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Effect of Mineral Admixtures on Properties of Polymer Modified Self Compacting Concrete

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ABSTRACT: The research work was carried out on experimental investigation of polymerized self-compacting concrete (PMSCC). Properties of concrete were checked by testing cubes, cylinder & beams. The specimens were cast for developing M30Grade self-compacting concrete (SCC) with locally available material. The objective of present work was to study effect of different proportion of mineral admixtures in the mix design and find out optimum percentage of mineral admixtures i.e. silica fume (SF) & marble powder (MP) with maximum strength criterion. The concrete was tested to find workability, compressive strength, split tensile strength & flexural strength. Having studied various properties optimum percentage of silica fume & marble powder to replace the cement was found.

***Keywords**: polymer modified self-compacting concrete, mineral admixtures, workability, compressive strength, Flexural strength, split tensile strength.*

1 INTRODUCTION: Self-compacting concrete (SCC) was developed in the middle of the 1980's in Japan. SCC flows alone under its dead weight up to levelling, airs out and consolidates itself thereby, without any entry of additional compaction energy and without any segregation. These characteristics were made possible by the development of highly effective water reducing agents (super plasticizers), those usually based on poly carboxylate ethers. The mixture composition of SCC deviates from conventional concrete.

PROPERTIES OF SCC

1	Filling Ability	:	Ability of to fill a formwork completely under its own weight.
2	Passing Ability	:	Ability to overcome obstacles under its own weight without hindrance.
3	Segregation resistance	:	Homogeneous composition of concrete during and after the Process of transport and placing.

SCC are divided into three different types according to the composition of the mortar:

a) Powder type
b) Viscosity – modifying agent (stabilizer) type
c) Combination type

For the powder type, a high proportion of fines produce the necessary mortar volume, while in the stabilizer type, fines content can be in the range admissible for vibrated concrete. The viscosity required to inhibit segregation will then be adjusted by using a stabilizer. The combination type is created by adding a small amount of stabilizer to the powder type to balance the moisture fluctuations in the manufacturing process.

The SCC essentially eliminates the need for vibration to consolidate the concrete. This results in an increase in productivity, a reduction in noise exposure and a finished product with few, if any external blemishes such as "bug holes". However, after completion of proper proportioning, mixing, placing, curing and consolidation, hardened concrete becomes a strong, durable, and practically impermeable building material that requires no maintenance.

2. RESEARCH SIGNIFICANCE

The SCC is widely used in construction engineering. PMSCC is also an interesting solution for concrete subjected to environmental conditions and for repairing applications. In structural repairs, SCC is preferred as a results of its advantages. So, PMSCC may be used successfully in repair of concrete elements or construct new concrete elements especially when concrete is subjected to sever conditions. This research aims to study the interactions between main SCC components (filler and high dose of chemical admixtures) andmain components of PMSCC which is polymer itself. The effect of these interactions on workability, compressive strength, tensile strength, flexural strength is studied. This type of concrete can be used to achieve the advantages of both SCC and PMSCC especially in area of repairs & maintenance.

3. EXPERIMENTAL PROGRAM

3.1. Concrete mixes and test parameters

Concrete mixes were classified into three groups. These groups were traditional concrete (TC), traditional self-compacting concrete (TSCC) and polymer modified self-compacting concrete (PMSCC). The materials used to produce TC were crushed stone (CA) with 12 mm nominal maximum size, naturalSand (FA) and 53 grade as perIS: 12269-1987ordinary Portland cement. Physical and mechanical properties of cement are conforming to IS: 4031 – 1988. High range water reducing admixture and filler are added to the previous materials to produce TSCC. Poly vinyl acetate (PVA) polymers a by-product available at comparatively low prices were added to produce PMSCC.

Cement content of 416.46 kg/m^3 and water content of 187.408 lit.Were kept constant in all concrete mixes. Also, in all concrete mixes, ratio between coarse aggregate and fine aggregate was kept equal to 0.46:0.54.

Effect of polymer type, polymer dose, filler type on the properties of PMSCC were studied. The studied doses of MP were 2.5%, 5.0%, 7.5% by weight of cement while for SF the studied doses were 2.5%, 3% and 5%. SF and MP were used as fillers. Superplasticizer dosages tried ranged from 1% to 3% with an increment of 0.5% by volume of water & the slump was studied. The optimum percentage was found to be 2%. On similar linesPVA was taken as7.5%, 10.0% & 12.5% by weight of water for TSCC and PMSCC. Optimum percentage was found as 10%.Modified polycarboxylic ether (MPCE) based chemical admixtures were used as superplasticizer to produce SCC.

SCC TESTS AND PROCEDURE

4.1. SLUMP FLOW & T50 TEST:

Slump Flow & T50 test[12]were used for measuring filling ability of concrete.The basic equipment used is the same as for the conventional slump test. The test method differs from the conventional one in the way that the concrete sample placed into the mould has no reinforcement rod and when the slump cone is removed the sample collapses. The diameter of the spread of the sample is measured, i.e. a horizontal distance is measured as against the vertical slump measured in the conventional test. While measuring the diameter of the spread, the time that the sample takes to reach a diameter of 500 mm (T50) is also sometimes measured. The Slump Flow cone shown in fig. 1.This test developed in Japanwas conductedas per EN 12350-2.

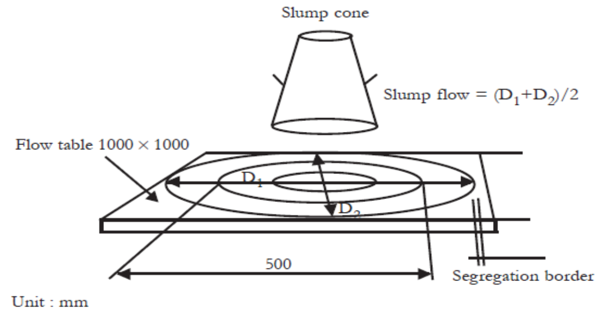


Fig. 1. Slump conetest apparatus

4.2. V-FUNNEL AT T5 MIN TEST:

The V-funnel test[12] was developed in Japan and used by Ozawa. The equipment consists of a V-shaped funnel, shown in fig.2the funnel is filled with concrete and the time taken by it to flow through the apparatus is measured. This test gives account of the filling capacity (flowability). The inverted cone shape shows any possibility of the concrete to block is reflected in the result. This is taken to be when light is seen from above through the funnel.The whole test has to be performed within 5 minutes. This test was conducted as per EN 12350-1.

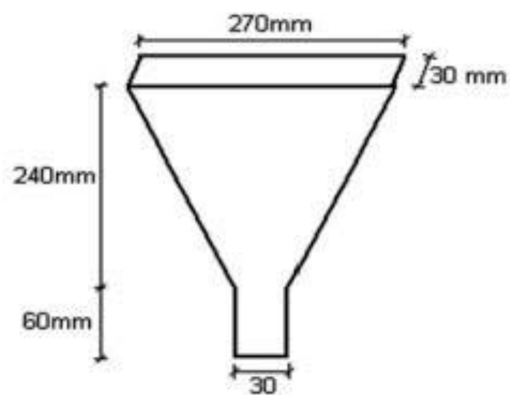


Fig. 2. V-funneltest apparatus

4.3. L-BOX TEST:

The L-box test [12]is used to measure the passing ability of SCC. Thismethod uses a test apparatuscomprising a vertical section and a horizontal trough into which the concrete is allowed to flow on the release of a trap door from the vertical section passing through reinforcing bars placed at the intersection of the two areas of the apparatus. The concrete ends of the apparatus H1 and H2measure the height of the concrete at both ends. The L-box apparatus shown in fig. 3.

TABLE 1 LIMIT FOR SCC
List of test methods for workability properties of SCC

No	Method	Property	Unit	Typical range of values	
				Min	**Max**
1	Slump-flow by Abrams cone	Filling ability	mm	650	800
2	slump flow & T50cm	Filling ability	sec	2	5
3	V-funnel	Filling ability	sec	6	12
4	Orimet	Filling ability	sec	0	5
5	J-ring	Passing ability	sec	0	10
6	L-box	Passing ability	(h2/h1)	0.8	1
7	U-box	Passing ability	(h2-h1) mm	0	30
8	Fill-box	Passing ability	%	90	100
9	V-funnel at T5 min	Segregation resistance	sec	0	3 sec
10	GTM Screen stability test	Segregation resistance	%	0	15

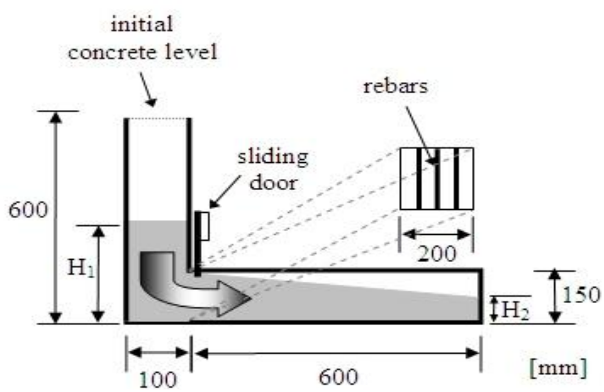


Fig. 3 L-boxtest apparatus

4.4 U-BOX TESTS:

The U-box test [12] is used to measure the passing ability of SCC.These are methods for testing flowability of SCC through an obstacle with coarse aggregates having the maximum size of less than 25 mm. Time and height to fill in the chamber B and amount of aggregate passed through the obstacle are measured for self-compactability.The U-box apparatus shown in fig. 4.

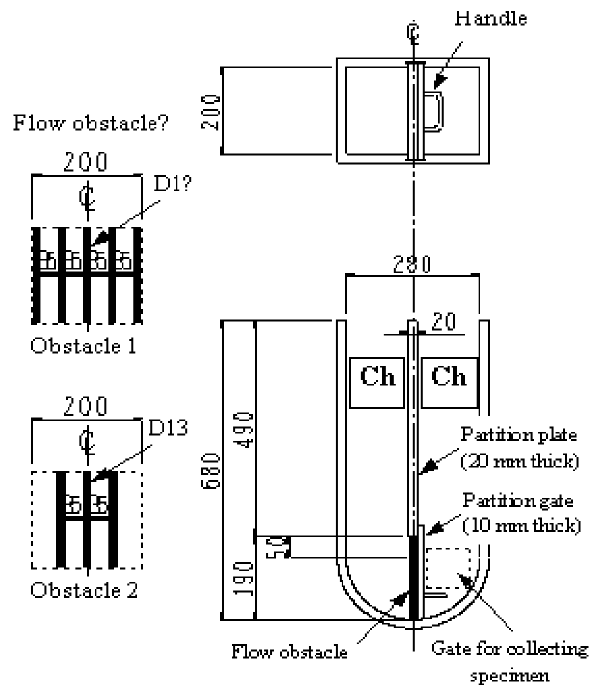


Fig. 4 U-boxtest apparatus

4.5 J-RING TEST:

The J-ring[12]test is used to determine the passing ability of the SCC. The equipment consists of a rectangular section (30mm×25mm) open steel ring, drilled vertically with holes to accept threaded sections of reinforcement bar. These sections of bar can be of different diameter spaced at different intervals; in accordance with normal reinforcement considerations. The diameter of the ring of vertical bars is 300 mm, and the height 100 mm.The J-ring apparatus shown in fig. 5.

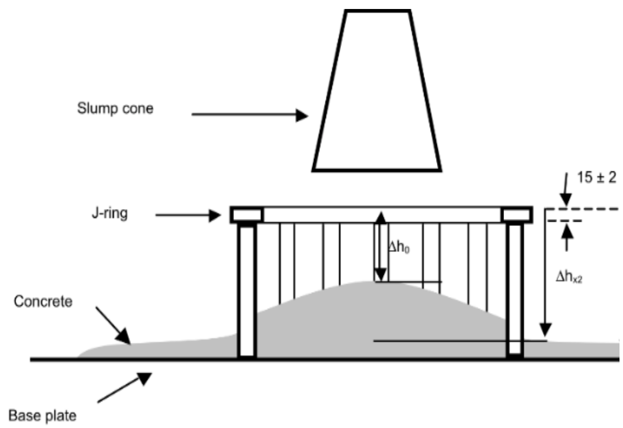


Fig. 5. J ringtest apparatus

4.6 FILL BOX TEST:

The fill box test [12]is used to measure the filling ability of SCC. It consists of a transparent rectangular box as shown in Fig.6 with number of obstacles through which the concrete islet to flow. The apparatus isplaced on a firm level support having a height of 1 meter approximately. Concrete is filled in the boxthrough the funnel provided at the topside of the box till it covers the top-most obstacles at the rear end of the box. The height of the concrete at both the ends is measured to calculate volume of concrete filled. Compare the net volume of concrete filled with respect to the contained volume of the box up to the top of the top most obstacles, which gives the filling capacity of SCC.

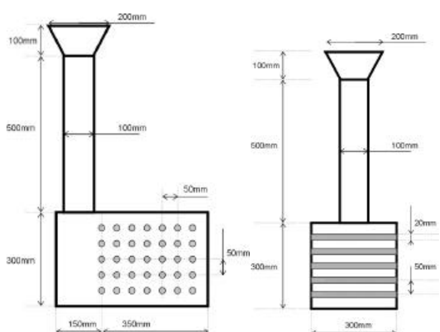


Fig.6 Fill boxtest apparatus

4.7 ORIMET TEST:

The Orimet[12]was developed at the University of Paisleyas a method for assessment of highly workable, flowing fresh concrete mixes on construction sites. The Orimet consists of a vertical casting pipe fitted with a changeable inverted cone-shaped orifice at its lower discharge end, with a quick-release trap door to close the orifice. Usually the orifice has 80 mm internal diameter which is appropriate for assessment of concrete mixes of aggregate size not exceeding 20 mm. Orifices of other sizes, usually from 70 mm to 90 mm in diameter, can be fitted instead. Operation consists simply of filling the Orimet with concrete then opening the trapdoor and measuring the time taken for light to appear at the bottom of the pipe. Open the trap door within 10 seconds after filling and allow the concrete to flow out under gravity.The Orimet apparatus shown in fig. 7.

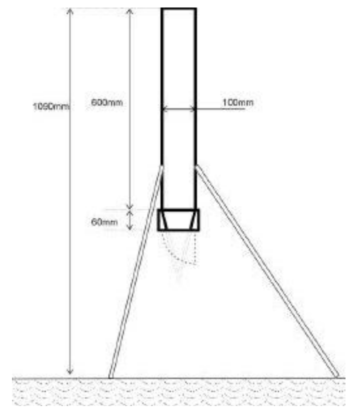


Fig. 7. Orimettest apparatus

4.8 GTM SCREEN STABILITY TEST:

GTM screen stability test[12] has been developed by the French contractor, GTM, to assess segregation resistance (stability). It consists of taking a sample of 10 litre of concrete, allowing it to stand for a period to allow any internal segregation to occur, then pouring half of it on to a 5mm sieve of 350mm diameter, which stands on a sieve pan on a weigh scale. After two minutes, the mortar which passed throughthe sieve is weighed, and expressed as a percentage of the weight of the original sample onthe sieve. Thesegregation ratio, if between 5 and 15% of the weight of the sample, the segregation resistance is considered satisfactory. Below 5% the resistance is excessive, and likely to affect the surface finish (blow holes likely). Above 15%, and particularly above 30%, there is strong likelihood of segregation.

4.9 COMPRESSIVE STRENGTH:

Use compression testing machine as per IS 516-1959. Cubes of 150×150 ×150 mm were used for compressive strength. The ages of testing were 3, 7 &28 days. Minimum average of three specimens was found in each test.

Description	Filler	Filler	Mix proportion				Plasticizer	Polymer PVA
	(% of cement)	(kg)	Water (Lit.)	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	(% of Water) (Lit.)	(% of Water) (Lit.)
TC		-					-	-
TSCC		-	187.40	416.46	957.86	821.96	2	
TSCC+P		-	168.66	416.46	957.86	821.96	2	10
TSCC+P+MP	5	20.83	168.66	395.63	957.86	821.96	2	10
TSCC+P+SF	2.5	10.41	168.66	406.05	957.86	821.96	2	10

4.10 SPLIT TENSILE STRENGTH:

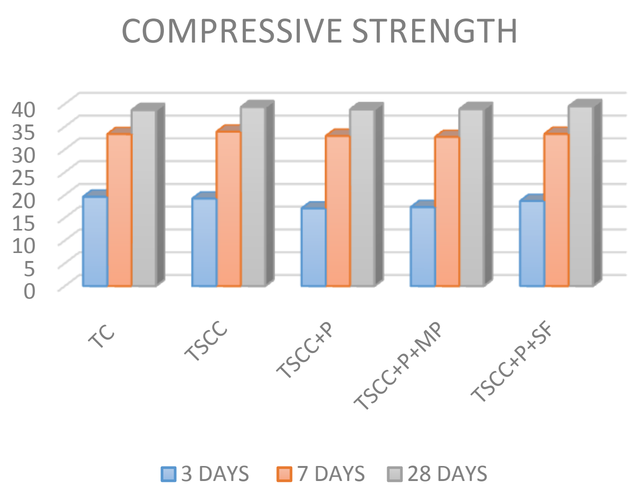
Cylinders of 150 mm diameter and 300 mm height were used to determine tensile strength. The tensile strength was measured by indirect splitting test. The age of testing was 28 days. This test was conducted as per IS: 5816 – 1999.

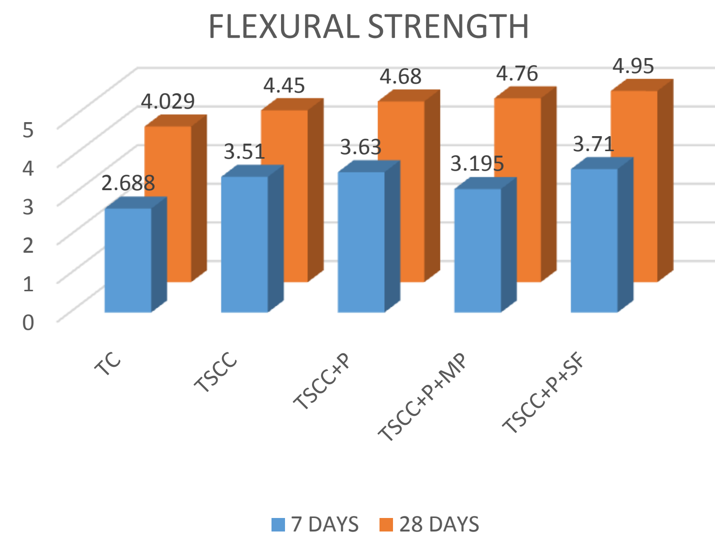
4.11 FLEXURAL STRENGTH:

Beams of 150 ×150 ×700 mm were used for flexural strength over a span of 400 mm, under symmetrical two-point loading according to IS: 516-1959.The ages of testing were 7 &28 days.

Table 2 Mix proportion on concrete

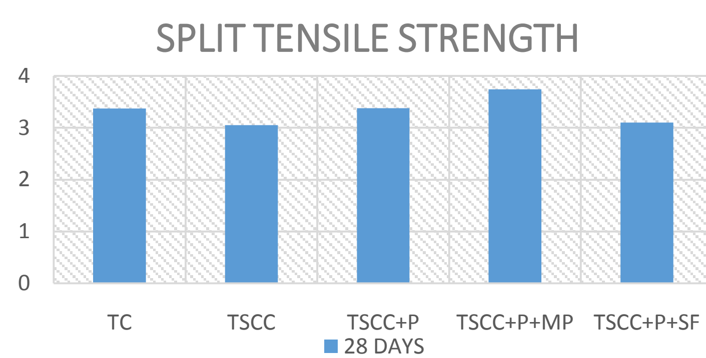
SCC strength graph:





6 CONCLUSION

1. When superplasticizer dosage was more than saturation dosage at that time bleeding occurred.



2. The Workability of concrete increases when polymer (PVA) proportion increases in SCC.
3. Use of polymer by more than 10% of volume of water delays the time required for hardening of concrete.

4. Optimum percentage of silica fume from view point of satisfying flowability requirement is found as 2.5%as replacement for cement for PMSCC. It also exhibits 5% additional flexural strength at 28 days of curing.
5. Optimum percentage of marble powder from view point of satisfying flowability requirement is found as 5%as replacement for cement for PMSCC. It enhances flexural strength at 28 days of curing by 2%.
6. Replacement of cement with marble powder is cheaper by about 3% considering only material component.

7 SCOPE OF FUTURE WORK

1. For the future work we can take different admixture & check effect on PMSCC.

2. One can try different polymers with different proportion to find a cost effective solution**.**

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