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MECHANICAL PROPERTIES OF HYBRID FIBRE REINFORCED CONCRETE

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Abstract: ***This paper contains the behavior of Hybrid Fiber reinforced concrete with the partial replacement of natural coarse aggregate with recycled coarse aggregate and cement with fly ash. Application of recycled materials in the building industry is essential for permanently sustainable development. Concrete is good in compression and weak in tension. Low tensile strength and the poor resistance to cracking of the concrete lead to severe effect in its properties. Introduction of fibers into concrete will increase its tensile strength and resistance to cracking. Polypropylene fiber and glass fibers are chemically inorganic. Because of increase in coal based thermal power plants there is an increment in the production of fly ash which is a waste material. If fly ash is not disposed properly it will be hazardous. As a solution it is used in the concrete as a partial replacement of cement. This replacement reduces the environmental pollution and improves the mechanical properties of concrete. This paper is focused on the experimental program aimed at verifying selected material properties of Hybrid fiber reinforced concrete in which all of the natural coarse aggregates are partially replaced by recycled aggregates and cement is partially replaced by fly ash. The combination of recycled waste, fibers and binder creates an unusual fiber reinforced concrete which is a new composite. In this study the percentages of recycled aggregate (25%), fly ash (20%) and polypropylene fibers (0.6%) are fixed as per previous literatures. And with this combination, different percentages (0%, 0.2%, 0.4%, 0.6%, 0.8% and 1.0%) of glass fibers are used to know the mechanical properties like compressive strength, split tensile strength and flexural strength of the Hybrid fibre reinforced concrete. The optimum dosage of the glass fibres with 0.6% polypropylene fibres is found at 0.6%.***

Keywords: Hybrid Fibre reinforced concrete, Recycled Aggregate, Polypropylene fibres, Glass fibres, Fly ash, Compressive strength, Split tensile strength, Flexural strength.

I. Introduction

Construction and demolition waste constitutes a major part of total solid waste production in the world. The most effective way to reduce the solid waste in construction is achieved by reusing and recycling the waste material. Application of recycled materials in the building industry is important for sustainable development and concrete recycling gains importance because it protects natural resources and eliminates the need for disposal. Concrete is one of the most widely used building materials which can be easily mixed with many materials in order to meet special needs to form virtually into any shape. The Concrete is a brittle material which is good in compression but weak in tension. To increase the properties of the concrete, additional material like fibers may be used. Concrete generally develops micro cracks and they increase to macro cracks under applied loads which lead to low tensile strength of concrete. Hence addition of fibers improves the tensile strength of concrete and helps to overcome the problems like cracking. In this experiment the percentages of recycled aggregate (25%), fly ash(20%) and polypropylene fibers(0.6%) are combined with the different percentages(0%, 0.2%, 0.4%, 0.6%, 0.8% and 1.0%) of glass fibers to know the mechanical properties like compressive strength, split tensile strength and flexural strength of the Hybrid fibre reinforced concrete.

II. Related works

Manu J Nair and Renny Varghese (2017) studied effect of different percentages of glass fibers and polypropylene fibers on concrete. The glass fiber content varies from 0-2.0% and polypropylene fiber content varies from 0-0.8% by weight of cement. Vineetha V. V and Arya Aravind (2017) concluded that concrete with 25% coarse aggregate replaced by recycled concrete aggregate with the addition of polypropylene and nylon fiber improved the compressive strength, flexural strength and split tensile strength of concrete. Srujan Varma Kaithoju and Mohammed Abdul Jabbar (2018) summarized that the hybrid fiber reinforced concrete with usage of fly ash up to 30% as partial replacement of cement not only improves the mechanical properties of concrete but also protects the environment from the hazards of fly ash.

III .**Objectives**

- To make use of locally available recycled waste material to avoid the landfills and conserve the non renewable resources.
- To attain the optimum proportion of glass fiber and polypropylene fiber by studying the compressive, split-tensile and flexural strengths of the hybrid fiber reinforced concrete with recycled coarse aggregate as partial replacement to natural coarse aggregate and fly ash as partial replacement to cement, to achieve this M25 grade of concrete is used for the investigation.

IV. **Materials Used and Their Properties**

1) **Cement:** Ordinary Portland cement of grade 53 confirming to IS: 12269-2013 is used. The specific gravity of cement obtained was 3.07 and fineness is 4%.
2) **Fine Aggregate:** Fine aggregate of Zone-II confirming to IS: 383- 1970 is used with Specific gravity 2.65, Bulk density 1640kg/m^3 and Fineness modulus 3.66.
3) **Coarse Aggregate:** Crushed granite is used as coarse aggregate confirming to IS: 383- 1970. The nominal size of coarse aggregate is 20mm with Specific gravity 2.68, Bulk density 1490kg/m^3 and Fineness modulus 7.36.
4) **Recycled Coarse Aggregate:** Laboratory waste recycled aggregates are used.

TABLE 1
PROPERTIES OF RECYCLED COARSE AGGREGATE

Sl. No	Properties	Values
1	Specific gravity	2.598
2	Bulk density	1324kg/m^3
3	Fineness modulus	7.01
4	Water Absorption	5.8%

5) **Polypropylene Fibers:** Polypropylene Fibers of length 12mm by Reliance Recron 3S of Grade A are used as shown in Fig.1(a). And specific gravity of the fibers is 0.91. Aspect ratio of fibers is 300 and tensile strength is 550-700MPa.
6) **Glass Fibers:** Anti-Crack Glass Fibers of length 12mm by Owens Corning of AR type are used as shown in Fig.1(b). And specific gravity of the fibers is 2.7. Tensile strength is 1400-1700MPa.

Fig.1 (a): Polypropylene Fibers

Fig.1 (b): Glass Fibers

7) **Fly Ash:** Class–F fly ash procured from the Kakatiya thermal power station located at Bhupalpally, Telangana is used.
8) **Water:** Potable water without any dissolved salts is used for mixing and curing.

V. **Experimental Results and Discussion**

The design mix proportion for M25 Grade Concrete was done according to IS 10262-2009. And the design mix proportion is **1:1.87:3.17** with the water/cement ratio of **0.5**. Test specimens of standard size 150mm x150 mmx150mm cubes for compressive strength, cylinders of diameter 150mm and height 300mm for split-tensile strength and beam specimens of size 500mmx100mmx100mm for flexural strength were cast. After the completion of casting, all the specimens were removed from the mould and submerged in clean and fresh water for 28 days.

- Compressive Strength = Load / Cross-sectional Area.
- Split tensile strength = $2P/\pi LD$.
- Modulus of Rupture, $R= PL/bd^2$.

TABLE 2

STRENGTH RESULTS OF HYBRID FIBER REINFORCED CONCRETE

S.NO	Mix proportion	Compressive Strength (N/mm^2)		Split-tensile strength (N/mm^2)		Flexural strength (N/mm^2)	
		7 days	28 days	7 days	28 days	7 days	28 days
1	Conventional concrete	20.44	31.56	2.12	3.11	3.64	5.23
2	25% RCA	19.83	30.24	1.98	2.96	3.61	5.15
3	20% FA + 25% RCA	20.5	31.37	2.16	3.04	3.67	5.27
4	25% RCA + 20% FA + 0.6% PP	21.10	32.46	2.28	3.19	3.78	5.41
5	25% RCA + 20% FA + 0.6% PP + 0.2% GF	21.83	33.58	2.35	3.32	3.86	5.53
6	25% RCA + 20% FA + 0.6% PP + 0.4% GF	22.51	34.63	2.41	3.46	3.94	5.66
7	25% RCA + 20% FA + 0.6% PP + 0.6% GF	23.34	35.93	2.52	3.58	4.13	5.87
8	25% RCA + 20% FA + 0.6% PP + 0.8% GF	22.91	34.24	2.38	3.37	3.91	5.61
9	25% RCA + 20% FA + 0.6% PP + 1.0% GF	21.82	33.56	2.27	3.26	3.83	5.49

RCA-Recycled Coarse Aggregate, FA-Fly ash, PP- Polypropylene fiber, GF-Glass fiber.

➢ **Compressive strength**

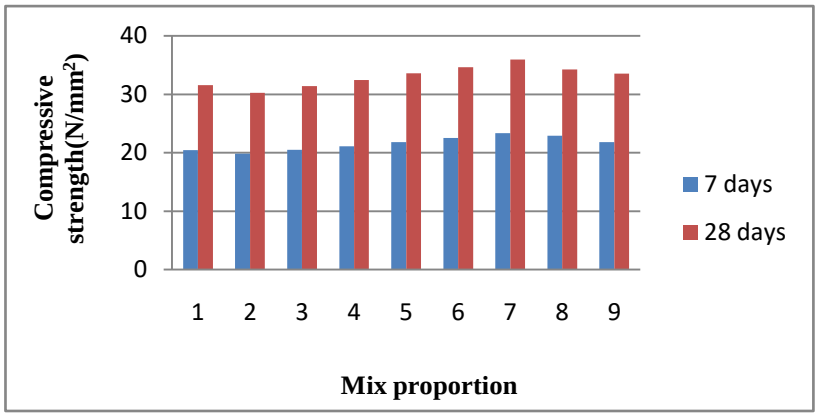

Fig 2: Average compressive strengths of mix proportions

From the above results it was observed that cubes cast with a combination of 0.60% of glass fibers and 0.60% of polypropylene fibers with recycled aggregate and fly ash gave a good compressive strength of 35.93MPa which is higher than the compressive strength of conventional concrete.

➢ **Split tensile strength**

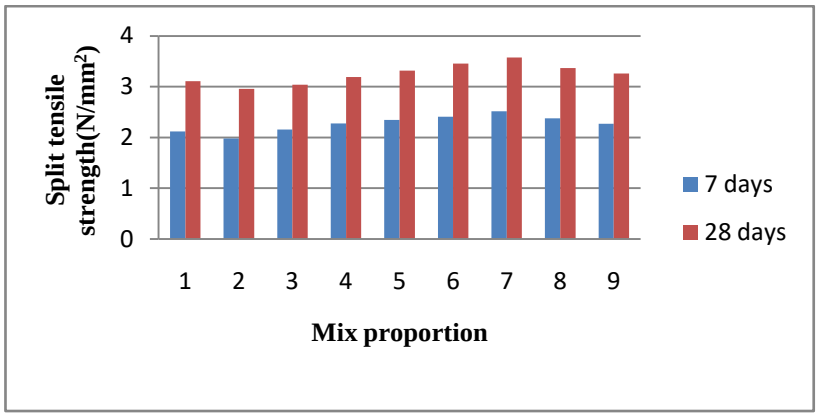

Fig 3: Average split-tensile strengths of mix proportions

From the above results it was observed that cylinders cast with a combination of 0.60% of glass fibers and 0.60% of polypropylene fibers with recycled aggregate and fly ash gave a good split-tensile strength of 3.58MPa which is higher than the split-tensile strength of conventional concrete.

➢ **Flexural strength**

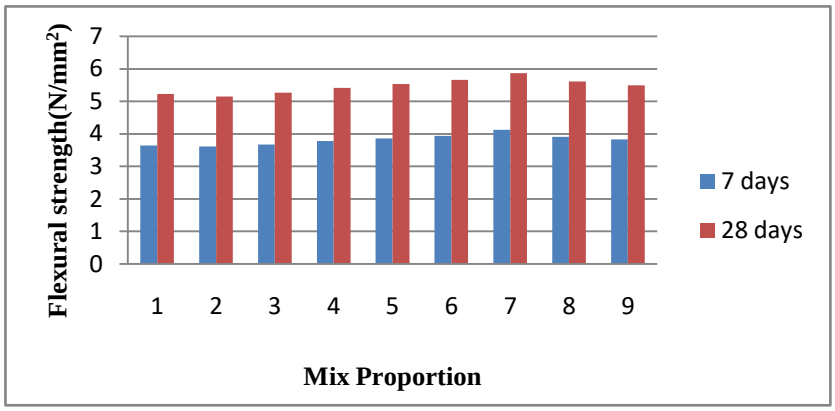

Fig 4: Average Flexural strengths of mix proportions

From the above results it was observed that prisms cast with a combination of 0.60% of glass fibers and 0.60% of polypropylene fibers with recycled aggregate and fly ash gave a good flexural strength of 5.87MPa which is higher than the flexural strength of conventional concrete.

VI. **Conclusion**

- The optimum dosage of the fibers in hybrid fiber reinforced concrete found at 0.60% of Polypropylene fiber and 0.60% of Glass fiber with recycled aggregate and fly ash replacement.
- It has been observed that the compressive strength at optimum dosage of fibers with recycled aggregate and fly ash is 14% greater than conventional concrete for 28 days curing.
- The split tensile strength at optimum dosage of fibers with recycled aggregate and fly ash is found to be 15% greater than conventional concrete for 28 days curing.
- The flexural strength at optimum dosage of fibers with recycled aggregate and fly ash is found to be 12% greater than conventional concrete for 28 days curing.

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