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Strength Properties of No Aggregate Concrete Using Fibers

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Abstract: In the present study an attempt has been made to understand the strength properties of no aggregate concrete (NAC) using steel fibers of different aspect ratio. No aggregate concrete (NAC) is a new type of concrete in which the use of coarse aggregates are totally avoided for preserving the natural stone, hillocks and hills. The use of sand is also avoided to preserve the river beds. This is a typical research work serving the agenda of sustainable development. As no aggregate concrete undergoes brittle failure and has low tensile strength, steel fibres of different aspect ratio are used in the present study. The strength properties such as compressive strength, flexural strength, and split tensile strength of no aggregate concrete with steel fibers are also studied.

Keywords: *Fly ash, No aggregate concrete (NAC), No aggregate concrete mixes with steel fibers.*

1. Introduction

In concrete technology, mortar is the combination of cement and sand. Concrete is the combination of cement, sand and coarse aggregate, water being the common input in both the cases. If the fine aggregates are totally eliminated from normal concrete it is called as no fines concrete. No fines concrete are also known as porous, pervious, gap-graded, permeable, and cellular concrete [1].

No fines concrete are generally used for pavements applications, less traffic roadways such as parking lots, residential roads and sidewalks [2]. In no fines concrete the typical grading of coarse aggregates used are of either single-sized or ranging between 9.5 mm to 19 mm. This typical size of grading is adopted in no fines concrete for gaining sufficient strength without reducing porosity [3]

A cementitious mix can be referred as a concrete only if it contains aggregates. Researchers call a mix without aggregates as a concrete with respect to its applications, performance and durability than conventional concrete. It is comparably strong and light weight than normal concrete. N Bhanumathidas and N Kalidas claim no aggregate concrete to be 10-20 times more durable than conventional concrete. Durability of concrete is attributed by the bond between cementitious matrix and aggregates. If the aggregates in concrete are omitted, resulting concrete which is free from a transition zone results in many durability issues. A no aggregate concrete does develop compressive strength upto 80 MPa. The natural stone can be conserved by the use of no aggregate concrete. Sand of good quality is difficult to obtain, hence is avoided thereby conserving river beds. NAC would be a pioneer in construction industry. An extensive research is required to understand the behaviour of NAC. The applicational methodologies are to be established through innovative structural designs. This may be the concrete for future generations [4].

The objective of this paper is to study the compressive strength, flexural strength and split tensile strength of no aggregate concrete with steel fibres.

2. Experimental Program

2.1. Materials Used

Ordinary Portland cement (43 grade) with specific gravity 3.0, conforming to IS: 8112-1989 [7] was used in this study. Fly ash (class F) of specific gravity 2.26 and Blaine's surface area of 3225 cm^2/gm, conforming to IS: 3812-2000 was used in the present study. Fly ash (class F) was collected from Raichur Thermal Power Station (RTPS), Karnataka. The gypsum powder of specific gravity 2.32 along with admixture was used in this project. Potable water was used in all mixes. Salts and other organic impurities were absent. Steel fiber was collected from Steel Fiber Company located in Chennai in Tamil Nadu. Two types of steel fibers having aspect ratio 50 and 37.7 were used in this project. Quantity of steel fibers used is 1.5% the total weight of mix considered in the study [6].

***Table 1**: Mix Proportion for 7 mixes*

Mix No.	Cement kg/m^3	Fly ash kg/m^3	Gypsum kg/m^3	Water kg/m^3	Super plasticizer kg/m^3	W/P ratio	Density kg/m^3
M1*	415.0	-	-	158.00	3.112	0.380	2447.05
M2	344.5	1378	27.56	309.76	6.890	0.177	2066.71
M3	344.5	1378	27.56	294.01	6.890	0.168	2050.96
M4	344.5	1378	27.56	276.50	6.890	0.158	2033.45
M5	344.5	1378	27.56	315.01	6.890	0.180	2071.96
M6	344.5	1378	27.56	297.51	6.890	0.170	2054.46
M7	344.5	1378	27.56	297.51	6.890	0.170	2054.46

**M1 is control concrete mix having fine and coarse aggregates 632 kg/m^3 and 1190 kg/m^3 respectively*

3. Mix Proportion

All the NAC mixes were designed for a target strength above 50 MPa. Total of 7 concrete mixes were prepared and compressive strength, flexural strength, split tensile strength were compared. Control concrete mix (M1), no aggregate concrete mixes without fibers (M2,M3,M4 and M5), no aggregate concrete mix with steel fibers of aspect ratio 50 (M6) and no aggregate concrete mix with steel fibers of aspect ratio 37.7 (M7) were designed in this paper. Quantity of steel fibers added are 1.5% the total weight of mix considered. NAC mixes were prepared in NAC PAN Mixture. NAC mixes are differentiated on water powder ratio. Mix proportion of all 7 mixes for 1 m^3 is shown in Table 1.

4. Results and Discussions

4.1. Compressive Strength

Mix M1 developed compressive strength of 53.03 MPa at 28 days. NAC mixes without fibers produced average compressive strength of 55.40 MPa at 28 days. Mix M6 developed compressive strength of 40.77 MPa at 28 days whereas mix M7 produced compressive strength of 42.97 MPa at 28 days.

4.2. Flexural Strength

Mix M1 developed flexural strength of 4.65 MPa at 28 days. NAC mixes (M2, M4 and M5) without fibers produced average flexural strength of 3.335 MPa at 28 days. Mix M6 and M7 developed same flexural strength of 5.25 MPa at 28 days.

4.3. Split Tensile Strength

Mix M1 developed split tensile strength of 2.79 MPa at 28 days. NAC mixes (M2 and M3) without fibers produced average split tensile strength of 2.758 MPa at 28 days. Mix M6 developed split tensile strength of 2.97 MPa at 28 days.

Results of tests conducted on hardened concrete are shown in Table 2.

***Table 2**: Strength properties of different mixes*

Mix No.	W/P ratio	Compressive strength (MPa)	Flexural strength (MPa)	Split tensile strength (MPa)
		28 days	28 days	28 days
M1	0.380	53.03	4.650	2.790
M2	0.177	62.00	3.130	2.770
M3	0.168	55.00	-	2.747
M4	0.158	46.43	4.050	-
M5	0.180	58.20	2.825	-
M6	0.170	40.77	5.250	2.970
M7	0.170	42.97	5.250	-

5. Conclusion

No aggregate concrete with six different mix designs were casted. Two steel fibers of different aspect ratios were used in mix M6 and M7.

Results of no aggregate concrete with fibers were compared with no aggregate concrete and with the control mix.

1. Compressive strength of mix M6 and M7 is found to be 40.77 MPa and 42.97 MPa at 28 days respectively. Average compressive strength of NAC mixes without fibers is more than other mixes.
2. Flexural strength of mix M6 and M7 is 5.25 MPa at 28 days. Flexural strength of these mixes is greater than other mixes.

3. Split tensile strength of mix M6 is 2.97 MPa which is highest among all the mixes at 28 days.
4. Overall by using steel fibers in NAC mixes, compressive strength is reduced but flexural strength and split tensile strength is increased.

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