138.00	75583.50	2516.50
16	**8013.00**	**2947.50**	**78531.00**	**-431.00**
17	8013.00	2791.00	81322.00	-3222.00
18	8013.00	2601.00	83923.00	-5823.00
19	8013.00	2443.00	86366.00	-8266.00
20	8013.00	2295.00	88661.00	-10561.00
21	8013.00	2156.00	90817.00	-12717.00
22	8013.00	2025.00	92842.00	-14742.00
23	8013.00	1903.00	94745.00	-16645.00
24	8013.00	1787.00	96532.00	-18432.00
25	8013.00	1670.00	98211.00	-20111.00

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Ashutosh Abrol, Jaypee University of Information and Technology, Waknaghat, Solan

@ ashutoshabrol52@yahoo.com

INVOICE

Invoice # INV-10764
Date 21 March 2018

CUSTOMER NAME
Ashutosh Abrol, Jaypee University of Information and Technology, Waknaghat, Solan

CUSTOMER ADDRESS
House No. 111 MG Road, Lutyen's Delhi, New Delhi, NCR 110006

SITE ADDRESS
House No 111 MG Road, Lutyen's Delhi, New Delhi, NCR 110006

JOB DESCRIPTION
To evaluate the cost of Conventional Building using software CostMiner

JOB TOTAL
₹585,703.64

DESCRIPTION	QTY	UT	PRICE	TOTAL
EXCAVATION				₹10,510.08
Main Wall	29.79	m^3	₹278.93	₹8,309.32
Partition Wall	7.89	m^3	₹278.93	₹2,200.76
LIME CONCRETING				₹41,472.72
Main Wall	8.94	m^3	₹3,706.23	₹33,133.70
Partition Wall	2.25	m^3	₹3,706.23	₹8,339.02
BRICKWORK IN FOUNDATION				₹178,452.99
Main Wall	49.65	m^3	₹3,183.25	₹158,048.36
Partition Wall	6.41	m^3	₹3,183.25	₹20,404.63
EARTHWORK IN FILLING PLINTH				₹5,129.95
Bedroom	22.8	m^3	₹110.75	₹2,525.10
Toilet	6.42	m^3	₹110.75	₹711.02
Kitchen	10.49	m^3	₹110.75	₹1,161.77
Lobby	6.61	m^3	₹110.75	₹732.06
DPC				₹3,602.34
Main Wall	7.61	m^2	₹390.71	₹2,973.30
Partition Wall	1.61	m^2	₹390.71	₹629.04
BRICKWORK IN SUPERSTRUCTURE				₹116,891.64
Main Wall	23.79	m^3	₹3,108.82	₹73,958.83
Slanting Wall	12.19	m^3	₹3,108.82	₹37,896.52
Partition Wall	4.57	m^3	₹3,108.82	₹14,207.31
Deductions (Door, Window)	-2.5	m^3	₹3,108.82	₹-7,772.05

DESCRIPTION	QTY	UT	PRICE	TOTAL
Deductions (Lintels-Door, Window)	-0.45	m^3	₹3,108.82	₹-1,398.97
WOOD WORK				₹93,468.62
Door	1.56	m^3	₹47,446.00	₹74,015.76
Window	0.41	m^3	₹47,446.00	₹19,452.86
GLASS WORK				₹7,015.27
Glass	3.13	m^2	₹2,241.30	₹7,015.27
LINTEL				₹1,229.36
Door	0.11	m^3	₹4,917.44	₹540.92
Window	0.14	m^3	₹4,917.44	₹688.44
FLOOR FINISHING				₹30,004.42
Bedroom	47.4	m^2	₹417.54	₹19,791.40
Toilet	8.45	m^2	₹417.54	₹3,528.21
Kitchen	13.8	m^2	₹417.54	₹5,762.05
Lobby	1.45	m^2	₹417.54	₹605.43
Beneath Doors	0.76	m^2	₹417.54	₹317.33
CEMENT PLASTER				₹47,687.55
Outer Walls	118.87	m^2	₹124.83	₹14,838.54
Bedroom	75.14	m^2	₹124.83	₹9,379.73
Toilet	40.33	m^2	₹124.83	₹5,034.39
Kitchen	53.73	m^2	₹124.83	₹6,707.12
Lobby	46.86	m^2	₹124.83	₹5,849.53
Ceiling	78.98	m^2	₹124.83	₹9,859.07
Deduction	-31.89	m^2	₹124.83	₹-3,980.83
PAINTING				₹50,238.70
Outer Walls	118.89	m^2	₹122.68	₹14,585.43
Bedroom	75.14	m^2	₹122.68	₹9,218.18
Toilet	40.33	m^2	₹122.68	₹4,947.68
Kitchen	53.73	m^2	₹122.68	₹6,591.60
Lobby	46.68	m^2	₹122.68	₹5,726.70
Ceiling	78.98	m^2	₹122.68	₹9,689.27
Deductions	-4.24	m^2	₹122.68	₹-520.16
TOTAL				₹585,703.66

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INVOICE

Ashutosh Abrol, Jaypee University of Information and Technology, Waknaghat, Solan

@ ashutoshabrol52@yahoo.com

Invoice # INV-10757
Date 21 March 2018

CUSTOMER NAME
Ashutosh Abrol, Jaypee University of Information and Technology

JOB DESCRIPTION
To compute the costing and estimation of a Green Building

CUSTOMER ADDRESS
House No 111, MG Road, Lutyen's Delhi, New Delhi, Jammu and Kashmir 110006

JOB TOTAL
₹644,067.50

DESCRIPTION	QTY	UT	PRICE	TOTAL
EXCAVATION				₹11,355.25
Main Wall	14.9	m^3	₹278.93	₹4,156.06
Partition Wall	7.89	m^3	₹278.93	₹2,200.76
Trombe Wall	9.78	m^3	₹278.93	₹2,727.94
Cavity Wall	8.14	m^3	₹278.93	₹2,270.49
LIME CONCRETE FOUNDATION				₹47,106.19
Main Wall	4.47	m^3	₹3,706.23	₹16,566.85
Partition Wall	2.25	m^3	₹3,706.23	₹8,339.02
Trombe Wall	2.03	m^3	₹3,706.23	₹7,523.65
Cavity Wall	3.96	m3	₹3,706.23	₹14,676.67
BRICKWORK IN FOUNDATION				₹199,908.10
Main Wall	24.74	m^3	₹3,183.25	₹78,753.61
Partition Wall	6.41	m^3	₹3,183.25	₹20,404.63
Trombe Wall	11.73	m^3	₹3,183.25	₹37,339.52
Cavity Wall	19.92	m^3	₹3,183.25	₹63,410.34
EARTHWORK IN FILLING PLINTH				₹5,129.95
Bedroom	22.8	m^3	₹110.75	₹2,525.10
Toilet	6.42	m^3	₹110.75	₹711.02
Kitchen	10.49	m^3	₹110.75	₹1,161.77
Lobby	6.61	m^3	₹110.75	₹732.06
DAMP PROOF COURSE				₹4,036.04
Main Wall	3.81	m^2	₹390.71	₹1,488.61
Partition Wall	1.61	m^2	₹390.71	₹629.04
Trombe Wall	3.04	m^2	₹390.71	₹1,187.76

DESCRIPTION	QTY	UT	PRICE	TOTAL
Cavity Wall	1.87	m^2	₹390.71	₹730.63
BRICKWORK IN SUPERSTRUCTURE				₹137,378.76
Main Wall	13.07	m^3	₹3,108.82	₹40,632.28
Partition Wall	4.69	m^3	₹3,108.82	₹14,580.37
Trombe Wall	6.16	m^3	₹3,108.82	₹19,150.33
Cavity Wall	4.27	m^3	₹3,108.82	₹13,274.66
Slanting Wall	6.1	m^3	₹3,108.82	₹18,963.80
Deductions (including Lintels)	9.9	m^3	₹3,108.82	₹30,777.32
WOODWORK				₹99,636.81
Door	1.75	m^3	₹47,446.10	₹83,030.68
Frames	0.23	m^3	₹47,446.10	₹10,912.60
Window	0.12	m^3	₹47,446.10	₹5,693.53
GLASSWORK				₹9,382.42
Glasswork	3.54	m^2	₹2,650.40	₹9,382.42
LINTELS				₹1,278.42
Door	0.11	m^3	₹4,917.00	₹540.87
Window	0.15	m^3	₹4,917.00	₹737.55
FLOOR FINISHING				₹30,881.26
Bedroom	30	m^2	₹417.54	₹12,526.20
Kitchen	34.5	m^2	₹417.54	₹14,405.13
Lobby	8.7	m^2	₹417.54	₹3,632.60
Door	0.76	m^2	₹417.54	₹317.33
CEMENT PLASTERING				₹47,735.40
Outer Walls	118.87	m^2	₹81.40	₹9,676.02
Bedroom	75.14	m^2	₹81.40	₹6,116.40
Kitchen	53.73	m^2	₹81.40	₹4,373.62
Lobby	46.68	m^2	₹81.40	₹3,799.75
Ceiling	323.9	m^2	₹81.40	₹26,365.46
Deductions	-31.89	m^2	₹81.40	₹-2,595.85
PAINTING				₹50,238.69
			Total	₹ 644097.50