STUDY ON USE OF COIR FIBER FOR HEAT INSULATING PURPOSE

A PROJECT REPORT

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in partial fulfillment for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

TEXTILE TECHNOLOGY

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE

ANNA UNIVERSITY : CHENNAI 600025

May 2006

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BONAFIDE CERTIFICATE

Certified That This Project Report " **STUDY ON USE OF COIR FIBER FOR HEAT INSULATING APPLICATON"** is the bonafide work of **D.ANNAMALAI, T.BOOPATHI, B.DHASHANAMOORTHY, M.SRINIVASAN** who carried out the project work under my supervision.

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ACKNOWLEDGMENT

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We immensely thankful and highly indebted to **Dr.J.Srinivasan**, Professor and head, Textile department, for his timely and valuable advices in exacting this project work successfully.

We thankful guide **Prof.D.L.venkatesh babu** civil department, for his highly valuable guidance, and suggestions, during the entire execution of this project work.

We sincerely thank, Prof **K.Arumugam** correspondent and, **Dr. A.Selva Kumar** joint correspondent for the execution of the project. We wish to express our sincere thanks to **Dr.K.K.Padmanabhan** Principal for his kind permission to carry out project work successfully.

We would like to record our thanks to civil department lectures, and **S.Sethuraman** lab technicians for helping us to carry out the project work in structural lab.

ABSTRACT

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This project describes about the comparative study of coir fiber and asbestos fiber composite and its behavioral aspects.

In this experimental investigation four number of coir sheets were cast with different fiber percentage and length (based on the total weight of cement fly ash and water) keeping the other ingredients to be the same. The tests were conducted as per Indian Standard 5913:2003. Tests are conducted for load bearing capacity, water absorption, impermeability, acid resistance, and density tests were performed on asbestos sheets and on the coir – cement sheet.

The test result's of water observation study, heat insulation study and density study were better when compared to asbestos sheet with respective cost per unit. A detailed review of literature has been presented in this thesis work.

சாராம்சம்

இந்த ஆராய்ச்சியில் நாங்கள் விவரிக்க போவது என்னவென்றால் தேங்காய்நார் அட்டைக்கும் அஸ்பெஸ்டாஸ் அட்டைக்கும் உள்ள வேறுபாட்டையும் அதன் தன்மைகளையும் பார்க்கிறோம்.

இந்த சோதனையில் நான்கு விதமான தேங்காய்நார் அட்டைகள் வெவ்வேறு நீள, அளவுகள் கொண்ட தேங்காய் நார்களால் வடிவமைக்கப்பட்டது (இது சிமெண்ட், பிளை ஏஸ் மற்றும் நீரின் மொத்த எடையை பொறுத்தது) இந்த சோதனைகள் அனைத்தும் இந்திய தரம் 5913 : 2004 கீழ் செய்யப்பட்டது.

இந்த சோதனையில் எடைதாங்கும் அளவு, தண்ணீர் உறிஞ்சும் அளவு, தண்ணீர் கசிவு, அமிலம் தாங்கும் அளவு, அடர்த்தி ஆகியவை அஸ்பெஸ்டாஸ் அட்டைக்கும், தேங்காய்நார் அட்டைக்கும் செய்யப்பட்டது.

இந்த சோதனை தண்ணிர் உறிஞ்சும் அளவு, வெப்பம் தடுக்கும் அளவு, அடர்த்தி ஆகியவை அஸ்பெஸ்டாஸ் அட்டையை காட்டிலும் தேங்காய்நார் அட்டை சிறந்து உள்ளது. அது போல் விலை அடிப்படையிலும் குறைவாக உள்ளது.

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INTRODUCTION

CHAPTER 1

INTRODUCTION

A large variety of fibres have been used as reinforcements to improve the strength and deformation characteristics of cement based matrix such as cement paste, mortar and concrete. Among the various fibres, asbestos fibres are the most widely used because of its certain special qualities. These qualities are high strength natural buoyancy for cement particles and chemical resistance. Over the years, the rates of consumption of asbestos as well as its price have risen considerably. So it can be foreseen that the world's deposit of asbestos may well be exhausted before the turn of this century.

Furthermore it has been realized in recent years that there may be a considerable health risk for persons working with asbestos (the so-called asbestosis), and the public health authorities in several countries have already banned the use of asbestos altogether for the manufacture of some of the products like plane and corrugated roofing materials, side panels, asbestos-cements pipes, fire proof and insulation materials of various types. This investigation has been aimed at finding suitable substitute fibres for various applications.

As a full or partial substitute for asbestos, natural fibres from coconut husk, bamboo, jute, sugar cane begasse, elephant grass and plantain may be used in tropical countries. Since coir fibers are abundantly available in most regions of south India and are relatively less expensive, an attempt has been made to investigate the suitability of these fibres for the manufacture of roofing elements. The roofing element will normally be in form of sheets and tiles.

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURS

2.1 Introduction

In recent years, lots of research works have been done on fibre composite, primarily with steel, glass and coconut fibres. In this chapter, an attempt has been made to review the available literature on fiber composite in general and coconut fiber in particular. Some of the theoretical and experimental investigations are discussed in this chapter.

2.2 Brief historical background

Ludwig hatcheck in 1899 invented asbestos cement which initiated the modern technology of the reinforcement of brittle cement and concrete matrices.

Porter in 1910 strengthened the idea of the inclusion of fibres in composite romouldi and his co-workers (3, 4, and 5) in U.S.A. on steel fibres in cement presented optimistic views, which have helped to arouse greater interest in this material.

Romouldi and Bateon in 1963 have carried out some works on the effect of fiber spacing on the composite.

Jack synder and David Lankard 6, pakotiprapha 7 and rajagopal[8] have carried out works on he effect of fiber orientation and fiber content on the composite,

Herbert krenehol and ole Hejgaard 9 presented a paper on the need for the replacement of asbestos.

State 10 described about the work done at Cornall University on the influence of incorporation of coconut fibres on mechanical properties of concrete in 1976.

Pramasivam, Nathan and Lee in 1984, reported a feasibility study of making coconut fiber reinforced corrugated slabs for use in low cost housing particularly for developing countries.

The SKAT 12 in 1987 has presented the most up-to-date state of the art, based upon a large number of field experience reports as well as laboratory test results on "Fiber concrete Roofing".

Mohandas has done a project on "Investigation on the behavior of coconut fiber reinforced corrugated sheets.

2.3 Theoretical and Experimental Investigation on Fiber Reinforced Composite

Many researchers have done investigation on the properties of fiber reinforced composite. Here an attempt has been made to discuss the theoretical and experimental investigation on the properties of fiber reinforced composite in general and coconut fiber in particular under the following subdivision.

2.4 Fiber Reinforced Composite under Direct Stress

In a general composite system comprising a matrix phase and fiber phase, the behavior and mode of failure of the composite depends on the relative stiffness of the matrix and fiber as well as fiber geometry and fiber matrix interfacial bond strength.

The behavior of fiber reinforced composite under uniaxial tension has been investigated by many researchers and the strength of the composite has been expressed based on the law of mixture as

$$X_c = X_m V_m + X_f V_f$$

Where x and v represents the stresses and volume fraction respectively and the suffixes c, m and f represents the composite, matrix and fiber respectively

In 1971, Surendra, p.shah and rangan investigated mechanical properties of concrete and mortar reinforced with randomly distributed steel fibers to study the mechanism of fiber reinforcement. Parameters chosen for the investigation were the volume fraction, length, orientation and type of fibers. Fibers were compared with conventional reinforcement in flexure, tension and compression. Some of the important conclusion was

1. The fibers have negligible effect on the load at which crack initiate in the matrix.
2. The fibers considerably increase the resistance of concrete to crack propagation and are due to increased tensile and flexural strength and also toughness of the fiber reinforced concrete.
3. The post cracking resistance provided by the fibers is influenced by aspect ratio and orientation of the fibers with respect to cracking direction.
4. The reinforcing action of the fibers can be predicted by using a composite materials approach based on the properties of individual components.

In 1976, state investigated mechanical properties of coir reinforced cement mortar composite. The important conclusion were

1. Modulus of toughness of beams was increased up to about 100% by the presence of fibers
2. Tensile strength was increased in the range of 5% to 39% by the presence of fibers.
3. Compressive strength was title affected by the presence of fibers.

4. Even after maximum load, the fibered concrete remained together in one piece, while the unfibered concrete failed catastrophically and brittle, falling into separate pieces. Further, the fibered concrete could continue to carry a further small sustained load after maximum load, while the unfibered could not except for a much smaller and erratic action among some compression specimen.

2.5 Global Coir Trades

Currently, the global annual production of coir fiber is about 350,000 metric tons (MT). Yet even in the world's top two producers, India and Sri Lanka, which account for about 90 % of global coir fiber production, combined, this renewable resource is underutilized; local coir mills process only a fraction of the available husks, which accurse more or less year round as a waste during coconut processing.

Traditional uses for the resilient and durable coir fiber include rope and twine, brooms and brushes, doormats, rugs, mattresses and other upholstery, often in the form of rubberized coir pads. In the 1980s and 90s, global exports of coir fiber fell by almost half, as western consumers shifted to synthetic foam and fibers. While in 1990 about 80 % of global production was exported, growth of the Indian domestic market dropped that rate to below 40 %.

Global trade volume for coir fiber, value added products – yarn, mats, rugs – and coir pith now stands at about $140 million per year with India and Sri Lanka respectively accounting for about $70 and $60 million of that amount. They give work to 500,000+ people, many of them women working part-time. The challenge for industry is to sustainbly expands markets for this versatile renewable resource while maintaining its role as employer for the rural poor.

2.6 Coir industry in India

Indian coir industry is an important cottage industry contributing significantly to the economy of the major coconut growing states and union territories, i.e., Kerala, Tamil nadu, Andhra Pradesh, Karnataka, Maharashtra, Goa, Orissa, Assam, Andaman & Nicobar, Lakshadweed, Pondicherry, etc. About 5.5 lakh persons get employment, mostly part time,
in this industry. The exports from this industry are around Rs. 70 crores.

India accounts for more than two-thirds of the world production of coir and coir products. Kerala is the home of India coir industry, particularly white fiber, accounting for 61 percent of coconut production and over 85 percent of coir products. Although India has a long coastline dotted with coconut palms, growth of coir industry in other coastal states has been insignificant.

Not more that 50 percent of the coconut husks is utilized in the coir industry, the remaining being used as fuel in rural areas. Production in the cooperative fold is not more than 20 to 25 percent. The development programmers so far undertaken aimed at revitalization of coir cooperatives, improvement in quality and product diversification. Efforts were also made for exploring wider exports markets for coir and coir products.

2.7 General Discussion Of Asbestos

What is asbestos?

Asbestos was called "the magic mineral' because its unique chemical composition and physical properties made it suitable for use in thousand of products from floor tiles to road signs, from sewage pipes to insulating mattresses. Asbestos fibers can be spun and woven as easily as cotton. The term asbestos is derived from a Greek word meaning "inextinguishable, unquenchable or inconsumable." It is generic name for a group of silicate minerals, the most common of which are detailed below.

Chrysotile:

Also known as white asbestos Chrysotile is a member of the serpentine group, so-named because the fiber is curly. Chrysotile fibers are the most flexible of all asbestos fiber and their resistance to alkaline attack makes Chrysotile a useful reinforcing material in asbestos-cement building products. Chrysotile and has traditionally been the most widely used of all asbestos types, accounting for approximately 95% of asbestos mined annually. The import and use of Chrysotile was banned in the UK in 1999.

How does asbestos kill?

As well as being ideally suited for multiple commercial uses, asbestos is also the "perfect carcinogen" as it acts as both a promoter and initiator of

Cancer. Experiment has shown that when an asbestos fiber enters a lung cell it can attract cancer-causing agents. Asbestos fibers are dangerous when inhaled and the dustiest processes are, in general, the most hazardous. That asbestos is a toxic material has been known for decades. Exposure to asbestos has been linked to several disease including asbestosis, lung cancer and mesothelioma.

Lung Cancer:

An article which appeared in the Lancet in 1934 presented evidence of a link between asbestos and lung cancer. Dr. Richard Doll's landmark paper. Mortality from lung cancer in asbestos workers was published in 1955; Dolls research showed that the incidence of lung cancer among men at an asbestos factory in Rockdale was ten times the national norm. Asbestos –related lung cancer can occur from occupational or environmental exposure; it is virtually incurable. The chances of recovery for those whose lung cancer is caused by asbestos are worse because the lungs may already damaged by the dust. On type of lung cancer asbestos causes, undifferentiated, small cell type, is the one with the least hope of treatment. The latency period for lung cancer associated with asbestos exposure is usually between fifteen and thirty five years. An article in the journal of the American Medical Association estimated that asbestos insulation workers who smoke had ninety two times the chance of dying from lung cancer as a non-smoking, on-asbestos worker.

2.8 Global Evidence against White Asbestos Fail To Alarm Indian Government

Asbestos and asbestos based industries are listed under 'Red Categories' by minister of environment and forest, government of India as heavily polluting and covered under central action plan. The Maharashtra pollution control board also listed them in the same category. Also the Indian minister of health informed that asbestos exposure cause's lung cancer and death in the lower house.

The Indian government has lowered import duties for asbestos by 68 % between 1995-2000, giving asbestos imports a decided advantage over polyvinyl alcohol fibers (PVA), whose duties are at about the levels that asbestos was in 1995.

The British Medical Journal (BMJ) of January 31, 2004 reinforces what environmental groups have been saying for many years. Many thousand's of workers have already suffered long, slow and painful death because of exposure to asbestos. Ban asbestos Network of India complements BMJ for publishing this paper.

METHODOLOGY

CHAPTER 3

METHODOLOGY

3.1 PROCESS PLAN

Procuring of coir fibers

⇓

Soaking of coir fiber in mineralized water

⇓

Mixing with dry cement at required
Percentage (as in table)

⇓

Sheet is made with wet mix

⇓

Kept under pressure for 1 day

⇓

Curing minimum of up to 7 days

⇓

Comparing of all the sheet by load bearing test

⇓

Production of main sheet

⇓

Testing of impermeability, acid resistance,
Density, water absorbance, load bearing

3.2 Material used

Cement

The ordinary Portland cement purchased from the same source was used for the entire specimen. The specific gravity of cement was found to be 3.15 and normal consistency was 31%. The compressive strength on 70.7mm mortar cubes were 18.33 N/mm^2 at 3 days and 25.33 N/mm^2 at 7 days. This cement satisfies the strength requirements per I.S.code (i.e. 16 N/mm^2 at 3 days and 22 N/mm^2 at 7 days).

The cement was in standard gunny bags and transferred later to the air -tight steel drums to avoid deterioration of quality.

Water

The water used for mixing and curing is from the same source of supply available in the laboratory for the entire specimen.

Coconut Fiber

The type of coconut fibers used is treated fiber, similar to those in coir ropes. The treated fibers purchased from the market were of uniform quality and of average length and diameter as 200mm and 0.16mm respectively. The specific gravity of the fibers was 1.6 mm respectively

Table 3.1 Physical and chemical properties of coir fiber

S.no	Item	Mean value S.I.Unit
1.	Average fiber length	200 mm
2.	Average fiber diameter	0.16 mm
3.	Specific Gravity	1.60
4.	Ultimate Tensile Strength	133 N/mm2
5.	Elongation at Break in %	29-105
6.	Energy at Break	3.412 x 10-2
7.	Benzene extract, percent	0.31
8.	Alcohol extract, percent	3.48
9.	Water extract, percent	1.18
10.	5 % NAOH extract, percent	4.33
11.	Lignin, percent	34.27
12.	Ash, percent	1.42
13.	Cellulose, percent	34.77

Mix Proportions

Table 3.2

Mix proportion	Fibre Length	Fibre Percentage	Cement Weight In Grams	Fly Ash Weight In Grams
M_1	Short Fiber (5 Mm)	9.0% (45 Grams)	420	42
M_2	Short Fiber (5 Mm)	4.5 % (22.5 Grams)	430	43
M_3.	Long Fiber (Avg 200 Mm)	9.0% (45 Grams)	420	42
M_4.	Long Fiber (Avg 200 Mm)	4.5 % (22.5 Grams)	430	43

The mix proportions were prepared based on literature review and standards.

3.3 Objects of the present Investigation

In this investigation, an attempt has been made to suggest an alternative for asbestos cements sheets. An attempt also has been made to develop a low cast technology of production of coconut fibers reinforced corrugated sheets. This method can be used in rural areas where there is no electricity with the availability of simple equipment.

To study the general behavior of coir reinforced cements sheets for constants thickness.

To observe the ultimate load carrying capacity of coir cement sheet and compare the asbestos sheet.

To determine physical, chemical and mechanical properties of coconut fiber and the coir cement mortar composite. (specific gravity, modulus of elasticity, ultimate tensile strength, chemical composition of fibers and density test, acid resistance test, impermeability test, water absorption test, compressive strength, tensile strength, flexural strength etc. of coconut fiber reinforced cement sand mortar composite).

INSTRUMENTATION AND TESTING

CHAPTER 4

INSTRUMENTATION AND TESTING

4.1 Introduction

One of the main objectives of this thesis is to calculate the ultimate load bearing capacity of the entire coir cement sheet made as in the table given. And then to compare there load bearing capacity of these sheets and to make a main coir cement sheet so that it can with stand higher load. The standard tests such as water impermeability, water absorption, density, acid resistance, and load bearing capacity tests are performed on asbestos sheets are performed on the coir cement sheet.

4.2 METHODS OF TEST

4.2.1 Visual Inspection

The sheet and boards shall be visually to check the following

1. Uniformity of texture
2. Flatness
3. Neatness and straightness of the trimmed edges and square ness of the Corner
4. Rectangularity

4.2.2 Water Absorption Test

Size of Specimen

From each of the sheets, boards selected in accordance with the sampling method given in the relevant specification, a specimen 175mm×75mm in the case of sheets and 25mm long in case shall be cut.

Testing Procedure

The specimen shall be completely immersed in water at 15 to 35°c for a period of 18 h. These shall be taken out and weighed after removing surplus moisture with a damp cloth (M1). The specimen shall then be placed in an air-oven capable of being raised to 150°c and then temperature constantly.

The heating shall be commenced with the oven ventilator wide open, raising the temperature from about 105 to 150°c to dry the specimen to constant mass. The test pieces shall then be cooled for at least 1 h in a desiccators containing anhydrous calcium chloride and weighed (M2)

Formula used

The absorption shall be calculated as follows

$$\text{Absorption percent} = \frac{m_1 - m_2}{m_2} \times 100$$

Where

m_1 = mass in g, of specimen after absorption,

m_2 = mass in g, of specimen after heating.

The specimen shall not be placed in contact with one another, but shall be distributed uniformly throughout the oven. Wet specimens shall not be introduced into an oven in which the drying of other specimens is already in progress.

4.2.3 Test for Impermeability

Test for impermeability shall be carried out as per I.S.5913:2003

Size of specimen

This test is performed on asbestos cement sheets. From each of the sheets selected in accordance with the sampling method given in the relevant specification, one square test piece about 100 mm × 100 mm shall be cut.

Testing Procedure

A transparent or metallic tube of 35±5 mm diameter and 300 mm long shall be sealed to the middle of the test piece and held vertically. The test piece shall be supported on a suitable arrangement, which provides the bottom surface to be inspected. The sealing of the tube shall be done for corrugated sheet at the center of the valley and for semi-corrugated sheets in the flat portion between corrugations. The tubes may be suitably shaped at the bottom for this purpose, as necessary.

The tube shall be filled up with water carefully to about 250 mm height, If necessary by providing overflow line to maintain the required constant height and it shall be ensured that water does not leak through the sealing. Arrangement shall be provided in the test equipment to evacuate entrapped air. The test shall be conducted at 15 to 35°c and at a relative humidity of 45 to 75 percent.

4.2.4 Load Bearing Test

Size of Specimen

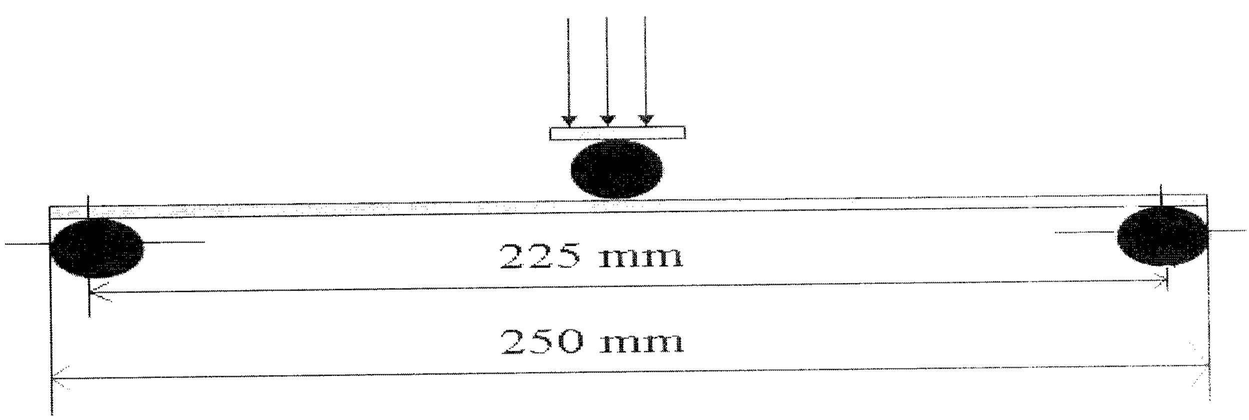
From each sheet selected in accordance with the method of sampling given in relevant standard, two specimens each measuring 250 X 250 mm shall be cut. The test piece shall be cut from the same part of the sheet as shown in fig. the fib redirection shall be marked on each if the test pieces. The specimens shall be tested in both longitudinal and transverse direction accordingly.

Testing Procedure

Immediately prior to the test, the specimens shall be completely immersed in water at 15° to 35°c for a period of 24hrs. The test specimen shall be placed centrally on self-aligning bearers, A, B and c as shown in fig. The underside of specimen shall be contact with bearers A and B. The bearers shall be of mild steel 40mm in diameter and shall be in the same horizontal plane and parallel to each other.

The distance between the bearers A and B at the lines of contact with the specimen shall be 225mm. Bearer C shall be midway between A and B measured horizontally and rest upon the surface of the specimen.

The load shall be applied at a uniform rate and so regulate that breaking occurs after not less than 5 s. Measure the thickness at two points along the section of breakage as indicated in fig. Reassemble the broken pieces and submit to a second bending test with then line of load application at right angles to that of first. Measure the thickness of the test piece in two points along with new section of breakage as indicated in fig.



Formula used

The unit bending stress (R_f) expressed in Mn/m^2 for longitudinal and transverse direction shall be calculated separately as below and the arithmetical means of two values so obtained shall be considers for each of the specimen

$$R_f = \frac{M}{W}$$

Where

$$M = \frac{PL}{4} \qquad W = \frac{be^2}{6}$$

Where

P = breaking load, in N

L = Clear span between the supports, in mm

b = actual width of test piece, in mm and

e = actual thickness of test piece in the breaking section, in mm

4.2.5 DETERMINATION OF DENSITY

Size of Specimen

The test shall be carried out on a 40mm X 60mm uncoated sample of material selected according to the procedure for sampling given in the relevant standard.

Testing Procedure

Determine the dry mass of the test specimen after drying sample to constant mass at a temperature of 100 to 105°c in an oven. Determine the volume of then test specimen by immersing saturated test specimen in water and measuring the volume of displaced water.

Formula used

Calculate density by the following formula

$$\rho = \frac{M}{V}$$

Where,

ρ – Density, in g/cm^3,

M – Dry mass of the test specimen, in g

V - Volume of the test specimen, in cm^3.

4.2.6 ACID RESISTANCE TEST

Size of Specimen

From each of the sheets selected in accordance with the sampling method given in the relevant standard, three specimen each having a total surface area including edges of approximately 10 000 mm^2 shall be cut.

Testing Procedure

Each specimen of pair of specimen shall be placed upright for 24 h in 270 ml of 5 percent acetic acid solution at 15 to 35°C contained in a vessel of such a size that the specimen is completely immersed. Separate vessels and solution shall be used for each specimen or pair of specimens. The concentration of the acetic acid shall be determined before and after the immersion of the specimen by titration against a solution of sodium hydroxide of known concentration (approximately 0.5N), using thymol blue as indicator. For titration, 10 ml of the acid solution shall be first stirred, and then diluted to 100 ml and 10 drops of thymol blue solution (0.040 g in 100 ml 95 percent alcohol) added to it.

The end point to be taken is that the color change from yellow to blue corresponding to pH value 8.0 to 9.5, the small amount of gelatinous precipitate formed does not interfere.

Formula used

The result shall be reported in terms of grams of acetic acid per square metre of area of the specimen and this value shall be calculated from the fall in concentration, assuming that one millimeter of 0.5 N sodium hydroxide solution is equivalent to 0.030 g of acetic acid as follows:

$$\text{Mass in g, of acetic Acid used per m}^2 = \frac{0.030 \times 270\,(x-y)}{10\,A}$$

$$= \frac{0.81\,(x-y)}{A}$$

Where

X = volume, in ml, of 0.5 N sodium hydroxide
Used at the initial titration

y = volume, in ml, of 0.5 N sodium hydroxide
Used at the final titration

A = area, in m^2, of unprotected asbestos cement of the specimen

4.3 Calculation

The load bearing of all the four types of sheets prepared (as in the table) were calculated and concluded, that on which percentage and length we get the highest load bearing value.

Specimen size = 250 mm x 250 mm

Formula used

$$M = \frac{PL}{4} \qquad W = \frac{be^2}{6}$$

Where

P = breaking load, in N

L = Clear span between the supports, in mm

b = actual width of test piece, in mm and

e = actual thickness of test piece in the breaking section, in mm

$$R_f = \frac{M}{W}$$

Where

R_f = Bending stress in N/mm^2 or $Mn/\ m^2$

Mix 1

9 % coir fiber (short fibers)

$$M = \frac{90 \times 225}{4}$$

$$= 5062.4 \ \text{N/mm}$$

$$W = \frac{250 \times 8^2}{6}$$

$$= 2133.33 \ \text{mm}^3$$

$$R_f = \frac{5062.4 \ \text{N/mm}}{2133.33 \ \text{mm}^3}$$

$$R_f = 2.37 \ \text{N/mm}^2$$

Mix 2

9 % coir fiber (long fibers)

$$M = \frac{188 \times 225}{4}$$

$$= 10575 \ \text{N/mm}$$

$$W = \frac{250 \times 8^2}{6}$$

$$= 2133.33 \ \text{mm}^3$$

$$R_f = \frac{10575 \ \text{N/mm}}{2133.33 \ \text{mm}^3}$$

$$R_f = 4.95 \ \text{N/mm}^2$$

Mix 3

4.5 % coir fiber (short fibers)

$$M = \frac{82 \times 225}{4} \qquad W = \frac{250 \times 8^2}{6}$$

$$= 4612.5 \text{ N/mm} \qquad = 2133.33 \text{ mm}^3$$

$$R_f = \frac{4612.5 \text{ N/mm}}{2133.33 \text{ mm}^3}$$

$$R_f = 2.16 \text{ N/mm}^2$$

Mix 4

4.5% long fibers

$$M = \frac{172 \times 225}{4} \qquad W = \frac{250 \times 8^2}{6}$$

$$= 9675 \text{ N/mm} \qquad = 2133.33 \text{ mm}^3$$

$$R_f = \frac{9675 \text{ N/mm}}{2133.33 \text{ mm}^3}$$

$$R_f = 4.53 \text{ N/mm}^2$$

Mix 5

Asbestos sheet

$$M = \frac{205 \times 225}{4} \qquad W = \frac{250 \times 8^2}{6}$$

$$= 11531.2 \text{ N/mm} \qquad = 2133.33 \text{ mm}^3$$

$$R_f = \frac{11531.2 \text{ N/mm}}{2133.33 \text{ mm}^3}$$

$$R_f = 5.4 \text{ N/mm}^2$$

Table 4.1 Load bearing test result of all Mixes

Mix proportions	Sheet Specification	Bending Stress In Mn/m^2
M_1.	9.0 % short fiber	2.37
M_2.	9.0% long fiber	4.95
M_3.	4.5 % short fiber	2.16
M_4.	4.5 % long fiber	4.53
M_5.	Asbestos sheet	5.40

TEST RESULT'S AND DISCUSSION

CHAPTER 5

TEST RESULT'S AND DISCUSSION

Sample Calculation

5.1 WATER ABSORBTION

Coir cement sheet

$$\text{Absorption percentage} = \frac{m_1 - m_2}{m_2} \times 100$$

m_1 = 100 grams $\quad$ m_2 = 78 grms

$$= \frac{100 - 78}{78} \times 100$$

$$= 28.205\ \%$$

Asbestos sheet

m_1 = 124 grams $\quad$ m_2 = 98 grams

$$\text{Absorption percentage} = \frac{128 - 98}{98} \times 100$$

$$= 26.53\ \%$$

5.2 ACID RESISTANCE TEST

Coir cement sheet

$$\text{Mass in g, of acetic Acid used per } m^2 = \frac{0.030 \times 270\,(x-y)}{10\,A}$$

$$= \frac{0.81\,(x-y)}{A}$$

Initial titration = 21.0 Final titration = 13.60

$$\text{Mass in g, of acetic Acid used per } m^2 = \frac{0.81\,(21 - 13.6)}{0.01}$$

$$= 599.4$$

Asbestos Sheet

Initial titration = 20.12 Final titration = 12.75

$$\text{Mass in g, of acetic Acid used per } m^2 = \frac{0.81\,(20.12 - 12.75)}{0.01}$$

$$= 596.97$$

5.3 DENSITY TEST

Coir cement sheet

$$\rho = \frac{M}{V}$$

M = 60.28 V = 36.35

$$\rho = \frac{60.28}{36.35}$$

$$\rho = 1.65 \text{ g/cm}^3$$

Asbestos Sheet

M = 58.65 V = 32.32

$$\rho = \frac{58.65}{32.32}$$

$$\rho = 1.81 \text{ g/cm}^3$$

Table 5.1 Water Absorption Test Result Of M_2 Coir-Cement Sheet

specimen	m_1 in grams	m_2 in grams	absorption percentage
1.	124.00	98.00	26.33
2.	122.45	97.35	25.78
3.	125.00	98.32	27.13
4.	124.12	98.12	25.47
5.	123.62	97.82	26.34

Mean 26.21 %

Table 5.2 Water Observation Test Result Of Asbestos Sheet

specimen	m_1 in grams	m_2 in grams	absorption percentage
1.	100.00	78.00	28.20
2.	102.31	80.60	26.93
3.	98.92	76.56	29.02
4.	97.66	75.44	29.50
5.	100.86	78.32	28.71

Mean 28.47 %

Table 5.3 Load Bearing Test Result of M_2 Coir-Cement Sheet

S.no	M In N/mm	W In mm^3	R_f In N/mm^2
1.	10575	2133.33	4.95
2.	10372	2133.33	4.86
3.	10472	2133.33	4.91
4.	10670	2133.33	5.00
5.	10380	2133.33	4.86

Mean 4.91

Table 5.4 Load Bering Test Result of Asbestos Sheet

S.no	M In N/mm	W In mm^3	R_f In N/mm^2
1.	11531.2	2133.33	5.40
2.	11478.4	2133.33	5.38
3.	11542.1	2133.33	5.41
4.	11398.6	2133.33	5.34
5.	11560.7	2133.33	5.41

Mean 5.38

Table 5.5 Acid Resistance Test Result of M_2 Coir-Cement Sheet

S.no	Initial Titration	Final Titration	Mass In Grams Of Acetic Acid
1.	21.3	13.60	623.70
2.	21.0	13.42	613.30
3.	20.3	12.71	614.71
4.	20.5	12.98	613.98
5.	21.2	13.52	622.08

Mean 617.55

Table 5.6 Acid Resistance Test Result of Asbestos sheet

S.no	Initial titration	Final titration	Mass In Grams Of Acetic Acid
1.	20.12	12.75	596.9
2.	21.00	13.46	591.3
3.	20.00	12.83	580.0
4.	20.36	12.92	602.0
5.	20.08	12.86	584.0

Mean 590.9

Table 5.7 Density Test Result of M_2 Coir-Cement Sheet

S.no	Mass in grams	Volume in cm^3	Density in g/cm^3
1.	60.28	36.35	1.65
2.	61.23	37.30	1.64
3.	60.10	35.97	1.67
4.	62.20	36.88	1.68
5.	61.56	37.20	1.65

Mean 1.66

Table 5.8 Density Test Result of Asbestos sheet

S.no	Mass in grams	Volume in cm^3	Density in g/cm^3
1.	58.65	32.32	1.81
2.	57.54	31.50	1.82
3.	58.90	32.18	1.83
4.	58.32	32.08	1.82
5.	57.60	31.40	1.83

Mean 1.82

Table 5.10 Comparison of Thermal Study between M_2 and Asbestos Sheets

TABLE	OUTSIDE TEMPERATURE	INSIDE TEMPERATURE	
		ASBESTOS SHEET	COIR-CEMENT SHEET
11.00 am	35°C	29°C	26°C
12.00 am	38°C	31°C	27°C
1.00 pm	39°C	32°C	28°C
2.00 pm	38°C	31°C	27°C
3.00 pm	35°C	29°C	26°C
4.00 pm	32°C	27°C	24°C

Table 5.9 Test Result Comparison between M_2 and Asbestos Sheet

S.no	Test	coir cement sheet	asbestos sheet
1.	Load bearing test	4.91	5.38
2.	Water observation	26.21 %	28.47 %
3.	Acid resistance	617.55	590.85
4.	Density	1.66	1.82
5.	Impermeability	No water drops	No water drops
6.	Cost per meter	Rs.30/meter	Rs.55/meter

CONCLUSION

CONCLUSION

The following conclusions are drawn within the limitation of experimental study.

GENERAL CONCLUSION

The coir reinforced cement sheet's are strong and possess good bending strength. The sheets possess good thermal insulation and are expected to provide greater comfort in tropical as compared to Asbestos sheets. Their preparation needs neither heavy machinery nor high capital investment. The sheets are cheaper than Asbestos sheets. The roofs made do not require any further finishing or water proofing treatment. Coir-Cement is lighter than asbestos sheet.

SPECIFIC CONCLUSION

The thermal insulation of coir-cement sheet is 3°- 4°c higher than asbestos sheet. Coir fiber sheet requires 30 percentage less cement as compared to asbestos cement sheet. The cost per square meter of flat coir-cement sheet is Rs.30/meter. The cost of flat A.C. Sheet is Rs.55/meter. There is a saving of about 45 % cost for the coir-cement sheet compared with Asbestos Sheet.

Load bearing test

The Load bearing test result of M_2 mix of coir-cement sheet shows higher value than all the other mixes. M_2 mix shows more or less equal in strength to that of asbestos sheets and is satisfactory in performance.

The water absorption test

The water absorption of M_2 mix of coir-cement sheet is 7.9 % lower than that of asbestos sheet.

Acid resistance test

The acid resistance of M_2 mix of coir-cement sheet is 4.3 % higher than that of asbestos sheet and is satisfactory in performance.

Water Impermeability

The Impermeability of coir-cement sheet also results in no water drops.

SUGGESTION FOR FUTURE RESEARCH

SUGGESTION FOR FUTURE RESEARCH

The following suggestions are made for future research.

- This investigation pertains to only two ranges of length and one type of fiber. Different lengths and types of fibers can be tried to determine the influence of fiber length on the strength of the sheet.

- In this investigation, the thickness of the sheet in kept as 8 mm. To reduce the cost and weight further 6 mm thickness may be adopted.

- Other fibers like jute, bamboo, Plantain, sisal, cellulose fiber can be carried out.

- Only one fly ash and cement ratio (1:10) used in this investigation. Fly ash and cement can be taken at different ratio for future investigation.

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