Economic optimization of Wall's Insulation Thickness on Energy Performance of Green buildings

G.R.K.D. Satya Prasad¹, Manas ranjan Panda², Hirok Jyoti Sarmah³, Nishant Ku. singh⁴, Hailendra Prasad⁵

¹Asscoaite Professor, Department of Electrical Engineering, GIET, Gunupur, Orissa, INDIA
²Asssiant Professor, Department of Mechanical Engineering, GIET, Gunupur, Orissa, INDIA
³,⁴,⁵Final Year UG student, Dept. of Mechanical Engineering, GIET, Gunupur, Orissa, INDIA

Abstract:

Heat losses of a building envelope are mainly depends on the heat penetration of the buildings. These heat losses can be minimized with proper insulation thickness of the walls. The insulation thickness and energy savings are calculated by using the life span of the building. Passive energy technologies will plays a vital role in deciding the insulation thickness of the buildings.

In this paper, a study has been done on energy saving in different types of building walls by using optimum insulation thickness with suitable insulation material.

Key words: Insulation thickness, Life-cycle cost analysis, Sustainable homes, Energy consumption.

1. INTRODUCTION

Buildings wall insulation thickness plays an important role in buildings energy consumption. The majority of the building designers are not aware of the importance of walls insulation thickness and to optimize the size of insulation thickness.

Inappropriate insulation thickness of the wall leads to a bad design of the building and hence consumes more energy by air-conditioning equipment of the building.

Insulation materials are preferred in terms of geographical area of the building, local weather conditions, number of floors, wall to window ratio, capacity of the air handling units etc.,

1.2 How insulation works

Insulation material of the wall depending on its thickness will depend on radiation, convection and conduction.

Radiation: This type of heat penetration depends on indirect contact heat process.

Conduction: Conduction type of heat penetration directly depends on direct contact of the heat process.

Convection: This type of heat process is by using an intermediate agent like air or fluids to transfer the heat in to buildings.

1.3 Performance

Insulation material performance mainly depends on the flow of heat energy in to the buildings. They are closely associated with the materials R-values and U-values. In other words; insulation material thermal resistance may resist the transfer of heat in to the buildings with proper optimization of the insulating material.

Thermal conductivity:
Thermal conductivity of the insulation material is an important parameter to decide the heat penetration in to the building. It is a constant measured in W/mK. The higher the thermal conductivity of the material the better the thermal conductivity of the building.

Thermal resistance:
Thermal resistance of the material is a product of thermal conductivity and insulation thickness. It is expressed in m²K/W.

U-value:
This value is applicable to any type of building material; like roofs, walls, basement, window glasses, doors etc., It is a measure to calculate the transmission of heat through any material. It is measured in W/m²K and gives an insight in to heat transfer through any medium.

2 Thermal insulation:

Thermal insulation in buildings is major causes for the excess energy consumption and increased electricity bills. A proper design of the thermal insulation of the building not only reduces the unwanted heat loss or gain and also it will
cause thermal comfort of the occupant with less installation costs. Some good insulating materials are rock wool, polystyrene, glass wool, cellulose, wood fiber, cotton denim etc.,

Many of these insulating materials are cheaper in cost and results in good thermal reflectance of the heat in to the buildings.

2.1 Planning

The design of the insulation material, how much material required will depend mainly on design of the building, location, energy usage, schedule of usage, personal preference, aesthetics of the building, active and passive energy systems etc.,

Insulation material is to be selected with careful choice and the mode of heat transfer with season to season variations. Hence, the type of the material will be selected with a combination of material which has to suit to all seasons.

A qualified energy auditor has to assess the initial conditions of the building and according to his final report, a decision has to make to plan for insulation material thickness by considering all technical parameters.

In cold climatic areas, the main concentration is on to reduce heat flow out of the buildings. Similarly in hot climatic conditions, the heat to be removed from the building and at the same time heat is restricted to penetrate in to the building.

2.2 Orientation - Passive Solar Design

Optimal planning of building essentials like windows, doors, roofs, basement are the main sources for buildings excessive energy consumption. A passive design building will be more effective in insulation

Building envelope

The thermal envelope of the building is depending on the living space of a building as well as the orientation of the building. Sun path will plays a crucial role in insulation thickness. Depending upon the buildings orientation in some directions the insulation material provided will be less and in some directions the insulation material requires more material.

The airflow will also play a crucial role while designing the walls insulation thickness. A better cross ventilated building will much lower impacts on buildings thermal load.

The lesser cross ventilated building requires much more active systems to increase the thermal comfort of the building.

2.3 Building Insulation Materials

There are two types of insulation materials are available for the walls insulation thickness. Bulk insulation thickness and reflective insulation thickness are the important insulation classifications are available in the market. The type of insulation is based on conduction, convection and radiation.

Conductive and convective insulators are comes under Bulk insulation.

Eco-friendly insulation

Eco-Friendly insulation are one in which they will not harm the environment. The impact on insulation is prime concern in these types of insulation materials.

3. Case studies & simulation results

The energy performance of a building envelope is influenced by a number of factors. For example, these may include design elements such as the physical orientation of the building and the amount of sunlight that penetrates into the interior living or work spaces. Other factors may also include the heat transfer characteristics (both losses & gains) and the location of the building envelope components, including walls, windows, doors, floors and the roof.

The energy performance of a building may also be influenced by any natural air infiltration through the building envelope.

The RETScreen software has been validated in a number of ways. For example, RETScreen has been compared with HOMER simulation tool, which uses hourly solar Insolation data.

These software tools are compatible with local weather conditions and integrated with local temperature and updated regularly with NASA database.

3.1 case study with simulation results

The project type is of Energy efficient Measures, this is of institutional facility type and the analysis method is considered as method 1. The Heating value reference is considered as LHV. Higher heating value is typically used in Canada and USA, while lower heating value is used in the rest of the world. Hence LHV is selected. This is of International wide software hence we can get the currency what we required. The climatic data conditions are obtained for this location which is included in Site reference conditions.

For selecting climate location:

To access the RETScreen Climate Database click on the "Select climate data location” hyperlink or use the RETScreen menu or toolbar.
Fig. 3.1: Gunupur climate data sheet
This is the extension of first window which show the data of climatic conditions of the considered location. While the latitude and longitude values are entered, the values of Air temperature, Relative humidity, Daily radiation-horizontal, Atmospheric, wind speed, Earth temperature, Heating Degree days, Cooling degree days are obtained for monthly basis. The data obtained is only for reference purpose not to run the model.

Energy Model

Insulation thickness analysis:

Fig. 3.2: Energy model worksheet

Fig. 3.3: Insulation thickness analysis

Summary of the results:
As shown in the fig. 3.1; by selecting from the drop down list, Gunupur weather conditions can be loaded in to the software.
According to the selection of insulation material as shown in fig 3.3; material can be selected with base case and proposed case.
Complete results with technical and economical constraints are obtained based on local climatic conditions, insulation thickness building orientation etc.,

Financial Analysis and summary of results:

As shown in fig 3.5; the financial viability of the project is with a payback period of 4.8 years.

4 Conclusions:
In financial analysis, the fuel rate for base case with proposed cases are compared even though the initial investment is high the payback period is very less by considering project life of 30 years.

The results obtained by using RETSCREEN software are realistic and gives very promising results for Energy Efficient Buildings by considering walls insulation thickness.

The building simulation results found that; how various parameters like building envelope, insulation thickness will depend on buildings energy performance by optimizing the energy needs without compromising the consumers comfort.
However, as the consideration of equipments was done optimistically for the desired building load and net profits will be higher than the results in simulation by considering carbon credits and subsidies from government organizations.

References:


7. Central automatic control or distributed occupant control for better indoor environment quality in the future Jørn Toftum* International Centre for Indoor Environment and Energy, Department of Civil Engineering, Technical University of Denmark, DTU, Building 402, DK-2800 Lyngby, Denmark

8. Room air temperature affects occupants’ physiology, perceptions and mental alertness Kwok Wai Tham*, Henry Cahyadi Willem Department of Building, School of Design and Environment, National University of Singapore, Architecture Drive, Singapore 117566, Singapore


10. An hourly modelling framework for the assessment of energy sources exploitation and energy converters selection and sizing in buildings Enrico Fabrizio a, Marco Filippi b, seph Virgon

11. A life cycle energy analysis of social housing in Brazil: Case study for the program "MY HOUSE MYLIFE" Jacob Silva Paulsen*, Rosa Maria Sposto Department of Civil and Environmental Engineering, University of Brasilia, 70910-900 DF, Brazil