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Optimization of Mechanical Properties of Glass Fiber Reinforced Concrete with the Combination of Rice Husk Ash

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Abstract:-Concrete, one of the most universally accepted construction material, exhibits higher values of compressive strength, but the same cannot be said in terms of its tensile strength. This is the prime explanation for the setback of this construction material, to be used in place of achieving a higher tensile strength. Different endeavors have been made to improve the overall tensile strength of concrete by using diverse materials. These materials were used either as a form of replacement of its main constituents, or simply as an addition to the other constituents. Out of all such materials, the use of different types of fibers, added a definite proportion of tensile strength without actually altering the configuration of the concrete blocks to a larger extent. This research is based on the optimization of glass fibers as a replacement of the Ordinary Portland cement (OPC) along with the use of rice husk ash (RHA). The purpose of this study is to obtain a proportion of both glass fibre and rice husk ash simultaneously, in order to obtain best results for different types of tests. Moreover, with the use of glass fibre which is having a property of being crack arrester, there occurs the restriction in the growth of micro cracks, which otherwise were susceptible to be enlarged under the application of load.

Key Words:Glass Fibre, Rice Husk Ash, Cementitious material, Compressive Strength, Split tensile strength.

I. INTRODUCTION

The use of Ordinary Portland Cement (OPC) in concrete is considered to be uneconomical and energy exhaustive in nature. This factor created a sense of urgency in the minds of researchers to provide an alternative to the said material, in order to provide accommodation for the populace. This factor escalated the exploration of utilizing a portion of the locally accessible materials that could be utilized as partial substitution, if not addition to Ordinary Portland Cement (OPC). The use of such materials proved to be both economical and ecofriendly as these were mostly obtained as by-products or industrial wastes, thereby reclaiming the reduction of accumulation of such wastes in the environment.

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Some of the major inventions include the use of materials like fly ash, timber ash, silica fume, blast furnace slag, rice husk ash, steel fiber, glass fiber and other plastic wastes. The utilization of different fibers in concrete not only improved the overall strength of concrete but also helped in arresting the cracks which are developed due to plastic shrinkage or due to plastic settlement of the fresh concrete. These cracks are formed due to segregation and bleeding when the fresh concrete is placed. Because of the very rapid moisture loss which is caused due to various factors including the relative humidity, air and concrete temperature difference and also due to wind velocity, the fresh concrete is subjected to plastic shrinkage which thereafter leads to the development of cracks on setting. Glass fiber reinforced concrete (GFRC) is able to overcome such defects and also possesses other major properties like being light in weight, fire resistant, good appearance and strength. In GFRC different sized fibers are embedded in the matrix (usually Alkali-resistant glass fibers), in the form that the concrete retains it's physical as well as chemical properties. This type of combination of fibers and cement matrix possesses a synergistic behavior in which the fibers act as load bearing components, while as the cement matrix allows the orientation and configuration of the GFRC toremain uniform throughout. Normally twotypes offibers are used in GFRC, short and long length. Short length fibers (3mm to 6mm) are used in order to control the proclamation of micro-cracks and to improve the eventual strength. Long length fibers (12mm to 20mm), on the other hand are used to restrict the macro-cracks and to enhance the post-crack contortion of concrete. There isa considerable difference if we compare the structural metals and fiber-reinforced composites. Structural metals on the application of load reveal yielding and plastic deformation, while as majority of the fiber-reinforced composites show elastic behavior during their tensile stress-strain characteristics. Also the general mechanism of development of damage and growth in both these types of reinforcements are quite different. Some of the important characteristics of fiber-reinforced composites are their low coefficient of thermal expansion, high damping possession and non-corroding behavior. But the major disadvantage of using GFRC is the low ductility

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which it offers on the exposure to outdoor environment. Moreover the usage of Rice Husk Ash (RHA) decreases the overall permeability of the concrete, enhances the resistance to CO_2 attack as well as improves the resistance to the corrosion in case of steel reinforced concrete. RHA is an agricultural waste which is produced from burning the rice husk at a controlled temperature of about 550^0C to 800^0C. At this temperature range, the amorphous rice husk ash gets formed, and if the temperature is increased beyond this limit then crystalline ash gets formed.RHA and glass fibers both are used as a replacement of the OPC during this research.

II. MATERIALS

The Ordinary Portland Cement of 43- grade confirming to IS: 8112-1989 was used during this study. The river sand confirming to IS: 383-1970 was used as fine aggregate. Coarse aggregate which was obtained from local quarry was used, also confirming to IS: 383-1970. RHA that was used during this experiment was obtained from Ludhiana, Punjab and was used in powdered form. It has a high pozzolanic action which imitates the hydration process of OPC thereby reduced the overall cement consumption during this experiment. The water that was used during this experiment was potable water confirming to IS: 456-2000. Glass fibers which are obtained from fine-machine tooling of the waste glass (Silicon dioxide) were used in two different lengths, short and long as discussed above.

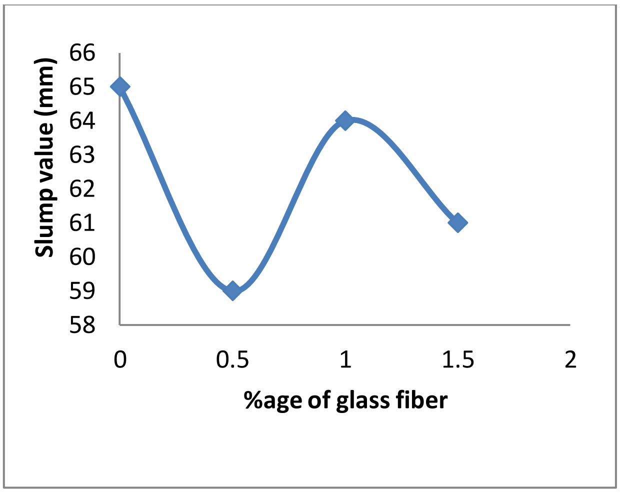
III. METHODOLOGY

M40 grade concrete mixes of glass fiber in the range of 0.5%, 1.0% and 1.5% along with RHA in the range of 10% and 20% as the replacement of cement were prepared. W/C ratio of the mix was taken as 0.40 (IS 10262-2009). A total no. of 108 samples was casted in which there were 36 cubes, 36 cylinders and 36 beams. These samples were casted as per different ratios of both RHA and glass fiber. These samples were casted and demolded after 24 hours and subsequently curing was done for their respective durations. For cubes and cylinders the testing was done after 7 and 28 days but for beams the testing was done after 14 and 28 days accordingly. Cubes were tested for compressive strength, cylinders for split tensile strength and beams for flexural strength respectively. Workability tests were also carried at the time of casting of the samples.

%age of RHA	%age of Glass Fiber	Compressive Strength (N/mm^2)	
		7 days	28 days
10%	0	26.5	42.5
	0.5	27.2	40.6
	1	28.6	42.8
	1.5	25.6	40.2
20%	0	27.5	41.4
	0.5	27.4	39.8
	1	29.5	42.1
	1.5	26.8	38.9

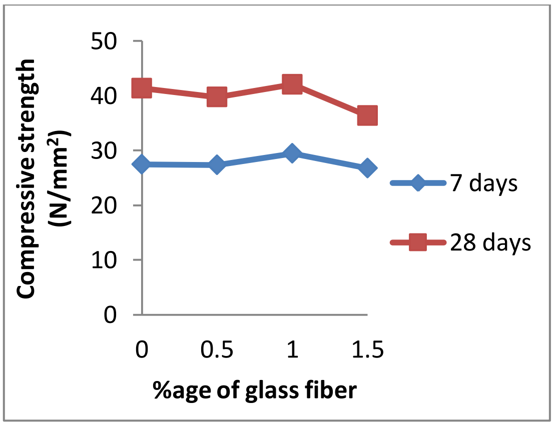
S. No.	Percentage of glass fiber	Slump Test (mm)
1	0	65
2	0.5	59
3	1	64
4	1.5	61

I. Workability Test



Graph-1: Workability Test

II. COMPRESSIVE STRENGTH.



Graph-2: Compressive Strength for 10% RHA samples.

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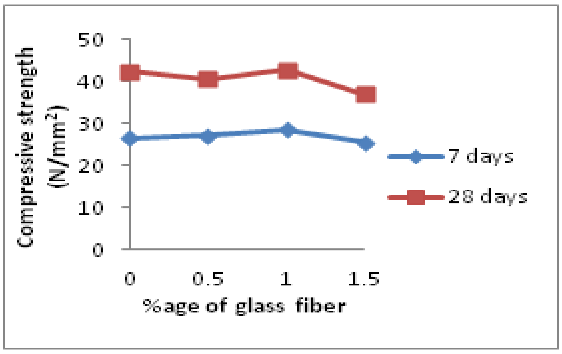
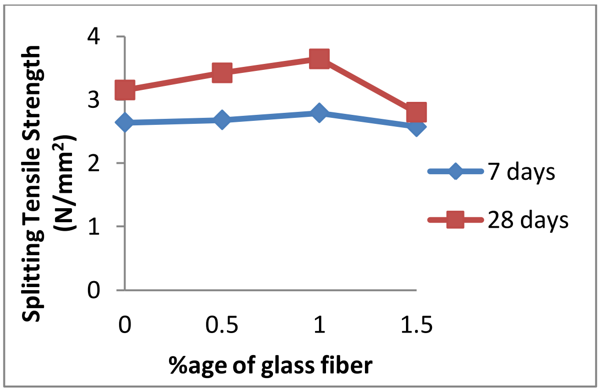


Graph-3: Compressive Strength for 20% RHA samples.

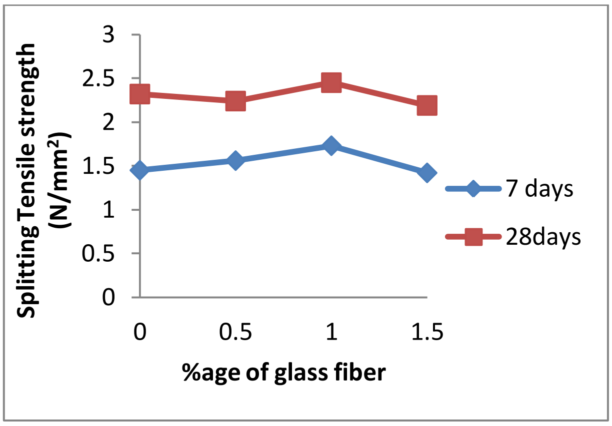
III. Splitting Tensile Strength.

%age of RHA	%age of glass fiber	Flexural Strength (N/mm^2)	
		14 days	28 days
10%	0	4.9	6.5
	0.5	5.2	6.9
	1	5.7	7.2
	1.5	5.6	7
20%	0	4.6	5.6
	0.5	4.8	6.2
	1	5.2	6.8
	1.5	5.1	6.4



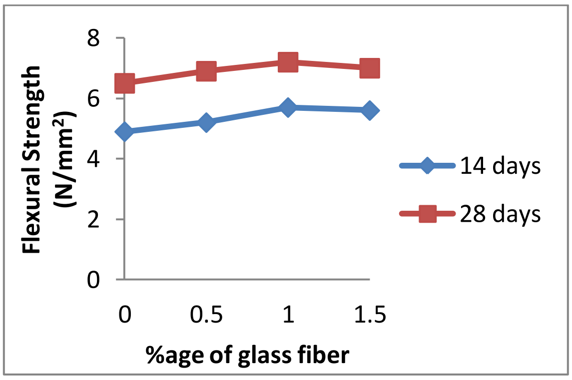
Graph-4: Splitting Tensile Strength for 10% RHA samples.

%age of RHA	%age of glass fiber	Splitting Tensile Strength (N/mm^2)	
		7 days	28 days
10%	0	2.64	3.15
	0.5	2.68	3.42
	1	2.79	3.64
	1.5	2.57	3.25
20%	0	1.45	2.32
	0.5	1.56	2.24
	1	1.73	2.45
	1.5	1.42	2.19

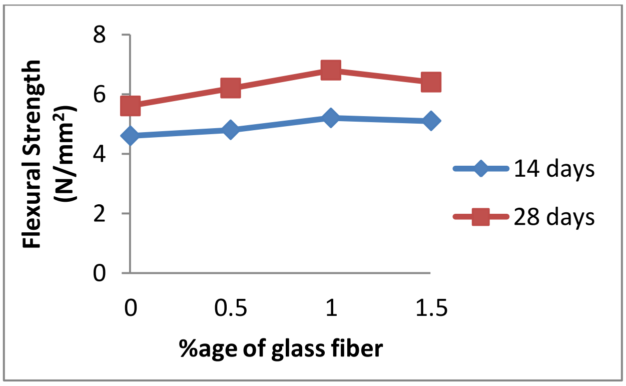


Graph-5: Splitting Tensile Strength of 20% RHA samples.

IV. Flexural Strength.



Graph-6: Flexural Strength of 10% RHA samples.



Graph-7: Flexural Strength of 20% RHA samples.

IV. RESULTS AND DISCUSSION.

In this study, different concrete specimens were subjected to compressive, splitting tensile and flexural strength tests to calculate the optimum value of both glass fiber and RHA replacement in M40 grade of concrete. The results obtained are summarized below:-

1. The compressive strength of samples was comparable to the conventional concrete as the results were pretty impressive. For different percentages the results were as comparable to the conventional concrete as these can be. For 0.5% replacement of glass fiber, the values of compressive strength showed a definite increase at 7 and 28 days.
2. For 10% RHA replacement, it was seen that the maximum value was obtained for 1% replacement of glass fiber at both 7 and 28 days respectively. Further replacements showed decrease in compressive strengths at both 7 and 28 days respectively.
3. For 20% RHA replacement, the trend was same as was in case of 10% RHA replacement as the maximum compressive strength of 29.5N/mm^2 was observed for 1% glass fiber replacement at the end of 7 days, which was higher as compared to 10% RHA replacement of the same percentage of glass fiber replacement. But at the end of 28 days the maximum compressive strength was observed to be slightly less for 20% RHA samples as compared to 10% RHA samples. Further increase in the glass fiber percentages showed a decrease in compressive strength for 20% samples as well.
4. For splitting tensile strength the values were comparable to the conventional concrete. For 0.5% glass fiber replacement, the splitting tensile strength values for 10% RHA at the end of 7 and 28 days were calculated as 2.68N/mm^2 and 3.42N/mm^2 respectively. For 1% replacement of glass fiber, the values for 10% RHA samples was calculated as 2.79N/mm^2 and 3.64N/mm^2 at the end of 7 and 28 days respectively as shown in table 3.
5. For 20% RHA samples, the splitting tensile strength values were showing an increasing trend for 1% glass fiber replacement as the values obtained were 1.73N/mm^2 and 2.45N/mm^2 at 7 and 28 days respectively. The other percentage replacements showed lesser tensile strengths at both 7 and 28 days. Also it can be seen that the tensile strength values obtained in case of 20% RHA replacement samples were surprisingly lesser as compared to 10% samples. This may be justified as the loss of pozzolanic effect of cement due to increased RHA percentage.
6. Flexural strength of all the samples was calculated at 14 and 28 days. The results were impressive and were greater than the fcr values calculated in accordance with the conventional values. For 10% RHA samples, the values obtained were higher for 1% glass fiber replacements than the other ones. Same was the case with 20% RHA samples. The results were also comparable for 1.5% glass fiber replacements as the values were nearly matching their 1% counterparts.

V. CONCLUSION.

For M40 grade of concrete the optimized strength values on the replacement of cement by RHA and glass fiber was obtained. For compressive strength, the highest values were obtained for 1% glass fiber. Same was the case regarding splitting tensile strength and flexural strength as the highest values were observed for 1% glass fiber and 10% RHA replacement. The further addition of glass fiber beyond 1% showed a decreasing behavior in all the cases. Moreover there was also decrease in the strength values when the RHA content was increased beyond 10%. This can be justified by the assumptions that there must be leaching of excessive silica during the hydration process which combined with glass fiber,resulting in the reduction of strength. This highlights the fact that the replacement of cement with 1% glass fiber and 10% RHA showed better and comparable results. So with the usage of these plastic fibers and wastage products, the overall mechanical properties of the concrete are preserved.

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