COMPARATIVE STUDY OF GYPSUM PANELS REINFORCED WITH SISAL FIBRE AND COIR FIBRE

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***Abstract*: In this current era there are some concerns of using synthetic fibres in regards to their impact on the environment, since they are non-recyclable and non- degradable. There are many attempts by various groups of engineers and researchers use natural fibres in engineering applications, in the hope of replacing synthetic fibres with natural fibres. In this study, the potential of utilizing natural fibres in construction substances is studied such as compressive strength and water absorption. Gypsum boards are reinforced using sisal fibres for the industrial and construction applications. The sisal fibre has been washed by fresh water and treated with concentration of NaOH (6%), to achieve a real interfacial adhesion between the gypsum and sisal fibre. Due to porous nature of sisal fibre-gypsum composites, as the presence of air voids work as traps and impeded the heat transfer, sisal fibre-gypsum composites performs better than glass fibre- gypsum composites as an insulation material. Hence in the project, we used sisal fibre and coir fibre as reinforcement in gypsum board by studying the mechanical behaviour of plain gypsum board. The optimum percentage of sisal fibre and coir fibre is found out by conducting test at different percentages. Experimental study is conducted to evaluate the compressive strength characteristics of sisal fibre and coir fibre reinforced gypsum board. Also water absorption of the optimum is also found out.**

Index Terms: Sisal fibre, Coir fibre, Gypsum powder

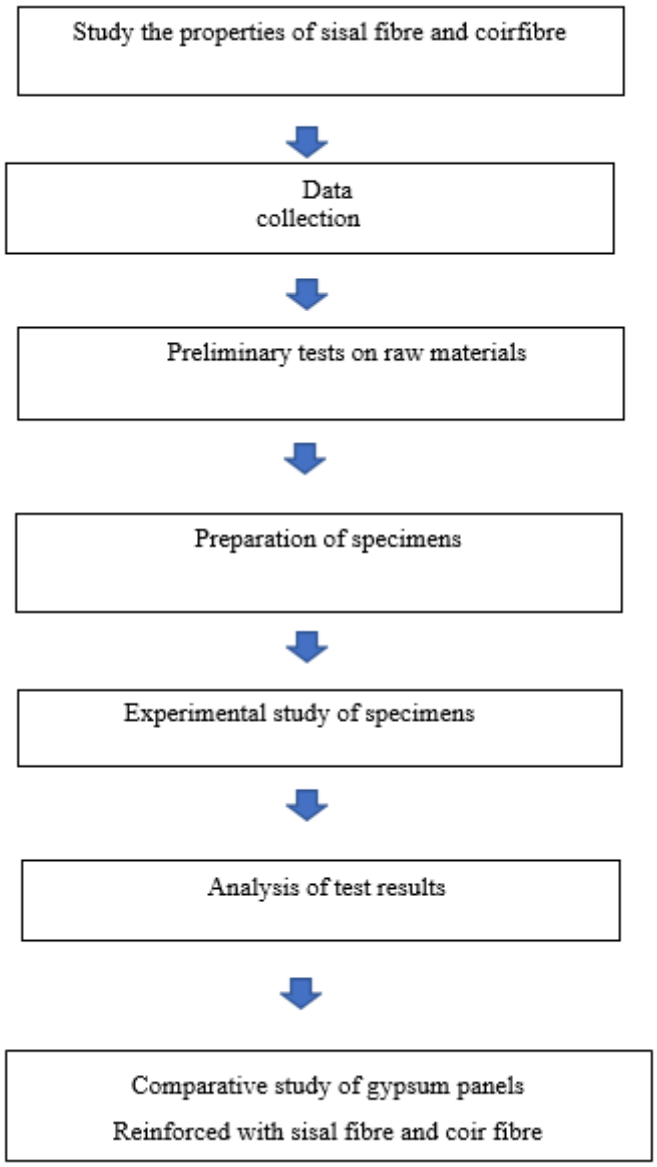
I. INTRODUCTION

Prefabricated gypsum boards have been commonly used in residential, industrial and commercial buildings. Facade panels, internal partitions and dry wall boards due to their low cost, light weight, thermalor acoustic insulation and fire resistance. Moreover, recycled gypsum, derived from gypsum waste plasterboard has recently been utilised as one of the wastes for ground improvement in desperate projects such asembankments, highways and significantly in geotechnical applications along with decreasing the Cost of ground improvement, this has many environmental benefits. Even though, the gypsum plaster itself has a compressive strength as high as 68.9 N/mm² at low water/plaster ratio. Gypsum plaster is weak in tension and it has low impact strength compared to another. In recent years glass fiber is reinforced in gypsum.Because it has light weight, versatility and strength. But application of a fiber as reinforcement in gypsumcould also be beneficial in terms of cost efficiency, energy savings and environmental protection. In recent years, there has been an increasing interest in the substitute of synthetic fibers in many civil engineering fields of natural fibers such as coir, sisal, etc

Sisal is one of the natural fibers which better than other natural fibers in many ways including its higherstrength, variation in its properties and quality due togrowing, poor crimp property so on. The sisal plant has a 7-10-year life span and typically produces 200-250 commercial usable leaves. Each contains an average of around 1000 fibers. Traditionally sisal hasbeen leading material agricultural twine because of itsstrength, durability, ability to stretch, affinity for certain dry stuffs and resistance to deterioration in salt water. Apart from ropes twine, sisal has been utilised as an environmentally friendly strengtheningagent to replace asbestos fiberglass in composite material in various uses.

Coir fibre is also a natural fibre which have high durability and high strength. It is suitable for green building material. The name coir comes from the word kayer. Floor mats, doors, brushes and mattress-like materials made up of natural fibres are extracted from the outer coconut husk. Coir is the hardest internal shell. Mechanical properties of material that exhibits its elastic and flexible (plastic) behaviour. In this study the mechanical properties such as transverse strength, compressive strength and water absorption of gypsum using sisal fiber and coir fibre as reinforcement and compared with those propertiesof plane gypsum board.

METHODOLOGY



Materials required

i. Gypsum
ii. Sisal fibre
iii. Coir fibre

Gypsum

Gypsum is a soft sulfate mineral composed of calcium sulfate dihydrate, with the chemical formula $CaSO_4 \cdot 2H_2O$. It is widely mined and is used as a fertilizer and as the main constituent in many forms ofplaster, blackboard/sidewalk chalk, and drywall. A massive fine-grained white variety of gypsum is called as alabaster. And it has been used for sculpture by many cultures including Ancient Egypt, Mesopotamia, Ancient Rome etc. Gypsum is crystallized into translucent crystals of selenite. It also forms as an evaporite mineral and as a hydration product of anhydrite.

Fig 1. Gypsum powder

Sisal fibre

It is one of the most widely used natural fibre and it is easily cultivated. It is obtained from theplant known as Agave sisalana. These plants produce rosettes of sword-shaped leaveswhich start out toothed, and gradually lose their teethwith maturity. Each leaf of sisal plant contains a number of long, straight fibres. It can be removed by a process called as decortication. The leaves are beaten to separate the pulp and plant material, leaving the tough fibers behind during decortication. The sisal fibers can be draw out and twist into thread for the production of twine and textile or it can be pulped to make paper product. In sisal agriculture there are no pesticides and chemical fertilizers used. It is a stiff fiber traditionally used in making twine, rope. It is used in automotive frictionparts (brakes, clutches), where it imparts green strength to performs, and for enhancing texture in coatings application.

Fig 2. Sisal fibre

Coir fibre

Coir fibre is also a natural fibre which have high durability and high strength. It is suitable for green building material. The name coir comes from kayer Floor mats, doors, brushes and mattress-like materials made up of natural fibres are extracted from the outer coconut husk. Coir is the hardest internal shell. Mechanical properties of a materialthat exhibits its elastic and flexible (plastic) behaviour.

Fig 3. Coir fibre

Tests on raw materials

Tests on gypsum is conducted to analyze it's characteristics. Consistency test and setting time test are conducted on the specimens as per IS 2542 part 1– 1981.The tests conducted on Gypsum are,

a) Consistency test on Gypsum
b) Setting time of gypsum

Casting of specimens

Specimens having 12 mm thickness is casted fordifferent tests as per IS I 2542

a) Water absorption test : 175mm x 75 mm
b) Compressive strength test : 70.71 x 70.71 x 70.71mm

Tests on specimens

Water absorption test and compressive strength test are conducted on the specimens as per IS 2542 part 2 – 1981.

Analysis of result

After the tests conducted the results are analyzed to find out the optimum content of fiber and gypsum combination.

Experimental test procedure

To meet objectives of the project, a detailed experimental study was carried out. The studyon the sisal fibre and coir fibre reinforced gypsum boards were checked out through detailed investigation of its strength properties by casting boards in different fibre proportions.

Tests on materials used for experiment

Tests on material used for experiment are normal consistency of gypsum plaster as per IS : 2542 (Part 1/Sec 1) -1978 and setting time of plaster as per IS : 2542 (Part 1/Sec 3) – 1978.

Normal consistency of gypsum plaster

In this experiment first clean the plunger, mould and base plate of the modified Vicat apparatus. Apply a thin coat ofa petroleum jelly or other suitable lubricant on the upper surface of the base plate in order to prevent leaks during the test. Sift a weighed quantity

of the sample (200 to 300 g as required to fill the mould) into a known volume of water. If the plaster is unretarded, add to the mixingwater 0.1 g of commercial retarder per 100 g of sample.

After allowing the sample to soak for 2 minutes, stir the mixture for 1 minute to an even fluidity. Pour this sample into the vicat mould, work slightly to remove air bubbles, and then strike off flush with the top of the mould. Wet the plunger of the modified vicat apparatus and lower it to the surface of the sample at approximately the centre of the mould. Read the scale and release the plunger immediately. After the rod has settled read the scale again. Readings are reproducible on a retarded mix, and therefore, in order to eliminate error 2 or 3 determinations should be made on each mix, care being taken to have the mould completely filled and the plunger clean and wet.

Fig 4. Consistency test on gypsum

Setting time of plaster

Mix 200 g of the sample in such quantity of water as will give a paste of normal consistency (using the method of mixing given in Part I/Section 1, except that no retarder shall be used when conducting the test), pour into the Vicat mould, shake a few times to remove the air entrapped and level off flush with the top of the mould. Allow the needle to sink into the pasteand remove it to the original position. After each penetration, wipe the needle clean and movethe mould slightly so that the needle will not penetrate at the same point twice. Depending uponthe character of the material, test the sample frequently at such intervals as are necessary to determine whether it complies with the requirements for time of setting for the product tested. Set shall be considered complete when the needle no longer penetrates to the bottom of the paste. Until set, store the test specimens in a cabinet at a temperature of 27 ± 2°C in an atmosphere having a relative humidity of 85 to 100 percent. Record as the time of setting of the sample the elapsed time in minutes from the time when the sample was first added to the water to the time when set is complete.

Casting of test specimens

Panels and cubes are casted for testing water absorption test and compression test respectively. For water absorption test the size of test specimen is 175 x 75 x 12mm. For compressive strength test the size of test specimen is 70.71 x 70.71 x70.71mm.

Mix proportion

Various mix proportions were calculated for different percentage of fibres and corresponding mass of gypsum and fibres were taken.

Batching

Batching is the process of measuring and combining the ingredients as per mix design. Batching accuracy is very important. It can be done by 2 methods.

i. Volume batching
ii. Weight batching

We have used weight batching for our tests.

Fig 5. Batching

Mixing

Mixing is done to control the workability of the mix. All mixing were done manually. Gypsum powder and firbres are mixed thoroughly and then it is mixed with water until a uniform mix is formed.

Fig 6.Mixing

Casting

After mixing it is introduced into the mould with proper compaction. The surface of the gypsum was smoothened, specimens were demoulded 1day after casting.

Fig 7. Casting

Fig 8. casted specimen

Tests on specimen

The tests on specimens are water absorption test (IS : 2542 (Part II/Sec 6 1981) and compression test(IS : 2542 (Part II/Sec 5 1981).

Water absorption test

In this test the specimens shall be completely immersed in water at 27 ± 2 ^{0}C for a period of 24 hours, with at least 30 mm height of water over the top of the specimen which shall be so positioned that it does not lie flat on the bottom of the container. These shall be taken out and weighed (W1) after removing surplus moisture with a damp cloth. The specimens shall then be placed in an air-oven capable of being raised to 105°C and then maintained at that temperature constantly. The specimens shall be dried until constant mass (within ± 0.1 percent of the mass of the specimens) is attained and the mass (W2) shall be recorded for each specimen.

Fig – 9 : Specimen immersed in water

The percentage absorption shall be calculated as follows:

Percentage absorption = $\frac{(W1-W2)}{W2} \times 100$

Where,

W1= Mass of specimen after absorption

W2=Mass of specimen after heating

Compressive strength test

Mix sufficient quantity of gypsum, fibre and water at normal consistency to produce mortar and cast into three specimen moulds. Coat the moulds with a thin film of mineral oil or other mould release agent and place on an oiled glass or metal plate. Fill the mould with mortar and compact it to expel air bubbles . As soon as the mortar or paste has set, cut off the excess to a plane surface flush with the top of the mould, using a stiff broad knife or similiar implement. Place the filled moulds in moist air (90 to 100 % relative humidity). Remove the cubes from the moulds at any time after they are thoroughly hardened, but retain in the moist air for not less than a total of 16 h. Test the cube using compression testing machine.

Fig – 10 : Compression testing

II . RESULT AND DISCUSSION

Consistency test

It is the amount of water required to mix a given amount of plaster to a state of fluidity. The required amounts are expressed as milliliters of water for 200g of gypsum.For the gypsum we have used for the test the consistency is 90 ml (that is 44%) of water for 200g of gypsum.

Setting time test

When the powder is mixed with water, the time that elapses from the beginning of the mixing until the material hardens is known as setting time.

Initial setting time : 5 minutes
Final setting time : 30 minutes

Water absorption test

The water absorption of gypsum board reinforced with sisal fibre is found to be 61.23%, 58.86%, 63.66% and 68.89% for 0%, 1%, 1.5% and 2% respectively, And the water absorption of gypsum board reinforced with coir fibre is found to be 61.23%, 61.43%, 66.32% and 60.87% respectively.

Table-1: Water absorption test results

Sisal fibre content in (%)	Weight after 24 hr immersion in water (w1), g	oven dried weight (w2),g	Water absorption in (%)	Avg.
0%	220	136	61.76	61.23
	225	140	60.71	
1%	250	157	59.23	58.86
	252	159	58.49	
1.5%	225	138	63.04	63.66
	230	140	64.28	
2%	225	133	69.17	68.89
	231	137	68.61	

Table- 2: Water absorption test results

Coir fibre content in (%)	Weight after 24 hr immersion in water (w1), g	oven dried weight (w2),g	Water absorption in (%)	avg
0%	220	136	61.76	61.23
	225	140	60.71	
1%	219	136	61.01	61.43
	212	131	61.83	
1.5%	237	143	61.73	66.32
	232	139	66.91	
2%	239	137	74.45	70.2
	234	141	65.95	

Result obtained is, for 1 % of sisal fibre reinforced in gypsum board is found to have a water absorption of 58.86. And for 2 % of coir fibre reinforced in gypsum board is found to have a water absorption of 70.2 .

Compressive strength test

Table – 3 : Compressive strength test result

SI no	Sisal fibre content(%)	compressive strength (MPa)
1	0%	5
2	1%	5.3
3	1.5%	6
4	2%	7.2

Table – 4 : Compressive strength test results

Sl no	Coir fibre content(%)	compressive strength (MPa)
1	0%	5
2	1%	5.15
3	1.5%	5.6
4	2%	6.2

Compressive strength goes on increasing while adding different percentage of fibres in gypsum.

III CONCLUSIONS

From the obtained test results it can be concluded that the sisal and coir can effectively used as fibre reinforcement for Gypsum. Gypsum absorbs more water than expected this can be overcame by using water proof coatings. Gypsum board can be used as substitution material against conventional partition wall system.

The water absorption of board is found to be optimum when adding 1 % of sisal fibre.

As we recommend this as inner partition wall system so the risk of water absorption is almost negligible. Further study have to done in this area to overcome this drawback.. Compression strength goes on increasing when fibre is added.

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