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Low Cost Reinforced Concrete Ceiling Sheet with Leaf-Sheath Fibre of Areca-Nut Palm

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Abstract:

The main purpose of this research is to manufacture the low cost reinforced ceiling sheets with leaf-sheath of Areca-nut palm fibre, locally available materials in Mawlamyine. The basic materials of ceiling sheet in this research are Myinegalay cement (Rhinoceros brand), Yangon River sand, water and natural fibre as Areca-nut palm fibre..

In this research work, the ceiling sheets are manufactured in the size of (2ft× 2ft× ¼ in). The length of fibres reinforced is generally half inch. Three different types of water-cement ratios (0.35,0.45,0.5) and three different fibre content (2%,3%,4%) are used in the production of reinforced ceiling sheets. All samples are cured for 28 days and the bending strength of reinforced ceiling sheets are tested by the bending tester machine in Hmawbi Asbestos cement ceiling sheets Industry.

Evaluations of strength and cost comparison between the natural fibre reinforced cement ceiling sheets and the asbestos cement ceiling sheet manufactured by machine plant in Hmawbi. Moreover, it is compared with the private reinforced ceiling sheets.

By manufacturing Leaf-sheath of Areca-nut palm fibre reinforced cement ceiling sheets with reasonable strength, they can use in the construction of low-cost housing in the Rural area of Myanmar. Therefore, ceiling sheets play a vital role in many developing programmes.

Keywords:fibre reinforced concrete, ceiling sheet, fibre reinforced ceiling sheet.

I. INTRODUCTION

Construction works in Myanmar are a great momentum with the development of country and population with the advancement of construction industries, ceiling sheet is an essential building components. The basic constituents of ceiling sheets making are cement, sand, fibre and water. The major factors affecting the characteristics of fibre reinforced concrete are water-cement ratio, percentage of fibres, and length of fibres.

The presence of micro cracks at the mortar-aggregate interface is responsible for the inherent weakness of plain concrete. The weakness can be removed by inclusion of fibres in the mix. The fibres help to transfer loads at internal micro cracks.

Natural fibres are used as reinforcements in fibre concrete and other composite elements. Natural fibre of various types is abundantly available in many parts of the world. Ceiling sheets made of natural fibres are available for cheaper and reasonable prices, freely in our country. In this thesis, Areca-nut palm fibre is used to withstand the bending strength of the fibre reinforced ceiling sheets.

Economics and other related factors in many developing countries where natural fibres of various origins are abundantly available, demand that construction engineers and builders apply appropriate technology to utilize. These natural fibre as effectively and economically as possible good quality fibre reinforced composite materials for housing and other needs.

This paper represents ceiling sheets with low cost natural Areca-nut palm fibre to resist the thermal effect in rural area. The properties of Rhinoceros cement are tested. Leaf-sheath fibre of Areca-nut palm are manufactured and testing the absorptionof this fibre. Then, the compressive strength and tensile strength of cement-mortar mix are tested in different water-cement ratios and different fibre contents (The strength is 3 days, 7 days and 28 days). Moreover, low cost reinforced ceiling sheets are manufactured in different water-cement ratios and different fibre content. In this thesis, various water-cement ratios are (0.35,0.45, 0.5) and various fibre content are (2%,3%,4%) are tested. The length of fibre is 0.5 in are used in the production of reinforced ceiling sheets. Natural fibre reinforced ceiling sheet sizes are produced in (2ft×2ft×1/4in) and the bending strength of ceiling sheets are tested.

II. LITERATURE REVIEW

A. General

The ceiling sheets produced in this research is the type of natural fibre reinforced concrete. It is obtained by mixing cement, water, sand and natural fibre in required proportions.

Normal Portland cement and fine aggregate matrix is used in fibre reinforced concrete. Cement is the well known building material and has indispensable place in construction work. The most important function of fine aggregate is to assist in producing workability and uniformity the mixture. Water is the most important and least expensive ingredient of concrete.The strength, durability and other characteristics of concrete depend upon the properties of its ingredients, on the proportions of the mix, the method of compaction and other controls during placing, compaction and curing.

B. Cement

The term cement used in the construction industry is a very binding material which is a finely ground material consisting primarily of compounds of lime, silica, alumina and iron.

The Portland cement used in this research work is Type (I) Portland cement.

C. Physical Properties of Rhinoceros Cement

The physical properties of Portland cement are (i) the fine of grading, (ii) the setting time, the strength and the consistency.

(1) Fineness Test

The fineness of the cement is a measure of the size of the particles of cement and is expressed in terms of specific surface of cement.

The residue by weight on a sieve of B.S No. 72 shall not exceed 1%.

The residue by weight on a sieve of B.S No.170 shall not exceed 10%.

In this research work, test for fineness is carried out by sieve analysis. Break with hand any lumps present in 100 gm of cement placed in 170 mesh sieve and sieve it by gentle motion of the wirst for 15 minutes continuously.

The fineness of Portland cement (Rhinoceros Brand) in this research work is 8% retained on No. 170 sieve.

(2) Consistency Test

This test is carried out to determine the percentage of water required for preparing cement paste of standard consistency.

By the B.S standard when the plunger penetrates the paste to a point 5 to 7 mm from the bottom of the mould. When the depth of penetration reaches a certain values, the water content required gives the standard consistence of between 26 and 33 (expressed as percentage by mass of dry cement).

Normal Consistency Test

Cement =400gm

Water =128ml =128/400 ×100= 32%

Standard Consistency=32%

Thus, normal consistency = 32×0.78 =24.96%

(3) Setting Time Test

This is the term used to describe the stiffening of the cement paste. Setting refers to a change from a fluid to a rigid state. The setting time is divided into two parts, namely, the initial and final setting times. Initial setting tine and final setting time of the cement shall be determined by means of the Vicat needle apparatus refer ASTM (1975).

ASTM (1975) prescribed the initial setting time should not be less than 45 minutes and the final setting time should not be greater than 8 hours.

The initial setting time of Portland cement used in this research work is 1:37 and. the final setting time of Portland cement used in this research work is 2:04.

(4) Specific Gravity Test

The specific gravity is to determine the weight per volume of the cement paste. The specific gravity of good Portland cement should be between 3.15 and 3.20. A specific gravity of natural cement as available in the market is usually 2.8 to 3.0 and slag cement is 2.75.

In this research work, the average specific gravity of the cement as determined by means of specific bottle is 3.08.

(5) Strength of Portland Cement

Cement-sand mortar made with specified materials under strictly controlled conditions are used for the purpose of determining the strength of Portland cement. There are several forms of strength tests: direct tension, compression and flexure.

Compressive Strength Test

It is one of the important properties of cement .Compressive strength test was conducted in accordance with the British Standard in which case (1:3) cement mortar cube specimens were used. The compressive strength at the time of failure for Ordinary cement should be less than the following values and referred in ASTM (1975).

After 3-days±1hr 1200psi

After 7-days±2hr 2000psi

In this research work, the average compressive strength of Rhinoceros cement is 1221 Psi for 3-days and 1995 Psi for 7-days.

Table I Compressive Strength Test Result for Rhinoceros Cement

3-days Strength	7-days Strength
C=25.3.09 T=28.3.09	C=25.3.09 T=1.4.09
(1)1204 (2)1232 (3)1240 (4)1201 (5)1210 (6)1239	(1)1946 (2)1922 (3)2107 (4)1978 (5)2028 (6)1988
Average=1221psi	Average=1995psi

Where C= casting Date and T= testing Date

Tensile Strength Test

The tensile strength of cement is determined by casting cement mortar in six standard briquette moulds and testing the specimens at 3 days and 7 days.

The average strength of briquette should be as follow and referred in ASTM (1975).

After 3-days ± 1hr 150psi

After 7-days ± 2hrs 275 psi

In this research work, the average tensile strength of Rhinoceros cement is 153 Psi for 3- days and 274 Psi for 7-days.

Table II Tensile Strength Test Result for Rhinoceros cement

3-days Strength	7-days Strength
C=25.3.09 T=28.3.09	C=25.3.09 T=1.4.09

(1) 152 (2) 144 (3) 145 (4) 155 (5) 170 (6) 150	(1) 272 (2) 261 (3) 280 (4) 277 (5) 283 (6) 268	Average=153psi	Average=274psi

Where C= casting Date and T= testing Date

Table III Test Results for Portland Cement

Sample Name	Specific gravity	Fineness	Consistency	Setting Time (hr;min)		Compressive Strength (psi)		Tensile Strength (psi)	
				I.S	F.S	3-day	7-day	3-day	7-day
Rhinoceros Cement	3.08	*	24.96	1:37	2:04	1221	1995	153	274

Remark: *92% passing BS service no.170

D. Sand

Sand particles consist of small grains of silica and are formed by decomposition of sand stone due to various weathering effect. It is mostly obtained from pits, shores, river beds and sea beds.The sand used in this research work is Yangon River sand. Sand is generally considered to have a lower size limit of about 0.07mm.

E. Physical Properties of sand

(1) Fineness Modulus

Fineness modulus (F.M) is defined as the sum of cumulative percentage retained onthe sieves of the standard series, divided by 100. The standard series are the No.100, 50, 30, 165, 8, 4 and 3/8in, 3/4in and 1-1/2in sieve of the US series. Typical range from 2.3 to 3.0, a higher value indicating a coarser grading.Fineness modulus of Yangon River Sand for this research is 2.65.

(2) Specific Gravity of Sand

The normal weight of fine aggregate has specific between 2.5 and 2.6.The specific gravity of natural fine aggregate lie between 2.6 and 2.7.The specific gravity of sand used in this research work is 2.5.

Table IV Result of Yangon River Sand

Test Name	Test Result	ASTM
Fineness modulus	2.65	2.3-3.0
Specific gravity	2.5	2.5-2.6

F. Mortar

A paste formed by mixing fine aggregate such as sand and binding material like cement or lime with water in specified proportions is called mortar. The mortar used in this research is cement mortar. The ratio of the mortar is (1:3) mortar i.e (cement: sand).

III. PRODUCTION OF NATURAL ARECA-NUT PALM FIBRE

A. Fibres

A fibre is a pliable hair like strand that is very small in diameter in relation to its length. Fibres are the fundamental units in making of textile yarns and fabrics. The main purpose of reinforcing concrete is to improve tensile strength and inhibit cracking. Fibre reinforced concrete is basically made of sand, cement, water and fibre.

B. Various Types of fiber Reinforced Concrete

Various types of fibre reinforced concrete are

(i) Steel fibre reinforced concrete
(ii) Polypropylene fibre reinforced concrete
(iii) Glass fibre reinforced concrete
(iv) Asbestos fibre reinforced concrete
(v) Carbon fibre reinforced concrete
(vi) Organic fibre reinforced concrete
(vii) Vegetable fibre reinforced concrete

C. Areca-nut Palm Fibre

The Areca-nut palm fibre cultivation is concentrated in the tropical belts. These fibres are extracted from the fibrous leaf of Areca-nut palm. Moreover, these fibres are easily extracted by hand. The fresh fibres are moderately strong and flexible. Areca-nut palm is a vegetable fibre, available in most developing countries.

D. Production of Areca-nut Palm Fibre

The leaf-sheath of Areca-nut palm fibres can be produced manually by the following steps.

(i) After cutting grown up leaf-sheath of Areca-nut palm, they are placed in the water tank to decay.
(ii) Water is often filled into the tank in order to immerse the leaf sheath of Areca-nut palm in the water.
(iii) After about one week at least, the leaf sheath become rotten and they are beaten by hammer.
(iv) The inner part of the Areca-nut palm strings will decay and then the strings will become fibres. In order to clean and not to be smelly, these fibres are washed with plenty of water about three times.
(v) After spreading and placing these fibres in the shadow for two days, these fibres are cut with scissors to obtain the

desire length. The average length of these fibres for this research is about half inch

(vi) These short-cut fibres have to be put into the air-tight plastic bags. In this way, the Areca-nut palm fibres are readily for mixing in the mortar to manufacture natural fibre reinforced cement ceiling sheets.

Table V Test Results for Water Absorption of Areac-nut Palm Fiber

Sample	Areca-nut palm Fibre		
Test No.	I	II	III
Weight of Dry Fibre (gm)	30	30	30
Weight of Container (gm)	93.7	93.7	93.7
Weight of Container + Dry Fibre (gm)	123.7	123.7	123.7
Weight of Container + Wet Fibre (gm)	181.3	178.7	188.7
Weight of Water (gm)	57.6	55	65
Water Absorption (%)	192	183.33	216.67
AverageWater Absorption (%)	197.33		

The average water absorption for Areca-nut palm fibre is 197.33%.

Table VI Compressive Strength (psi) at 3-days

Water-cement ratios	0.35			0.45			0.5		
Fibre-cement ratio (by wt)	2%	3%	4%	2%	3%	4%	2%	3%	4%
(1) (2) (3)	1436 1465 1378	1247 1330 1291	1262 1131 1001	1305 1218 1146	1190 1102 1115	1001 1030 1015	1189 1305 1102	1001 1015 986	1001 986 972
Average	1426	1291	1131	1223	1136	1015	1198	1001	986

Table VII Compressive Strength (psi) at 7-days

Water-cement ratios	0.35			0.45			0.5		
Fibre-cement ratio (by wt)	2%	3%	4%	2%	3%	4%	2%	3%	4%
(1) (2) (3)	2306 2248 2349	1943 2117 2161	2052 1826 1727	2117 2175 2059	1610 1943 1826	1639 1826 1798	2030 2001 2074	1754 1658 1740	1552 1537 1610
Average	2301	2074	1868	2117	1793	1755	2035	1717	1566

Table VIII Compressive Strength (psi) at 28-days

Water-cement ratios	0.35			0.45			0.5		
Fibre-cement ratio (by wt)	2%	3%	4%	2%	3%	4%	2%	3%	4%
(1) (2) (3)	4031 4234 4002	4018 3872 3625	3611 3596 3901	3872 3959 3886	3640 3364 3741	3509 3669 3321	3988 3756 3553	3509 3466 3480	3032 3045 3118
Average	4088	3838	3703	3906	3582	3450	3765	3485	3065

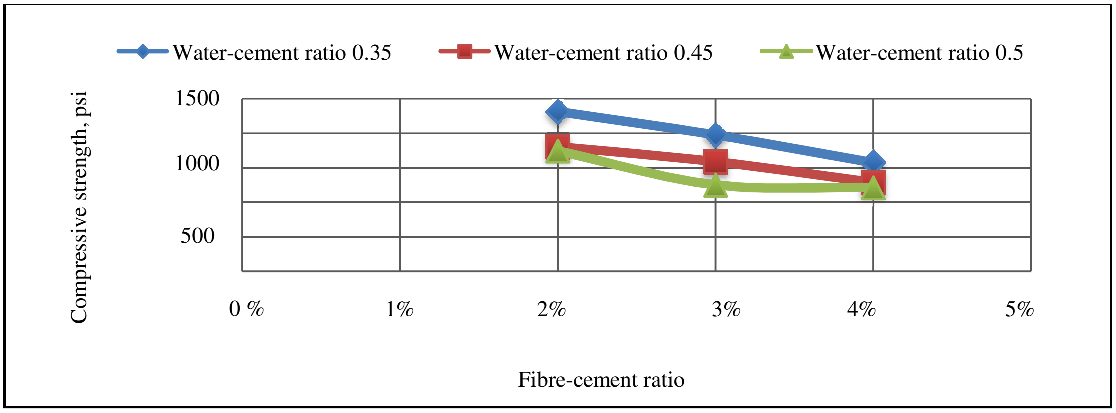

Fig.1 Compressive Strength (Psi) at 3-days

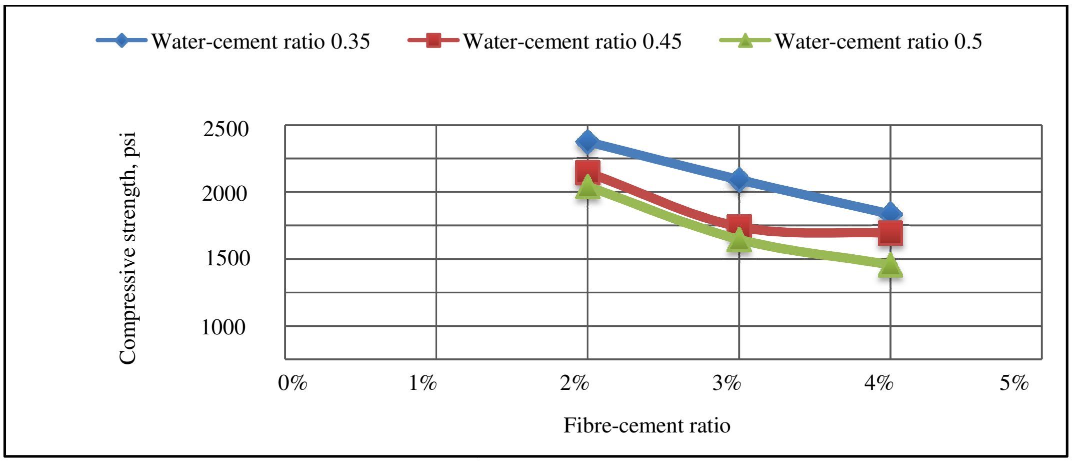

Fig.2 Compressive Strength (Psi) at 7-days

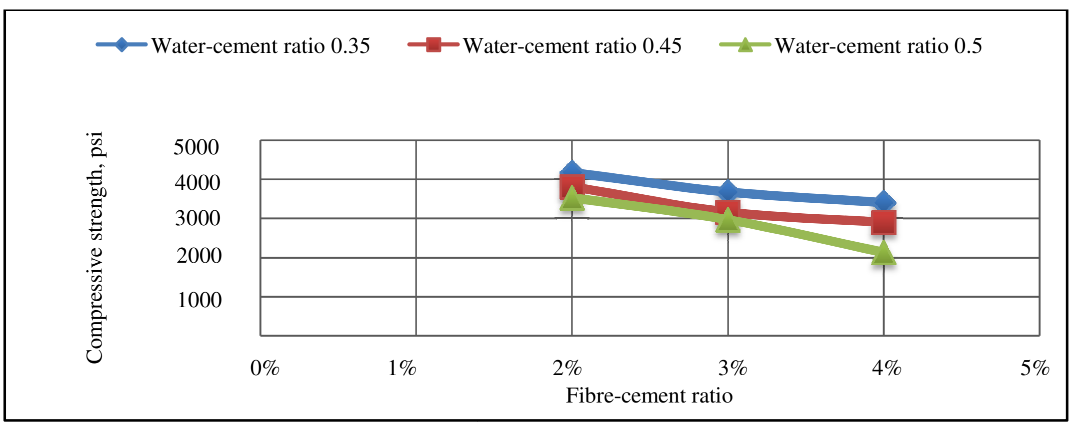

Fig.3 Compressive Strength (Psi) at 28-days

Table IX Tensile Strength (Psi) at 3-days

Water-cement ratios	0.35	0.45	0.5

Fibre-cement ratio (by wt)	2%	3%	4%	2%	3%	4%	2%	3%	4%
(1) (2) (3)	145 131 123	119 123 118	122 102 115	113 109 128	107 114 119	112 108 104	123 114 106	113 107 105	110 100 102
Average	133	120	113	117	113	108	114	108	104

Table X Tensile Strength (Psi) at 7-days

Water-cement ratios	0.35			0.45			0.5		
Fibre-cement ratio (by wt)	2%	3%	4%	2%	3%	4%	2%	3%	4%
(1) (2) (3)	305 290 319	261 276 283	225 236 247	290 283 261	254 239 245	236 225 229	254 268 261	252 236 236	228 221 214
Average	305	273	236	278	246	230	261	241	221

Table XI Tensile Strength (Psi) at 28-days

Water-cement ratios	0.35			0.45			0.5		
Fibre-cement ratio (by wt)	2%	3%	4%	2%	3%	4%	2%	3%	4%
(1) (2) (3)	434 441 409	410 405 420	413 406 398	418 425 418	399 412 406	400 386 405	407 418 415	398 381 370	363 377 389
Average	428	412	406	420	405	397	413	383	376

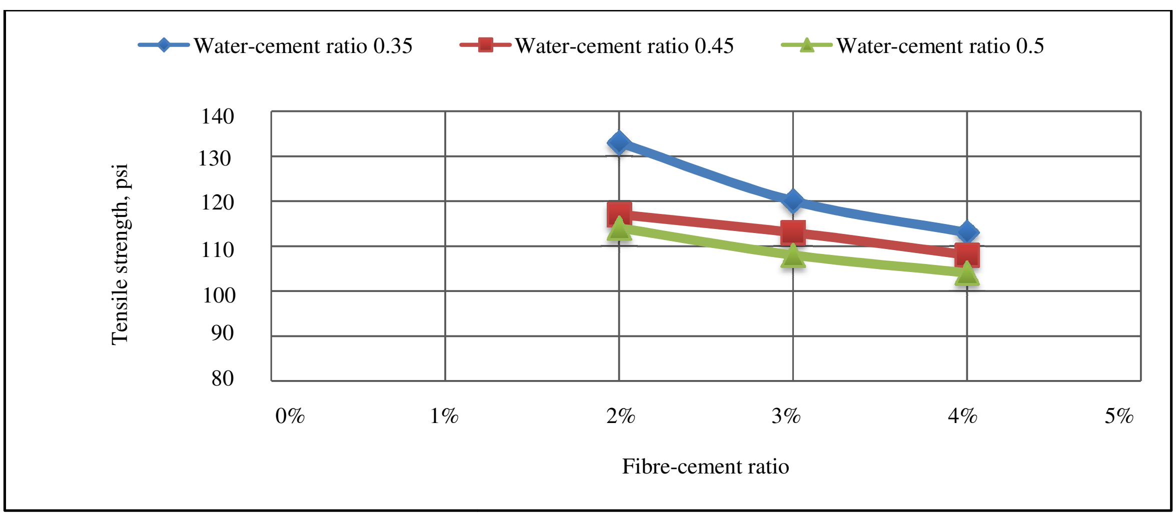

Fig.4 Tensile Strength (Psi) at 3-days

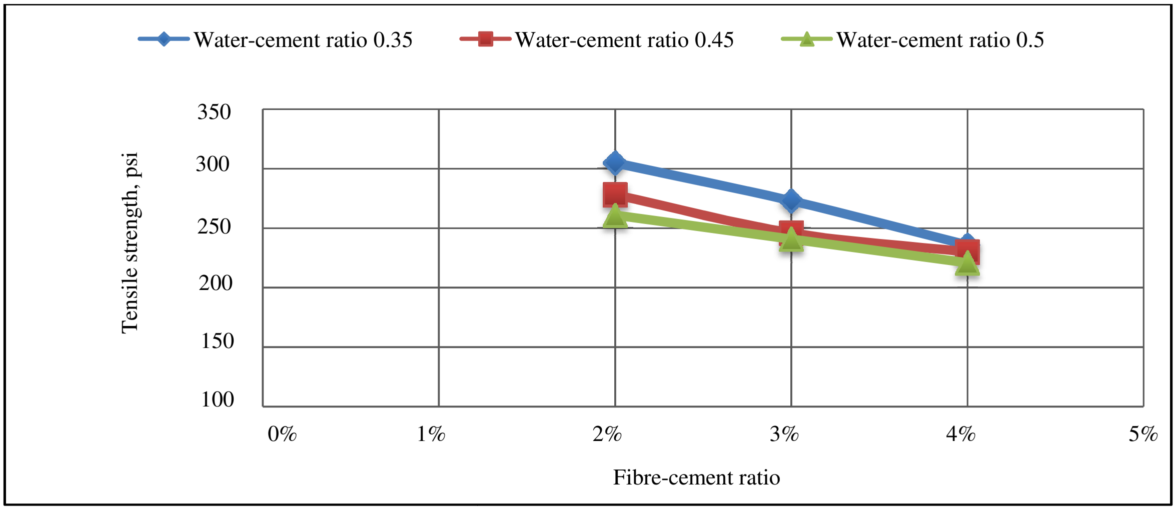

Fig.5 Tensile Strength (Psi) at 7-days

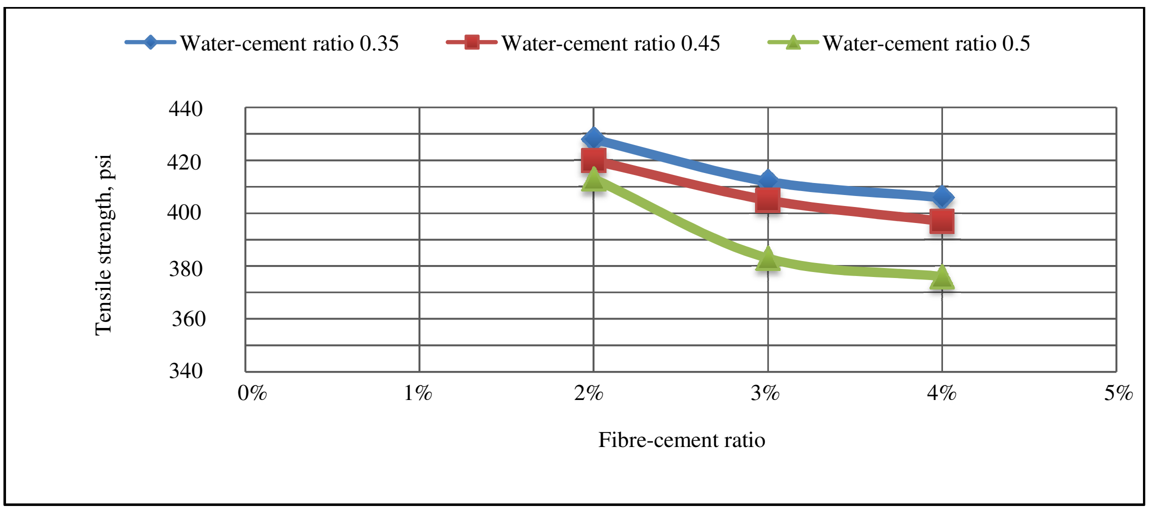

Fig.6 Tensile Strength (Psi) at 28-days

Table XII Compressive Strength (Psi) at3-days, 7-days and 28-days

Properties	Mortar mix type (1:1)								
Water-cement ratios	0.35			0.45			0.5		
Fibre-cement ratio (by wt)	2%	3%	4%	2%	3%	4%	2%	3%	4%
Compressive Strength at 3-days	1426	1291	1131	1223	1136	1015	1198	1001	986
Compressive Strength at 7-days	2301	2074	1868	2117	1793	1755	2035	1717	1566
Compressive Strength at 28-days	4088	3838	3703	3906	3582	3450	3765	3485	3065

Table XIII Tensile Strength (Psi) at 3-days,7-days and 28-days

Properties	Mortar mix type (1:1)								
Water-cement ratios	0.35			0.45			0.5		
Fibre-cement ratio (by wt)	2%	3%	4%	2%	3%	4%	2%	3%	4%
Tensile Strength at 3-days	133	120	113	117	113	108	114	108	104
Tensile Strength at 7-days	305	273	236	278	246	230	261	241	221
Tensile Strength at 28-days	428	412	406	420	405	397	413	383	376

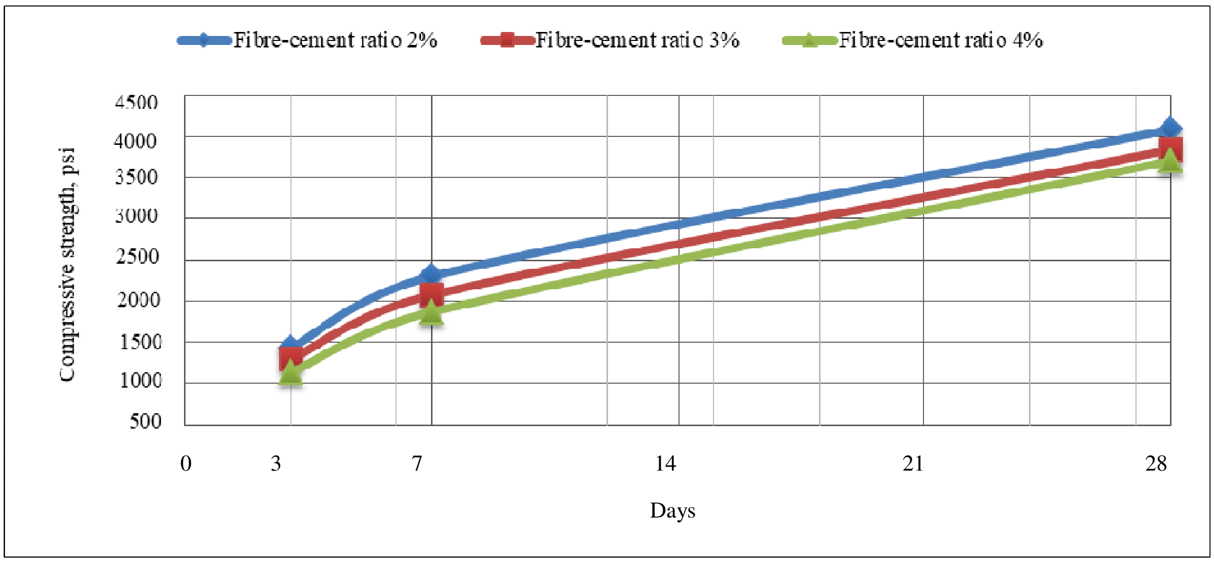

Fig.7 Compressive Strength (Psi) with Water-Cement Ratio 0.35

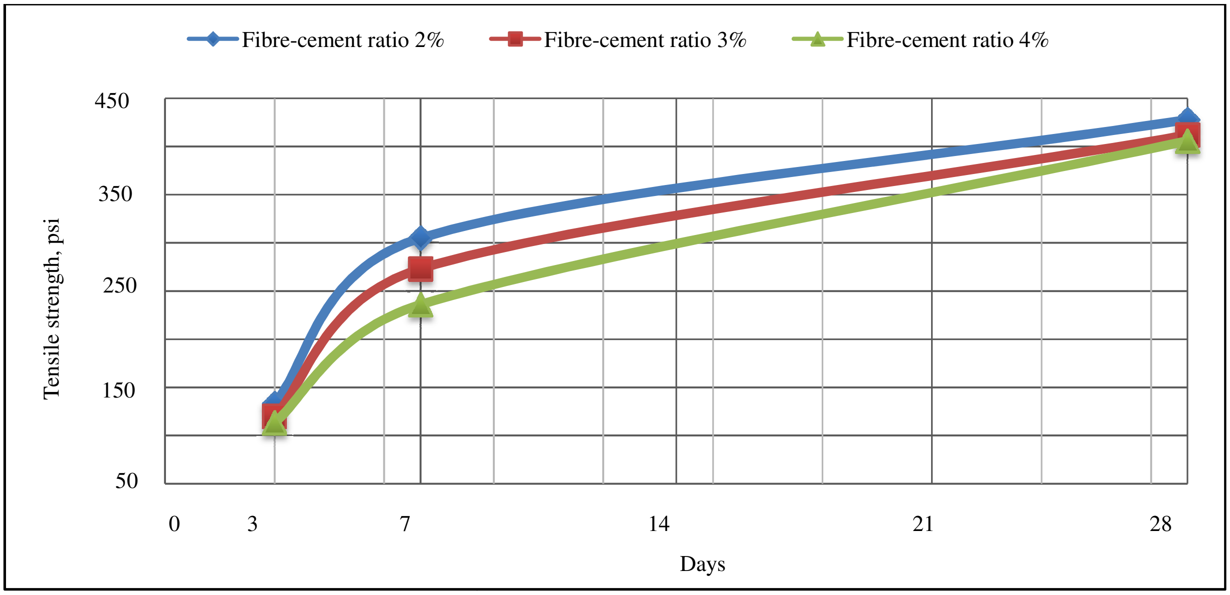

Figure.8 Tensile Strength (Psi) with Water-Cement Ratio 0.35

IV. PRODUCTION OF NATURAL FIBRE REINFORCED CEILING SHEETS

A. General

The ceiling is the most essential part of house Ceiling sheets are used for various purposes, especially to keep the interior of building warm in winter and to prevent the thermal effect in summer.

.The ceiling sheet shall consist essentially of normal Portland cement reinforced with natural fibres. The ceiling sheets specified in this research work is Portland cement ceiling sheets reinforced with natural Areca-nut palm fibres.

B. Various Types of Ceilings

There are various kinds of ceilings;

(i) Acoustical Ceilings
(ii) Suspended Ceilings
(iii) Luminous Ceilings
(iv) Heating Ceilings
(v) Skylight Ceilings
(vi) Concrete Ceilings
(vii) Wood Ceilings
(viii) Cloth Ceilings
(ix) Plank Ceilings
(x) Asbestos Cement Ceilings
(xi) Natural fibre Reinforced Cement Ceilings

C. Natural fibreReinforced Cement Ceiling Sheet

The ceiling sheets shall consist of Ordinary Portland cement reinforced with natural fibres. The natural fibres are sisal, plantain, bamboo, jute, coconut coir, MaingKaing and etc. Natural fibre reinforced ceiling sheets consist of small diameter discontinuous discrete natural fibre of different origin randomly distributed cementitious matrix.

D. Production of Natural Areca-nut PlamFibre Portland Cement Sheets

Areca-nut palm fibre reinforced cement ceiling sheets can be easily and economically produced by manual method in the rural area of Myanmar.There aretwo types of batching the ingredients of concrete,

(1) By weight
(2) By volume

In this research work, the batching of materials is done by weighting.

(I) Making of Formwork

To give the desire shape to the cement mortar and when it sets and to hold cement mortar till it sets and gains enough strength to support its own weight and the live load coming on to it, a temporary stage is erected. This temporary staging is known as formwork.

Commonly used formworks are of wood or steel. Formwork used for this research work is made of wood. The size of this wood formwork is (2ft× 2ft×1/4in).The freshly mixed cement mortar reinforced with Areca-nut palm fibre is poured into this formwork which hold this matrix until it sets.

(II) Fibre Preparation

Areca-nut palm fibre preparation must be made before mixing in order to give good ceiling sheet. These fibres should be clean, free from silt, dirt and good in opening. It should be fibrous.

(III) Mixing of Ingredients

Clean sand and short-cut Areca-nut palm fibres are mixed in the dry state. In this research work, the amount of Areca-nut palm fibres is measured as the weight of cement is 2%, 3% and 4% respectively. Cement is then spread over the sand and fibres are mixed by turning over from one end of the heap to another r and cutting with shovel until the mix appears uniform.

The water is gradually added to the trough formed by the uniform dry mix and the mix is turned over until a homogeneous mixture of uniform color and consistency is obtained. The right amount of water is used in mixing concrete.

Portland cement mixture and sand fibres mixture are mixed in the required proportion. The ratio of (1:1) such as (Portland cement: sand) is suitable and available in this research work. Take care of the matrix is necessary to mix thoroughly.

(IV) Water-cement Ratios and Concrete Strength

The water-cement ratio is to be maintained as low as possible to give the material consistent quality and workability. The greater is the excess of water, the greater would be the decrease in strength of the concrete.

In this research work, dry mix is carried in pans to the work site. And then the mason has to add water in it. The water-cement ratios used for making the ceiling sheets are 0.35, 0.45 and 0.5respectively.

By making many experiments, it can be concluded that the water-cement ratios less than 0.35 will cause the cracks on the dry ceiling sheets because that mortar mix is too stiff. And the water-cement ratios greater than 0.5 will not cause workability of making ceiling sheets i.e. the cement mortar mix is too fluid and it cannot be handled and moulded in the wood formwork.

(V) Placing and Compaction

Placing is the process of transferring the mortar matrix from the conveying device to its final place. After mixing the concrete with water, it should be used within 30-minutes i.e. before the initial setting of cement starts. To secure good ceiling sheet, it is necessary to make certain preparations before placing.

The formwork should be examined for correct alignment and adequate rigidity to withstand the weight of ceiling sheet impact loads. Firstly, the wood formwork is placed on the plastic sheet which is laid on the hard glass plate or concrete slab.

Compaction is important to develop quantities like strength durability, imperviousness by making the concrete dense and free from voids. After the mortar mix has been placed in the formwork, it should then be rolled manually by using steel float. In this way, the plane surface and compaction will achieve in order to make cement mortar penetrates all corners of the formwork.

(VI) Curing

Curing is essential in the production of quality mortar matrix. To obtain good quality hardened mortar the placing and compaction of the mortar must be followed by curing in a suitable environment during the early stages of hardening.

Curing should be done for a period of three weeks. The objective of curing is to prevent the loss of moisture from concrete due to evaporation. In this research work, the Areca-nut palm fibre reinforced Portland cement ceiling sheets are immersed in the water tank for 28-days.

V. CONCLUSIONS

Within the scope of this research, the following conclusion can be drawn based on the experimental results.

(1) By studying the test results, the compressive strength of fibre reinforced concrete having 0.35 of water-cement ratio with 2.0% of fibre –cement ratio is higher than the other mixes.

(2) By studying the test results, the tensile strength of fibre reinforced concrete having 0.35 of water-cement ratio with 2.0% of fibre-cement ratio is higher than the other mixes.

(3) The workability of fibre reinforced concrete is good in the water-cement ratio of 0.35.

(4) By studying the test results, the compressive strength and the tensile strength of fibre reinforced concrete having 0.35 of water-cement ratio are not much difference in 28-days strengths.

(5) Therefore, the best result of fibre–cement ratio 2%, 3% and 4% is depend on the adjustment of bending strength results and economical point of view.

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