Summer 8-5-2018

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International Journal of Engineering & Technology, 7 (3) (2018) 1295-1298

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET
doi: 10.14419/ijet.v7i3.13177
Research paper

Preparation and characterization of decorative and heat insulating floor tiles for buildings roofs

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Abstract

Since the beginning of the 5th century, people felt the urge to construct a sort of heat insulation system to their houses. This research paper focuses on the preparation, development and design of heat insulating tiles using materials like automobile tires powder and rice husk which are materials that are available at almost negligible costs and great amounts. Throughout this paper, experimental work will be provided to document, analyze and compare different insulating materials based on their thermal conductivity factor (K-factor), economic aspects, contribution to a greener earth, and mechanical properties. The results show that a mixture of used automobile tires powder and epoxy has a K factor of 0.0117 W/m°C, and that of a rice husk mixture with epoxy is 0.0118 W/m°C. These values are considerably lower than the K factor of the currently used polyurethane foam (which is 0.026 W/m°C), and therefore these mixtures are more efficient heat insulators than the currently used foam. Calculations have also shown that the manufacture of these mixtures cost 65% less than that of the polyurethane foam.

Keywords: *Use about five key words or phrases in alphabetical order, Separated by Semicolon.*

1. Problem definition and objectives

The increased demand of heat insulating materials used in buildings has aroused due to the green house effect that causes the temperatures to rise significantly during the summer. Currently, a great proportion of the polyurethane foam produced annually is used in the production of spray foam which is used as an insulating layer between the walls of buildings to reduce heat transfer between the outer environment and the inside of the buildings. Due to the characteristics of polyurethane foam which will be discussed in details later, polyurethane foam acts as an effective heat insulator. However, combining more than one insulating material to form a composite heat insulating layer is proved to have a more efficient effect in heat insulation and therefore reduces energy consumption by reducing the use of heating and cooling systems in buildings.

This research project studies the preparation and characterization of decorative and heat insulating floor tiles for buildings roofs in order to reach a design that provides a higher efficiency in heat insulation, uses economical substances to create the tile, makes use of materials that are the waste of other industries, and provides a touch of beauty and elegance to the roofs.

2. Brief background/literature review

The importance of material science is that it is a field that is not only covering a specific research field but it is also widely used in many applications such as cosmetic, pharmacy, agriculture, and natural products, and other potential applications in sensors, catalysis and energy conversion.[1-9] Throughout the years, people have been using different materials to insulate their houses/buildings. In the medieval era, people used straw and mud as insulation. In 1932, the field of heat insulation started to develop properly and fiber-glass was used for insulation. Around the 1950s cellulose started to be used instead of fiber-glass and in 1970 spray polyurethane foam started to be used for insulation and is still used until this very day. [10] Automobile tire consists mainly of synthetic and natural rubbers, with lower percentages of carbon black, nylon fiber and polyester, steel wire, different chemicals like waxes, clays, silica, and pigments.[11] Rice husk is the outer layer of the grain that is separated from the rice grain in the milling process. Rice husk consists of cellulose (around 50%), lignin (around 25 to 30%) and silica (around 15 to 20%) [12]

3. Methodology/approach to the problem

The experimental work focuses on the preparation of heat insulating tiles using the automobile tire powder mixed with epoxy and rice husk mixed with epoxy. This is achieved by mixing each of the automobile tire and rice husk with epoxy (3:1 by volume) and leaving the samples for 24 hours in a mould to cure. Then it focuses on measuring the heat insulating efficiency (K factor) of these materials. This is achieved by setting up a simple experiment that is based on the theory of Lee's Disc experiment [13]. Finally, a mechanical hardness test is performed on the tiles' top layers to test the samples' hardness and applicability for use as tiles.

3.1. Materials

The choice of the materials used is based on their possible ability to insulate heat, withstand impact, and form a rigid structure. Epoxy is known commercially is KEMAPOXY 150. It consists of the epoxy resin and the hardener (both in the liquid state). It is prepared by mixing the epoxy and the hardener together with a ratio 2:1 respectively (ratio is by weight). [14] Polyester is prepared by adding 1.5 weight% initiator and 1.5 weight% activator to the epoxy resin liquid. The initiator and activator are NEVER to be mixed together as this will lead to an EXPLOSION.[7] Polyurethane foam is formed by mixing together equal volumes of polyisocyanate and polyol. The mixture starts to expand as the gas escapes and within 2 hours is completely dry and rigid.[15] Used automobile carbon tires are grind in millers into fine powder. This powder has a very low density and is very dusty. It has an intense black colour due to the presence of carbon black. Rice husk is the product of milling rice during the harvest season (October and November). It is in the form of ash and can easily be obtained from any agricultural area during these seasons and all year long from the storage [16].

3.2. Method of preparation

The automobile tire powder is mixed with epoxy (3:1 by volume) and left to cure in a steel 30 cm x 20cm x 1 cm mould for 24 hours. The same procedure is repeated but using rice husk. A polyurethane reference sample is prepared by mixing together equal volumes of di-isocyanate and diol. Then a sample of pure epoxy and a sample of pure polyester are prepared (for the tile's top layer) by adding the respective resins to the hardener (in case of the epoxy) and to the initiator and activator (in case of the polyester)[8]. The samples are left for 3 days to cure completely. A sample of each of the automobile tire mixture, rice husk mixture, epoxy and polyester is prepared in a petri-dish to prepare for the heat insulation test.

Fig. 1: Automobile Tire Power and Rice Husk Mixed with Epoxy Preparation.

Fig. 2: Epoxy and Polyester Layers Preparation.

Fig. 3: Heat Insulation Test Samples Preparation.

3.3. Experimental procedure

3.3.1. Heat insulation test

Fig. 4: Heat Insulation Test Set-Up.

The heat insulation test is performed by placing the samples on top of a calorimetry cup inside a cardboard box where 2 candles are lit (as a source of heat). The temperature difference between the calorimetry cup and the environment is recorded every 5 minutes over a period 25 to 30 minutes to be later used in the K factor calculations.

3.3.2. Hardness test

The hardness test is performed using a Schmidt Shore D hardness device. The needle tip of the device is immersed into the sample of polyester and epoxy until the base of the needle is aligned with the surface of the sample. The analogue metre reads the hardness value in Shore D as in figure 5 below. [3].

Fig. 5: Hardness Shore D Test.

4. Results and discussion

4.1. K Factor calculations

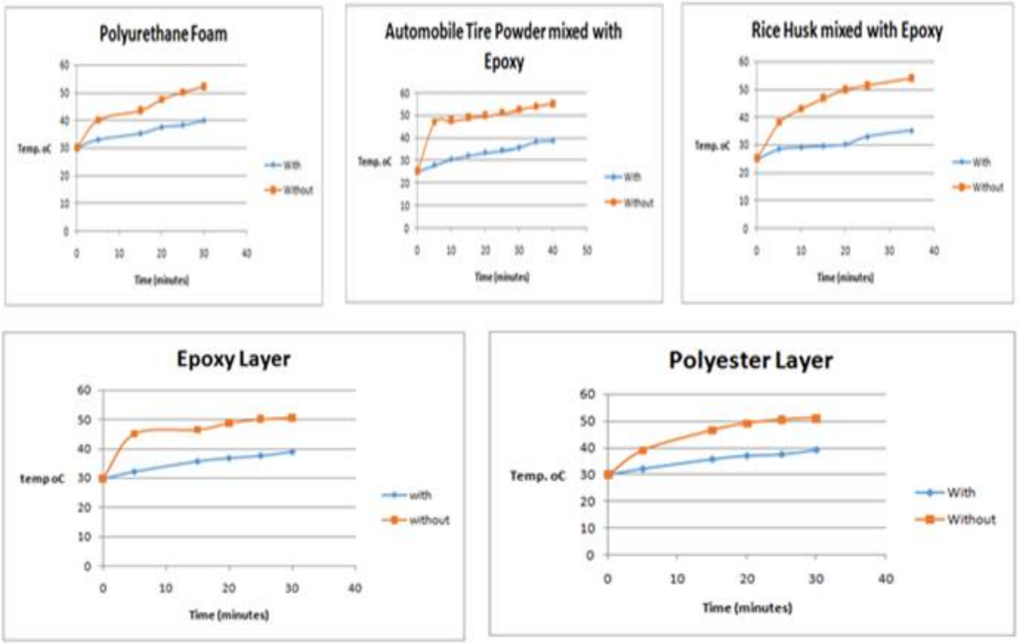

Fig. 6: Temperature Difference Graphs.

The following graphs summarize the temperature differences with insulation and without insulation recorded for the different samples:

*These graphs are used to calculate the K factor using the following relation:

Q = $\frac{KA(T2-T1)}{x}$

Where,
Q is the heat flow,
K is the K factor,
A is the surface area of the sample
(T2-T1) is the average temperature difference between insulated and non-insulated area
And x is the thickness of the sample.

For Polyrethane (the reference)
"K" polyurethane = 0.026 W/m°C
"A" polyurethane = $\pi r^2 = \pi\ (5)^2$ = 78.54 cm^2 = 78.54 x 10^{-4} m^2
(T2- T1) polyurethane = (from the previous graphs) 10.6°C
"x" = 2 cm = 0.02 m
Therefore Q polyurethane = $\frac{0.007854*10.6\ K}{0.02}$ = 4.16 K

*For the epoxy Sample:
Let Q polyurethane = Q epoxy
Therefore, [$\frac{KA(T2-T1)}{x}$] Polyurethane = [$\frac{KA(T2-T1)}{x}$] Epoxy
"A" epoxy = $\pi r^2 = \pi$ x $(4.4)^2$ = 60.82 cm^2 = 60.82 x 10^{-4} m^2
(T2- T1) epoxy = (from the previous graph) 12°C
"x" epoxy = 1.5 cm = 0.015 m
Q epoxy = 4.86 K epoxy
Therefore, 4.16 K polyurethane = 4.86 K epoxy
"K" polyurethane = 0.026 W/m°C
Therefore, K epoxy = 0.0222 W/m°C

These steps are repeated for all the samples and the following table of K factors is obtained:

Table 1: K Factor Values for Different Samples

Compound Material Name	K factor (W/m°C)
Epoxy	0.0222
Polyester	0.0202
Polyurethane	0.026
Automobile Tire Powder with Epoxy	0.0117
Rice Husk with epoxy	0.0118

The K factor is the industrial indication of the heat insulation properties of a material. The lower the K factor, the better the material is in insulating. The results suggest that both automobile tire powder mixture and rice husk mixture have lower K values than the currently used polyurethane foam, and are therefore more efficient heat insulators.

4.2. Hardness test results

The following table shows the Hardness test results of epoxy and polyester:

Table 2: Hardness Results of Epoxy and Polyester

Material	Hardness (in Shore D)
Epoxy	85
Polyester	82

The hardness test suggests that both polyester and epoxy are almost equally hard, and according to Michael Hernandes [3] a material that has a shore D value higher than 50, is considered very hard.

5. Conclusion

In conclusion, the aim of this project was to design and prepare a heat insulating tile that offers higher efficiency and lower costs than the currently used polyurethane foam. By comparing the designed automobile tire powder mixture and the rice husk mixture with the polyurethane foam, the K factor of both tire powder and rice husk is found to be around 0.0117 W/m .°C while the K factor of polyurethane foam is 0.026 W/m .°C. This suggests that both materials are much more efficient at heat insulation than polyurethane foam. A simple cost analysis is performed and suggests that the tire powder mixture and rice husk mixture are both around 65% cheaper than the polyurethane foam. The research also aimed to contribute to a greener earth by making use of the used automobile tires and the rice husk, both of which cause great pollution percentages when disposed by setting open fires.

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