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Banana Fibre as Alternative Thermal Insulation and Comparison with Conventional Thermal Insulation in Buildings

Mrs.Shobha R[1],Mr.Vinod BR[1]Mr.Vivek Vedant[2]Pawan Bhatia[2]

[1]*Assistant Professor, BMS Institute of Technology &Management, Bangalore-560064*

[2]*U.G. Student, Department of Civil Engineering, BMS Institute of Technology & Management, Bangalore-560064*

shobhar@bmsit.in,vinodbr@bmsit.in,vvedant5.vv@gmail.com

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Abstract:
Usage of Natural material as a thermal insulating optionfor building is also an alternative for energy savings. Banana fibre is a locally available material and it has properties of weatherproof and thermal insulating, hence it is being considered as the insulating material for making energy efficient buildings.
In this study, we compare banana fibre, polystyrene and mineral wool as insulation material for buildings by conducting the energy analysis using Revit models. From the analysis, it is observed that Banana Fibre Insulation is 13.04% more efficient than model without Insulation, whereas Polystyrene is 13.43% and Mineral Wool is 13.83% more efficient than model without Insulation.

Keywords: *Energy Analysis, Banana Fibre, Mineral Wool, Polystyrene.*

I. INTRODUCTION

In recent decades, the immediate infrastructural rise in the construction sectorhas led to the energy crisis, which is needed to be addressed and good practices for efficient energy consumption should be necessitated while planning for either residential purpose or commercial purpose. AEC, Maintenance and Serviceability sectors are one of the biggest consumers of energy in the world which sums up to about 40% of energy produced across the globe.

Therefore, AEC sector patrons should apprehend the fulfillment of sustainable goals and energy consumption ofupcoming building projects. Although,mediums like polystyrene and mineral wool have long term financial benefits, they may have harmful effects on human body and cause environmental pollution by emission of toxic gasses and particle.

Therefore, Natural thermal insulating characteristics of plant base lignocelluloses materials such as Banana fiber has indicatefavourable insulating characteristics for use as Alternative Building Insulation option. Banana fiber has various desirable properties such as durability, grease proof, fire resistant, water resistant, tensile strength, resistant to UV light, sound observant, light weight and high spin-ability. Banana fiber also showcases properties of insulation. These properties make banana fiber an attractive alternative for use as building thermal insulation.

OBJECTIVES

- To use Banana Fiber as an alternative material for the thermal insulator for heating and cooling in the building.
- To evaluate the energy consumption in the building using Banana Fiber as an insulator.
- To use BIM as Energy Analysis tool using the REVIT Insight 360.
- To collate conventional insulation methodslike Mineral Wool and Polystyrene with Banana fiber by conducting energy analysis of the insulation mediums.

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II. LITERATURE REVIEW

Several studies have been carried out for energy analysis of alternative insulation mediums like banana fibre, coconut fibre etc. Some of them were discussed below.

KamarAljundi et al. [1], the study conveys the effects about the reliability and flexibility of energy analysis using BIM-based simulations as well as the advantages and drawbacks of utilized BIM tools when compared with Energy Plus results and measurements. These instruments were used to study the thermal energy performance of a well-insulated test cell and to study the impact of a change of thermal mass and insulation thickness to analyse the advantages and disadvantages of each tool. And it was concluded that these BIM tools enabled the patrons to conveniently experiment different design alternatives for the entire life cycle of the project, beforehandthe implementation of the concluding design solutions to the project, while saving time and money and contributing for the achievement of more energy efficient buildings.

KrishpersadManohar et al. [2], Thermal isolation is allocated to reduce the loss of heat in structures. Importance of the natural biodegradable fiber which acting as thermal insulation, the natural biodegradable lignocelluloses materials are coconut fiber, sugarcane fiber, banana fiber and palmfiber which are having good thermal insulating properties. They have done experiment on these materials in order to select the best biodegradable material for thermal insulation. Among these materials, banana fibre has lower thermal conductivity and qualifies to stands in the range 0.02W/m.K to 0.04W/m.K which is range of building thermal conductivity.

NuthanDummenahally [3], The development of energy sustainable building practices to have positive effects on environmental and annual life cycle performance in terms of energy consumption during operational stage by accommodating BIM for the project and by assessing the configurations of alternative materials which will have higher impacts on building performance by minimizing the annual usage of operational energy, leading to improvementin energy efficiency parameters of the building.

Christian Daniel Douglass [4],currently, more than 300 softwares are available for evaluating and analyzing energy efficiency, evaluating resources of renewable energy, and proposing sustainability in AEC projects. BIM is a step by step process it covers all features of buildings. Autodesk Revit Architecture is incorporated to create building information models and this data is exported to analysis tools like Autodesk Ecotect and Design Builder. This provides information about weather, heating and cooling loads, heat loss and various energy conservation measures. A set of three instructional modules is developed to demonstrate BIM-based methods for building energy analysis.

- Module 1: Building Model Creation it contains Digital Sketching, Creation of the Building Information Model
- Module 2: BIM Data Export and Import it collects all data and Final Analysis is done.
- Module 3: Simulation and Data Analysis in this all energy conservation measures (ECM) Analysis is done.

Building information modeling, building energy simulation, sustainable design, or parametric solid modeling increase the use of energy efficiency.

III. PROJECT DETAILS

The project details considered are as follows:

- Site Details: A site with size of 70x50 metres having a total area of 3500 sq.m.is considered and is in premises of Bangalore.

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- Building Information: A commercial building of G+2 floors havingfour metres floor height with the built area 2270 sq.m.is planned.
- Mechanical Properties of Insulation: The energy analysis data required for the simulation consists of the following insulating properties of the selected materials respectively.

Table 1: Properties of Standard Insulation

Material	Polystyrene
Behavior	Isotropic
Thermal Conductivity	0.0360 W/m.K
Specific Heat	0.96 J/g.℃
Density	100.00 kg/m3
Emissivity	0.9

Table 2: Properties of Banana Fibre

Material	Concrete Masonry
Behaviour	Isotropic
Thermal Conductivity	0.287 W/m.K
Specific Heat	0.8 J/g.°C
Density	400 kg/m3
Emissivity	0.95

Table 3: Properties of Concrete Masonry

Material	Mineral Wool
Behaviour	Isotropic
Thermal Conductivity	0.0350 W/m.K
Specific Heat	1.4700 J/g.°C
Density	23.00 kg/m3
Emissivity	0.95

Table 4: Properties of Mineral Wool

Material	Banana Fibre
Behaviour	Isotropic
Thermal Conductivity	0.0415 W/m.K
Specific Heat	1.76 J/g.℃
Density	73.40 kg/m3
Emissivity	0.9

IV. METHODOLOGY

In the present study, the following procedure is adopted to analyse the banana fibre as an insulating material and comparing it with conventional building insulation.

A. Development of Architectural Plan-AutoCAD

A two dimensional plan was created using AutoCAD. The area utilized was 2270sq.m with optimum space for commercial area (no. of shops-89) consisting all the amenities such as staircase, parking provision, lift, restroom, corridor, emergency exit etc. While maintaining the maximum spacing between the columns as six metres, wall thickness of 0.3m is considered.

B. Development of 3D Model using REVIT Architecture

3D model was developed by importing the 2-d plans from AutoCAD.

Revit is software in BIM (building information modeling) with tools to create intelligent 3D models of buildings, which can then be used to produce construction documentation.

A working model is prepared with all the defined elements like wall thickness, light fixtures and other design material.

Insulation materials are also introduced into Revit by duplicating model and properties of their thermal resistance.

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C. Energy Analysis with REVIT and Observations

Energy analysis in REVIT 2018 was conducted through Insight 360. Energy analysis was conducted for the various conditions.

- Energy analysis without dedicated insulation system.
- Energy analysis with Standard Insulation system (eg. Glass fiber, Mineral wool, Asbestos, Polyurethane, etc.)
- Energy analysis with Banana Fiber as Insulation material.

V. RESULTS AND DISCUSSION

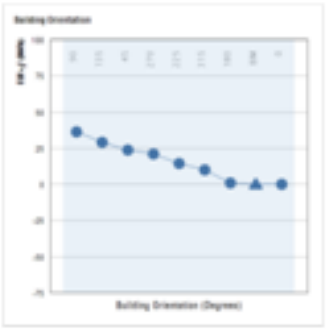
The energy analysis was conducted over the following types of insulation material used in REVIT models:

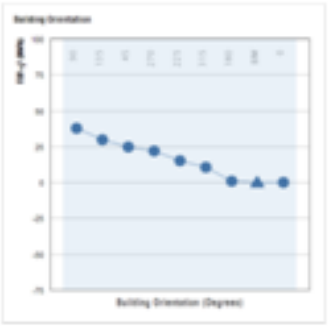
- No dedicated insulation
- Banana fiber as insulation
- Polystyrene
- Mineral Wool

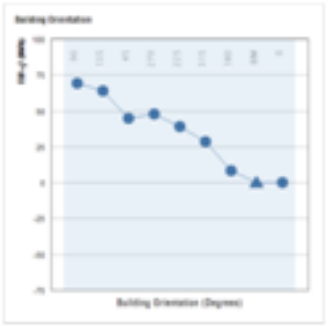
To generate the Energy Unit Intensity (EUI) and energy consumption efficiency provided by different insulating substances, nine parameters were evaluated. Those parameters are discussed in this section.(Order Of Graphs: - 1, Without Insulation, 2. Polystyrene Insulation, 3.Mineral Wool Insulation, 4.Banana Fibre Insulation.)

A. Building Orientation

The building is initially oriented facing true south. From the graph we understand that the model orientation is optimal. Increasing the orientation by 900 has maximum effect on Energy Use Intensity (EUI).(1, Without Insulation, 2.Polystyrene Insulation, 3.Mineral Wool Insulation, 4.Banana Fibre Insulation.)

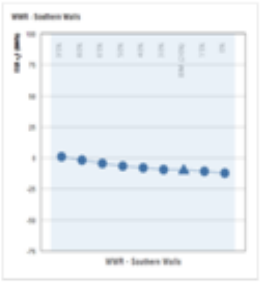


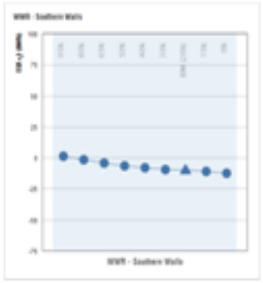


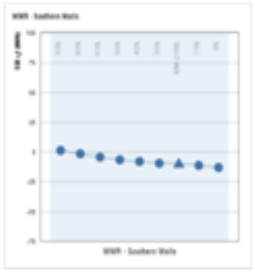


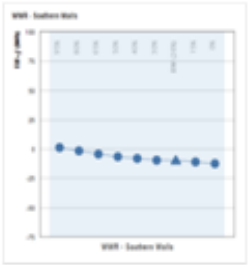
B. Window to Wall Ratio

Window to wall ratio affects the EUI as it affects Day-lighting, heating and cooling. Window to wall ratio is maximum for the South wall which is 26%.









C. Window Glass

Window glass refers to the type of glass panels used in the analysis. For this model the available options are SglClr, DblLoE, DblClr, TrpLoE and SglClr being the least efficient and TrpLoE being most efficient.

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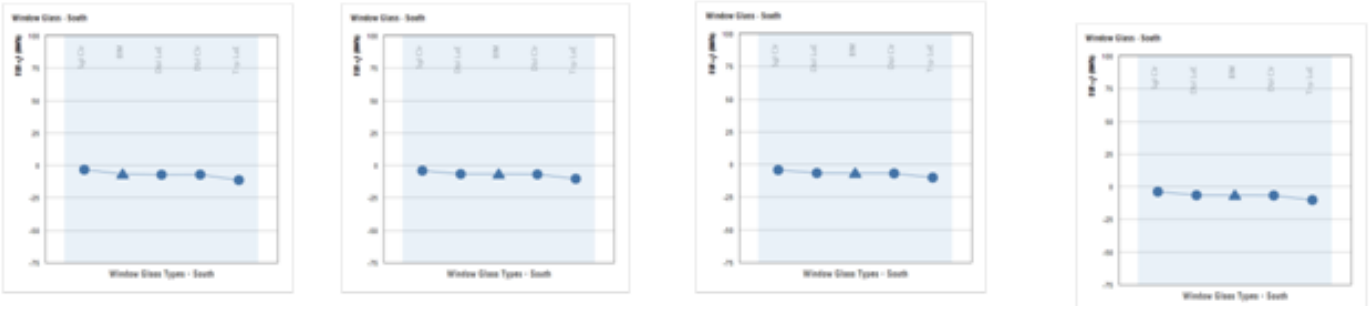
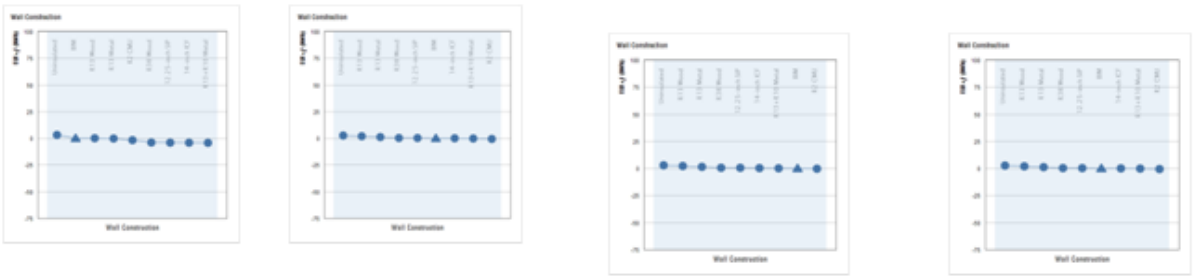


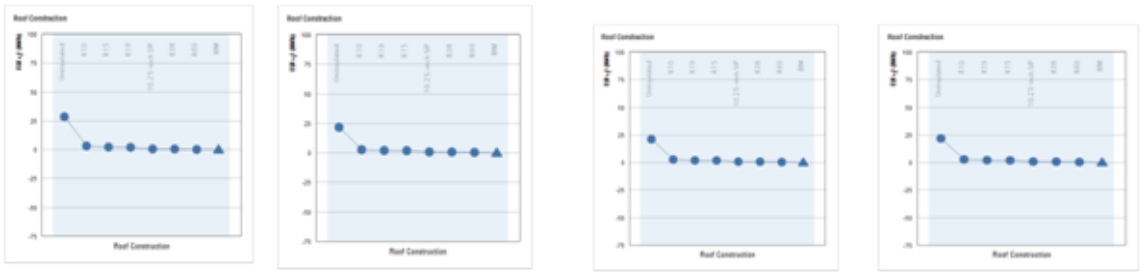
D. Wall Insulation

This represents the overall ability of the constructed wall to resist heat loss or heat gains. From The graphs we can understand that uninsulated wall is the least efficient and wall with R2 CMU wall is the most effective.



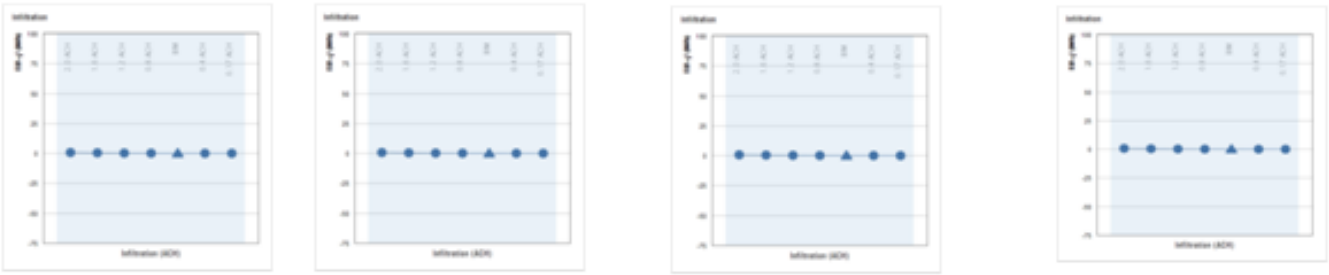
Roof Insulation

This represents the overall ability of the constructed roof to resist heat loss or heat gains. From The graphs we can understand that uninsulated roof can cause and average increase of 23 kWh/m2/yr in energy use intensity.



E. Infiltration

ACH (Air Change per Hour) for the model is rated between 2.0 to 0.17 in the graph. As ACH value increases efficiency of HVAC system decreases. ACH of the model is 0.6.



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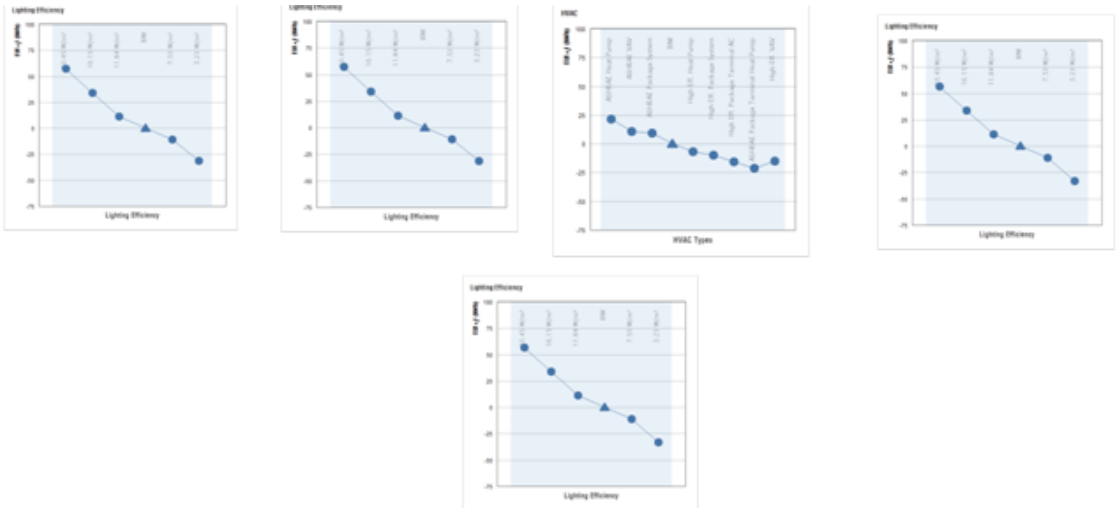
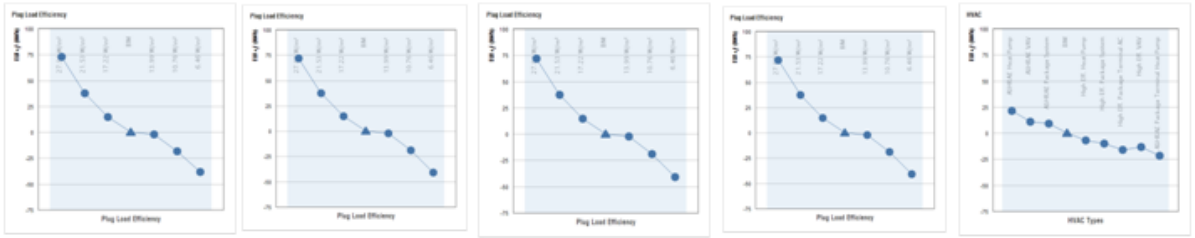
F. Lighting Efficiency

As Current increases efficiency decreases and EUI increases. Lighting efficiency of the model lies between 11.84 W/m2 and 7.53 W/m2.



G. Plug Load Efficiency

Plug load efficiency for the model lies between 17.22 W/m2 and 13.99 W/m2. As Plug Load increases EUI also increases



H. HVAC(Heating, Ventilation and Air Conditioning)

The HVAC System used for the models is Central VAV, Electric Resistance Heat, and Chiller 5.96 COP. From the graph we can understand that it meets the standard of ASHRAE and components of higher efficiency are available to further decrease CUI.

I. CONCLUSIONS

We made an attempt to explore the possibilities of using alternative material as insulation substances for structures such as banana fibre. Based on simulations carried out in REVIT Insight 360 and bycomparison of results and materials' properties, the following conclusions has been derived:

- It was observed that the resulting Energy Use Intensity (EUI) for Model without insulation, with Banana fiber insulation, with Polystyrene insulation and with Mineral Wool insulation are 253 kWh/m2/yr., 220 kWh/m2/yr, 219 kWh/m2/yr and 218 kWh/m2/yr respectively.
- On comparison of efficiencies of different materials, it is concluded that Banana Fibre Insulation is 13.04% more efficient than model without Insulation, whereas Polystyrene is 13.43% and Mineral Wool is 13.83% more efficient than model without Insulation.
- Since, Banana fiber is a locally sourced natural material with a life-cycle expectancy of 30 years and Eco friendly, it fits as perfect alternative for insulation material as compared to mineral wool and polystyrene.

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