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STUDY ON BEHAVIOR OF HIGH DENSITY CONCRETE BY ADDING STEEL PUNCHES

J. Naresh[1] V. Kastro Kiran[2]

Assistant Professor, Department of Civil Engineering, Bharat Institute of Engineering and Technology, Telangana, India[1]

Assistant Professor, Department of Civil Engineering, Vignan Institute of Technology and Science, Telangana, India[2]

naresh.pandu225@gmail.com, kastrokiran@gmail.com

Abstract: Concrete is the most important engineering material and the addition or replacement of some of the materials may change the properties of concrete. In recent years a lot of research work has been carried out in order to obtain more durable and long term performance of concrete structures in the dynamic environment. In this research, concrete mixes of different proportions are prepared by replacing coarse aggregate with steel punchings and tested for mechanical properties of concrete. Four different proportions of steel punches are replaced, namely, 0%, 10%, 20% and 30% for M25 grade of concrete. The aim of this study is to increase the density of concrete and to accomplish it by using steel treatment waste (steel punchings) as coarse aggregate.

Keywords: *High density concrete, steel punches, Concrete*

1. Introduction

Density of normal concrete is in the order of 2400kg/m^3, and where as that of light weight concrete is less than normal density i.e., 1900kg/m^3 or so. To call the concrete as high density concrete, it must have a unit weight ranging 3000-3840kg/m^3 which is about 50% higher than the unit weight of conventional concrete. Increasing the density of concrete can be made possible by using steel punchings as a partial replacement of coarse aggregates. High density concrete is normally used in railways, radiation shielding in nuclear power plants.

With increasing environmental pressure to reduce waste and pollution and to the increasing demands for recycling, the concrete industry has begun adopting a number of methods to achieve good strength properties. In recent years, focus has been turning towards the utilization of natural and industrial wastes. Recycling materials like plastic, steel, and glass has become very common in replacing the coarse and fine aggregates in concrete. In this research, steel punchings are used as a replacement of coarse aggregates.

2. Literature review

Ismail and AL-Hashmi examined the potential for using waste iron in concrete mixes as a partial replacement for coarse aggregate. The experimental study indicated that conversion of iron waste into aggregates could offer a feasible solution for waste management. The tests of those waste-iron concrete mixes revealed that this method performed efficiently to improve compressive, flexural strength, increase density, but decrease the slump value. Topco in his work used barite aggregate instead of traditional silica-calcareous aggregate to increase its weight. He prepared several concrete mixes at different w/c ratios to determine the most favorable w/c ratio of high density concrete produced with barite. It was concluded that the most favorable w/c ratio is 0.40 and the cement dosage should be greater than 350 kg/m3.

Kilincarslan et al. have performed an experimental work to investigate the effect of barite rate in concrete mix on physical and mechanical properties of concrete. It was obvious that the density of concrete increased with the increase of barite rate in concrete. 3507 kg/m3 was the maximum value of concrete density obtained in this work.

3. Scope and objectives

The objectives of this study are:

i) Development of three different grades M25 of concrete.

ii) Investigating the fresh and hardened state properties using steel punches at varying proportions for the M25 grade of concrete.

iii) Studying on different on density, strength and workability of M25 grade concrete.

4. Experimental programme

4.1 Materials used:

Ordinary Portland Cement of grade 53 confirming to IS 12269-1987 is used and coarse aggregate of size 20mm confirming to IS 383-1970 and fine aggregate passing through 4.75mm sieve are used. Steel punchings in cylindrical shape and of different diameters and heights are obtained from a local factory. Table 1 shows the physical properties of different types of steel punchings.

Table 1: Physical properties of steel punchings

Steel punchings	Diameter (mm)	Height (mm)
1	3.6	1.3
2	4.5	1.3
3	4.9	1.4
4	5.3	1.1
5	6.4	1.6
6	7.2	1.7
7	7.7	2.9
8	11.7	3.8

4.2 Preliminary tests:

Tests on cement:

Before performing the tests for mechanical properties, cement, coarse aggregate and fine aggregates tests are performed. Cement tests like normal consistency, initial and final setting times, fineness modulus, compressive strength, soundness and specific gravity tests are performed. Table 2 shows the results of various cement tests.

Table 2: Test results of cement

Test name	Results
Standard consistency	30%
Initial setting time	40min
Final setting time	8hours
Fineness modulus	2.5%
Compressive strength	52.5MPa
Soundness	2mm
Specific gravity	3.21

Tests on aggregates:

Aggregates typically make up 70-80% of the volume of concrete and hence the properties of aggregates play an important in deciding the mechanical properties. Aggregates tests like specific gravity, bulk density, fineness modulus, moisture content and absorption tests are carried out. Table 3 shows the tests results of coarse and fine aggregates.

Table 3: Aggregate test results

Test name	Coarse aggregate	Fine aggregate
Specific gravity	2.601	2.768
Bulk density	1.6g/cc	1.656g/cc
Fineness modulus	3.07	6.73
Moisture content	0%	0%
Absorption rate	0.51%	0.39%

Mix design:

The mix is prepared for M20 grade of concrete based on IS 10262-2009 for 0%, 10%, 20% and 30% replacement of coarse aggregates with steel punchings. Table 4 shows the mix design for different proportions of steel punching replacement. Cubes of size 150mmx150mmx150mm and cylinders of size 150mm diameter and 200mm height are cast and cured for 28days.

Replacement (%)	Cement (kg/m^3)	Coarse aggregate (kg/m^3)	Fine aggregate (kg/m^3)	Water ($kg/m^{3)}$	Density (kg/m^3)
0	408	1143	699	191.5	2441.5
10	408	1028.9	6980.4	191.5	2638
20	408	914.5	698.4	191.5	2834.7
30	408	800.3	698.4	191.5	3031.4

Test results

To determine the workability properties, slump test and compaction factor tests were performed. Mechanical properties like compressive strength, flexural strength and split tensile strength are performed on cubes and cylinders.

Workability tests:

Slump cone test: The slump test indicated a decreasing trend of workability as the percentage of replacement increases. Table 5 shows the slump test results of different proportions of steel punchings in M20 grade mix.

Table 5: Slump test results

Slump value (mm)	% of replacement
84	0
80	10
71	20
66	30

Compaction factor test: The compaction factor test indicated a moderate decreasing trend of workability as the percentage of replacement increased. Table 6 shows the compaction factor test results.

Table 6: Compaction factor test results

Compaction factor	% of replacement
0.89	0
0.862	10
0.846	20
0.831	30

Mechanical properties:

Compression test: The compression test is conducted in universal testing machine on cube specimens at 7 and 28 days. Table 7 shows the compression test results of M20 mix at varying percentage of replacement of coarse aggregate with steel punchings.

Table 7: Compression test results

% Replacement	Compression test		Density
	7 days	28 days	
0	21.13	43.7	2441.4
10	20.53	42.76	2638
20	15.76	34.63	2834.7
30	16.06	37.93	3031.4

Split tensile strength Test:

The split tensile strength test indicates a decreasing trend of tensile strength value with the percentage of replaced Scrap. Table 7 below shows the average modulus of elasticity recorded during the test.

Table 7: Split Tensile test results

Scrap	Density (kN/m^3)	Tensile Strength (Mpa)	
		7 Days	28 Days
0%	2441.4	6.96	11.10
10%	2368.07	6.96	11.00
20%	2834.77	2.83	9.83
30%	30319.46	7.4	11.23

Flexural strength Test:

The flexural strength test indicates a increasing trend of flexural strength value with the percentage of replaced Scrap. Table 7 below shows the average modulus of elasticity recorded during the test.

Table 8: Flexural Test results

Scrap	Density (kN/m^3)	Flexural Strength (MPa) 28 Days
0%	2441.4	23.66
10%	2638.079	25.66
20%	2834.77	27.66
30%	3031.469	28.66

Conclusion

1.By using steel punches in concrete mix, acceptable properties in fresh and hardened state can be attained

2.The studies are showing that the workability property slump and compaction factor values decrease with addition of waste steel.

3.The studies are showing that the mechanical properties like compressive strength is gradually decreasing with increase in increase in steel %, as the steel is strong in tension.

4. The studies are showing the very light changes in the split tensile test results, there is only a slight effect of steel replacement on tensile strength.

5.The studies are showing that there is a continuous increase in the flexural strength of concrete with increase in waste steel %.

Recommendations for Further Studies

Further testing and studies on the replaced scrap concrete is highly recommended to indicate the strength characteristics of scrap (steel punching's) for application in high density concrete.

Below are some of the recommendations for further studies:

1. Although by decreasing the water/cement ratio, scrap can achieve high density concrete. But the workability will be very low. Therefore, it is recommended that adding admixtures such as super plasticizer and silica fume into the mixing so that the workability will be improved.
2. More investigations and laboratory tests should be done on the strength characteristics of replaced scrap. It is recommended that testing can be done on concrete slabs and walls. Some mechanical properties such as creeping and abrasion were also recommended.
3. More trials with different particle sizes of scrap and percentage of replacement of scrap are recommended to get different outcomes and higher density characteristics in the replaced scrap concrete.

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