Heat loss and payback time of insulation materials construction essay

This is an empirical research on the topic heat loss and payback time of different insulation material. Insulation is one of the commonly used tool and also used as an effective techniques for heat loss prevention. This paper studies the different insulation materials and their comfort ability in preventing heat loss and their payback time period. The paper is analytical in nature and evaluates empirically as to how to measure the heat loss or gain and payback time of different insulation materials for cavity walls and what are the steps that can be taken prevent or control heat loss.

Introduction

Today, the world is concerned with factors like pollution, energy conservation, CO2 emissions and climate change. Each and every section of human and technical advancement is offset by some form of pollution that can have long term effects on the environment and consequently sustainability of life on Planet Earth. Automobiles, industries, and agriculture are some of the more popular areas of concern. But few are aware of the fact that the construction industry in general and private dwellings in particular plays a much larger role in polluting the environment. This observation can be verified from the figures and statistics as follows.

The top twenty polluting countries in terms of CO2 emissions are given below.

http://www. ucsusa. org/global_warming/science_and_impacts/science/graph-showing-each-countrys. html

It can be seen that the United Kingdom is the eighth most polluting country in the world. But it is far lower in terms of volume when compared to the United States, Japan, and the fast growing economies like India, China, and Russia. The UK also comes in eighth place in terms of per/capita emissions (9. 66 tonnes per person). Taking these figures into consideration, the country can be classified as a moderately polluting one. For example, Australia's place in terms of total CO2 emissions is sixteen, but it's per/capita emission figures stand at 20. 58. The United States come second with 19. 78. The top polluter, China has only per/capita emissions of 4. 58. http://www. ucsusa. org/global_warming/science_and_impacts/science/graph-showing-each-countrys. html

While the size of the population is a factor in bringing down per/capita emission figures, the case of Australia and the United States reveal that even countries with lower population levels can be responsible for high levels of emissions.

It appears that the construction industry do contribute significantly to emissions. It is estimated that the construction industry in general contribute approximately thirty three percent of total green house gas emissions. (Page 3) http://www. ciob. org. uk/filegrab/TheGreenPerspective. pdf? ref= 539 According to another observation, the situation is more serious in case of private dwellings. " Most people's concern about carbon emissions or a carbon footprint centres around gas-guzzling cars or flights. But in reality much of the problem is closer to home, or indeed in the home. Lighting and heating buildings generates 50% of Britain's carbon dioxide emissions while the production of building materials accounts for a further 10%" http://www.

guardian. co. uk/business/2007/feb/28/communities. society In this context, the current study is significant because it is concerned with heat loss effectiveness and the economic (payback period) benefits that home owners derive from having efficient insulation.

In this context, it is important that the construction industry provides technology in the form of insulation that can conserve energy (in terms of heat loss). This paper reviews the benefits of using insulation material in conserving heat loss and also the long term economic benefits that accrue from using such materials. The paper will focus on dwelling construction and not on large scale industrial, office, or housing projects. It is hoped that this study will provide a foundation for further studies in any form of construction with regard to use of insulation materials for energy and heat conservation. Heat loss and payback time is for cavity wall insulation materials(EPS, rockwool, phenolic foam, cork, sheep's wool, polyurethane foam, cellular glass, cellulose)in a semi detached dwelling of 8400 x 5500 mm outer dimension over period of time like from (2001-2010)and for future weather predictions as well like (2020, 2030, 2040, 2050)in various counties of England. It will also take into consideration factors like temperature variations across seasons and geographical locations in the United Kingdom.

The designing process has a lot to do in controlling heat loss. However, majority of the structures do not have enough system for preventing the loss. Though there are various techniques available in the market to reduce the heat loss, majority of them are not used due to different reasons such as non-reliability. One of the commonly used heat loss prevention technique is insulation. The State and its people are motivated in heat loss savings not only because they can save money, but they can protect the unnecessary loss of resources and energy as well. If proper heat loss prevention technique is applied there can have a great amount of savings. And if the technique used is insulation technique, then the chance o f savings would be high as there are lots of advantages to insulation technique compared to other techniques (Egan, 1975).

Before going deep into the concepts of heat loss and insulation technique of prevention of heat loss it is better to have an understanding of the term heat. The term heat can be defined as the " interaction between two substances which occurs by virtue of their temperature difference when they communicate" (Moss, 1998, p. 2). It is the nature of the heat it is not constant at any place, but it will move from one place to another. However this movement depends on the temperature of that place. The heat can be lost in different ways such as conduction, infiltration…. etc (Parker, 1997).

There are different mechanisms to calculate the quantity of heat loss and these techniques also helps in designing such walls which has less quantity of heat loss. The different insulation material used in the walls can cause difference in the quantity of heat loss. This paper conducts a study of heat loss and payback time of different insulation materials for cavity walls. The different techniques are evaluated on the basis of payback time of the technique used. The payback time refers to the return on the investment of the techniques for preventing heat loss. Here the return in the sense both comfort and saving of money are considered.

Research Background

The heat loss is serious loss as it causes so many problems including financial problems. Though there are different preventive techniques are available for controlling the heat loss, most of them are not able to give expected result. One among such techniques is insulation technique. There are so many drawbacks for insulation techniques also. Therefore there is a relevance and great amount of significance to conduct a research on the topic heat loss and insulation techniques of preventing heat loss. The wrong selection of insulation materials is one of the main reasons for high amount of heat loss. When heat loss is measured it can be seen that the heat lost when one material of insulation is different from quantity of heat lost when another material of insulation is used.

Un-insulated walls can also cause serious problems in terms of energy lost and other problems. The purpose of the building or the wall is also has a significant role in selecting the insulation technique. The moisture problem is one of the main factors to be considered. If the moisture problem is high, then insulation cannot do much do in preventing heat loss. The insulation materials should be selected in such a way that, it can ensure a control in moisture and air. Selecting the incorrect kind of insulation technique can increase the moisture problems. The insulation process would be easy and highly efficient, if the flow of air and moisture is properly controlled. The insulation process in such form is highly expensive and therefore it must be done with at most care. The reason is that, if there is no enough return on such insulation, the effort and money would be waste. Therefore each kind of insulation technique should be deeply analyzed in terms of its efficient application and then the selection decision should be made.

Research Aim and Objectives

This paper will address the topic of heat loss and payback period of different insulation materials. The main intention behind the research is to evaluate how effectively the heat loss can be avoided and how payback period of different insulation material can be calculated using analytical methods. The research is conducted in the context of commercial building where huge investments are made to avoid huge loss. But most of the cases are futile in the sense that either they lack proper insulation material or identifying major causes of heat loss in domestic and commercial environments. This study will explain how to insulate a building and how much insulation is needed including how to measure or calculate heat loss in a building. The specific objectives can be briefed as below:

To investigate into how to Measure or Calculate & Stop Building Heat Loss

To assess and evaluate the various methods of how to measure or calculate heat loss (or gain) in a building

To Identifying different building design temperatures & how to use a home energy audit or heat loss analysis

To assess the payback period of different insulation materials and how they can be perfectly calculated

A Literature Review

Heat loss is an important concern when considering the huge impact it has on saving energy which is the need of the time. Maintaining a proper temperature in a building consumes a large portion of energy worldwide. A building which is properly sealed, moisture-protected and insulated walls help increase comfort, reduce noise, and save on energy costs. However, there are different insulation materials out there which differs in there qualities especially in the R value which is a measure of thermal resistance of a material, the higher the R value the lower the heat loss. This topic covers information on different insulation materials, their payback periods, influence of weather on them, different climatic conditions in UK and its impact on building insulation materials.

Heat loss of insulation materials

Insulation slows the rate at which heat is lost to the outdoors. Heat flows in three ways: by conduction, convection and radiation. The main function of insulation is to keep the heat in. To be effective, insulation must be resistant to heat flow, able to fill a space completely and evenly without compacting and durable.

How heat loss of insulation materials happens?

Exposure to moisture

Joints and cracks in the insulation allow water to travel in the insulation

Corrosion

Insulation that are not rated for the highest temperature of the material being covered

Long-term exposure to heat reduces the strength of the insulation material.

Insulation that do not should fit snugly all over the wall

Using tape to cover gaps or hold insulation

How is Heat Lost

Heat can be absent in a array of ways. Some of these are calefaction accident by infiltration, losses by advice through floors, ceilings, individual bottle windows, double bottle or artificial covered windows, doors, and calefaction losses by conduction through walls. There are mainly three such a method in which calefaction moves (Murphy, 1976). These are convection, advice and radiation. This accident by agency of conduction can be anticipation of as the alteration of calefaction activity through or aural a solid. This alteration amount varies from actual to material. Heat can also be transferred through a fluid. This is alleged convection. Infiltration heat loss, on the added hand, can be anticipation of in the afterward way (Croy, 1984).

Heat is transferred by conduction, convection or radiation, or by a combination of all three. Heat always moves from warmer to colder areas; it seeks a balance. If the interior of an insulated fish hold is colder than the outside air, the fish hold draws heat from the outside. The greater the temperature difference, the faster the heat flows to the colder area.

Conduction. By this mode, heat energy is passed through a solid, liquid or gas from molecule to molecule in a material. In order for the heat to be conducted, there should be physical contact between particles and some temperature difference. Therefore, thermal conductivity is the measure of the speed of heat flow passed from particle to particle. The rate of heat flow through a specific material will be influenced by the difference of temperature and by its thermal conductivity.

Convection: By this mode, heat is transferred when a heated air/gas or liquid moves from one place to another, carrying its heat with it. The rate of heat flow will depend on the temperature of the moving gas or liquid and on its rate of flow.

Radiation: Heat energy is transmitted in the form of light, as infrared radiation or another form of electromagnetic waves. This energy emanates from a hot body and can travel freely only through completely transparent media. The atmosphere, glass and translucent materials pass a significant amount of radiant heat, which can be absorbed when it falls on a surface (e. g. the ship's deck surface on a sunny day absorbs radiant heat and becomes hot). It is a well known fact that light-coloured or shiny surfaces reflect more radiant heat than black or dark surfaces, therefore the former will be heated more slowly.

A chance for any of the above transfer of heat ends up in heat loss.

The Moisture Problem

The attendance of damp in the exoteric walls of a architecture reduces the effectiveness of insulation and may in actuality adulterate the framing and structural materials as able-bodied as accord to cruddy stains and affect the building's appearance. Vapor manual through a actual is agnate to that for calefaction advice through a apparent which was declared earlier. It is dependent on time, apparent area, breath pressures on both abandon of the surface, thickness, and permeability, which is a measurement of a material's ability to address moisture. One blazon of botheration is if abstract forms on walls, floors or beam sections of a building. Here the insulation amount (R) is bargain because air pockets in the insulation actual are now abounding with water. It is this baptize that creates the problem. That is because baptize is a good aqueduct or poor insulator (Argue, 1980)

Moisture problems occur when indoor air comes into contact with single window panes or uninsulated walls.

Symptoms of moisture indoors

Odours, frost and ice on cold surfaces, damp feeling , surface discoloration, staining, texture changes, deformed wood surfaces, wood decay, sweating pipes, water leaks, and dripping, peeling, blistering and cracking paint, crusty, powdery, chipping paint and masonry, and high indoor humidity.

Outdoor sources of moisture.

Foundation drainage slabs, below grade walls, splash back, Construction details, blocked exterior air circulation are few main sources of the moisture outdoors.

Indoor sources of moisture.

Occupants, firewood stored, attic, crawl spaces, construction materials, inadequate use of exhaust fans, aquariums and house plants, humidifiers, air conditioners and plumbing leaks.

Identification and Prevention of Heat Loss

One way in which to appraise a structure's accessible calefaction accident is to employ energy audits. Audits are classified into three types, blazon A, B, and C (Shurcliff, 1980). These classes are based on the abyss or acuteness of the audit. The residential sector apropos itself with affairs A audits and chic B audits. Program audits are conducted by able auditors while B audits are commonly mail in blazon audits. The attributes of these audits may be on website audits where one identifies locations in which activity is captivated or lost. There are a variety of methods acclimated in free these locations of calefaction loss. One such method is the use of bittersweet techniques.

A key agency in the blockage of calefaction accident is the use of able insulation materials accompanied by actual accession techniques. Thermal insulation is any material, or aggregate of materials, which provides attrition to the flow of calefaction energy (Strother, 1990).

Insulation can appear in a array of shapes and material make-ups. It may appear as sheets, rolls, or blankets. It may also be of a part blazon that is caked or destroyed in. The part blazon is usually made up of bottle fiber, bedrock absolute or artificial area the cycle or absolute blazon may be made of bottle cilia or bedrock wool. These abstracts alter in their advantages and disadvantages.

1. Provide adequate insulation levels. Reducing the energy use of a building is usually the single most important thing you can do to reduce the building's overall environmental impact. Don't substitute a " green" insulation material for a nongreen material if the change will hurt energy performance.

2. With lower R-value materials, increase insulation thickness. If substituting a green insulation material for a higher-R-value but more environmentally damaging insulation material, design the building to permit greater insulation thickness so that there is no sacrifice in energy performance.

3. Try to avoid HCFC-foamed insulation materials. HCFCs are far less destructive to stratospheric ozone than CFCs, but damaging nonetheless. When it can be done without reducing overall energy performance, avoid all HCFC based insulation, including extruded polystyrene, polyisocyanurate, and spray polyurethane. Expanded polystyrene or rigid fiberglass can be substituted for extruded polystyrene and polyisocyanurate. HFC-blown polyurethane

(SuperGreen Foam), CO 2-blown isocyanurate (Icynene), or CO 2-blown polyurethane (Resin Technologies when it becomes available) can be substituted for conventional HCFC-blown polyurethane.

4. With highly conductive framing systems, avoid thermal bridging by installing a layer of insulating sheathing. With steel framing, for example, it does not make sense to design the walls to accommodate thicker or higher-R-value cavity-fill insulation when the steel will dramatically reduce the average wall R-values; instead, minimize the cavity-fill insulation and spend your budget putting insulative sheathing over the framing.

5. Choose high-recycled-content insulation materials. With cavity-fill insulation, cellulose and mineral wool have higher recycled content than fiberglass. Among the different fiberglass products, Schuller International’s products have the highest post-consumer recycled content. Among extruded polystyrene products,

Amofoam is the only one available with recycled content.

6. With built-up roofing systems, install a layer of sheathing between the insulation and the roofing surface so that reroofing is possible without destroying the insulation.

7. When substituting fiber insulation materials for boardstock insulation, consider the impact of using more framing material. Boardstock insulation is selfsupporting, while cavity-fill fiber insulation materials require a framed cavity. Even though the fiber insulation material might be environmentally superior, when you factor in the additional framing resource required, the advantages may not be as great.

8. With most fiber insulation materials, you should install a continuous air barrier between the insulation and the living space to keep fibers out of the indoor air. 9. For chemically sensitive individuals, specify a non-offgassing insulation material, such as the new Miraflex fiberglass from Owens Corning, or Air Krete.

As additional testing information becomes available, consider Icynene and Greenwood Cotton insulation for these applications.

10. Choose an insulation contractor who recycles scrap insulation. Batt insulation scraps and Icynene trimmings can be chopped into loose-fill insulation.

Reference: http://extension. oregonstate. edu/catalog/pdf/ec/ec1437. pdf

2. 1 Insulation as a technique of heat loss prevention

Insulation is extensively used as a tool for heat loss prevention. Insulation can be defined as “ the act of protecting something by surrounding it with material that reduces or prevents the transmission of sound or heat or electricity”

There are mainly two types of insulation materials. They are organic materials and inorganic materials. The different organic materials of insulation are polystyrene, polyurethane, phenolic foam, polyethylene foam etc. Different types of inorganic materials are mineral wool, calcium silicate, cellular glass, micro porous silica, magnesia, ceramic fibre, vermiculite and perlite.

As the main purpose of insulation is control the heat loss, the insulation materials used must be able to prevent heat loss. Commonly used insulation materials are explained below

Calcium silicate

This form of insulation material is generally used in surfaces and also in piping. They will not easily get in contact with fire. This material makes use of organic and nonorganic fibre materials. The temperature range is 37. 8°C – 648. 9°

Glass

The following subdivisions are there in this category.

Fibrous:

This material has a very good capacity to absorb sound. The temperature covered is -40. 0°C to 37. 8°C. This is also a commonly used insulation material.

Cellular

This material can be transferred into different shapes. The temperature covered is -267. 8°C to 482. 2°C. The qualities of this material are it can resist number of chemical and it is not combustible.

Mineral fiber

This material is having high limit with regard to the upper temperature. The higher temperature is 1037. 8°C. This material has a very good capacity to absorb sound .

Perlite

This material has low contraction and the material last for a long period. The material rough one and shape is designed beforehand.

Other materials used are elastomeric, foamed plastic, insulating cement… etc.

Estimated Embodied Energy of Several Insulation Materials

It surprises a lot of people to learn that a state-of-the-art, energy-efficient, passive-solar house built today may consume less heating and cooling energy over 30 or even 50 years of operation than was required to build it. This means that if our society wants to continue the impressive gains that have been made over the past 20 years in reducing energy use, we will need to focus attention on embodied energy as well as operating energy. Embodied energy is the energy required to produce and transport materials. If two insulation materials insulate equally well and other manufacturing impacts are comparable, the one with lower embodied energy is environmentally preferable. While the embodied energy of insulation materials is usually quite low compared with the energy a given amount of insulation will save over its lifetime, it is nonetheless important. Embodied energy values for common insulation materials are compared in Table 3. Because these values were obtained from different sources and may have been obtained using different assumptions, they should not be considered highly accurate. They do provide useful order-of-magnitude comparisons, though.

Just how embodied energy values relate to environmental performance of a product is complicated by the fact that different fuels have different environmental impacts. For this broad comparison, it is reasonable to assume that a Btu of energy used by one industry is roughly comparable in terms of resource use and resultant pollution to a Btu used by another industry.

Reusability and Recyclability

Most insulation material reaches the end of its life not because it has worn out or has ceased to function properly, but because the building it was installed in is altered or taken down. The most obvious exception to this is commercial roofing. Many built-up roofing systems incorporate both rigid insulation and asphaltic roof surfacing. When re-roofing becomes necessary, the whole roof surface is often removed-insulation and all. The reusability of insulation materials is dependent on how those materials were installed. To facilitate re-roofing without replacing the insulation, Mike Tobin of AFM Corporation recommends installing a layer of sheathing between the insulation and the roofing membrane. If rigid boardstock insulation can be removed without breaking it up, it can often be reused. Performance of reused polyisocyanurate insulation will not be as good as that of new material, both because some of the low-conductivity gases will have escaped and because of nail holes. XPS, EPS, and all fiber insulation materials should not appreciably change in their insulating performance, though dust in fiber insulation materials will make working with the stuff at best disagreeable and at worst hazardous. A new product introduced in 1993, the " Big Green Machine," is designed to chop up batt insulation to produce a loose-fill product for insulating attics (see EBN Vol. 3, No. 2). While primarily used by insulation contractors to reuse scraps left over from batt insulation jobs, the machine should also work for reprocessing batts recovered from old buildings during remodeling or demolition. The Big Green Machine can also be used to process waste Icynene insulation; large quantities of which are typically generated during installation. Because of dust and dirt, it is unlikely that any fiber insulation materials could be easily recycled into products other than insulation. Of the foam insulation materials, polystyrene (EPS, XPS) is easier to recycle than polyisocyanurate or polyurethane. Polystyrene is a thermoplastic, meaning that it can be melted and reformed into other products with minimal chemical modification.

Polyisocyanurate and polyurethane are thermoset plastics that do not melt; most of the research being done on recycling of these materials is focusing on grinding the insulation and using the resultant powder as an additive in various unrelated materials.

Another issue of concern relating to disposal of insulation is the CFC blowing agents that are “ banked” in our existing buildings. A large portion of the CFC blowing agents that have been used in building insulation over the past 20 years have not yet been released into the atmosphere; they are still in the insulation. If studies show that even phasing out new production of CFCs and HCFCs is not enough to stem the ozone depletion that is occurring, there might be pressure to capture and thermally destroy CFCs in foam insulation that is being disposed of.

This is already happening to a limited extent with refrigerators that are being recycled by utility companies through demand-side management programs.

Increasing the payback time

The insulation technique is sued for savings. That is economic saving and giving better result. To ensure insulation technique used is efficient and effective, certain points need to be given due consideration. First of the entire place where insulation is to be effected must be measured including finding out the temperature of that place. Then conduct an estimation of the loss in terms of oil and other items, if the insulation is not conducted. After that a detailed study of different factors including the temperature need to be conducted. Next important aspect is to find out the suitable insulation materials based on the analyses and requirements. After this process is done then directly start to talk about the dealers with regard insulation process and cost involved in it.

A comparison of in economic terms if insulation is done and if insulation is not done is to be conducted.

The payback time can be increased if the proper selection of insulation material is done. While selecting the insulation material following points must be considered.

The selected material is economical

Friendly with regard to temperature

insulation material must have good qualities

Life span of insulation material is long

Payback period of different insulation materials vary depends on various factors

Here is a list of factors for various well known insulation materials.

Durability

Durability of building materials, including insulation, is a very important environmental consideration. Clearly, more durable materials are environmentally superior to less durable ones. Most insulation materials will perform very well over lifetimes measured in decades or even centuries. There are exceptions, however, and various factors that affect performance over time.

The biggest long-term performance concern with cellulose insulation is possible loss of fire-retardant chemicals. Because borates are water soluble, they can leach out if the insulation gets wet. Some people claim that those chemicals gradually disappear even if the material does not get wet, though these claims have not been substantiated. According to Dan Lea of CIMA, there is a shift within the industry toward ammonium sulfate fire retardants, which actually improve in fire retardancy performance over time. A concern with ammonium sulfate, however, is corrosion of metals in contact with the insulation, particularly with wet-spray applications.

Other concerns with loose-fill fiber insulation are settling, displacement as a result of wind, and infestations of rodents. It is also possible that, over many decades, dust and dirt accumulation could reduce the R-value-either by compressing the insulation or by filling air pockets.

Insulation materials that rely on reflectivity for their thermal performance are prone to reduced performance as accumulating dust reduces the reflectivity. Oak Ridge National Laboratory has published a number of studies on impact of dust on radiant barrier performance.

Rigid foam insulation materials that were produced using low-conductivity blowing agents (CFCs and HCFCs) are prone to R-value drift as the blowing agents leak out of the cell structure and air leaks in. Polyisocyanurate foam comes from the factory with an insulating value over R-8 per inch (RSI/m-55), but that may drop as low as R-5. 6 (RSI-39), according to some estimates.

Depending on the material (especially the facing), the application, and installation practices, a reduction to R-5. 6 per inch might take from several years to a century or more.

In some parts of the country, foam insulation materials are also prone to infestation of wood-boring insects, such as carpenter ants. Tunnels and nesting cavities will reduce thermal performance and, with foam-core panels, may affect structural performance as well. To address this concern, EPS manufacturers affiliated with AFM Corporation now incorporate a borate additive into EPS foam-core panels.

Reference:

http://allweathergreen. com/pdfs/ComparisonofInsulationofProducts. pdf

Heat Loss of Insulation materials and the Impact of Weather

Heat is transferred from hot areas to cooler areas. So when a building is hot by various mechanisms especially, other energy forms to generate heat, the heat is being transferred to colder areas outside as long as it is warmer inside than out.

The heat loss from a dwelling can be divided into two main categories:

Fabric heat loss – h