Experimental Investigation on Corrosion Behaviour of RCC on Partial Replacement of Fine Aggregate with Foundry Sand in Alkaline Condition

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ABSTRACT:

This research studied the feasibility of partially or fully replacing normal concrete sand with chemically bound foundry sand in ordinary portand cement mixes. This was foundry sand bound with polymer binders to form moulds for iron casting. A series of tests were then performed to investigate the influence of foundry sand content on fresh and hardened concrete properties including workability, cube compressive strength, split cylinder tensile strength, elastic modulus in compression, modulus of rupture.

It was shown that despite its fineness, foundry sand could be mixed with concrete without apparent difficulty and give highly workable mixes. Concrete properties, including strengths and modulii of elasticity were comparable to those of normal concrete with some occasional small losses in strength only. Base on the results to date, it can therefore be concluded that the chemically bound foundry sand investigated in this study can be used to partially or fully substitute regular sand in concrete with no apparent issues. This shows promisw for developing an additional viable solution to tackle this type of waste.

Keywords: Industrial Solid Waste Management, foundry sand, concrete properties .

1 . INDRODUCTION

There are about 35,000 foundries in the world with annual production of 90 million tones. In terms of number of foundries China has the highest score (9374), followed by India (6000). The share of Iron foundries is the maximum i.e. almost 56%, followed by steel with 14% and then the non-ferrous ones with 30%. There are more than 5000 foundry units in India, having an installed capacity of approximately 7.5 million tons per annum. The majority (nearly 95%) of the foundry units in India falls under the category of small-scale industry. These foundry units generate approximately 1,710,000 t (1.71 MT) waste foundry sand per year. In United States of America, metal casting foundries dispose of approximately 9 million metric tons of waste foundry sand (WFS) in landfills in 2000.

Generally, waste foundry sand (WFS) is sub-angular to round in shape. Green sands are black, or gray, whereas chemically bonded sands are of medium tan or off-white color. Grain size distribution of waste foundry sand is uniform, with 85–95% of the material between 0.6 mm and 0.15 mm, and approximately 5–20% of foundry sand can be smaller than 0.075 mm.

- **The specific gravity varies between 2.39 -2.79**
- **Low absorption capacity and non – plastic**
- **The density lies in the range of 1052- 1554 kg/m^3**
- **The absorption capacity is of 0.38 – 4.5 %**

The measurements may be attributed to the variation in sand mineralogy, particle gradation, grain shapes and fine contents. Good gradation and round shape lead to a com-pact structure and high density. Correlation of absorption with fine content and grain size can be interpreted by the law that a finer particle leads to a higher specific surface area, which favors the absorption of water.

2. MATERIALS

The properties of selected material for this experimental study have been reported as given below.

2.1 CEMENT

Ordinary Portland current 53 Grade with physical and chemical properties as give in table has been used in this experimental study

Table-1. Physical Properties of Ordinary Portland cement

Characteristics	Result
Fineness (retained on 90mm sieve)%	4.6
Soundness (mm)	1.9
Initial Setting Time (sec)	109
Final setting time (sec)	298
Compressive strength (MPa)	
3 days	22.1
7 days	35.6
28 days	42.5

2.2 FINE AGGREGATE

Locally available river sand conforming to grading Zone II of IS: 383-1970 was used in this experimental work.

2.3 WASTE FOUNDRY SAND

Foundries for the metal – casting Industries generate by products such as used foundry sand. Foundries successfully recycle and reuse the sand many times in a foundry and the remaining sand that is termed as foundry sand is removed from the foundry. It can be used in concrete to improve the characteristics of concrete by partial replacement of fine aggregate or cement, or full replacement of fine aggregate.

2.4 COARSE AGGREGATE

Locally available crushed stones conforming to graded aggregate of normal size 12.5 as per IS: 383-1970, was used in this experimental work.

Table 2: Properties of Fine aggregate, foundry sands and coarse aggregates

Charcteristics	Specific Gravity	Fineness Modulus	Bulk Density (Kg/m^3)
Fine Aggregate	2.57	2.64	1753
Waste Foundry Sand	2.2	1.89	2589
Coarse aggregate (10mm)	2.704	6.45	1670
Corse aggregate(20mm)	2.825	7.68	1630

2.5 WATER

The water used for the study was free of acids, organic matter, suspended solids, alkalis and impurities when present may have adverse effect on the strength of concrete. Portable water with pH value 7 conforming to IS: 456-2000 was used for making concrete and curing this specimen as well.

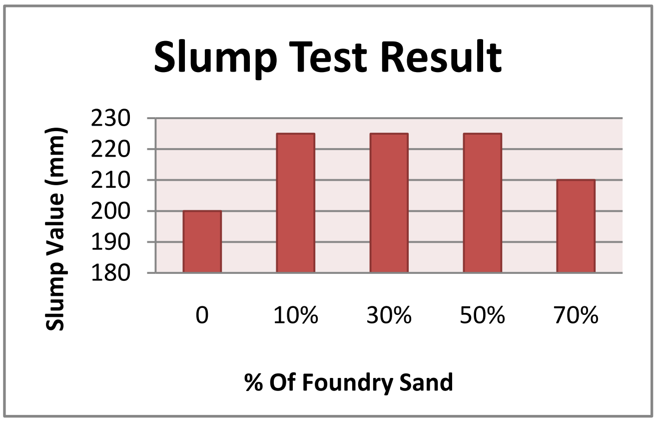
3. PREPARATION AND CASTING OF SPECIMENS

The different concrete specimens such as cubes (150mmX150mmX150mm) to determine compressive strength, cylinders (150mm diameter and 300mm length) to determine split tensile strength and beams (10mmX10mmX50mm) to determine flexural strength were cast. All the specimens were prepared in accordance with Indian Standard Specifications IS: 516-1959[16]. All the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there is no gaps left from where there is any possibility of leakage of slurry. A careful procedure was adopted in the batching, mixing and casting operations. Vibrations were stopped as soon as the cement slurry appeared on the top surface of the mould. The specimens were removed from moulds after 24 hours and cured in water till testing or as per requirement of the test. The test was done for 0%, 10%, 30%, 50% and 70%.

4. RESULT AND DISCUSSIONS

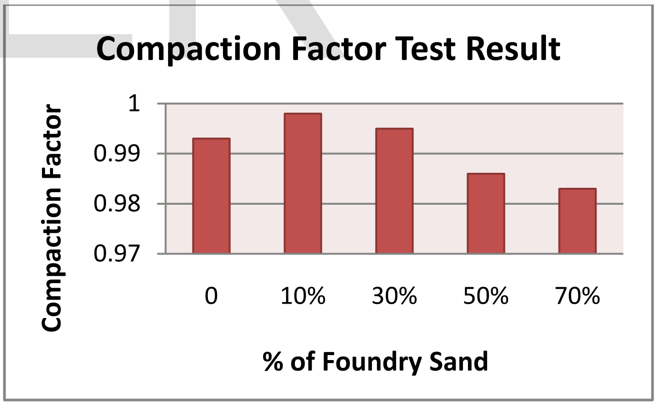
4.1 Slump Test

Slump test were performed according to BSEN 12350-2:2000 (BSI, 2000a) to assess concrete workability. Fig below shows results of slump tests for each foundry sand percentage performed in mixes of w/c ratio of 0.55. These showed that all mixes had very high slump and hence workability, although they contained much finer sand than regular concrete sand.



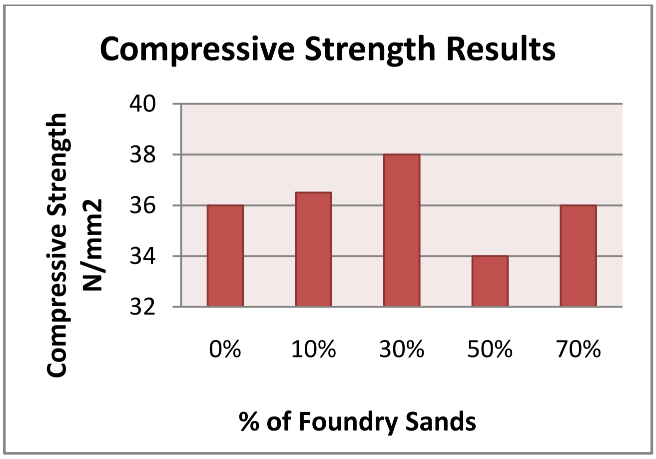
4.2 Compaction Factor

The degree of compaction, called the compacting factor, is measured by the density ratio i.e. ratio of density actually achieved in the test to the density of the same concrete fully compacted. The density of concrete in the cylinder is calculated after passing the concrete through the two hoppers, and the density actually achieved by the fully compacted concrete is defined as the compacting factor. The later density can be obtained by actually filling the cylinder with concrete in three layers, each tamped or alternatively calculated from the absolute volumes of the ingredients.



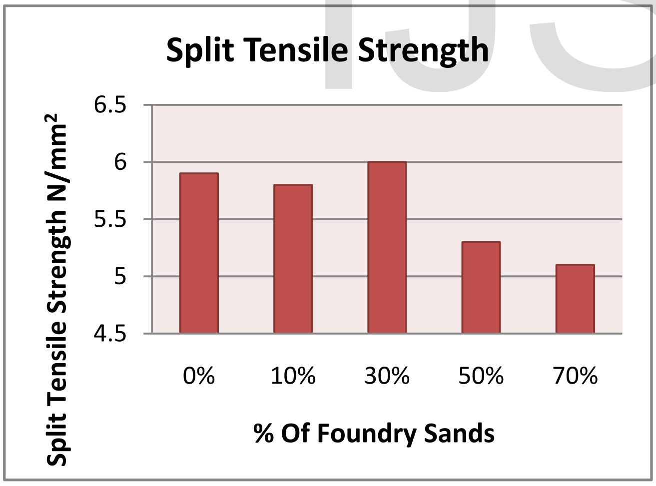
4.3 Compressive Strength

The compressive strength of reference mix (M0) and all other mixes prepared, using used foundry sand and fly ash, silica fume are shown in Table 5. It was observed that the increase in compressive strength was observed gradually up to 30% replacement of fine aggregates by used foundry sand and then decreased. The maximum compressive strength was obtained 38.70 N/mm2 at 30% used foundry sand. Maximum compressive strength was obtained with mix (M3) 30% used foundry sand which was 17.14% more compared reference mix. Variation of compressive strength of M25 grade with different percentage replacement of fine aggregate by used foundry sand is as shown in figure . It was observed that as fly ash percentage in concrete increased, its compressive strength decreased. Mix which was replaced by 30% of used foundry sand and 10% fly ash (M2) obtained a compressive strength 32N/mm2 which was 3.124% more than the reference mix (M0).



4.4 Split Tensile Strength

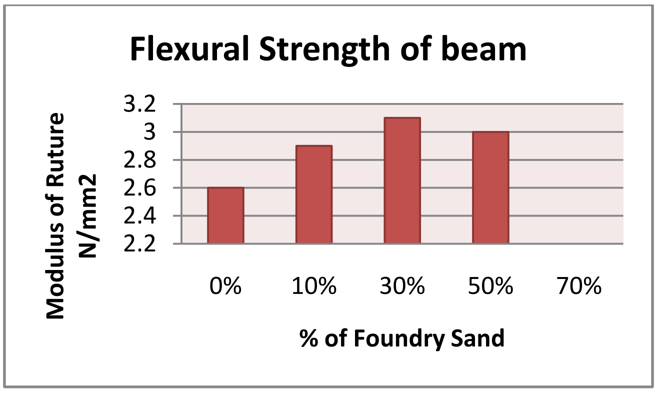
Split tensile strength of mix 0% , 10%, 30%, 50% and 70% was made. In the mix of 30% replacement of foundry sand with natural sand was the optimum value, which is of $6N/mm^2$.



4.5 Flexural Strength

Beam of 500mm length and a section of 100mm x 100mm were cast for mixes with w/c = 0.55 and various foundry sand percentages, and tested after 28- days curing. First the static modulus of elasticity Ec was determined according to BS 1881-121:1983(BSI, 1983). Modulus of Elasticity is a property crucial to te long- term serviceability of concrete. Ec values of beams with various percentages of foundry sand were found to be close to that of the control mix similar except in two case where Ec was reduced by 13% and 17% respectively.

The test result for the flexural strength of beam is given in the figure below:



5. CONCLUSION

From the results it was shown that mixes with the tested chemically bound foundry sand had properties, workability, strength and modulus of elasticity comparable to those of normal concrete. Based on these findings it can therefore be concluded that this type of foundry sand can be used as a substitute for regular sand for concrete with no apparent adverse effects on the concrete, as none of the recorded properties appeared to present any significant changes with respect to the control mixes with regular concrete sand. Therefore the use of this type of foundry sand in concrete shows promise for developing an additional recycling route for this material. An area that would need further investigation is possible effects linked to corrosion of metal reinforcement due to the chemistry of this sand. Industrial scale tests would be needed to evaluate any effects linked to manufacturing process.

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