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Coconut Shell as an Alternative for Asbestos in Asbestos Cement Sheets

Rajakumar R[1], Midhun T M[2], Anoop K[3], Aiswarya S[4], Deepthi K R [5], Anusree A D[6]
6th Semester B Tech Students of Civil Engineering Department[1, 2, 3, 4, 5, 6], Sahrdaya College of engineering Kodakara
Email: rajakumarr007@gmail.com[1], midhuntm94@gmail.com[2]

Abstract- Most of the corrugated roofing sheets have damaged due to tearing out at its corrugations by high wind loads and impact loads. The strength of these corrugations can be improved with fiber reinforcement, as the fibers are the crack arresters and absorbs energy. At a time asbestos was the dominant fibrous material used for making corrugated roofing sheets. Due to its adverse effect on human health and environment its use is banned or restricted to a level .Therefore an alternative for asbestos is essential .In this paper fibrous coconut shell powder is used as reinforcement in cement matrices for producing corrugated roofing sheets has been investigated and reported. Coconut shell is a durable material and not easily destroyed by microbiological action. Because of its low density, coconut shell can be used as lightweight aggregate to make low-density concrete. Ordinary Portland cement based roofing sheets were cast manually with coconut shell powder as a reinforcing agent and the strength of the corrugations of the above composite sheets in terms of Flexural load is experimentally evaluated. Thus the possibility of use of coconut shell fiber as a better alternative for asbestos is been investigated. It is found that the flexural strength of the cement based coconut shell fiber corrugated roofing sheets was improved as compared to the corrugated sheets without coconut shell fibres. Apart from this if the content of silica when increased will make the specimen more water resistant, adding ammonium sulphate will improve the fire resistant property of the specimen.

Index Terms- Asbestos, Coconut shell, Flexural strength.

1. INTRODUCTION

Asbestos is a fibrous mineral occurring in natural deposits. Asbestos fibers are divided into two classes, serpentine and amphibole, on the basis of their crystal structure. Amphiboles are characterized by having very strong and stiff fibers, which makes them a serious health hazard. Amphibolic asbestos fibers can penetrate body tissue, especially in the lungs, and eventually cause tumors to develop. In reference of the situation persisted few decades earlier, presently the exposure to asbestos fibre is restricted in developed and industrialized countries and pressure has started mounting in the developing countries.

Coconut shell have good durability characteristics, high toughness and abrasion resistant properties, it is suitable for long standing use. The shell is similar to hard woods in chemical composition, though lignin content is higher & cellulose content is lower. Calculated on the dry basis, coconut shell contains approximately the following percentage: cellulose 33.61; lignin 36.51; pentosans 29.27 and ash 0.61. The percentage composition of coconut shell ash is approximately as follows: K20, 45.01; Na20, 15.42; CaO, 6.26; MgO, 1.32; Fe203 + Ab03, 1.39; P20s, 4.64; S03, 5.75 and SiO, 4.64. It has a hardness value of 20kg/cm^2 while tested in Rockwell hardness testing machine, abrasion resistance of 65%,density of 1.6g/cm^3 and compressive strength of 5kg/cm^2.

2. COCONUT SHELL CHARACTERISTICS

2.1 Tensile properties

The mechanical properties of the coconut particle filled epoxy resin composite materials were determined by universal testing machine at 0.1mm/min strain rate under displacement control mode.

Table 1: Tensile Properties of coconut shell particle reinforced

S. NO	20 wt% Shell powder reinforcement	25 wt% Shell powder reinforcement	35 wt% Shell powder reinforcement
Ultimate strength (MPa)	30.60	29.40	25.20
Modulus of elasticity (MPa)	856.00	756.00	654.00
% elongation	25.44	25.436	21.00

2.2 Density

Density is one of the most important mechanical properties of the particle board material. The density of coconut shell particle reinforced composite for various wt % of particle are presented in Table No.2. From table No.2 it is observed that density decreases with respect to wt% of shell particle. But there is remarkable decrease of 0.12 g/cm3 in density when wt% of shell particle changes from 20% to 35%. Here it is possible to comment that density decreases with increase of wt% of particle. The decrease in density can be related to the fact that the coconut particles are light in weight but occupy substantial amount of space. Particles are not closely bonded to each other due to open mould casting method.

Table 2: Density of coconut shell particle reinforced composite

S. NO	Coconut particle (20 wt %) (gm/cm^3)	Coconut particle (25 wt %) (gm/cm^3)	Coconut particle (35 wt %) (gm/cm^3)
1	1.293	1.287	1.170
2	1.287	1.283	1.171
3	1.285	1.278	1.173
Mean	1.288	1.283	1.171

3. CHARACTERISTICS OF CORRUGATED AC SHEET

3.1 Load Bearing Capacity

The load bearing capacity of corrugated and semi-corrugated sheets shall be not less than 5 N/mm^2 width of specimen tested, when tested in accordance with IS 5913: 1989.

3.2 Impermeability (Optional Test)

The specimens shall not show during 24 hours of test any formation of drops of water except tracts of moisture on the lower surface, when tested in accordance with IS 5913: 1989.

3.3 Frost Cracking (Optional Test)

This test may be performed by mutual agreement between the purchaser and the manufacturer for sheets to be used in special situations likely to be affected by frost. Visual examination of the specimens when tested for frost cracking in accordance with IS 5913: 1989, shall not show any cracking, surface alteration or delamination.

3.4 Density (Optional Test)

Density of the specimens shall be not less than1'40 g/cm3, when tested in accordance with IS 5913: 1989.

4. EXPERIMENTAL ANALYSIS

4.1 Materials and methods

Ordinary Portland cement (OPC - 53 grade); graded river sand conforming to IS: 383[44]; potable water and coconut shell powder (passing through IS 300µm sieve, 20%, 15%, 10%, 5%, 2%, and 1%- by weight of cement); were the various material used. Coconut shell was been collected from the locality and been crushed using an abrasion testing apparatus and is sieved through IS 300µm sieve

4.2 Preparation and testing of specimens

*Galvanized corrugated sheets*1.0m x 1.2m x 0.5mm (commercially available) was used as a mould to cast coconut shell fiber cementitious composite corrugated sheets of size 440 x 230 x 6 mm. 1:2 mix (Cement: Sand) was selected and adopted to cast the sheets. Six coconut shell fiber contents in the range of 20% to 1% were considered, for the flexural strength studies on the corrugations of roofing sheets. Altogether 6 mix combinations were considered (20%, 15%, 10%, 5%, 2%, and 1%). For each mix combination, three sheets were cast. Water content required for each combination of the mix was obtained from the flow table test for 1:2 mix coconut shell fibers, at a constant flow value of 50.

4.3 Casting procedure

A brief description of the casting procedure is given below:

(i) A molding frame made of plywood (size 440 x 230 x 6 mm) is kept over a plywood sheet. A plastic sheet is placed in between the frame and the plywood sheet, to provide a smooth surface for casting and for easy demoulding.

(ii) Freshly mixed mortar was carefully placed within the mould frame and spread to cover the entire area, and properly leveled.

(iii) The mortar mix was spread into a uniform thickness and the surface was leveled and smoothened.

(iv)The plywood molding frame was removed carefully and the flat molded mortar specimen was gently placed over a Galvanized corrugated sheets by lifting up the plastic sheet. Care was taken to ensure that the flat molded mortar specimen comes over the valley of the 'Galvanized corrugated sheets' so that the wet or green mortar will not slide down.

(v) After shifting the molded mortar over the 'Galvanized corrugated sheets' a PVC pipe having its diameter equal to dimensions of the valley was rolled over the wet mortar in the valleys and in the ridges so as to get a smooth finishing on the wet cementitious mortar specimen.

(vi)The above sheets were then 'moist cured' initially for 3 days and then subjected to 'immersion curing' for the remaining 25 days to complete 28 days of normal curing.

5. TESTS AND TEST PROCEDURE

Generally roofing sheets are expected to fulfill certain properties such as : (i) light in weight so as not to impose a heavy load on the building; (ii) good flexural strength - so as to offer a good load - (super imposed/total) carrying capacity; (iii) ductility - so as to sustain impact loading; (iv) water tightness - so as to prevent penetration/seepage of rain water into the building ; (v) fire resistant - so as to prevent/retard ignition and spreading of fire; (vi) good thermal properties - so as to provide a 'pleasant indoor climate' for a comfortable living. In the present study, tests were conducted to determine the following characteristics of the coconut shell fiber reinforced cement sheets: (i) flexural strength of the corrugated sheets and (ii) water absorption test on the corrugated sheets.

Fig. 1. Placing mould

Fig. 2. Transferring mixture into the mould

Fig. 3. Leveling using float

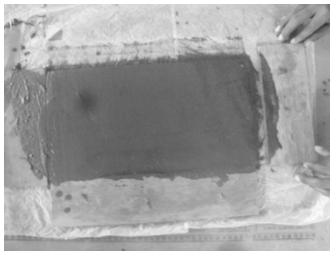


Fig. 4. Demoulding

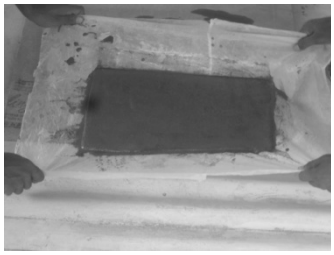


Fig. 5. Transferring to a corrugated sheet

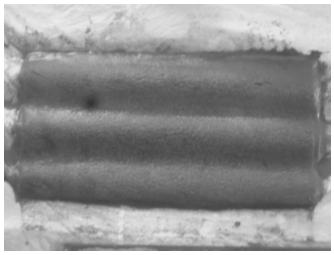


Fig. 6. Finished tile

5.1 Flexural strength test on the corrugated sheet

The testing arrangement for the flexural (bending) tests are similar to that of testing of tiles and as specified in IS: 654-1972 [50]. Corrugated sheets are subjected to a central line load over a simply supported span. The corrugated sheets were all tested in natural dry condition and the load was calculated from the weight of lead balls collected in the steel bucket. Load was gradually applied till failure of the specimen.

5.2 Test for water absorption

For the water absorption test the prepared sample of coconut shell fiber reinforced cement sheets, specimens are dried in an oven for a specified time and temperature and then placed in a desiccator to cool. Immediately upon cooling the specimens are weighed. The specimens are then emerged in water at agreed upon conditions, often 23°C for 24 hours or until equilibrium. Specimens are removed, patted dry with a lint free cloth, and weighed. The difference in two values are noted and the percentage of water absorbed is been calculated from the above noted values.

6. RESULTS AND DISCUSSIONS

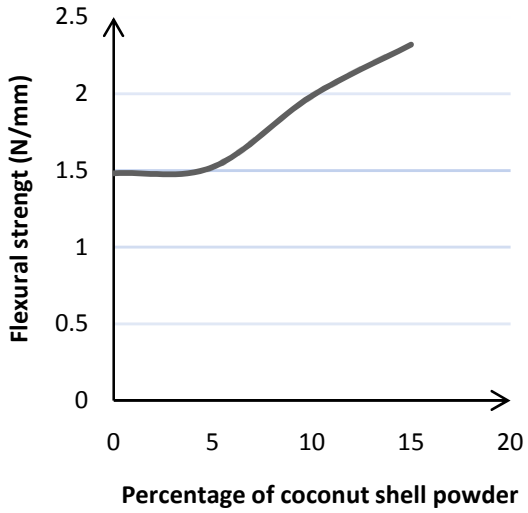
6.1 Flexural load

The Flexural load characteristics of coconut shell fiber reinforced cement sheets is been tested and are given in table below

Table 3: Flexural strength distribution

Observation no	Mix ratio (cement: sand)	Percentage of coconut shell powder	Flexural strength N/mm
1	1:2	0%	1.48
2	1:2	5%	1.52
3	1:2	10%	1.99
4	1:2	15%	2.32

Fig. 7. Flexural strength vs. Percentage coconut shell powder



From the graph it is evident that the flexural strength of the roofing tile increases with the increase in the content of coconut shell fiber.

6.2 *Water absorption test*

The water absorption characteristics of coconut shell fiber reinforced cement sheets is been tested and are given in table below.

Table 4: Water absorption %

Observation No	Wet weight Kg	Dry weight Kg	Percentage of water absorbed
1	1.685	1.543	8.4%
2	1.695	1.537	9.3%
3	1.708	1.553	9.1%

As per IS 459: 1992 the water absorption value of ac sheets should be less than 30% of the total mass. The obtained values are within the limit thus the prepared specimen is good in water resisting property.

7. CONCLUSIONS

Coconut shell is available as a waste product from the coconut industry obtained during the breaking operation of coconuts. The annual production of coconut plucking in Malaysia alone is estimated to be about RM24, 430, 410 in 113,839.9 hectare plantations. It would not be a problem to have a large volume of coconut shell to be replaced in concrete or particle in board. Coconut shell is a durable material and not easily destroyed by microbiological action. Because of its low density, coconut shell can be used as lightweight aggregate to make low-density concrete.

From the studies that we are conducted, we conclude that coconut shell can be used as a substitute for asbestos in Asbestos Cement sheets. Thus reducing the bad effect caused by Asbestos.

8. RECOMMENDATIONS

For improving the properties of roofing tiles made with coconut shell:

The content of silica if increased will make the specimen more water resistant. Adding ammonium sulphate will improve the fire resistant property of the specimen. Changes in the casting procedure such as use of vibrating table in casting can improve the strength related characteristics of the specimen

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