Experimental investigation on the mechanical properties of wood sawdust and plaster of paris reinforced composite

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Abstract. In this work the wood sawdust and plaster of paris have been reinforced to form a new composite material. The materials which have been used are wood sawdust and plaster of paris. Wood sawdust is a derivative of several operations on wood such as drilling, routing, sanding, milling, sawing, planing etc. and plaster of paris is made from gypsum. Gypsum is heated at 373 K in a furnace to lose some water content and thus POP (plaster of paris) is formed. Both materials are mixed together with the help of water to form a paste and are freezed at 0°C for 24 hours. And three different samples are made by varying the ratio of sawdust and plaster of paris. The samples are obtained in the 15cm x 15cm x 3.5cm dimensions by using a plastic box and is given in the laboratory for testing various properties such as density, ash content, hardness, compression load, hardness at -40°C etc. Three different samples are in the ratios (WSD: POP): 3:1, 1:1, 1:3 are obtained. Out of three the third sample gives the best result and can be used as a construction material in cold places.

Keywords. Composite, wood sawdust, plaster of paris, properties, hardness

1. Introduction

Sawdust is a waste product formed by various operations done on wood such as milling, cutting, planing, sawing, routing etc., it has no practical use. However it has been used several times to form a new composite which can be used in construction sector [1], [5], [6]. Plastic waste is one of the major problems nowadays and is responsible for environmental pollution to a great extent. Thus it has been blended with wood sawdust so as to reduce plastic accumulation and reduce trees cutting [3], [8], [10]. Wood sawdust is also mixed with polypropylene to enhance the properties of wood sawdust and polypropylene such as thermal stability, water absorption etc. so that it can be used in furniture industry, automobile industry and various other industries [2], [4], [9]. Wood sawdust is also mixed with the waste of plant to form chipboards and other items based on dispersed wood [7]. In this project wood saw dust (WSD) and plaster of paris (POP) have been reinforced together to get a new composite material. Plaster of paris has not been used with wood sawdust before to make any construction material. In this paper a total of four experiments have been carried out to arrive at why POP should be used as binding agent with WSD and in last experiments three samples have been
prepared with different WSD to POP ratios in order to get the best composition of WSD and POP which gives the best desirable properties.

2. Materials used

Materials which are used in this composite are wood sawdust and plaster of paris. Wood sawdust is formed as a waste product by various operations on wood such as sanding, cutting, milling, drilling etc. Plaster of paris is formed by heating gypsum at 373 K in a furnace. CaSO$_4$.2H$_2$O (gypsum) → CaSO$_4$.1/2H$_2$O (plaster of paris) + 3/2H$_2$O. Here CaSO$_4$.1/2H$_2$O is plaster of paris and its chemical name is calcium sulphate hemihydrate. Its setting time is 15-20 minutes, density is 780-800 kg/m$^3$, transverse strength is 15-20 kg/m$^2$, compressive strength is 1-3 N/mm$^2$, whiteness is 80-85, fineness is 99, shelf life is six months from date of manufacturing, manufacturing is ‘in house’. Plaster of paris is used in plastering the fractured bones, used in dentistry, making toys, statues and decorative items etc. Another important material which is used in this composite is water, its density in liquid form is 1g/ml at 0°C and boiling point is 100°C.

3. Methodology

It is very simple to make WSD-POP composite, take some quantity of wood saw dust and plaster of paris and mix it well with water to obtain a semi solid paste. Obtain a specific shape with the help of container in which the paste will be kept, fix it properly with the hands so that no voids is left out and keep the container in the freezer (0°C) for 24 hours so that it gets solidified properly. After this take out the composite keep it at the room temperature and note down its temperature. After 15 minutes take out the composite from the container and give it in the laboratory for testing.

4. Experiments and observations

Experiment 1: take 30g of wood sawdust and mix it with 15g of water and keep the paste in small paper glass, allow the composite to get freezed at 0°C for 24 hours. After 24 hours take out the composite from the cup and allow it to cool down at normal room temperature. Note down its temperature after 5 minutes from the time it has been taken out. Observation: temperature of the composite after it has been taken out from the freezer (after 5 minutes) is 10°C, time for which the composite retained its shape is 120 minutes. Inference is there is a need of using a binder to give permanent shape to the composite. Experiment 2: take 30g of wood sawdust and add water in three different quantities i.e. 10g, 20g, 30g, and allow the three samples to get freezed for 24 hours at 0°C. Observation: the temperature of the three samples at room temperature is 0°C and time for which composites retain its shape (all three samples) is 120 minutes. Inference is quantity of water has no effect on the composite. Experiment 3: take 30g of wood sawdust and mix it with different other possible materials which can act as a binder and add water accordingly to get a semi solid paste. Keep the paste in freezer and allow it to get freezed for 24 hours. Take out the composite and note down its temperature and time retention for its shape (table 1).

| Sawdust + binding agent | Temperature (°C) | Shape retention time |
|-------------------------|------------------|----------------------|
| Calcium                 | 10               | 30 min               |
| Plaster of paris        | 10               | permanent            |
| Detergent               | 08               | 15 min               |
| Readymade cement        | 10               | 40 min               |
| White cement            | 10               | 45 min               |
| Kolam powder            | 08               | 30 min               |

Table 1. Observation for experiment 3.
Inference is wood sawdust with pop gives the best result. Experiment 4: prepare three samples (figures 1, 2, 3) for WSD-POP composite by varying the ratios of wsd to pop i.e. 3:1, 1:1, 1:3 (table 2).

Table 2. Composition of different samples.

| Parameters | Sample 1 | Sample 2 | Sample 3 |
|------------|----------|----------|----------|
| Total mass | 500g     | 500g     | 500g     |
| WSD        | 375g     | 250g     | 125g     |
| POP        | 125g     | 250g     | 375g     |
| Water      | 1000ml   | 550ml    | 450ml    |

Figure 1. Sample 1: the ratio of WSD:POP by mass is 3:1.

Figure 2. Sample 2: the ratio of WSD:POP by mass is 1:1.
Figure 3. Sample 3: the ratio of WSD:POP by mass is 1:3.

Give all the samples in the laboratory for determining its density, ash content, hardness, compressive strength, hardness at low temperature (-40°C), sample size is 15cm × 15cm × 3.5 cm.

5. Result and discussion

Properties of all the three samples have been noted down in table 3 and graphs have been made to do comparative study of properties of all the three samples (figures 4, 5, 6, 7, 8).

Table 3. Properties of all three samples.

| Parameters                              | Sample 1       | Sample 2       | Sample 3       |
|-----------------------------------------|----------------|----------------|----------------|
| Density                                 | 0.59g/Cc       | 0.95g/Cc       | 1.24g/Cc       |
| Ash content                             | 8.6%           | 17.76%         | 37.2%          |
| Shore ‘a’ hardness                      | NA             | 30,30,35,35,33 | 79,79,80,80,80 |
| Condition at low temperature (-40°C), kept for 5 minutes | the sample cracks | sample becomes hard | sample becomes hard |
| Compressive load                        | NA             | 0.4 KN         | 1.6 KN         |
| Shore ‘a’ hardness at -40°C kept for 5 minutes | NA             | 40,40,42,42,42 | 82,82,85,85,85 |

From figure 4 we can make out that as the proportion of pop increases the density of samples also increases as pop is denser than wsd. In figure 5 as the proportion of pop increases the ash content of the composite also increases. In sample 1 the proportion of pop is less that’s why its hardness cannot be obtained due to its poor strength. And hardness increases as pop proportion increases in the composite (figure 6). At -40oC temperature, sample 1 cracks whereas samples 2 and 3 become harder, sample 1 cracks due to less proportion of binding agent pop, whereas sample 2 and sample 3 become harder due to their comparatively higher proportion of pop (binding agent). In figure 7, as pop proportion increases the compressive strength of the sample also increases. As pop proportion increases the sample becomes harder at low temperature (figure 8).
Figure 4. Samples Vs density.

Figure 5. Samples Vs ash content.

Figure 6. Samples Vs hardness number.

Figure 7. Samples Vs compression load.
6. Conclusion

From the results and discussion we can conclude that the desirable properties for the composite material (WSD-POP Composite) such as hardness, compressive strength, hardness at low temperature, increases with increase in pop proportion. Thus, the composite with wsd and pop in the ratio 1:3 gives the best result and can be used as the construction material in cold places.

Acknowledgements

I express my thanks to my project guide Mr A Muniappan, Assistant Professor at Saveetha School of Engineering, SIMATS for his support. I also extend my warm thanks to my college Saveetha School of Engineering, SIMATS for giving this opportunity and Kidao Laboratories, Chennai, India for carrying out the testing of my samples.

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