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BEHAVIOUR OF PAVER BLOCK BY ADDITION OF WASTE RUBBER

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Abstract— Concrete is one of the most widely used construction materials in the industry due to its durability and aesthetics. Paver blocks, made from concrete, find versatile outdoor applications such as in street roads, sidewalks, and various construction sites. Paver blocks offer low-cost maintenance and easy replacement when damaged. However, the quality of concrete used in making paver blocks is crucial, as it directly impacts their durability. Rubber, a material utilized in various fields worldwide, often poses challenges in terms of disposal after use. This study aims to investigate the inclusion of waste rubber in concrete and its effects on the properties of paver blocks. The research focuses on the development of rubber mold paver blocks with the incorporation of waste rubber.

Keywords— Rubber Mould Paver Block, Compressive strength.

I. INTRODUCTION

Concrete, an artificial engineering material comprising Portland cement, water, fine and coarse aggregates, and a small amount of air, stands as one of the most widely used construction materials globally. Its plasticity allows it to be molded into various shapes, making it highly desirable in construction. Concrete offers flexibility in surface textures and colors, catering to diverse structural needs such as highways, bridges, dams, buildings, runways, irrigation structures, and more. Its strength, cost-effectiveness, and durability further contribute to its popularity. While concrete exhibits impressive compressive strength, its tensile strength is comparatively lower, but this deficiency can be addressed by incorporating steel reinforcement. The longevity of concrete is evident from ancient Egyptian columns, which have stood the test of time for over 3600 years.

HISTORY OF PAVER BLOCK

Concrete paver blocks were initially introduced in Holland in the 1950s as a replacement for paver bricks, which had become scarce due to the post-war construction boom. These blocks were rectangular in shape and roughly the same size as traditional bricks.

Block paving, also known as brick paving, is a widely used decorative method for creating pavements or hard standings. One of the primary advantages of using bricks is that individual units can be lifted and replaced, allowing for remedial work beneath the surface without leaving a lasting mark. Common areas of

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use include driveways, pavements, patios, town centers, pedestrian precincts, and road surfacing. Bricks are typically made of concrete or clay, although other composite materials are also utilized. The manufacturing process varies for each material, with clay bricks requiring firing in a kiln to harden, while concrete bricks need to set.

Concrete paving bricks are a porous form of brick created by mixing small stone hardcore, dyes, cement, sand, and other materials in varying proportions. Modern block paving methods often incorporate recycled materials such as crushed glass and old building rubble.

Various laying patterns can be achieved using block paving, with the herringbone pattern being the most common due to its strength and interlock. This pattern involves setting the blocks at either 45 degrees or 90 degrees to the perpendicular, providing excellent stability. Other popular patterns include stretcher bond and basket weave, with the latter more suitable for areas receiving light foot traffic due to its weaker bond.

II. LITERATURE REVIEW

Maulik Sharma et al (2007): The quality of concrete used in making paver blocks significantly impacts their durability. This study explores the inclusion of bacteria in concrete to assess its effects on the properties of paver blocks, aiming to develop rubber mold paver blocks with bacterial inclusion.

P. Kirubagharan et al (2010): In this project, rubber powder is utilized as a cement replacement material in concrete paver blocks to enhance strength and reduce carbon dioxide emissions during casting. Experimental results indicate that replacing 20% of cement with rubber powder yields a compressive strength of 51 MPa and an impact strength of 15 blows, making rubber pavers a viable alternative.

BHAVNABEN K. SHAH (2013) (polypropylene fiber): In this study, polypropylene fiber is added to the top layer of concrete paver blocks in varying proportions of 0.1%, 0.2%, 0.3%, 0.4%, and 0.5% by weight. After 24 hours, the specimens undergo water curing until they are tested at 7, 14, and 28 days for compressive strength and water absorption.

G. Navya, J. Venkateswara Rao (2014) (polyester fiber): Concrete paver blocks are composed of cement, fine aggregate, and quarry dust in the bottom layer, while the top layer consists of a mixture of cement, semi-grit, dolomite powder, and pigment. Polyester fiber, in proportions of 0.1%, 0.2%, 0.3%, 0.4%, and 0.5% by weight of the concrete, is added to the top layer. The specimens are tested for compressive strength, flexural strength, and water absorption at 7 and 28 days.

R. Bharathi Murugan and C. Natarajan (2017): This study evaluates the mechanical properties of precast concrete paving blocks (PCPB) containing waste tire crumb rubber. The wet cast method is employed, and the fine aggregate (river sand) is replaced with waste tire crumb rubber in percentages of 5%, 10%, 15%, 20%, and 25% by volume. Mechanical tests are conducted at 7, 28, and 56 days, and the results are compared with conventional PCPB without rubber.

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Dr. R. Bharathi Murugan (2019): Similar to the previous study, waste tire crumb rubber is incorporated into precast concrete paving blocks using the wet cast method. Mechanical tests are conducted at 7, 28, and 56 days, and the fine aggregate (river sand) is replaced with waste tire crumb rubber in percentages of 5%, 10%, 15%, 20%, and 25% by volume.

III. MATERIALS

GENERAL INTRODUCTION:

This chapter provides details of the materials used and the tests conducted on them. It also outlines the procedure for designing the mix. The main ingredients of concrete include cement, coarse and fine aggregates, and water. Local raw materials such as Ordinary Portland Cement (OPC), river sand, and potable tap water were utilized. Detailed descriptions and properties of each material are provided in the following sections.

CEMENT:

Cement is a crucial component of concrete, acting as a binder that sets and hardens independently. The term "cement" originated from the Romans, who used it to describe masonry resembling modern concrete. Cementum, cimentum, and cement are terms used to refer to hydraulic binders made from crushed rock and burnt lime, with volcanic ash and pulverized brick additives.

AGGREGATES

Aggregates are inert, granular, and inorganic materials that typically consist of stone or stone-like solids. They can be used alone, such as in road bases and fills, or in combination with cementing materials like Portland cement or asphalt cement to form composite materials or concrete. In Portland cement concrete, approximately three-fourths of the volume is occupied by aggregate, making it a crucial component affecting both the fresh and hardened properties of the concrete.

The most common aggregates used are sand, gravel, and groundnut shells. Sand is a naturally occurring granular material composed of finely divided rock and mineral particles, with silica (silicon dioxide, $SiO2$) being the most common constituent. Gravel, on the other hand, consists of unconsolidated rock fragments with a particle size range from granule to boulder-sized fragments.

Particle Shape and Texture

The shape, texture, and surface conditions of aggregates significantly influence the workability of fresh concrete and the bond between the aggregate and the mortar phase. Rounded particles generally require less water and paste volume for a given workability compared to crushed particles. Crushed aggregates may result in higher compressive strength for water-cement ratios below 0.4.

FINE AGGREGATE

Sand, which is used as fine aggregate in concrete, varies in composition depending on local rock sources. It primarily consists of silica ($SiO2$) or calcium carbonate (e.g., aragonite). Sand particles range in diameter from 0.0625 mm to 2 mm. In this study, river sand conforming to grading zone III as per IS 383:1970 was used.

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COARSE AGGREGATE

Gravel, composed of unconsolidated rock fragments, is another important aggregate used in construction. It has various applications, including surfacing roadways in rural areas. Crushed granite stone aggregate in sizes ranging from 3 to 12 mm was used in this study.

WATER

Water is essential in construction for preparing mortar, mixing cement concrete, and curing work. The quality and quantity of water significantly affect the strength of mortar and concrete. Clean water free from alkalis, acids, oils, salts, sugars, organic materials, and other deleterious substances is required. Potable water with a pH value not less than 6 is generally considered suitable for mixing and curing.

PLASTICIZER:

Plasticizers are additives used to improve the workability and plasticity of concrete, making it easier to handle and place. They help in reducing the water content required for the mix without affecting the properties of concrete. Sg Plasto 100 is an example of a plasticizer commonly used in construction.

WASTE RUBBER:

Waste rubber, typically sourced from damaged bike tubes and vehicle tubes, is used as a material in construction. The rubber is cut into pieces measuring approximately 5-6 cm in length and 2-3 mm in thickness. It is often used in various applications such as rubber mould paver blocks, RCC slabs, beams, and columns.

TESTS ON MATERIALS:

Tests on cement are essential to ensure its quality and suitability for use in construction projects. These tests can be categorized into field tests and laboratory tests.
Field tests are conducted on-site and provide a preliminary assessment of cement quality, typically used for small-scale works or during the purchasing process.
Laboratory tests, on the other hand, are more comprehensive and confirm the quality of cement for use in critical applications. These tests include determining the initial and final setting time of cement, which is crucial for ensuring proper handling and placement of concrete.
Initial setting time refers to the time taken for the cement paste to lose its plasticity after the addition of water, while the final setting time is the duration until the paste attains sufficient firmness to resist pressure. The ideal setting times ensure that the concrete remains workable for an adequate duration without setting too quickly or too slowly.
The procedure for determining the initial and final setting times involves specific methods and equipment to measure the changes in the cement paste's consistency over time. These tests help ensure the proper performance of cement in construction applications.

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INITIAL AND FINAL SETTING TIME:

The initial and final setting times of cement are crucial parameters that determine its workability and handling characteristics. The table below presents the results of the test conducted to determine these setting times:

S. No	Time in Minutes	Depth of Penetration (mm)
1	5	0
2	12	2
3	24	3
4	32	4
5	45	5
6	52	6
7	65	7

The initial setting time is the duration from the moment water is added to the cement until the paste starts losing its plasticity. In this test, the initial setting time is approximately 12 minutes.

The final setting time is the duration until the paste has completely lost its plasticity and has attained sufficient firmness to resist certain pressure. In this test, the final setting time is approximately 65 minutes.

FINENESS OF CEMENT:

The fineness of cement plays a significant role in its hydration rate and, consequently, the development of strength. The fineness test is conducted using the IS-sieve method to determine the particle size distribution of cement particles.

Observations from the fineness test:

Trail	Wt (w1) (g)	Retained (w2)	%
1	100	2	2%
2	100	4	4%
3	100	2	2%

Average % of fineness = (2 + 4 + 2) / 3 = 2.66%

The average percentage of fineness of the cement sample is calculated to be approximately 2.66%. Finer cement particles offer a greater surface area for hydration, leading to faster strength development. However, excessively fine grinding can result in air set and early deterioration of the cement.

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SPECIFIC GRAVITY OF CEMENT:

The specific gravity of cement is a crucial parameter that indicates its density compared to water. This test determines the specific gravity of cement by comparing its weight to that of an equal volume of water at a specified temperature. Kerosene is used in this test as it does not react with cement.

The specific gravity of the cement used in this study is found to be 3.10.

TESTS CONDUCTED ON AGGREGATES:

Aggregates play a significant role in determining the properties of concrete and asphalt mixtures. Various tests are conducted to ensure that aggregates meet the required specifications for their intended use. The following tests were conducted on the aggregates:

1. Specific gravity of fine aggregate: 2.57
2. Fineness modulus of fine aggregate: 2.71
3. Specific gravity of coarse aggregate: 2.74
4. Fineness modulus of coarse aggregate: 4.85

MIX DESIGN:

For the M30 grade of concrete, the mix design involves determining the appropriate proportions of cement, fine aggregate, coarse aggregate, and water. The following table illustrates the mix design for M30 concrete:

Wt in kg/cu.m	Cement	Fine aggregate	Coarse aggregate	Water
1	369.2	919.28	1020.1	147.68
2	1	2.4	2.76	0.4

EXPERIMENTAL PROCEDURE:

Mixing of the concrete is carried out using pan mixers, where cylindrical pans containing the concrete are rotated while blades mix the materials. Compaction is achieved using a table vibrator, which consists of a steel platform mounted on flexible springs and driven by an electric motor. The normal frequency of vibration is 4000 rpm with an acceleration of 4g to 7g. Vibrating tables are efficient for compacting stiff and harsh concrete mixes required for precast elements and laboratory test specimens.

The compressive strength test measures the ability of a material to withstand axial loads pushing it together. In the context of this study, the compressive strength of concrete specimens containing different percentages of waste rubber was evaluated at 7 days and 28 days.

The results of the compressive strength test are presented in the table below:

Sl.no	% Waste Rubber Added	Weight (kg)	Compressive Strength (N/mm^2) - 7 days	Compressive Strength (N/mm^2) - 28 days
1	0	0	22.91	37.68
2	0.2	0.260	23.64	38.14
3	0.4	0.521	23.53	38.01

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4	0.6	0.781	23.25	37.51
5	0.8	1.042	23.26	37.53
6	1	1.303	23.23	37.48

These results indicate that the compressive strength of the concrete specimens generally remains consistent or slightly increases with the addition of waste rubber up to 0.6%, after which there is a slight decrease at higher percentages. The compressive strength values are expressed to the nearest 0.1 N/mm^2.

The figure below illustrates the compressive strength of the concrete specimens at 7 days and 28 days.

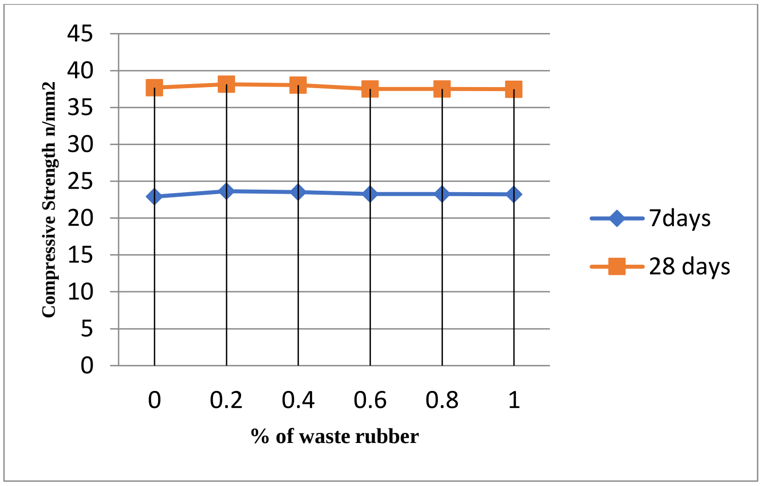

Figure: 7&28 days Compressive Strength Test

The tensile splitting strength and flexural strength tests were conducted to evaluate the performance of concrete specimens containing different percentages of waste rubber.

The results of the tensile splitting strength test are presented in the table below:

Sl.no	% Waste Rubber Added	7 days Split Tensile Strength	28 days Split Tensile Strength
1	0	3.35	4.34
2	0.2	3.42	4.41
3	0.4	3.39	4.35
4	0.6	3.38	4.27
5	0.8	3.38	4.28
6	1	3.37	4.20

These results indicate the split tensile strength of the concrete specimens at 7 days and 28 days with varying percentages of waste rubber.

The flexural strength test results are provided in the table below:

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Sl.no	% Waste Rubber Added	7 days Flexural Strength	28 days Flexural Strength
1	0	3.35	4.34
2	0.2	3.42	4.41
3	0.4	3.39	4.35
4	0.6	3.38	4.27
5	0.8	3.38	4.28
6	1	3.37	4.20

These results show the flexural strength of the concrete specimens at 7 days and 28 days with different percentages of waste rubber.

The figures below illustrate the split tensile strength and flexural strength tests at 7 days and 28 days:

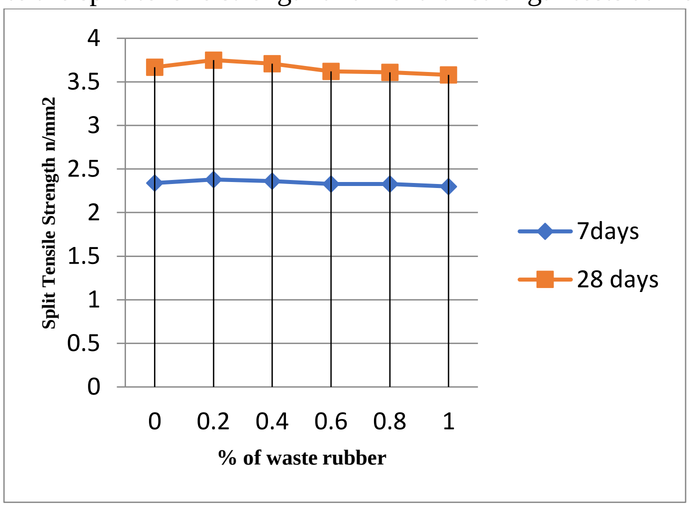

Figure: 7&28 days Split Tensile Strength Test

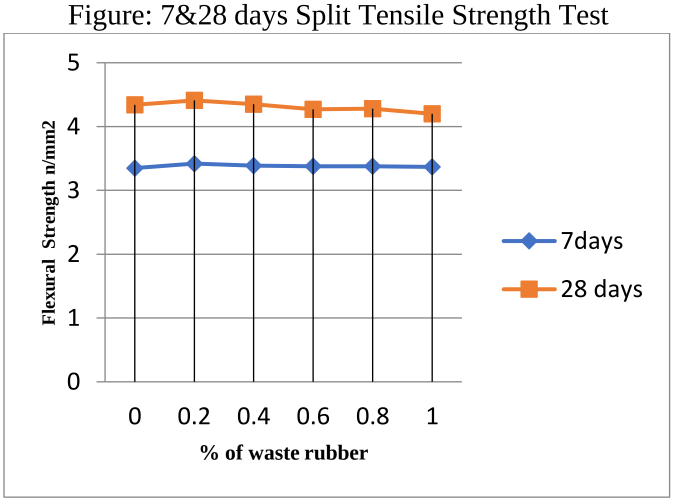

Figure: 7&28 days Flexural Strength Test

Conclusion

- Mix 1, containing 0.2% Waste Rubber Tire Tube (WRTT) fiber, exhibited the highest values of compressive strength, split tensile strength, and flexural strength compared to other mixes.
- Generally, as the percentage of WRTT fiber increased, there was a decrease in compressive strength, split tensile strength, and flexural strength of the concrete.
- The decrease in strength with increasing rubber content may be attributed to bond defects between the rubber particles and the concrete matrix.
- Overall, the reduction in compressive, split tensile, and flexural strength is primarily due to the bonding characteristics between the rubber particles and the cement paste.

These findings suggest that while the inclusion of waste rubber in concrete may offer certain benefits, such as improved sustainability and waste management, it also poses challenges in maintaining the mechanical properties of the concrete. Further research and optimization may be needed to address these challenges and fully realize the potential benefits of incorporating waste rubber in concrete mixtures.

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