International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 08 | Aug - 2021 ISSN: 2582-3930

Energy Analysis of School Building using BIM tools with Sustainable Material

Shubham Pachagade[1], Dr. Sachin J. Mane[2]

[1]Civil Engineering Department D. Y. Patil College of Engineering Akurdi Pune
[2]Civil Engineering Department D. Y. Patil College of Engineering Akurdi Pune

---

Abstract -In total World Energy Consumption, Building shares 22- 40% Energy which made necessary to investigate the Energy Analysis. Energy Analysis can be done by the two ways manually or by using software. This study uses Autodesk Revit and Autodesk Insight for the Energy Analysis of School building situated in Chempanthotty Kannur, Kerala. In terms of Energy(kWh/m^2/yr) and Cost (USD/m2/yr) by using a four different material namely Fly Ash brick, AAC Block, Solid Burnt Clay Brick and Solid Concrete Block by considering the parameters Window Wall Ratio (WWR), Lightning Efficiency, Window Shading, Operational Schedule and Building Orientation. The results shows that lower the Thermal value of material is equal to more sustainable material and more sustainable material is having a low ASHRAE value. The Energy Consumption of Building by using Solid Concrete Block is 321 kWh/m^2/yr, Solid burnt Clay brick is 305 kWh/m^2/yr, Fly Ash brick is 293 kWh/m^2/yr, AAC Block is 254 kWh/m^2/yr. The Cost required for Energy consumption of the Building by using Solid Concrete Block is 22.3 USD/m^2/yr, Solid burnt Clay brick is 20.7 USD/m^2/yr, Fly Ash brick is 20.1 USD/m^2/yr, and AAC Block is 17.1 USD/m^2/yr. The result shows that AAC block is more sustainable followed by Fly Ash Brick, Solid burnt Clay Brick, and Solid Concrete Block.

Key Words: Building Information Modeling, Green Building, Energy Analysis, Solar Radiation, Energy Optimization.

1. INTRODUCTION

In total energy consumption, the building sector shares a huge contribution. Due to this there is an increasing demand in Energy Efficient measures within the buildings. According to the International Energy Agency there is a research going on to identify the Energy loss and Energy consumption within the building which affect the Building performance. The advanced technology leads many changes in Energy Analysis and Building Design process. It becomes more important to create comfortable environment, reduce carbon dioxide emission and optimise Energy of building. Due to this scientist in the whole world researching about strategies that affect energy consumption in building though the Energy analysis [7]. If the building is properly designed and constructed the Energy saving can be achieved in a Building. Energy modelling technology is one of the effective ways to reach building energy efficiency by proposing alternative designs, Energy standards, and economic optimisation during design process of building [6]

Building Energy Modelling (BEM) is not enough at all to synchronise with virtual planning and design process and this lead to not well implement during the initial stage of design. Therefore there should be a need of technique to manage all the parameters, Energy standard, norms. This can be achieved by using the BIM tools which help in generative designs, object-oriented, data rich, parametric digital presentation. BIM so help designer to analyse the data and make decisions to improve the process. Based on BIM platform, BIM base BEM has recently emerged in Trend. BIM base BEM uses the pre-design model including Architectural Design, Mechanical loads, Material properties and HVAC to provide input to BEM tools which lead to time and energy saving to use within accuracy.

1.1 Problem statement

To understand and optimise Energy Use intensity (EUI) and saving potential of building a study is to be conducted with the help of BIM and Energy simulation program. The maximum use of our deflecting resources in building, it is necessary to move towards the sustainability. It also help the environment also add cost saving for owner. Building Energy simulation work on each and every module and provided the solution for each short coming.

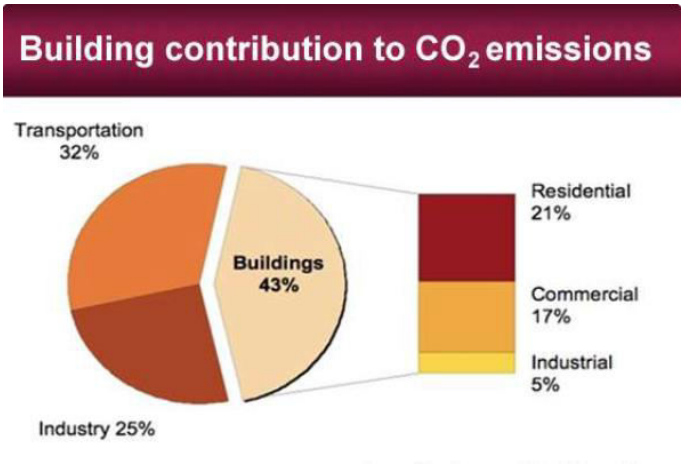

Fig -1: Building Contribution to CO_2 emission

Source: Pew Center on Global Climate Change

1.2 Building Energy Consumption

Building energy analysis refer to the computation of all the internal and external parameters of building which include features like day lighting, solar energy, thermal factor, orientation, heating and cooling, physical building mass. The main reasons for energy modelling are:

1. To complete with energy standard
2. Economic efficiency
3. Allocation of annual energy budget

While doing energy analysis following points should be considered:

1. Thermal Characteristics
2. Natural Ventilation

3. Solar System
4. Indore Climate
5. Build In Appliances
6. Indoor Climate

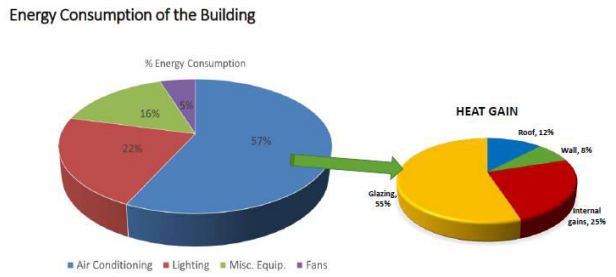

Fig -2: Energy Consumption in building
Source: Pew Centre on Global Climate Change

1.3 Condition of India in terms of Energy

For the implementation of economic development plan, Energy demand is increase in India. According to the World Resource Institute Report 2017, India is responsible for nearly 6.65 % of total global carbon emission [27]. The developing country India investing in infrastructure for the economic development of the country which lead to use the construction material which are responsible for increase in the carbon emission in India. Building contributes nearly 43% of CO_2 emission whereas transportation and industry contribute 25% and 32% respectively. The higher percentage of CO_2 emission from the Building section is due to used of Cement, admixture, and much other construction material. So it is necessary to find a sustainable material which is Environmental friendly. Similarly the design of the building also contributes in reducing the energy consumption of the building.

Because of this there is a need of finding a sustainable material and optimise design of the Building. This can be done either by Software or Manually. In this project work Revit and Insight software are used to energy analysis to find out the sustainable material for the Building.

2. MATERIAL AND SOFTWARE.

2.1 Site Plan

The School Building has 3 Floor (Ground, First, Second Floor) having 9 Class Room, 12 Toilet, 1 hall,1 Staff Room, 1 Computer Lab, 1 Office Room, 1 Sick room.

The Location of this Project is Chempanthotty, Kannur, Kerala 670631 Latitude: 12.0896075 & Longitude: 75.495627.

The Total Plot area of the project is 20295.00 m^2 whereas the total build-up Area is 1909.03m^2

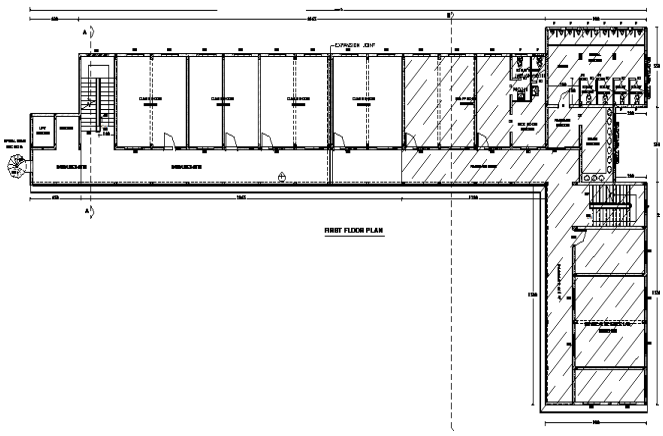

Fig -3: Site Plan of School Building

Table -1: Area details

Area Details			
Floor	**Build-up Area (M^2)**	**Floor Area(M^2)**	**Carpet Area(M^2)**
Ground F	613.84	539.26	431.41
First F	613.84	539.26	431.41
Second F	613.84	539.26	431.41
Third F	1909.03	67.51	54
Total Area	**1909.03**	**1685.29**	**1348.23**

Climatic Condition

The climate is tropical in Kannur. Rainfall is significant most months of the year, and the short dry season has little effect. The average annual temperature in Kannur is 26.4 °C. In a year, the rainfall is 2410 mm.

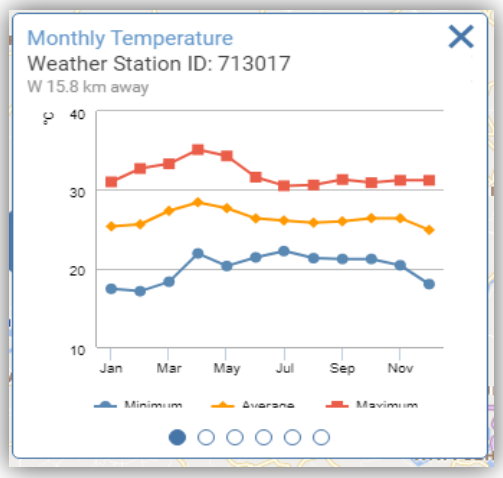

Fig -4: Climatic Condition of Chempanthotty, Kannur

2.2 Software

Autodesk Revit

In 1997, Revit Technology Corporation created Revit software which is a later on purchase by the Autodesk in 2002. Revit software provide Autodesk's BIM platform. The Revit software is specific software for all the phases of Modelling, Design and Construction Documentation system. Revit is the Parametric Software which simultaneously creates 3D at 2D drafting. The advantage of Revit based application is that it provides development for basic concept conceptual study to the more detailed building drawing. At current situation Revit is well-known and market leader for the BIM Architectural design. Revit software has been increasingly used in Architectural design due to advantage brought about by the BIM technology which collect all the information represent a building into single virtual mode. Revit has three Modules-Architectural, Structure and MEP [7]. Revit software compatible with window (7, 8, and 10) and it feature gb XML interface. The Energy Analysis in Autodesk Revit software has been developed from the last few years. Before 2015, Autodesk sold the Ecotech Energy Analysis software which is now upgraded and called a Green Building Studio where Insight 360 is the recent developed cloud based software. Insight 360 is the Plug-in for Revit software which allowed optimising Energy Analysis, Heating Cooling load and Solar

Radiation in details. To carry out Building Energy Analysis through Insight Plug-in we must have an Autodesk account. This platform allows interacting with obtained result by visualising in three-dimensional Model.

Autodesk Insight 360

Autodesk Revit includes access to Autodesk Insight 360 as per the Revit subscription. Insight 360 provides with the Revit uses better Energy and Environment performance throughout the building lifecycle. By simply applying geographical location and leverage in Revit automatically generate Energy Analytical Model. Insight360 empowered Architect and integrated team clear guidance recommendation by initiative Energy Simulation that lead to better Energy performance outcome. Instantly other range potential desired outcome to the energy cost range help to quickly identify key Energy performance and compare design scenario. Insight 360 integrate many exciting workflow such as a Revit Energy Analysis, Lightning Analysis tools provide holistic approach to building performance. Architect, Engineer, owner or any stakeholder of Building Energy and Environment performance Autodesk Revit + Insight 360 is the powerful and impactful to better Energy and Environmental performance. Autodesk Insight uses ASHRAE standard for the energy efficiency. ASHRAE is the American Society of Heating, Refrigerating and Air-Conditioning Engineers. It is global society. It promotes sustainable technology for wellbeing of human. They have particular ranges of R value and U value standard for Energy Efficiency of the Building. By adopting that ranges we can reach up to level of Energy Efficient.

2.3 Materials

For Energy Analysis of the School Building 4 Material are used namely:

1. Fly Ash Bricks
2. AAC Blocks
3. Solid Brunt Clay Bricks
4. Solid concrete Blocks

3. METHODOLOGY

The process required for the Energy Analysis of the Building explained with the help of following Flow Chart. The work flow of the project is in the following way.

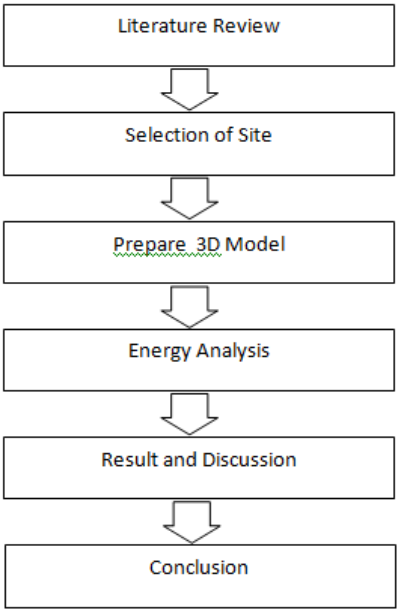

Fig -5: Work flow of project

Literature Review

A vast Literature survey is carried out by researcher through National and International Journal on this topic. Research use different software for the Analysis of the Building by considering different Parameter. Some of the researcher uses Building Orientation parameter whereas some of uses lighting efficiency. By studied the entire research work in this project work, Window wall ratio, Lighting Efficiency, Building Orientation, Operating Schedule and Window Shading is takes into consideration.

Selection of Site

For this project work a site of School Building which is situated in Chempanthotty, Kannur, Kerala is selected.

Prepare 3D Model

For the creation of the 3D model, Autodesk Revit Software is used. Revit software is used for the Architectural Modeling, Structural Modeling and MEP Modeling. The Material is assign to the Model namely: Fly Ash Brick, AAC Block, Solid Concrete Block and Solid burnt Clay Brick and Energy Analysis is carried out by using Autodesk Insight cloud based Software.

Energy Analysis and Optimization

- **Create Energy Model**

This feature allows you to inspect the energy analytical model so that you can validate its before running the energy simulations. The energy analytical model is based on conceptual masses, building element, or both depending on the analysis mode selected in the Energy Setting dialogue.

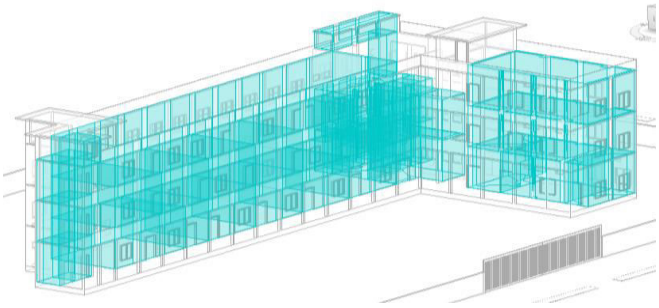

Fig -6: Energy Model

Generate

Create the energy analytical model and generate design option and potential performance outcome with Insight.

Optimize

After successful creation of the Analytical Energy Model the model is optimize to analyze the Energy optimize of the Model. The Model is added to Insight 360 platform.

Result

Insight 360 cloud based software analysis the model and provides the ASHRAE value in term of cost in USD/m^2/yr and Energy in kWh/m^2/yr.

4. RESULT

Solar Radiation Analysis

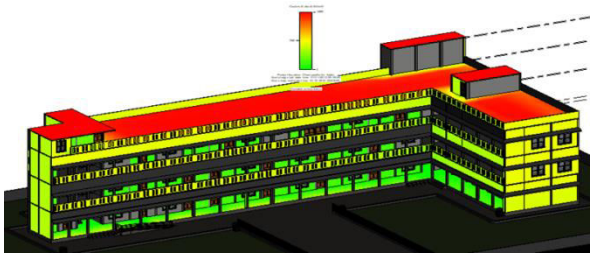

Fig -7: Solar Radiation Analysis of Building

Fig. shows the solar radiation intensity of the building. From the figure, the maximum intensity of the solar radiation is at the top the building. The Red colour in Legend show the maximum intensity of sun to the surface which is 1599kWh/m^2, the yellow colour shows the Medium Solar Radiation which is 799 kWh/m^2 whereas the Green colour shows the Minimum Radiation of the Sun. From the Analysis, It is observed that Total Voltaic Solar Energy is produced is 2,75,332 kWh/year, whereas Total solar panel area required is 2068 m^2. The total cost in Energy saving is Rs. 41,300 per year. The payback period is 23.6 year.

Table -2: Solar Radiation Analysis of the Building

Photo voltaic solar Energy	2,75,332 kWh/year
Energy Saving	Rs.41,300
Total solar panel Area	2068 m^2
Payback period	23.6 year

Table -3: Result of Energy Analysis using different Material.

Material	Specific Heat kJ/Kg K	Thermal Conductivity W.m/K	Density kg/m3	ASHRAE Value	
				Energy kWh/m^2/yr	Cost USD/m^2/yr
Solid Concrete Block	0.30	1.41	2349	**321**	**22.3**
Solid Brunt Clay Brk	-	0.620	1440	**305**	**20.7**
AAC Blocks	1.24	0.184	642	**254**	**17.1**
Fly Ash Bricks	0.93	0.856	1650	**293**	**20.1**

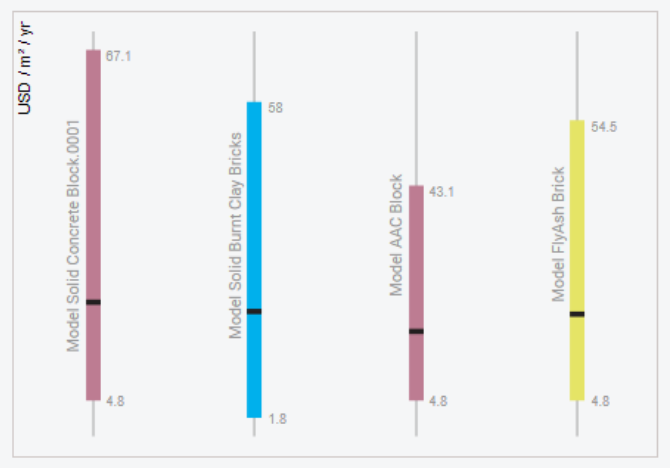

Fig -8: Model Comparison

CONCLUSION

- The Total Energy Saving is Rs.41,300 per year and Photon voltaic solar Energy 2,75,332 kWh/year.
- The Energy Consumption of Building by using Solid Concrete Block is 321 kWh/m^2/yr, Solid burnt Clay brick is 305 kWh/m^2/yr, Fly Ash brick is 293 kWh/m^2/yr, AAC Block is 254 kWh/m^2/yr.
- The Cost required for the Building by using Solid Concrete Block is 22.3 USD/m^2/yr, Solid burnt Clay brick is 20.7 USD/m^2/yr, Fly Ash brick is 20.1 USD/m^2/yr, AAC Block is 17.1 USD/m^2/yr.
- The AAC block is more sustainable material followed by Fly Ash Brick, Solid burnt clay Brick and Solid Concrete block.

REFERENCE

1. Irbaz Hasan , Syed Shujaa Safdar Gardeziin: BIM-Based Energy Optimization – Case study of High-RiseBuilding in Pakistan" Journal of Sustainability Perspectives: Volume 62 1 Issue 1 , 2021
2. Bhavana Dinesh: Bim-Based Energy Use Predictions And Savings Potential For A Residential BUILDING, .researchgate publication DOI:10.13140/ RG.2.2.25352.85763
3. Samuel Egwunatum, Esther Akwara, Richard Akaigwe: Optimizing Energy Consumption in Building Designs Using Building Information Model (BIM), Slovak Journal of Civil Engineering, Vol. 24, Issue No. 3, 2016, pp. 1 – 4.
4. Nnanna Otuh,(2019).BIM Based Energy Analysis/ Sustainability for Educational Buildings – A Case Study, 2016, pp. 1 – 5
5. Kuldeep Mishra and Amit Goel: Energy Analysis of High Rise Building Integrated with BI, Indian Journal of Science and Technology, Vol 12(6), DOI: 10.17485/ijst/2019/v12i6/141917,
6. Hao Gaoa, Christian Kochb, Yupeng Wua,: Building information modeling based building energy modeling: A review. https://doi.org/10.1016/j.apenergy.2019.01.032.
7. Haider Al Habibi: Analysis And Optimization Of Energy Performance For A Building In Csus Campus" Indian Journal of Science and Technology, vol. 68, no. 2, pp. 953-963, February. 2017
8. Zhen Liu : A Building Information Modelling (BIM) based Water Efficiency Framework for Sustainable Building Design and Construction Management, 8(6):599
9. R.R. Gajewski, T. Kułakowski: Towards Optimal Design Of Energy Efficient Buildings" Jingming Li, instudy A

review of currently applied building information modeling tools of constructions in China".

10. Mohamed M. Ouf,: Energy consumption analysis of school buildings in Manitoba, Canada, Volume 6, Issue 2, December 2017, Pages 359-371.
11. Daniel Stine: Dynamic Energy Optimization with Revit® and Insight 360, Available from: Revit-and-Insight-360.pdf
12. G. Gourlis, and I. Kovacic: Building Information Modelling for analysis of energy efficient industrial buildings A case study", Renewable and Sustainable Energy Reviews, vol. 68, no. 2, pp. 953-963.
13. Georgios Gourlis: Building Information Modelling for analysis of energy efficient industrial buildings – A case study Volume 68, Part 2, February 2017, Pages 953-963
14. Luka Adani: BIM and Mechanical Engineering—A Cross-Disciplinary Analysis" Industry 4.0 April 2021 Sustainability 13(8):4108 DOI:10.3390/su13084108
15. Jin-Up Kim,: Development of A BIM-Based Maintenance Decision-Making Framework for the Optimization between Energy Efficiency and Investment Costs", 2480; doi:10.3390/su10072480
16. Ju Hyung Kim, Jaehyun Park, Junglo Park, Juhyung Kim: Building information modelling based energy performance assessment system: An assessment of the Energy Performance Index in Korea" Vol. 12 No. 3, 2012 pp. 335-354.
17. Autodesk :Building Information Modeling for Sustainable Design 20paper.pdf.
18. Reeves and et al : Guidelines for using Building Information Modeling for energy analysis of Buildings, vol. 5, no. 4, pp. 1361-1388, 2015.
19. Ryan and Sanquist: Validation of building energy modeling tools under idealized and realistic conditions," vol. 47, pp. 375-382, 2012.
20. Poel: Energy performance assessment of existing dwellings,vol. 39, no. 4, pp. 393-403, 2007
21. El Chaar and El Zein: Review of photovoltaic technologies, Renewable and sustainable energy reviews, vol. 15, no. 5, pp. 2165-2175, 2011.
22. Tonkin: SunPowerSource types of solar panels. Available: https://www.sunpowersource.com/types-of-solar-panels/.
23. Eldin: A review on photovoltaic solar energy technology and its efficiency, in 17th international middle-east power system conference (mepcon15), at mansoura university, egypt, 2015, pp. 1-7.
24. Energy Efficiency & Renewable Energy: Organic Photovoltaics Research. Accessed on: July 20,2019
25. U.S. Department of Energy: Solar Technologies - Market ReportAvailable: https://www.nrel.gov/docs/fy12osti/51847.pdf, Accessed on: August 16,2019.
26. Eco-Niwas Samhita: Energy Conservation Building Code for Residential Buildings) Part I: Building Envelope Published by Bureau of Energy Efficiency 4th Floor, Sewa Bhawan, R K Puram, New Delhi, India
27. Charles Rajesh Kumar. J & M. A. Majid: Renewable energy for sustainable development in India: current status, future prospects, challenges, employment, and investment opportunities Energy,Sustainability and Society volume 10, Article number: 2
28. Nagaraju Kaja: An Overview of Energy Sector in India International Journal of Science and Research (IJSR) Value (2015): 78-96.