International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Utilization of Crumb Rubber in Concrete Pavement

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DOI: https://doi.org/10.55248/gengpi.2023.4.33499

ABSTRACT

Crumb rubber is recycled rubber made from used tyres from cars and trucks. As a result of growing vehicle usage, the number of wastetyres is continuously rising. Each year, the world produces close to one billion waste tyres. The number will increase and reach 1200 million by 2030. Benzothizole, a substance in crumb rubber that is acutely toxic, irritating to the respiratory system, and sensitising to the skin, is also present. A study reveals that when these tyres are heated up, harmful chemicals are released. It has been determined that the chemical carbon black, which makes approximately 20–40% of crumb rubber, causes cancer. The rural roads are the foundation of village development, and they have contributed to increased rural incomes and the opening of new livelihood. By substituting crumb rubber for fine aggregate in the concrete mix design.

Keywords:*Crumb rubber, Concrete*

INTRODUCTION

The construction industry utilises concrete extensively all over the world. It is adaptable, has desirable engineering characteristics, and is made from reasonably priced materials that can be moulded into any shape. It has a tendency to be brittle. Every year, more than ten billion tonnes of concrete are used. It was ranked second after water in terms of global usage. The Latin word "concretus," which means compact or condensed, is where the word "concrete" originates. Concrete is made with the basic components of sand (fine aggregate, or FA), gravel (coarse aggregate, or CA), cement (used as a binder), and water. 11,000,000 new automobiles are added to Indian roadways annually on average. A possible hazard to the environment comes from the addition of around 30,000,000 waste tyres each year. The amount of tyres added to the current tyre dumps or landfills has increased even if the tyres are being recycled. The amount of such trash tyres produced greatly beyond the amount that is now recycled. Discard rubber tyres are a significant global environmental concern. As a result, this collected waste material might be employed in civil engineering projects. In recent decades, concrete that uses discarded rubber as aggregate has become more common. The removal of trash tyres has been a major ecological problem in metropolitan communities all over the world as the number of automobiles increases and more garbage tyres are produced. Because tyres are difficult to biodegrade and potentially harm the environment, they typically generate "black pollution" when they are discarded as garbage. As a result, concrete is created utilising crumb rubber from the outside of discarded tyres as a partial replacement for FA, and the finished product is known as CRC (Crumb rubber concrete).

LITERATURE REVIEW

Harshit B. Prajapati. The negative environmental effects of amassing waste tyres have prompted researchers to look into various options for getting rid of them. Concerns about Crumb rubber concrete created shrinkage and cracking are also raised when portion of fine aggregates are replaced with low-stiffness rubber particles. This study thoroughly examines these issues and provides a thorough understanding of the characteristics of crumb rubber concrete, employing crumb rubber in terms of both coarse aggregate (CA) and fine aggregate (FA). When concrete in a mould becomes harder to compact as the crumb rubber content rises, it is absorbed for CRC. When crumb aggregates are used in place of CA, things become more complicated. There is a mix proportion issue, and it becomes more complicated as the crumb aggregate is increased.

S.Naveen Kumar. Rubber is now used more frequently as a result of urbanisation and the daily exponential increase in the number of cars. As a result, there is also an increase in the quantity of rubber waste, which is typically dumped in landfills. Compressive strength is observed to decline as fine aggregate replacement with Crumb rubber increases. Despite a drop in compressive strength, there was a significant increase in flexural strength. In terms of mechanical properties, It was discovered that a 2-4% substitution of fine aggregate with crumb rubber was the best replacement. As more Crumb rubber was used to substitute fine aggregate., the amount of water absorption increased.

Musa Adamuet al. examined issues with flexural strength and fatigue in pavements that were dynamic fatigue stresses from moving cars on the surface are present.. They improved the ductility, bending formation, and brittleness of RCC by incorporating crumb rubber into the concrete.

Eventually, they discovered a sharp decline in the mechanical and durability qualities of concrete as a result of the adverse effects of the rubber particle's poor bonding with cement.

Hanbing Liu etal. studied how the volume content of treated rubber and crumb rubber affected concrete performance. Amino acrylate, chloroprene adhesive, synthetic acrylate, emulsion, ethoxyline resign, synthetic resign, and unsaturated resigns were the modifiers used in the study to treat rubber. The addition of synthetic and ethoxyline resign improved additional results in terms of mechanical properties. Finally, safe strength requirements were reached by replacing the fine aggregate by 20% and the entire mixture by 5% with crumb rubber.

KhubshbuTak and Uttam Panchori have investigated how concrete's mechanical characteristics are affected by altering its surface with crumb rubber. This process involved cleaning the crumb rubber with NaOH, oxidising it with $KMnO_4$ solution, and then sulphonating it with $NaHSO_3$ solution. They also discovered that treatment significantly increased the interfacial bonding strength between crumb rubber and cement paste by 41.1% using Fourier-transform infrared spectroscopy (FT-IR). Additionally, the compressive strength of rubber with 4% modified powder was 48.7% higher than rubber with regular crumb rubber based on the analysis of mechanical properties.

EXPERIMENTAL MATERIALS

Crumb Rubber

In order to create rubber concrete, crumbled rubber is used in place of some of the fine aggregate in concrete. Its specific gravity ranges from 0.51 to 1.2, bulk density ranges hile Water adsorption, strength, and stiffness are all lower than those of fine aggregate, ranging from 524 kg/m3 to 1273 kg/m3. A non-polar, hydrophobic compound called crumb rubber repels water while encasing air on its surface.. Also, it has a distinct gradation from fine aggregate, which, according to particle size analysis, is below the lower limit of the curve. Thus, it modifies the grading to a non-continuous aggregate gradation when it partially replaces fine aggregate in rubber concrete. Due to the less specific gravity of crumb rubber compared to FA, partial substitution of FAss with crumb rubber in rubber concrete is often done by volume of the components.

Figure 1: Crumb rubber

Cement

A binder, or chemical compound that chemically binds things together, is cement. It fuses with other substances, hardens, and sets. Cement is often used to bind sand and gravel (aggregate), not by itself. Concrete is produced by mixing cement with sand and gravel, while mortar for masonry is produced by mixing cement with fine aggregate. Concrete, the substance that is utilised the most frequently in existence, is the second most widely used resource in the world after water. Building cement is primarily inorganic and commonly made of lime or calcium silicate. Depending on how effectively it sets in the presence of water, it can be categorised as hydraulic or non-hydraulic. Now a days, it is difficult to get OPC as all the industries are reducing the manufacture of OPC. So, we did this research with PPC (Portland Pozzolana cement).

Coarse aggregate

The bulk within the components of concrete is provided by coarse aggregates to the extent of 70–75 percent. It is the main component of the concrete. It becomes glued when combined with cement and water, which causes the entire strong matrix to be bound in a solid mass known as concrete. Larger size filler elements in construction are known as coarse aggregates. They are categorised according on the sizes of the aggregate particles, as the name suggests. Compared to fine particles, coarse aggregates have a smaller surface area. Concrete, railroad track ballast, and other construction materials need coarse particles. For CRC, locally accessible 20 mm coarse aggregate that has been graded according to IS 383:1970 is used.

Fine aggregate

According to IS 383:1970, fine aggregate is defined as material was passes through in IS 4.75mm sieve. Sand is spherical, off-white, and brightly coloured. Building sand has no cost because it is typically available, but transportation costs are higher. Without the need of blasting materials or any crushing equipment, processing is simple using standard machines. Any organic materials, radiation, large blocks, or concrete stones are absent from sand. Sand is used in the production of masonry blocks, road paving, plastering, filling under foundations, reinforced ready-mix concrete, and backfill, mortar, and concrete.

Water

For all kinds of employment, water is a commonly accepted essential element liquid. In this study, casting and curing are done using potable water, respectively. Every aggregate is held together by a paste that is created when water and cement are combined. Because of the water-to-cement ratio (w/c proportion), water plays a crucial part in concrete. In this study, the w/c ratio is reduced by 0.40.

DESIGN MIX

The water-cement ratio (w/c ratio), which is 0.40, is used for all mix proportions. Crumb rubber is substituted for fine aggregate (FA) at a volumetric ratio of (2%, 4%, 6%) FA when using a single water cement ratio (w/c ratio) of 0.40. The table below displays the nomenclature for design mixes.

Table 1: Design mix

Concrete Mix	Meaning
A0	Control Mix concrete design for M30
B1	Mix design with replacement of 2% Crumb rubber as FA
B2	Mix design with replacement of 4% Crumb rubber as FA
B3	Mix design with replacement of 6% Crumb rubber as FA

Table 2: Mix proportion for M30 pavement-grade concrete by using IRC 15

S.NO	Material Required	Quantity(kg/m^3)	Mix proportion
1	Cement (ppc)	394.32	1
2	Sand	738.91	1.87
3	Coarse aggregate (20 mm)	1141.91	2.89
4	Water content	157.728	0.4

EXPERIMENTAL METHODOLOGY

The CRC was subjected to a test assessment in which FA was replaced with crumb rubber to varying degrees by cement volume. The w/c ratio for all mixtures is 0.40. CRC is composed of cement, fine, coarse, and crumb rubber. For each concrete mix, cubes measuring 150 mm by 150 mm by 150 mm, cylinders measuring 150 mm by 300 mm for split tensile tests, and beams measuring 500 mm by 100 mm by 100 mm for flexural strength tests were cast with FA partially replaced by crumb rubber.

Compressive strength test

A specimen of material is said to be in compression when it is piled in a way that, should this happen, the material will compress and shorten. A universal testing device is widely used to determine compressive strength. Often, compressive strengths are provided in relation to a specific specialised standard. One of the most important engineering qualities of concrete is its compressive strength. The mechanical technique of classifying concrete based on grades is common. The universal testing device used for compressive strength tests at GMRIT, Rajam, is depicted in Fig. 2. A specimen that measured 150mm * 150mm * 150mm was cast for the compression test, and it was put through its paces using the test method outlined in IS: 516-1959. The following equation may be used to determine compression test:

Compressive Strength (N/mm2) = P / A

Where

P = Specimen Failure Load (N)

A= Specimen Area (mm2)

Figure 2: Specimen after Failure for Compressive Strength test

Flexural Strength Test

Beam with dimensions of 500 x 100 x 100 mm were used for the flexural test. According to AS PER IS: All beams were correctly cured for 28 days (516-1959). Four beams were cast, with one being normal, and their flexural strengths were compared. Flexural strength testing equipment was used for the experiment.

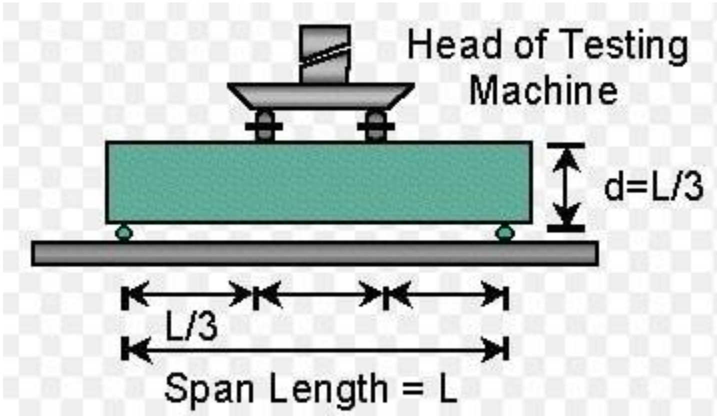

Figure 3: Flexural Strength Test

When an is more than or equal to 13.3 cm, flexural strength or modulus of rupture (fb) is given by fb = Pl/bd2;

otherwise, fb = 3Pa/bd2.

Where

Measured along the centre line of the specimen's tensile side,

a is the distance from the line of fracture and the closest support (cm)

b is the specimen's width (cm)

d is depth point (cm)

l is the support length(cm)

P = The Maximum Load the Specimen Took (kN)

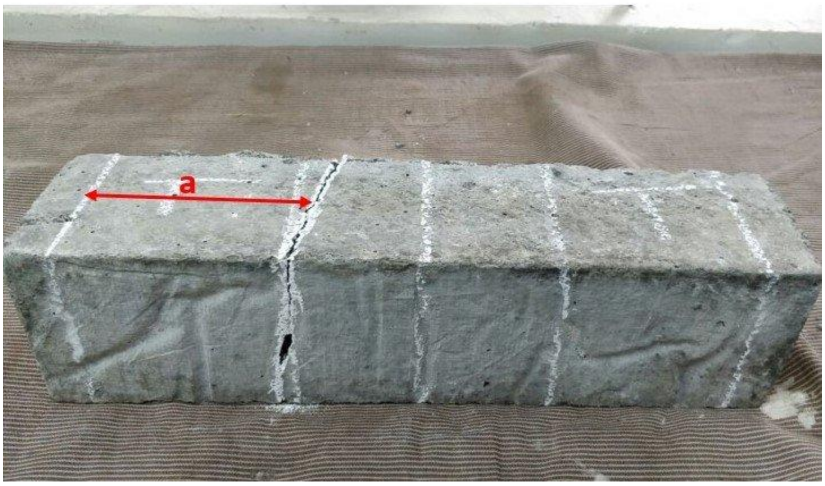

Figure 4: Specimen after Failure for Flexural Strength test

Split Tensile Strength test

One of the essential and significant characteristics of concrete is its tensile strength. Due to its weak tensile strength and brittleness, concrete is often not anticipated to sustain the direct tension. In order to determine the load at which concrete members may break, it is essential to determine the tensile strength of concrete. The cracking is a tension failure illustration. A well-known indirect test for determining the tensile strength of concrete is the splitting test, commonly referred to as split tensile strength of concrete. Around 10% of compressive strength is tensile strength. Once the specimen loses its capacity to withstand the increasing weight and no more load can be maintained, the load must be applied gradually and steadily at a rate of roughly 140 kg/sq cm/min. Following that, it is important to record the maximum load applied to the specimen as well as the appearance of the concrete and any unusual traits of the failure type.

As a result Strength of Tension =2P/πDL

P = The load at which the sample snaps (N)

D = specimen's diameter in millimetres

L = length (mm)

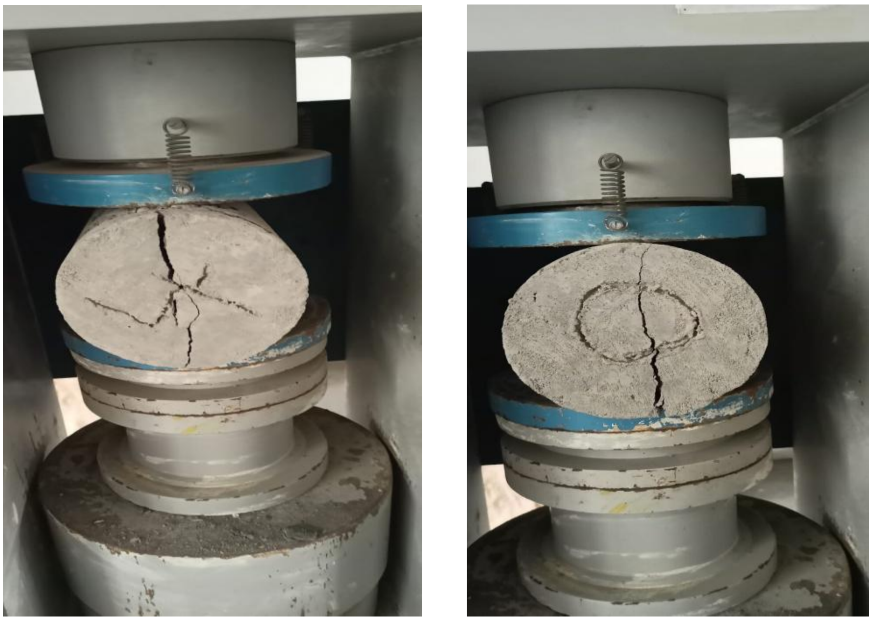

Figure 5: Specimen after Failure for Split Tensile StrengthTest

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