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AN EXPERIMENTAL INVESTIGATION FOR DEVELOPMENT OF STRENGTHS OF HIGH STRENGTH CONCRETE USING SILICA FUME AND STEEL FIBERS IN COMPOSITE

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ABSTRACT

The present work deals with the results of experimental investigations on silica fume concrete, steel fiber reinforced concrete. Effect of these fibres on various strengths of concrete are studied. Fiber content varied from say (0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%, 3.5%, 4.0%, 4.5%, and 5%) by weight of cement.

The silica fume is used at constant percentage of 7.5% by weight of cement. Various strengths considered for investigation are compressive strength, flexural strength, split tensile strength for silica fume and steel fibre reinforced concrete.

Bond strength is also studied. Cube of size 150 mm for compressive strength, Prisms from flexure tests were used for split tensile strength, beams of size 700 mm x 150 mm x 150 mm for flexural strength were cast. All the specimens were water cured up to 28 days and tested subsequently.

The workability is measured with the slump cone test. he density at 28 days is calculated. Ductility of concrete is found to increase in the fibre reinforced concretes as observed from the load deflection study. The Poisson’s ratio is found to vary within the specified limits.

The Static and Dynamic Modulus of concrete are studied. Relation between compressive strength and flexural strength are developed. A comparison of results of silica fume concrete fiber reinforced concrete with that of normal concrete showed the significant improvements in the results of various strengths.

Keywords: Steel fiber, Silica Fume, Volume fraction, Workability, Strengths, Elastic constants, NDT.

INTRODUCTION

In recent decades, the use of discrete short fibers was introduced as a solution to enhance concrete tensile strength. Several metallic and synthetic types of fibers can be used for this purpose. However, the most focus was on the use of steel fibers, which have high tensile strength and proven crack bridging potential. Such characteristics of the steel fiber can be used to alter the brittle behavior of concrete under tensile stresses to a more ductile behavior. Steel fiberreinforced concrete was also proven to be much more ductile than normal concrete under seismic and impact loads.

Addition of fibre can improve ductility of concrete without decreasing compressive strength. Concrete ductility will affect the process of initial cracking until the concrete collapses due to impact. Certain types of fibres enhance the performance of the concrete.

This research evaluates the compressive strength, flexural strength of the concrete which is essential in rigid pavement. It has been broadly used for overlay roads, airfield pavements and bridge decks. Recently the use of Steel fibre and Silica fume in concrete in construction has been increased. The determination of properties of steel fibre and silica fume (or micro silica is very significant to enhance the properties of concrete.

The quality of good and durable concrete depends on the properties of raw material in concrete also proper mix design, use of admixtures, proper mixing, placement, efficient curing. Steel fibre and Silica Fume is one of the good additional materials in concrete. Silica fume reduces bleeding on concrete by absorbing water in concrete.

SPECIMEN DETAILS

Table 3.10: Schedule of Specimen Preparation

Sr. No.	Mix designation	Silica Fume content (%)	Steel Fibre content (%)	W/C ratio	Compression Test		Flexure test		Pull out test		Split tensile test	
					7 days	28 days	7 days	28 days	7 days	28 days	7 days	28 days
1	M0	0.0	0.0	0.36	3	3	3	3	3	3	3	3
2	M1	7.5	0.5	0.36	3	3	3	3	3	3	3	3
3	M2	7.5	1.0	0.36	3	3	3	3	3	3	3	3
4	M3	7.5	1.5	0.36	3	3	3	3	3	3	3	3
5	M4	7.5	2.0	0.36	3	3	3	3	3	3	3	3
6	M5	7.5	2.5	0.36	3	3	3	3	3	3	3	3
7	M6	7.5	3.0	0.36	3	3	3	3	3	3	3	3
8	M7	7.5	3.5	0.36	3	3	3	3	3	3	3	3
9	M8	7.5	4.0	0.36	3	3	3	3	3	3	3	3
10	M9	7.5	4.5	0.36	3	3	3	3	3	3	3	3
11	M10	7.5	5.0	0.36	3	3	3	3	3	3	3	3

Total Number of Specimens = 264

DETAILS OF TEST SPECIMENS FOR TESTS ON HARDENED CONCRETE

The specimen used was cubes, beams specimens and cube specimens specially prepared to measure bond strength. Dimensions of each test specimen are as under:
Cube: 150mmx150mmx150mm
Beam: 150mmx150mmx700mm

- Beam specimens were used to determine flexural strength, equivalent split tensile and equivalent compressive strength.
- Cubes of 150mm size were used to find the compressive strength.
- Especially cubes of 150mm size and 16mm rod were used to find the bond strength.

TESTING OF SPECIMENS

Workability of wet concrete is determined by slump cone test and bulk density is calculated by taking weight of concrete cylinder in wet state.

Compressive strength of cubes are determined at 7 days and 28 days using compression testing machine (CTM) of capacity 2000 KN. Universal testing machine (UTM) of capacity 100 tones was used to determine the equivalent cube strength on beam prisms. Split tensile test, flexure test and bond strength is carried out on universal testing machine of 40 tones capacity.

OPTIMUM FIBRE CONTENT

It is the fibre content in SFRC at which concrete gains the maximum strength. Optimum fibre content for various strengths of SFRC is presented in Table given below.

Table - Optimum Fibre Content maximum strength:

Strength MPa	SFRC	
	Fibre Content (%)	**Max. Value of Strength, MPa**
Compressive strength	4.5	45.32
Flexural strength	4.5	11.18
Split tensile strength	4.5	7.59
Bond strength	4.5	19.18

CONCLUSIONS

This chapter presents a summary of present study, the major conclusions and future scope of the investigation are as follows -

1. The maximum compressive strength, flexural strength, split tensile and bond strengths achieved are 45.86, 11.46, 8.22 and 20.63 at 5% of steel fibre volume fractions respectively.
2. Empirical expressions have been established to predict the values of flexural strength, split tensile strength, and bond strength for SFRC in terms of cube compressive strength. Results predicted from these expressions are in excellent agreement with the theoretical and experimental results in this investigation.
3. In general, the significant improvement in various strengths is observed with the inclusion of steel fibres in the plain concrete. However, maximum gain in strength of concrete is found to depend upon the amount of fibre content. The optimum fibre content to impart maximum gain in strength varies with type of the strength.
4. Satisfactory workability was maintained with addition of fibre of given dosage.
5. The equivalent compressive strength of SFRC also increases as % of fibre increases.
6. While testing plain cement concrete cube spalling of concrete is observed. However, it is not observed in SFRC cubes due to randomly distributed fibres.
7. Flexural strength of SFRC is increase with increasing percentage of fibre.
8. The width of cracks is found to be less in SFRC than that in plain cement concrete beam.
9. The split tensile strength at 7 days and 28 days of curing observed to be increasing marginally.
10. The pullout force is increased with increase in fibre content.
11. In all fibre content mode of failure was changed from brittle to ductile failure when subjected to compression and bending.
12. Optimum fibre content for all strength observed between 3.0 to 5.0 %.
13. Poisson’s ratio varies between 0 .11 to 0.26 at 28 days.
14. In rebound hammer testing the mean strength is lesser than the calculating strength.
15. Velocity criteria for concrete quality grading is given by IS 13311 (Part I) 1992 from this criteria the grading of concrete quality is good.

SCOPE FOR FUTURE WORK

The present work has good scope for future research. Some of the research areas are as follows:

1. Behaviour under temperature effect for same fibre content.
2. Behaviour under freeze and thaw effect.
3. Same parameters with recycled aggregates.
4. Behaviour under creep and shrinkage.
5. Fracture analysis.
6. Stress transfer mechanism.
7. Study of impact resistant, abrasion resistant and permeability of SFRC and resistant to chemical attach.

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APPENDIX

Regression Analysis

Strength	**Days**	**SFRC**	**R^2**
Compressive strength	7 days	F_{ck} =0.0156 V_f^3-0.2975 V_f^2+2.1572 V_f + 29.122	0.9812
	28 days	F_{ck} =-0.016 V_f^3+ 0.3072 V_f^2 -1.212 V_f + 42.973	0.9586
Flexure strength	7 days	F_f = -0.0113 V_f^3 + 0.2452 V_f^2-1.0821 V_f + 8.137	0.9860
	28 days	F_f = -0.0153 V_f^3 + 0.2913 V_f^2-1.2018 V_f + 9.6121	0.9614
Split tensile strength	7 days	F_t = -0.0061 V_f^3 + 0.1278 V_f^2- 0.4537 V_f + 3.9088	0.9803
	28 days	F_t = -0.0089 V_f^3 + 0.1814 V_f^2 - 0.6501 V_f + 5.0533	0.9710
Bond strength	7 days	τ_{bd} = 0.0161 V_f^3- 0.2955 V_f^2+1.6359 V_f + 8.9835	0.9436
	28 days	τ_{bd} = -0.0104 V_f^3+ 0.1201 V_f^2 + 0.8119 V_f +10.24	0.9391
Equivalent compressive strength	7 days	F_{ck} = - 0.0019 V_f^4+ 0.0641 V_f^3- 0.766 V_f^2+ 4.2935 V_f + 31.70	0.9910
	28 days	F_{ck} = 0.0035 V_f^4-0.0933 V_f^3+ 0.861 V_f^2-2.635 V_f + 45.177	0.9893

Comparison of UPV and compressive strength	28 days	f_{cu} = -0.016 v^3 + 0.3072 v^2-1.212v +42.973	0.9586
Comparison of UPV and flexure strength	28 days	F_f= -0.015 v^3 + 0.2913 v^2-1.2018 v + 9.6121	0.9619
Comparison of Dynamic Modulus and Compressive Strength	28 days	E_d = 0.575 f_{cu} + 28.319	0.9452
Comparison of Modulus of Rigidity and Compressive Strength [35]	28 days	G = -0.014 $f_{cu}^{\ 2}$ + 0.3493 f_{cu} + 11.433	0.9905
Comparison of Modulus of Rigidity and Compressive Strength [41]	28 days	G = - 0.0025 $f_{cu}^{\ 2}$ + 0.2857 f_{cu} + 11.891	0.9977

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