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A Review Paper on Internal Thermal Insulation for Masonry Wall in Historic Multifamily Building

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Abstract *Energy saving has become a strategic goal in the whole world, that will lead to protect environment and conserve natural resources. The energy consumption in buildings for heating and cooling is considered as one of the major sources of energy consumption in a lot of countries. The Volatile and increasing energy prices, concern over environmental impact, and occupant health and comfort – these are the drivers of green building today. In fact, these trends have become of paramount importance for commercial, institutional and residential building owners. Thermal insulation in buildings is an important but largely ignored factor to achieving thermal comfort for its occupants. Insulation reduces unwanted and expensive heat gain or loss and can decrease the energy demands of cooling and heating systems. Different types of insulating materials in use today include rigid polyurethane foam, polyurethane spray, expanded and extruded polystyrene foams, glass wool; rock wool etc. Thermal insulation also involves a range of designs and techniques to address the main modes of heat transfer: conduction, radiation, convection and evaporation condensation*

***Key Words*: Thermal insulation, Energy saving, Renewable resources, Building insulation, Thermal performance**

1. INTRODUCTION:

Thermal insulation is an important technology to reduce energy consumption in buildings by preventing heat gain/loss through the building envelope. Thermal insulation is a construction material with low thermal conductivity, often less than 0.1W/mK. These materials have no other purpose than to save energy and protect and provide comfort to occupants. Of the many forms, shapes and applications of thermal insulation, this lecture focuses on industrial insulation products that are commonly used for building envelopes– i.e., floor, walls and roof.

1.1 GENERAL

- Methods of heat transfer :

Heat transfer (or heat) is thermal energy in transit due to a spatial temperature difference. Whenever temperature difference exists in a medium or between media, heat transfer must occur.

- Conduction:

A diffusive process wherein molecules transmit their kinetic energy to other molecules by colliding with them. The temperature gradient exists in a stationary medium, which may be a solid or a fluid. Conduction heat transfer is the flowing of heat energy from a high-temperature object to a lower-temperature object.

- Convection:

A process associated with the motion of the medium. When a hot material flows into a cold material, it will heat the region - and vice versa. The term refers to heat transfer that will occur between a surface and a moving fluid when they are at different temperatures. Convection is the primary way that heat moves through gases and liquids.

- Radiation:

All surfaces of finite temperature emit energy in the form of electromagnetic waves. Hence, in the absence of an intervening medium, there is net heat transfer by radiation between two surfaces at different temperatures.

1.2 Objective of the Project:

1. Reduction of energy consumption for heating and cooling, depending on the indoor conditioning system and on the climate (by 30 % at least).
2. Improving thermal comfort by stabilizing the surface temperature of the inside walls.
3. If the thermal insulation is external, reduction of thermal stress of the framework, by stabilizing its temperature.
4. Building lifetime prolongation, by reduction of the thermal stresses, and above other by reduction of the energy cost.
5. Improvement of the long-term architectural look of the building.
6. Resist the heat transfer through walls and roof of building.
7. Maintain comfortable living conditions.
8. Keep room cooler in summer and warm in winter.
9. Result in lot of fuel saving and maintenance cost.
10. Helps in reduction of noise level, absorbs the vibrations generated by the system.

2. LITERATURE REVIEW:

Research performs by various investigators

Following is the literature for the research done by the various researcher references for the present research.

1. Bjorn Petter Jelle [a,b,*][2011]

The advantages and disadvantages of the thermal building insulation materials and solutions have been treated. Both traditional, state-of-the-art and possible materials and solutions beyond these have been investigated. Examples of these may be mineral wool, expanded polystyrene, extruded polystyrene, polyurethane, vacuum insulation panels, gas insulation panels, aerogels, and future possibilities like vacuum insulation materials, nano insulation materials and dynamic insulation materials. Various properties, requirements and possibilities have been compared and studied. Among these are thermal conductivity, perforation vulnerability, building site adaptability and cuttability, mechanical strength, fire protection, fume emission during fire, robustness, climate ageing durability, resistance towards freezing/thawing cycles, water resistance, costs and environmental impact. Currently, there exist no single insulation material or solution capable of fulfilling all the requirements with respect to the most crucial properties.

2. L.Aditya[a,*],[2017]

In residential sector, air conditioning system takes the biggest portion of overall energy consumption to fulfil the thermal comfort need. In addressing the issue, thermal insulation is one efficient technology to utilize the energy in providing the desired thermal comfort by its environmentally friendly characteristics. The principle of thermal insulation is by the proper installation of insulation using energy-efficient materials that would reduce the heat loss or heat gain, which leads to reduction of energy cost as the result. This paper is aimed to gather most recent developments on the building thermal insulations and also to discuss about the life-cycle analysis and potential emissions reduction by using proper insulation materials.

3. N. Pugazhenthi,[2017]

This study will help in the development of polymer materials in industries for withstanding mechanical and thermal properties of phenol-formaldehyde. In this, reinforcing materials was used to improve the mechanical and thermal properties of phenol-formaldehyde. The reinforcing material was recycled cellulose fiber. Here the composite preparation of polymer was discussed and SEM image of the composite was taken and analyzed. By using TGA test, thermal stability of the composite was discussed respectively. The mechanical properties like tensile strength and impact strength were taken and compared with original material. The mat was prepared by using compression molding machine and specimens were prepared with ASTM STD for testing the mechanical properties. The composite materials have increased mechanical properties when compared with the original material.

4. Alexey Zhukov[1*],[2017]

Construction system consists of materials with different properties. The use of materials in the design should ensure maximum of its performance and its durability. The use of thermal insulation materials is an effective way to form the thermal envelope of a building, reducing energy costs and increasing the durability of building structures. The properties of materials are determined by their structure, which is formed in the process of technological influences. Formation of the insulating shell of oil and gas industry objects is possible only when considering the special features of the thermal insulation layer in the construction and the use of high-quality materials that retain their characteristics, both in the early stages of operation and throughout the calculation period. The first is achieved by competent design, the second - the possibility of assessing the properties of thermal insulation (and predicting changes in these properties over time) directly in the construction site.

3. METHODOLOGY:

3.1 Definition of Insulation:

Insulations are defined as those materials or combinations of materials which retard the flow of heat energy by performing one or more of the following functions:

1. Conserve energy by reducing heat loss or gain.

2. Control surface temperatures for personnel protection and comfort.

3. Facilitate temperature control of process.

4. Prevent vapour flow and water condensation on cold surfaces.

5. Increase operating efficiency of heating/ventilating/cooling, plumbing, steam, process and power systems found in commercial and industrial installations.

6. Prevent or reduce damage to equipment from exposure to fire or corrosive atmospheres.

7. Assist mechanical systems in meeting criteria in food and cosmetic plants.

8. Reduce emissions of pollutants to the atmosphere.

The temperature range within which the term "thermal insulation" will apply, is from -75°C to 815°C. All applications below -75°C are termed "cryogenic", and those above 815°C are termed "refractory".

Thermal insulation is further divided into three general application temperature ranges as follows:

A. LOW TEMPERATURE THERMAL INSULATION

1. From15°C through 1°C - i.e. Cold or chilled water.

2. 0°C through -40°C - i.e. Refrigeration or glycol.

3. -41°C through -75°C - i.e. Refrigeration or brine.

4. -76°C through -273°C (absolute zero) - i.e. Cryogenic. (Not addressed in this manual).

B. INTERMEDIATE TEMPERATURE THERMAL INSULATION

1. 16°C through 100°C - i.e. Hot water and steam condensate.

2. 101°C through 315°C - i.e. Steam, high temperature hot water.

C. HIGH TEMPERATURE THERMAL INSULATION

1. 316°C through 815°C - i.e. Turbines, breechings, stacks, exhausts, incinerators, boilers.

3.2 Properties of Insulation:

Not all properties are significant for all materials or applications, if the property is significant for an application and the measure of that property cannot be found in manufacturers' literature, effort should be made to obtain the information directly from the manufacturer, testing laboratory or insulation contractors association.

The following properties are referenced only according to their significance in meeting design criteria of specific applications. More detailed definitions of the properties themselves can be found in the Glossary.

3.2.1 THERMAL PROPERTIES OF INSULATION

Thermal properties are the primary consideration in choosing insulations. Refer to the following Glossary for definitions.

a. Temperature limits: Upper and lower temperatures within which the material must retain all its properties.

b. Thermal conductance "C": The time rate of steady state heat flow through a unit area of a material or construction induced by a unit temperature difference between the body surfaces.

c. Thermal conductivity "K": The time rate of steady state heat flow through a unit area of a homogeneous material induced by a unit temperature gradient in a direction perpendicular to that unit area.

d. Emissivity "E": The emissivity of a material (usually written εor e) is the relative ability of its surface to emit energy by radiation. It is the ratio of energy radiated by a particular material to energy radiated by a black body at the same temperature.

e. Thermal resistance "R": Resistance of a material to the flow of heat.

f. Thermal transmittance "U": The overall conductance of heat flow through an "assembly".

3.2.2 MECHANICAL AND CHEMICAL PROPERTIES OF INSULATION

Properties other than thermal must be considered when choosing materials for specific applications. Among them are:

a. Alkalinity (pH) or acidity: Significant when moisture is present. Also insulation must not contribute to corrosion of the system.

b. Appearance: Important in exposed areas and for coding purposes.

c. Breaking load: In some installations the insulation material must "bridge" over a discontinuity in its support. This factor is however most significant as a measure of resistance to abuse during handling.

d. Capillarity: Must be considered when material may be in contact with liquids.

e. Chemical reaction: Potential fire hazards exist in areas where flammable chemicals are present. Corrosion resistance must also be considered.

f. Chemical resistance: Significant when the atmosphere is salt or chemical laden and when pipe content leaks.

g. Coefficient of expansion and contraction: Enters into the design and spacing of expansion/contraction joints and/or use of multiple layer insulation applications.

h. Combustibility: One of the measures of a material's contribution to a fire hazard.

i. Compressive strength: Important if the insulation must support a load or withstand mechanical abuse without crushing. If, however, cushioning or filling in space is needed as in expansion/contraction joints, low compressive strength materials are specified.

j. Density: A material's density may affect other properties of that material, such as compressive strength. The weight of the insulated system must be known in order to design the proper support.

k. Dimensional stability: Significant when the material is exposed to temperature; expansion or shrinkage of the insulation may occur resulting in stress cracking, voids, sagging or slump

l. Fire retardancy: Flame spread and smoke developed ratings are of vital importance; referred to as "surface burning characteristics".

m.Resistance to ultraviolet light: Significant if application is outdoors and high intensity indoors.

n. Resistance to fungal or bacterial growth: Is important in all insulation applications.

o. Shrinkage: Significant on applications involving cements and mastics.

p. Sound absorption coefficient: Must be considered when sound attenuation is required, as it is in radio stations, some hospital areas where decibel reduction is required.

q. Sound transmission loss value: Significant when constructing a sound barrier.

r. Toxicity: Must be considered in the selection of all insulating materials.

3.3 Materials of Insulation:

The following is a general inventory of the characteristics and properties of major insulation materials used in commercial and industrial installations.

3.3.1. Organic Thermal Insulating Materials:

- **Cork:** cork thermal insulation is primarily made from the cork oak, and can be produce as both filler material or as a board. Its thermal conductivity values is between 0.040 and 0.050 W/(m.K).It has low thermal conductivity with reasonable compressive strength.

Fig. 1. Cork

- **Polyurethane :**
It is form by reaction between iso-cyanates and polyols. The insulation material is produced as boards or continuous on production line. Its thermal conductivity value for pur are between 0.020 and 0.030 w/(m.k).i.e. it is lower than mineral wool, polystyrene and cellulose product.

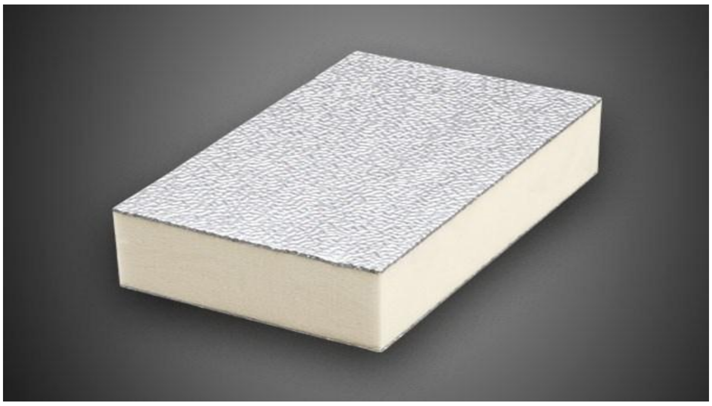

Fig. 2. Polyurethane

- **Polystyrene :**
Polystyrene product are made of organic cellular plastic for insulation purposes, polystyrene is commercially produced in two forms expanded polystyrene and extruded. Thermal conductivity of EPS are between 0.030 and 0.040 W/(m.K) and thermal conductivity of XPS are between 0.025 and 0.035 W/(m.K).

Fig. 3 Expanded Polystyrene

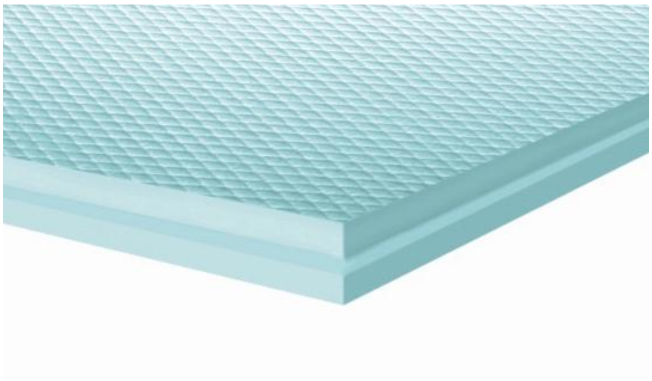

Fig. 4 Extruded Polystyrene

3.3.2. Inorganic Thermal Insulating Materials:

- **Glass mineral wool:**
  Made from molten glass, usually with 20% to 30% recycled industrial waste and post-consumer content. The material is formed from fibres of glass arranged using a binder into a texture similar to wool. The process traps many small pockets of air between the glass, and these small air pockets result in high thermal insulation properties. The density of the material can be varied through pressure and binder content.

Fig. 5 Glass mineral wool

- **Calcium silicate**
  Calcium silicate insulation is composed principally of hydrous calcium silicate which usually contains reinforcing fibers; it is available in molded and rigid forms. Service temperature range covered is 35°C to 815°C. Flexural and compressive strength is good. Calcium silicate is water absorbent.

Fig. 6 Calcium silicate

- **Mineral Fiber:**
  Glass: Available as flexible blanket, rigid board, pipe covering and other pre-molded shapes. Service temperature range is -40°C to 232°C. Fibrous glass is neutral; however, the binder may have a pH factor. The product is non-combustible and has good sound absorption qualities.
  Rock and Slag: Rock and slag fibers are bonded together with a heat resistant binder to produce mineral fiber or wool. Upper temperature limit can reach 1035°C. The same organic binder used in the production of glass fiber products is also used in the production of most mineral fiber products. Mineral fiber products are non-combustible and have excellent fire properties.

Fig. 7 Mineral Fiber

- **Cellular Glass:**
  Available in board and block form capable of being fabricated into pipe covering and various shapes. Service temperature range is -273C to 200°C and to 650°C in composite systems. Good structural strength, poor impact resistance. Material is non-combustible, non-absorptive and resistant to many chemicals.

Fig. 8 Cellular Glass

- **Expanded Silica, Or Perlite:**
  Insulation material composed of natural or expanded perlite ore to form a cellular structure; material has a low shrinkage coefficient and is corrosion resistant; non-combustible, it is used in high and intermediate temperature ranges. Available in pre-formed sections and blocks.

Fig. 9 Expanded Silica, Or Perlite

- **Elastomeric Foam**
  Foamed resins combined with elastomers to produce a flexible cellular material. Available in pre-formed sections or sheets, Elastomeric insulation offer water and moisture resistance. Upper temperature limit is 105 ^{o}C. Product is resilient. Fire resistance should be taken in consideration.

Fig. 10 Elastomeric Foam

- **Foamed Plastic**
  Insulations produced from foaming plastic resins create predominately closed cellular rigid materials. "K" values decline after initial use as the gas trapped within the cellular structure is eventually replaced by air. Foamed plastics are light weight with excellent cutting characteristics. The chemical content varies with each manufacturer. Available in pre-formed shapes and boards, foamed plastics are generally used in the lower intermediate and the entire low temperature ranges. Consideration should be made for fire retardancy of the material.

Fig. 11 Foamed Plastic

- **Refractory Fiber**
  Refractory Fiber insulations are mineral or ceramic fibers, including alumina and silica, bonded with extremely high temperature inorganic binders, or a mechanical interlocking of fibers eliminates the need for any binder.

  The material is manufactured in blanket or rigid form. Thermal shock resistance is high. Temperature limits reach 1750°C. The material is non-combustible. The use and design of refractory range materials is an engineering art in its own right and is not treated fully in thismanual, although some refractory products can be installed using application methods illustrated here.

Fig. 12 Refractory Fiber

- **Insulating Cement**
  Insulating and finishing cements are a mixture of various insulating fibers and binders with water and cement, to form a soft plastic mass for application on irregular surfaces. Insulation values are moderate. Cements may be applied to high temperature surfaces. Finishing cements or one-coat cements are used in the lower intermediate range and as a finish to other insulation applications.

Fig. 13Insulating Cement

5. SCOPE OF PROJECT:

- Up to 30 % energy saving can be achieved by thermal insulation of buildings, if you decide for thermal insulation focus on building structures which allow the highest heat losses, which is fundamental for highest efficiency.
- This applies mainly to thermal insulation of the external cladding, exchange of windows or insulation of non-heated rooms.
- At the same time right regulation of the heating system and solar protection are important: up to 50 % of energy savings can be obtained when thermal insulation is associated with efficient solar protection.
- Enhancing the market value of the building. If thermal insulation is by stabilizing its temperature

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