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Analysis of Cost Effective And Energy Efficient residential Building Using BIM

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Abstract : This paper investigates cost-effective building materials and energy-efficient structures. Everyone in the world requires shelter, but not everyone has the financial means to build it, and some restrictions apply. The scarcity of natural resources has resulted in an increase in the cost of construction materials, which has become a major issue in our society. Because India is a developing country, various constructions are taking place on a daily basis. In addition, various studies are also being undertaken in a number of locations in order to minimize the cost of building construction. When creating a structure, we must consider environmental safety and promote more energy efficient construction in our world. We can preserve sustainability in this way. As a result of our reliance on nonrenewable energy sources for various buildings, natural resources are depleted, and the cost and demand for materials rise. The cost of building should not rise any further and should remain sustainable. The primary goal of this project is to lower the cost of building construction in the housing sector by using novel materials that are more energy efficient. We can make a significant contribution to the building business by implementing these innovative ideas.

***IndexTerms* - Energy Efficient Building, Autodesk Revit, Green Building Studio, Cost Comparison, Building Information Modelling.**

I. INTRODUCTION

Sustainability is the need of time, the word may be used in buildings, towns, cities, traffic and transport etc. Tushar Jadhav (2016) pretends in his paper that sustainability is the term used for technology and methodology used for saving cost of construction and conserving energy, it may be in the form of fuel, electricity or other means. While designing the sustainable building, understanding of thermal performance of roof and wall is important. Dr. M. B. Kumthekar (2012) aggrieves that main aspects of the design of thermally comfortable buildings are minimizing the flow of heat & reducing wall & roof surface temperature under summer conditions. Up to certain extent indoor thermal environment can be controlled by proper design & planning of building sections in relation to the climatic conditions. In this analysis, energy consumption and costing of the building sections has been provided. This will enable the Engineers to choose proper material like AAC blocks to improve economical and energy efficiency.

II. METHODOLOGY

The purpose of analyzing energy and designing of residential building Autodesk Revit and GBS will used. The model involved actual Residential building project. This involved using Building models created in Revit for analysis within Revit and export to GBS for further analysis.

• Create a 3D model using the Autodesk Revit software.
• Export it to the gbXML format for further analysis in Revit GBS software.
• Analyse and run results in the Green Building Studio software using conventional material.
• Analyse cost and energy of same 3D model with sustainable / energy efficient material.
• Performing cost comparison between conventional material based building and energy efficient building.

2.1 Use of Sustainable material

In construction of any type of building these are three basic material.

- Bricks
- Concrete
- Reinforcement

To make building energy efficient and economical here we are replacing

- AAC blocks in place of conventional clay brick.
- Reinforcement and concrete quantity will be reduce in structure due to reduction in dead load of building components.

2.2 Building Details

All the details required for designing model is given below
Type of Building = G+3 Building
Plan of Building = Square Regular Plan
Plan Area = 20m× 10m
Type of frame: Ordinary Shear wall with OMRF frame fixed at the base
No. Of bays in X-Direction = 3 bays
No. Of bays in Y-Direction = 5 bays
No. Of bays in Z-Direction = 4 bays
Number of story: 3
Depth of slab: 100 mm
Spacing between frames: 3m
Total Building Area : 744 m^2

Figure No.1 : 3D Model Of Building

2.3 Description of loading

Live load on floor level: 2 kN/m^2
Live load on roof level: 1.5 kN/m^2
Floor Finish: 1.25 kN/m^2
Dead load of slab: 3.75 KN/m^2

2.4 Materials

Grade of Concrete = M20 concrete
Grade of Steel = Fe 500 steel

2.5 Export to gbXML Using Energy Settings :

We may export the model to gbXML and use other tools to undertake further analysis after creating an energy analytical model with Revit

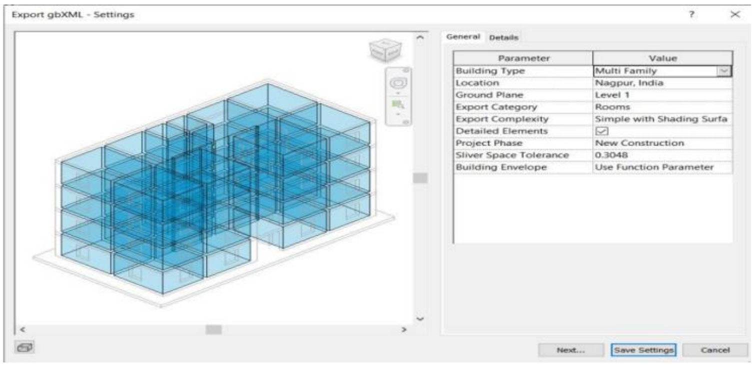

Figure No.2 : Export to gbxml Format

Following table shows detail parameters given as input with gbxml format

Table No.1 : Parameters

Name	G+3
Building Type	Multi Family Residential
Schedule	24/7
Project Type	Test Project: For Learning or demonstration only
City	Nagpur
State	Maharashtra
Postal Code	440001
Country	India
Time Zone	Indian Standard
Currency	Indian Rupee (INR)

III. RESULTS AND DISCUSSION

3.1 Energy, Carbon, and Cost Summary : Base Run and Design Option provides a detailed comparison of the project base run.

- Annual Cost of Energy : The entire yearly utility cost for all power and fuel utilized by project is approximated.
- Lifecycle cost : Over a 30-year period, the expected total cost of all power and fuel utilized project.
- Annual CO2 Emission : Carbon emissions are calculated using on-site fuel consumption and regional power fuel sources. Projects in areas with coal-fired power plants, for example, will emit more CO2 than those in areas with hydroelectric power plants.
- Annual energy Consumption : The projected amount of power and gasoline your project will use over the course of a year.
- Lifecycle Consumption of energy : The projected amount of power and gasoline your project will use over the course of 30 years

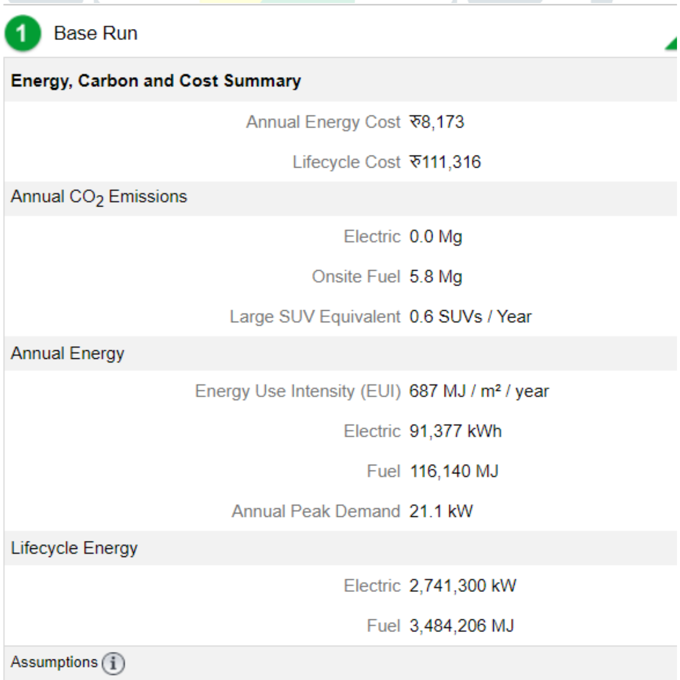

Figure No. 3 :- Energy,Carbon and Cost Summary

- Annual energy use intensity = 687 MJ/m^2/year
- Annual electric consumption = 91,377kWh
- Annual Fuel consumption = 1,16,140 MJ

3.2 Energy End Use Chart : In a graphical style, further breakdowns of predicted energy usage for main electric and gas end uses including lighting, HVAC (heating, ventilation, and air-conditioning), and space-heating are offered. By clicking on the pie charts, we can view more information about each category.

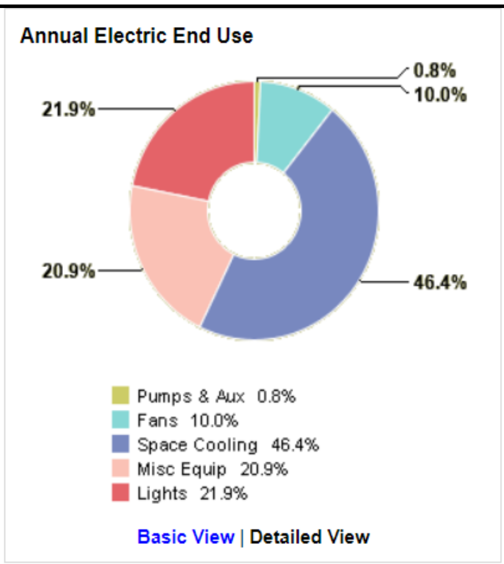

Figure No. 4 :- Annual Electric End Use

- Total consumption on space cooling = 46.4%
- Total consumption on lights = 21.9 %
- Total consumption on miscellaneous equipment = 20.9 %
- Total consumption on Fans = 10%

IV. SCHEDULE AND ESTIMATION

4.1 Calculation for No. Of Bricks

Brick size in m = 0.19m x 0.09m x 0.09m (Without Mortar)
Volume of Brick = Length x Width x Height
= 0.19 x0.09 x 0.09
= 0.001539 m^3
Mortar Used = 0.01m
Brick size in mm = 0.20m x 0.10m x 0.10m (With Mortar)
Volume of Brick = Length x Width x Height
= 0.20 x 0.10 x0.10
= 0.002 m^3
No. Of bricks in 1 m3 = Volume of 1 m3 /Volume of 1 Brick in Mortar
= 1/0.002
= 500 Bricks
Taking,
Market Value of Conventional Brick = Rs. 9/Brick

Figure No.5 : AAC Block (Same Size as conventional brick)

Market Value of AAC Block = Rs. 4/Block

4.2 Wall Schedule

Following table shows total length, area,volume and no. Of bricks required to construct whole building with total cost of conventional bricks and AAC blocks.

	Length	Area	Volume	No. Of Bricks	Cost of Brick
Schedule of Conventional Brick	485.9 m	1276 Sq.m	382.82 Cu.m	191412	1722711 Rs.
Schedule of AAC Block	485.9 m	1276 Sq.m	382.82 Cu.m	191412	7,65,650 Rs.

Table No. 2 Totals of AAC and conventional bricks

4.3 Cost comparison between Conventional Brick And AAC Block

Total No. Of Brick/Block = 191412
As per market value mentioned above,
Total Cost of Conventional Bricks = 17,22,711 Rs.
Total Cost of AAC Block = 7,65,650 Rs

Table No. 3 Comparison between Conventional And AAC Bricks

Total Cost Of Conventional Brick	Total Cost of AAC Block	Total Savings	% Savings
17,22,711 Rs.	7,65,650 Rs.	9,57,061 Rs.	55.56%

Total Saving of Cost = Total Cost of Conventional Bricks - Total Cost of AAC Block
= 1722711 - 765650
Total Saving of Cost = **9,57,061 Rs**.
Total saving in using AAC block is Rs. 9,57,061 and that is **55.56%** of total cost of conventional brick.

4.4 Calculations For Concrete

Concrete mix ratio for M20 grade :- 1:1.5:3

- Volume of wet Concrete = 1 m^3

Volume of dry Concrete = 1 x 1.54 = 1.54 m^3

- Volume of Cement required = (1/1+1.5+3) x 1.54 = 0.28 m^3

Weight of cement = 0.28 x 1440 = 403.2 kg
No. Of Bags = 403.2/50 = 8.094 ~ 9 bags (1 bag = 50 kg cement)

- Volume of Sand required = (1.5/1+1.5+3) x 1.54 = 0.42 m^3

Sand required in brass =0.42/2.831 = 0.148 brass

- Volume of Aggregate required = (3/1+1.5+3) x 1.54 = 0.84 m^3

Aggregate required in brass = 0.84/2.831 = 0.296 brass
Taking ,
Market value of 50kg cement bag = 340 Rs./bag
Market value of 1 Brass sand = 4200 Rs./brass
Market value of 1 Brass aggregate = 2950 Rs./brass

- Cost of Cement = 9 x 340 = 3060 Rs.
- Cost of Sand = 0.148 x 4200 = 621.6 Rs.
- Cost of Aggregate = 0.296 x 2950 = 873.2 Rs.

Total Cost of 1m3 Concrete = 3240 +453.6 + 625.4 = **4555 Rs/m^3**

4.5 Conventional Brick Structure quantity take off

Following figure shows steel and concrete quantity take off in conventional brick structure.

```
       **************  CONCRETE  TAKE OFF  **************
             (FOR BEAMS, COLUMNS AND PLATES DESIGNED ABOVE)
   NOTE: CONCRETE QUANTITY REPRESENTS VOLUME OF CONCRETE IN BEAMS, COLUMNS, AND PLATES DESIGNED ABOVE.
         REINFORCING STEEL QUANTITY REPRESENTS REINFORCING STEEL IN BEAMS AND COLUMNS DESIGNED ABOVE.
         REINFORCING STEEL IN PLATES IS NOT INCLUDED IN THE REPORTED QUANTITY.

       TOTAL VOLUME OF CONCRETE =        72.0 CU.METER

                   BAR DIA          WEIGHT
                   (in mm)         (in New)
                  --------         --------
                      8               17644
                     10                4929
                     12               31972
                               ------------
                    *** TOTAL=        54545

   102. FINISH
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Figure No. 6 :Conventional Brick Structure quantity take off

- Total volume of Concrete of Conventional Brick Structure = 72 m^3
- Total Cost of Concrete of Conventional Brick Structure = 72 x 4555 **= 3,27,960 Rs.**
- Total weight of steel used in Conventional Brick Structure = 54,545 kg
- Market value of fe500 reinforcement steel = 53Rs./kg
- Total Cost of Steel of Conventional Brick Structure = 54545 x 53 **= 28,90,885 Rs.**

4.6 AAC Block Structure quantity take off

Following figure shows steel and concrete quantity take off in AAC brick structure.

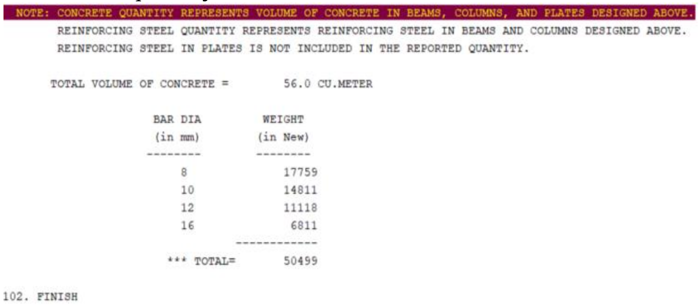

Figure No. 7 : AAC Block Structure quantity take off

- Total volume of Concrete of Conventional Brick Structure = 72 m^3
- Total Cost of Concrete of Conventional Brick Structure = 72 x 4555 = **3,27,960 Rs.**
- Total weight of steel used in Conventional Brick Structure = 54,545 kg
- Market value of fe500 reinforcement steel = 53Rs./kg
- Total Cost of Steel of Conventional Brick Structure = 54545 x 53 = **28,90,885 Rs.**

V. COST COMPARISON BETWEEN CONVENTIONAL BRICK STRUCTURE AND AAC BLOCK STRUCTURE

Following table shows overall comparison in cost of bricks, concrete and steel.

Table No. 4 : Cost Comparison

Structural Components	Cost of Conventional Brick Structure (Rs.)	Cost of AAC Block Structure (Rs.)	Savings in Cost (Rs.)	Savings in Percent (%)
Bricks	17,22,711	7,65,650	9,57,061	55.56%
Concrete	3,27,960	2,55,080	72,880	22.23%
Steel	28,90,885	26,76,447	2,14,438	7.41%
Total	49,41,556	36,97,177	12,44,379	25.18%

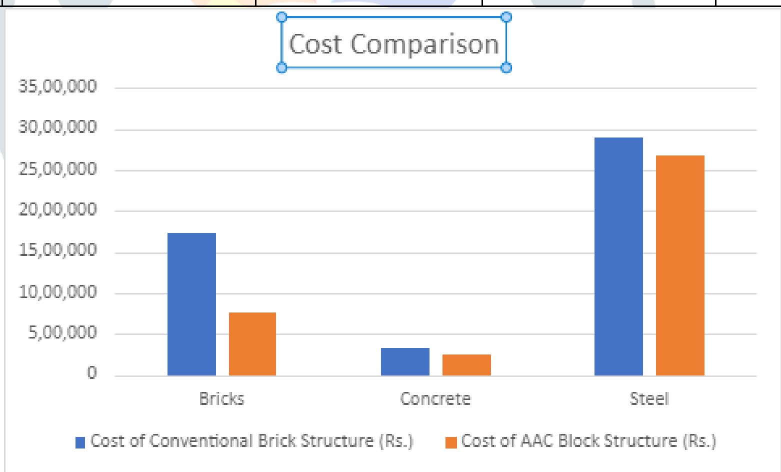

Figure No. 8 : Cost Comparison

Total Saving = **12,44,379Rs**.

AAC Block Structure had saved **25.18%** of total cost of Conventional Brick Structure.

VI. CONCLUSION

The primary goal of the project was to propose energy efficient and cost effective residential building. With replacement of conventional material with energy efficient material. This propose shown result in significant saving in energy and provided much more thermal comfort than conventional building. This research has also shown saving in cost comparison between AAC block structure and Conventional brick structure.This results will help engineers future to make sustainable changes at designing level of building

- The results of energy analysis shows annual use of energy is 687MJ/m^2/year. We can save upto 30% of consumption complimenting factors like LEED credit and Natural ventilation potential.
- Monthly cooling load is maximum in months of march, april, may and june similarly monthly heating load is maximum in months of November , december, january and february.
- Monthly Fuel consumption is on peak in december, januery and maximum fuel consumed is 1,16140 MJ.
- Also Monthly electricity consumption is on peak in May, june and maximum electricity consumed is 91,337kWh.
- Total saving in using AAC block is Rs. 9,57,061 and that is 55.56% of total cost of conventional brick.
- Total saving in using concrete is Rs. 72,880and that is 22.23% of total cost of concrete used in conventional brick structure.
- Total saving in using steel is Rs. 2,14,483 and that is 7.41% of total cost of steel used in conventional brick structure.
- Overall Cost saving in comparison of conventional brick structure and AAC block structure is Rs. 12,44,379 and it shows AAC block structure shows 25.18% savings in cost.

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