

# “Sustainable Concrete: Partial Substitution Of Sand With Crumb Rubber And Cement With Silica Fume- Experimental Study”

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## Abstract:

The growing accumulation of waste rubber and the demand for environmentally sustainable construction materials have prompted significant interest in alternative concrete technologies. One such approach involves the partial replacement of fine aggregate with crumb rubber and cement with silica fume. This combination has demonstrated potential in enhancing the mechanical and durability properties of concrete while mitigating environmental impact. This review systematically examines existing literature on the use of crumb rubber and silica fume in concrete, with emphasis on their influence on workability, compressive strength, performance, toughness, and long-term durability. Additionally, the effects of mix design variables, curing conditions, and replacement ratios are evaluated. While crumb rubber tends to decrease strength parameters, the inclusion of silica fume can effectively compensate for these losses and improve overall performance. The synergistic use of these materials presents a promising route toward more sustainable and high-performance concrete. This paper also identifies key research gaps and outlines future directions for optimizing these materials in both structural and non-structural applications.

Keywords— CRUMB RUBBER, SILICA FUME, CONCRETE

## INTRODUCTION:

The rapid growth of the automotive industry has led to a significant increase in waste tire generation, posing severe environmental concerns. The disposal of waste tires has become a major issue worldwide, with millions of tires being discarded every year. The traditional methods of disposal, such as landfilling and burning, are no longer viable due to environmental and health concerns. Similarly, the construction industry faces challenges related to the depletion of natural resources and environmental degradation. The increasing demand for concrete has led to a significant consumption of natural aggregates,

resulting in the depletion of natural resources and environmental degradation.

To address these issues, researchers have been exploring innovative ways to utilize waste materials in construction. One such approach is the use of crumb rubber, derived from waste tires, and silica fume, a byproduct of silicon metal production, as partial replacements for sand and cement in concrete. Crumb rubber is a recycled material obtained from waste tires, which can be used to improve the ductility, energy absorption, and resistance to cracking of concrete. Silica fume, on the other hand, is a highly reactive pozzolan that can enhance the strength and durability of concrete.

The incorporation of crumb rubber and silica fume in concrete can provide several benefits, including reduced environmental pollution, conservation of natural resources, and improved mechanical properties of concrete. However, the use of crumb rubber can also lead to a reduction in the compressive strength of concrete, which can be mitigated by the addition of silica fume.

This experimental research aims to investigate the effects of incorporating crumb rubber and silica fume on the mechanical properties of concrete. The study will evaluate the compressive strength of concrete mixes containing different proportions of crumb rubber and silica fume. The findings of this research can provide insights into the potential benefits and applications of this sustainable approach, contributing to the development of eco-friendly construction practices.

The use of waste materials in construction can help reduce the environmental impact of the construction industry, conserve natural resources, and promote sustainable. This research can pave the way for the development of sustainable concrete mixes with development improved properties, reducing the environmental footprint of the construction industry. By utilizing waste materials, we can create a more sustainable and environmentally friendly construction industry, contributing to a better future for generations to come

### **Literature review:**

Erhan Güneyisi et al. (2004): This study examined the properties of concrete mix with crumb rubber and silica fume. The results showed that the strength of concrete decreased

with increasing rubber content. Specifically, the compressive strength of concrete mixes with 10%, 20%, and 30% crumb rubber replacement showed a significant decrease compared to the control mix. The authors attributed this decrease to the weak bond between the rubber particles and the cement paste.

Kaloush et al. (2005): The authors observed that the tensile strength of concrete decreased with increasing rubber content, but the strain at failure increased. This suggests that rubberized concrete may exhibit improved ductility. The study found that the tensile strength of concrete mixes with 10% and 20% crumb rubber replacement decreased by 15% and 30%, respectively, compared to the control mix. However, the strain at failure increased by 20% and 40%, respectively.

Kumaran et al. (2008): This study found that the properties of rubberized concrete can be improved by partially replacing cement with superplasticizers and industrial waste. The authors observed that the compressive strength of concrete mixes with 5% silica fume and 10% crumb rubber replacement improved by 15% compared to the mix without silica fume.

Sivakumar et al. (2016): The authors examined the properties of concrete with silica fume and found that durability improved with silica fume and crumb rubber. The study found that the addition of 10% silica fume and 5% crumb rubber improved the resistance to chloride ion penetration and reduced the water absorption of concrete.

Gayathri and Seyon Raja (2020): This study conducted an investigation on M20 grade concrete with replacement of cement with silica

fume and fine aggregate with crumb rubber. The results showed that the compressive strength of concrete mixes with 10% silica fume and 5% crumb rubber replacement was comparable to the control mix.

Kotresh and Belachew (2014): The authors observed that the strength of rubberized concrete can be achieved by improving bond properties. The study found that the use of silica fume improved the bond strength between the rubber particles and the cement paste, leading to improved compressive strength.

Shah et al. (2014): This study investigated the thermal properties of concrete using crumb rubber as partial replacement of coarse aggregates. The results showed that the thermal conductivity of concrete decreased with increasing crumb rubber content, indicating improved thermal insulation.

Sivakumar and Venkata Krishnaiah (2015): The authors found that concrete mix with crumb rubber has less bonding strength compared to normal concrete. The study observed that the bonding strength of concrete mixes with 10% and 20% crumb rubber replacement decreased by 20% and 40%, respectively, compared to the control mix

### **AIM:**

The aim of this research is to investigate the utilization of crumb rubber and silica fume as partial replacements for sand and cement in concrete, with a focus on evaluating their effects on the mechanical properties and durability of concrete. Specifically, this study aims to:

- Determine the optimal replacement percentages of crumb rubber and silica fume for achieving improved concrete performance.

- Evaluate the effects of crumb rubber and silica fume on the compressive strength of concrete.
- Develop sustainable concrete mixes that reduce waste and promote environmental sustainability.

This experimental approach will provide insights into the potential benefits and applications of crumb rubber and silica fume in concrete, contributing to the development of more sustainable construction materials. The study will also investigate the interaction mechanisms between crumb rubber, silica fume, and cement paste, providing a deeper understanding of the behavior of these materials in concrete. By exploring the use of waste materials in concrete, this research aims to promote sustainable construction practices and reduce the environmental impact of concrete production. The findings of this study will contribute to the development of more sustainable concrete

**Objectives:**

1. To investigate the effect of crumb rubber and silica fume on concrete strength: Evaluate the mechanical properties of concrete with partial replacement of sand with crumb rubber (up to 5%) and cement with silica fume (up to 15%).
2. To determine the optimal replacement percentages Find the optimal percentages of crumb rubber and silica fume that yield the best results in terms of compressive strength.
3. To evaluate the compressive strength Determine the compressive strength of concrete cubes with 5%,10%,15% silica replacement of cement by crumb rubber replaced sand at varying percentages.
4. To compare results with ordinary concrete Compare the mechanical properties of crumb rubber concrete with ordinary concrete to evaluate the feasibility of using crumb rubber and silica fume in concrete.
6. To promote sustainable construction practices Explore the potential benefits of using waste materials like crumb rubber and silica fume in concrete to reduce environmental impact and promote sustainability.

**Research methodology :**

The research methodology for this study involves an experimental approach to investigate the utilization of crumb rubber and silica fume as partial replacements for sand and cement in concrete. The study aims to evaluate the effects of crumb rubber and silica fume on the mechanical properties of concrete, including compressive strength.

**Material Selection:**

**Cement:** Ordinary Portland Cement (OPC) 53 grade will be used.

**Fine Aggregate:** Locally available river sand will be used.

**Crumb Rubber:** Crumb rubber will be used to partially replace sand in varying percentages (0-15%).

**Silica Fume:** Silica fume will be used to partially replace cement in varying percentages (0-15%).

**Mix Design:**

A control mix will be designed using conventional concrete materials. Then, crumb rubber and silica fume will be used to partially replace sand and cement, respectively, in varying percentages. The mix design will be based on relevant standards and guidelines.

**Specimen Preparation:**

Concrete specimens (cubes) will be prepared for each mix design. The specimens will be cast and cured according to relevant standards.

**Testing:**

The specimens will be tested for compressive strength at different ages (7 and 28 days). The testing procedures will follow relevant standards, such as ASTM C39 for compressive strength.

**Data Analysis:**

The test results will be analyzed to evaluate the effects of crumb rubber and silica fume on the mechanical properties of concrete. The results will be compared with the control mix to determine the optimal replacement percentages of crumb rubber and silica fume.

**Comparison:**

The results will be compared with the conventional mix to evaluate the effects of crumb rubber and silica fume on the mechanical properties of concrete. The comparison will help to determine the optimal replacement percentages of crumb rubber and silica fume.

By following this research methodology, the study aims to provide insights into the potential benefits and challenges of using crumb rubber and silica fume in concrete production. The findings of this study will contribute to the development of sustainable concrete mixes and provide a better understanding of the effects of crumb rubber and silica fume on concrete properties.

**MIX DESIGN**

**DEFINITION:** Mix design is the process of selecting suitable ingredient if concrete and determines their relative proportion with the object of certain minimum strength and durability as economically as possible.

**3.5.2 DESIGN OF M25 GRADE CONCRETE**

Design parameters

Characteristic strength: 25 N/mm<sup>2</sup>

Degree of quality control: Good

Type of exposure: severe

Data on material

Cement used: Grade 53 conforming to IS: 12269- 1987

Specific gravity of cement: 3.15

Sand: Conforming to zone II

Specific gravity of fine aggregate: 2.64

**RESULTS**

using crumb rubber and silica fumes is shown in

Fineness of modulus: 2.71

Specific gravity of coarse aggregate: 2.89

Bureau of Indian Standards method

(a). Target mean strength for specified characteristic cube strength is

$$F_{ck} = f_{ck} + t_s \\ = 25 + 1.65 \times 4 \\ = 31.60 \text{ N/mm}^2$$

(b). Selection of water cement ratio

From table no 5 IS.456-maximum water cement ratio 0.60

Base of experience of water cement ratio 0.55  
0.55 < 0.60 hence ok

(c). Selection of water and cement content

Maximum water content for 25 mm aggregates, estimated water content =  $186 + 6/100 \times 186$  For 100 mm slump = 197 liters (No ad- mixtures used) Calculation of cement content W/C ratio = 0.55 Cement content =  $197/0.55 = 358$  kg (300 kg/m cube) OK

(d) Proportion of volume of course aggregate and fine aggregate from table no.3 Volume of course aggregate corresponding to 20mm size aggregate and fine aggregate ( Zone 1 ) water cement ratio 0.50

Volume of course aggregate 0.62

Volume of fine aggregate =  $1 - 0.62 = 0.38$

Mix calculations

a. Volume of concrete = 1 m cube

b. Volume of cement = mass/specific gravity 1/1000

$$= 340/3.15 \times 1/1000$$

$$= 0.107 \text{ m}^3$$

c. Volume of water = mass/specific gravity 1/1000

$$= 187/1 \times 1/1000$$

$$= 0.187 \text{ m}^3$$

d. Volume of all in aggregates  $i = a - (b + c)$   
 $= 1 - (0.107 + 0.187)$   
 $= 0.706 \text{ m}^3$

e. Mass of CA = density volume specific gravity 1000

$$= 0.706 \times 0.62 \times 2.89$$

$$= 1265 \text{ kg}$$

f. Mass of FA = density volume specific gravity" 1000

$$= 0.70 \times 0.30 \times 2.64 \times 1000$$

$$= 708 \text{ kg}$$

Mix proportion on trail only

Cement = 340 kg/m<sup>3</sup>

Fine aggregate = 708 kg/m<sup>3</sup>

Course aggregate = 1265 kg/m<sup>3</sup>

Water cement ratio = 0.55

**RESULTS AND DISCUSSION**

According to the procedure and process of experiment, Compression strengths of concrete mix were determined for the Crumb rubber Concrete with the silica fumes and the testing of the sample has been executed for the 7 and 28 days. The results of compressive strength for concrete mix (MC) without using crumb rubber and silica fumes is shown in

The results compressive strength for concrete mix (MCS1) Cement for 7 and 28 days are shown in

S. No.	Days	Specimen No.	Load (KN)	Compressive strength (N/mm <sup>2</sup> )	compressive strength (Avg.)
1	7	1	380.4	16.9	16.3 N/mm <sup>2</sup>
2		2	370.8	16.4	
3		3	333.3	14.8	
4	28	1	589.2	26.1	25.36 N/mm <sup>2</sup>
5		2	574.1	25.5	
6		3	552.9	24.5	

S. No.	Days	Specimen No.	Load (KN)	Compressive strength (N/mm <sup>2</sup> )	compressive strength (Avg.)
1	7	1	295.6	13.1	11.83 N/mm <sup>2</sup>
2		2	257	11.4	
3		3	267.5	11	
4	28	1	468.5	20.8	18.76N/mm <sup>2</sup>
5		2	373.1	16.8	
6		3	422.2	18.7	

S. No.	Days	Specimen No.	Load (KN)	Compressive strength (N/mm <sup>2</sup> )	compressive strength (Avg.)
1	7	1	464.8	20.6	19.81 N/mm <sup>2</sup>
2		2	445.7	19.8	
3		3	411.2	18.9	
4	28	1	702.4	31.2	31.79 N/mm <sup>2</sup>
5		2	734.5	32.6	
6		3	710.7	31.5	

The results compressive strength for concrete mix (MCS2) with 5% partial replacement of crumb rubber of Fine aggregates and 5% partial replacement of silica fumes of Cement for 7 and 28 days are shown in

The results compressive strength for concrete mix (MCS3) with 10 % partial replacement of crumb rubber of Fine aggregates and 10% partial replacement of silica fumes in cement for 7 and 28 days are shown in

The results compressive strength for concrete mix (MCS4) with 15 % partial replacement of crumb rubber of Fine aggregates and 15% partial replacement of silica fumes in cement for 7 and 28 days are shown in

## CONCLUSIONS

Following conclusions were made from this study:

The strength of the concrete reduces with the increment of the amount of crumb rubber used in the concrete. However, the optimal results were observed with the 5% crumb rubber sample by attaining approximate 80% of the standard strength of M25.

The strength parameter of crumb rubber concrete shows a positive response when silica fume have been added as a binding product in the mixture by partial replacement of the cement with the amount 5% , 10% , 15% .

The strength which is measured is Compressive strength and the new mix gives a considerable result as with use of 5% silica fume content the compressive strength attained is approximate 90% of the standard strength of M25.

The strength obtained with the use of 10% silica fume content provided the compressive strength of approximate 60% of the standard strength of M25

The strength obtained with the use of 15% silica ume content provided the compressive strength of approximate 40% of the standard strength of M25.

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S. No.	D	Sp	Lo	Com	compressive strength (Avg.)
	a	eci	a	pressive strength (N/mm <sup>2</sup> )	
	y	m	d		
	s	e	(		
	n	N	K		
	o.	o.	N)		
1	7	1	13	5.9	5.6 N/mm <sup>2</sup>
2		2	12	5.3	
3	da	3	127.1	5.6	
4		1	17	7.9	10.66N/mm <sup>2</sup>
5	2	2	26	12	
6	8	3	27	12.1	
	da		2.8		
	ys				

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