

Experimental investigation on impact of sand mining in coastal regions and potential reuse of silica sand as construction material

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High quality silica sand has been consumed by foundry in large quantity for casting and moulding process. Foundry successfully recycles and reuses the sand. When it can no longer be reused, it is removed from foundry, termed as Waste Foundry Sand (WFS) and normally disposed off in landfill. The dumping of the fine fraction of WFS and the continuous depletion of sand for construction are two serious environmental problems that can be solved simultaneously by using WFS as construction material. The study aims to determine the optimum percentage of WFS for partial replacement of fine aggregate in concrete and concluded that WFS could be used in making good quality concrete.

[Keywords: *Sand mining, Coastal erosion, Silica sand, Waste Foundry Sand, Construction material*]

Introduction

Sand Mining is important for economic development of developed and developing countries as the demand for sand increases in industry and construction. Sand is an important mineral for our society protecting the environment, buffer against strong tidal waves and storms, habitat for crustacean species and marine organisms, used for making concrete, filling roads, building sites, brick making, glass manufacturing, moulding material in metal casting industries, sand papers, reclamations and in tourism industry in beach attraction. For centuries, beach sand has been mined for construction and heavy minerals extraction as well as silica sand (A.Kumar B.B Hosetti). Depletion of sand in the stream bed and along coastal areas causes the deepening of rivers and estuaries and enlargement of river mouths and coastal inlets. The effect of mining is compounded by the effect of sea level rise due to increased shoreline erosion rates and results in destruction of natural beaches and marine ecosystem, reduced protection from storms and tsunamis and loss of coastal aesthetics. Most beach sand is derived locally from the sea and in many regions sand carried by rivers to the coast is a major source of beach sand. Thus the river inputs and mining

output should be balanced in such a way that the coastal erosion is controlled or minimised (A.Kumar B.B Hosetti).

River sand is an important component in construction industry since it acts as a filler material in production of concrete. The continuous depletion of fine natural aggregates through sand mining for manufacture of concrete and the dumping of the fine fraction of WFS are two serious environmental issues that can be solved simultaneously by using WFS in concrete production. The possibility of substituting natural fine aggregate with industrial by product like WFS without sacrificing strength and durability offers technical, economic and environmental advantages. The lack of an established process for evaluating and permitting reuse is a significant barrier for the Indian states to develop a regulatory structure that simultaneously ensures environmental protection and appropriate beneficial reuse. Hence this paper aims to reuse WFS as partial replacement of fine aggregate in concrete and study its effect on mechanical properties of concrete.

Materials and Methods

Ordinary Portland Cement of grade 53 was used in this study. The basic properties of the cement were tested and the cement meets the requirements of IS 12269-1987. Crushed angular aggregates of 20 mm size were used as coarse aggregate and natural river sand was used as fine aggregate for production of concrete. The properties of fine and coarse aggregate meets the requirements of IS 383-1970 with specific gravity of sand and coarse aggregate as 2.6. Unit weight of sand and coarse aggregate was 1760 kg/m³ and 1570 kg/m³. Locally available foundry sand was used as partial replacement of fine aggregate. Foundry sand with specific gravity 2.5 and water absorption 1.5 was used. The foundry sand showed lower fineness modulus than the regular sand. Table 1 gives the chemical composition of foundry sand.

Table 1. Chemical composition of WFS

Composition	Loss of ignition	Sand & silica	Calcium oxide (CaO)	Iron oxide (Fe ₂ O ₃)
Percentage %	0.25	98.69	0.21	0.13

Table 2. Mix Proportions of concrete mixtures

Mix no	CM	F10	F20	F30	F40
Cement kg/m ³	370	370	370	370	370
Foundry Sand %	0	10	20	30	40
W/C ratio	0.5	0.5	0.5	0.5	0.5
Fine aggregate kg/m ³	592	532.8	473.6	414.4	355.2
Coarse aggregate kg/m ³	1180	1180	1180	1180	1180
Slump mm	90	81	64	57	48
Fresh concrete density kg/m ³	2327.7	2319	2316.5	2317.3	2315.8

In order to investigate the effects of WFS on mechanical properties of concrete, concrete cubes of size 150mm for compressive strength, cylinders of size 150x300 mm for split tensile strength and beams of size 500 x 100 x 100 mm

for flexural strength were casted using five mix proportions. First was control mix without foundry sand and the other four mixtures contained foundry sand. Fine aggregate was replaced with foundry sand by weight in the proportions ranged from 10% to 40% at the increment of 10%. Mix proportions are as given in Table 2. The control mix without foundry sand was proportioned as per Indian Standard Specifications IS 10262: 2009 to obtain a 28 day cube compressive strength of 37 MPa. After casting, all the specimens were stored at room temperature in the casting room. They were demolded after 24 hours and were immersed in water curing tank. After required period of curing, the specimens were taken out of the curing tank and their surfaces were wiped off. Tests were performed at the ages of 7 and 28 days in accordance with IS 516: 1959.

Results and Discussion

Fresh concrete properties such as slump, unit weight were determined according to IS 1199 – 1959. Slump is a measure indicating the consistency or workability of concrete. Table 2 shows the results of the slump test and fresh concrete density for all concrete mixtures. Concrete produced with low percentages of WFS obtained workability similar to control mix. The presence of finer waste foundry sand particles in concrete leads to increase in water demand and hence decrease the workability of concrete mixtures containing higher percentages of WFS.

Compressive strength of concrete mixtures made with and without WFS was determined at 7 and 28 days of curing. There was marginal increase in the compressive strength of concrete mixtures with the inclusion of WFS as partial replacement of regular sand. At 28 – day, control mixture CM achieved a compressive strength of 37 MPa, whereas mixture F10 achieved a compressive strength of 40.5MPa. An increase in compressive strength of 9.45%, 20.75%, 30.67% was achieved for F10, F20, F30 mixtures respectively in comparison with CM mix. The decrease of 8.1% was observed for the mix F40. The comparison between 7 days and 28 days strength was shown in Fig. 1

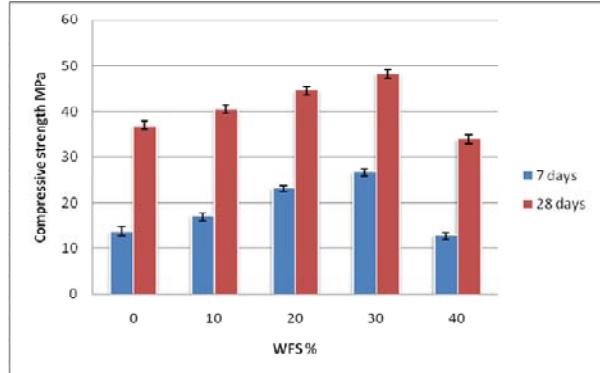


Fig. 1. Compressive strength test results of mixtures with and without WFS.

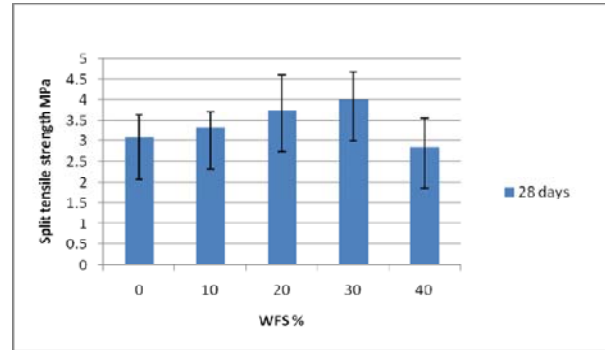


Fig. 2 Split tensile strength of concrete mixtures with and without WFS

Split-tensile strength of concrete mixtures made with and without foundry sand was determined at 28 days. The 28 day split tensile strength of control mix CM was observed as 3.08 MPa. Split tensile strength of concrete mixtures increased with increase in WFS content. The increase of 7.5%, 17.86%, 23.19% was observed for the mixtures F10, F20, F30 respectively and a decrease of 7.31% for F40 mixture was observed. The 28 days split tensile strength was shown in Fig. 2.

The flexural strength of all WFS mixes was observed to be greater than the strength of control mix CM. The flexural strength results of concrete mixtures are shown in Fig.3. The 28 day flexural strength of control mix was found to be 4.9 MPa. Flexural strength of foundry sand ble 3 shows an increase of 8.75%, 17.5%, 24.03% for the mixtures F10, F20, F30 respectively and a decrease of 8.65% for F40 mixture was observed at 28 days. It was observed that the greatest increase in compressive strength, split tensile strength and flexural strength was achieved by substituting 30% of the fine aggregate with WFS and the reason behind this increase in strength could be due to particle packing of dense matrix because WFS is fine comparable to fine aggregate.

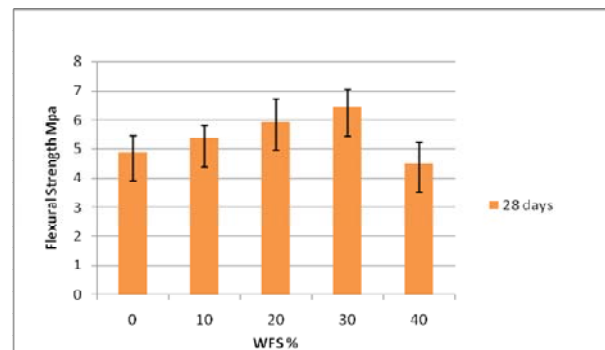


Fig. 3 Flexural strength of concrete mixtures with and without WFS

Conclusion

Present study shows that there is a significant increase in mechanical strength by the inclusion of Waste Foundry Sand for 30% sand replacement. It was concluded that WFS could be used in making good quality concrete for partial replacement of sand thereby protects the river and coastal regions from adverse effects of sand mining.

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