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AN EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF CRUMB RUBBER AS SAND AND SILICA FUME AS CEMENT IN CONCRETE

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Abstract

Concrete is the one of the most widely used construction material throughout the world. Hence it has been labelled as the backbone to the infrastructure development of nation. To fulfill the requirement of industries I have to replace fully or partially the constituent materials of concrete by using waste material. It was carried out to evaluate the properties of concrete by replacing the cement with varying the percentage of silica fume and fine aggregate by crumb rubber. A comparison of partially replaced concrete with conventional concrete was also include into the study.The mix design arrived for an M40 mix. As I know the carbon dioxide produced by cement industry causes environmental pollution and global warming. In 1000Kg of cement manufacturing process approximately 900Kg of carbon dioxide is emitted. In order to reduce the cement production into atmosphere waste byproducts are used admixture in study so that environmental pollution and natural resources consumption is reduced. In India, silica fume and crumb rubber are thrown away as waste. In the present study, I used silica fume as a partial replacement of cement and crumb rubber as partial replacement of sand and various properties like compressive strength, split-tensile strength, and flexural strength of concrete was determined. Keeping crumb rubber as constant and varying silica fume percentage I find strength of concrete.

Keywords: Crumb Rubber, Silica Fume, Admixture.

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1. INTRODUCTION

Cement is the costliest and energy intensive component of concrete. The unit cost of concrete can be reduced by partial replacement of cement with silica fume and partial replacement of fine aggregate with crumb rubber. Scrap tyres and silica fume increases the waste which is a major issue for environment. The utilization of crumb rubber and silica fume instead of throwing it as a waste material can be partly used on economic grounds with partial replacement of fine aggregate and cement. It has been used particularly in mass concrete applications and large volume placement to control expansion due to heat and also helps in reducing cracking at early ages. Silica fume is byproduct of producing silicon metal or ferrosilicon alloys. One of most beneficial use of silica fume in concrete because its chemical and physical properties. Concrete containing silica fume can have high strength and can durable. It is the action of human being that determines the worth of any materials having potentials for gainful utilization remain in the category of waste until its potential is understood and put to right use. Crumb rubber and silica fume are such example, which has been treated as a waste material in India. This project comprises of replacing of cement (OPC, 53 grades) for different percentage Silica fume and fine aggregate with crumb rubber and then testing them for their strength.

2. LITERATURE REVIEW

Mohammed et al. (2012) focused on improving acoustic, thermal and electrical properties of hollow concrete block by partially replacing fine aggregate with crumb rubber. The result shows that the addition of fly ash and silica fume in crumb rubber concrete enhanced the compressive strength of hollow concrete block by creating better interfacial transition zone.

Eldin et al., (1993) conducted a study on rubber tyre particles as concrete aggregate. They concluded that the particle size and the amount of crumb rubber in concrete mixture must be investigated to obtain relevant strength of concrete.

Khatib and Bayomy, (1999) investigated the properties of rubberized portland cement concrete. Results showed that rubberized PCC mixes can be made and are workable to a certain degree with the tire rubber content being as much as 57% of the total aggregate volume. However, strength results showed that large reductions in strength would prohibit the use of such a high rubber content. It is suggested that rubber contents should not exceed 20% of the total aggregate volume.

Pierce and Blackwell, (2013) conducted research on concluded that the potential of scrap tire rubber as lightweight aggregate in flowable fill. Crumb rubber can be used as a complete replacement for concrete sand in flowable fill. Crumb rubber contents as high as 38% by weight (57% by volume) can be mixed in flowable fill without noticeable segregation of the rubber, although there is measurable bleeding in some cases. Crumb rubber offers other benefits when used in flowable fill, such as improved ductility and higher thermal insulation. These and other technical benefits need to be explored further.

Najim and Hall, (2010) investigated that the reutilization of waste rubber from scrap vehicle tires in the construction industry has a direct limiting impact on environmental pollution. As well, the low density of rubber aggregate compared with a conventional aggregate can significantly contribute to developing semi lightweight and lightweight concrete that can help in more economical building design.

3. METHODOLOGY

Materials used in the study:

Cement

The broadly and most generally utilized cement in all types of construction works is Ordinary Portland Cement (OPC). It is of three types 33 grades, 43grade, and 53 grades. One of the important benefits is the faster rate of development of strength. In the present work Ordinary Portland Cement (OPC) 53 grade as referred to as IS: 12269-2004 was used for testing.

Fine aggregate

As per IS 383:1970, an aggregate which is retained on IS 4.75mm sieve is called fine aggregate. Sand is shining yellow, off-white, and rounded.

Coarse aggregate

As per IS 383:1970, an aggregate which is retained on IS 20mm sieve is called coarse aggregate. Coarse aggregates are responsible for providing 70-75% bulk within the constituents of concrete. It is the prime ingredient within the concrete.

Silica Fume

Silica fumes also known as micro silica is a fine-grain, thin, and very high surface area silica. It is sometimes confused with fumed silica (also known as pyrogenic silica) and colloidal silica. These materials have different derivations, technical characteristics and applications. Silica fumes are a by-product of silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fumes is in concrete.

Crumb Rubber

Crumb rubber is a term usually applied to recycled rubber from automotive and truck scrap tires. During the recycling process, steel and fluff are removed leaving tire rubber with a granular consistency. It is the processing of the tire into fine granular or powdered particles using mechanical or cryogenic processes. The steel and fabric component of the tires are also removed during this process. Crumb rubber consists of particles ranging in size from 4.75 mm to less than 0.075 mm.

Water

The workability of the concrete mainly depends on the water percentage. When water is mixed with concrete mix the process of hydration starts and the hardening of the paste goes on subsequently. Water should have a normal pH value from 6-8. Water should not carry any salt in it because if we are using reinforced concrete, then it can cause the reinforced steel material to corrode.

Table 1. Concrete Mix proportions for Trials

Particulars	CC0	CRSF0	CRSF5	CRSF10	CRSF15

Cement(kg/m3)	**432.56**	**432.56**	**410.93**	**389.30**	**367.66**
Sand(kg/m3)	**656.62**	**623.8**	**623.8**	**623.8**	**623.8**
Aggregate(kg/m3)	**1176**	**1176**	**1176**	**1176**	**1176**
Crumb rubber(kg/m3)	**0**	**32.83**	**32.83**	**32.83**	**32.83**
Silica fume (kg/m3)	**0**	**0**	**21.63**	**43.26**	**64.90**
Water(kg/m3)	**186**	**186**	**186**	**186**	**186**

Where,

CC0 = controlled concrete

CRSF0 = Crumb rubber (CR) 5% replacement of fine aggregate, Silica fume (SF) 0% replacement of cement.

CRSF5 = Crumb rubber (CR) 5% replacement of fine aggregate, Silica fum (SF) 5% replacement of cement.

CRSF10 = Crumb rubber (CR) 5% replacement of fine aggregate, Silica fume (SF) 10% replacement of cement.

CRSF15 = Crumb rubber (CR) 5% replacement of fine aggregate, Silica fume (SF) 15% replacement of cement.

The various strength tests that are to be done listed as below.

- Compressive Test
- Split Tensile Test
- Flexural Test

Figure 2. Compressive Strength of Concrete

Figure 3. Split Tensile Strength of Concrete

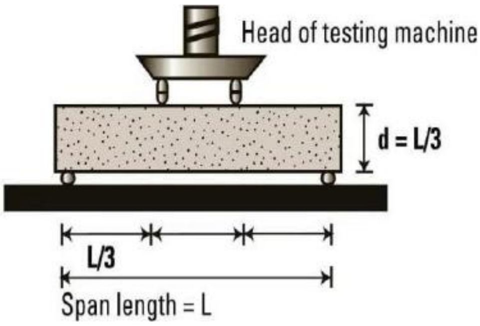

Figure 4. Flexural Tensile Strength of Concrete

4. RESULTS & DISCUSSIONS

Compressive Strength Report

Compressive strength is defined as the capacity of a material or structure to resist compression when a load is applied to it, to push it together. In other words, we can say the compressive strength of the material can also be defined as the minimum amount of load required at which that particular material breaks down. In this experiment, we tested all the cubes that we had cast with different ratios of silica fume and crumb rubber for their compressive strengths. Cube specimens of size 150mm were casted as per the Indian Standard specification IS: 516-1959.

Table 2. Comparison between Compressive Strength (N/mm^2) of Modified Concrete and Conventional Concrete

Days	CC0	CRSF0	CRSF5	CRSF10	CRSF15
At 7 Day	**28.27**	**25.54**	**27.15**	**29.70**	**27.07**
At 28 Days	**41.34**	**38.67**	**40.86**	**43.23**	**41.02**

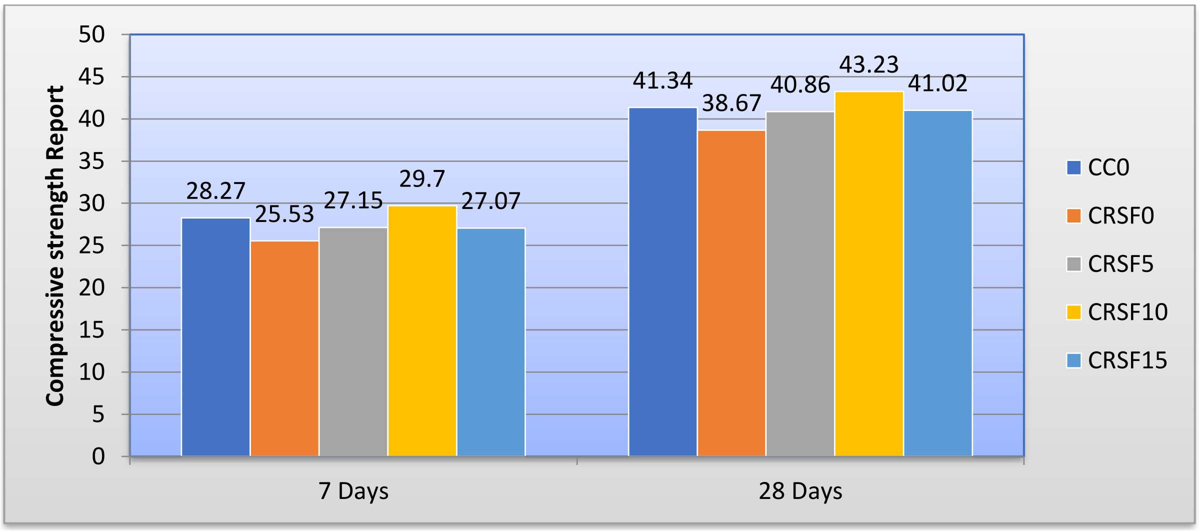

Figure 5. Graph shows the compressive strength for different curing durations

Split Tensile Strength Report

A split tensile strength test was used to determine the tensile strength of concrete. The test was performed on the cylinder with the dimension of 300 mm in length and 150 mm in diameter after 7 days and 28 days using the UTM. The split tensile strength was computed using the expression $Fct = 2P/\pi DL$, where, Fct is the split tensile strength in MPa, P is the maximum compressive load on the cylinder (in Newton), l is the length of the cylinder in mm, and d is the diameter of the cylinder in mm.

Table 3. Test result of Split Tensile strength

Days	CC0	CRSF0	CRSF5	CRSF10	CRSF15
At 7 Days	2.16	1.92	2.08	2.23	2.12
At 28 Days	3.12	2.97	3.09	3.39	3.04

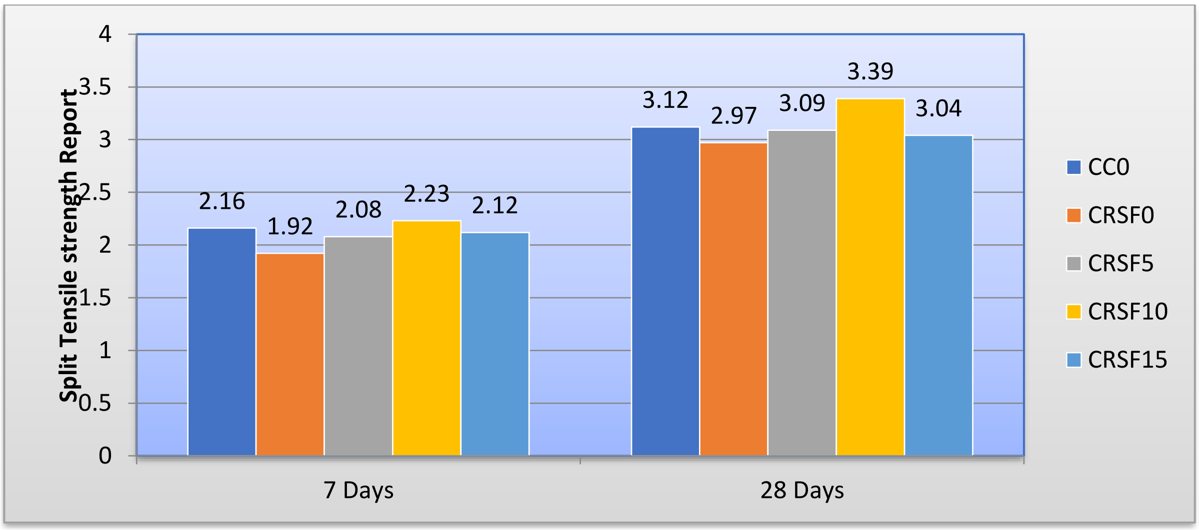

Figure 6. Graph shows the Split tensile strength result for different curing durations

Flexural Strength Report

Flexural strength is defined as the tendency of the material to oppose its deformation when a specific amount of load is applied to it. It is also known as bend strength and fracture strength. The beams of size 10 × 10 × 50 cm that we have casted were compacted in vibrators and then after de-moulding and curing them the tests were conducted on them after 7 and 28 days respectively to check their flexural strengths. For experimenting, firstly we have to prepare the trial mix and then pour it into the mould. The mould is then placed aside for 24 hours at room temperature. After 24 hours beams are demoulded very carefully and transported to the curing tank for curing. After that, the test can be conducted for different duration of time in the testing equipment. The reading can be noted down and the flexural strength of concrete is determined.

Table 4. Test result of Flexural Strength

Days	CC0	CRSF0	CRSF5	CRSF10	CRSF15
At 7 Days	**2.91**	**2.67**	**2.75**	**3.04**	**2.88**
At 28 Days	**4.39**	**3.80**	**4.14**	**4.57**	**4.12**

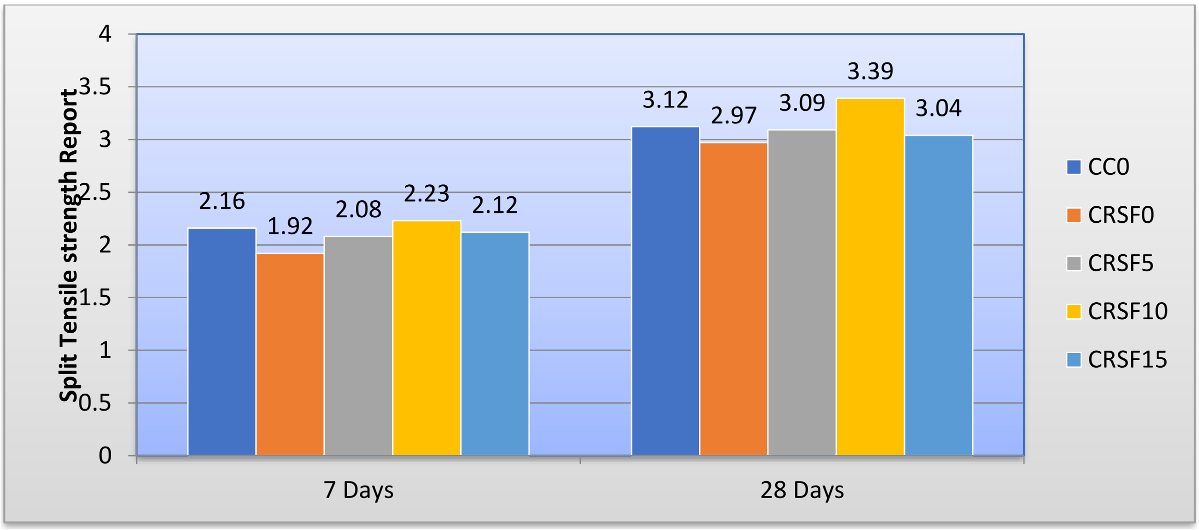

Figure 7. Graph shows the flexural strength result for different curing durations

5. CONCLUSION

Based on the above test results concluded the following:

- The 7-day and 28-day compressive strength, split tensile strength and flexural strength of the specimens increased by the addition of silica fume to concrete containing crumb rubber. This happens because of the filling capability of silica fume fine particles as well as good adhesion between the rubber and the cement paste.
- The optimum replacement level of cement by silica fume is found to be 10 % by weight along with the partial replacement of fine aggregate with 5% crumb rubber as it gives more compressive, flexural & split tensile strength than that of controlled concrete.

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