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Enhancing the Compressive Strength of the Fly Ash Brick by Fibre Reinforcement

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Abstract:- In the present scenario, an alternate for clay bricks is fly-ash bricks which plays a key role in the construction of framed structures because of its less weight which will reduce the dead weight of the structure, due to its light weight concept and another advantage is low cost. Such fly ash bricks are not subject to load bearing structure because of its slight reduction in compressive strength compared with nominal clay brick. So majority of the fly ash bricks were used in the framed structures construction. In this study a concern to increase compression strength using coconut fibre is carried out, with this another proportion of replacement to the fly ash is done with rice husk ash. By varying the proportion of fibre and rice husk ash of 5% and 10%, with coconut fibre's aspect ratio of 150, is mixed separately and also in the combined proportion of 5% and 10% of coconut fibre and rice husk ash. A comparison has been carried out for the normal brick to the fibre reinforced brick and fibre reinforced rice husk ash by replacing fly ash in brick. From the comparison the test result has shown a significant change in the compressive strength by the addition of coconut fibre than the addition of rice husk ash to the normal fly ash brick and also the test results showed significant changes in the water absorption quality and other properties of the fly ash brick.

Keywords:- *Fly Ash Brick; Rice Husk Ash; Coconut Fibre; Aspect Ratio; Fibre Reinforced Brick; Ordinary Portland Cement(OPC);*

I. INTRODUCTION

About180 billion tonnes of clay brick production per year consumes 540 million tonnes of clay, makes 26305 hectares of land barren, and consumes 30 million tonnes of coal equivalent, generates 26 million tonnes of Carbon Dioxide. A 10% switchover to fly ash bricks will use 30 million tonnes of fly ash every year, save environment and coal. There has been impressive increase in the power generation in India from a low capacity of 1362 MW in 1947 to about 112050 MW in 2004. Indian coal has high ash content around 35-45% and low calorific value 35004000 KCal/Kg as a result of which huge quantity of ash is generated. A typical 200 MW unit produce around 50-60 M.Tons of ash per hour in India. Generally 0.40 hectare land is needed per M.W. of power production. Power being considered as an engine of growth, has always been a focus area for most of the developing countries including India. The power generation in India has increased from 1362 MW in 1947 to 200000 MW in 2012 and ash generation will reach a figure of around 200 M. Tons per year. This would require about 40000 hectares of land for the construction of ash ponds. Further, Government of India has planned for enhancement of installed capacity to 3, 00,000 MW by 2017 (Vimal et al. 1995). Coal based power plants not only produce of millions of megawatts of power but also millions of tons of fly ash. Most of the coal based power plants were set-up with sole aim of power generation (Dhar, 2001). Environmentally safe disposal of large quantity of fly ash is not only problematic but also expensive. Keeping in view the gravity of the fly ash disposal problem, global efforts are mooted to utilize fly ash in bulk quantities.

As per the studies done on this flyash bricks show some reduction in the strength when compared to conventional bricks, to overcome that issue and to increase the strength of the brick fibres and agricultural wastes were added. Agricultural wastes such as oil palm, pineapple leaves, sugarcane bagasse ash, paper pulp, coconut coir, rice husk, rice straw, jute, hemp, corncob and sawdust were used in production of cement-based composites. Based on literature, the utilization of natural fibre reinforced cement composites offer several advantages, e.g., increased flexural strength, post-crack load bearing capacity, improved bending strength, etc. and also stated that the use of coconut fibres in polymer concrete shows better flexural strength than artificial fibres. So, to increase the strength and to have better performance than the conventional bricks, coconut fibres were incorporated and the performance of the bricks were analysed. These coconut fibres has shown great Other than coconut coir, rice husk ash is used as a filler material though, the rice husk ash is also having pozzolonic properties like fly ash it can be used as a replacement material for the fly ash. When the rice husk ash is used as additive to increase strength it shows poor performance, because it is also in the powdery form, so it cannot engage to the strength parameters of the brick so it can be only used as a filler material. The bonding material used in the fly ash bricks are lime or Ordinary Portland Cement (OPC). On comparing both the binders, the OPC has many advantages when compared to lime. The setting time and the load bearing capacity of the OPC is somewhat greater than the lime. The project deals to increase the compressive strength of the fly ash brick, among the two binders, OPC is used as a binder for the brick. Quarry dust is another material used in the brick to fill the remaining space. It is used in the combination form of powdery and gravel particles, though the powdery particles does not enhance the strength parameters, somewhat coarser particles were mixed which helps to the

strength parameters of the brick. Quarry dust is a obtained from the granite crushing process produced during quarrying activities and due to the easy availability and the low cost it is used in plenty of applications like cement mortar, building block, concrete and in controlled low strength material these quarry dust is incorporated as a main ingredient in the building industries.

II. MATERIALS USED

A. Fly ash:

Fly ash consists primarily of oxides of silicon, aluminium iron and calcium. Magnesium, potassium, sodium, titanium, and sulphur are also present to a lesser degree. When used as a mineral admixture in concrete, fly ash is classified as either Class C or Class F ash based on its chemical composition.

Class C ashes are generally derived from subbituminous coals and consist primarily of calcium alumino sulphate glass, as well as quartz, tricalcium aluminate, and free lime (CaO). Class C ash is also referred to as high calcium fly ash because it typically contains more than 20 percent CaO.

Class F ashes are typically derived from bituminous and anthracite coals and consist primarily of an aluminosilicate glass, with quartz, mullets, and magnetite also present. Class F, or low calcium fly ash has less than 10 percent CaO.

B. Quarry dust:

Quarry dust is a by-product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes; during the process the dust generated is called quarry dust and it is formed as waste. It is grey in colour and it is like fine aggregate. Natural granite aggregate having density of 2700 kg/m2 .The specific gravity was found to be 2.58 to 3. The concept of replacement of natural fine aggregate by quarry dust which is highlighted in the study could boost the consumption of quarry dust generated from quarries. The availability of sand at low cost as a fine aggregate in concrete is not suitable and that is the reason to search for an alternative material and the quarry dust is used in order to increase the strength of the brick. When we use lime, gypsum, their hardening period and due to powdery form they need to be compressed at high load, but when we use this quarry dust, their hardening period is reduced and it bonds quickly with cement and achieves strength.

C. *Rice* husk ash:

Rice milling industry generates a lot of rice husk during milling of paddy which comes from the fields. This rice husk is mostly used as a fuel in the boilers for processing of paddy. Rice husk is also used as a fuel for power generation. Rice husk ash (RHA) is about 25% by weight of rice husk when burnt in boilers. A fire source was maintained under the furnace in which the husk was dumped for around 10 minutes, after which the husks slowly burned for more than one day. The ash was left inside the furnace to cool down before it was collected. The rice husk ash possesses a chemical composition similar to many of the organic fibres. Rice husk ash consists of Cellulose (C5H10O5), Lignin (C7H10O3), Hemi cellulose, .SiO2, Holo cellulose. These are compounds within them in common. The rice husk ash may vary depending upon the source as well as the type of treatment. Treatment in the sense the rice husk is burned to have proper properties.

D. Ordinary Portland cement:

OPC 53 Grade cement is required to conform to BIS specification IS:12269-1987 with a designed strength for 28 days being a minimum of 53 MPa or 530 kg/sqcm.53 Grade OPC provides high strength and durability to structures because of its optimum particle size distribution and superior crystallized structure.

E. Coconut coir:

Coconut Coir, or coconut fibre, is a natural fibre extracted from the husk of coconut and used in products such as floor mats, doormats, brushes and mattresses. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Benefits of Coconut Coir. Coconut coir's primary benefit that most growers boast about is its improved water retention ability, including its ability to be easily re-hydrated. At the same time, coconut coir also possesses aeration properties which are important in soilless growing.

III. TESTS ON RAW MATERIALS

After performing fineness test, initial setting time test and specific gravity test the results are tabulated.

Raw Materials	*Fineness*	*Initial setting Time*	*Specific Gravity*
Fly ash	4.3%	-	1.53
Quarry dust	3.4%	-	2.19
OPC	4%	33	3.16
Rice husk ash	6.2%	-	0.33

Table 1:- Raw Materials Test Results

IV. ASPECT RATIO OF FIBRE

Aspect ratio of a fibre is defined as the ratio to the length and the diameter of the fibre. Many researchers have shown that the addition of small closely spaced and uniformly dispersed fibre to concrete transforms the brittle cement composite into a more isotropic and ductile material. This may be due to the fact that a fibre of lower aspect ratio can be compacted well with slurry infiltration without producing more voids, which can exhibit higher absorption of impact energy and flexural energy thus giving rise to higher values of impact strength, flexural strength and compressive strength indices. The impact strength also

shows a decreasing trend with increase in aspect ratio of fibres.

Aspect ratio of coconut coir fibre taken for the investigation is 150. That the diameter of the fibre is about 0.2mm (avg.) and the length taken is about 3cm. The length of the fibre chosen for the investigation is based on the easy working condition while mixing and compaction of the brick and based on the studies. After the studies and the test results obtained from the raw materials, they were taken for the production of the brick.

A. Proportioning:

Before, the manufacture of the brick, the exact proportioning of the bricks have to be done in order to have a engineered quality of production and to maintain the quality and to know the quantity of the materials needed for an exact number of bricks. Totally, 63 count of bricks were moulded, the quantity of bricks is counted on the basis of that each proportion of brick has three days of compressive strength test, for each test three bricks are needed. So, totally single proportion will hold nine bricks. Totally, seven proportions were made, that each one proportion holds nine bricks which lead to a count of 63 bricks for the test. Water absorption test for three periods hold only three bricks for each proportion, so those bricks were not moulded separately, they were taken from that ninebricks.

Proportioning of the brick is done by keeping the percentage of cement and quarry dust as same and from the percentage of fly ash, the replacement of coconut coir and rice husk ash is done. For a normal factory made brick without any extra addition of additives, the percentage of materials is kept at 60% flyash, 30% quarry dust and 10% cement. In this project, the percentage of the quarry dust and he cement is kept as same as 30% and 10% respectively.

In the 60% of fly ash, replacement is done up to 10% of the additives. Fly ash is replaced for 5% and 10% with the additives. The additives coconut coir and rice husk ash were added in the brick in 5% and10% as separate proportions and also the additives were added in a combined form of 5% and 10%. In the combined proportion, for 5% the additives were added in a perfect proportion of 2.5% coconut coir and 2.5% rice husk ash. Likewise, for 10% the additives were added at 5% coconut coir and 5% rice husk ash. The additives proportion were done in a long stretch of 5 and 10 percent, because to find out a weaken part of percentage is occurring before 5 percentage or in between 5 to 10 percentage and or above 10 percentage.

The proportion of the materials in percentage for a single brick is done as,

	Fly ash (%)	Quarry dust (%)	OPC (%)	Coconut coir (%)	Rice husk ash (%)
Normal	60	30	10	-	-
5 R	55	30	10	-	5
5 C	55	30	10	5	-
5 RC	55	30	10	2.5	2.5
10 R	50	30	10	-	10
10 C	50	30	10	10	-
10 RC	50	30	10	5	5

Table 2:- Proportion of Materials in Percentage (%)

The proportion of the materials in kilograms for each proportion (i.e., for 9 bricks in each proportion) is done as,

	Flyash (kg)	Quarry dust (kg)	OPC (kg)	Coconut coir (kg)	Rice husk ash (kg)
Normal	13.5	6.75	2.25	-	-
5 R	12	30	10	-	1.125
5 C	12	30	10	1.125	-
5 RC	12	30	10	0.5	0.5
10 R	11.25	30	10	-	2.25
10 C	11.25	30	10	2.25	-
10 RC	11.25	30	10	1.125	1.125

Table 3:- Proportion of Materials in Kilogram

V. TEST ON BRICKS

A. Shape and size:

The shape and size of a brick should be uniform that when it is used for a structural component building purpose. So the brick has to be in a perfect shape of rectangular and also it is important that all the bricks should be in that rectangular shape without any odd one out. Then the size of the brick should also be perfect in size not only in shape. The size of the brick should be uniform, then only it is possible to calculate the quantity of brick needed for a construction and also to have a uniform weight. The size of the brick were designed as defined in the Indian standard codal provisions, that the size of the brick is 190*90*90cms. (i.e., 190 cm in length, 90 cm in breadth, 90 cm in height)

B. Colour:

The colour of the flyash brick is greyish. It is important to maintain the colour uniformity of the brick. If the colour uniformity is not properly handled, then it will results to an anaesthetic appearance and also it indicates that the mixture used for casting of the brick is not homogenously mixed. If the mixture is mixed homogenously then it will not result to nonuniformity in colour. And also the differences in the colour will be due to the water used in the mixture, if the water used is salty, then it will give efflorescence's and lead to colour variance

in the bricks.

C. Compressive strength test:

For each proportion three bricks were tested and the values were tabulated and graphed and comparison is carried out within the designed proportions of the fly ash brick. The graphs were shown below for each above mentioned proportions.

	7 days	14 days	28 days
Normal	3.626	3.903	3.69
5R	1.05	1.24	1.21
5C	7.9	9.697	15.679
5RC	12.76	13.26	14.274
10R	0.94	0.97	1.045
10C	12.7	15.982	19.968
10RC	3.7	11.622	13.91

Table 4:- Compressive Strength (N/MM2) Results

a. Normal Proportion:

In normal proportion, the bricks were made out of using only flyash, quarry dust and Ordinary Portland Cement (OPC). From the test results, the load carrying capacity of the brick is found to be moreover equal and it is around 3-4 N/mm2. The materials used in the proportion were taken of the quantity in percentage of about 60% flyash, 30% quarry dust, 10% OPC.

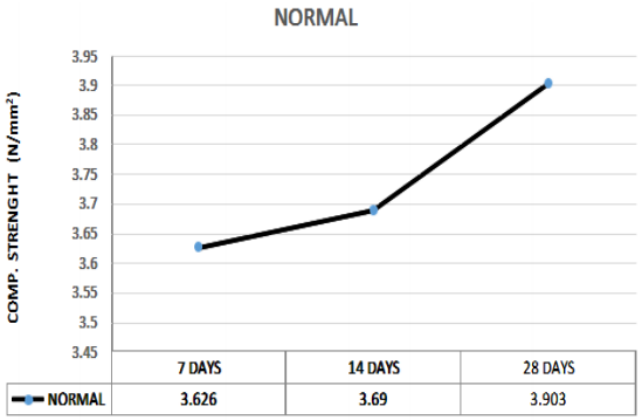

Fig 1:- Compressive strength test results of normal proportion

b. 5 R Proportion:

In 5 R proportion, the materials used to cast the bricks are flyash, quarry dust and Ordinary Portland Cement (OPC) and the additive Rice husk ash (RHA). Here, the rice husk ash is used as a replacement in the percentage of flyash. So the percentage of the materials used in the proportion will be of about 55% flyash, 30% quarry dust, 10% OPC and 5% rice husk ash. From the compression strength test conducted, the results were found to be of around 1 N/mm2. When compared to the normal mix and this, the strength decreases due to the reduction in the quantity of flyash and due to the addition of rice husk ash, the weight of the brick reduces but it also reduces the strength, So rice husk ash can be only used as a filler materials and it cannot be used as a replacement material because if it is used as a replacement, then it reduce strength.

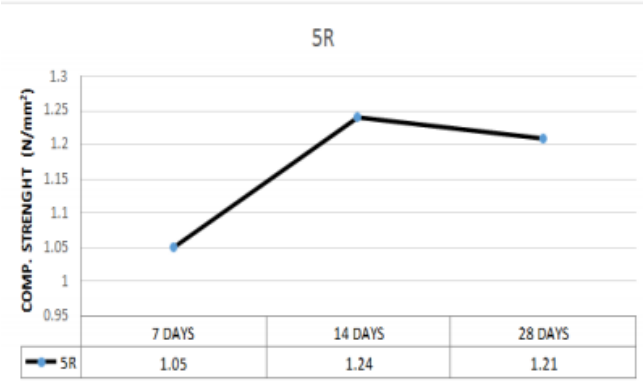

Fig 2:- Compressive strength test results of 5R proportion

c. 5 C Proportion:

In 5 C proportion, the materials used to cast the bricks are flyash, quarry dust and Ordinary Portland Cement (OPC) and the fibre coconut coir (CC). Here, the coconut coir is used as a replacement in the percentage of flyash. So the percentage of the materials used in the proportion will be of about 55% flyash, 30% quarry dust, 10% OPC and 5% coconut coir. From the compression strength test conducted, the results were found increasing gradually on increase of days. When compared to the normal mix and this, the strength increases due to the addition of fibre, also weight of the brick reduces. The usage of the fibre creates a strong link inside the brick thus it holds the brick even it gets cracks at its normal state, the further loading is carried by the fibre and makes the bricks to withstand heavy loadings.

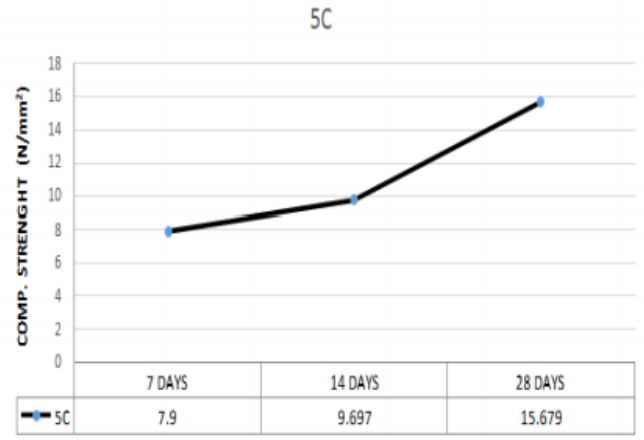

Fig 3:- Compressive strength test results of 5 C proportion

d. 10 RC Proportion:

In 10 R proportion, the materials used to cast the bricks are flyash 50%, quarry dust 30% and Ordinary Portland Cement (OPC) 10% and Rice husk ash (RHA) 10%. Here, the rice husk ash is used as a replacement in the percentage of flyash. From the test conducted, the results

were found to be of around and below 1 N/mm2. When compared to 5 R mix and this, the strength decreases due to the further addition of rice husk ash, the weight of the brick kept decreasing with increase of RHA, but it also shows reduced strength when compared to other proportions. So, rice husk ash can be only used as a filler materials and it cannot be used as a replacement material.

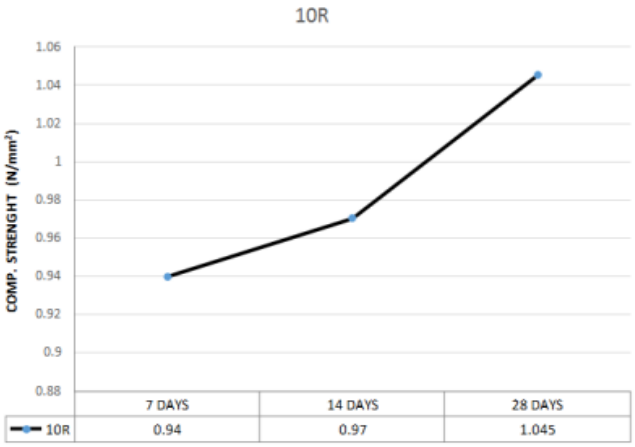

Fig 5:- Compressive strength test results of 10 R proportion

e. 10 C Proportion:

In 10 R proportion, the materials used to cast the bricks are flyash 50%, quarry dust 30% and Ordinary Portland Cement (OPC) 10% and the fibre coconut coir (CC) 10%. Here, the coconut coir is used as a replacement in the percentage of flyash. From the results, it were found to be the strength gets increasing gradually on increase of days. When compared to the other mixes, the strength increases due to the addition of fibre, also weight of the brick remains same. The usage of the fibre creates a strong link inside the brick thus it holds the brick even it gets cracks at its normal state, the further loading is carried by the fibre and makes the bricks to withstand heavy loadings. The addition of more coir then 5 C helps to increase the strength more, but when it overs a certain percentage it makes the brick to lose strength.

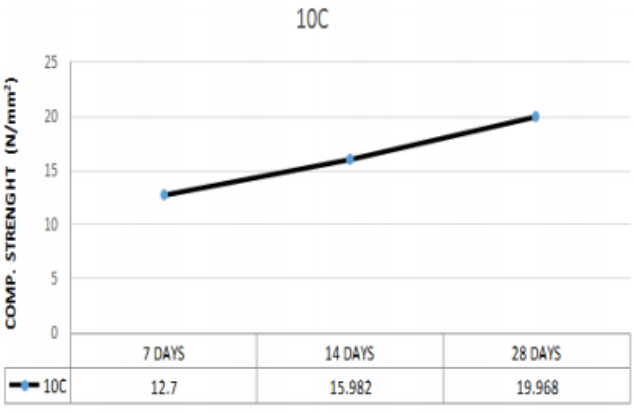

Fig 6:- Compressive strength test results of 10 C proportion

f. 10 RC Proportion:

In 10 RC proportion, the materials used to cast the bricks are flyash 50%, quarry dust 30% and OPC 10%, RHA 5% and CC 5%. Here, both additive were used as a replacement in the percentage of flyash. The test results were found to be increasing proportional to the period. When compared to the5 RC mix and this, the strength is low at its initial state due to the addition of rice husk ash, but as the period increasing the brick attains high strength with the added coir fibre, which makes the brick to withstand heavy loads. The weight of the brick is not having a huge changes but it increases the strength.

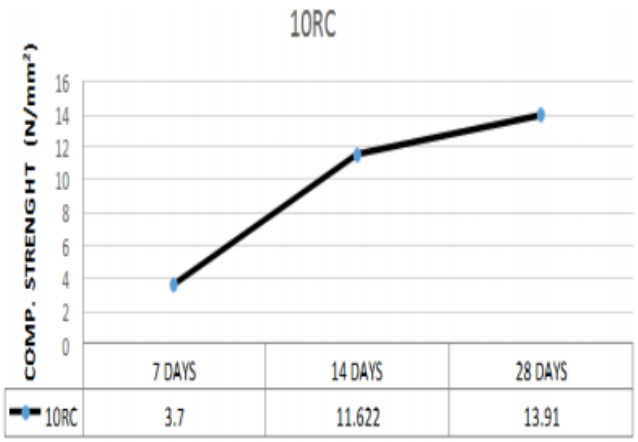

Fig 7:- Compressive strength test results of 10 RC proportion

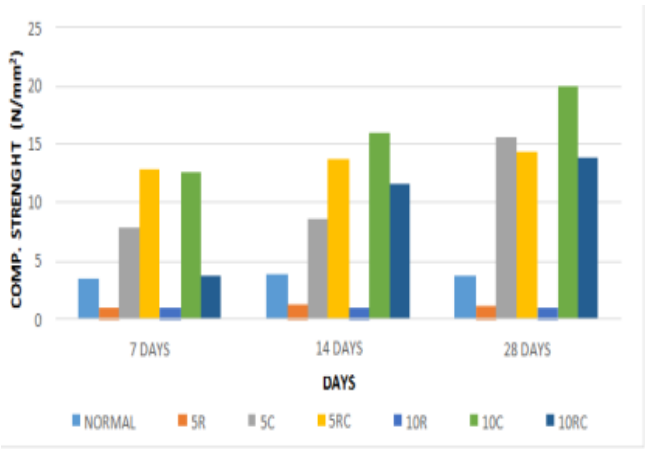

Fig 8:- Comparison compressive test results for different proportions

D. Water absorption test

Water absorption quality of the brick is the ability of the brick to absorb the water when it is exposed to condition like that. If the quality of the brick was needed to be high, then its water absorption quality has to be low. When the brick absorbs more water, it leads to reduction in its strength.

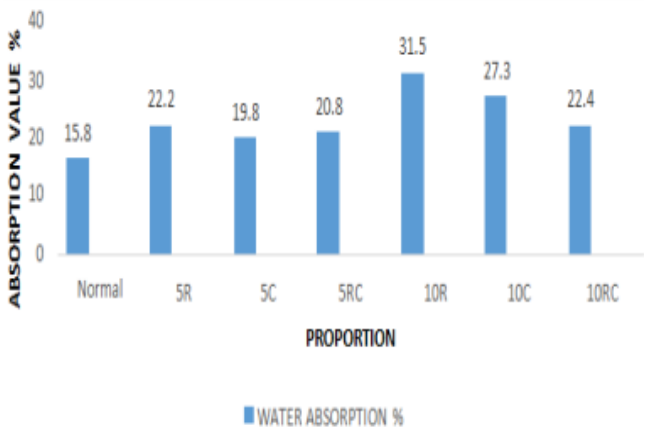

Fig 9:- Water absorption test result for different proportions

E. Efflorescence test:

It is the test to find out any presence of salt content on the surface of the brick or while the manufacture of the brick. The presence of salt content in brick leads to react with the external environment situations. So it is important to identify the presence of salt in the bricks. The efflorescence test results of the bricks are nil.

VI. CONCLUSION

From the investigation carried out on the bricks made with the incorporation of the coconut coir and the rice husk ash at certain percentage with the normal ingredients and tested. From the test results it is concluded that,

- Use of normal fly-ash bricks for load bearing walls is very limited due to low strength and majorly used for framed buildings.
- By the addition of coconut coir to the normal flyash bricks has shown a huge enrichment in compressive strength.
- The use of coconut coir in the brick up to 10% has shown good results, further addition of coconut coir is not still investigated.
- Rice husk ash usage in the brick has only having one advantage that it will reduce the weight of the brick from its original weight.
- Rice husk ash does not concentrate on the strength parameters of the brick.
- When coir is added, the strength of the brick varies from the 7 th day to 28th day. This says that the brick with coconut coir will have a gradual increase in its strength. Strength parameters of the brick incorporated with rice husk ash will have equal values
- Water absorption of the coconut coir brick is lower than the rice husk ash added brick, but water absorption of normal brick is lower than the coconut coir bricks

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