An Experimental Study of Replacement of Steel Slag with Coarse Aggregate In Concrete

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Abstract- *In this experimental investigation iron slag rendered as scrap was used as coarse aggregate in place of crushed stone in the preparation of concrete. Concrete containing iron slag in various percentages of 25, 50, 75 and 100 was prepared and tested for its compressive and split tensile strength. Such replacement of coarse aggregate can solve to some extent the depletion of natural resources and save the environment from degradation. It was observed that at 75 per cent replacement level the compressive strength after 28 days of curing attained a value of 50.33 N/mm2. This was found to be 2.2 per cent greater than that of normal concrete. The split tensile strength for the corresponding replacement level was found to be 2.26 N/mm2 that was 14.14 per cent higher than the normal concrete. Further, in order to have a basic understanding of the fire resistance of the concrete containing 100 per cent replacement of iron scrap it was subjected to elevated temperature of 800°C for 120 minutes continuously. From this fire resistance test it was observed that no damage was caused to the concrete containing iron scrap.*

However, there was a marginal reduction of 7.9 per cent in weight and 15.17 per cent reduction in compressive strength compared to that of concrete before heating. The conclusion derived, therefore, is that iron slag scrap can be used as coarse aggregate in the preparation of concrete in place of natural aggregate. This will no doubt help to stop degradation of the environment.

I. INTRODUCTION

In civil engineering, concrete structures such as raft foundation, retaining wall and massive dam which are almost built by this material are very popular structural type [1]. Such structures usually require large volumes of concrete. In the volume of concrete the share of aggregate is typically between 70% and 80% which forms the major part of nearly 3 tons of concrete produced each year for every human on the plant, making it the most man-made product in the world [2]. The aggregates greatly influence different properties of concrete such as workability, dimensional stability, strength and durability [3].

It is the usual practice to use river sand as fine aggregate and crushed granite, gravel and limestone of different sizes and shapes as coarse aggregate in the preparation of concrete. These materials are quarried from natural sources. Excessive use of such materials will result in depletion of natural resources as well as environmental degradation. Hence, it is all the more essential to search for alternatives to these materials [4]. Towards this goal, it is better to consider the use of wastes like iron slag, bottom ash, copper slag, sintered sludge pellets, etc., generated by human activities. Use of such wastes as aggregates will to some extent solve the problem of shortage of aggregates in concrete making at several construction sites, and also minimize the problems associated with aggregate mining and waste disposal. Even though some progress has been made in this direction, still, deeper research is required to evaluate the waste materials as aggregate in concrete. With this view in mind one of the wastes, namely, iron slag scrap, was used as coarse aggregate in the preparation of concrete. The use of slag aggregates from iron and steel production in construction dates back to the Romans who used crushed slag from the crude iron production of that time to build their roads [5]. Nowadays, slag is still used to build roads.

II. METHODOLOGY OF WORK

A. Material And Its Property

Sr.No	Property Of Cement	Value
1	Fines of cement	7.5%
2	Grade of cement	53 Grade(OPC)
3	Specific gravity of cement	3.15
4	Initial setting time	30min
5	Final setting time	60min

B. Material Used

3.1 Cement

Ordinary Portland cement, 53Grade conforming to IS: 269 – 1976. Birla super cement is used for casting all the cubes. Different types of cement have different water requirements to produce pastes of standard consistence. Different types of cement also will produce concrete have a different rates of strength development. It is also important to ensure compatibility of the chemical and mineral admixtures with cement.

3.2 Fine Aggregate

Locally available river sand conforming to Grading zone III of IS: 383 –1970.Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens. Sand is clear from soil and other clay material.

3.3Course Aggregate

Locally available crushed blue granite stones conforming to graded aggregate of nominal size 20 mm as per IS: 383 – 1970.Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

C. Tests

A. Specific Gravity On Coarse Aggregate

1. Clean the pycnometer, dry it and find mass of pycnometer with conical brass cap, washer and screw ring accurate to 0.1gm (W1 gm).
2. Take 200gm to 400gm of oven dried aggregate sample in the pycnometer replace conical brass cap and screw ring. Find mass of pycnometer (W2 gm).
3. Fill the pycnometer to half of its height with distilled water and mix aggregate and water with the help of glass rod. Add more up to neck with constant stirring to remove entrapped air. Replace conical brass cap, washer and screw ring, fill the pycnometer flush with hole in the conical cap with water using dropper. Wipe the pycnometer form outside using blotting paper. Find mass of pycnometer with aggregate and water (W3 gm).
4. Empty the pycnometer, clean it with water. Fill it completely with distilled water to the top of conical cap and wipe it out from outside and make it dry. Find the mass of pycnometer full of the water (W4 gm).
5. Repeat above step 2 and step 3 for two more aggregate specimens from the same aggregate sample.
6. Report the specific gravity as average of three test results.

B. Water Absorption

1. Take sample of aggregate not less than 1000gm.
2. Wash the sample to remove finer particle and dust.
3. Drain out the sample and immerse it in a distilled water at a temperature between 22C and 32C with a cover of at least 5 cm of water above the top of the container.
4. Immediately after immersion remove the entrapped air from the sample by stirring a rod into the container and keep the sample immersed for a period of 24+1/2 hours afterwards.
5. Remove the water from container and allow to drain for a few minutes. Gently empty the aggregate from container on to one of the dry clothes.
6. Allow aggregate to surface dry on the cloth and then transfer it to second dry cloth for about 10min or until it appear to be completely surface dry.
7. Take weight of this surface dry and saturated aggregate. (A)
8. Place the aggregate in the shallow tray, at temperature of 100 to 110C in an oven and maintain temperature for 24+1/2 hours.
9. Remove the sample from oven, allow it to cool in air tight container and record its weight. (B)

C. Fineness Modulus

1. Make the test sample air dry by drying it at temperature or by heating it at temperature of 100C to 110C in an oven and then cooling it at the temperature.
2. Weight the dried sample.
3. Place the sample on the set of sieve and sieve successively on the appropriate sieve starting with the largest.
4. Shake each sieve separately over a clean tray until not more than trace passes but in any case, for a period of not less than two minutes. The shaking should be done with a varied motion backward and anticlockwise. Break lump of fine materials if present by gentle pressure with fingers against the side of sieve.
5. At the end of sieving, clean 150micrpn and 75micron sieve from the bottom by light brushing with fine camel hair brush.
6. On completion of sieving weigh the material retained on each sieve, together with any material cleaned from mesh.

4. Impact Crushing Value

1. Remove the sample from the measure and fill it in the metal cup fixed to base plate. Tamp it with 25 strokes once only. Weigh the metal cup. Find weight of sample(W1) by deducting weight of empty cup form it.

2. Raise the hammer (weigh of hammer=14kg) till its lower face is 380mm above upper surface of the sample and allow it to fall freely on the sample. Give 14 similar blows (total no. of blows=15) at an interval of not less than one second.
3. Remove the crushed aggregate from the cup and sieve it through 2.36mm sieve.
4. Weigh the fraction passing through 2.36mm sieve. (record it as W2).
5. The fraction retained on the sieve shall also be weighted. (record it as W3)
6. If the total weight(W2+W3) is less than initial weight W1 by more than one gram, the result shall be discarded and fresh test is made. Two tests shall be carried out.

III. RESULT

7 DAYS TEST: STRENGHT IN KN/M

	0%	15%	30%	45%
CUBE 1	10.37	12.16	11.57	12.52
CUBE 2	9.22	8.69	13.94	10.28
CUBE 3	12.85	13.27	10.67	11.20
MEAN	10.813	11.373	12.068	11.373

Fig 3.1 7th day compressive strength

14 DAYS TEST: STRENGHT IN KN/M

	0%	15%	30%	45%
CUBE 1	18.62	19.06	19.33	17.51
CUBE 2	18.88	19.2	19.51	18.66
CUBE 3	18.66	19.42	19.42	17.86
MEAN	18.72	19.22	19.22	18.01

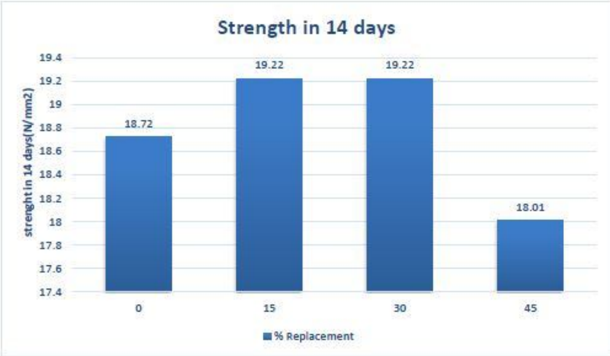

Fig 3.2 14th day compressive strength

28 DAYS TEST: STRENGHT IN N/mm²

	0%	15%	30%	45%
CUBE 1	21.42	22.08	22.53	22.26
CUBE 2	20.75	21.82	22.71	22.13
CUBE 3	21.02	22.31	22.93	22.44
MEAN	21.06	22.07	22.72	22.27

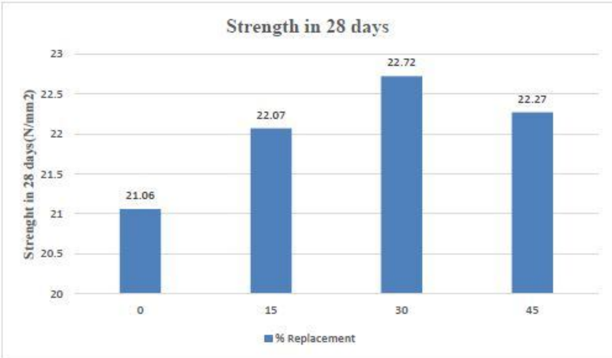

Fig 3.3 28th day compressive strength

STRENGTH COMPARISON:

Strength comparison done for the four mixes of 0%,15%,35% and 45%.

Fig 3.3 compressive strength comparison

IV. CONCLUSION

1. The use of steel slag as replacement of coarse aggregate in concrete is beneficial for the better workability and strength it imparts up to 45% replacement level.
2. The study concluded that compressive strength of concrete improved by 5-10% at all the grade of concrete at 30 % replacement of normal crushed coarse aggregate with steel slag.
3. In comparing with 0%, 15%, 30%, 45% replacement of iron slag aggregate 30% cube attains maximum strength compared to all grade of concrete.
4. With higher level of replacement of CA with ISA after 30% the strength of concrete decreases gradually. So, it's ok to replace the iron slag up to 45% for normal work and 30 % for important concrete work
5. As we increase the % of iron slag aggregate in the nominal concrete the water required for paste also increases as due the water absorption of the iron slag.
6. The coefficient of permeability was found to be negligible in all the samples of concrete mixes containing furnace slag whereas the coefficient of permeability was more in concrete mixes without furnace slag.
7. This experimental study has proved to be better way to disposal of steel slag.

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