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An Experimental Study on Self Compacting Concrete with Partial Replacement of Cement by Silica Fume and Crumb Rubber

Chekka Rajendra Prasad[1], Yema Srilatha[2], Burgula sritha[3], Mittapelly Saiteja[4], Devarai Naveen[5]
[1]*Department of Civil Engineering, CMR College of Engineering &Technology (A), Kandlakoya (V),Medchal District,Hyderabad-501401, Telangana State, India*
[2, 3, 4, 5]*UG. Students, Department of Civil Engineering, CMR College of Engineering & Technology (A), Kandlakoya (V), Medchal District, Hyderabad-501401, Telangana State, India*

Abstract: Self-compacting concrete (SCC) is a type of concrete that can flow and consolidate under its own weight without the need for vibration. SCC has many advantages such as improved workability, durability, surface quality, and reduced noise and labour. However, SCC also requires a high amount of cement and fine materials, which increases the cost and environmental impact of concrete production. Therefore, the use of supplementary cementitious materials such as silica fume and crumb rubber is beneficial to reduce the cement content and enhance the properties of SCC. This study aims to explore the effects of mixing silica fume and crumb rubber on the fresh and hardened properties of SCC. This involves the preparation of various concrete mixes with different percentages of cement replaced by silica fume and crumb rubber. Through a series of experiments, we evaluate the fresh and hardened properties of the SCC mixes, fresh properties such as workability, passing ability, and filling ability, while hardened properties including compressive strength, tensile strength, and flexural strength. The result obtained from these tests are compared with conventional concrete of M_{30} grade od concrete specimens. Hence the use of silica fume and crumb rubber leads to reduction in cement quantity for construction purpose and its use should be promoted for better performance as well as environmental sustainability.
Keywords: Self compacting concrete, silica Fume, Crumb Rubber, Workability, Compressive strength, Split tensile strength, Flexural strength.

I. INTRODUCTION

Self- compacting concrete is well known for its compaction without the use of vibrators. As a result, SCC offers several advantages, including improved construction efficiency, reduced labour costs, and a superior surface finish. However, its performance can be further optimized by incorporating supplementary materials and fibres. In the construction sector, crumb rubber is often used as an additive in asphalt pavements and concrete mixtures. The combination of silica fume and crumb rubber within the M30 grade SCC represents a unique opportunity to enhance the material's structural performance, reduce its environmental impact, and open new avenues for innovative construction. The following sections of this study will delve into the detailed methodology, testing procedures, and anticipated outcomes, shedding light on the intricate interplay of these components in the quest for more resilient and sustainable concrete.

A. Objectives

1) To investigate the influence of silica fume and crumb rubber on the properties of self-compacting concrete.
2) Analyse the workability, flow characteristics, and filling ability of the SCC mix when using silica fume and crumb rubber as partial replacements for cement.
3) Evaluate and compare the mechanical properties of the self-compacting concrete (SCC) mix with the standard M30 grade concrete. This includes assessing parameters like compressive strength, tensile strength, flexural strength.

B. Scope

The scope of the project involves a comprehensive investigation into the feasibility and performance of include silica fume and crumb rubber as partial replacements for cement in self-compacting concrete (SCC) mixtures of M30 grade. The project aims to explore the effects of these supplementary materials on both the fresh and hardened properties of SCC.

The experimental program will involve the preparation of various concrete mixes with different percentages of cement replaced by silica fume and crumb rubber, followed by testing and analysis of the results. Comparisons will be made between conventional SCC mixes and those contain silica fume and crumb rubber to determine the influence of these additives on the overall performance of SCC.

C. *Methodology*

1) Problem identification
2) Material selection and collection
3) Literature survey
4) Calculations of quantities
5) Sample preparation
6) Tests on fresh and hardened concrete
7) Analysing results
8) Conclusion.

II. MATERIALS AND ITS PROPERTIES

A. *Materials*

1) Silica fumes
2) Crumb rubber
3) Complast sp430 DIS
4) Cement (opc 53)
5) Fine aggregate
6) Course aggregate
7) Water

B. *Properties*

Properties of supplementary materials

1) *Silica Fume*

Silica fume which is also known as micro silica having particle size of 0.035mm is used to improve the durability, reduces thermal cracking, reduce permeability and improve strength.

2) *Crumb Rubber*

Crumb rubber which is obtained from waste tires crushed into a fine powder having the size of 0.155mm is used to increase tensile strength and workability of the concrete. It can also make concrete cheaper.

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III. MIX DESIGN

According to the code book IS 10262:2019 we calculated mix proportions for M30 grade and the quantities for $1m^3$ of concrete as follows

Grade	cement	F.A	C.A	water
Mix M30	443.34	667.84	963.24	212.8
	1	1.5	2.17	0.48

IV. TESTING OF SPECIMEN

A. Fresh Concrete Tests
1) Slump flow test
2) V-funnel test
3) U-box test
4) L-box test

B. Hardened Concrete Tests
1) Compressive test
2) Split tensile test
3) Flexure test

V. RESULT AND DISCUSSION

A. Fresh Properties
1) Slump Flow Test

Table 2 Slump Flow Test Results

SAMPLE	SLUMP FLOW(MM)
5% replacement of cement with sf and rubber	655
10% replacement of cement with sf and rubber	662
15% replacement of cement with sf and rubber	668

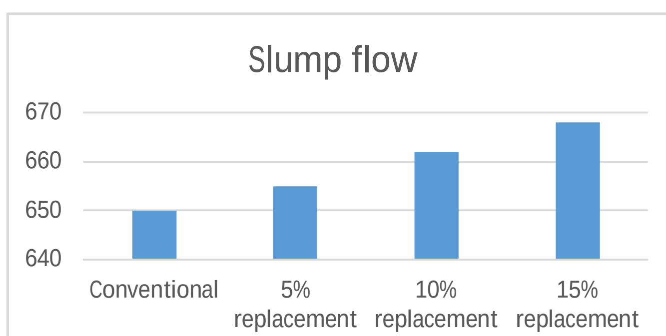

Fig 3,4 Slump Flow Test & Graph of Slump Flow Test(mm)

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2) V-Funnel Test

Table 3 V-Funnel Test Results

SAMPLE	FLOW TIME(SEC)
5% replacement of cement with sf and rubber	7
10% replacement of cement with sf and rubber	7.82
15% replacement of cement with sf and rubber	8.01

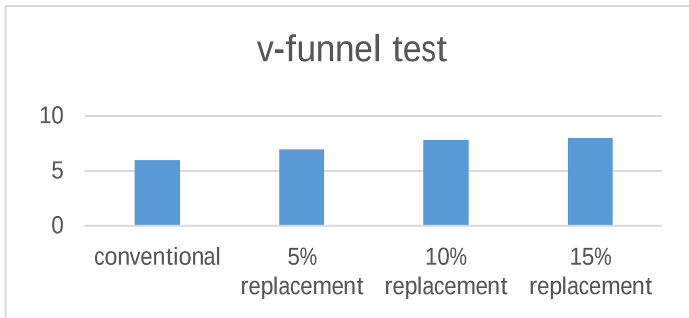

Fig 5,6 V-Funnel Test & Graph of V-Funnel Test

3) L- Box Test

Table 4 Box Test Results

SAMPLE	HEIGHT DIFFERENCE
5% replacement of cement with sf and rubber	0.84
10% replacement of cement with sf and rubber	0.91
15% replacement of cement with sf and rubber	0.95

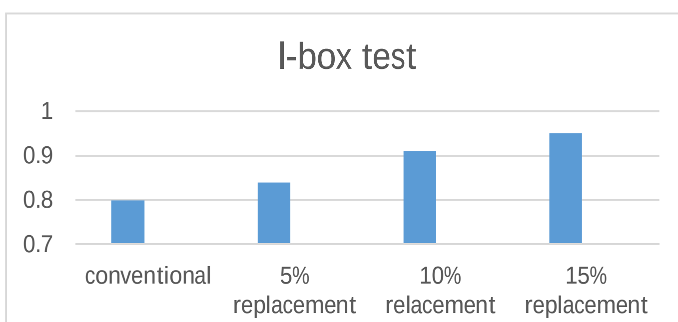

Fig 7,8 L-Box Test and Graph of L-Box Test

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4) U-Box Test

Table 5 U-Box Test Results

SAMPLE	Height difference(mm)
5% replacement of cement with sf and rubber	17
10% replacement of cement with sf and rubber	21.52
15% replacement of cement with sf and rubber	23.05

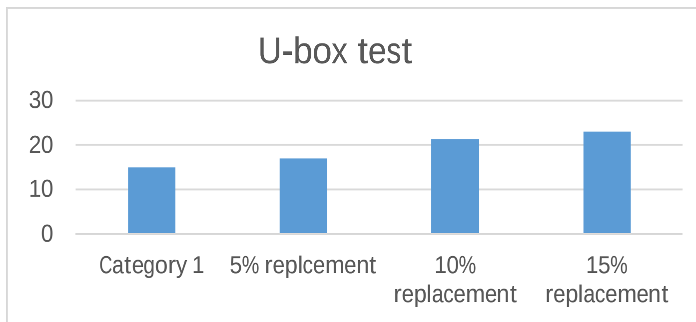

Fig 9,10 U-Box Test & Graph of U-Box Test

B. Hardened Properties

1) Compressive Test

Table 6 Compressive Test Results

SAMPLE	Compressive strength at 28 days
5% replacement of cement with sf and rubber	31.15MPa
10% replacement of cement with sf and rubber	30.48MPa
15% replacement of cement with sf and rubber	28.05MPa

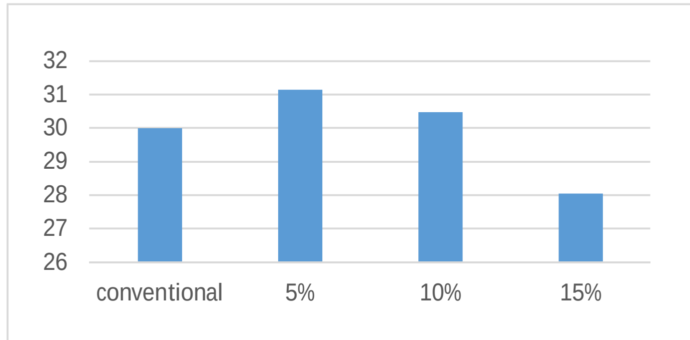

Fig 11,12 Compressive Test & Graph of Compressive Test

2) Split Tensile Test

Table 7 Split Tensile Test Results

Sample	Split tensile strength at 28 days
Conventional concrete	3 MPa
5% replacement of cement	3.45 MPa
10% replacement of cement	3.75MPa
15% replacement of cement	2.05MPa

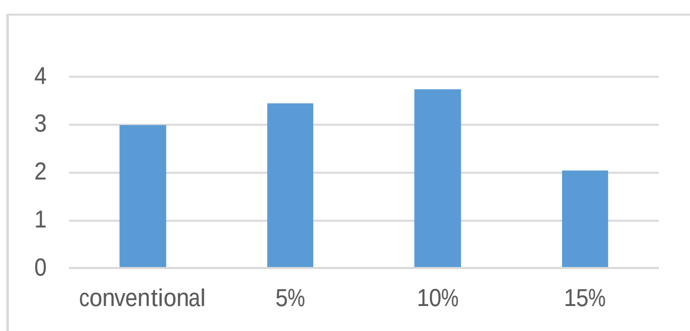

Fig 13, 14 Split Tensile Test & Graph of Split Tensile Test

3) Flexure Test

Table 8 Flexural Test Results

Sample	Flexure strength at 28 days
Conventional concrete	3.8 MPa
5% replacement of cement	4.08 MPa
10% replacement of cement	4.41MPa
15% replacement of cement	3.5MPa

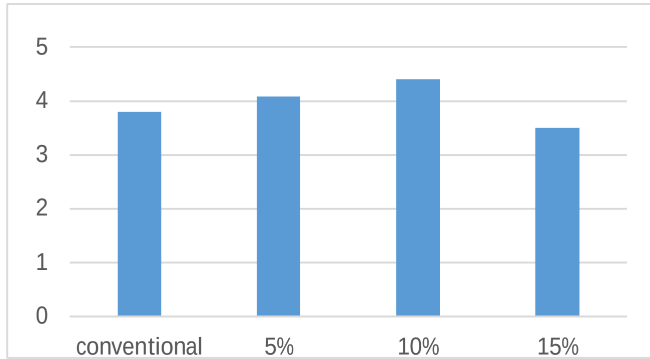

Fig 13, 14 Split Tensile Test & Graph of Split Tensile Test

VI. CONCLUSION

The investigation into self-compacting concrete (SCC) incorporating varying percentages of silica fume and crumb rubber replacements has provided valuable insights into its mechanical properties and workability. Results indicate that replacing cement with these materials at 5% to 10% levels enhances compressive, tensile, and flexural strengths while maintaining satisfactory workability, crucial for placement and finishing. However, a 15% replacement leads to diminishing strength characteristics. The pozzolanic reaction of silica fume and the reinforcing effect of crumb rubber contribute to these improvements. Additionally, SCC mixes exhibit excellent flow ability, passing ability, and filling ability, meeting code requirements. Optimal replacement levels lie within the 5% to 10% range, balancing strength enhancement and workability improvements, offering an efficient and sustainable solution for concrete production. These findings underscore the potential for using supplementary materials in SCC to enhance performance while addressing sustainability concerns in the construction industry.

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