

A Comparative Study on the Flexural Behaviour of Crumb Rubber Concrete and Conventional Concrete

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ABSTRACT: In this experimental study, effects of Crumb rubber powder on the strength of concrete were investigated. The Study focus on partial replacement of fine aggregate by Crumb rubber powder in M30 grade concrete which is treated with NaOH solution. They were incorporated into concrete at the levels of 0%, 5%, 10%, 15% and 20%. This paper presents a detailed experimental study on compressive strength, split tensile strength and flexural strength at an age of 7 and 28 days. Flexural Test has been carried out using the specimen of size 1000mm x 250mm x 200mm. Test results shows that use of Crumb Rubber which is treated with NaOH solution in concrete has improved the performance of concrete in strength at 5% and 10% percentage replacements. The increase in compressive strength of concrete was observed up to 10% Crumb Rubber replacement for fine aggregate (river sand) and were reduced as the increase in the replacement ratios.

KEYWORDS: crumb rubber, NaOH treated, compressive strength, split tensile strength, flexural strength

1. INTRODUCTION

There are many studies have been conducted to use industrial by-products in cement as binder and aggregate in concrete industries. In the recent years, the efforts have been made to use industry by-products such as fly ash, silica fume, ground granulated blast furnace slag, glass cullet, etc., in the field of construction. The potential applications of industry by-products in concrete are as partial aggregate replacement or as partial cement replacement, depending on their chemical composition and grain size. Artificially manufactured aggregates may be at a considerable distance from the point of use, in that case the cost of transporting is a disadvantage. In the last 20 years, a lot of works concerning the use of several kinds of urban wastes in building materials industrial process have been published. Many researchers have extended their study to use new kinds of wastes to investigate some of the basic aspects relating to strength and behaviour. It has been found that apart from the addition of wastes, environmental benefits, also produces good effects on the properties of final products. One of the new waste materials used in the industry is waste Tyre rubber powder as a partial replacement for fine and coarse aggregates. Crumb rubber powder is made up of: (as shown in Figure 1.1) 71% recoverable rubber 14% steel 3% fiber 12% extraneous material

Shu et al. (2013) have studied the recycling of waste tyre rubber and its application in PCC, treatment methodology and advantages are discussed. Waste tyre rubber are produced in the ranges from rubber chips (25mm to 50mm) and rubber powder (4.75mm to 0.075mm). Due to the hydrophobic nature of the rubber the bond between untreated rubber and cement is weak thus there is a reduction in the compressive strength. In order to increase the strength of the specimen chemical treatment of rubber particles is necessary so as to create a bond between the rubber and cement paste. The various treatment methods are, Treatment with NaOH, HNO₃, METHOCEL ether solution, surface treatment with cement paste, washing of rubber particles with water before application, silane coupling agent, oxidation of rubber particles, these are some of the treatment methods by which the strength of the rubber concrete can be increased.

Youssf et al. (2014) have investigated that the possible future use of crumb rubber concrete for structural

purpose have been studied. In this experiment he replaced the rubber powder as a partial replacement of fine aggregate in the ratio of 0%, 5%, 10% and 20%. He used fiber reinforced polymer confinement as a means to overcome the material deficiency. The study showed a positive result thus there is an increase in the compressive strength when the member is confined with FRP.

II.MATERIAL PROPERTIES

2.1 MATERIALS

The ingredients used in this experiment were cement (OPC grade 53), fine aggregate (river sand), coarse aggregate, crumb rubber powder, super plasticizer and sodium hydroxide pellets.

2.2 CRUMB RUBBER POWDER

Crumb rubber is recycled rubber produced from automotive and truck scrap Tyres. During the recycling process, steel and Tyre cord (fluff) are removed, leaving Tyre rubber with a granular consistency. Continued processing with a granulator or cracker mill, possibly with the aid of cryogenics or by mechanical means, reduces the size of the particles further. The particles are sized and classified based on various criteria including color. The properties of crumb rubber is shown below.

Table 2.2: Properties of Crumb Rubber

S.No	Physical properties	Result
1.	Specific gravity	1.63
2.	Fineness Modulus	4.43%
3.	Water Absorption	2%
4.	Color	Black



Figure 2.2 Crumb Rubber Powder

2.3 SODIUM HYDROXIDE

Due to the hydrophobic nature of the rubber the bond between untreated rubber and cement is weak therefore sodium hydroxide solution is used as a chemical agent for the purpose of treatment of crumb rubber powder in order to attain rough surface over the rubber particles so as to create a bonding between the cement paste.

2.4 SUPER PLASTICIZER

Conplast SP430 is a chloride free, superplasticising admixture based on selected sulphonated naphthalene polymers (as shown in Figure 2.4). It is supplied as a brown solution which instantly disperses in water. It provides excellent acceleration of strength gain at early ages and major increases in strength at all ages by significantly reducing water demand in a concrete mix



Figure 2.4 Super Plasticizer

III. MIX DESIGN

3.1 GENERAL

The mix design for this experimental investigation has been prepared based on the guidelines in the IS 10262 – 2009. All the samples in this experimental investigation has been followed with the same M30 mix. This ratio of mix is selected from the previous literature studies. The following table shows the mix proportions:

Table 3.1 Mix Proportioning

Water	Cement	Fine aggregate	Coarse aggregate
197 litres	438 (Kg)	706.91 (Kg)	1113.9 (Kg)
0.45	1	1.61	2.54

The specimen of standard cube of (150mmx150mmx150mm) and standard cylinders of (300mmx100mm) and prisms of (1000mmx250mmx200mm) were used to determine the compressive strength, split tensile strength and flexural strength of concrete. Three specimens were tested for 7&28 days with proportion of crumb rubber replacement.

IV. EXPERIMENTAL PROGRAM

4.1 EXPERIMENTS CONDUCTED

The following experiments are conducted on the specimen cast.

- Compression test
- Splitting tensile test
- Flexural test

Specimen Details

From the study of the past literatures, the conventional concrete grade was chosen as M30 for replace the crumb rubber in the fine aggregate. Tests for physical properties of the materials have done and the mix ratio for the concrete was calculated by the materials properties as 1:1.61:2.54 and the water to cement ratio of 0.45% had been chosen additionally superplasticizer of 1.5% is used for the purpose of increase in workability without disturbing the w/c ratio.

Treatment of Crumb Rubber

Sodium hydroxide solution of normality 0.1N per litre is prepared. Crumb rubber powder is taken in a tray and the prepared NaOH solution is poured into the tray till the powder gets fully soaked. The tray is left undisturbed for 30 minutes later on the powder is filtered from the solution and left to dry under room temperature. The following figure shows the treatment process.



Figure 4.1 Treatment of Crumb Rubber

4.2 COMPRESSIVE STRENGTH TEST

The compressive strength of the matrix depends upon the materials used and their bonding within the matrix. However, in this study crumb rubber powder which is treated with NaOH solution is partially replaced on certain

percentages with fine aggregate and the study is made for the ages of 7 days and 28 days. The results are given in the table below.

Table 4.2 Compressive Strength Results

Fine aggregate replacement by Crumb Rubber in %	7 days	28 days
0%	22.41	34.74
5%	22.12	32.27
10%	21.76	31.59
15%	18.05	26.19
20%	12.84	18.02

4.3 SPLIT TENSILE STRENGTH TEST

The Split tensile strength test has been carried out with the crumb rubber powder which is treated with NaOH solution and it is partially replaced on certain percentages with fine aggregate and the study is made for the ages of 7 days and 28 days. The results are given in the table below.

Table 4.3 Split Tensile Strength Results

Fine aggregate replacement by Crumb Rubber in %	7 days	28 days
0%	2.42	4.23
5%	2.14	3.70
10%	2.09	3.46
15%	1.92	2.39
20%	1.79	2.19

4.4 FLEXURAL STRENGTH TEST

The flexural strength test of the specimen which has the crumb rubber powder which is treated with NaOH solution and it is partially replaced on certain percentages with fine aggregate and the study is made for the ages of 7 days and 28 days. The results are given in the table below.

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Table 4.4 Flexural Strength Results

Fine aggregate replacement by Crumb Rubber in %	7 days	28 days
0%	5.08	6.87
5%	4.82	6.05
10%	4.10	5.74
15%	3.76	4.34
20%	3.34	4.12

V. CONCLUSION

From this experiment the effective utilization of crumb rubber powder in the concrete mix as a replacement of fine aggregate has been studied. Thus the NaOH treatment has shown some increase in result when comparing it to the results of the non-treated rubber concrete. The low percentage of replacements has shown increase in strength where as an increase in replacement percentage there is a reduction in strength automatically.

There has been an increase in compressive strength when the replacement of crumb rubber is in the range of 5% and 10%.

Similarly split tensile strength and flexural strength also increases for the same percentages of replacement.

Even though the replacements with NaOH treated rubber has shown some increase in results still the bonding ability of rubber is low.

Therefore it is required to do further investigations with the other treatment methods like using silane coupling agent, methocel ether solution, oxidation, Hno₃ etc., to get better results.

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