© 2017 IJSRSET | Volume 3 | Issue 5 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

An Experimental Study on Self Compacting Concrete by Partial Replacement of Fine Aggregate with Manufactured Sand

Y. Bala Krishna Mohan, P. J. D. Anjaneyulu, M. K. M. V. Ratnam, M. K. S. S. K. Chaitanya

Pursuing M. Tech. in Structural Engineering, Department of Civil Engineering, D.N.R. College of Engineering & Technology, Bhimavaram, West Godavari Dist, Andhra Pradesh, India

Asst. Professor, M. Tech, Department of Civil Engineering, D.N.R. College of Engineering & Technology, Bhimavaram, West Godavari Dist, Andhra Pradesh, India.

Asst. Professor, M. Tech, H.O.D, Department of Civil Engineering, D.N.R. College of Engineering & Technology, Bhimavaram, West Godavari Dist, Andhra Pradesh, India.

Asst. Professor, M. Tech, Department of Civil Engineering, Anil Neerukonda Institute of Technology & Sciences, Sangivalsa, Visakhapatnam Dist, Andhra Pradesh, India.

ABSTRACT

In the present situation the scarcity of natural sand has become a problem for the construction industry, after much research the developed technology gave rise to new generation sand named as M-sand or Manufacture sand. The M-sand is produced by crushing rocks and stones to sizes and shape similar to N-sand or Natural sand. In the present study an effort has been made to investigate the potential usage of M-sand in SCC. Self-Compacting Concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. In the work, an attempt has been made to make a comparative study on the fresh and hardened state properties of M35 self-compacting concrete with the replacement of River sand by manufactured sand. This paper presents an Experimental Investigation on Strength aspects like Compressive and Split Tensile Strength of Self Compacting Concrete and Workability tests (Slump, L-box, U-box, V-Funnel and T50) are carried out. The methodology adopted is that manufactured sand is replaced by 0%, 25%, 50%, 75% and 100% in natural sand and performance is measured.

Keywords: M-Sand- Manufacture Sand, SCC- Self Compacting Concrete, N-sand- Natural Sand

I. INTRODUCTION

The development of new technology in the material science is progressing rapidly. In last three decades, a lot of research was carried out throughout globe to improve the performance of concrete in terms of strength and durability qualities. Consequently concrete has no longer remained a construction material consisting of cement, aggregate, and water only, but has becomes an engineered custom tailored material with several new constituents to meet the specific needs of construction industry. The growing use of concrete in special architectural configurations and concrete in special architectural configurations and closely spaced reinforcing bars have made it very important to produce concrete that ensures proper filling ability, good structural performance and adequate durability. In recent years, a lot of research was carried out throughout the world to improve the performance of concrete in terms of its most important properties, i.e. Strength and durability. Concrete technology has under gone from macro to micro level study in the enhancement of strength and durability properties from 1980's onwards. Till 1980 the research study was focused only to flow ability of concrete, so as to enhance the strength however durability did not draw lot of attention of the concrete technologists. This type of study has resulted in the development of self-compacting concrete (SCC), a much needed revolution in concrete industry. Self-compacting concrete is highly engineered concrete with much higher fluidity without segregation and is capable of filling every corner of form work under its self-weight only (Okamura 1997). Thus SCC eliminates the needs of vibration either external or internal for the compaction of the concrete without compromising its engineering properties.

This concrete was first developed in Japan in late 80's to combat the deterioration of concrete quality due to lack of skilled labours, along with problems at the corners regarding the homogeneity and compaction of cast in place concrete mainly with intricate structures so as to improve the durability of concrete and structures. After the development of SCC in Japan 1988, whole Europe started working on this unique noise free revolution in the field of construction industry. The last half of decade 1991-2000 has remained very active in the field of research in SCC in Europe. That is why, Europe has gone ahead of USA in publishing specifications and guidelines for self-compacting concrete (EFNARC 2002). Now, all over the world, a lot of research is going on, so as to optimize the fluidity of concrete with its strength and durability properties without a drastically increase in the cost. The first North American conference on design and use of self-consolidation concrete was organized in November 2002. At present many researchers are working in numerous universities and government R&D organizations due to benefits of the use of this concrete. A very limited work is reported from India, where the future for concrete is very bright due to scarcity of skilled man power, non-mechanization of construction industry, abundant availability of construction materials available at very low cost. Therefore, it can be said that SCC is still quite unknown to many researchers, builders, ready mix concrete producers, academia etc.

a) Powder type of self-compacting concrete: This is proportioned to give the required self-compatibility by reducing the water-powder (Material<0.1mm) ratio and provide adequate segregation resistance. Super plasticizer and air entraining admixtures give the required deformability.
b) Viscosity agent type self-compacting concrete. This type is proportioned to provide self-compaction by the use of viscosity modifying admixture to provide segregation resistance. Super plasticizers and air entraining admixtures are used for obtaining the desired deformability.
c) Combination type self compacting concrete this type is proportioned so as to obtain self-compatibility mainly by reducing the water powder ratio, as the quality fluctuations of the fresh concrete due to the variation of the surface moisture content of the aggregates and their graduations during the production. This facilitates the production control of the concrete.

II. METHODS AND MATERIAL

This chapter deals with the experimental program particulars. The materials used, concrete mix details, casting procedure, curing and testing procedures are explained.

2.1 Materials:

Cement:

Portland Slag Cement, commonly known as PSC, is blended cement. Slag is, essentially, a non-metallic product comprising of more than 90% glass with silicates and alumina-silicates of lime. At JSW Cement, we use superior quality slag produced at our steel manufacturing plant, conforming to IS: 12089 standards for producing PSC. It is created with a combination of up to 45- 50% slag, 45% – 50% clinker, and 3-5% gypsum. PSC has been voted as the most suitable cement for mass construction because of its low heat of hydration. The multi-fold advantages of PSC.

Fine Aggregate (Natural Sand):

Locally available river sand which is free from organic impurities is used sand passing through 4.75mm sieve and retained on 150 micron IS sieve is used in this investigation. River sand confirming to IS: 2386-1975 is used.

Coarse Aggregate Properties:

The crushed coarse aggregate of 20 mm maximum size rounded obtained from the local crushing plant is used in the present study. The physical properties of coarse aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS : 2386-1975.

Water:

Water is an important constituent of concrete, it should receive due attention in preparation and for quality control of concrete. Strength and other properties of concrete are developed as a result of reaction of cement and water and thus water plays a critical role. Quality of mixing and curing water sometimes leads do distress and disintegration of concrete reducing the use full life of the concrete structure. Water used or concrete mixture should contain substances which can have harmful effect on strength or durability of the concrete in service. Certain substances if present, in sufficient qualities in water may have an injurious amounts of oils, acids, alkalies, salts, organic matter, sewage and other substances which are deleterious to concrete or steel reinforcement. Ordinary potable water of normally pH 7 is used for mixing and curing the concrete specimen.

Manufactured Sand:

Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word. Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-Sand is its availability and transportation cost. Since this sand can be crushed from hard granite rocks, it can be readily available at the nearby place, reducing the cost of transportation from far-off river sand bed. Thus, the cost of construction can be controlled by the use of manufactured sand as an alternative material for construction. The other advantage of using M-Sand is, it can be dust free, the sizes of M-sand can be controlled easily so that it meets the required grading for the given construction.

Chemical Admixture:
Chemical admixture reduces the cost of construction the cost of construction, modify the properties of concrete and improve the quality of concrete during mixing, transportation, placing and curing.

Poly carboxylate ether – based super plasticizers:

Commercially available poly carboxylate ether (PCE) -based super plasticizers (SP) master glenium SKY8233 was used in all the SCC mixtures it is an F-type high range water reducer, in conformity with ASTM: C 494, IS 9103: 1999 & IS 2645: 2003.

Viscosity modifying admixtures:
The Viscosity modifying agent (VMA) shall be GLENIUM STREAM 2, an organic ready to use, liquid admixture specially formulated for applications in Rheodynamics concrete. The product shall comply with EFNARC VMA guidlines 2006.

2.2 Mix Design

SCC is ushering in revolution in the concrete technology. It is not only easy to place to concrete in congested reinforcement structures but also compacts it without noisy vibrations. SCC ensures high durability si9nce air voids and other flaws are likely to be absent in this concrete.

So, SCC requires some special properties in mix proportioning. The important property like flow ability cannot be achieved by just increasing the water content in the mixer. Adding more water to a concrete mixer will not only cause weakening of the concrete but also severe segregation.

2.3 Methods

2.3.1 Tests on Concrete:

Testing of concrete plays an important role in controlling and conforming the quality of cement works. The basic tests to be conducted in the field as well as in the lab based on its state of concrete are given below

1. Tests on Fresh SCC
2. Tests on Hardened SCC

2.3.1.1 Tests on Fresh SCC

For determining the self compatibility properties (slump flow, T-50 time, U box, L box and V funnel) tests were performed on all mixtures the order of testing was:

a) Slump flow test and measurement of T50 time
b) U-box test method
c) L-box test method
d) V-funnel test method

Slump Flow Test Method:

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It was first developed in Japan for use in assessment of underwater concrete. The test method is based on the test method for determining the slump. The diameter of the concrete circle is a measure for the filling ability of the concrete. This is simple, rapid test procedure, though two people are needed if the T50 time is to be measured. It can be used on site, though the size of the base plate is somewhat unwieldy and level ground is essential. It is most commonly used test, and gives a good assessment of filling ability. It gives no indication of the ability of the concrete to pass between reinforcement without blocking, but may give some indication of resistance to segregation. It can be argued that the completely free flow, unrestrained by any boundaries, is not representative of what happens in practice in concrete construction, but the test can be profitably be used to assess the consistency of supply of ready-mixed concrete to a site from load to load.

U Box Test Method

This is a simple test to conduct, but the equipment may be difficult to construct. It provides a good direct assessment of filling ability-this is literally what the concrete has to do-modified by an unmeasured requirement for passing ability. The 35 mm gap between the sections of reinforcement may be considered too close. The question remains open of what filling height less than 30 cm. is still acceptable. The test was developed by the Technology Research Centre of the Taisei Corporation in Japan. Sometimes the apparatus is called a "box shaped" test. The test is used to measure the filling ability of self- compacting concrete. The apparatus consists of a vessel divided by a middle wall into two compartments, shown by R1 and R2 in Fig.An operating with a sliding gate is fitted between the two sections. Reinforcing bars with nominal diameters of 13mm are installed at the gate with centre-to-Centre spacing of 50mm.This creates a clear spacing of 35mm between the bars. The left hand section is filled with about 20 litre of concrete then the gate lifted and concrete flows upward into the other section. The height of the concrete in both sections is measured.

L Box Test Method

This test, based on a Japanese design for underwater concrete, has been described by Peterson. The test assesses the flow of the concrete, and also the extent to which it is subjected to blocking by reinforcement. The apparatus is shown in figure.

The apparatus consists of a rectangular section box in the shape of an "L‟, with a vertical and horizontal section, separated by a moveable gate, in front of which vertical lengths of reinforcement bars are fitted. The vertical section is filled with concrete, and then the gate lifted to let the concrete flow into the horizontal section. When the flow has stopped, the height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section (H2/H1 in the diagram). It indicates the slope of the concrete when at rest. This is an indication passing ability, or the degree to which the passage of concrete through the bars is restricted. The horizontal section of the box can be marked at 200 mm and 400 mm from the gate and the times taken to reach these points measured. These are known as T20 andT40 times and are an indication for the filling ability. The sections of bar can be of different diameters and spaced at different intervals: in accordance with normal reinforcement considerations, 3x the maximum aggregate size might be appropriate. The bars can principally be set at any spacing to impose a more or Less severe test of the passing ability of the concrete.

V Funnel Test Method

The test was developed in Japan and used Ozawaetal. The equipment consists of a V- shaped tunnel, shown in fig. An alternative type of V-funnel, the O funnel, with a circular section is also used in Japan. The described V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum aggregate size of 20mm.The funnel is filled with about 12 litre of concrete and the time taken for it to flow through the apparatus measured. After this the funnel can be refilled concrete and left for 5 minutes to settle. If the concrete shows segregation then the flow time will increase significantly. Though the test is designed to measure flow ability, the result is affected by concrete properties other than flow. The inverted cone shape will cause any liability of the concrete to block to be reflected in the result – if, for example there is too much coarse aggregate. High flow time can also be associated with low deformability due to high paste viscosity, and with high inter-particle friction.

2.3.1.2 Tests on Hardened SCC

The main aim of flow characteristics and strength characteristics of self-compacting concrete produced from different percentages of that material partial replacement of manufacture sand. The different percentages of replacement of m-sand experimentation are 0%, 25%, 50%, 75%, 100 % and at 7, 14, 28, 56 and 90 days the concrete has been tested. Casting and curing of test specimen after casting, the moulded specimens were left on the casting room at room temperature for 48h. They were than de-moulded and cured in water for 7, 14, 28, 56 and 90 days.

Compressive Strength

Compressive strength can be defined as the measure maximum resistance of a concrete to axial loading. The specimens used in the compressive test are: 150 mm x 150 mm x 150 mm. There are three specimen were used in the compression testing for each mixes. The compression testing machine used for testing the cube specimens is of standard make. The capacity of testing machine is 2000 KN. The machine has a facility to control the rate of loading with a control valve. The plates are cleaned before the testing of cubes. After the required period of curing, the cube specimens are removed from curing tank and cleaned to wipe off the surface water. It is placed on machines such that the load is placed centrally. The smooth surface of specimen is placed on the bearing surfaces.

Split Tensile Strength

The split tensile strength of concrete is determined by casting cylinders of size 150 mm x 300 mm. The cylinders were tested by placing them uniformly. Specimens were taken out from curing tank at the age of 7, 14, 28 and 90 days of moist curing and tested after surface water dipped down from specimens. This test was performed on Universal Testing Machine (UTM) as shown in fig. Split Tensile strength of concrete is tested on cylinders at different percentage of cement replacements content in concrete. The strength of concrete has been tested on cylinder at 7, 14, 28 and 90 days. 7 days test has been conducted to check the gain in initial strength of concrete. 28 days test gives the data of final strength of concrete at 28 days curing. Compression testing machine is used for testing the Split Tensile strength test on concrete along with two wooden boards. At the time of testing the cylinder taken out of water and dried and then tested.

Flexural Strength

Flexure specimens shall be beams whose cross section is a square with a side length not less than three times the maximum coarse aggregate size and not less than 100 mm. The beam length shall be at least 80 cm longer than three times the side length of the cross-section. The standard cross-sectional size of flexure specimens is 100 by 100 mm or 150 mm by 150 mm. Self-compacting concrete shall not be shifted with a sieve to reduce the size of specimens as practiced for normal concrete.

III. RESULTS AND DISCUSSION

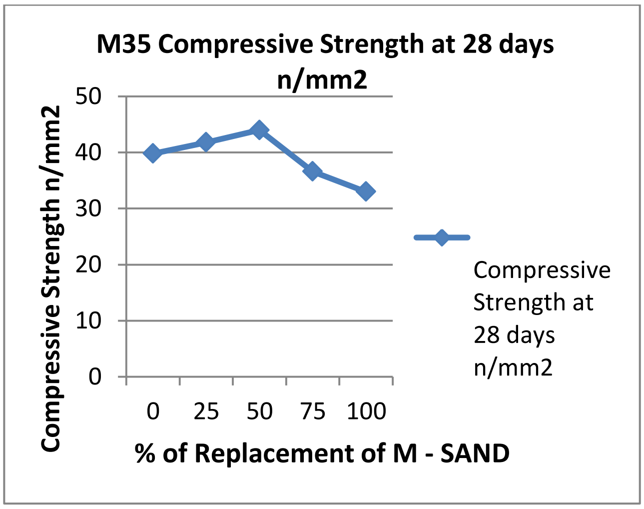
3.1 Results:

Compressive Strength Result and Graph:

For studied, the total number concrete cube specimens of (150 x 150 x 150 mm) was caste and tested at 7, 14, 28, 56 and 90 days. The result for average value of specimens, were calculated and is shown in the table below.

M35 Grade	
% of Replacement of M - SAND	**Compressive Strength at 28 days n/mm2**
0	39.8
25	41.8
50	44
75	36.6
100	33

Graph:

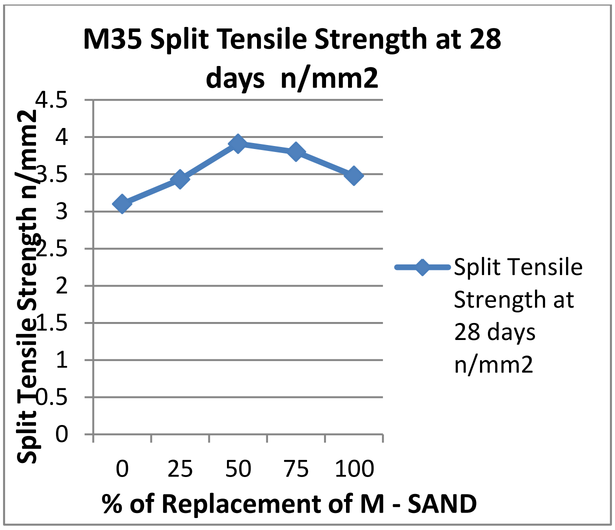


Split Tensile Strength Result and Graph

In accordance with IS-516 the split tensile strength of conventional and partially replaced concrete cylinders for 7, 14, 28, 56 and 90 days strength is determined by testing the cylinder specimens in the universal testing machine.

M35 Grade	
% of Replacement of M - SAND	Split Tensile Strength at 28 days n/mm2
0	3.1
25	3.43
50	3.91
75	3.8
100	3.48

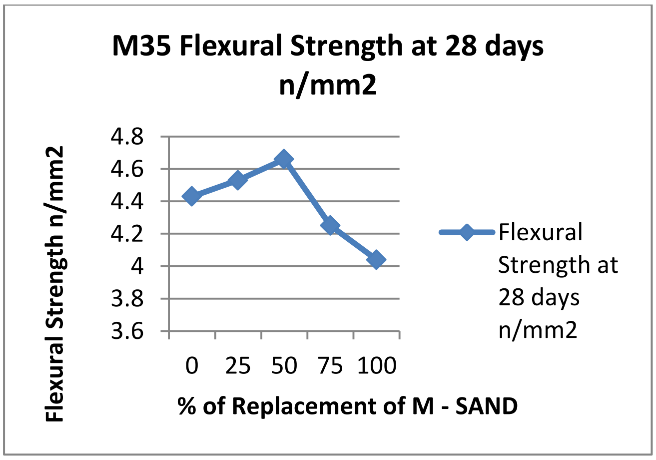
Graph:



Flexural Strength Result and Graph

It is a measure of an unreinforced beam to resist failure in building. It is measured by loading 150 mm x 150 mm x 700 mm concrete beam. The flexural strength is expressed as modulus of rupture in Mpa and is determined by the centre point loading. In accordance with IS-516 the flexural strength of conventional and partially replaced concrete beams for 7, 14, 28, 56 and 90 days strength is determined by testing the beam specimens in the universal testing machine.

Graph:



3.2 Discussions

For the SCC mix, with the increase of Dosage of M-Sand, the SCC flow properties are decreasing to some extent. For the 100% replacement of sand with M-Sand; SCC flow properties are not achieved successfully.

The above table presents the strength criteria for the CUBE & CYLINDER Specimens with respective to Compressive strength and split tensile strength. It can be observed that; with the increase of M-Sand dose, strength properties are not to the specified one, i.e., Target strength. The maximum replacement of natural sand with M-Sand is up to 50%, at this dose, SCC flow properties and strength criterion holds good.

For every increase in the M-Sand dose, percentage increase in the strength, both in compression as well as split tensile strength were calculated. From the table, it can be observed that the compressive strength is increased to a maximum of about 10% and split tensile strength is increased to a maximum of about 7% at 50% replacement of natural sand with M-Sand. Therefore, it can be stated that; at 50% M-Sand dose, Strength criteria hold good.

In our work, we made an effort to make a relationship between compressive strength and split tensile strength, by the literature study, the relationship is established. From IS: 456-2000, Flexural strength relation with compressive strength is used.

IV.CONCLUSION

Based on the experimental study on the SCC for M30 and M35 grade concrete, the following conclusions are drawn:

- The mix design for M-Sand SCC using NAN-SU method and “EUROPEAN GUIDELINES FOR SCC” is arrived.
- Conventional Fine aggregate i.e., sand is replaced with M-Sand and based on the test results, the optimum dose is found.
- The replacement dosage is made at a variation of 25% interval.
- The optimum replacement of M-Sand is found to be 50% from the study.
- SCC flow properties are satisfied with the EUROPEAN GUIDELINES at the optimum dose of M-Sand.

- The target mean strength is achieved mostly at 50% replacement of sand with M-Sand. At this dose, by the use of M-Sand , there is increase in the split tensile strength of about 7% and increase in compressive strength is about 10% is observed.
- Relation between Split tensile strength and Compressive strength is established.
- The relationship between compressive strength and flexural strength which has been given by IS: 456-2000 is tabulated.
- Compressive strength test results was found 50% is maximum strength achieves.
- Split tensile strength test results was found 50% is maximum strength achieves.
- Flexural strength test results was found 50% is maximum strength achieves.

V. REFERENCES

[1] CHAMPION, J. M. and JOST, P., 'Self-compacting concrete: Expanding the possibility of Concrete Design and Placement', Concrete International, Vol.22, No.4, pp. 159-178, June 1998.

[2] HEINE, HANS J. "Saving Dollars Through Sand Reclamation – Part 1," Foundry Management and Technology. 111:5 (May, 1983), pp.22-25.

[3] HENDERSON, N. "Self-compacting concrete at Millennium point", CONCRETE, vol.34, No. 4, April 2000, pp.26-27.

[4] KAMESWARA RAO, C.V.S (1983) "Analysis of Some Common Workability Tests". Indian Concrete Journal, 57 (3): 71-73 and 75.

[5] KATHY STANFIELD, "Self-compacting concrete a Growth area", The Structural Engineering Volume. 76, No’s 23 and 24, pp. 462-463.

[6] NAGATAKI, S. And FUJIWARA, H. "Self-compacting property of Highly-Flowable Concrete" ICI Journal July-September 2002.

[7] KLAUS HOLSCHEMACHER, "Structural Aspects of Self- compacting concrete", NBM & CW, July 2002, pp. 8-12.

[8] MAHINDRAKAR A.B. Research work Study on Red Mud by, KLESCET, Belgaum, 1999.

[9] MEHTA, P.K., 'Concrete structure: Properties and materials', Prentice Hall, pp. 367-378, 1986. ICI Journal July-Sep 2002.

[10] MICHEAL J. CAMPION and PHILLIPPE JOST, "Self-compacting concrete", Concrete Int. 2000, pp. 31-34.

[11] OKAMURA, H (1997),"Self-Compacting High Performance concrete", Concrete International, Vol. 19, No. 7, pp-50-54.

[12] OKAMURA. H. and OUCHI. M, "Self-Compacting Concrete - Development, present use and future", Its International RILEM Symposium on Self Compacting Concrete, 1999, Concrete International pg 3-14.

[13] OKAMURA, H., OZAWA, K. and OUCHI, M. "Self-compacting concrete. Structural concrete". 1, No. l, March 3-17-2000.

[14] SHETTY. M. S. Concrete Technology, by S. CHAND Publisher.

[15] SUBRAMNIAN. S., CHATTOPADHYAY. D, "Experiments for mix-proportioning of self-compacting concrete", The Indian Concrete Journal, Jan 2002.

[16] TAKEUCHI. H., HIGUCHI. M., and NANNI. A. "Application of flow able Concrete in Tunnel lining", Concrete International. Vol. 16. No. 4, April 1994. Pp.26-29.