

Innovative Thermal Insulation Materials for Energy Saving in Concrete Buildings

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ABSTRACT: This article fits as the fundamental reference for developers in the field of building insulation applications and for policy makers to implement insulation as one of the energy conservation strategies. The rapid increment in earth temperature generates the requirement of insulation. This requirement guides the researchers to find its applications of the different insulations in different situations. The insulation finds in various purposes for domestic and industries to reduce heat loss, or to maintain inside temperature conditions of buildings, etc. Insulation provides the some sort of solution for energy conservation and technical key to reduce the energy losses. The presented review focuses on recent thermal applications and research of different materials as insulation, their uses at variant atmospheric conditions or at its dimensional constraints. The needs of thermal insulation give path for research or invention of new materials. Finally, the special features of different existing materials and their applications are summarized.

KEYWORDS: Energy Conservation, Thermal Insulation, Renewable Materials, Concrete Buildings, Natural Soil

I. INTRODUCTION

This paper is intended to congregate the recent developments on the building thermal insulations. One of the easy and effective ways to conserve the energy is through building insulation. The major purpose of mounting the insulation material in the building is to diminish the energy utilization for heating or cooling by increasing the thermal resistance of the building envelope. Insulation is an applicable technological key for cutting energy consumption in buildings. Thermal insulations are important in maintaining the inside environment of the buildings. Thermal insulation is competent technology to exploit the energy in providing the desired thermal comfort by its environmental friendly characteristics. The principle of thermal insulation is by the proper installation of insulation using energy efficient materials that would decrease the heat loss or heat gain, which leads to reduction of energy cost as the result. The paper presents the importance of the thermal insulating investment of the building in three areas: economic, environmental and social. Vegetal materials were one of the first construction materials used by humans, but the development of petrol based synthetic materials in the last century replaced them in main stream construction techniques. However, since environmental impacts and resource exhaustion are progressively more becoming a central issue. Natural thermal insulations are mainly developed from woody materials and industrial fibers, but these raw materials are not always locally available.

II. LITERATURE REVIEW

Tao Xie et al. In this paper, the researchers have investigated transient heat transfer characteristics of a new kind of combined Multilayer Thermal Insulation Material (MTIM), which is composed of two kinds of nanoporous super insulations (silica aerogel and alumina aerogel), as well as adding two kinds of PCM. Based on the constructed Finite Volume numerical model, the results indicated that, putting the PCMs at the bottom of the MTIM fails to enhance the thermal insulation performance of the MTIM. In contrast, putting the PCMs at the middle of the MTIM can improve the thermal insulation performance of the MTIM successfully. There is a most favorable doping content of the PCMs that can direct to the lowest of the temperature of the MTIM which makes the thermal insulation performance of the MTIM to be the best. **Zhao-hui Liu et al.** in this work, they have successfully prepared a mortar with SiO₂ aerogel particles. In this work they have studied and determined the properties like density, mechanical properties, softening coefficient, auto-genous shrinkage, antifreeze performance and thermal conductivity of SiO₂ aerogel. The results show that when the dosage was 0.2%, 0.05% and 1% respectively, the thermal conductivity was the lowest (0.0859 W/mK). **J. Zhang et al.** they investigated the thermal insulation properties of both domestic and wild silkworm cocoons under both steady and non-steady state thermal conditions. The inner temperature of silkworm cocoons showed significant thermal damping characteristics against sudden changes in outside temperature. However, the wild cocoons exhibited a

higher level of thermal buffer than the domestic ones. **Rosanne Walker and Sara Paviathis** paper investigates the in-situ thermal performance of seven internal insulation options, on a historic brick wall, using site and laboratory techniques. The paper concludes that the aerogel and PIR board have the best thermal performance with particularly low thermal conductivity and low thermal diffusivity, which would contribute towards indoor thermal comfort. **Jorge Pinto et al.** the research showed that corn's cob, an agricultural waste, has the potential to be used as a sustainable building material for thermal insulation. An experimental work concluded that there are major similarity between the corn's cob and the Extruded Polystyrene (XPS) material in terms of chemical composition and microstructure. These findings suggest that the use of corn's cob, taking simultaneously a role of filling material and a thermal insulation material, is very likely a lost ancient building technique/solution. **BjørnPetterJelle** they concluded that currently there exist no single thermal building insulation material or solution which satisfies all the requirements with respect to the most crucial properties. Hence, it is important to choose the most suitable one from today's existing traditional and state-of-the-art thermal insulation materials and solutions and conduct research to continuously improve today's existing traditional and state-of-the-art thermal insulation materials and solutions. **Jerman, Robert and Cerný** in this paper, they present the measurements of complete sets of heat and moisture transport and storage parameters of selected thermal insulation materials in dependence on moisture content. The two widespread thermal insulation materials, specifically hydrophobic mineral wool and expanded polystyrene, are selected as reference materials. **Ruifang Zhang et al.** the paper introduces a new kind of thermal insulation material using coal fly ash as main raw material by the method of foaming and slip casting process. The thermal conductivity of the sintered thermal insulation material, measured by the Transient Plane Source (TPS) at room temperature, and it could reach as low as 0.0511 W/(m K). As an environmental friendly material, it is appropriate for wall application to save energy. **NunoPargana et al.** the aim of this paper was to evaluate the environmental impacts and the consumption of renewable and non-renewable primary energy on the production of conventional thermal insulation materials: polyurethane, expanded and extruded polystyrene, expanded cork agglomerate and expanded clay lightweight aggregates. Insulation materials have proved to be a good technology to reduce energy consumption and hence help achieve sustainability in buildings. **Edmund Konroyd-Bolden and Zaiyi Liao** this research focuses on control of solar radiation, and the role windows play as transfer medium between indoor and outdoor environments. A timely control of solar thermal energy input, and building thermal energy output with the use of operable window insulation is investigated during the heating season in the local Toronto climate. **Robin E. Clarke et al.** this paper reports on an experimental study of nine materials and four buffer types to better quantify these effects. An analytical model has been developed, allowing measured roughness to be expressed as flat high and low areas of varying height and area fraction so that thermal resistance and height variations may be predicted as a function of roughness. These predictions have agreed reasonably well with optical roughness measurements. **Yuka Kusama and Yuji Ishidoy** this study investigated the use of PCM plaster as a thermal storage finishing material for the walls and ceiling of a residence. The PCM plaster includes microcapsules capable of efficiently storing and discharging heat. **Folke Björk and Tomas Enochsson** in this experimental study properties of condense formation, drainage and moisture dependent heat transmittance were studied for three different thermal insulation materials often used in railway carriages. It was noted how a higher moisture accumulation resulted in a bigger influence of moistures on thermal transmissivity at steady state. **Zoltán Pásztor et al.** the employment of large amounts of bark coming from the timber harvesting inadequately implemented, most common solution for it is the energy production, namely burning. In this research had been developed new uses, ensuing in higher value-added utilization. As natural bark protects the live parts of trees in the case of small forest fires, it is also possible to apply it as thermal insulation material. The practical utilization of thermal insulation panels made of tree barks needs further investigations from different aspects such as fire-proofing and mechanical properties and durability. **Bozena Orlik-Kozdon** The author of the paper presents the practical, environmental and economic results of research studies carried out on a building component used for thermal insulation in horizontal partitions and in for other applications. It involves the use of waste materials and their further reapplication in the production of insulation products. This thermal insulation was developed from polystyrene waste. **Syed FarrukhAlamZaidi et al.** Thermal insulation is very important for controlling the inside environmental conditions of the buildings. In this work inorganic polymer foams have been successfully produced by using available natural soil. Samples with varying amounts of soil and liquid contents were used to prepare foams where hydrogen peroxide was used as foaming agent. **Juan Pablo Cardenas-R et al.** Hydrangea Macrophylla (HM) stem fibers present a porous microstructure, very similar to expanded polystyrene (EPS). In addition, this bio material presents a very low thermal conductivity with high density, having an excellent potential to be used as insulation material. A possible use of HM fibers in a PU matrix like block type insulation would be feasible, and if the amount of HM can be increased would be a brilliant opportunity to diminish the environmental impacts of these types of insulating foams. **Yang Wang et al.** in this paper, the thermal conductivity of compound core was much lower than that of unfilled SiC foam in high temperature. It was also observed that the thermal conductivities of compound cores with the density ranged from 1.23 to 1.38 g/cm³ increased accordingly. **JanuszAdamczyk and Robert Dylewski** In this paper, a broad overview of the methods used to calculate the specific heats of building

materials, effective heat capacities and general thermal flux trends across building materials has been provided. This paper proposes a methodology for assess the economic and environmental benefits. Indeed, deep knowledge of the stationary and dynamic thermal properties and behaviors of building envelopes is fundamental to properly choice i.e. insulation materials and generally to reach good building energy performances. **Roberto Ricciua et al.** the requirements for high energy efficiency of buildings are seen as the main drivers for developing new thermal insulation products and systems. The impact of high level of thermal insulation of building envelopes is a significant part of the total performance of the buildings: Energy performance, building physics and indoor conditions. The investment in basic and applied research promotes the development of thermal and multifunctional insulation systems and materials. **Tuomo Ojanen et al.** a comparative study of internal versus external thermal insulation systems has been carried out to make residential buildings more energy efficient. Both external and internal thermal insulation significantly reduces the total energy requirement, but they bring different benefits in terms of wall protection and mold formation, and installation of the thermal insulation is more suitable in exterior. **Paraschiv Lizica Simona et al.** this paper evaluated the effects of thermal insulation on thermal comfort in low-income tropical housing. The outcome of this study indicates that the roof insulation is the most efficient strategy to improve thermal comfort and reduce the risk of overheating. External wall insulation was also found to be effective although not as effective as roof insulations. Internal wall insulation should be avoided for brick walls as it could deteriorate indoor thermal comfort conditions. However, the priority should always be given to roof insulation followed by the external wall insulation. Floor insulation also deteriorates the conditions and should therefore be avoided. **Arman Hashemi** there is many thermal insulation materials and solutions, both on the market and still at a research level. This study was briefly summarized that, the information on high performance thermal insulations for building applications. Vacuum Insulation Panels (VIP) and Aerogel they have several satisfying characteristics, such as low thermal conductivity and low weight. On the other hand, the challenges with brittle structures (aerogels) and loss of vacuum (VIP) will always be present with these solutions. **Haakon Fossen Gangasaetter et al.** this study is about a review on the air filled thermal insulation materials used for building, with respect to both novel laboratory developments and commercial. VIP, even if today's solutions require a core with vacuum in the pores, is also treated briefly, as they bear the promise of developing high-performance thermal insulation materials without the need of vacuum. **Jiří Zach et al.** the foamed geo-polymers can be a promising alternative to other foamed materials. The research result confirms that, the foamed geopolymers produced from fly ash from CHP plant have reasonable mechanical properties and performance of a construction product. The research shows that the hydrogen peroxide (H₂O₂) is a good foaming agent. **Michaach et al.** Insulation products are used to block the transfer of heat, increasing its performance and decreasing its thickness are critical challenges to provide the required comfort to users during their rest period. It possesses low thermal conductivity (highest thermal resistivity) and low air and water permeability, being the one with lighter weight. These findings suggest that the cork-based blankets may be a viable alternative to synthetic polymers in order to develop more sustainable composite materials in home textiles. **Raquel Carvalho et al.** the using of PCM as thermal insulation materials has been studied experimentally. From the results which are obtained can be made the conclusions that, insulating the South wall lead to higher reduction in the indoor temperature and maximum saving in electricity cost of zone was (1.35 Dollar/ Day m³) when using 1 cm thickness of PCM for all walls. The main objective of their work was to develop different low thickness fibrous structures with improved thermal insulation properties by incorporating cork particles within nonwoven structures. After production, samples were tested for their thermal behaviour using Alambeta equipment. **Mushtaq I. Hasana et al.** in this paper, an experimental study has been conducted for using PCM as thermal insulation materials by its incorporating with layers of the walls and the ceiling. The effect of PCM and its role in improvement of thermal comfort and thermal performance is experimentally studied.

III. CONCLUSION

This review article fits as the fundamental reference for developers in building insulation application and for policy makers to implement insulation as one of the energy conservation strategy. One of the easy and effective ways of energy conservation technologies available today is through building insulation. It offers several applications in commercial, residential and industrial sectors. Thermal insulation is an important technology to reduce energy consumption in buildings by preventing heat gain through the building envelope. The main objective of installing insulation material in the building is to reduce energy consumption for heating or cooling by increasing the thermal resistance of the building envelope. By increasing the insulation thickness the thermal conductivity will be reduced, while the insulation cost will be increased until it exceeds the savings, which this additional thickness will not bring any economic benefit. The best insulation options for an attic are open cell spray foam, fiberglass, and cellulose. Cellulose is the oldest insulation material used for not only the attic, but other areas of the home as well. Cellulose can be either a loose-fill or blown-in material and is primarily made of recycled newsprint or denim. New thermal insulation solutions are needed to fulfill the performance and buildability requirements. There is on-going strong development of new insulation materials and applications and also the performance properties of conventional

insulations are continuously improved. Using the PCM as thermal insulation materials in buildings contributed to improvement of thermal comfort. Using the PCM lead to reduce the indoor temperature of zone and reducing the cooling load. Using PCM as insulation materials leads to saving of electricity consumption. SiO₂ aerogel is a solid material with 3D network structure, has a very low density and low thermal conductivity, can be used as a kind of high efficient heat conservation and heat insulation material, as well as SiO₂ aerogel particles.

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