Flyash Based Self Compacting Concrete by Using Rubber Fibers

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Abstract— Throughout the world, the disposal of used tires is a major environmental problem causing environmental hazards such as bleeding ground for mosquitoes, producing uncontrolled fire and they are pollute & contaminating the soil and vegetation. Therefore, there is an urgent need to identify alternative outlets for these tires, with the emphasis on recycling the waste tire. Concrete is an excellent structural material and considered as essential for the modern civilization and human society. Now, the use of waste tires in concrete has become technically feasible and the concrete is being considered as light weight concrete. This study reviews the feasibility of using waste tires in the form of fibers with FR 4.75 in concrete to improve the workability as well as protecting the environment. Also it reviews the potential application in the field by exploiting its unique characteristics and properties. In this study, we outline the use of rubber fibers in SCC in different mix ID's by using M40 grade and show how it is suitable for the concrete, its uses, benefits and way to future study. Rubber fibers are used in this study as partial replacement of coarse aggregate, in this experiment we cast cubes of 150x150x150mm size, cylinders of 150mm dia & 300 mm length and prisms of 100x100x500mm in size for 7days & 28days testing as partial replacement of coarse aggregate and testing under compression, tensile & flexure. This rubber fiber concrete is not a strength based concept, tried to protect our environment on this earth from pollutants. Rubber fiber Concrete has light weight, fire resistance, resistance from water absorption & ductility.

Keywords: Metakaolin, RFSC Concrete, Superplasticiser, Rubber Fibers, Natural Aggregates

I. Self-Compacting Concrete

A. Introduction

Self Compacting Concrete as the name signifies that, it can be able to compact itself without any additional vibration or compaction i.e. without application of any other external energy. It should be able to assume any complicated form work shapes without cavities and entrapped of air. The reinforcement should be effectively covered and the aggregates should be fully soaked with the concrete mix. In addition, the concrete should be self-compacting type and self-deforming without any external mode of compaction.

Terminology

- Scc- Self Compacting Concrete
- Psc- Portland Slag Cement
- Nca- Normal Coarse Aggregate
- Rca- Recycled Coarse Aggregate
- Asr- Alkali-Silica Reactivity
- Tbc- Ternary Blended Concrete
- Ra - Recycled Aggregate

B. Objective of Paper

The main objective of the present work is to study the behavior of Self-Compacting Concrete at Though rubberized concrete has proven its applications in various construction fields, still a lot of research has to be done to measure the elastic constants and mechanical properties of rubberized concretes by adding rubber in different volume proportions, water-cement ratios, aspect ratios and in different forms such as fiber chips, so that the appropriate strength can be explored. A research is underway using the grade of cement 53, to improve the strength, fine sand and coarse aggregate of a combination of 10mm and 20mm. The waste tyre rubber shall be used in the form of fibers by partially replacing the coarse aggregate by 0, 2.5, 5, 7.5, 10, 15, & 20%. The grade of SCC used was M40 & the water-cement ratio in the proposed research is taken as 0.46. It is recommended that to improve the strength characteristics and other mechanical properties of rubberized concrete, some admixtures (Chemical or Mineral) can be added as a partial replacement of cement. To get more workability and strength enhancement of waste tyre modified concrete, a required quantity of super plasticizer shall be added. The above concrete shall be mixed in a Pan mixer for uniform distribution of waste tyre rubbers in the concrete to avoid balling as well as accumulation of waste tyre rubbers in the concrete. The proposed concrete will have high resistant to acid attacks and high resistance against freezing & thawing. This is called as New Generation Concrete (NGC).

II. Ingredients of Materials

Different ingredients used in this work are

1) Portland slag Cement
2) Fine aggregate
3) Coarse aggregate
4) Met kaolin
5) Water
6) Admixtures
    1) Mineral admixtures
    2) Chemical admixtures
7) Flyash
8) Glenium B233

III. Test Data Materials

A. Results of Tests on Cement

Sl.No	Tests conducted	OPC-53
1	Normal consistency (%)	29%
2	Specific gravity	3.15
3	Setting time Initial Final	 103min 215min

B. Physical properties of Fly ash:

S.No	Characteristics	Properties
1	Specific gravity	2.34
2	Specific surface area	$420m^2/kg$

C. Chemical Composition of Fly ash:

S.No	Characteristics	Percentage contents	Percentage (Range)
1	Silica, Sio_2	68	35-67
2	Alumina Al_20_3	23	16-28
3	Iron oxide Fe_20_3	4	4-10
4	Lime CaO	1.1	0.7-3.6
5	Magnesia Mgo	0.5	0.3-2.6
6	Sulphar Trioxide So_3	0.03	0.1-2.1
7	Loss on Ignition	0.3	0.4-1.9

D. est results on Fine aggregates

S.No	Test conducted	Values
1	Specific gravity	2.66
2	Field moisture content	4-6%
3	Water absorption	1.10%
4	Bulk density	$16.89KN/m^3$
5	Fineness modulus	2.72

E. Test results on coarse aggregates

S.No	Test conducted	Values
1	Specific gravity	2.68
2	Field moisture content	4-6%
3	Water absorption	1.0%
4	Bulk density	$16.95KN/m^3$
5	Fineness modulus	7.01

IV. MIX PROPORTIONING

A. General

To produce SCC the major work involves designing an appropriate mix proportion and evaluating the properties of the concrete thus obtained. In practice, SCC in its fresh state shows high fluidity, Self-Compacting ability and segregation resistance, all of which contribute to reducing the risk of honey combing of concrete. With these good properties, the SCC produced can greatly improve the reliability and durability of the reinforced concrete structures. In addition SCC shows good performance in compressive strength test and can fulfill n other considerations that requirements in the structural design.

B. Guide lines for SCC

The ingredients for SCC are similar to other plasticized concrete cement, coarse aggregate, fine aggregate, and water, mineral and chemical admixtures. No standard or all -encapsulating method for determining mixture proportions currently exist for SCC. However, many different proportion limits have been listed in various publications. Multiple guidelines and "rules of thumb" about mixture proportions for SCC were found. The table summarizes this information

Description	High fines	VMA	Combination
Cementitious, (kg/m3)	750-1000 (450-600)	650-750 (385-4500)	650-750 (385-450)
Water/cementation ns material	0.28-0.45	0.28-0.45	0.28-045
Fine aggregate mortar %	35-40	40	40
Fine aggregate/total aggregate %	50-58	-	-
Coarse aggregate/total mix %	28-48	45-48	28-48

Table 4.1: Limits on SCC Material Proportions

V. EXPERIMENTAL INVESTIGATIONS:

One SCC Mix of M40 grade with W/C 0.46 with different types of admixtures were developed in the laboratory and FR 4.75 type rubber fibers were added to these SCC mixes and Rubberized SCC was developed. The experimental program me consisted of casting and testing of SCC and RFSCC elements in compression, tension and in flexure. Cubes of 150x150x150mm Size were cast for testing in compression. Also prisms of size 100 X 100 X 500 mm were cast for testing in flexure under two point loading and also cylinders (150mm diameterx300mm height) testing for splitting tensile test.

A. Brief description of the project work:

The present investigation was aimed to study the mechanical property and flexural behavior of SCC and RFSCC.

For these SCC mixes were developed in the laboratory with help of Nan Su Method of mix design & different guidelines using different mineral and chemical add mixtures.

Rubber Fiber for SCC was added to these mixes and RFSCC was developed.

SCC & RFSCC were tested in fresh state to find filling ability, passing ability and segregation resistance of mixes.

After testing in fresh state SCC and RFSCC were poured in moulds of cubes, cylinders, prisms and demoulded after 24 hours & cured for 7, 28 & 56days.

These specimens were tested in compression, tension and in flexure and results in hardened state were observed and studied.

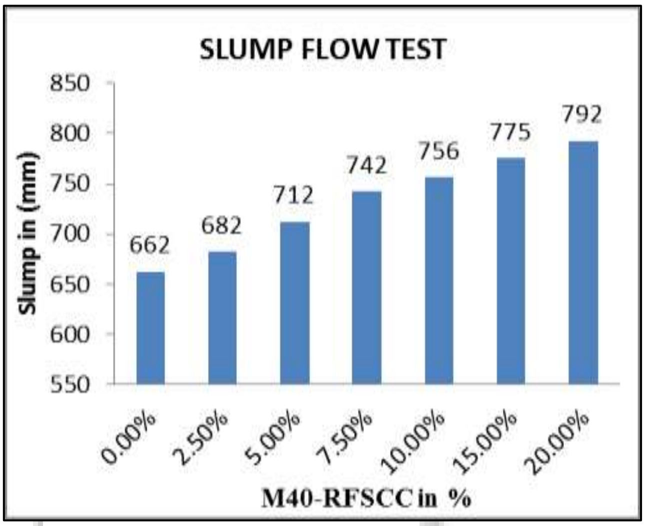
B. Testing of SCC in fresh state

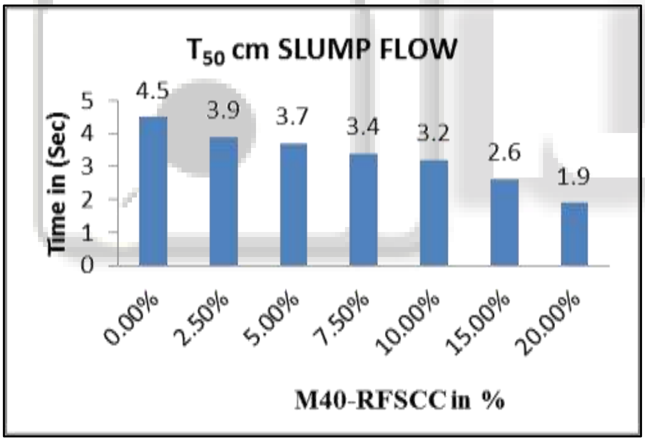
Since SCC will not use external consolidation (by definition), the behavior of concrete while in the fresh state will determine the quality of placement. Thus, if a concrete displays signs of segregation to is insufficient in its flow ability or deformability while fresh, the concrete will not perform in the manner it should and will most likely result in a poor quality hardened concrete. The tests that have been developed by others that allow a user to define a concrete as SCC or not are, at this time not yet incorporated (deformability, flow ability and segregation resistance) of

SCC have been under development since the introduction of SCC. The quantities differ according to the type of construction and any specific requirements that must be net. Examples of these tests include the Slump flow, L-Box, V-Funnel, Orimet and J-Ring. Following figures shows examples of some of these tests.

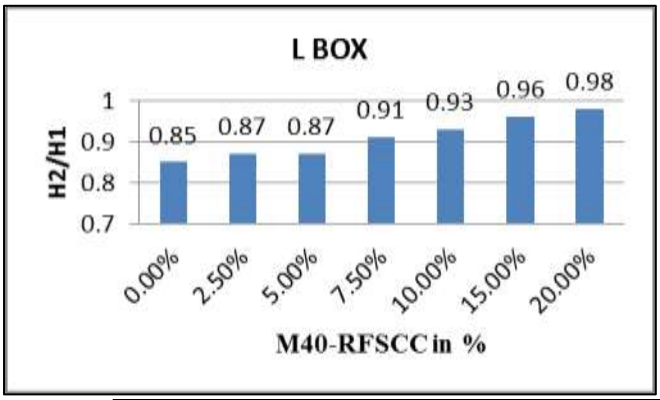
Fresh concrete properties of SCC and RFSCC in different mix proportions

C. Slump Flow Test

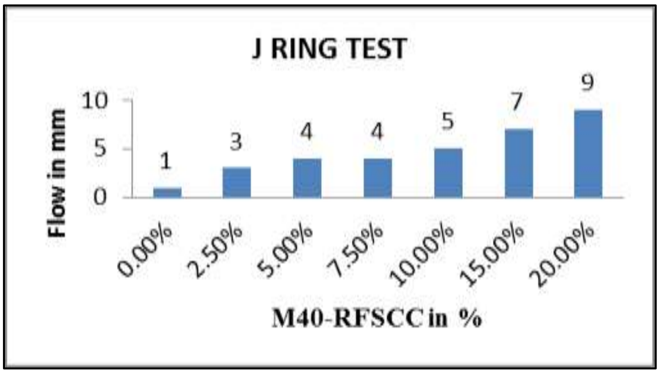




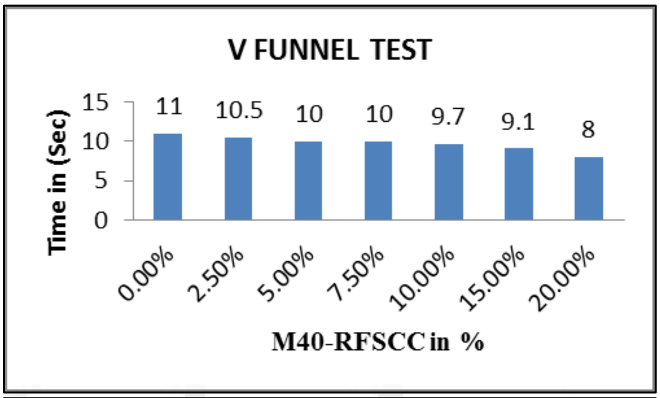
D. L-Box Test

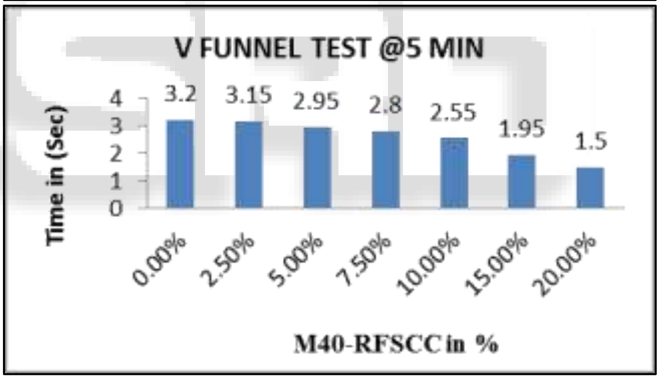


E. J-Ring Test



F. V-Funnel Test





mix id	Rubber fiber in %	Compressive strength in (Mpa)			Comparison RFSCC with SCC (%)		
		7 Days	28 Days	56 days	7 Days	28 Days	56 days
SCC	0	40.9	51.38	54.07	-	-	-
RFSCC-1	2.5	29.79	37.63	39.57	-27.16	-26.76	-26.81

RFSCC-2	5	27.61	35.54	37.45	-32.49	-30.82	-30.73
RFSCC-3	7.5	24.69	33.98	36.12	-39.63	-33.86	-33.19
RFSCC-4	10	23.09	32.86	33.98	-43.54	-36.04	-37.15
RFSCC-5	15	18.85	28.23	29.95	-53.91	-45.05	-44.6
RFSCC-6	20	14.98	23.21	24.68	-63.37	-54.82	-54.35

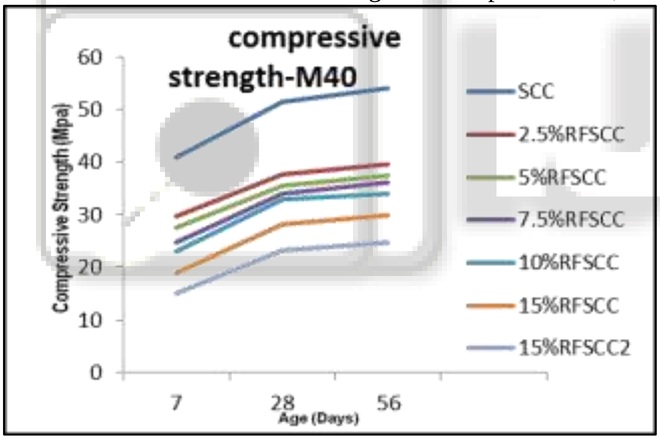
Table 5.2: Compressive Strength & Comparison at 7, 28 and 56 days for SCC and RFSCC Elements-M40 grade.

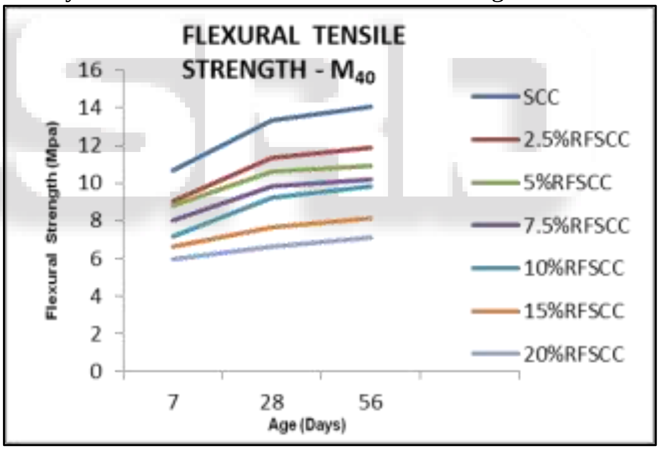
Mix Id	Rubber fiber in %	Compressive strength in (Mpa)			Comparison RFSCC with SCC (%)		
		7 Days	28 Days	56 days	7 Days	28 Days	56 days
SCC	0	2.48	3.46	3.66	-	-	-
RFSCC-1	2.5	2.13	2.46	2.58	-14.11	-28.9	-37.7
RFSCC-2	5	2.02	2.28	2.38	-18.54	-34.1	-42.07
RFSCC-3	7.5	1.96	2.12	2.21	-20.96	-38.72	-39.61
RFSCC-4	10	1.78	1.98	2.08	-28.22	-42.77	-43.16
RFSCC-5	15	1.45	1.75	1.83	-41.53	-49.42	-50
RFSCC-6	20	1.12	1.52	1.59	-54.83	-56.06	-56.55

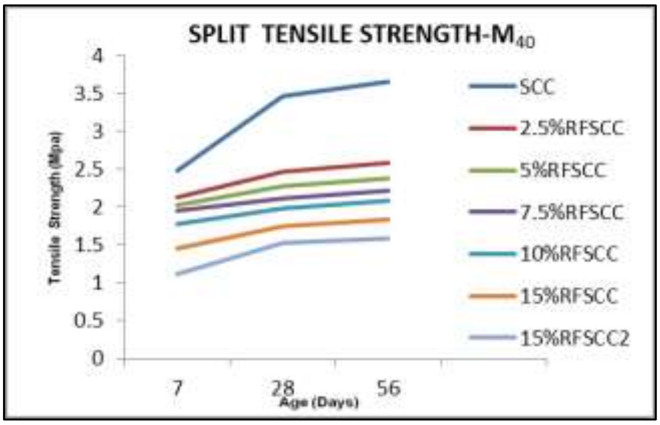
Table 5.2: split tensile Strength & Comparison at 7, 28 and 56 days for SCC and RFSCC Elements-M40 grade

Mix Id	Rubber fiber in %	Flexural strength in Mpa			Comparison RFSCC with SCC (%)		
		7 Days	28 Days	56 days	7 Days	28 Days	56 days
SCC	0	10.66	13.32	14.06	-	-	-
RFSCC-1	2.5	9.07	11.36	11.89	-14.91	-14.71	-15.43
RFSCC-2	5	8.82	10.64	10.9	-17.26	-19.96	-22.47
RFSCC-3	7.5	7.99	9.81	9.97	-25.04	-26.35	-29.08
RFSCC-4	10	7.19	9.21	9.85	-32.55	-30.85	-29.94
RFSCC-5	15	6.65	7.65	8.12	-37.61	-42.56	-42.24
RFSCC-6	20	5.96	6.65	7.12	-44.09	-50.07	-49.35

Table 7.3: Flexural Strength & Comparison at 7, 28 and 56 days for SCC and RFSCC Elements-M40 grade







VI. Discussion of Test Results

A. *Strength Characteristics*

The compressive strength values obtained by testing standard cubes made with different SCC and RFSCC mixes with different proportions of rubber fiber of 0-20%. The SCC mix has strength above 40 MPa in compression & good strength parameters in tension as well as in flexure which is required strength. But in RFSCC compressive, split tensile and flexural strength was decreased up to 54% in compression, 60 in split tensile and 51% in flexure, when the fibrous rubber content was increased up to 20% C.A replacement.

B. *Workability*

The results indicated that there was an increasing in slump value when crumb rubber content increased from 0% to 20%. It is observed that flowing ability was increases when the rubber content increased from 0-20%. In L-Box test the ratio of H_2/H_1 for RFSCC was increases with compare to SCC.

Although the strength data developed in this study (compressive strength and flexural) and others (split tensile test) indicated a systematic reduction in strength with the increased of crumb rubber content but the crumb rubber concrete mixes remained an acceptable workability.

By using rubber fiber the strength variations are about 25-50% decreases and in this experiment, the strength parameters was decreased with compare to SCC but it was fire resistance, economical, ductility, light weight, acid resistance, & more workability.

In this experiment the partial replacement of coarse aggregate by rubber fiber (0, 2.5, 5, 7.5, 10, 15, and 20 %) by volume, therefore the weight of RFSCC samples was less than SCC samples.

Photos:

SCC FRESH CONCRETE

RFSCC CONCRETE

RUBBER FIBRES (2.5,5,7.5,10% , 15% ,20%)

FAILURE IN SPILT TENSILE STRENGTH

VII. NAN SU ET- AL METHOD MIX DESIGN FOR M40 GRADE

This method has been proposed by Nan-Su et al. The steps involved in the mixture proportioning of SCC are

1) Calculation of fine and coarse aggregate contents Fine and coarse aggregate contents are calculated considering unit volumes of loosely piled saturated surface dry fine and coarse aggregate, packing factor and volume ratio of fine and total aggregate.
   W_{CA} = PF X Wcal (1-S/a)
   W_{FA} = PF X Wfal S/a
   S/a = Volume ratio of fine aggregate to total aggregate.
   It is generally taken between 50% to 57%
   Assuming an average value of 54% = 0.54
   Loose density of Coarse Aggregate : 1465 Kg/m^3
   Loose density of Fine Aggregate : 1635 Kg/m^3
   Rodded density of Coarse Aggregate : 1680 Kg/m^3
   Rodded density of Fine Aggregate : 1710 Kg/m3
   The term Packing factor (PF) of Aggregate is defined as ratio of mass aggregate of tightly packed state to that of loosely packed state (lower PF value is preferred)
   PF (for Coarse Aggregate) : 1680/1465 = 1.1467
   PF (for Fine Aggregate) : 1710/1635 = 1.0458
   W_{cal} - Unit volume mass of loosely piled saturated surface dry coarse aggregate in air, Kg/m3 = 1465 Kg/m^3
   W_{fal} - Unit volume mass of loosely piled saturated surface dry fine aggregate in air, Kg/m3 = 1635 Kg/m^3
   W_{CA} = Content of coarse aggregate in SCC, Kg/m^3
   W_{CA} = PF X Wcal (1-S/a)
   = 1.0458 X 1465 (1- 0.54)
   = 704.76 Kg/m^3
   W_{FA}= Content of fine aggregate in SCC, Kg/m^3
   W_{FA} = PF X W_{fal} X S/a
   = 1.0458 X 1635 x 0.54
   = 923.33 Kg/m^3
2) Calculation of cement content
   Cement content is calculated using the practical experience in Taiwan i.e generally SCC requires 1 Kg of cement to produce a cylinder compressive strength of 0.14MPa. Using this a relationship is established between the cement content (C) and designed cylinder compressive strength (f_c) expressed in MPa. i.e
   C = 7 f_c
   C = 7 X 40 = 280 Kg where C is Cement content
3) Calculation of mixing water content required by cement
   Mixing water content required by cement in Kg/m^3 can be obtained by multiplying the cement content with the water-cement ratio by weight which can be determined by compressive strength.
   W_{wc} = (w/c) C
   W_{wc} - Mixing water content required by cement, Kg/m^3
   w/c - The water-cement ratio = 0.46
   W_{wc} = (w/c) C = 0.46 X 280
   = 128.8 Kg
4) Calculation of filler
   Mass of filler is calculated considering specific gravities of cement, coarse aggregate, fine aggregate, water and filler material along with air content.
   V_{pf} = 1- W_{CA}/1000 x G_{ca} - W_{FA}/1000 x G_{fa} - C/1000 x G_c - W_{wc} /1000 x G_w - V_a
   G_{ca} - Specific gravity of Coarse aggregate
   G_{fa} - Specific gravity of fine aggregate
   G_c - Specific gravity of Cement
   G_w - Specific gravity of water
   V_a - Air content in SCC about 1% to 1.5%
   From the specific gravity of filler, the mass of filler in one m^3 of concrete be calculated as
   W_f = (V_{pf} x 1000 x G_f) / (1 + W/F)
   W_f = Mass of Filler
   G_f = Specific gravity of Filler Mixing water content required by filler paste is
   W_{wf} = (W/F) x W_f
   G_{ca} - Specific gravity of Coarse aggregate= 2.67
   G_{fa} - Specific gravity of fine aggregate = 2.63
   G_c - Specific gravity of Cement= 3.15
   G_w - Specific gravity of water = 1.0
   V_a - Air content in SCC is 1.5% = 0.015
   V_{pf} = 1 - [704.7 / (1000 x 2.67)] - [923.3 / (1000 x 2.63)] -[280 / (1000x3.15)] - [128.8 / 1000 x 1] – 0.015
   = 1 - 0.2639 – 0.351 - 0.088 - .1288 - 0.015
   = .1533
   From the specific gravity of filler, the mass of filler in one m^3 of concrete be calculated.
   G_f= Specific gravity of Filler (taking fly ash as filler) = 2.3
   W/F= Ratio of water filler by weight
   = 0.34
   The mass of filler in one m^3 of concrete is given by
   W_f = (V_{pf} x 1000 x G_f) / (1 + W/F x G_f)
   = (0.1533 x 1000 x 2.3) / [1 + (0.34) x 2.3] = 197.86 Kg
5) Calculation of mixing water content required for filler
   Mixing water content required by filler paste is
   W_{wf} = (W/F) x W_f
   = 0.34 x 197.86 = 67.28 Kg
6) Calculation of mixing water content needed in SCC
   The total water content needed in SCC is obtained by adding amount of water needed for cement and filler
   W_w = W_{wc} + W_{wf}
   W_w = 128.8 + 67.28 = 196.08 Kg
7) Calculation of total mass of concrete
   Mass of powder = 280 + 197.86 = 477.86 Kg
   Total mass of concrete = Powder + water + CA + FA
   Total mass of concrete =477.86 + 196.08+ 704.7 + 923.3
   = 2301.96 Kg
8) Calculation of super plasticizer dosage
   Dosage of super plasticizer is taken the range from 500 ml to 1500 ml per 100 kg of cementitious material.
9) Trial mixes and adjustment of mix proportion
   Trial mixes are to be carried out using the contents of materials calculated above. If the results of the quality

control tests fail to meet the performance required of the fresh concrete, adjustment should be made until all properties of SCC satisfy the requirements specified in the design.

Different trial mixes were attempted in the laboratory to get a SCC mix, which gives required fresh and hardened properties.

Finally small changes are made to the proportions of ingredients obtained by Nan Su et al method of mix design and the final proportions of SCC mix are obtained for different filler materials and their combinations.

A. *Final mass of ingredients of SCC are as follows:*

Weight of Cement = 280 Kg
Weight of filler (Fly Ash) = 197.86 Kg
Weight of water = 196.08 Kg
Weight of CA = 704.76 Kg
Weight of FA = 923.33 Kg
Superplastisizer dosage =500 ml to 1500 ml by weight of cementitious material.

Cement+fly ash	F.A	C.A	W/P	Water
477.86	923.33	704.76	0.410	196.08
1 :	1.93 :	1.47 :	0.410 :	0.410

Table 9.1: Final mass of ingredients of SCC ($1m^3$ of concrete)

B. *Development of SCC and RFSCC*

Numbers of attempts were made in the laboratory to get optimum dosages of mineral and chemical admixtures to produce SCC & FRSCC. SCC of 40 Mpa Strength without segregation and bleeding with satisfying the properties both in fresh and hardened states. From these trials SCC Mix with fly ash admixture with different dosages, which had given relatively high compressive strengths were selected for the investigation.

S. No.	Designation	Cement (Kg/m3)	Fly Ash (Kg/m3)	Powder (Kg/m3)	W/P	Rubber Fiber (Kg/m3)	Water (Lts/m3)	F.A (Kg/m3)	C.A (Kg/m3)	S.P (Lts/m3)	VMA (Lts/m3)
1.	SCC	280	197.86	477.86	0.410	0	196.08	923.33	704.76	0.5-1.5	0.035
2.	RFSCC-1	280	197.86	477.86	0.410	4.795	196.08	923.33	687.14	0.5-1.5	0.035
3.	RFSCC-2	280	197.86	477.86	0.410	9.591	196.08	923.33	669.52	0.5-1.5	0.035
4.	RFSCC-3	280	197.86	477.86	0.410	14.386	196.08	923.33	651.90	0.5-1.5	0.035
5.	RFSCC-4	280	197.86	477.86	0.410	19.182	196.08	923.33	634.28	0.5-1.5	0.035
6.	RFSCC-5	280	197.86	477.86	0.410	28.77	196.08	923.33	598.88	0.5-1.5	0.035
7.	RFSCC-6	280	197.86	477.86	0.410	38.364	196.08	923.33	563.80	0.5-1.5	0.035

Table 7.1: Mix proportions of SCC & RFSCC

VIII. CONCLUSIONS

A. *Conclusions*

- Ease of preparation and finishing was also assessed. It was found that rubber fiber concrete mixes did not pose any difficulties in term of finishing, casting, or placement, and that a good quality finish can be achieved although additional effort is required to smooth the finish surface.
- The test results show that the use of rubber aggregate in OPC concrete mixes produces a significant reduction in concrete compressive strength which increases with increasing rubber fiber content.
- The various rubberised concrete mixes were designed in accordance with standard mix design procedures for SCC with a 40 MPa target compressive strength. As expected, the target strengths were not achieved for the mixes incorporating rubber fiber. However, concrete mix design is approximate and any concrete batch must be tested to ensure that the specified properties are achieved.
- FRSCC is light weight, acid resistance, economical, more workability and mainly eco-friendly.
- The rubber fiber is very less cost with compare to aggregate and it will be found at various retreading & tyres manufacturing companies, we use disposed rubber waste for the casting of cubes, cylinders & prisms in the laboratory. Advantage in this project is economical but strength is less than permissible of SCC

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