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Thermal Insulation Using Waste and Recycled Material

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Abstract

Adopting more sustainable practises, especially in terms of reducing energy use and greenhouse gas emissions, is one of the primary concerns nowadays. Hence, it's crucial to consider environmentally efficient steps at all stages of the building process, including the use of more sustainable materials. On the other hand, the reliability and negative effects of today's thermal insulators must also be taken into account. This review examines the possibility and viability of using waste and recycled materials as thermal insulation. It concludes show that not only do these substances classify as effective raw materials for thermal insulation panels, but they are also environmentally and economically feasable alternative for modern insulation materials. Additionally, they are considerably safe for personal and commercial usage.

Keywords Thermal insulation, Waste materials, Recycled materials, Sustainable development, Eco-efficient building solution.

Introduction

The global market increasingly provides a diverse range of thermal insulation materials for commercial buildings. Over the last 40 years or so, cellulose-based natural fibers have become extremely popular as a raw material for thermal insulation.[1] The 2 most common thermal insulators are: Fiberglass and Mineral wool. Both of them come with their own set of disadvantages.

Producing fiberglass (Pultrusion) releases fumes and air pollutants into the atmosphere, albeit less than most manufacturing processes. Mineral wool exposure can be deemed harmful to health[1]. Both Mineral wool and Fiberglass absorb moisture and their 'R- Value' gets reduced. Both the processes are comparatively expensive.

[1] *IARC October 2002, vol.38 pg.34 marks rockwool/ mineral wool as Group 2B "possibly carcinogenic to humans".*

As a result, the use of certain waste materials as well as recycled plastics like PET used in waterbottles, which is another necessity for a sustainable growth, should also be a feasible alternative.

These waste materials can include bulk waste like sawdust, crumbled expanded polystyrene waste, shredded paper, bio-mass waste, processed straw, silica fume and fly ash, recycled

post consumer PET bottles to name a few.

Governments, companies, and individuals can transform the building sector through a variety of actions to achieve an energy-efficient environment, beginning with an increasing understanding of the global energy problem.The Combination of Waste and processed/recycled materials like Processed dry wool and recycled PET combat such disadvantages of modern Thermal Insulators. However, this requires extensive research in its own regard. More studies need to be conducted in order to fully manipulate the combination of waste and recycled materials in order to statistically maximize effectiveness while minimizing cost and environmental risks.

Literature Review on Thermal insulation of Waste materials

Processed Straw

The possibilities of minimising heat transfer in the straw of a varying structure are investigated in this study. Barley straw was used to perform the experiments. Strongly horizontally and vertically oriented straw stalk specimens were prepared to test the effect of straw stalk orientation on thermal conductivity. In broad calorimeters, to reduce heat transfer through gaseous conduction and convection.

In the study by Jolanta Vėjelienė [1], chopped and defibered barley straw stalks were used for vertically and horizontally focused experiments. Small straw bales were carefully prepared into vertically and horizontally oriented straw when specimens were strongly oriented.

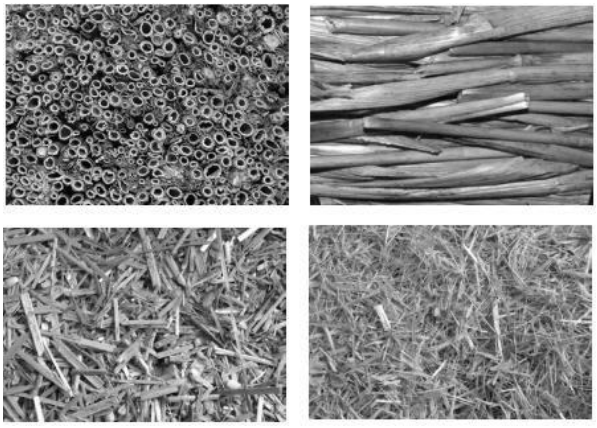

Fig.1 Straw specimens used (Source: Vėjelienė, Jolanta, 2012, pg.97)

A test on thermal conductivity was carried out applying guarded hot plate apparatus λ- Meter EP 500 and, the relationship between thermal conductivity and material density of differently oriented straw can be approximated using the experimental results by the approximate formula:

$\lambda = 0.0000175.\rho 2 - 0.00036.\rho + 0.10312$ (1)

It concludes the following (pg.101-102):

The thermal conductivity of straw mostly depends on the orientation of straw stalks in the specimen matrix. Mechanical processing like chopping and defibering reduced Thermal conductivity significantly.When materials are coated with infrared absorbers, thermal conductivity may be reduced by more than 20%.The thermal conductivity of chopped straw depends on the content of graphite and the efficiency of additives depends on the density of material.

Bulk waste materials

Maricica Vasilache , Marian Pruteanu and Costel Avram in 2002 [2], focused on the idea of composite elements being able to meet the criteria of thermal efficiency, as well as the calculation of the thermal conductivity of bulk materials such as sawdust, crumbled expanded polystyrene waste, shredded paper, and bio-mass waste.

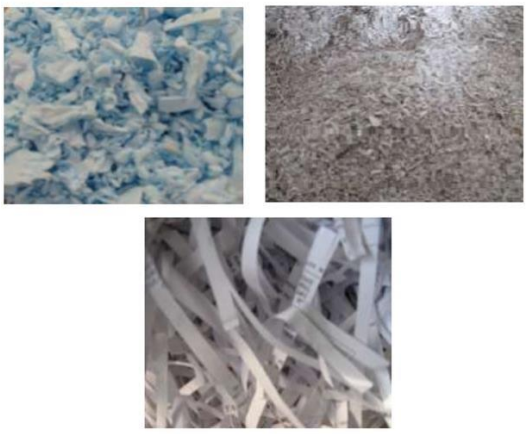

Fig 2. Bulk waste specimen used clockwise from top left, Polysterene, Sawdust and Hredded waste paper (Source: Vasilache, Maricica & Pruteanu, Marian & Avram, Costel, 2010 pg.1277

When the obtained thermal conductivity results were compared to the values of polystyrene and mineral wool, it was discovered that these materials can be used successfully as thermal insulation for new and existing structures.

PET and recycled plastic

Polyester fiber, recycled from post-consumer PET bottles

The main objective of this study by Francesca Intini and Silvana Kühtz [3] was to create thermal insulation panel for buildings out of recycled materials, primarily to save energy during manufacturing and to support the climate. This research looks at a panel for building thermal and acoustic insulation in particular. Polyester fiber was obtained from the processing of post-consumer polyethylene terephthalate (PET) bottles to make the panel.

The findings of this study indicate that using waste PET reduces the environmental effect of using virgin PET while retaining high thermo-physic properties. The energy savings during

building operation are usually greater than the total energy usage associated with the manufacturing process (pg. 314)Since the panel made of PET must be replaced or recycled after the building is demolished, its life is averaged with that of the building. When virgin PET is compared to recycled PET, the findings are almost identical, demonstrating the project's progress.In addition to this,s compared to panels made from virgin fibre, recycled fibre panels have a significantly lower environmental impact (PET).

Table 1. Aggregated inventory data for 1 kg of thermal insulation panel and for the functional unit. (Source: Francesca Intini, Silvana Kühtz 2011 p.g.308 Table 4)

Elements	Unit	Quality for 1kg of thermal insulation panel	Quality for 1 functional unit
Internal recycled fiber	kg	0.25	0.244
PET virgin fiber	kg	0.208	0.222
External recycled fiber	kg	0.375	0.399
Packaging	kg	0.19	0.202
Electicity	kWh	0.226	0.241
Natural gas	m^3	0.046	0.049
Transport	km	0.286	0.305

Waste Terephthalate (PET) mechanical properties

This paper by M. Sulyman, J. Haponiuk, and K. Formela [4] summarises experimental efforts on the use of poly(ethylene terephthalate) (PET) in civil engineering. -PET plastics can help the environment and the economy in a variety of ways. It assists in reducing natural resource misuse. It reduce emission levels in the atmosphere by conserving electricity. PET plastics can help the environment and the economy in a variety of ways. As a binder for aggregates, asphalt is commonly used in road pavement construction. However, high temperature rutting, medium temperature fatigue, and low temperature cracking damage are all well-known symptoms of asphalt mixture or coating layer temperature susceptibility. As a result, asphalt mixture adjustment is sometimes used to enhance its application.

Case studies have shown that adding small amounts of a variety of polymer binders to road pavement asphalt and building concretes will boost their efficiency and reinforcement in both cases. This ensure the mechanical properties of PET in buildings.

Textile Subwaste

This research work by Anabela Paiva, Humberto Varum, Fernando Caldeira, Ana Sá, David Nascimento, Nuno Teixeira [5] focused on the possibility of using textile subwaste as an alternative building thermal insulation material for double external walls in a sustainable way.

Literature Review on Thermal Insulation of Recycled Materials

This investigation by Hanson, James & Kopp, Kevin & Yesiller, Nazli & Cooledge, Craig & Klee, Emily (2016), [6] looked at the use of recycled materials in underground building.

Assessments were carried out for three different environments: mild, temperate, and arid.

The amount of heating and cooling energy used to keep the warehouses at a set temperature was calculated. A variety of insulation materials, including those derived from waste, were evaluated. The use of shredded tyres and waste textiles was compared to simulations using traditional XPS insulation and no insulation.

The findings showed that the recycled waste materials were sufficient to supply insulation. The output of textile waste materials, in particular, was comparable to or better than that of traditional insulation, suggesting that they could be used as thermal insulation in underground construction.

Conclusions and Future Scopes

This review focuses on possibility and efficiency of constructing thermal insulation panel, particularly for buildings, in order to produce effective thermal insulation while also keeping in mind environmental degradation.The straw study [1] shows how potential agriculture waste can be feasabily be used as a thermal envelope.The success of the PET studies [3][4] can also be enlarged by an efficient waste water treatment plant and managing waste generated by making panels. A large amount of C02 emission which could have taken place is reduced by recycling PET. This research has indeed been successful when panels made from recycled PET were compared to products have same use or function of insulation.

Post-consumer PET bottles were used to create an effective thermal insulation panel. A life cycle analysis was used to evaluate the energy and environmental advantages associated with its usage in residential buildings. The results show that the use of recycled PET involves a significant reduction of the environmental impacts.

Also, Bio-based sandwich panels were found to have a comparable ability to retain heat energy as mineral fibre.[7]Finally, the conclusion of the textile study [5] emphasises the utility of using solid waste in various construction uses and as a thermal insulation material. It also leads to a more profitable and long-term construction market.

However, various questions like effectiveness of bulk sawdust as IR absorbents over non conducive air gaps as better insulators remain unanswered. Furthermore, since all of these experiments have focused on individual waste components, the effectiveness of mixed waste and recycled materials as thermal insulation remains unknown. In and of itself, this necessitates further analysis.Regardless, these results throw light on a new means of sustainable development. The findings are encouraging, and further efforts in the areas of waste recycling and green energy use would aid us in our mission of making the environment a safer and healthier place for future generations.

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