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A Case Study of Thermal Insulation Thickness and Testing Parameters in Buildings

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ABSTRACT

Thermal insulation plays a major role in green buildings. In current scenario environment has been change due to many parameters. The different parameter such as temperature, acid rain, radiation and humidity and some other such as manufacturing activity. Sometimes automobile vehicles are also because they affect environment daily. Therefore, more CO_2 emission emitted in to the atmosphere by combustion of fossil fuels cause global warming. Hence combustion of fossil fuels used for heating building. In this case study we investigated environmental effect of thermal insulation for decreases temperature losses in building thickness. Mainly in this case study it has been found that CO_2 emission decreased by using thermal insulation.

Keywords: environmental effect, thermal insulation thickness

INTRODUCTION

Worldwide environmental problems, acid precipitation, stratospheric ozone depletion and the greenhouse effect are three out of quite a number of such problems, whose threat to mankind and nature has become increasing awareness during the last years. Theo most important of the other global environmental problems are the spreading of desert, the erosion, the sea pollution, the loss of animal and plant species and general destruction of soils.

Potentially the most important environmental problems relating to energy utilization is global climate change, also known as the global warming or the greenhouse effect. Increasing concentrations of greenhouse effect such as C, N_2O, CO_2, ozone in the atmosphere are increasing the manner in which these gases trap heat radiated from the earth's surface, thereby raising the surface temperature of the earth. The earth's surface is estimated to have risen by perhaps 20 cm. such changes can have wide ranging effects on human activities all over the world (Dincer& Rosen, 1999).

As long as the amount of the greenhouse gases within the atmosphere is constant, the temperature of the earth will also remain constant. But since the industrial revolution the CO_2 concentrations in the atmosphere and many other greenhouse gases have risen considerably, because mankind has emitted increasing amounts of these greenhouse gases in to atmosphere.

Energy consumption for space heating is increasing. Low quality fuel consumption together with the increasing energy demands for space heating have caused very high air pollution. The energy saving is maintained by reduction the energy consumption is buildings. There are a few ways to reduce heat loss, one of which is to apply an optimum insulation thickness to external walls. Wall and roof insulation can produce energy saving up to 77% (Statiscal book and Refiksaydam centre, 2000).

ECONOMIC THICKNESS OF BUILDING INSULATION

The cost of installed insulation increases with thickness. This increment cost is in terms of labor as well as material. The life cycle costing (LCC) spreads the initial cost of the insulation over the number of

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years the insulation is expected to be in service. Since insulation is often applied in multiple layers and more insulation does not necessarily imply the better, the optimum economic thickness of insulation is defined as the thickness of insulation for which the cost of the added increment of insulation is just balanced by the increased energy savings over the useful life of the building project. As thickness increases, the average slope of the curves increases with the number of layers because the labor and material costs increase at a more rapid rate. Insulation lowers the energy demand by reducing the size and capital cost of the air-conditioning equipment required for an installation. The point A on the total cost curve corresponds to the economic insulation thickness (Thakur, et al., 2009).

WALL INSULATION

Wall insulation is very important in areas where low ambient temperatures persist. During night when cold conditions prevail at the ground level, if the wall is not insulated properly, will allow fast conduction of cold inside and lowering the air temperature inside. In case of external application insulation is fixed to the brick wall with speed washers and then a second layer of brick is fixed.

Figure 1: Different layer of wall insulation

THE HEAT LOSS CALCULATION FOR EXTERNAL WALLS

The external wall is built as composite structure, which is generally formed with bricks in outside, insulation at the middle and plaster layers on both sides. Stropor of 3, 4, and 5 cm thickness is commonly used as insulation materials.

The heat losses at buildings generally occur through external walls, windows, ceiling, floor and air infiltration. The heat loss from windows due to the infiltration is not taken into account in this study since the insulation does not affect that heat loss. On the other hand, only the heat loss from external walls in considered in this study.

The heat loss from walls in unit area:

$$Q = U.\Delta T \qquad (1)$$

The annual heat loss in unit area, Q_A, can be determined using the degree days, DD, the wall conductance, U as given by the following equation [6]:

$$Q_A = 864{,}00.DD.U \qquad (2)$$

The annual energy requirement is calculated by dividing the heat loss per year to the system efficiency:

$$E_A = (86{,}400.DD.U) / \eta \qquad (3)$$

where U is the coefficient of heat conductivity which is given below:

$$U = \frac{1}{R_i + R_w + R_{in} + R_o} \qquad (4)$$

where R_i and R_o are the layer coefficients of inner and outer air, R_w is the total thermal resistance of the wall materials without the insulation, R_m is the thermal resistance of the insulation materials:

$$U = \frac{1}{R_t + R_{in}} \qquad (5)$$

$$R_{in} = \frac{1}{k} \qquad (6)$$

in above equations R_t is the sum of R_o, R_w and R_i. Substituting those three values in eq. (3) gives the energy consumption per year as follows:

$$E_A = \frac{86,400.DD}{\left(R_t+\frac{1}{k}\right).\eta} \quad (kJ) \qquad (7)$$

the fuel consumption per year as follows:

$$M_F = \frac{86,400.DD}{\left(R_t+\frac{1}{k}\right).\eta.LHV} \quad (kg / year) \qquad (8)$$

where LHV is lower heating value of fuel.

TESTING OF THERMAL INSULATION

The testing of thermal insulation materials and their various properties may be conducted as per the following ASTM/BIS standards:

Adhesion of thermal insulating cements

ASTM C-353	Adhesion of dried thermal insulation or finishing cement
ASTM C-383	Adhesion, wet of thermal insulating cements to metal

Breaking load

ASTM C-203	Breaking load and calculated flexural strength of block type thermal insulation
ASTM C-446	Breaking load and calculated modulus of rupture of preformed insulation for pipes

Combustibility

ASTM D-92	Flash and fire points by Cleveland Open Cup Tester
ASTM D-93	Flash point by Pensky-Martens Closed Tester
ASTM D-568	Test for flammability of flexible plastics
ASTM D-635	Test for flammability of self supporting plastics
ASTM D-2582	Test for heat of combustion of hydrocarbon fuels by bomb calorimeter tester
ASTM D-2863	Test for flammability of plastics using oxygen index method
ASTM E-84	Test for surface burning characteristics of building materials
ASTM E-136	Test for non combustibility of elementary materials
ASTM E-162	Test for surface flammability of materials using radiant heat energy source

Mechanical stability

ASTM C-421	Mechanical stability of performed thermal insulation

Corrosion

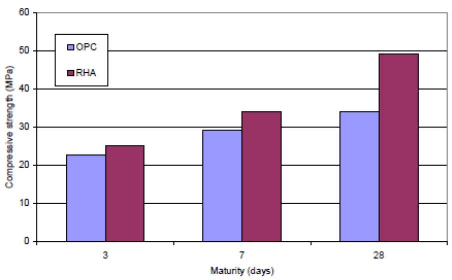
ASTM C-464	Corrosion effect of thermal insulating cements on base metal
ASTM C-692	Stress corrosion effect of wicking type thermal insulation on stainless steel

Covering capacity

ASTM C-166	Covering capacity and volume change upon drying of thermal insulating cements

Compressive strength

ASTM C-165	Recommended practice for measuring compressive properties of thermal insulation
ASTM C-354	Tests for compression strength of thermal insulation
ASTM C-495	Test for compressive strength of lightweight insulating concrete
ASTM D-1621	Test for compressive properties of rigid cellular plastics



Graph 1: Compressive strength

Density

ASTM C-519	Density of fibrous loose fill building insulations
ASTM C-520	Density of granular loose fill insulations
ASTM C-303	Density of preformed block type insulation
ASTM C-302	Density of preformed pipe covering type thermal insulation
ASTM D-1622	Apparent density of rigid cellular plastics

Dimensional stability

ASTM C-548	Dimensional stability of low temperature thermal block and pipe insulation

Hardness

ASTM C-569	Test for indention hardness of preformed thermal insulation

Hot surface performance

ASTM C-411	Hot surface performance of high temperature thermal insulation

Specific heat

ASTM C-351	Mean specific heat of thermal insulation

Thermal heat transfer

ASTM C-177	Steady state thermal conductivity properties by means of the guarded hot plate
ASTM C-518	Steady state thermal conductivity properties by means of the heat flow meter
ASTM C-236	Thermal conductance and transmittance of built up sections by means of the guarded hot plate
ASTM C-335	Thermal conductivity of pipe insulation
ASTM C-691	Thermal transference of non homogeneous pipe insulation above ambient temperature

Water absorption

ASTM C-209 (part 13)	Insulating board

Water vapour transmission

ASTM E-96	Water vapor transmission of materials in sheet form
ASTM C-355	Water vapor transmission of thick materials

Shrinkage due to heat

ASTM C-356	Shrinkage, linear of preformed high temperature thermal insulation subjected to subjected to soaking heat

Resistance to external loads

ASTM C-854	Resistance to external loads on metal reflective insulation

Resistance to dropping

ASTM C-487	Resistance to dropping of preformed block type thermal insulation

Emittance

ASTM C-445	Normal total emittance of surfaces of materials 0.01″ or less in thickness at approx.

	room temperature
ASTM C-835	Test for total hemispherical emittance of surfaces from 20 to 1400°C

Heat flux

ASTM C-745	Heat flux through evacuated insulation using flat plate boil off calorimeter

Maximum use temperature

ASTM C-447	Recommended practice for estimating maximum use temperature of preformed homogeneous thermal insulation

Indian Standard Methods of test for Rigid Cellular Thermal Insulation Materials

Figure 2: IS : 11239 (Part 1 to 12)

Dimensions	**IS : 11239** Part 1
Apparent density	**IS : 11239** Part 2
Dimensional stability	**IS : 11239** Part 3
Water vapor transmission rate	**IS : 11239** Part 4
Volume percent of open and closed cells	**IS : 11239** Part 5
Heat distortion temperature	**IS : 11239** Part 6
Coefficient of linear thermal expansion at low temperatures	**IS : 11239** Part 7
Flame height, time of burning and loss of mass	**IS : 11239** Part 8
Water absorption	**IS : 11239** Part 9
Flexural strength	**IS : 11239** Part 10
Compressive strength	**IS : 11239** Part 11
Horizontal burning characteristics	**IS : 11239** Part 12

Indian Standard Mineral Wool Thermal Insulation Materials- Method of Test **IS 3144 : 1992**

Indian Standard for Expanded Polystyrene for Thermal Insulation Purposes **IS 4671: 1984**

Methods for the Test of Thermal Conductivity of Thermal Insulation Materials (two slab guarded hot plate method)**IS 3346 : 1980**.

RESULT

Most of energy consumption in buildings is for heating. To reduce the usage of energy, heat insulation used provides substantial savings in the fuel consumption. Therefore, a significant reduction in the amount of combustion gases exempt from burning of fossil fuels is also achieved. For this purpose, CO_2 emission amounts emitted to the atmosphere have been calculated for an external wall of 1 m^2 using the above equations and parameters given in table 1. The variation of the fuel used and CO_2 amounts emitted to the atmosphere with insulation thickness respectively for a 1 m^2 external wall of a building using fuel-oil reduction in the amount of fuel and emission by approximately 80% have been obtained in the case of using an optimum thickness of 10 cm. this optimum thickness of 10 cm has been calculated in previous work (Çomaklı&Yuksel,2003 &2004).

Heat insulation is done in external walls, ceilings and floorings in a building. Heat loss occurring in these place is the 53% of the total heat loss in the building. By applying this optimum insulation thickness in the buildings, the amount of fuel consumed and emission to the environmental will be reduced by 27%. This ratio can be increased up to 50% by using more energy saving methods done in the other parts of the buildings.

In heating season, fuel-oil and coal are consumed because of burning of fuel, atmosphere is polluted with CO_2. When energy saving is done in the buildings, there will be reduction of CO_2 emitted to the atmosphere. However, because optimum insulation thickness is generally not used in the buildings, the required reduction in the emission of flue gas is not provided. As a result of this air pollution reaches to serious degrees in the cities winter conditions are hard.

CONCLUSION

In this case study paper it has been investigated that for reduction of heat transfer in different thickness of building the insulation is used. selecting and applying optimum insulation, the amount of CO_2 emission to the environment will be reduced around 26 to 27 percent. This percentage can be increased up to 50 percent by using more energy saving methods done in the other parts of buildings. It will be clear from the above that there is considerable potential for energy saving and CO_2 reduction within the building. The CO_2 reduction and saving energy which could be achieved in the existing building would be limited by the rate of uptake of individual measures and so would depend upon the prevailing market conditions. In future building there would be opportunities to use thermal insulation and reduce heat losses.

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