



Comparison of Thermal Insulation Concrete Panel Yield Based on Natural Fibres: A Review

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Abstract: Over time, many researchers have conducted studies to investigate the construction sector by assessing those related to energy, environmental and economic problems to find ways to improve global sustainability. The studies on the use of natural fibers: wheat, date palm and hemp as an insulating material in concrete panel yields have been conducted through ten previous research studies. In the market, there are various types of thermal insulation materials but these materials are sold at high prices and even worse some of them contain harmful chemicals that can threaten the health of consumers. This study is intended to identify ten previous research studies on the use of natural fibers in concrete panel yield as thermal insulation materials. Also, to analyse the data of density and coefficient of thermal conductivity accumulated through Microsoft Excel and propose the best concrete panels yield between these three types of natural fibers. The research was based on the value of density and coefficient of thermal conductivity of concrete panel yield. The results reveal that the presence of natural fibers in concrete panels can insulate heat well. The lowest thermal conductivity coefficient obtained from concrete of Hemp Fibre Gypsum (HG) with 0.051 W/mK. The composition of 35g of hemp fiber, 200g of gypsum and 130ml of water has shown that the amount of fibre and binder used plays an important role in determining the value of density and thermal conductivity. Finally, based on the analysis that has been conducted, found that density and thermal conductivity are inversely proportional when there is a change in the composition of fibers and binders in the concrete panel yields.

Keywords: Thermal conductivity coefficient, natural fibres, concrete panel yields

1. Introduction

The construction and development sector in Malaysia is now growing rapidly. Today's economic development is not only focused on the construction of skyscrapers but also on the housing development sector. Over time, many researchers have conducted studies to investigate the construction sector by assessing those related to energy, environmental and economic problems to find ways to improve global sustainability [1]. Building materials are considered sustainable if they are able to withstand mechanical, physical and chemical stress and have the least impact on the environment throughout its life cycle [2].

Most of the building materials used today are able to adversely affect humans and the environment throughout the life cycle of the building. Concrete is the oldest and most common construction materials in the world, therefore the material used for concrete should be taken into account as it is a mandatory structure of the building [3]. A study found that 33.3% of total energy consumption, 30% of greenhouse gas and 56.7% carbon dioxide emissions [4] are attributed from buildings in most countries [2].

Thermal insulation is defined as a material or combination of materials that inhibits the flow of thermal energy [5]. It is one of the most effective alternatives to save energy and provide thermal comfort to occupants in building [5].

According to the Energy Commission [22] in 2013 reported, the consumption of electricity by domestic consumers only is 20.6% and it shows the consumption is excessive and requires energy efficiency strategies to reduce electricity consumption and environmental pollution. The application of thermal insulation has been found to be able to provide comfort as well as creating more comfortable environment [6].

However, the use of synthetic insulating materials in the market nowadays like fiberglass can lead to lung cancer [7]. The previous research found that synthetic thermal insulation has destructive impact on air, water quality and human health especially those with breathing disorders [8]. In fact, synthetic versions of insulating materials are difficult to recycle once their lifespan expires [9]. Therefore, the development of natural fibers as an insulating material for building materials is a thoughtful idea and should be highlighted.

The thermo-physical properties of building material are crucial to control the use of energy to cool and heat the building [4]. Therefore, natural fibers are the best choice as a thermal insulation alternative in building materials for the high strength, stiffness, thermal properties and corrosion resistance [9] of natural fibers making it the best choice to use as reinforcement in composite materials [10]. The low mass density and cell structure also have shown their thermo-physical properties [11]. The other characteristics of natural fibers are eco-friendly, low cost and its renewable resources make it biodegradable [12].

This research objective is to identify ten previous research on the use of natural fibers: wheat, date palm and hemp fiber in concrete mixtures as thermal insulation materials. Other than that, the research is also to analyse the density and heat conductivity test data for the three different fibers from ten previous research through Microsoft Excel software. The instrument used, Microsoft Excel is to assist in data analysis by graphing the data obtained from ten previous research studies to make a comparison of the value of density and thermal conductivity of concrete panels in order to achieve the third objective which is to propose the best concrete panels yields between these three types of natural fibers: wheat, date palm and hemp fiber.

2. Materials and Methodology

The research methodology briefly lists the procedures to analyze the concrete panels yields from three different types of natural fibers, wheat, date palm and hemp fibers that have the lowest coefficient of thermal conductivity, below 0.01 W/mK to be considered as thermal insulation materials [7]. The relationship between density and thermal conductivity coefficient also be discussed. Fig. 1 shows a research methodology flow chart from overall of the study conducted.

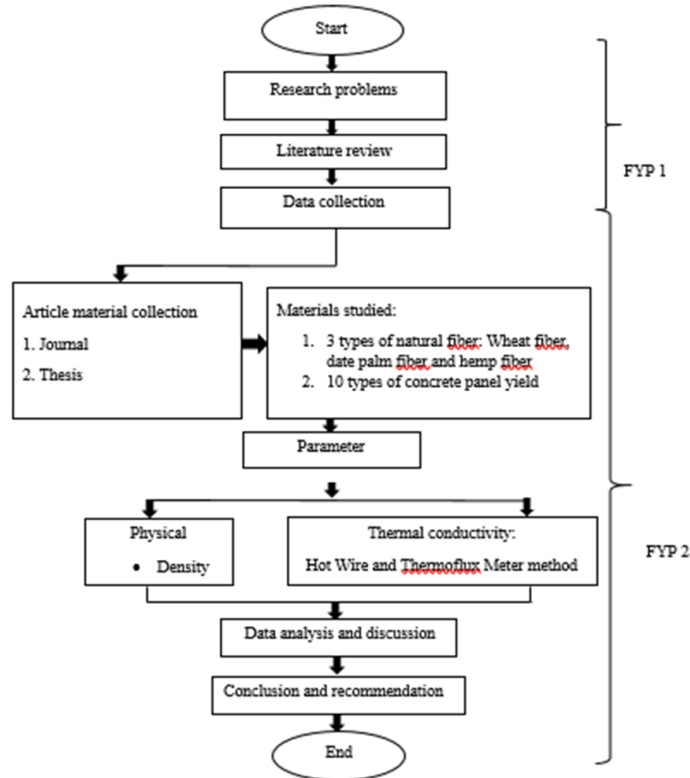


Fig. 1 - Research methodology chart

2.1 Materials

The natural fiber material used in this study is as thermal insulation material in the concrete panel yields. The results of previous studies found that the use of natural fiber in concrete helps in improving global sustainability [1].

- Wheat fiber
The composites made from wheat fiber have great potential due to their low-density properties, less adverse effects on the environment and also have good thermal properties [13].
- Date palm fiber
The concrete based on date fiber is found to be able to reduce the value of density, thermal conductivity, compressive strength of composites and increased water absorption capacity [14].
- Hemp fiber
Cannabis sativa has high strength and stiffness which makes it a useful material and suitable for use as a reinforcement in composite materials [10]. It is also cheap and available natural fiber [12].

2.2 Methods

Based on the ten previous research studies, there are two types of thermal conductivity methods that are widely used: Hot Wire and Thermoflux Metre method. Both types of methods are to obtain the value of thermal conductivity for concrete panel yields.

2.2.1 Hot Wire Method

The method uses platinum wire which serves as a heating element and also as a thermometer. Measurements are made based on the analysis of the temperature response of the analysed material to the heat flow impulse. Heatflux is move with electric heating. The heating resistor is inserted into the heated probe directly with the tested sample. Assessment of thermal conductivity and volume of thermal capacity is based on periodic temperature records in parallel with time [17].

2.2.2 Thermoflux Metre by Using FOX 200 Heat Flow Device

The instrument consists of two basic bases. The test is performed by inserting a sample between the two bases with the temperature in the test chamber being 20°C and the site temperature, 0°C. Both bases on the FOX 200 instrument show temperature differences (ΔT) throughout the sample. The sample thickness (L) is set to suit the thickness target for the compressed sample or the actual sample dimension. FOX Series combines four optical encoders, one at each corner to ensure maximum accuracy. The thermal flux (Q / A) generated from the steady state heat transfer through the specimen is measured by two proprietary thin film heat flux transducers covering the surface area of the upper and lower samples. Average heat flux is used for the calculation of thermal conductivity (λ) and heat resistance (R) according to Fourier's Law [16].

3. Results and Discussions

The data have been successfully collected as a result of ten previous studies on the use of natural fibers in panel concrete mixtures as thermal insulation materials. The data for density and thermal conductivity tests for the three different fibers: wheat, date palm and hemp fibers from ten previous research journals are shown in Table 1.

Table 1 - Turbidity test of copper solution with rive husk activated carbon after adsorption

No	Type of concrete	Density, ρ (kg/m ³)	Thermal conductivity coefficient, λ (W/mK)
1	Hemp Fibre Gypsum (HG) [16]	332	0.051
2	Hemp concrete [18]	263.20	0.065
3	Hemp fibre and binder [19]	233.03	0.074
4	Hemp rapeseed concrete [20]	690	0.089
5	Date palm fiber and lime [4]	680	0.091
6	Lime Wheat Concrete (LWC) [21]	479	0.092
7	Sunflower stalk and wheat fibre [7]	166	0.095
8	Date palm concrete (MDP) [17]	984	0.140
9	Date Palm Concrete (DPC) [14]	546	0.185
10	Milled wheat straw and plaster [8]	138	0.254

3.1 Thermal Conductivity Coefficient, λ

The thermal conductivity coefficient obtained from the review are shown in Fig. 2. According to Fig. 2, the highest value of thermal conductivity coefficient for concrete panel are from the mixture of wheat straw and plaster that were conducted by using Thermoflux Meter method [8]. The highest coefficient of thermal conductivity in the concrete mix of 130g milled wheat straw and 1000g plaster is due to the low fiber content of milled wheat straw which is 130g. It is believed that the heat conduction is mainly done through fiber [15], therefore the lower the amount of fiber, the higher the coefficient of thermal conductivity of material. Hemp Fiber-Gypsum (HG) concrete is a concrete mixture consisting of 35g of hemp fiber, 200g of gypsum and 130ml of water that were found to obtain the lowest thermal conductivity coefficient of 0.051W/mK [16]. The study conducted is a comparison between two types of fiber, namely Sheep Wool-Gypsum (WG) and also hemp fiber, Hemp Fiber-Gypsum (HG). The results of the study found that the low thermal conductivity value is due to the amount of binder, gypsum reduced by 20% compared to the Sheep Wool-Gypsum (WG) recipe which consists of 35g of sheep wool, 250g of gypsum and 160ml of water. An increase in the value of thermal conductivity of 10% is observed due to the thermal properties of hemp fibers which are different compared to sheep wool.

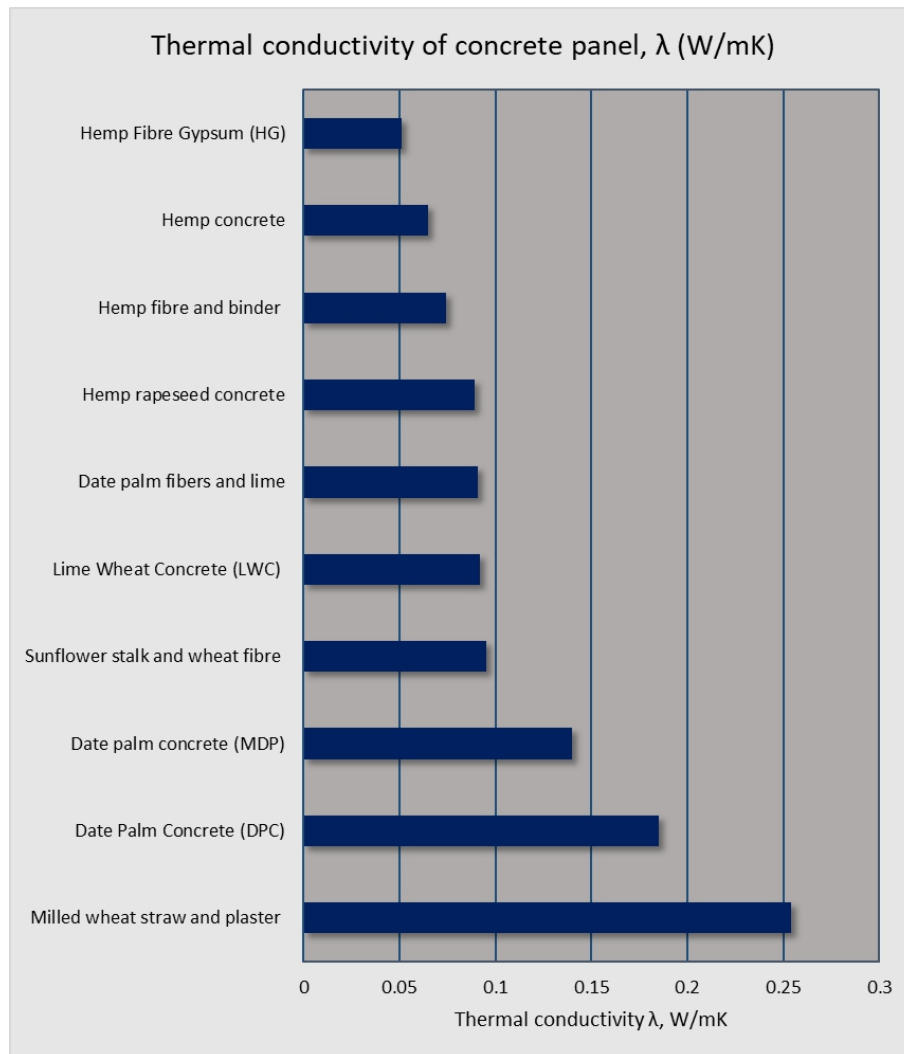


Fig. 2 - Thermal conductivity coefficient of concrete panel, λ (W/mK)

3.2 The Relationship Between Thermal Conductivity Coefficient and Density

The density and coefficient of thermal conductivity are the important parameters to determine the optimal point for selecting the type of insulation building material [17]. The relationship between thermal conductivity coefficient and density of the concrete panel yield that has been analysed by using Microsoft Excel software are shown in Fig. 3. According to Fig. 3, it is shown that an increase of density value influences the increase of thermal conductivity coefficient, and the decrease of density value affects the decrease of thermal conductivity coefficient. A concrete panel yield consisting of milled wheat straw and plaster with a composition of 130g and 500g obtained the highest value of

thermal conductivity coefficient of 0.254W/mK with a density of 138kg/m³. Meanwhile, the concrete panel yield of 35g hemp fiber, 200g gypsum and 130ml of water has the lowest coefficient of thermal conductivity of 0.051W/mK with a density as low as 332kg/m³. From Fig. 3, it shows that Date Palm Concrete (MDP) obtained the highest density value of 984kg/m³ with low thermal conductivity value of 0.14W/mK. The concrete panel yield of Nadia's studies has used 62% of cement where it has exceeded 50% of the total ingredients. The study by Nadia concludes that the increase in density value is due to the use of excessively high amount of binder in concrete panel yield [17]. This study also proves that value of density and thermal conductivity are inversely proportional when there is a change in the composition of fibers and binders in the concrete panel yields.

The relationship between thermal conductivity coefficient and density for these two types of fibers are slightly different from the results of the study which states that the density and coefficient of thermal conductivity are directly proportional [5]. This is because the value of density and coefficient of thermal conductivity is also influenced by the amount of binder and the type of binder used [7],[16]. The results of concrete panels yield with the highest coefficient of thermal conductivity use high amount of plaster binder, which is 500g. Meanwhile, the results of concrete panels with the lowest coefficient of thermal conductivity use only 200g gypsum type of binder. It is clear here, the more amount of binder used, the higher the thermal conductivity coefficient. Next, a study conducted states that the value of thermal conductivity decreases in parallel with the decrease in density and increase in the amount of fiber [4],[17]. The fibers embedded in the composite tend to produce and increase the porosity and air in the matrix [17]. Consequently, the more fiber used, the higher the porosity and cause a reduction of density. Then, the low-density values will result in low thermal conductivity [7].

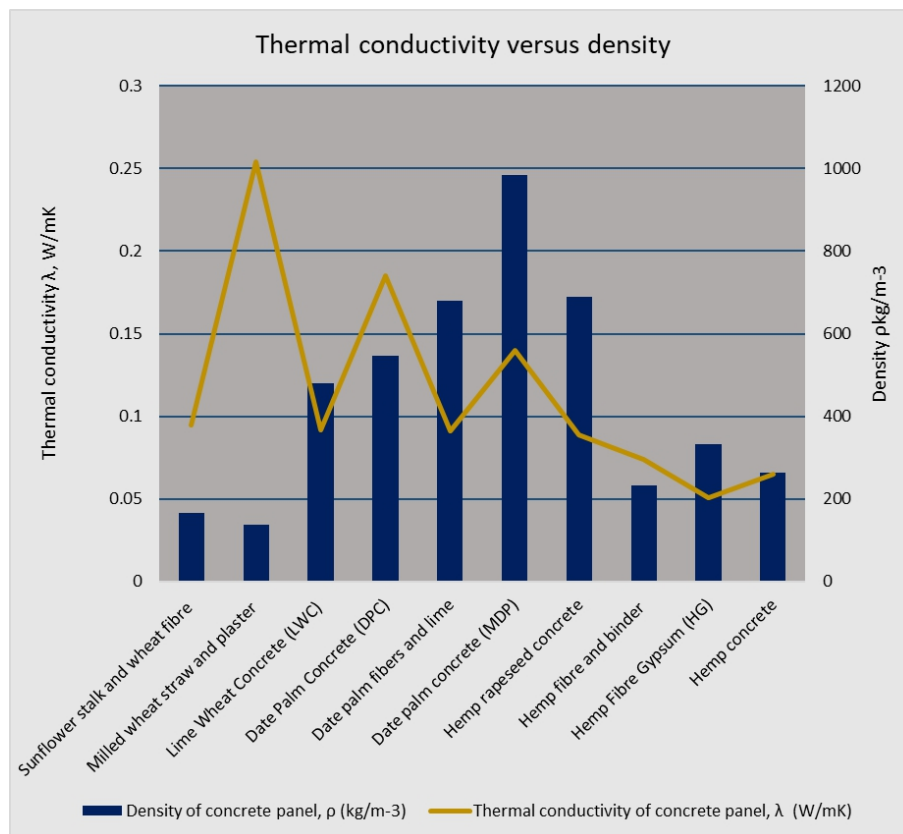


Fig. 3 - Thermal conductivity versus density

4. Conclusion

In conclusion, based on the 10 articles reviewed, the most suitable natural fiber to be used as insulating material in concrete panel yield is the concrete consisting of 35g hemp fiber, 200g gypsum and 130ml of water due to the low amount of binder used. Its low thermal conductivity coefficient, 0.051 W/mK and 332 kg /m³ of density make it the best thermal insulating concrete panel. Based on the study, all objectives have been successfully achieved. Finally, based on the analysis that has been conducted, found that density and thermal conductivity are inversely proportional when there is a change in the composition of fibers and binders in the concrete panel yields.

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