American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-2, Issue-4, pp-67-71
www.ajer.us

Research Paper Open Access

Evaluation of Relationship Between Mechanical Properties of High Strength Self Compacting Concrete

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Abstract: In the present experimental investigation an attempt is made to report relationship between compressive strength , Split tensile Strength and Flexural Strength of High Strength Self Compacting Concrete with mineral admixtures . It is well known that the properties of concrete are affected by cementitious matrix, aggregate and the transition zone between the two phases. Reducing water powder ratio and addition of pozollona admixtures like Fly ash and Micro silica are often used to modify the micro structure of the matrix and to optimize the transition zone.

Keywords: *Self Compacting Concrete, Segregation Resistance, Filling ability, Passing Ability, Water-Powder Ratio.*

I. LITERATURE REVIEW

C. SELVAMONY et.al (1) involved evaluating the Effectiveness of various percentages of mineral admixtures in producing SCC. Okamura's method, based on EFNARC specifications, was adopted for mixed design. DRSRIRAVINDRARAJAHet.al (2) investigated into the development of self-compacting concrete with reduced segregation potential. The fine particle content is increased by replacing partially the fine and coarse aggregates by low-calcium fly ash. S. VENKATESWARA RAO et.al (3)aims at developing standard and high strength Self Compacting Concrete (SCC) with different sizes of aggregate based on Nansu's mix design procedure. Also, fly ash optimization is done in study with the graded coarse aggregate. OKAMURA (4) proposed a mix design method for SCC based on paste and mortar studies for super plasticizer compatibility followed by trail mixes. However, it is emphasized that the need to test the final product for passing ability, filling ability, and flow and segregation resistance is more relevant. DR.SRINIVASA RAO. P(5) had proposed the relationship between Splitting Tensile Strength and Compressive Strength by the test results and found that Split Tensile Strength is proportional to 0.78 power of Compressive Strength for normal concrete. DR.SESHADRI SEKHAR .T. P6) had proposed the mix design for high strength self compacting concrete of M100 mix using fly ash and Micro silica as Mineral admixtures . DR SESHADRI SEKHAR .T (7) had proposed the relationship between Compressive Strength , Flexural strength and Splitting Tensile Strength for self compacting concrete mix of different grades ranging from M30 to M65.NIHAL ARIOGLU ET.AL (8)had studied ratio of split tensile strength to cylinder compressive strength as a function compression strength of concrete.

Research Significance

In fact, concrete researchers have shown that the true tensile strength, as determined from the split cylinder test, is between 65 and 75 per cent of the modulus of rupture for normal concrete. It has been well established that the splitting tensile test of the cylindrical specimen gives more reasonable tensile strength estimation than the direct tensile test or the modules of rupture test. The acceptance of the split cylinder test is based on the fact that the stress distribution is reasonably uniform along the vertical diameter of the cylinder, which has been shown to be the plane of principle tensile stress for about 80 per cent of its length.

In a number of recent investigations of the behaviour of actual concrete dams during earthquakes, it has become apparent that a limiting factor has been that the tensile strength of any concrete is only a fraction of its compressive strength. However, ACI building code provisions are primarily based on tests of relatively mature concrete elements, and provisions may not provide consistent safety margins when applied to young concrete. In ACI, such strengths as modulus of rupture, shear, and splitting tensile strength of concrete are expressed in terms of the square root of the compressive strength. These empirical relationships were derived from tests on relatively mature concrete specimens, and the square root function was probably chosen as a matter of convenience so that calculations could be readily performed with a slide rule. However, recent research has shown that a square root relationship between splitting tensile strength and compressive strength is not the most appropriate relationship for maturing concrete. It is evident that most concrete researchers believe, from analyses of test data that the true test data is representative of power relation, which lies between 0.6 and 0.8.

For a newly development material like Self Compacting Concrete studies on Compressive, Split Tensile and Flexural strength are of paramount important for instilling confidence amongst the engineers and builders. The literature indicates that while some studies are available on the Compressive Strength, Split Tensile Strength and Flexural Strength of Self Compacting Concrete. Comprehension studies which involve relationship between the parameters Compressive Strength, Split Tensile Strength, Flexural Strength are not available High Strength Self Compacting Concrete Mixes. Hence, considering the gap in the existing literature, an attempt also has been made to obtain a relationship between the splitting tensile strength, Flexural Strength and Compressive strength.

Experimental Programme

The objectives of the experimental study that was conducted are given below.

(i) To develop Mathematical Relationship between Compressive Strength, Split Tensile Strength and Flexural Strength.

II. MATERIALS

Cement

Ordinary Portland cement of 53 grade having specific gravity was 3.02 and fineness was 3200cm^2/gm was used in the investigation. The Cement used has been tested for various proportions as per IS 4031-1988 and found to be confirming to various specifications of are 12269-1987.

Coarse Aggregate

Crushed angular granite metal of 10 mm size having the specific gravity of 2.65 and fineness modulus 6.05 was used in the investigation.

Fine Aggregate

River sand having the specific gravity of 2.55 and fineness modulus 2.77 was used in the investigation.

Viscosity Modifying Agent

A Viscosity modified admixture for Rheodynamic Concrete which is colourless free flowing liquid and having Specific of gravity 1.01$\pm$0.01 @ 25^{0}C and pH value as 8$\pm$1 and Chloride Content nil was used as Viscosity Modifying Agent

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Admixture

The Modified Polycarboxylated Ether (BASF Glenium™ B276 SURETEC) based super plasticizer which is pale yellow colour and free flowing liquid and having Relative density 1.10$\pm$0.01 at 25^{o}C, pH >6 and Chloride Ion content <0.2% was used as super plasticizer.

Fly Ash Type-II fly ash confirming to I.S. 3812 – 1981of Indian Standard Specification was used as Pozzolana Admixture.

Micro Silica

The Micro silica having the specific gravity 2.2 obtained from Oriental Trexim, Private Limited was used in the present investigation

Test Specimens:

Test specimens consist of 150X150X150 mm cubes, 150 X 300 mm cylinders and 100X100X 500 mm beams were casted for Mix 100 and tested as per IS 516 and 1199.

III. DISCUSSION OF RESULTS

Quantities of materials required per 1 cum of High Strength Self Compacting Concrete mixes

Table 1.0 gives the quantities of material required for High Strength Self Compacting mix of grade M 100. The Trail Mixes were carried by verifying the fresh state properties with EFNARC guidelines.

Fresh State properties of High Strength Self Compacting Concrete mixes

Table 2.0 provides a summary of the fresh state properties of High Strength Self Compacting Concrete of Mix 100. As it is evident, the basic requirements of high flow ability and segregation resistance as specified by guidelines on High Strength Self Compacting Concrete mixes by EFNARC are satisfied. The Rheological properties are maintained by adding suitable quantities of super plasticizers which satisfies the EFNARC (8) guidelines.

Mathematical Relationship Betweeen Mechanical Properties of High Strength Self Compacting Concrete Mix M 100

Table 3.0 gives the Compressive Strength , Flexural strength and Split Tensile Strength of M 100 grade of High Strength Self Compacting Concrete for 7, 28, 56 , 90 , 180 and 270 days . Based on the results of the specimens the mathematical equations were obtained expressing Compressive Strength, Split Tensile Strength and Flexural Strength for High Strength Self Compacting Concrete of Mix M 100. Fig 1.0 shows the graphical behaviour of Compressive Strength and Split Tensile Strength, fig 2.0 shows the graphical behaviour of Compressive Strength and Flexural strength. The mathematical relationship between both between Compressive Strength – Split Tensile Strength and Compressive Strength – Flexural Strength of Self Compacted Concrete depicts that they are obeying Power Law. Plate no 1, 2 and 3 gives the test setup for measuring Compressive Strength, Split tensile Strength and Flexural Strength.

The Relationship between Compressive Strength – Split Tensile Strength is given by

$ft = 0.043fck^{1.064}$ with coefficient of variation $R^2 = 0.990$

The Relationship between Compressive Strength –Flexural Strength is given by

$fcr=0.031fck^{1.125}$ with coefficient of variation $R^2 = 0.989$

IV. CONCLUSIONS

- The Relationship between Compressive Strength – Split Tensile Strength is given by $ft = 0.043fck^{1.064}$ with coefficient of variation $R^2 = 0.990$
- The Relationship between Compressive Strength –Flexural Strength is given by $fcr=0.031fck^{1.125}$ with coefficient of variation $R^2 = 0.989$
- The Relationship between Compressive, Split Tensile and Flexural Strength of High Strength Self Compacting Concrete are in accordance with power's law.
- The Water –Powder Ratio of .022 is used for getting High Strength Self Compacting Concrete of Mix M 100.

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Table 1.0 Quantities of Materials for 1m^3 of High Strength Self Compacting Concrete mix of M 100

Mix	Cement (Kg/m^3)	Fly ash (Kg/m^3)	Micro Silica (Kg/m^3)	Water (Kg/m^3)	Coarse Aggregate (kg/m^3)	Fine Aggregate (Kg/m^3)	SP (kg/m^3)	V.M.A (Kg/m^3)	Water /Powder Ratio
Mix 100	500	125	75	154	774.985	766.195	11.2	0.35	0.22

Table 2.0 Fresh Concrete properties of High Strength Self Compacting Concrete Mix M 100

		Mix 10	Permissible limits as per Efnarc Guidelines	
			Min	Max
V-Funnel		12 sec	6 sec	12 sec
Abrams slump flow		665 mm	650mm	800mm
T_{50cm} slump flow		4.5 sec	2 sec	5 sec
L-Box	H_2/H_1	0.90	0 .82	1.0
	T_{20}	1sec	1sec	2 sec
	T_{40}	2 sec	2sec	3sec
V-Funnel at $T_{5\,min}$		14 sec	11 sec	15 sec

Table 3.0 Compressive Strength, Flexural Strength and Split Tensile Strength of High Strength Self Compacting Concrete Mix M100

Sample ↓	Compressive Strength (Mpa)						Split Tensile Strength(Mpa)						Flexural Strength(Mpa)					
Days ⇒	7	28	56	90	180	270	7	28	56	90	180	270	7	28	56	90	180	270
1	93.38	117.18	122.38	133.18	14322	144.12	5.43	7.21	7.32	8.02	8.42	8.72	4.98	7.02	7.27	7.75	8.28	8.46
2	92.64	116.92	122.74	132.48	141.38	145.29	5.49	7.13	7.42	7.83	8.51	8.48	5.66	7.11	7.12	7.85	8.61	8.58
3	95.49	118.21	123.12	133.16	138.75	147.26	5.47	7.12	7.46	7.84	8.46	8.46	4.68	7.24	7.28	7.58	8.28	8.42
4	93.35	117.12	121.18	133.12	143.17	144.37	5.26	6.98	7.41	7.86	8.32	8.38	5.44	6.28	7.42	7.79	8.22	8.68
5	92.46	116.92	122.95	132.42	140.12	148.25	5.24	6.92	7.48	7.78	8.43	8.92	5.12	7.12	7.32	7.85	8.32	8.42
6	93.39	115.83	123.47	133.28	141.60	148.81	5.29	7.12	7.31	7.95	8.38	8.94	5.15	6.87	7.29	7.52	8.45	8.80
Average value	93.62	117.03	122.64	132.94	141.38	146.35	5.36	7.08	7.40	7.88	8.42	8.65	5.18	6.94	7.25	7.72	8.36	8.56

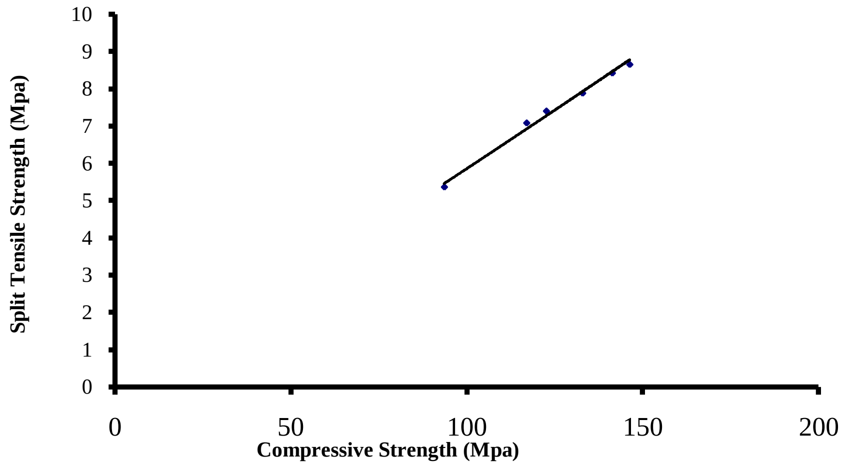

Fig 1.0 Relationship between Compressive Strength and Split Tensile Strength

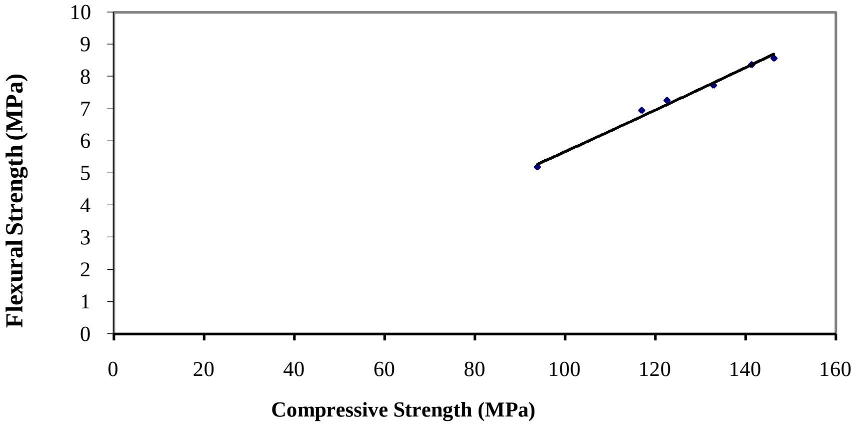

Fig 2.0 Relationship between Compressive Strength and Flexural Strength

Plate No1 Test Set up for measuring Compressive Strength

Plate No2 Test Set up for measuring Flexural Strength

Plate No3 Test Set up for measuring Split Tensile Strength