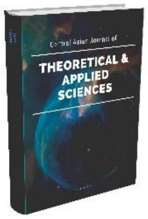

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Concrete Durability Characteristics as a Result of Manufactured Sand

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Abstract: *Due to a surge in construction activities and infrastructure developments, concrete is the most in-demand material. Because there is less natural sand available, building projects are becoming more expensive. An effort has been made in the current endeavour to provide a substitute for natural sand. Abrasion, impact, and water absorption resistance of M40 and M50 grades of concrete have been studied with manufactured sand as fine aggregate and the results have been compared with conventional sand concrete. Durability studies, such as water absorption, rapid chloride permeability test, sorptivity, acid resistance, alkaline resistance, impact resistance, and abrasion resistance, have also been studied. According to the findings, using synthetic sand in place of sand as fine aggregate increases durability attributes by up to 70%, and using it exclusively results in concrete with superior durability than traditional sand concrete.*

Keywords: *Manufactured sand, Admixtures, sorptivity, rapid chloride permeability test, durability.*

I. INTRODUCTION: To satisfy the demands of globalisation, India is currently taking significant steps to expand infrastructure, including elevated corridors, large power plants, motorways, metro rail systems, rail over bridges, etc. Concrete is utilised in large quantities and plays a significant part in construction activities. The component that must be used in the manufacturing of concrete nowadays is river sand. Since river sand is more expensive to transport and hence increases construction costs, a replacement material for natural river sand has been researched in this work. The manufactured sand utilised in this project serves as an alternative to natural sand. It is produced by smashing granite boulders in a vertical shaft impact crusher. The concrete's resistance to weathering, chemical attack, or any other degrading process defines its durability. In this study, the durability characteristics of the concrete are evaluated and addressed. Ilangovan et al[1] .'s research demonstrates that quarry rock dust can completely replace river sand in fine aggregate applications. In comparison to normal sand concrete, the drying shrinkage strains of quarry rock dust concrete are significantly greater. The water penetration depth for quarry rock dust concrete is 10 mm and for natural sand concrete is 15.8 mm. The water absorption for quarry rock dust concrete is 3.8% and for natural sand concrete is 2.6%. As a result, the durability of the concrete with quarry rock dust is higher than that of conventional concrete. When natural sand was replaced with 40% quarry rock dust, Sahu et al. [2] found an increase in compressive strength, flexural strength, split tensile strength, and durability tests. Ilangovan and Nagamani's [3, 4] research demonstrates that quarry dust can completely substitute natural sand in concrete when properly treated before to use. According to Perumal and Sundararajan's research [5], silica fume had a positive impact on high performance concrete's strength and durability qualities, as well as its capacity to withstand acid and seawater. resistance to impact and abrasion. The surface of water absorption and sorpvitity for excellent concrete are 1.95% and 0.0505 mm/min.0.5, respectively, which are lower than the values recommended by Taywood Engineering Ltd. As demonstrated by Muthupriya et al. [6], the introduction of mineral admixtures in concrete improves the durability and strength attributes of high performance concrete. According to Pavia and E. Condrel [7], OPC concrete was more durable than GGBS concrete when exposed to silage effluent because of the large increase in capillary suction, water absorption, and permeability over time, The silos' concrete is subjected to severe chemical attack over its lifetime. According to Guptha S. M. [8], silica fume concrete exhibits greater acidic resistance and alkaline resistance, and as a result, weight loss is significantly less than with control mix concrete. The sorptivity and water absorption of concrete with partial cement replacement by thermal industry waste were experimentally assessed and reported by Jayeshkumar Pitroda et al (fly ash).

II. Materials and Methods

Materials Used

Cement: It uses regular Portland cement that conforms to IS: 12269-1987 [12]. The physical and chemical parameters determined by the standard test carried out in accordance with the IS Code and summarised in Table (1).

Coarse Aggregate: The material is crushed blue granite stone with a specific gravity of 2.70 and a fineness modulus of 6.72, graded according to IS: 383-1989 [13]. The computed physical characteristics are listed in Table (2).

Fine aggregates:

Natural river sand: Fine aggregates are made up of locally accessible natural river sand and have a specific gravity of 2.60 and a fineness modulus of 3.44. Table contains the physical properties that were computed and tabulated (2).

Manufactured sand: Vertical shaft impact crushers (VSI - crushers) are used to produce manufactured sand in three steps: crushing, screening, and washing. The 400 tonnes per hour plant capacity of the VSI Crusher. The granite boulders are broken down into aggregates, which are then fed into rotopactors to further break down the aggregates into sand to the desired shape and size as fine aggregates. The aggregates are then screened to remove any fine, micro fine, and dust particles before being washed with water jets to remove any remaining dust particles. The final product complies with all the specifications of IS 383 - 1989. Sand produced using VSI crushers is requisite particle size distribution, clean, angular, and robust.

Table (1): Physical and chemical properties of cement (OPC 53 Grade).

S. No.	Property / Composition	Result
1	Specific gravity	3.15
2	Standard consistency	31%
3	Initial setting time	33
4	Final setting time	385
5	Compressive strength 7 days 28 days	 43.50MPa 57.50MPa
6	Silicon dioxide ($Si0_2$)	19.85%
7	Aluminum Oxide (Al_2O_3)	5.65%

8	Ferious oxide (Fe_2O_3)	5.20%
9	Calcium oxide (CaO)	62.55%
10	Magnesium oxide (Mgo)	0.91%

Table (2): Physical properties of course and fine aggregates.

S. No.	Property	Coarse aggregate	Msand	Natural Sand
1	Specific gravity	2.70	2.45	2.60
2	Bulk density	1510	1556	1460
3	Water Absorption (%)	0.45	1.00	1.15
4	Moisture constent	0.85	1.15	1.10
5	Fineness particlesLess than 0.075 mm(%)	-	5.30	4.14
6	Finess modules	6.72	3.54	3.44
7	Impact value	12.50	-	-
8	Sieve analysis	-	Zone-II	Zone -II

Mix design:

Using the requirements IS:10262-2009 [15], IS:456-2000, and SP:29 [16], the concrete for grades M40 and M50 is designed while taking good degree of quality and moderate exposure circumstances into consideration to attain the targeted levels of strength and durability. The weight ratio was used to measure the mix proportions, and the kilogram is the unit of measurement for the mix proportions (kg). The mix designations are M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, and M11 for 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100%, respectively.

Test specimens and test procedures:

Concrete cube specimens measuring 150 x 150 x 150 mm were used as test specimens for the water absorption, acid resistance, and alkaline resistance tests. Cylindrical specimens measuring 100 mm diameter and 200 mm height were used for impact resistance. Concrete cube specimens measuring 100 mm diameter and 50 mm thickness were used for the sorptivity test. All test specimens were cast and allowed to cure for the corresponding number of days. In a concrete mixer, the elements were thoroughly combined to produce concrete with a consistent consistency. To obtain the most accurate findings, the specimens were thoroughly compressed on a vibrating table, completely cured before being removed from the curing tanks, and then properly cleaned and dried to room temperature.

III. DURABILITY TESTS:

Water absorption test: Using the oven drying process, a water absorption test is carried out in accordance with ASTM C 642-97 [17]. For a period of 28 days, concrete cube specimens are submerged in water. The specimen was then removed from the curing tank and air dried in the environment to eliminate the surface moisture. The initial weight of the sample was recorded as W1, and the final weight as W2 after oven drying at 110 oC for 24 hours and letting it cool at room temperature.

Rapid chloride permeability test: RCPT testing in accordance with ASTM C-1202 was used to evaluate the impact of chloride ion penetration [18]. For the test, a concrete specimen measuring 100 mm by 50 mm is appropriately cast and allowed to cure for 28, 90, and 180 days. The specimen was placed in a 0.5 N sodium chloride solution with one head submerged, and the other end was submerged in a 3% sodium hydroxide solution for six hours while it was attached to a 60 V, DC electrical potential. In order to assess the chloride ion penetration values of the specimen and compare the results with standards, the charge that travelled through this cell in coulombs for concrete specimen was determined.

Sorptivity: According to ASTM C - 1585 [19], the sorptivity of the cylindrical 100 mm in diameter and 50 mm in thickness M40 and M50 grade concrete specimen is determined. In the current experiment, samples were tested for sorptivity by submerging them in water and monitoring the mass gain at regular intervals of 30 minutes over the course of two hours.

Alkaline resistance: A concrete cube of 150 mm x 150 mm x 150 mm was used in an experiment to test the alkaline resistance of concrete samples for M40 and M50. The specimen is weighed initially (W1), and samples are then obtained every 28 days, 56 days, and 90 days in 5% sodium sulphate solution. Throughout the whole test, the pH of the sodium sulphate solution is correctly maintained at 12. The specimen is removed from the solution, carefully dried with tissue paper, and weighed after being held at room temperature for the duration of the test. The weight is recorded as W2. The proportion of weight loss resulting from sulfate/alkaline assault is then determined and shown. Figure (5) depicts the setup for the alkaline resistance test.

Impact resistance test: The impact resistance of a concrete sample of 100 mm in diameter and 64 mm in thickness was tested using a drop weight hammer testing machine in accordance with ACI Committee 28-89 [20]. The specimen was kept centred and on the base plate. A 45 N drop weight was used as the impact load. The number of strikes needed to cause the initial and ultimate failure of concrete samples by dropping a hammer from a height of 457 mm was noted. For the traditional sand concrete, 100% made sand concrete and the best replacement of concrete, tests were carried out and results were presented.

IV. RESULTS AND DISCUSSIONS:

The following durability properties were examined in the test results for concrete of Grade M40 and M50, and they were addressed. Concrete made with normal sand and the results produced with artificial sand were contrasted.

Water absorption: It has been noted that the water absorption for the M40 and M50 grade concrete mix with produced sand concrete is lower than the sand concrete used in traditional construction. Figure (1) displays the water absorption rates for M40 and M50 Grade Concrete after 28 days. The data reveals that the rates for concrete made with manufactured sand are falling as a result of the microfilter impact of the manufactured sand's fines content.

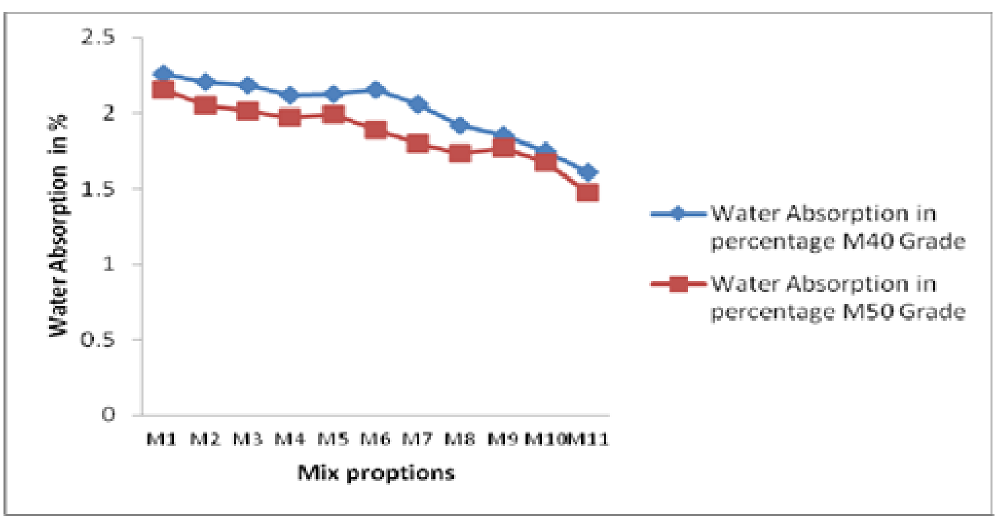

Figure (1): Water absorption examination for M40 and M50 grade concrete.

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Rapid chloride permeability test: When testing concrete of grades M40 and M50, the RCPT method is used. The test results revealed that as the amount of manufactured sand replacement increased up to 100%, the concrete's strength decreased throughout the course of 28 days, 90 days, and 180 days in the concrete specimen. The permeability of traditional sand is in a moderate zone up to a 20% replacement of sand, after which the permeability of manufactured sand concrete exhibits low permeability zones for M40 and M50 concrete, respectively. This is because M sand has the right particle size and fines percentage, which reduces the permeability of the concrete made with manufactured sand compared to ordinary sand. Figure (2) demonstrates that the RCPT values for manufactured sand are trending lower than those for ordinary sand.

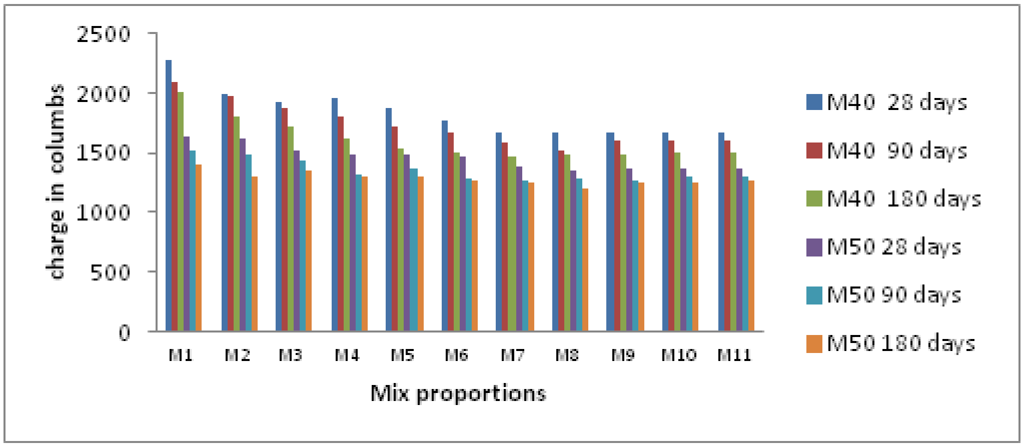

Figure (2): RCPT values for M40 and M50 grade concrete.

Sorptivity: Figure (3) shows that, up to the ideal percentage of natural sand replacement with manufactured sand, the sorptivity of the concrete with manufactured sand is lower than that of the conventional sand concrete. Full substitution of conventional sand also provides less value than concrete made with conventional sand. Hence, our findings show that synthetic sand performs better in sorptivity tests as well.

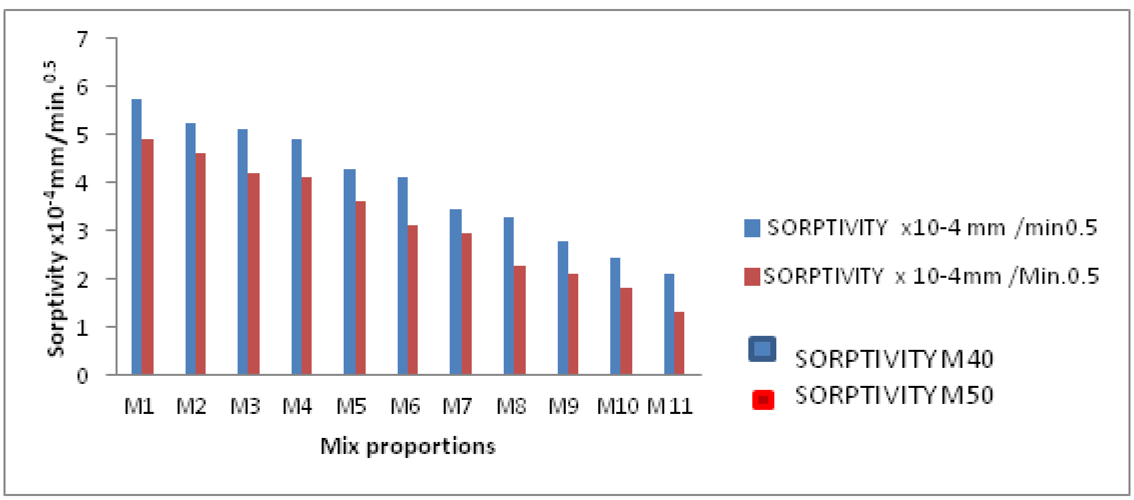

Figure (3): Sorptivity values for M40 and M50 grade concrete.

Alkaline resistance: Contrary to traditional sand concrete, produced sand concrete loses less weight as a result of sodium sulphate solution. The sulphate resistance for concrete grades M40 and M50 is shown in Figure (4). The proportion of weight loss in the figure shows that manufactured sand concrete is less resistant to sulphates than conventional sand concrete, and it is implied that manufactured sand concrete is more durable due to its higher alkaline resistance.

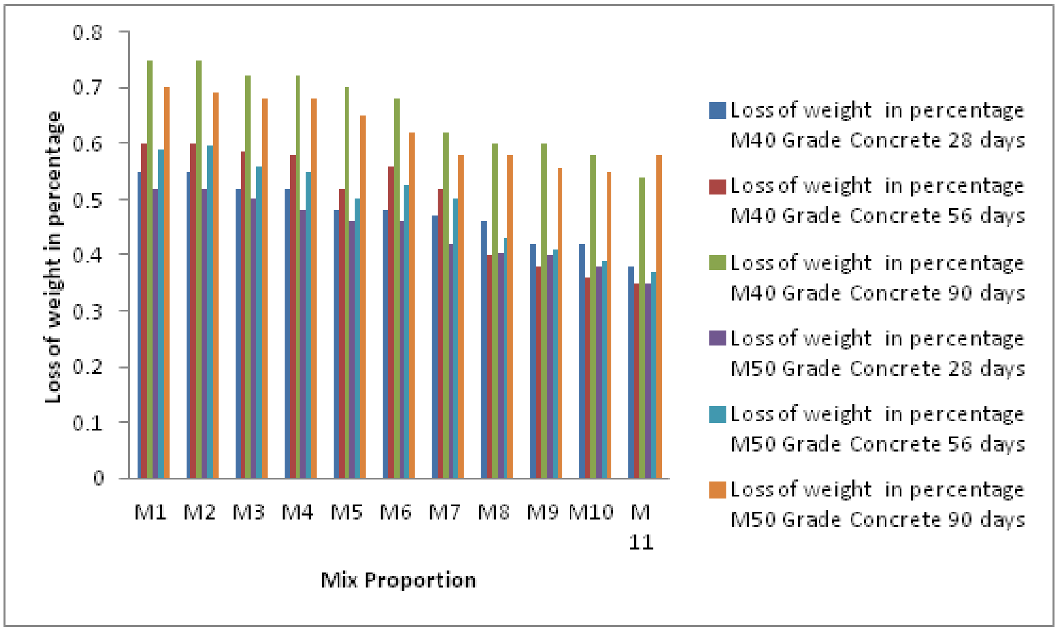

Figure (4): Alkaline Resistance for M40 and M50 Grade of Concrete.

Impact resistance: The impact resistance test findings for M40 and M50 grade concrete reveal that the mix incorporating manufactured sand had a greater average number of drops at failure and a higher average impact energy more resistance than standard sand concrete. The findings from an experimental evaluation of impact energy for concretes of grades M40 and M50 are depicted in Figure (5).

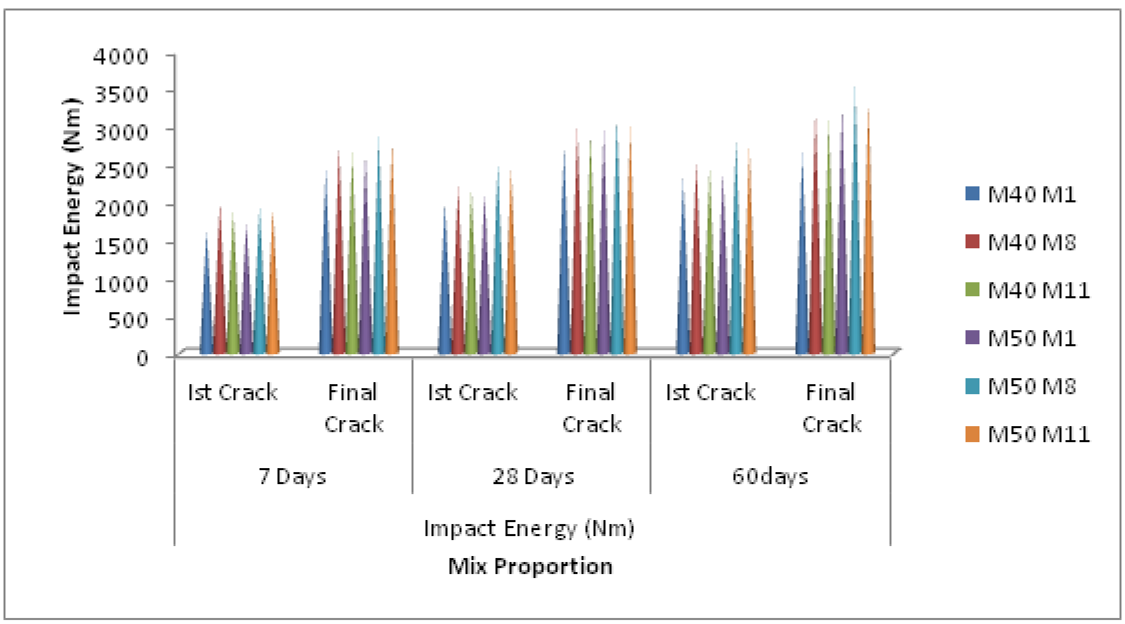

Figure (5): Impact resistance of the concrete of grade M40 and M50.

V. CONCLUSIONS

The preceding experimental data and analysis of the findings demonstrate that the durability properties of concrete are improved up to the point of optimum replacement by increasing the percentage of replacement with produced sand concrete. This is caused by the particles and microfines in the produced sand, which give concrete good cohesion. Alongside being an ideal alternative, artificial sand also produces concrete that is more durable than that made with ordinary sand, qualifies and meets Indian norms and specifications, and costs less than natural sand.

- Concrete of grades M40 and M50 made with manufactured sand exhibits less water absorption than concrete made with conventional sand, and concrete made with a lower water binder ratio is impermeable.
- Concrete made with manufactured sand has lower chloride ion penetrability than concrete made with ordinary sand, indicating that it has less permeability.
- Compared to normal sand concrete, mixes including synthetic sand have better levels of acid and alkaline resistance. This means that produced sand concrete loses less weight than traditional sand concrete owing to acid and alkaline attack.
- Compared to traditional sand concrete, manufactured sand concrete is more resistant to impact and abrasion.

The results presented above strongly support the use of manufactured sand as a fine aggregate in concrete construction for sustainable developments, and it can also be inferred that, when taking into account the durability characteristics of manufactured sand concrete, a full replacement of conventional sand with manufactured sand is also feasible.

VI. REFERENCES

1. R. Ilangovan, N. Mahendran and K. Nagamani , Study and durability properties of concrete containing quarry dust as fine aggregates, ARPN Jounal of Engineering and applied sciences 101 (3) (2008) 20-26.
2. K. Sahu, Sunil Kumar, and A. K. Sachian, Quarry stone waste on fine aggregate for concrete, The Indian Concrete Journal (2003) 845- 848.
3. R. Elangovan and K. Nagamani, Studies on strength and behavior of concrete by using quarrydust as fine aggregate, CE and CR Journal , New Delhi (2003) 40 -42.
4. R. Elangovan and K. Nagamani, Application of quarry rock dust as fine aggregate in concrete construction, National Journal of construction Management, NICMAR, Pune, December (2006)5-13.
5. K. Perumal, R. Sundara Rajan, Effect of partial replacement of cement with silica fume on the strength and durability characteristics of high performanceconcrete, 29th conference on our world in concrete and structures, Singapore, 25-26 Aug (2004) 397- 404.
6. P. Muthu Priya, K. Subramanian, and B.G. Vishnu Ram, International Journal of Earth Science and Engineering 3(3) June (2010)416- 433.
7. S. Kaviya and E. Condren, Study of the durability of OPC versus GGBS concrete on exposure to silage effluent, Journal of Materials in Civil Engineering, 20 (4) (2008) 313 – 320.
8. S. M. Guptha, Experimental study on the behavior of high strength concrete, Ph.D. Theses (2001)KU Kurukshetra.
9. Jayashkumar Pitroda, M. S. Umrigar, Evalution of sorptivity and water absorption of concrete with partial replacement of cement by thermal industry waste (Fly Ash), International Journal of Engineering and Innovative Technology (IJEIT) 2(7) (2013) 245- 249.
10. Jayakumar Pitroda, L. B. Zala, F. S. Umrrgar, Durability of concrete with partial replacement of

cement by paper industry waste (Hypo sludge), Internal Journal of Innovative Technology and Exploring Engineering 2(3) (2013) 101- 104.

11. Shyam Prakash V., Ready mixed concrete using manufactured sand as fine aggregate, 32nd conference in our World in concrete structures, Singapore 28-29 Aug (2007).
12. IS 12269 (1987) Specification for ordinary Portland cement, Bureau of Indian Standards, New Delhi.
13. IS 383 (1929) Specification for coarse and fine aggregates from natural sources, Bureau of Indian standards, New Delhi.
14. IS 456 (2000) Code of practice for plain and reinforced concrete, Third Revision, Bureau of Indian standards, New Delhi.IS 10262 (2009) Reccommended guide lines for concrete mix, Bureau of Indian standards, NewDelhi.
15. SP 29 specification for concrete mix design, Bureau of Indian standards, New Delhi.
16. ASTM C 642-97, standard test method for density, absorption and voids in hardened concrete, American Society for Testing and Materials.
17. ASTM C -1202, Standard Test method for electrical indication of concrete's ability to resist chloride iron penetration, American Society for Testing and Materials.
18. ASTM C -1585, Standard test method for measurement of rate of absorption (Sorptivity) of water, American Society for Testing and Materials.
19. ACI Committee 28-89, Standard test methods of impact resistance.
20. ASTM C-944, Standard method of test for abrasion resistance of concrete or mortar of test by rotating cutter methods, American Society for Testing and Materials.

