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Preparation of Material for Thermal Analysis as Insulation Composite

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ABSTRACT

Composite materials are combined in such a way as to enable us to make better use of their virtues while minimizing to some extent the effects of their deficiencies. A structural composite is a material that consists of two or more phases on a macroscopic scale, whose mechanical performance and properties are designed to be superior to those of the constituent's materials acting independently. The thermal properties of some Natural dispersed fiber composites like (Rice Husk, Bagasse and Corncob) are investigated with the purpose of determining their use as insulators in various applications. Using varied composition percentages of each sample, increasing and decreasing quantities to determine best mixtures has assisted in accurate recommendation. The work has explored the potentials for using composite samples of Rice Husk, Bagasse and Corncob as materials for thermal insulation, a solution which offers a reduction in resource use, promote recycle of the wastes, less dependent on toxic chemical types in wood/cellulose based insulators, in addition to reducing energy consumed by altering internal air conditions. The criteria for evaluation include experimental determination of Thermal Conductivities and Specific Heat Capacities for composites samples and other dependable properties.

1. Introduction

A composite material consists of two or more physically and/or chemically distinct, suitably arranged or distributed phases, with an interface separating them. It has characteristics that are not depicted by any of the components in isolation. Most commonly, composite materials have a bulk phase, which is continuous, called the matrix, and one dispersed, non-continuous, phase called the reinforcement, which is usually harder and stronger.

The Dispersed phase is embedded in the matrix in a discontinuous form. This secondary phase is called dispersed phase. Dispersed phase is usually stronger than the matrix and other phases, therefore it is sometimes called reinforcing phase.

Energy demand in building can be significantly reduced with the use of thermal insulation. The use of thermal insulation in walls and roofs can reduce the demand for air conditioning thereby reducing the cost of cooling and pollution of the environment. The evaluation of thermal properties of new materials is quite important. For several of their engineering applications in microscopic or macroscopic structures for instance, we need to know how they are able to dissipate heat. The same is true for those systems suitable for the recover or storage of energy. Besides this necessity of measuring the thermal properties of new component materials, the study and development of relevant experimental methods is quite important for researchers and students of engineering too. Here then, we propose a method that allows to have an experimental approach to the problem of thermal transport. Agricultural wastes such as rice husk, sugarcane stalks, coconut fibre, corn cob or stalk oil palm shell and leaves or straw from cereal crops have high degree of fibrous content (lingo-cellulosic compound) and can serve as the main ingredient for composite materials making them suitable for manufacturing boards.

One of the most important parameters is the volume (or weight) fraction of reinforcement, or fiber volume ratio. The distribution of the reinforcement determines the homogeneity or uniformity of the material system. The evaluation of thermal properties of new materials is quite important. For several of their engineering applications in microscopic or macroscopic structures for instance, we need to know how they are able to dissipate heat. The same is true for those systems suitable for the recover or storage of energy. Besides this necessity of measuring the thermal properties of new component materials, the study and development of relevant experimental methods is quite important for researchers and students of engineering too.

2. Objectives

The main objective of the present work is to develop composite structure from agricultural waste and to find the thermal behaviour of that composite using Experimental method.

Also the main objectives are

1. To find out the alternative to current insulating materials.
2. To find out the thermal conductivity for the developed composite samples.
3. To find out the thermal resistivity for the same samples.
4. To find out the appropriate composition from the prepared samples.

3. Problem Definition

As thermoplastics and plastics are mostly banned in Maharashtra state, the demand of alternative is more in the market as new insulating material. Also to reduce the cost of insulating material.

4. Literature Survey

Anabela Paiva, Sandra Pereira, Daniel Cruz, Humberto Varum, Jorge Pinto, Ana SA "A contribution to the thermal insulation performance characterization of corn cob particleboards". They studied that an alternative expedite experimental set-up is proposed to evaluate the thermal insulation performance of corn cob particleboards. Testing in thermal insulation performance under real thermal and hygrometric conditions, using more realistic sample dimensions, testing simultaneously several samples and monitoring continuously for several days the thermal behaviour of a product are some advantages of this proposed technique. Therefore, it has shown to be accurate and versatile. Through the proposed experimental methodology, a parametric thermal insulation study of the corn cob particleboard in which the impact of its thickness on its thermal insulation performance was also possible to Perform. This paper conclude that an alternative expedites experimental set-up based in ISO 9869 was proposed to evaluate the thermal insulation performance of corn cob particleboard. In brief, it consists of using a confined room able to guarantee a constant interior temperature and having a window, working as an alternative solution for a thermal test cell. The particleboard sample is inserted in an XPS support panel and the set replaces a window. A heat flux meter system formed by two heat flux sensors, four superficial temperature sensors, a data-logger and a computer is adopted to measure the heat flow cross the sample and the superficial temperature of the inner surface of the sample. In parallel, thermo hygrometric sensors placed in the interior and the exterior allow the measuring of the respective interior and exterior temperatures and relative humidity. Since the material under study was corn cob particleboard, considered as having a low thermal inertia, a five days test was adopted. This proposed experimental set-up proved to be accurate, made it possible to perform thermal insulation performance tests under real thermal and hygrometric conditions, in situ, to use more realistic sample dimensions, to test more than one sample at the same time and to monitor the thermal behaviour of a product continuously for several days. Technical aspects related to the connection between the corncob particleboard sample and the XPS support panel, the fixation of the set (i.e. corncob particleboard inserted in the XPS support panel) to the window frame and the respective sealing up, and the perfect contact between the surfaces of the heat flux sensor and the inner surface of the corncob particleboard sample need to be done carefully in order to avoid undesirable thermal condition faults. In the Portuguese north region context, this experimental methodology is more adequate to carry out during the winter or the summer seasons in which it is more reliable to ensure the desirable significant thermal gradient between indoors and outdoors. Through this experimental methodology it was possible to do a parametric study of the corncob particleboard in which the impact of the thickness of the panel in its thermal insulation performance was verified. Thicker corncob particleboard has small thermal transmission coefficient corroborating. Finally, the proposed alternative expedite experimental set-up can be easily adopted for the thermal insulation performance study of other alternative sustainable engineered materials or products.

Danny Santoso Mintorogoa, Wanda K Widigdoa, Anik Juniwatia "Application of coconut fibres as outer eco-insulation to control solar heat radiation on horizontal concrete slab rooftop". studied that many countries alongside equator will experience excessive solar radiation, regardless the top and four sides of the buildings' surfaces. Due to the modern architectural concept and fast growing industry and economic, hundreds of rows of two-to-three-story shops and office houses have been built on the central business districts. Those buildings built are equipped with flat bare and uninsulated concrete rooftop. Only few of flat rooftops are equipped with numerous un-eco-insulation developed in the world such as asphalt roll membranes, single-ply rubber membranes, Ethylene Propylene Diene Monomer (EPDM), and Thermoplastic Polyolefin. This paper deals with the use of coconut fibres to build thermal insulation on concrete slab roofing's and the experimental measurements of roof surface and indoor air temperatures derived from dynamic climatology of solar radiation. Monthly average temperatures on rooftop concrete slab and room air temperatures were conducted. Coconut fibres will be considered as natural sustainable insulator with the following aspects: practicing to respect natural materials within the built environment, promoting less hazardous roofing insulation of the material used, limiting the impacts on the urban-built atmosphere, and preserving cooling energy demand by mitigating the flat concrete rooftop thermal onto the room. The room air thermal saving covered by coconut fibres is around 2.8 – 3.1 different, and the rooftop surface thermal saving with coconut fibres is 13different, compared to conventional bare concrete slab roofing's. The energy consumption reduction is around 3% (average) and 9% (maximum). This paper concluded that Concrete rooftops covered with coconut fibres have lower surface heat fluxes during the daytime and are faster to release the stored heat due to the natural perforating material of coconut fibres. Coconut fibres rooftops experience a lower indoor air temperature during the daytime but not at the night time. Coconut fibre is a natural material, therefore it decomposes faster and more easily. It pertains a clean built environment. Coconut fibres can be recycled as a natural material. Coconut fibres can be introduced as an insulation to flat concrete rooftops besides straw and fibre reeds.

Jorge Pinto, Anabela Paiva, Humberto Varum, Ana Costa, Daniel Cruz, Sandra Pereira, Lisete Fernandes, Pedro Tavares, Jitendra Agarwal "Corn's cob as a potential ecological thermal insulation material". We have studied that tabique construction is one of the main Portuguese traditional building techniques that use earth based building materials. It is peculiar building technique which uses corn's cob as a filling material for the external tabique walls. The existing tabique construction in Tars-os-Montes e Alto Douro region of north-east Portugal was studied to learn from it for modern day construction. 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 significant similarities between the corn's cob and the extruded polystyrene (XPS) material in terms of microstructure and chemical composition. Furthermore, the results obtained from an expeditious experimental thermal procedure indicate that the corn's cob may have adequate thermal properties for building purpose. This paper concluded the analyses of those buildings also suggest that the earth based mortar conserves biological materials such as timber and corn's cob, since the building system is not in direct contact with the ground and also the earth covers all the faces of those biological materials, protecting them from the rain and biological attack. The corn's cob presents three layers which are different in terms of shape, texture, density and colour. The corn's cob material is heterogeneous, in contrast to common thermal insulation building materials, which is related to its origin being a natural biological material. SEM/EDS's results indicate that there are some interesting similarities between the corn's cob and the extruded polystyrene (XPS) materials. These similarities are related to the closed cellular microstructure type, as well as to the presence of the same chemical elements. 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. Furthermore, these findings give guidance for future conservation/renovation actions of existing tabique constructions. An expeditious experimental procedure for comparing the thermal behaviour of corn's cob and XPS was presented. Thermography results indicate that the corn's cob may have adequate thermal properties for building purpose. Further research is required to assess fundamental thermal properties such as thermal conductivity of this biological material.

K .El Azharya, Y.Chihaba, M.Mansourb, N.Laaroussia, M.Garouma "Energy Efficiency and Thermal Properties of the Composite Material Clay-straw". They proposed that unfired clay is a sustainable building material resisting to the hard climatic conditions. In order to improve the energy efficiency of this ecological material, this work tries to develop the thermal properties of unfired clay as an insulation material by mixing it with straw. An experimental measurement of thermal properties of unfired clay mixed with straw was done by using the flash method to determine the thermal diffusivity and the state hot plate method to estimate the thermal conductivity in order to deduce the thermal capacity. A building was simulated using the unfired clay–straw envelope with the climate data of south Morocco region, for the purpose to establish its thermal inertia and its ability to bring a good comfort by limiting summer overheating and keeping the heat in winter without heating and cooling systems. This paper concluded that, devoted to obtain the thermal comfort in the habitat through the judicious use of clay-based building materials. The composite material of clay-straw has valuable thermal properties for the storage of heat and the regulation of temperature changes between day and night during the winter period and prove its ability of resisting to the Warm and dry climate without any use of cooling or heating system.

Abdulkareem S., Ogunmodede S., Aweda J.O., Abdulrahim A.T., Ajiboye T.K., Ahmed I.I., Adebisi J.A. "investigation of thermal insulation properties of biomass composites". Investigated the thermal properties of Kapok, Coconut fibre and Sugarcane bagasse composite materials using molasses as a binder. The composite materials were moulded into 12 cylindrical samples using Kapok, Bagasse, Coconut fibre, Kapok and Bagasse in the ratios of (70:30; 50:50 and 30:70), Kapok and Coconut fibre in the ratios of (70:30; 50:50 and 30:70), as well as a combination of Kapok, Bagasse and Coconut fibre in ratios of (50:10:40; 50:40:10 and 50:30:20). The sample size is a 60mm diameter with 10mm – 22mm thickness compressed at a constant load of 180N using a Babenberg compression machine. Thermal conductivity and diffusivity tests were carried out using thermocouples and the results were read out on a Digital Multi-meter MY64 (Model: MBEB094816), while a Digital fluke K/J thermocouple meter PRD-011 (S/NO 6835050) was used to obtain the temperature measurement for diffusivity. It was observed that of all the twelve samples moulded, Bagasse, Kapok plus Bagasse (50:50), Kapok plus Coconut fibre (50:50) and Kapok plus Bagasse plus Coconut fibre (50:40:10) has the lowest thermal conductivity of 0.0074, 0.0106, 0.0132, and 0.0127 W/ (m-K) respectively and the highest thermal resistivity. In this regard, Bagasse has the lowest thermal conductivity followed by Kapok plus Bagasse (50:50), Kapok plus Bagasse plus Coconut fibre (50:40:10) and Kapok plus Coconut fibre (50:50). This paper concluded that drawn from the investigation of thermal insulation properties of biomass composites: Kapok works better (good thermal insulator) when combined with Coconut fibre and Bagasse's at a percentage of 50%.The particle size of Coconut fibre and that of Bagasse helps reduce heat flow, hence they serve as good thermal resistance materials. All the samples investigated in this work can withstand a medium temperature range of 150 to 450 in degree. Sample B (Sugarcane Bagasse), Sample D2 (Kapok and Bagasse 50:50), Sample E2 (Kapok and Coconut fibre 50:50) and Sample F1 (Kapok, Bagasse and Coconut fibre 50:40:10) can be used for a high temperature application range of above 450 degree.

5. Material Preparation

The methodology and experimentation started with the preparation of samples having different compositions of filler material and natural fiber material. The composition of natural fiber is kept in increasing order so as to get the desired thermal properties.

The materials used for the experimentations are the corncob, rice husk, bagasse and starch. The materials are converted into small fine particles by crushing them into the mixer grinder. Rice husk has the more fibrous content as compared to other natural materials so it is used as main material in the composition.

The sweet potato starches had superior bulk properties which could present them as possibly more robust and effective diluents compared to commercial maize starch. The sweet potato starches were superior to the commercial maize starch as tablet binder in concentrations of 3 - 8 % w/w. They also, demonstrated stronger disintegrant capacity in concentrations of 1 - 3 % w/w; with an in-vitro dissolution pattern in paracetamol tablets that suggests a quicker onset of action than tablets with maize starch disintegrant. They have been used as diluent, binder and or disintegrant in concentrations that depend on the quality and source of the starch.

sweet potato varieties and their starches are used in the food industry and their nutritional value well investigated, this is the first report of their suitability as excipients for use in the pharmaceutical industry and the possible commercial viability of the Hi-starch variety. It is also the first report of their superiority as binder and disintegrant compared to commercial maize starch


Figure: Rice Husk Figure: Baggase

Figure: Corncob

12 number of samples of the different materials were prepared (Table 1). All Samples are composition of the materials in different mass percentage. The samples were prepared into cylindrical shapes of thickness (t), radius (R) and volume, V given by Equation 1.

Figure: Potato starch

Sample no	Rice husk	Bagasse	corncob	starch
1	40	20	-	40
2	20	20	20	40
3	60	-	-	40
4	20	-	40	40
5	-	60	-	40
6	-	20	40	40
7	-	40	20	40
8	40	-	20	40
9	-	-	60	40
10	20	40	-	40
11	30	30	-	40
12	20	20	-	60

Table: Samples and their weight compositions

6. Methodology for experimental setup

The thermal conductivity (κ) of any material is a measure of its effectiveness in conducting heat. Thermal conductivity was determined using heat transfer from the heat source to the sample. Prior to the determination of thermal conductivity, thermal history of individual material was determined. The thermal conductivity tests was conducted in line with the thermal properties of the materials were established using steady-state, one-dimensional condition. The method is based on the principle of hot wire in which a heat pulse is supplied to the sample and the increase in temperature recorded by thermocouple. Type K thermocouple was connected to cold and hot ends of the specimen as well as the centre to measure the temperature

The thermocouple was connected to 1200 watt heat source, and inserted into the sample at the middle. The temperature was recorded at 30 second intervals and the total time used per sample was 5 minutes. The thermal conductivity was obtained by Equation

$$Q=KA\Delta T/\Delta L$$

Where, K is the thermal conductivity (w/m/k), A is the cross- sectional area of the sample (m2), ΔL is the distance between the two wires of the thermocouple, ΔT is the temperature (k) And Q is the quantity of heat supplied (Watt).

(60%B) show higher thermal conductivity in that order respectively. In fig no 5.3 shows rice husk, corncob with bagasse (20%R+20C+20%B) and rice husk with bagasse (40%R+20%B) shows higher thermal resistivity.

7. Results and Discussion

Sample	Thermal conductivity (w/mk)	Thermal Resistivity (mk/w)
1	78.3112	0.01277
2	58.6152	0.01706
3	64.2350	0.01556
4	82.9045	0.01206
5	153.6731	0.00650
6	98.8655	0.01012
7	101.9653	0.00981
8	131.8455	0.00759
9	133.3414	0.0075

10	180.5044	0.00554
11	162.8111	0.00614
12	125.2343	0.007985

Table: Results

8. Conclusion

The following conclusions were drawn from the investigation of thermal insulation properties

1. From the graph of thermal conductivity, it can be concluded that the thermal conductivity of sample no 5 is maximum and that of sample no 2 is minimum.
2. The sample no 5 consists of 20% rice, 40% sugar, 40% starch.
3. The sample no 2 consists of 20% rice, 20% bagasse, 40% starch.
4. The sweet potato starches had superior bulk properties which could present them as possibly more robust and effective diluents compared to commercial maize starch

The used of these material reduces the risk of environmental pollution. Also we have been able to show that these wastes can be used for the production of panels or broad sheet of required thickness for used as walling materials or thermal resistant materials.

In proving that all samples passed each tests and recommended ranges, it shows that it favours insulation materials for naturally cooled design in sub/tropical region.

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