Experimental Study on Flexural Strength of Concrete using Crumb Rubber

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Abstract

The main objective of the project is to cast and study the crumb rubber concrete for its compression and flexural strength. The addition of silica fume coated rubber crumbs to the concrete shows a phenomenal increase in compressive strength and flexural strength. This led to the additional trial of rubber plate embedded in concrete prism to improve the flexural strength. This plate is intended to act as a reinforcement to reduce the stress in the concrete element and in turn increase its flexural strength. The prism reinforced with rubber plates are tested for improved flexure strength. The rubber in the rubber plate is binded by two materials namely asphalt and cyanoacrylate. The rubber plates are prepared separately using procedures which are explained in detail in the further chapters. These plates are then laid on a layer of concrete which acts as cover block. This was tested and the results compared to experimentally prove the best suited ingredient

Keywords: crumb rubber concrete, flexural strength of concrete, crumb rubber, waste rubber

*1.*INTRODUCTION:

1.1. Concrete

Concrete is structural material consisting of a hard, chemically inert particulate substance, known as aggregate usually sand and gravel, that is bonded together by cement and water. It can also be described as a composite material composed of fine and coarse aggregate bonded together with fluid cement that cures over time. Concrete is the second most used substance in the world after water. [1]Concrete is expected to be a key material for structures resilient to climate disasters as well as a solution to mitigate the pollution of other industries, capturing wastes such as coal fly ash or bauxite tailings and residue.

1.2. Crumb Rubber

Crumb rubber is recycled rubber produced from automotive and truck scrap tires. Crumb rubber is produced by reducing the size of scrap tire. During the recycling process, steel sand tire cords (fluff) are removed, leaving tire rubber with a granular consistency. Continued processing with a granulator or cracker mill, possibly with the aid by mechanical means, reduces the size of the particles further. Crumb rubber is recycled rubber produced from automotive and truck scrap tires. Crumb rubber is made up of 71% recoverable rubber, 14% of steel, 3% fiber and 12% extraneous material. The crumb rubber used has sieve retaining at 500 microns. Crumb rubber is available in many sizes but for our project the size of crumb rubber is 2mm to 4mm.Thus we are adding it in different forms a different binder to increase the flexural strength of concrete.

1.3. Asphalt

Asphalt is also known as bitumen. It is a sticky, black, highly viscous liquid or semi-solid form of petroleum. It may be found in natural deposits or may be a refined product, and is cleared as a pitch. The primary use of asphalt is in road construction, where it is used as the glue or binder mixed with aggregate particles to create

asphalt concrete. Its other main uses are for bituminous waterproofing products, including production of roofing felt and for sealing flat roofs. Asphalt consists of compounds of hydrogen and carbon with minor properties of nitrogen, oxygen and sulfur [10-11].

1.4. Cynoacrylate

Cyanoacrylate are a family of strong fast acting adhesives with industrial, medical and household users. They are derived from ethyl cyanoacrylate and related esters. Cyanoacrylates are mainly used as adhesives. Thin layers bond effectively, thick layers much less so. They bond many substances, including human skin and tissues, natural fibres, cotton, wool, and leather. Cyanoacrylate glue has a low shearing strength, which has led to its use as a temporary adhesive in cases where the piece needs to be sheared off later. cyanoacrylate adhesives are colorless, one-part, room-temperature-curing adhesives that are available in viscosities ranging from water-thin liquids to thixotropic gels. When pressed into a thin film between two surfaces, cyanoacrylates cure rapidly to form rigid thermoplastics with excellent adhesion to most substrates like plastics, metals, rubber, wood, skin, etc. Highly reactive cyanoacrylic esters, such as methyl or ethyl cyanoacrylate, cure through anionic polymerization at room temperature, with trace amounts of water or amines as catalysts. Adherend surfaces generally contain sufficient amounts of absorbed water to catalyze polymerization, which is then completed in around 30 seconds for rubber and 1–2 minutes for metals and plastics. Fixture times for low viscosity adhesives are lower than for those with higher viscosity. Basic surfaces cure more rapidly than acidic surfaces, and only minimal shrinkage occurs during curing. The rapid curing of cyanoacrylates reduces or eliminates the need for clamps or holding fixtures.[2] Joints made with cyanoacrylates are frequently stronger than the bulk material, especially with thin plastic substrates.

1.5. Silica Fume

Silica fume are also known as micro silica. It is an amorphous polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150mm. Silica fume, a by-product of the ferrosilicon industry, is a highly pozzolanic material that is used to enhance mechanical and durability properties of concrete[9]. It may be added directly to concrete as an individual ingredient or in a blend of Portland cement and silica fume. It is an excellent admixture reduces thermal cracking caused by the heat of cement hydration. It has been found that silica fume reduces bleeding because of its effect on rheologic properties. Effects on Strength of Hardened Concrete. Silica fume has been successfully used to produce very high-strength, low-permeability, and chemically resistant concrete. Using silica fume in concrete gives high compressive strength, tensile strength and flexural strength. It enhances durability. Since the particle of silica fume is 150 times smaller than cement, it reduces permeability[4].

2. TEST SETUP:

M30 grade concrete was mix designed and all the material test were conducted as per Indian Standards. The mechanism of casting was broadly classified in five types.

Control concrete (CC) obtained from mix design for M30 grade concrete, 10 % crumb rubber was replaced with fine aggregate (CRC 10%), 10 % Silica Fume was replaced with fine aggregate (SFC 10%) and to further improve flexural strength two types of concrete embedding plate were casted Crumb rubber cyanoacrylate plate (CRCAP) and crumb rubber asphalt plate (CRAP) were casted For CC, CRC and SFC a total of 27 cubes and 27 cylinders and 27 prisms were casted for compressive, split tensile and flexural test at 7 , 14 and 28 days respectively. For CRCAP and CRAP separate 18 prisms were casted and tested for flexural strength at 7, 14 and 28 days.

2.1 CYANOACRYLATEPLATE

Cyanoacrylate is a colourless transparent adhesive. It sets rapidly within seconds on contact with ultraviolet rays or water. This is used for gluing hard materials such as ceramics and glass. It is one of the very few adhesives that can stick processed vulcanized rubber[3]. The process of formation of bond between the materials is an

exothermic process. It has a sharp and irritating odour which is produced while using. The cyanoacrylate plate is made as a mixture of crumb rubber binded by cyanoacrylate.

2.2 CYANOACRYLATEPLATE PREPARATION

The first trial of the plate was cast in a wooden cast.25 gm of crumb rubber was measured and a layer of crumb rubber about the thickness of 10mm was evenly spread in the cast. A bottle of cyanoacrylate is of quantity 20 ml approximately 30-35ml of cyanoacrylate was poured per layer. Another layer of crumb rubber for the same thickness is layered. The cast is allowed to cool for 2-3 minutes. The cast is then upturned and tapped on the bottom to identify any unstuck crumb rubber. If the presence of any free crumb rubber is identified, then more amount of cyanoacrylate is added. The first trial failed as the wood and rubber got stuck together. The next trial was cast in the same wooden cast which was lined with an aluminium sheet and greased thoroughly with turpentine oil. After drying up of the plate, the aluminum sheet is pulled up by its edges from which the crumb rubber plate is peeled off[6].

Fig. 1. (a) Cyanoacrylate Plate; (b) Cyanoacrylate Plate During the Casting

2.3 ASPHALT PLATE

Asphalt is a black or brown material that has a consistency varying from viscous liquid to glassy solid. It is obtained either as a residue from the distillation of petroleum or from natural deposits. Asphalt consists of compounds of hydrogen and carbon with minor proportions of nitrogen, Sulphur, and oxygen[7]. Asphalt has a melting point of about 50-70℃. It is majorly used in pavements. The asphalt plate is made by heating asphalt to its melting temperature and then mixing rubber crumbs which is then cast into the shape of a plate.

2.4 ASPHALT PLATE PREPARATION

The ratio for the mixing of asphalt and crumb rubber is done through trial-and-error method The ratio of asphalt to rubber crumb is 2:1 as suggested by the literature. The asphalt of weight 200 gm was measured and heated for about 10-12 minutes. After the asphalt completely melted the previously measured crumb rubber of 100 gm is added and mixed[8]. The mixture is immediately poured into a cast and allowed to set as the mixture of the mentioned ratio takes a lot of time and stays in the liquid state for a long time. The next mix was done in the ratio 1:1 This mix sets within a minute by mixing 200 gm of melted asphalt and 200 gm of crumb rubber. This is then cast into the desired shape.

Fig2. (a) Asphalt Plate

3. TEST RESULTS:

3.1 Average compressive strength

All the cube specimens were cured in water tank and tested after 7, 14 and 28 days. The average value of compressive strength is given the table below

Table 1 Average Compressive strength test

Concrete Type	Compressive strength (N/mm^2)		
	7 days	14 days	28 days
CC	18.11	25.6	45.8
CRC	6.8	7.55	9.03
SFC	19.22	36.88	50.2

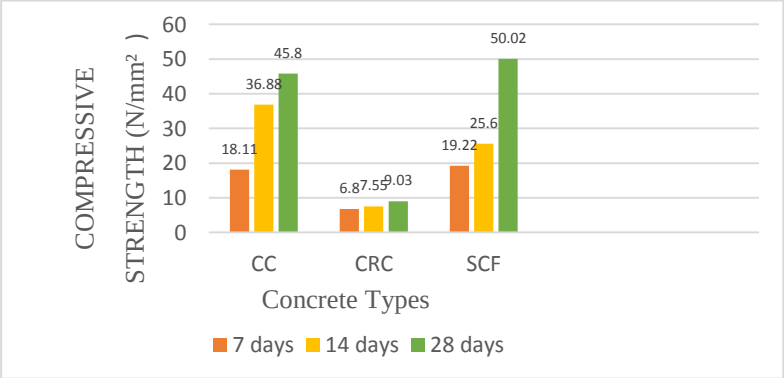

Fig 3 Average Compressive strength test

3.2 Average split tensile strength

All the cylinder specimens were cured in water tank and tested after 7, 14 and 28 days. The average value of split tensile strength is given the table below

Table 2Average Split strength test

Concrete Type	**Split strength (N/mm^2)**		
	7 days	**14 days**	**28 days**
CC	5.66	8.56	11.33
CRC	4.3	5.66	11.03
SFC	7.35	10.4	11.88

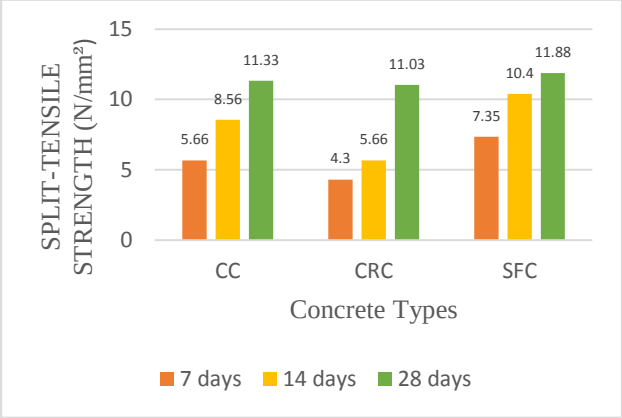

Fig 4 Split Tensile strength comparison of CC, CRC and SFC

3.3 Average flexural strength test

All the prism specimens were cured in water tank and tested after 7, 14 and 28 days. The average value of flexural strength is given the table below

Table 3 Average flexural strength test

Concrete Type	**flexural strength (N/mm^2)**		
	7 days	**14 days**	**28 days**
CC	5.5	5.8	6.5
CRC	4.8	5.5	6.2
SFC	5	5.9	7.5
CRCAP	2.5	3	5.8
CRAP	2.7	4.8	6.6

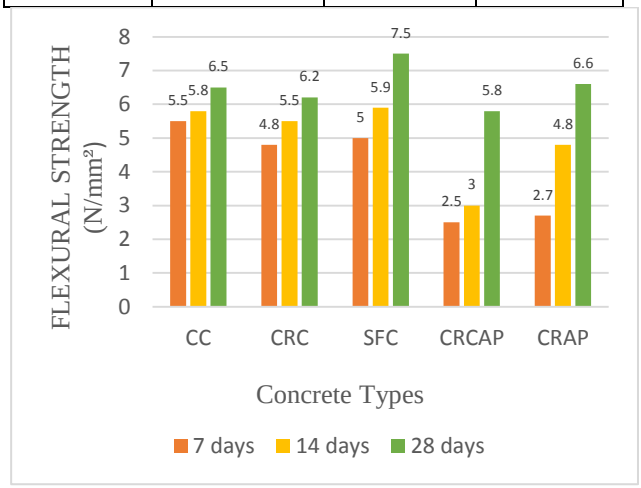

Fig 5 Flexural strength comparison of CC, CRC, SFC, CRCAP and CRAP

4. Conclusion

The conclusion of this experimental project is stated as below:

1. The addition of unprocessed crumb rubber decreases the compressive strength of the concrete by 80.28%, its split tensile strength by 2.64% and its flexural strength by 4.61% after curing of 28 days.
2. The addition of unprocessed crumb rubber along a with fine powder such as silica fume to increase the adhesiveness, increases the compressive strength of concrete.
3. The compressive strength is increased by 9.60%, split tensile strength is increased by 4.85% and the flexural strength is increased by 15.38% after curing of 28 days.
4. The plates of asphalt and cyanoacrylate binded rubber crumbs are placed at the bottom of a concrete prism as a reinforcement for increasing flexural strength.
5. The failure of the asphalt plate can be accounted to the inconsideration of the hydration of heat which melted the asphalt binding the rubber and ooze out through pores.
6. The reason for the failure of the cyanoacrylate plate can be chalked up to the non-adhesiveness between concrete and cyanoacrylate.

5.References

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