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EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF HYBRID REINFORCED CONCRETE WITH PARTIAL REPLACEMENT OF FLY ASH AND COCONUT SHELLS

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ABSTRACT: The depletion of natural building materials and disposal of waste materials are two most important challenges which are put in front of a Civil Engineer or Researcher. To encounter this type of challenge, an idea of using agricultural waste as substitution of building materials is proposed, where both problems can be solved by a single solution. This investigation is based on that idea where fly ash and coconut shells (CS), which are waste materials, replaced for binder and coarse aggregate (building materials). The main reason for choosing fly ash is to reduce disposal of industrial waste which cause pollution and CS, depending upon its availability. The entire research work is carried out in 3 stages. The first stage is completely aimed to propose the best proportion of substitution for binder and its effects on both compression and tension. For these different proportions i.e., 20%, 25% and 30% are substituted out of which best result is chosen to be fixed. The second stage is carried on CS, where the best proportion and its effects on compressive and split tensile strength. For these different proportions like 10%, 20%, & 30% are chosen. In the third stage, to compensate the structural integrity hybrid fibers in different proportion i.e.1% (steel 1% + 0% Polypropylene), 1.2% (steel 1% + 0.2% Polypropylene) and 1.4% (steel 1% + 0.4% Polypropylene) are incorporated. Results indicate that partial replacement of fly ash at 25%, CS at 20% and hybrid fibres at 1.2% obtain the optimum range. Addition of hybrid fibers seems to be costlier but when considering overall concrete i.e., with substitutions can compensate and on the other hand it provides a perfect utilization of wastes and preservation of building materials. Further, by adopting this proportion in normal concrete can help in being economical and eco-friendly.

KeyWords: Coconut shell, Blended concrete, Hybrid fibers, Polypropylene, Eco-friendly

1. INTRODUCTION

Concrete is the widely used number one structural material in the world today. The demand to make this material lighter has been the subject of study that has challenged scientists and engineers alike. The challenge in making a lightweight concrete is decreasing the density while maintaining strength and without adversely affecting cost. Introducing new aggregates into the mix design is a common way to lower a concrete’s density. Normal concrete contains four components, cement, crushed stone, river sand and water. The crushed stone and sand are the components that are usually replaced with lightweight aggregates. Lightweight concrete is typically made by incorporating natural or synthetic lightweight aggregates or by entraining air into a concrete mixture. Some of the lightweight aggregates used for lightweight concrete productions are pumice, perlite, expanded clay or vermiculite, coal slag, sintered fly ash, rice husk, straw, sawdust, cork granules, wheat husk, oil palm shell, and coconut shell. The exponential growth rate of population, development of industry and technology, and the growth of social civilization would be considered as the underlying factors that have causes the increased waste production. Recently, the importance of countermeasures to deal with waste materials has been pointed out, because such materials continue to increases in each and every year. The use of alternative aggregate has become necessity for the construction industry because of the economic, environmental and technological benefits derived from their use. The high cost of conventional building materials is a major factor affecting housing delivery in India. In developing countries where abundant agricultural and industrial wastes are discharged, these wastes can be used as potential material or replacement material in the construction industry. This will have the double advantage of reduction in the cost of construction material and also as a means of disposal of wastes. It is at this time the above approach is logical, worthy and attributable.

Presently in India, about 960 million tons of solid wastes are being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Of this 350 million tones are organic wastes from agricultural sources; 290 million tones are inorganic waste of industrial and mining sectors. However, it is reported that about 600 MT of wastes have been generated in India from agricultural sources alone. The major quantity of wastes generated from agricultural sources are sugarcane bagasse, paddy and wheat straw and husk, vegetables wastes, food products, tea, oil production, jute fibre, groundnut shell, wooden mill waste, coconut husk, cotton stalk etc. The new and alternative building construction materials developed using agro-industrial wastes have ample scope for introducing new building components that will reduce to an extent the costs of building materials. One such alternative is coconut shell (CS), which is a form of agricultural solid waste. It is one of the most promising agro wastes with its possible uses as coarse aggregate in the production of concrete. This has good potential to use in areas where crushed stones are costly. Statistical data of coconut production shows that, India is producing nearly 27% of total world production and the annual production of coconut is reported to be more than 12 million tons. Presently the coconut shell waste being used for making mosquito coils agarpathies etc. Only few studies have been reported on use of coconut shells as aggregate in concrete.

This project work presents the results of a test carried out on the comparative characteristics of concrete produced using Fly ash as substitute for cement and coconut shells (CS) as substitute for conventional coarse aggregate. The main purpose of using theses partial substitutes is to encourage the use of eco-waste products as construction materials in small scale constructions. This is to encourage and bring awareness to small scale developers incorporating these materials for construction.

2. MATERIALS USED

Coconut Shells (CS)

Coconut shell is located in between the coconut flesh and coconut husk. Most of handmade decorative are created by using coconut shell due to their strength. Coconut shells are also used to make charcoal which is use as fuel and this coconut charcoals are far better than other charcoals.

Coconut shell is an agricultural waste and is available in plentiful quantities throughout tropical countries worldwide. In many countries, coconut shell is subjected to open burning which contributes significantly to CO2 and methane emissions. Coconut shell is widely used for making charcoal. The traditional pit method of production has a charcoal yield of 25–30% of the dry weight of shells used. The charcoal produced by this method is of variable quality, and often contaminated with extraneous matter and soil. The smoke evolved from pit method is not only a nuisance but also a health hazard.

The coconut shell has a high calorific value of 20.8MJ/kg and can be used to produce steam, energy-rich gases, bio-oil, biochar etc. It is to be noted that coconut shell and coconut husk are solid fuels and have the peculiarities and problems inherent in this kind of fuel. Coconut shell is more suitable for pyrolysis process as it contain lower ash content, high volatile matter content and available at a cheap cost. The higher fixed carbon content leads to the production to a high-quality solid residue which can be used as activated carbon in wastewater treatment. Coconut shell can be easily collected in places where coconut meat is traditionally used in food processing

Physical properties of Coconut Shells (CS):

Coconut Shells possess hard characteristics as coarse aggregates. Several Researches made attempts to use Coconut Shells as coarse aggregates replacing normal granite aggregates traditionally used for concrete production. In their investigations found out that, the specific gravity of Coconut Shells is 1.46, while the maximum thickness of the shell was found to be about 3-8 mm. Shells are one of the wastes produced during processing of Coconut.

The shells are of different shapes, such as angular and polygonal depending on the breaking pattern of the nut. The surfaces of the shells are fairly smooth for both concave and convex faces. However, the broken edge is rough and spiky. The thickness varies and depends on the species of palm tree from which the palm nut is obtained and ranges from 3-8 mm. The shells have a 24 h water absorption capacity range of 6.1 to 6.17%. This value implies that the coconut shells have high water absorption compared to conventional gravel aggregates that usually have water absorption of less than 2%. This high water absorption could be due to the high pore content. It was reported that the porosity of the shell high.

Because of the higher porosity of coconut shells than conventional aggregates, loose and compacted bulk density is 1783 kg/m3 and the specific gravity is 1.74. These ranges of densities show that coconut shells are approximately lighter than conventional coarse aggregates. The densities of the shell are within the range of most typical lightweight aggregates. The shell is hard and does not easily suffer deterioration. This shows that it is much lower than conventional coarse aggregates and has a good resistance to wear. Furthermore, the aggregate impact value and aggregate crushing value of coconut shells aggregates were much lower as compared to conventional crushed stone aggregates. This shows that coconut shells aggregate has a good absorbance to shock.

3. EXPERIMENTAL WORK

The study has been made to evaluate the effect on mechanical properties ofM30 grade concrete made with replacement of cement with Flyash (25%) and the replacement of coarse aggregate with Coconut Shells in different percentages (5%, 10%and 15%) and with addition of hybrid fibres in different proportions.

Experimental program consists of three parts,

• To find the strength characteristic by 25% of flyash in cement.

• The strength characteristic by partially replacing cement by flyash and different percentage of Coconut shells (CS) as coarse aggregate replacement.

• To find the strength characteristic by partially replacing cement with flyash and coarse aggregate with Coconut shells (PKS) and with addition of different percentages of Hybrid fibers.

4. TEST RESULTS

Compressive strength: the compressive strength of standard cubes (150x150mm) for different proportions of fly ash replacement for 7 days and 28 days. The strength attained for 20% substitution for 7 days is 27.52 MPa where a decrement of 5.6% & for 28 days is 38.37 MPa which decreased about 1.6% for conventional concrete. Later in another mix, 25% is replaced which imparted the 7 days strength of 31.9 MPa and 41.94 MPa for 28 days. A clear increase of 9.6% & 8.14% is observed in 7 and 28 days for normal concrete. Later for looking of more strength another 5% of fly ash is replaced but unfortunately strength is decreased to 26.84 & 36.46 MPa for 7 & 28 days when compared with previous mix. The percentages of decrease for 7 & 28 days with previous mix (25%) are 8.34% & 6.36%. Thus the maximum proportion is investigated. The variations in strengths are shown in Fig.1

Table 1: Compressive strength of cubes

Specimen	Fly ash content (%)	Compressive strength in N/mm²	
		7 days	28 days
Mix 1	0	29.08	38.78
Mix 2	20	27.52	38.37
Mix 3	**25**	**31.95**	**41.94**
Mix 4	30	26.84	36.46

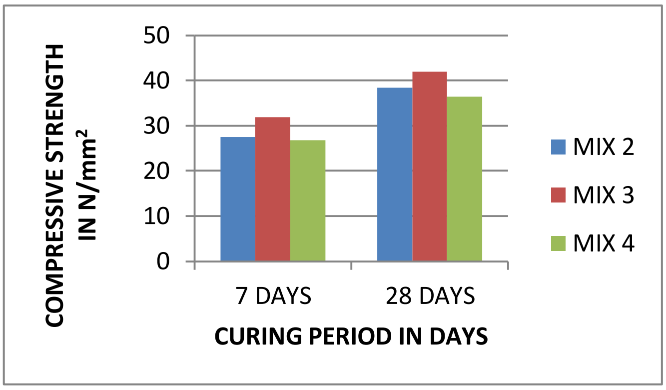

Figure 1: Graph: Compressive strength V/s curing period in days

Addition of Fibers:

The volume fraction of steel filers in CS concrete is kept constant at 1% and the volume fractions of Polypropylene (PP) were 0%, 0.2% and 0.4% respectively in different mixes for the optimum mix. The results of the compressive strength test and split tensile strength test for 28 days for hybrid fibers (steel + polypropylene (pp)) are added in various proportions, i.e. 1%(steel 1%), 1.2%(steel 1% + pp 0.2%) and 1.4% (steel 1% + pp 0.4%) are 38.92 N/mm², 42.27N/mm², 36.95 N/mm² and 4.01N/mm², 4.46N/mm², 3.75 N/mm² respectively. From the results it was observed that at 0.2% PP fibers, the obtained compressive strength and tensile strength values are higher than that of 0 % PP fibers and 0.4% PP fibers. This specifies that the optimum hybrid fiber content for this project was taken at 1.2 %(steel 1% + pp 0.2%).

Table 2: Compressive strength of cubes

Grade of concrete	Specimen	Fly ash content (%)	CS (%)	Hybrid Fibers		Compressive strength in N/mm²	
				Steel %	PP %	7 days	28 days
M30	Mix 8	25	20	1	0	31.26	38.92
	Mix 9	25	20	1	0.2	33.47	42.27
	Mix 10	25	20	1	0.4	29.14	36.95

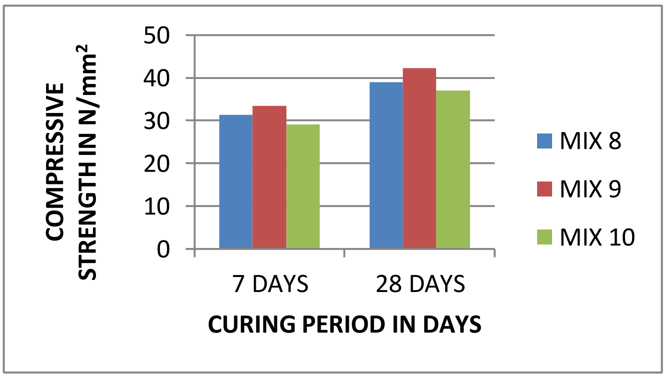

Figure 2: Graph: Compressive strength V/s curing period in days

Table 3: Tensile strength of cylinders

Grade of concrete	Specimen	Fly ash content (%)	PKS (%)	Hybrid Fibers		Tensile strength in N/mm²	
				Steel %	pp %	7 days	28 days
M30	Mix 8	25	20	1	0	1.89	4.71
	Mix 9	25	20	1	0.2	2.23	5.64
	Mix 10	25	20	1	0.4	1.51	4.52

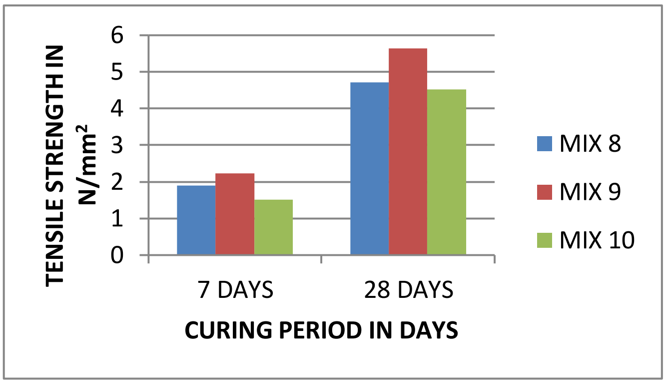

Figure 3: Graph: Tensile strength V/s curing period in days

5. CONCLUSIONS

The strength characteristics of normal concrete without any replacement are compared with replacements. By the results obtained from the substitution of mix with fly ash, coconut shells along with boost of hybrid fibres can be assured of the following:

1. The compression and tensile strength of concrete by replacing 25% fly ash obtained for 28 days are 41.94 MPa and 3.86 MPa, which are higher than the results obtained for conventional concrete.
2. The fly ash utilization contributed to the increased strength at early stages due to its fineness which makes it to form a dense pack.
3. The compression strength of concrete after substituting with coconut shells in 10%, 20% and 30% for 28 days are 39.26 MPa, 40.12 N/mm^2 and 37.43 MPa and tensile strength are 3.84 MPa, 3.91 MPa and 3.72 MPa.
4. It is clearly noted that there is an increase in both strengths from 10% to 20% replacement. Next, both strengths are decreased in 30% increment level.
5. They reduce the environmental pollution and show their influence on the cost of construction substantially.
6. After adding the hybrid fibers to the optimum concrete mixture, the corresponding strengths that were obtained at 1.2% fiber level are 42.27 MPa and 5.64 MPa.
7. Strength properties can be enhance by incorporating hybrid fibers.
8. By implementing 25% of fly ash as binder, 20% of CA as coconut shells and with supplementary of hybrid fibers 1.2% (steel 1% + pp 0.2%) in normal concrete can inculcate a beneficial mixture proportion in field execution.

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