STM JOURNALS

Journal of
Polymer & Composites

ISSN: 2321-2810 (Online)
ISSN: 2321-8525 (Print)
Volume 11, Special Issue 12, 2023
DOI (Journal): 10.37591/JoPC

http://engineeringjournals.stmjournals.in/index.php/JoPC/index

Research JoPC

Parametric Analysis of Energy Saving In Building Walls by Applying Various Insulation Materials

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Abstract

The parameters which include Present Worth Factor, the wall structure, thermal conductivity of insulation material, thickness of insulation and the heating/cooling load of building, affect the energy savings in buildings. This study focuses on parametric analysis of the energy savings for building walls by using insulations (Expended Polystyrene and Glass wool). The annual energy requirements of house have been obtained by heating Degree-Days (DD) concept. For economic analysis, the Life Cost method has been used to determine optimum insulation thickness. Day by day the energy consumption is gradually increased. But the amount of energy source is limited. So it is necessary to conserve the energy resources for future. In general the heat losses will occurs through Boundary walls, Roof, any opening like door opening or window opening and floor. But during the analysis of energy saving, only the outer boundary envelops is considered due to maximum amount of heat is transmitted through Boundary walls. Results show that with an increase in Present worth Factor (PWF), energy saving increases. But energy saving decreases with increase in thermal conductivity of insulation materials. Initially, energy saving will increase with increase in insulation thickness, then it will be maximum and after that it will decrease with increase of insulation thickness. Maximum energy saving will occur at optimum thickness. It means that insulation should be provided on building wall at optimum thickness. Energy saving has higher value by using Expended Polystrene(EPS) insulation as compared to Glass wool.

Keywords: Insulation material, Life cycle method, Energy saving, Thermal conductivity, Present Worth Factor, Degree-Days.

INTRODUCTION

Heat loss occurs due to temperature difference across building envelope. Heat transfer also depends upon area of external walls. For minimization of heat loss, insulation application over building wall is the best method. So it is essential to select the proper insulation material with optimal insulation thickness for energy saving. Total cost consists of insulation as well as energy consumption cost. The purpose of the present study is to show the parametric impact of energy saving in the case of brick wall type walls by applying two types of insulation (EPS & GW). The optimization technique used is Life cycle method for finding optimum insulation thickness.

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Received Date: November 03, 2023
Accepted Date: November 21, 2023
Published Date: February 13, 2024

Citation: Subhash Mishra, Suneel Kumar Kalla, Yogendra Mohan Agarwal, Vivek Gupta. Parametric Analysis of Energy Saving In Building Walls by Applying Various Insulation Materials. Journal of Polymer & Composites. 2023; 11(Special Issue 12): S113–S118.

Energy requirement for room air heating with and without the application of insulation for comparing of energy saving calculation was reported [1]. The amount of energy saving by application of the local material was described [2]. The thermal behaviour of curved roof buildings was analysed and it was found that curved roof building has lower room temperature as compared to horizontal roof building [3]. The energy saving for building walls in presence of insulation in year 2006 for selected cities from four weather zones of Turkey had calculated [4]. Degree-hours method was used to determine the heating energy requirement in building [5]. Zero energy requirement building construction was used to reduce CO_2 gases emission [6]. The correlation between thermal conductivity and the thickness of given insulation material were derived for building wall [7]. Thermal performance of vault roof passive house was investigated [8]. The heating and cooling load for multilayer walls was calculated in the climatic zones of Turkey. For finding the heating and cooling load, implicit finite difference method (IFDM) was used [9]. The different parameters i.e. thickness of insulation, heating load, cooling load and thermal conductivity of insulation was explored and Parametric analysis was done for calculation of energy saving in building wall[10]. The ventilation system, which is used for natural cooling system in building wall, was defined [11]. A thermal comfort condition in air-conditioned spaces was described [12]. The method of energy saving by thermal insulation had been considered for the parameter like Interest rate, lifetime, and electricity cost [13].

On the basis of above mentioned literature review, the present study aims to investigate the influences of different parameters on energy saving.

BUILDING MATERIALS AND STRUCTURE OF EXTERNAL WALLS

In this study, the sandwiches wall type on which the external wall insulation is applied is considered. 2 cm internal plaster, 9 cm Brick wall material, and 2 cm external plaster is used for external wall construction. Figure 1. shows the wall surface, which is insulated at outer surface and plastered on each side.

Mathematical Models for Heating Load

The heat losses in building occur through external envelope, windows opening, top surface of the inside of a room, floor and air leakage. In this study, heat transmission through external envelope has been considered.

The heat loss through external envelope per unit cross-sectional area is

$$Q_h = U_O \times (T_r - T_a) \tag{1}$$

Where U_o is the overall heat transfer coefficient of building wall, T_r is the room temperature and T_a is atmospheric temperature.

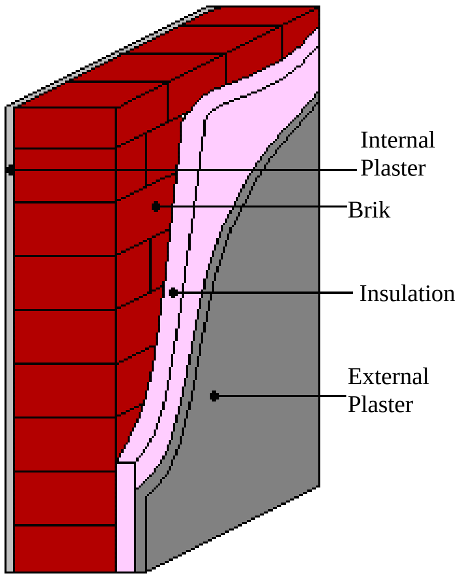

Figure 1. Sandwich type of walls.

Annual heating loss through external wall is

$$Q_{Ah} = 86400 \times DDV \times U_0 \tag{2}$$

Where DDV is the Degree-Days Value. On putting the value of overall heat transfer coefficient in equation (2), we get

$$Q_{Ah} = 86400 \times \frac{DDV}{\left(R_{tw} + \frac{x}{k}\right) \times \eta_s} \tag{3}$$

Where η_s is the efficiency of heating system, R_{tw} is total thermal resistance of building wall, x is thickness of wall and k is thermal conductivity of insulation.

Energy Saving and Optimization of Insulation Thickness

During the analysis of energy cost, life cost analysis (LCA) is used. By using this method, total heating cost has been calculated. The useful life of building wall is considered as 15 years. Total heating cost is formulated in the terms of life cycle (N) and presents worth factor (PWF). For finding the value of PWF, inflation and the interest rate are taken as 5 % and 4 %.

The total heating cost of room air of insulated building is

$$C_t = C_A \, PWF + C_{ins} \, x \tag{4}$$

Where C_A is annual cost of heating of room air and C_{ins} is insulation cost.

For finding the optimum value of insulation thickness, the first derivative of total cost is zero. The expression of optimum thickness can be written as

$$X_{opt} = \left(\frac{86400 \times DDV \times C_t \times PWF \times k}{LCV \times C_i \times \eta_s} \right)^{0.5} - \left(k \times R_{tw} \right) \tag{5}$$

Energy saving (E_S) is calculating by using equation

$$E_S = C_t - C_{Ins} \tag{6}$$

RESULTS AND ANALYSIS

Energy saving is determined for different types of composite building walls. The heat losses in building occur through external envelope, windows opening, top surface of the inside of a room, floor and air leakage. In this study, heat transmission through external envelope has considered.

PWF value depends upon the useful life of insulation and it also affects the energy saving. The effect of variation of the value of PWF on the energy saving is linear. The Energy saving has increases with the increase of PWF value.

In this analysis, life cost analysis (LCA) is used to determine the total heating cost. When present worth factor is multiplied by the present value we get the total cost. Basically inflation and interest rate is required to determine the present worth factor.

Figure 2 illustrates the effect of present worth factor on energy saving by using LPG energy sources, when Brick wall construction is considered. The useful life of insulation, inflation and interest rates affect present worth factor (PWF). Based on formulated data, energy saving increases with the increase of present worth factor. From Figure 2, it observed that energy saving is 25% higher by using Expended Polystrene.

The different parameters (Present worth factor, thermal conductivity of insulation), the heating/cooling loads of the mud house and mechanical characteristics of insulation material) all affect the energy saving. This analysis mainly concentrated on effect of these parameters on energy saving. The energy saving for Brick Wall construction by using different thicknesses of insulation have been presented in Table 1.

Figure 3 shows the variation of energy saving with insulation thickness for EPS and GW insulation materials, when Brick wall construction has been considered. From Figure 3, it can be seen that

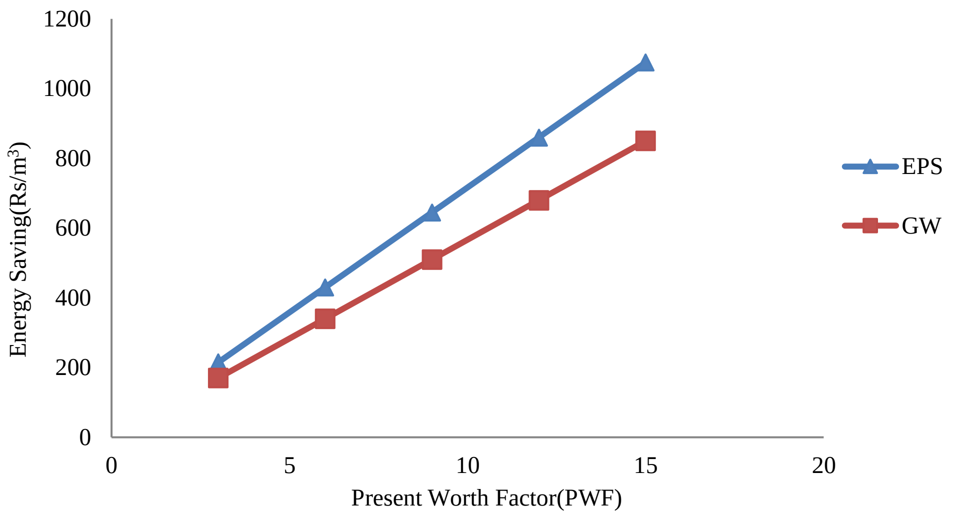

Figure 2. Variation of Energy saving with present worth factor for Brick wall construction.

Table 1. Effect of variation of insulation thickness on energy Saving for Brick wall construction

S.N.	Insulation Thickness(m)	Energy Saving(Rs/m^3)	
		Expended Polystrene (EPS)	***Glass Wool(GW)***
1	0	0	0
2	0.045	3600	4250
3	0.090	4408	5150
4	0.135	3500	5250
5	0.180	2700	4725

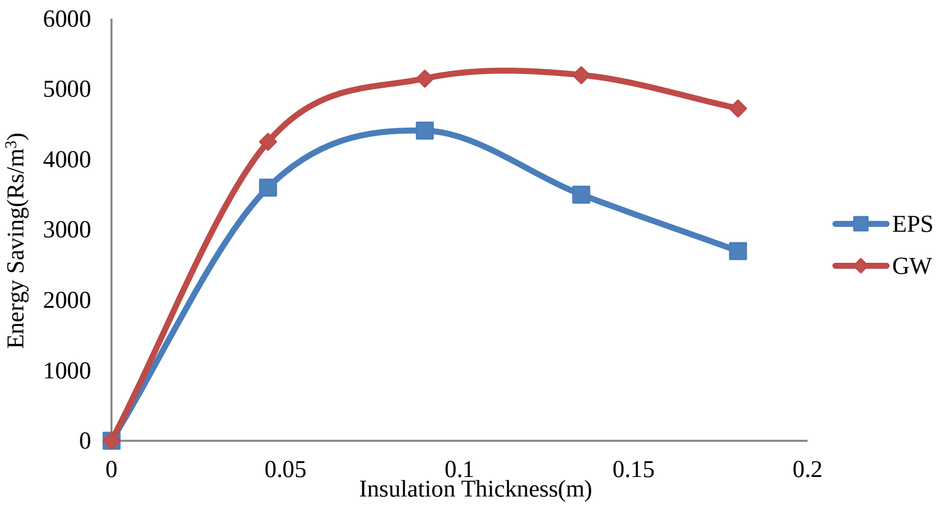

Figure 3. variation of energy savings with insulation thickness for Brick Wall Construction.

initially, energy saving will increase with increase with insulation thickness, then it will be maximum and after that it will decrease with increase of insulation thickness. Maximum energy saving will occur at optimum thickness. It means insulation has to be applied to building wall at optimum thickness. 14.4% lesser energy saving is obtained for Glass Wool (GW) as compared to Expanded Polystrene (EPS) insulation.

The effect of thermal conductivity on energy saving for Brick wall for two type of insulations is presented in Table 2. Thermal conductivity has adverse effect on energy saving. If the thermal conductivity of insulation has higher value, then heat transfer through boundary envelope has higher value. So higher amount of energy is required for comfort condition. For higher energy saving, those insulation materials are chosen which have the least thermal conductivity.

From Table 2, it can be observed that among all fuel sources, coal is the most efficient from energy saving point of view. The energy saving for Brick wall building using four different fuels have been presented in Table 3.

Figure 4 shows the energy saving for different fuel for brick wall construction. It is realized that by using coal, energy saving has maximum value and by using natural gas, energy saving has minimum value. As a result, it is observed that in brick wall construction, INR1575/m^3 and INR745/m^3 amount of energy saving will occur by using coal and natural gas respectively.

Table 2. Effect of Thermal conductivity on Energy Saving for Brick wall construction

S.N.	**Thermal Conductivity (W/mk)**	**Energy Saving(Rs/m^3)**	
		Expanded Polystrene (EPS)	***Glass Wool (GW)***
1	0.01	5867	5328
2	0.02	4520	5136
3	0.03	4620	4957
4	0.04	4266	4788
5	0.05	4057	4629

Table 3. Energy Saving in building wall for different fuel type

S.N.	**Types of Fuel**	**Energy Saving(Rs/m^3)**	
		Expended Polystrene (EPS)	***Glass Wool (GW)***
01	Coal	1575	1245
02	Natural Gas	910	720
03	Fuel Oil	1356	1072
04	LPG	942	745

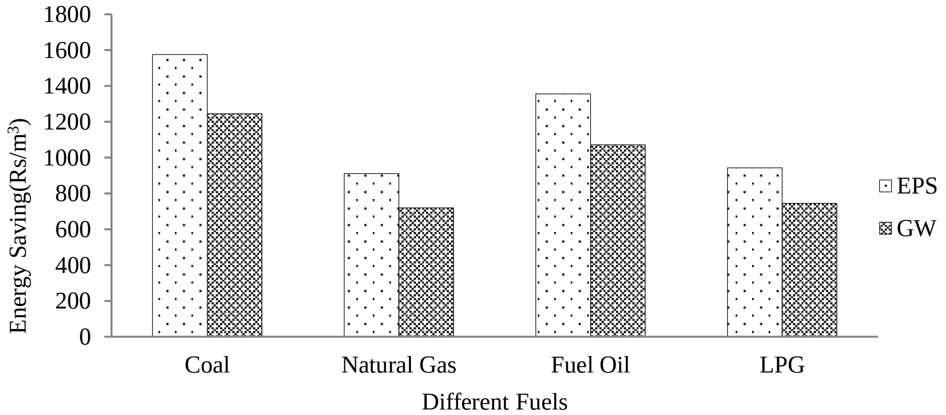

Figure 4. Energy saving for different fuel in Brick wall construction.

CONCLUSION

This study reveals the following conclusions:

1. As thermal conductivity of insulation increases, energy saving decreases. So it is beneficial to use those insulation materials which have lesser thermal conductivity.
2. The highest and lowest energy saving value is INR1575/m^3 and 745 Rs/m^3 respectively by using coal and natural gas as energy sources by the application of Expended Polystrene and Glass wool respectively.
3. Energy saving increases with increasing the Present Worth Factor but energy saving has higher value by using Expended Polystrene as compared to Glass wool insulation..
4. Insulation thickness has significant effect on energy saving of building wall.
5. If we apply the insulation material with increasing thermal conductivity to building wall, energy saving gradually decreases.

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