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Effect of Iron Slag and Robodust on the Mechanical Properties of Concrete

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Abstract: Concrete is the composite material which is contains cement, coarse and fine aggregate. The real fact is that the concrete production was observed to be 10 billion tons per year, which is double the utilization of other building materials such as timber, steel, etc. Due to the efficient properties of concrete, it is broadly used in the construction of the buildings. To increase the mechanical properties of concrete and to make it more efficient, researcher have been conducting many experiments using various other materials as the substitute of cement, fine aggregate and coarse aggregate. Manufacturing of cement produces more carbon dioxide and thus in turn creates air pollution. In order to decrease carbon dioxide production, minimize the waste materials and to make the concrete eco-friendly and economical, robodust and iron slag has been adopted in this study. In this research, 30% robodust has been replaced with fine aggregate and 10%, 20%, 30%, 40% and 50% iron slag has been replaced with cement. The combination of robodust and iron slag replacement with fine aggregate and cement respectively has shown good increase in mechanical properties of concrete in contrast to conventional concrete.

Keywords: Concrete, cement, robodust, iron slag.

I. INTRODUCTION

Concrete is the common substance used for construction purpose. Due to the increase in construction works, the natural resources are deteriorated at rapid rate. In order to save our natural resources, my dissertation work is based on the replacement of river sand with Robodust and Cement with Iron slag is used to achieve concrete strength. The concrete is the best eminent and mostly used in construction material, due to its own gainful production, properties and upkeep over timber and steel. A concrete is simple mixture of cement, coarse aggregates, fine aggregates and water.

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The Orthodox binding material of cement has now grown into lavishly day by day and its creation involves adverse environmental imports byproducts such as heavy fabrication of Carbon dioxide (CO_2). Other materials such as river sand has become insufficient and it is enough use origins ruin of river bed and drop in ground water revitalize. Makings of concrete now suited unusual and affluent. Assembly and disproportionate use of constituents of concrete causes harmful environmental imports. Natural sand is the crucial components used for the assembly of concrete have now developed a scare and costl. Later huge ultimatum for substitute construction materials that change the stream sand material without mutable the looked-for properties of concrete moreover in fresh or in hard-bitten statuses. The grinder dust twisted from granite crusher plants is an unusual construction material that supplants the river sand in copiously or somewhat sizes and baptized as robosand. It is habitually recognized by numerous unlike names such as Shake sand, Crushed sand, Green sand, Poabs sand, Robosand, Pozzolona sand and Barmac sand,. This Robosand is much superior from river sand and its cost almost close to river sand. Other Predictable concrete binding material is cement which fixes all the other materials to form a single form, which becomes exclusive and the assembly is not eco-friendly. Later there is abundant claim for supplementary and alternative cementitious materials in construction works (Ramakrishna et al, 2015). Iron slag is an industrial byproduct, its industrious use award an opportunity to reposition the utilization of limited natural incomes on a large scale. Iron slag is a byproduct gained in the creation of pig iron and is created by the mixture of earth elements of iron ore along with limestone flux. Steel and Iron slags can be discerning by the cool treating when uninvolved from the boiler in the manufacturing. Generally, the slag composed of aluminum, calcium, silicates, magnesium and manganese in several travels. Although the chemical structure of slag is same, the physical characters of the slag differ with the changeable manner of cool treatments. The slags can be used as cement chief constituents as they have greater pozzolanic properties (Chetan et al, 2014).Partial substitution of crush stone dust with fine aggregate has shown improved in flexural strength, but the standard of concrete drops when the crusher sand is used beyond a limit. The split tensile strength was noticed to be 14.62% higher at 7days and 8.66 % larger at 28 days (Hameed and Sekar, 2009).

II. MATERIALS AND METHODS

OPC 43 grade cement used as a primary reinforcement. Coarse aggregate of size 10 mm to 20 mm was used. River sand has been adopted as the fine aggregate. Iron slag was taken from the steel industry.

Constant 30% robodust has been replaced with fine aggregate. 10%, 20%, 30%, 40% and 50% iron slag has been replaced with cement.

A. Tests on Ordinary Portland cement

OPC is generally used as binding material in concrete which creates a solid matrix. Foremost aim of the OPC is to upsurge the cohesive property inside the concrete ingredients, to make virtuous strength. Initially, OPC physical properties and chemical properties are studied for producing the mix design. Table 1 shows OPC 43 grade cement properties.

Table 1. OPC 43 grade cement properties

Tests conduceted	Experimental values	Values specified in IS 8112:1989
Specific gravity	3.08	-
Standard Consistency	30%	-
Initial setting time	32 mins	Should not be less than 30 mins
Final setting time	220 mins	Should not be greater than 600 mins

B. Properties of aggregates

According to IS 383-1970, tests was conducted on both coarse and fine aggregate. The aggregate which are mainly used in a combined manner are of 20 mm and 10 mm sizes are in fraction of7 0:30 ratio. The constitution of fine aggregate and coarse aggregate are exhibited in Table 2 and Table 3 respectively.

Table 2. Properties of Coarse aggregate

Properties	Description
Aggregate colour	Grey
Aggregate shape	Angular
Specific gravity of 20 mm aggregate	2.66
Specific gravity of 10 mm aggregate	2.33
Fineness modulus of 20 mm aggregate	6.92
Fineness modulus of 10 mm aggregate	6.64

Table 3. Properties of fine aggregate

Properties	Description
Zone	II
Specific gravity	2.49
Fineness modulus of aggregate	2.51

III. MIX DESIGN

According to IS 10262 – 2009, M-25 mix has been adopted for this study. The quantities of materials replaced are tabulated in Table 4.

IV. MECHANICAL TESTS CONDUCTED ON CONCRETE

Compressive strength test was carried out on the sample size of 150 mm x 150 mm x 150 mm according to IS 516 – 1959. After 7 days and 28 days water curing period, compressive strength was carried on the samples. The arrangement for compressive test is exhibited in Figure 1. Split tensile strength was carried on specimen size of 150 mm x300 mm. The split tensile test setup is displayed in Figure 2. The flexural strength of concrete is found by casting beam of size 100 mm x100 mm x 500mm. The beams were tested by positioning them consistently. Specimens were removed from the tank at 7 and 28 days curing and tested. The setups for compressive, split tensile and flexural test are displayed in Figure 3(a, b and c).

(a) Compressive strength setup

(b) Split tensile setup

(c) Flexural strength setup

Fig. 3. Setup of mechanical tests

Table 4. Quantities of materials replaced

Mix	Cement (kg/m^3)	Coarse ggregate(10mm) (kg/m^3)	Coarse ggregate(20mm) (kg/m^3)	Fine aggregate (kg/m^3)	Iron slag (kg/m^3)	Robodust (kg/m^3)
Normal mix	11.4	16.81	16.81	26.23	-	-

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M-IS10	10.26	16.81	16.81	18.362	1.14	7.87
M-IS20	9.12	16.81	16.81	18.362	2.28	7.87
M-IS30	7.98	16.81	16.81	18.362	3.42	7.87
M-IS40	6.84	16.81	16.81	18.362	4.5	7.87
M-IS50	5.7	16.81	16.81	18.362	5.7	7.87

Where,
M-IS 10 = Mix containing iron slag 10% and robodust 30%
M-IS 20 = Mix containing iron slag 20% and robodust 30%
M-IS 30 = Mix containing iron slag 30% and robodust 30%
M-IS 40 = Mix containing iron slag 40% and robodust 30%
M-IS 50 = Mix containing iron slag 50% and robodust 30%

V. RESULTS AND DISCUSSIONS

A. Compressive strength

The main problem associated with concrete is to struggle the compressive stresses in most of the structural applications. Compressive strength of all the mixes increases at the age of 7 and 28 days on replacing with the constant percentage of robodust and varying percentage of iron slag. The compressive strength values are shown in Table 5. There is well bonding of iron slag with other ingredients and also iron slag behaves as a cement material. The iron slag has the ability to resist the loads in compression way. The compressive strength as compare to the normal mix decreases slightly up to 30% of slag replacement but after as the percentage of slag improves the compressive strength also increases at 40% as contrasted to normal strength. Then again, the compressive strength starts to decrease at 50% of slag replacement with cement and constant robodust percentage which is clearly indicated in Figure 4 (a). Therefore, the higher compressive strength is attained at ratio 30:40 combinable

Table 5. Compressive strength results

Mix	Compressive strength (N/mm^2) 7 days	Compressive strength (N/mm^2} 28 days
Normal mix	26.44	33.91
ISCD-M 10	18.51	23.20
ISCD-M 20	14.23	17.56
ISCD-M 30	10.44	14.2
ISCD-M 40	34.38	41.69
ISCD-M 50	21.40	26.08

B. Split tensile strength

Split tensile strength of concrete as shown in Table 6. Table 6 indicates the loss in split tensile strength for dissimilar ratios of iron slag with cement and robodust with typical sand. There is reduced in split tensile strength because the iron slag does not behave as a tension member and does not make a bond with cement. A singular reinforce concrete the steel behaves as a tension member hence the strength surges there.

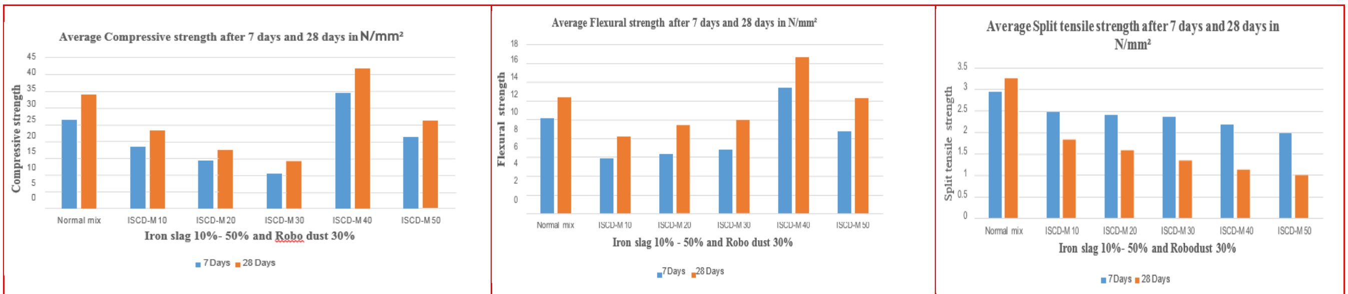
Table 6. Split tensile strength results

Mix	Split tensile strength (N/mm^2) 7 days	Split tensile strength (N/mm^2} 28 days
Normal mix	2.93	3.24
ISCD-M 10	2.46	1.82
ISCD-M 20	2.41	1.57
ISCD-M 30	2.35	1.33
ISCD-M 40	2.17	1.12
ISCD-M 50	1.98	0.99

The split tensile strength for all the combinations reduced in contrast to the normal mix at the age of seven and twenty-eight days which is clearly shown in Figure 4 (b). It is because the iron slag in the concrete does not behave as a tension member and also does not make a strong bonding with other components. So as in case of compressive strength it is not increased in such a way as it reduces frequently. It behaves as a compression member and has the compressive strength as same as steel. It only forms a hard matrix when mixed in concrete with cement and does not show such effective strength.

C. Flexural strength

Generally, the maximum mutual concrete structure subjected to flexure is beam members in the structural systems and strength of concrete for structures is commonly calculated by virtue of bending tests. When plain concrete undergoes to bending, then tensile, compressive stresses and moreover in some cases direct shear stresses may form. When iron slag and robodust is mixed in reinforced concrete and composite then the tensile strains occur. The strength increased with the different ratios of replacements of cement with iron slag and sand with robodust. The flexural



(a)Compressive strength	(b) Split tensile	(c)Flexural strength

Fig. 4 Hardened concrete results

strength results are tabulated in Table 7.

Table 7. Flexural strength results

Mix	Flexural strength (N/mm^2) 7 days	Flexural strength (N/mm^2} 28 days
Normal mix	2.93	3.24
ISCD-M 10	2.46	1.82
ISCD-M 20	2.41	1.57
ISCD-M 30	2.35	1.33
ISCD-M 40	2.17	1.12
ISCD-M 50	1.98	0.99

As like as the compressive strength is increasing for all the mixes, here also the flexural strength increases frequently in contrast to the normal mix. As the substitute percentages increases correspondingly the flexural strength also increases which is clearly shown in Figure 4 (c). But with less increase in the percentage of replacement of slag with cement less percentage of flexural strength is increasing. The flexural strength starts to decrease after 10% replacement of iron slag with cement and at 40% of slag replacement with cement. Then again, the flexural strength at 50% of slag replacement with cement starts to decrease. Therefore, the maximum flexural strength is achieved at a ratio of 30:40 combinable. Flexural strength is generally checked for beams so the beam is a sensitive element it fails immediately.

VI. CONCLUSIONS

From the research work done, it is concluded that by partially replacing the natural sand with RoboDust and partial replacement of cement with Iron slag, that unwanted materials can be beneficially and efficiently utilized in future for the building purpose in concrete mix as alternate materials without distressing the desired properties of normal concrete. The properties of the iron slag are similar to the cement and attain the maximum strength after 7 days and 28 days on replacing 40% with the cement. On the other hand, Robodust also behaves like natural sand (fine aggregate) due to its advantageous properties, having angular particles and gives the maximum strength by replacing it up to 30% with the natural sand. On addition of these materials to the conventional concrete mix, they behave as a composite material.

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AUTHORS PROFILE

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