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A study on crushed sand on the hydrating behavior of Portland Pozzolona cement

Sarvesh Nandal[1], Er Hardik dhull[2]

[1] Department of Civil Engineering (Structure and Construction), Maturam Institute of Engineering and Management, Rohtak, Haryana, India

[2] Assistant Professor, Department of Civil Engineering, Maturam Institute of Engineering and Management, Rohtak, Haryana, India

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Abstract

The research paper details the experimental programme and methodology for the evaluation of fresh properties (workability), hardened properties (density, compressive strength and splitting tensile strength), durability properties (chloride-ion permeability, sorptivity and water absorption), and mineralogical & microstructural characteristics (X-Ray diffraction, i.e., XRD and Scanning Electron Microscopic, i.e., SEM) of concrete mixes made with In this chapter, the processes that have been implemented for the physical testing of the component materials that are used for manufacturing concrete are detailed. These constituent materials include cement, coarse aggregate, natural sand, and sandstone quarry dust. This chapter also discusses the technique that was used for the mix design of concrete, the specifics of test specimens that were used to carry out the various tests, the procedure that was used for casting, as well as the test procedures that were used, and the age of the specimen that was tested.

Keywords: X-Ray, Diffraction, Scanning, Electron, Microscopic

Introduction

All concrete mixes utilised UltraTech Cement's OPC 43. Bureau of Indian Standard standards analyse cement's fineness, soundness, standard consistency, beginning and final setting time, compressive strength, and specific gravity. Cement fineness was verified using BIS 4031(Part 1):1996's 90-micron sieve. Le-Chattier tested soundness under BIS 4031(Part 3):1988. Vicat equipment tests standard consistency, beginning and final setup time per IS 4031(Part 4):1988 and BIS 4031(Part 5):1988. BIS 4031(Part 6):1988 tests cement's compressive strength. 1:3 cement mortar cubes were manufactured using BIS 650:1991-compliant sands. Cubical specimens were examined at 70kN/minute using a compression testing machine (CTM) complying to BIS 516:1959 to assess cement-mortar cubes at ages 3, 7 and 28 days. Specific gravity was evaluated using the density bottle technique per BIS 4031(Part 11):1988. BIS 8112:1989 specifies all cement's physical characteristics.

As coarse aggregate, this experiment uses 20mm and 10mm aggregate. Both coarse aggregates were local. Sieve analysis, specific gravity, water absorption, and bulk density are analysed by Bureau of Indian Standard standards. Aggregates were sieved using BIS 2386(Part 1):1988's technique and compared to BIS 383:1970's standards. BIS 2386(Part 3):1963 specifies how to evaluate coarse aggregate's specific gravity, water absorption, and bulk density. Water basket technique was used to calculate coarse aggregate specific gravity. Concrete was cast in steel moulds. Before mixing concrete, all moulds were cleaned and lubricated. Before casting, they were thoroughly tightened. To avoid slurry leakage, no gaps were left. Vibrating table two-layer compacted concrete samples. After casting, concrete specimens were kept in the casting chamber for 24 hours before de-moulding and curing.

Test Procedures

Workability

The ease with which concrete may be mixed, transported, compacted, and finished with suffering the least amount of loss in its homogeneity is referred to as the workability of the concrete. The slump test is by far the most common and widely used test for determining the workability of concrete in the construction industry all over the globe. The concrete's workability was examined using a slump test in accordance with the Indian Standard Specifications that are outlined in BIS 1199:1959. A mould in the shape of the frustum of a cone with a bottom diameter of 200 mm, a top diameter of 100 mm, and a height of 300 mm was filled with four layers that were about similar in size. Each layer was tempered using a normal tempering rod with 25 strokes.

Following the completion of the filling and levelling of the surface, the mould was removed by raising it in a vertical direction, which allowed the concrete to sink. The results of the tests on workability were recorded as slump in millimetres, which is the difference in height between the mould and the highest point of the subsided concrete mass.

Fig 1: Slump Test of Concrete

It is generally agreed that the feature of hardened concrete that is most essential is its compressive strength. Tests of the compressive strength were carried out in accordance with the Indian Standard Specifications and followed the protocol outlined in BIS 516:1959. Using standard cube specimens of 150mm 150mm 150mm, the compressive strength of concrete was measured at the ages of 7 days, 28 days, and 90 days after it was placed. For the purpose of determining the compressive strength of concrete, a Compression Testing Machine (CTM) with a capacity of 5000kN was used. The concrete specimen was removed from the mould twenty-four hours after the casting and then put in the curing tank to guarantee that it would cure properly. At each age that was given, a specimen was positioned in the middle of the bearing plates of the CTM, and load was applied continuously and evenly at a set loading rate of 140 kilogrammes per square centimetre per minute. The load was gradually raised until the specimen failed, at which point the maximum force that could be sustained by each specimen was recorded.

Fig 2: Compressive Strength Test on Compression Testing Machine

Results and Discussion

Sieve analysis, bulk density, specific gravity, and water absorption were evaluated for 20mm and 10mm aggregates. Sieve analysis, silt content, bulk density, specific gravity, and water absorption were performed on fine aggregate. Along with physical testing, sandstone dust was analysed by SEM, EDS, and XRD. Next, mix design for M30 concrete and mix proportioning are described. All-in aggregate grade is provided. Natural sand was partially replaced at rates of 10%, 20%, 30%, 40%, and 50% with crushed sand, and various tests were conducted to evaluate the effect of natural sand replacement with sandstone on workability, density, compressive strength, splitting tensile strength, water absorption and sorptivity, and chloride-ion permeability of M30 grade concrete. We compare the attributes of various combinations. SEM and XRD studies are also used to analyse the mineralogical and microstructural changes caused by Crushed Sand.

Properties of Raw Materials
Crushed sand has a greater micro-fine content and water absorption than natural sand, although having a slightly higher specific gravity. Both natural and crushed sand meet BIS 383:1970 Zone II standards. Fig. compares sand and sandstone particle sizes.

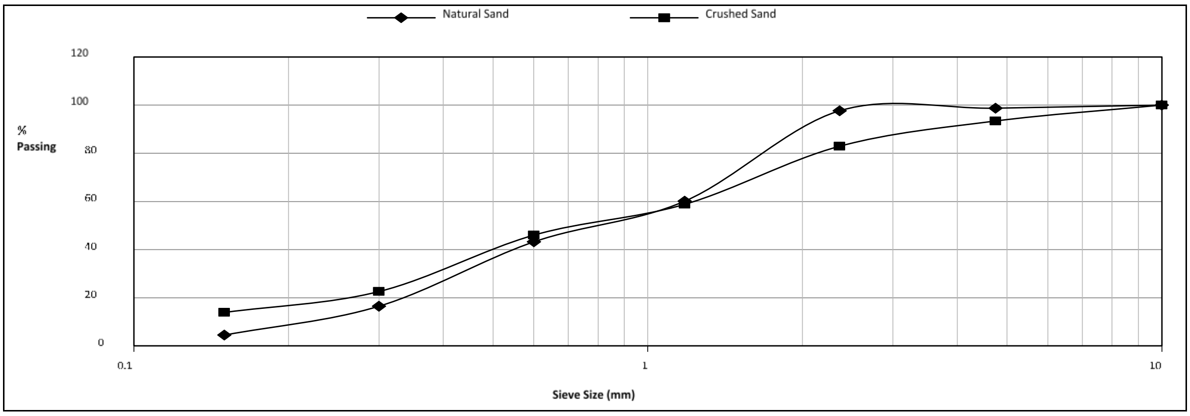

Fig 3: Effect of Replacement of Natural Sand with Crushed sand on Workability of Concrete

Fresh Properties of Concrete
In order to investigate the impact that replacing natural sand with sandstone quarry dust has on the workability of concrete, the slump was measured for each of the different concrete mixes. Figure 4 is a visual representation of the observations made about the workability of all concrete mixes shown as slump in millimetres.

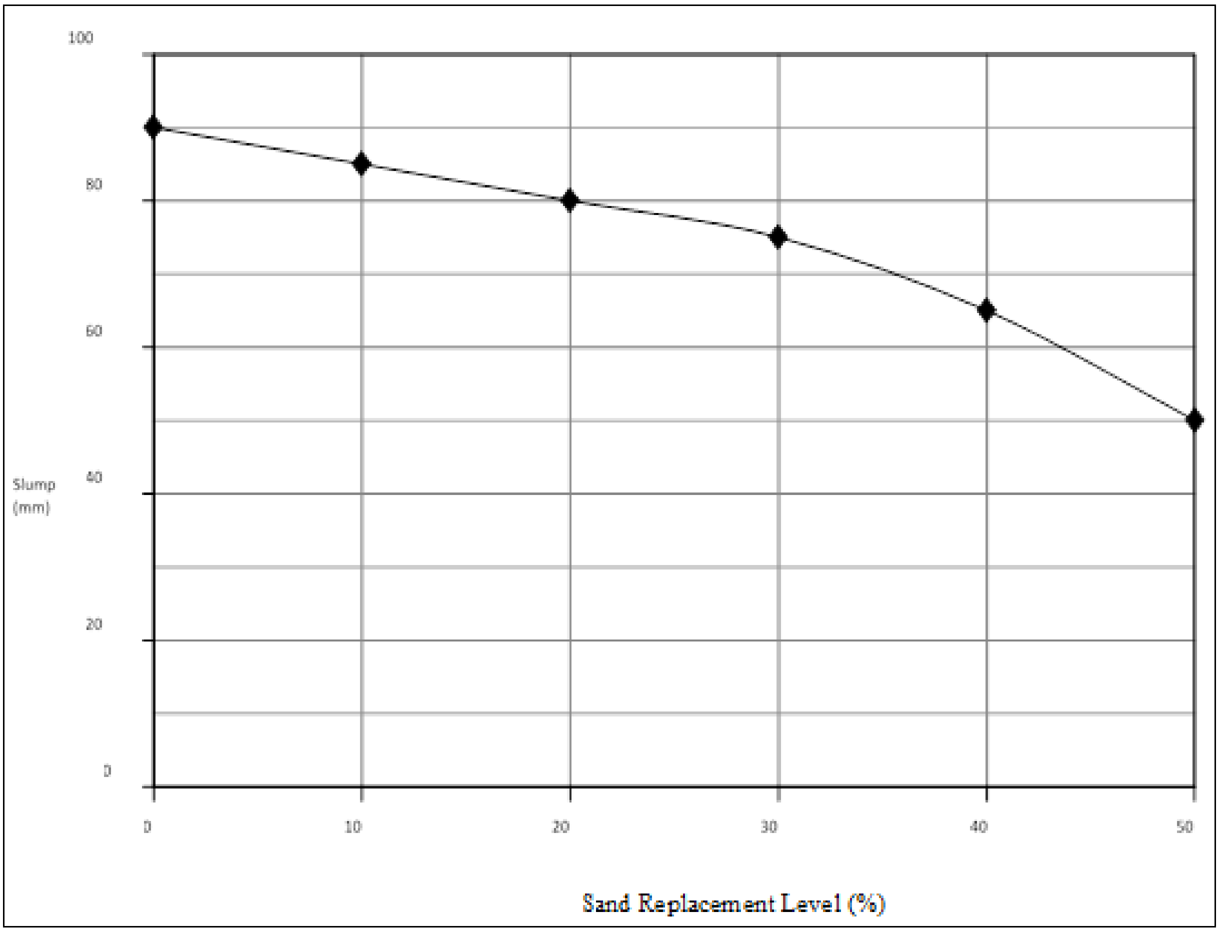

Fig 4: Effect of Replacement of Natural Sand with Crushed sand on Workability of Concrete

All sandstone-sand concrete mixes slumped less than control concrete. With crushed sand as a partial substitute for natural sand, concrete workability decreases, and the decline is more significant at 40% and 50%

replacement. Control mix slumped 90mm, whereas 50% sand mix slumped 50mm. Shi-Cong and Chi-Sun found a similar decrease in workability using quarry dust as a partial sand substitution.
The variation in particle size distribution and form between natural sand and sandstone quarry dust decreases workability. Fig. 4.1 compares natural sand and sandstone dust particle sizes. Natural sand contains 0.5% silt, whereas quarry sand has 6.8%. SEM photos demonstrate that sandstone quarry dust particles are angular with rough surfaces, while natural sand particles are spherical with smooth surfaces. When natural sand was substituted with sandstone of identical weight, specific surface area increased owing to excessive micro-fines. Sandstone dust's angular form increases concrete's water consumption, reducing workability. Sandstone quarry dust particles have a rough surface, which increases friction between paste and coarse aggregate and reduces concrete workability. According to Indian Standard Specifications BIS 456:2000, the slump of all concrete mixes is 50-100mm, which is medium workability. All concrete mixes may be used to create substantially reinforced parts such slabs, beams, and columns.
Inclusion of sandstone sand as a partial replacement for natural sand increases concrete's water demand, i.e., more water is required to achieve the same workability as control concrete. As increasing water content reduces compressive strength, superplasticizers may be employed to counterbalance the detrimental effect of crushed sand on concrete workability. Sand as a substitute for natural sand increases concrete's compressive strength at all ages compared to control mix. At 7 days, the control mix had a compressive strength of 29.77 MPa, whereas CS10, CS20, CS30, CS40, and CS50 mixes had 31,24, 32.78, 34.22, 35.44, and 33.91 MPa. At 28 days, the control mix's compressive strength was 36.13 MPa, whereas CS10, CS20, CS30, CS40, and CS50 mixes were 37.67, 39.73, 40.80, 41.83, and 40.55 MPa, respectively. At 90 days, the control mix had a compressive strength of 38.49 MPa, whereas CS10, CS20, CS30, CS40, and CS50 had 40.57, 42.58, 44.74, 46.96, and 44.65 MPa. Compressive strength of concrete increases with sand replacement level, peaks at 40%, and then decreases. Concrete mixtures age similarly. Fig. 5 shows the compressive strength of all concrete mixtures at various ages.

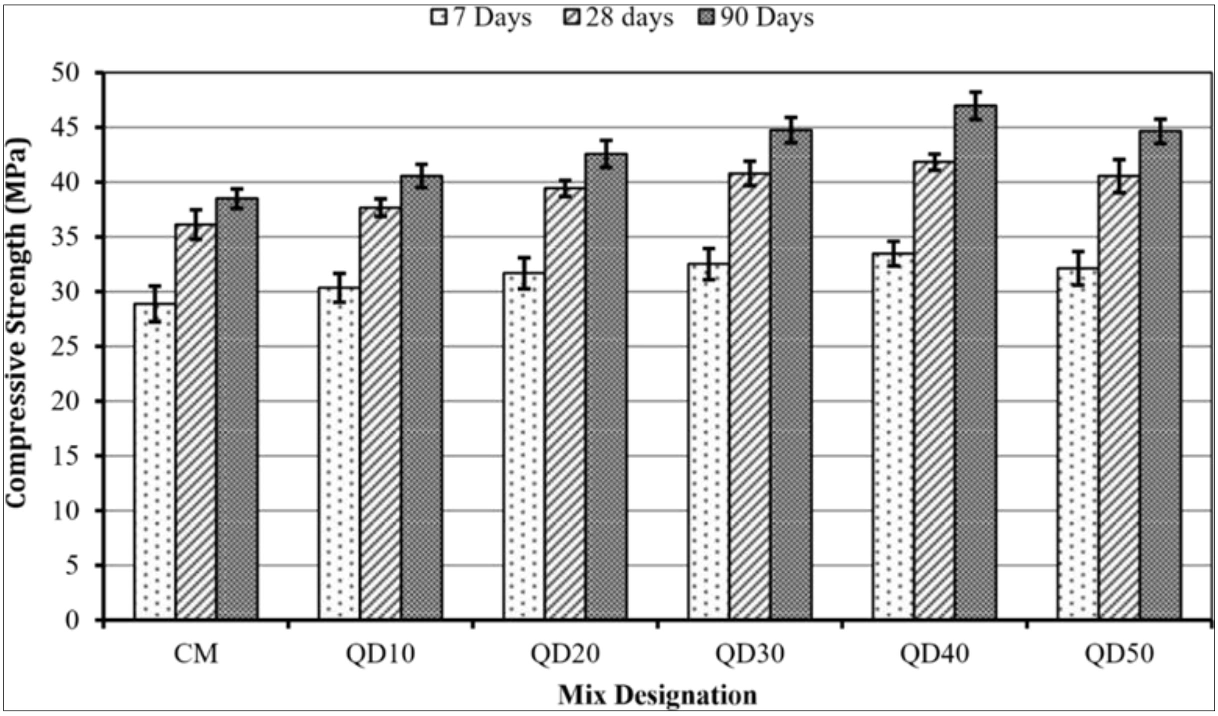

Fig 5: Effect of Replacement of Natural Sand with Crushed sand on Compressive Strength of Concrete

Regression analysis shows that concrete's compressive strength is directly related to its density at all ages. R2 is 0.9289, 0.9391, and 0.9387 for 7 days, 28 days, and 90 days for the linear change between 1-day concrete density and compressive strength. Density and compressive strength are strongly correlated.
As crushed sand has a higher specific gravity than natural sand, its dust particles will be stronger, which may also boost compressive strength. Sandstone particles may improve bonding between fine aggregate and cement paste by refining the interfacial transition zone. Quarry dust's rough surface may have helped fine aggregate particles mix with cement paste.
Table 4.10 and Figure 4.9 show that concrete's compressive strength is highest at 40% sand replenishment and decreases at 50%. Two facts explain this decline. First, concrete workability decreases as sand replacement level increases, and concrete mix with 50% sand replacement has a low slump (50mm) compared to other mixes. This reduction in workability may affect concrete's compressive strength, causing inappropriate compaction. As quarry dust concentration rises, micro-fines and aggregate surface area likewise rise. As cement concentration is constant for all mixtures, 50% sand substitution makes cement paste insufficient to cover aggregate particles. At greater sand replenishment levels, concrete compressive strength begins dropping after peaking.

Conclusion

It has also been noted that rate of growth in compressive strength as compared to control mix is larger at 7 days and 90 days, as compared to that of at 28 days. For instance, in CS40 concrete mix, rate of increase in compressive strength as compared to control mix at 7 days and 90 days was 19.0 percent and 22.0 percent, respectively. However, rate of growth in compressive strength for the same concrete mix at 28 days was 15.8 percent. Such tendency is more pronounced in concrete mixtures with greater replacement ratios of 30 percent, 40 percent and 50 percent . Higher rate of growth in compressive strength at early age may be explained on the basis of rapid cement hydration owing to the presence of rock dust micro-fines. These micro-fines contained in sandstone crushed sand functions as nucleation sites to expedite the process of cement hydration and increase the development of hydration products at early ages, notably tricalcium aluminate. This mechanism may have resulted in continued hydration of cement with age. So rate of growth in compressive strength at 90 days is likewise greater. It may be established that concrete mix with 40 percent sand substitution has maximal compressive strength at all ages. So blend of 40 percent sandstone crushed sand and 60 percent natural sand can be considered as best mixture to produce maximum compressive strength.

References

1. Beixing L, Jiliang W, Mingkai Z. Effect of limestone fine content in manufactured sand on durability of low- and high- strength concrete, Construction and building materials,2009:23:2846-2850
2. BIS. Concrete mix proportioning ─ Guidelines, bureau of Indian Standards, New Delhi
3. BIS. Methods of sampling and analysis of concrete, BIS, New Delhi, 1959, 1199.
4. BIS. Methods for test for aggregate: Part 1; Particle size and shape, BIS , New Delhi, 1988, 386.
5. BIS. Methods of Test for Aggregates for Concrete – Specific Gravity, Density, Voids, Absorption & Bulking, BIS , New Delhi, 1963, 2386(3)
6. BIS. Specification for coarse and fine aggregate for natural sources, BIS, New Delhi, 1970, 383.
7. BIS. Methods of physical tests for hydraulic cement: Part 1; Determination of fineness by dry sieving, BIS, New Delhi, 1996, 4031(1)
8. BIS. Methods of physical tests for hydraulic cement: Part 3; Determination of soundness, BIS, New Delhi, 1988, 4031(3)
9. BIS. Methods of physical tests for hydraulic cement: Part 4; Determination of consistency of standard cement paste, BIS, New Delhi, 1988, 4031(5)
10. BIS. Methods of physical tests for hydraulic cement: Part 5; Determination of initial and final setting time, BIS, New Delhi, 1988, 4031(Part 5).
11. BIS. Methods of physical tests for hydraulic cement: Part 6; Determination of CS of hydraulic cement (other than masonry cement), BIS, New, Delhi, 1988, 4031(6).
12. BIS. Methods of physical tests for hydraulic cement: Part 11; Determination of density, BIS, New Delhi, 1988, 4031(11).
13. BIS: Plain and reinforced concrete ─ Code of practice, bureau of Indian Standards, New Delhi