International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 04 | Apr 2021 www.irjet.net p-ISSN: 2395-0072

STUDY OF MECHANICAL BEHAVIOR OF COCONUT FIBER REINFORCED CONCRETE INCORPORATING EGG SHELL POWDER

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Abstract - *There has been a consistent research in the field of construction industry in a view to produce a concrete which could able to resist all varieties of loads. A concrete should be good at compressive strength, flexural strength and split tensile strength and should also be durable enough for all kinds of extreme environment conditions. Since years, the research is still under progress and there has been an evolution of various types of concrete which are having their own applications. In my present work, waste egg shell powder is being used as one of raw material in concrete. In addition to egg shell powder, a small amount of coconut fiber is also added to examine the change in the mechanical properties of concrete. Egg shell powder is used as a substitution in place of cement in various percentages such as 3%, 6%, 9% and 12% and initially the experiments were conducted to determine the properties, without including coconut fiber. In the second set, both egg shell powder and coconut fiber are introduced and the tests were conducted. Coconut fiber is added as 0.5%, 1%, 1.5% by volume of concrete in each percentage replacement of egg shell powder and tests were conducted to know the properties. for every replacement, water absorption tests were also conducted and studied.*

Key Words: **Egg shell powder, coconut coir, water absorption, compressive strength, flexural strength**

1. INTRODUCTION

Concrete is one of the amazing discoveries in the field of construction industry. Though there are many alternatives in various other fields but there is no other alternative than concrete in the construction field. There are three major materials which forms the concrete which are cement, fine aggregate and coarse aggregate.

One of the key favorable property of the concrete is it can easily accommodate within itself various other materials in substitution of cement, sand and coarse aggregate. There has been a continuous research on concrete by incorporating some waste materials in concrete to study its behavior. Addition of any other material except cement, sand and coarse aggregate causes a slight change in the mechanical properties of concrete. In many of the researches, it had become successful in producing fruitful results up to some extent but later shows a declination.

Nowadays, construction industry is aiming to bring out a concrete which could be cheaper and also good at resisting all kinds of loads. In this process, most of the waste materials are being used as an alternative in concrete which could bring down the cost of concrete largely. Putting the waste products into effective use is something like saving the environment from getting degraded.

One of the major waste product is egg shell which comes out as waste from households, poultry farms, fast food centers etc. Egg shells were dumped as waste which are later collected by municipality officials and dumped for landfills. Egg shell is a rich source of calcium and from the past study, it is seen that contribution of egg shell ash in the construction industry is hugh. Egg shell powder resulted in giving a good strength parameters when mixed with concrete. Thus, the cost of construction reduces marginally with the introduction of egg shell as it is good at producing good strength results.

2. LITERATURE REVIEW

An extensive work has been carried out previously upon the introduction of egg shell powder in the concrete. Here is the list of works done which enlighten the behavior of concrete mixed with egg shell powder and coconut fiber.

M. Sophia and N. Sakthieswaran (2019) carried out several experiments on the partial substitution of gypsum with egg shell powder by 2.5%, 5%, 7.5%, 10%, 12.5% and 15% by weight and resulted that there has been a remarkable improvement in mechanical properties and high resistance to water absorption. In the same way egg shell powder is also introduced in concrete to have an enhanced mechanical properties.

Hanifi Binici and Erdi Cinpolat (2015) proposed a new property of egg shell powder that it can safeguard the buildings against external radiation effect, when incorporated in mortar. But, in his investigations, compressive and flexural strength declined upon the addition of egg shell powder but came out to be an effective protective shield against radiations and can be used in wall plastering.

Sheelan M. Hama (2017) performed experimental work on replacing coarse aggregate by plastic waste and cement by egg shell powder and glass powder in various proportions and tested for compressive, flexural and water absorption. Later, it was concluded that mix with 1% plastic waste and 5% egg shell powder gave satisfactory results.

P. Pliya and D. Cree (2015) introduced chicken egg shell powder as a limestone filler in Portland cement and conducted detailed study on the mechanical performance of

cement. Later he proposed that egg shell incorporated limestone is inferior to normal limestone in cement in terms of mechanical properties.

T. Hemalatha, Maitri Mapa, Neenu George, Saptarshi Sasmal (2016) emphasized on high volume fly ash concrete where they tried to increase the strength parameters of concrete by introducing calcium carbonate extracted from egg shells and lime sludge which accelerates the heat of hydration process.

Mehran Khan and Majid Ali (2019) proceeded his work on coconut fiber in addition with fly ash and silica fume which are used as a replacement material in concrete and several tests were conducted to come out an enhanced properties. So, finally he demonstrated that at 10% replacement of fly ash, the coconut fiber reinforced concrete exhibited good strength parameters when compared to normal concrete.

Majid Ali, Xiaoyang Li, Nawawi Chouw (2013), presented the bond relationship between coconut fiber and concrete where he conducted pullout tests with the help of an Instron tensile machine. From his experimental data, it was extracted that the maximum bond strength with concrete is achieved only when length of fiber is 30 mm, fibers are thick and when concrete is prepared by design ratio 1:3:3

3. MATERIALS USED

3.1 CEMENT:

Cement is one the major component in the manufacturing process of concrete. It has the property to stick to any other raw material added in the preparation process of concrete, especially when comes in contact with water and hence produces a good paste. Here, in my present work, OPC 53 grade cement is used whose properties are shown below.

3.2 FINE AGGREGATE

Fine aggregate is first graded to decide the zone to which it belongs to. Generally, there are four categories of fine aggregate Zone-I, Zone-II, Zone-III & Zone-IV. In this work, sand of zone-III is chosen whose properties were given below. Generally, fine aggregate is passed through 4.75 mm sieve.

3.3 COARSE AGGREGATE:

Coarse aggregate is another fundamental raw material which gives strength, hardness and increases the volume of the concrete. In my present work, coarse aggregate of size 20 mm and angular crushed shape is chosen.

3.5 ADMIXTURE

A chemical admixture "Super plasticizer confirming to IS 9013" is used in our work.

3.6 EGG SHELL POWDER

Egg shells which are the major waste products that comes out from poultry farms and fast food centers, collected in bulk and later processed to form powder that could be used in our work. Egg shells collected are cleaned to avoid addition of any unwanted particles and then crushed to form powder. Then it sieved to pass through 2 mm sieve which is used as partial replacement of cement in my work.

3.7 COCONUT FIBER

Coconut fiber or coir is a natural byproduct obtained from the husk of coconut. Coconut husks were collected from the coconut water shops and coconut fibers or coir is separated manually to have a single thread fiber. It is fibrous material which is introduced to increase the tensile property of concrete to some extent. Each coconut fiber of diameter 10 to 20 um and length 10 cm is chosen.

Table 1: Concrete Mixes

CUBES	BEAMS	CEMENT (%)	EGG SHELL POWDER (%)	COCONUT FIBER (%)
C1,1	B1,1	100	0	0
C1,2	B1,2	100	0	0
C2,1	B2,1	97	3	0
C2,2	B2,2	97	3	0
C3,1	B3,1	94	6	0
C3,2	B3,2	94	6	0
C4,1	B4,1	91	9	0
C4,2	B4,2	91	9	0
C5,1	B5,1	88	12	0
C5,2	B5,2	88	12	0
C6,1	B6,1	100	0	0.5
C6,2	B6,2	100	0	0.5
C7,1	B7,1	97	3	0.5
C7,2	B7,2	97	3	0.5
C8,1	B8,1	94	6	0.5
C8,2	B8,2	94	6	0.5
C9,1	B9,1	91	9	0.5
C9,2	B9,2	91	9	0.5
C10,1	B10,1	88	12	0.5
C10,2	B10,2	88	12	0.5
C11,1	B11,1	100	0	1.0
C11,2	B11,2	100	0	1.0
C12,1	B12,1	97	3	1.0
C12,2	B12,2	97	3	1.0
C13,1	B13,1	94	6	1.0
C13,2	B13,2	94	6	1.0
C14,1	B14,1	91	9	1.0
C14,2	B14,2	91	9	1.0

C15,1	B15,1	88	12	1.0
C15,2	B15,2	88	12	1.0
C16,1	B16,1	100	0	1.5
C16,2	B16,2	100	0	1.5
C17,1	B17,1	97	3	1.5
C17,2	B17,2	97	3	1.5
C18,1	B18,1	94	6	1.5
C18,2	B18,2	94	6	1.5
C19,1	B19,1	91	9	1.5
C19,2	B19,2	91	9	1.5
C20,1	B20,1	88	12	1.5
C20,2	B20,2	88	12	1.5

4. RESULTS & DISCUSSIONS

4.1 Water Absorption Results:

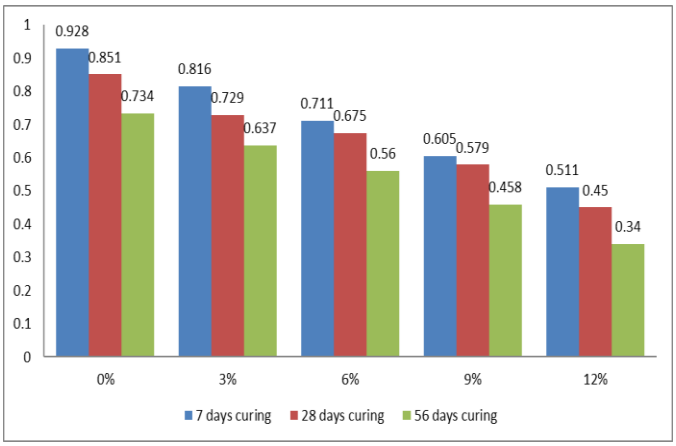

Chart -1: Water absorption percentage of cubes for various replacement of Egg shell powder with 0% coconut fiber for 7 days, 28 days & 56 days of curing

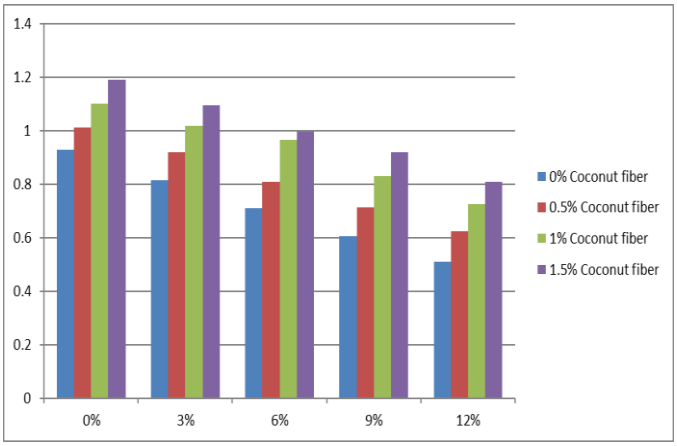

Chart -2: Variation in water absorption for different replacements of egg shell powder with 0%, 0.5%, 1% & 1.5% coconut fiber for 7 days curing

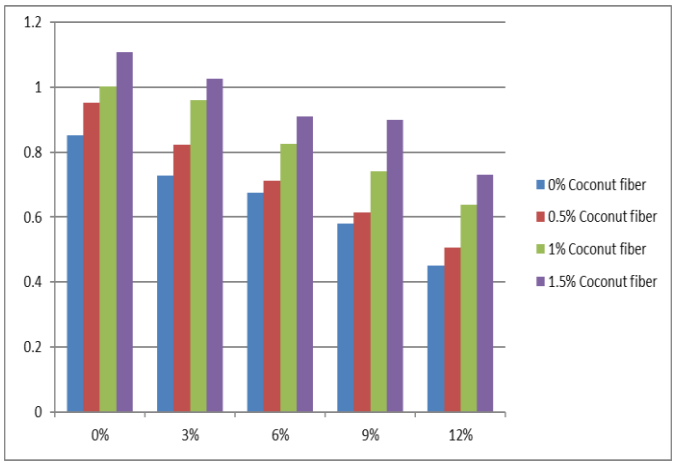

Chart -3: Variation in water absorption for different replacements of egg shell powder with 0%, 0.5%, 1% & 1.5% coconut fiber for 28 days curing

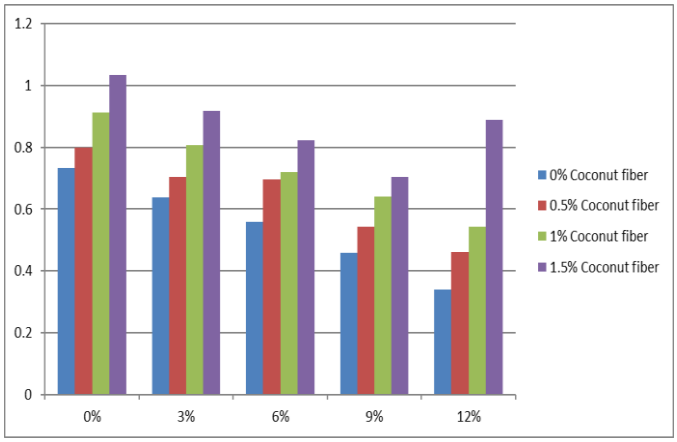

Chart -4: Variation in water absorption for different replacements of egg shell powder with 0%, 0.5%, 1% & 1.5% coconut fiber for 56 days curing

Discussions:

It has been seen from the water absorption results that initially water absorption percentage decreases as the amount of egg shell powder increases in the mixture, without coconut fiber for 7 days curing, 28 days curing & for 56 days curing as shown in graph 1. Whereas, the least water absorption percentage of 0.340% is observed at 56 days of curing, for cubes replaced by 12% egg shell powder & 0% coconut fiber. Later with the introduction of coconut fiber along with the egg shell powder, there has been a gradual increase in water absorption percentage for 0.5%, 1% & 1.5% coconut fiber, might be because of more porosity with the addition of coconut fiber. The gradual increase in water absorption percentage for 7 days curing is shown in graph 2, for 28 days curing is shown in graph 3 and 56 days curing is shown in graph 4. The maximum water absorption percentage of 1.191 is witnessed at 7 days of curing for 1.5% addition of coconut fiber. And the water absorption values decreases with the increase in curing period.

4.2 Compressive Strength Results:

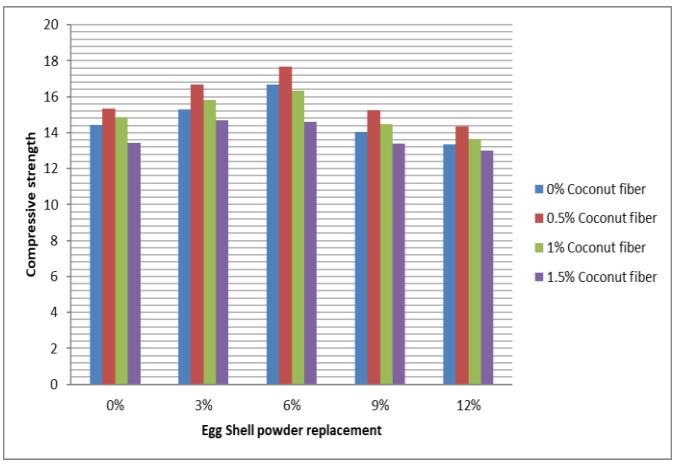

Chart -5: Variation of compressive strength with 0%, 0.5%, 1%, 1.5% coconut fiber for 7 days curing

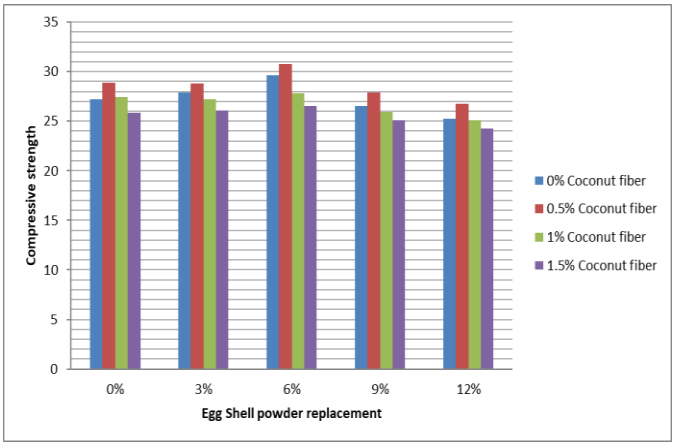

Chart -6: Variation of compressive strength with 0%, 0.5%, 1%, 1.5% coconut fiber for 28 days curing

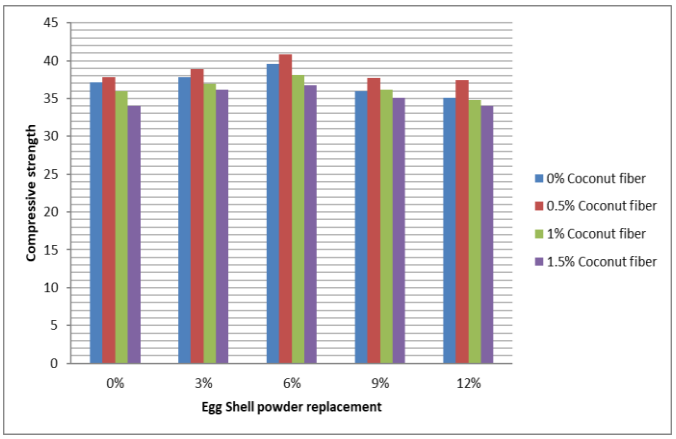

Chart -7: Variation of compressive strength with 0%, 0.5%, 1%, 1.5% coconut fiber for 56 days curing

Discussions:

After the various experiments conducted for the compressive strength test, it was observed that at 6% replacement of egg shell powder and 0% addition of coconut fiber, the maximum compressive strength i.e 16.66 N/mm2 is obtained for 7 days curing when compared to the ordinary concrete cube as shown in graph 9. Similarly, the compressive strength showed the peak value of 29.6 N/mm2 at 6% replacement of egg shell powder for 28 days curing as shown in graph 11. The same behavior is seen for 56 days curing also, the strength was highest at 6% substitution of egg shell powder with 0% addition of coconut powder as shown in graph 11. But, later with 9% & 12% replacement, compressive strength values decreased. Then, the same experiments were conducted with the introduction of both egg shell powder and coconut fiber and the results were obtained. It was witnessed that at 6% replacement of egg shell powder & 0.5% addition of coconut fiber, the compressive strength is maximum i.e 17.68 N/mm2 when compared to normal concrete cube without egg shell and coconut fiber as seen in graph 10. Similarly, the highest strength of 27.8 N/mm2 is seen at 6% egg shell powder and 0.5% coconut fiber for 28 days of curing as noticed in graph 12. Consequently, for 56 days curing also, the strength was highest at 6% egg shell powder and 0.5 % coconut fiber as shown in graph 14. But, strengths at different other replacements like 9% & 12% egg shell powder and 1% & 1.5% coconut fiber, declined gradually.

4.3 Flexural Strength Results:

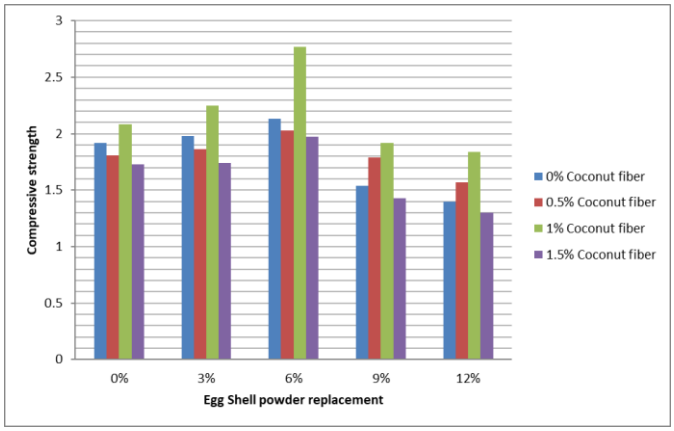

Chart -8: Variation of flexural strength with 0%, 0.5%, 1%, 1.5% coconut fiber for 7 days curing

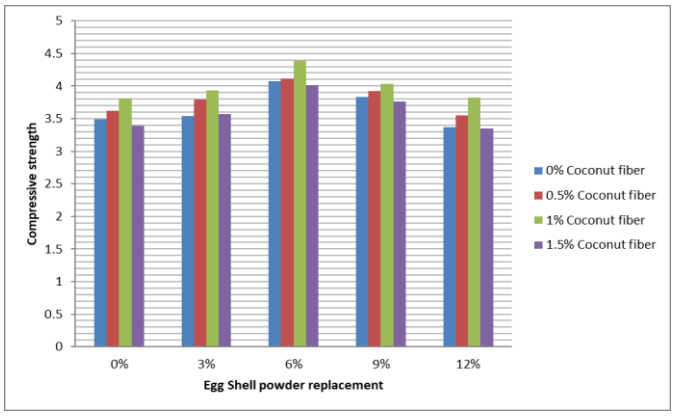

Chart -9: Variation of flexural strength with 0%, 0.5%, 1%, 1.5% coconut fiber for 28 days curing

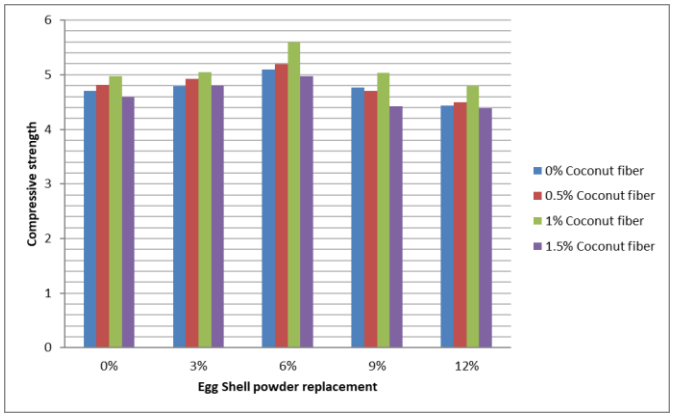

Chart -10: Variation of flexural strength with 0%, 0.5%, 1%, 1.5% coconut fiber for 56 days curing

Discussions:

After the various experiments conducted for the compressive strength test, it was observed that at 6% replacement of egg shell powder and 0% addition of coconut fiber, the maximum compressive strength i.e 16.66 N/mm2 is obtained for 7 days curing when compared to the ordinary concrete cube as shown in graph 9. Similarly, the compressive strength showed the peak value of 29.6 N/mm2 at 6% replacement of egg shell powder for 28 days curing as shown in graph 11. The same behavior is seen for 56 days curing also, the strength was highest at 6% substitution of egg shell powder with 0% addition of coconut powder as shown in graph 11. But, later with 9% & 12% replacement, compressive strength values decreased. Then, the same experiments were conducted with the introduction of both egg shell powder and coconut fiber and the results were obtained. It was witnessed that at 6% replacement of egg shell powder & 0.5% addition of coconut fiber, the compressive strength is maximum i.e 17.68 N/mm2 when compared to normal concrete cube without egg shell and coconut fiber as seen in graph 10. Similarly, the highest strength of 27.8 N/mm2 is seen at 6% egg shell powder and 0.5% coconut fiber for 28 days of curing as noticed in graph 12. Consequently, for 56 days curing also, the strength was highest at 6% egg shell powder and 0.5 % coconut fiber as shown in graph 14. But, strengths at different other replacements like 9% & 12% egg shell powder and 1% & 1.5% coconut fiber, declined gradually.

5. CONCLUSIONS

Various conclusions were drawn from the results obtained from the experiments which are shown below:

1. It was found that the water absorption result values decreases gradually as the number of days increased for curing for various substitutions of egg shell powder and 0% coconut fiber both for cubes & beams for every 7 days, 28 days and 56 days curing.
2. It is also seen that with the introduction of coconut fiber as 0.5%, 1% and 1.5% by volume water absorption values increased.
3. Compressive strength values increased till 6% replacement of egg shell powder decreased beyond that without any introduction of coconut fiber.
4. Compressive strength values showed an increment till 6% egg shell powder replacement & 0.5% coconut fiber and declined with further replacements.
5. The same behavior is followed for flexural strength also. Initially, flexural strength increased up to 6% replacement of egg shell powder and 0% coconut fiber and decreased further.
6. Flexural strength values increases up to 6% replacement of egg shell powder and 1% coconut fiber and declined with further replacements.

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