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A Brief Review of Experimental Studies of Paver Blocks Manufactured with Concrete Demolition Wastes

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Abstract- **This paper reviews past studies on concrete paver blocks constructed using construction and demolition wastes (CDW). The review work focuses on studies using recycled aggregate with partial replacements of natural aggregates. The results from the experimental investigation of workability, density, water absorption, abrasion resistance, compressive strength, flexural strengths, etc of concrete reported earlier were reviewed. The split tensile strength, impact value, crushing value tests, etc that were conducted to evaluate the performance of the paver blocks were analyzed in this study. The critical observations of the past work were summarized at the end of this paper.**

Keywords- **Paver blocks, interlocking concrete block pavement, pavement engineering, concrete demolition wastes, low volume traffic roads, recycling**

I. INTRODUCTION

Paver blocks were first used in Holland as an alternative to paver bricks and are now used worldwide. The common shape of these blocks is rectangular form but other shapes are also available. It is observed that paver blocks, laid interconnected to each other, can survive for several years if designed and maintained properly (Rethinavelsamy et al (2016); RT, A. et al (2021); Bajpai, R et al (2021)). Paver blocks resist slipping and sliding and therefore are widely used in parking lots, bay areas, low-volume traffic roads, city streets, and lanes (Nandi et al (2022); Poon et al (2007); Da Silva et al (2015)) (refer to Fig. 1). The damaged blocks could be easily replaced and thus making it very beneficial for use. With the recent advancement in construction techniques and the use of efficient materials, the blocks are found to be strong enough to bear heavy traffic loads (Ling et al (2012); Machado et al (2022)). The blocks are found to withstand braking and shearing stresses generated due to heavy volume traffic loads (Jankovic et al (2012); Saboo et al (2020); Serrano-Guzman et al (2011)). The construction of these blocks requires a large number of materials. Therefore efforts have been made to use different types of construction wastes to replace the natural aggregates (Yang et al (2011); Uygunoğlu et al (2012)). Construction and Demolition (CDW) wastes are comprised of materials, such as demolished structural concrete, tiles, bricks, rocks, glass, etc (Abdulmatin, A. et al (2019); Kundu et al (2018)) (refer to Fig. 2). The present study reviews the work of past researchers on the use of demolition wastes for making paver blocks. The focus of the study is on the results obtained by different tests conducted by the researchers.

The present paper has been written as follows. In Section 2, the literature review has been presented and in Section 3, the observations were summarized.

Figure 1: Paver blocks used in parking lots & in common space

Figure 2: Demolition waste of floor tiles

II. LITERATURE REVIEW

Numerous studies have been done on the use of demolition wastes, industrial wastes, and byproducts as cement and natural aggregate substitutes in the construction of concrete paving blocks. Some of such past works are discussed here.

Chan et al (2006) work outline a study on the utilisation of demolition waste in the manufacture of paving blocks for residential usage. The results of this study have shown that the paving blocks made with construction wastes had a higher water absorption rate than the paving blocks made with river sand. With an increase in block density, the paving blocks' capacity to absorb water is reduced. In comparison to blocks without pigment, the water absorption of pigmented blocks was comparable to or lower. The ready-made blocks could survive the harsh environmental exposure. Nandi et al (2021) investigated the utilization of waste originating from asphalt pavements' in concrete paver blocks. The study has developed a design method by incorporating a staged mixing approach and a time-controlled dual source compaction process that requires a vibratory hammer and table vibrator. The design method could produce various classes of concrete paver blocks with different RAP proportions to cater to various traffic types. Due to the well-graded properties and low asphalt proportion, fine RAP aggregates produced concrete paver blocks with much lower flexural and tensile splitting strengths as well as higher compressive strength than coarse RAP concrete mixes. Eshmaiel et al (2014) have looked into ways to lessen the amount of cement in paving blocks using waste and by-product materials such as ground granulated blast-furnace slag (GGBS), plasterboard gypsum (PG), and cement bypass dust (BPD) etc. Different mixtures' binary and ternary blend combinations are taken into consideration. A cementitious mix containing GGBS, BPD, and plasterboard gypsum up to

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5% by weight can replace portland cement without having a significant impact on the strength or durability of the blocks, according to tests on the tensile strength, skid/slip, and freeze/thaw resistance of paving blocks. Selected mixtures' results from XRD and XRF tests have been presented and analyzed. When compared to the percentage of cement used in factories, the cement content of concrete blocks made with GGBS, and BPD can be reduced by up to 30%.

Habib Musa Mohammad et al. (2022) performed compressive strength tests on paver blocks made with various percentages of scrap steel aggregates and elastic cushions. The results show that such paver blocks can provide up to 50% greater strength than regular paver blocks. They have suggested that the weight of cement could be reduced depending on the volume category of the paving block aggregates. Manuel Contreras Llanes et.al.(2021) in their work investigated the use of natural sand and gravel, and fine and coarse recycled aggregates in making paver blocks. Results have shown that water absorption is low and the tensile strength is gone high. The production expenses of the paver blocks were reduced in this study. D. Chandan Kumar et al. (2022) – have used wastes from the brick-making process in the production of paver blocks. The treated waste brick powder was used to replace concrete paving blocks at different mixing ratios. The compressive strength and density of the blocks were evaluated and found that the strength of the blocks had increased. S. Suchithra et.al (2022) – It has been investigated whether building and demolition trash, as well as recycled plastic waste, may be used to make paver blocks. They suggested that C&D waste be mixed with melted polyethylene terephthalate wastes. The study was done to find the durability, water absorption, compressive strength, and flexural strength of the blocks and have seen acceptable results for their use.

Jerome Song Yeo et al. (2021) have used various types of waste materials in making the paver blocks. Some of such waste materials were soda-lime glass, recycled concrete wastes, marble waste, crumb rubber wastes, etc. The study investigated the impact of waste materials on the mechanical properties of paving blocks. The study has shown that soda-lime glass, recycled aggregates, marble wastes, and crumb rubber wastes could be mixed at appropriate proportions to make high-performance paver blocks. Gyanendra Kumar Atari et.al. (2022) investigated the impact of adding coarse recycled concrete aggregates at different percentages in the concrete mix to make paver blocks. The results showed that the workability increased by 2.6 percent at a coarse RCA of 45 percent, while at 100% SD and 100% SCD, it decreased by 4.6 percent and 10.2 percent, respectively. The observations show that coarse RCA can substitute up to 45% of natural aggregates. Byung Hyun Ryu et al. (2020) made a pervious paving block from plastic wastes. Flexural tests, in situ permeability tests, clogging tests, and freeze-thaw durability tests are done to test the durability of the pervious blocks. Results show that the pervious blocks could be used in city street paving.

G. Balasubramanian et al. (2020) have done tests in this study to compare the compressive strength of a typical block to the results of completely replacing fine aggregate with demolition trash. Concrete paver blocks with the M40 mix design were used in the test. Results show that the concrete paver blocks compressive strength has decreased slightly compared to the conventional concrete mix. Therefore, low load-bearing pavements can employ the concrete blocks created from demolition trash. The study has suggested using such paver blocks for low-volume traffic roads. Lucy Feleke Nigussie et al. (2019) conducted tests on the different types of concrete mixes with varying amounts of recycled fine aggregate (RFA) in place of natural sand. The use of recycled hollow concrete blocks in place of natural river sand affected the concrete's workability, density, and compressive strength. The workability, density, and compressive strength of M-25 grade concrete were studied with the potential effects of RFA. The test results have shown greater strength and durability properties. Yazi Meng et al. (2018) highlight the typical qualities of concrete blocks made using waste materials. The study shows that the fire resistance properties of the blocks were improved by using recycled crumb rubber, plastic wastes, and crushed bricks. Moreover, the proportion of waste materials used in concrete blocks can be increased significantly to substitute the natural aggregate to meet the specifications for concrete blocks.

Mr. Shantanu G. Pande et al. (2018) have used recycled aggregate concrete (RCA) in making paver blocks by replacing coarse aggregates. The paver blocks were tested for compression strength, tensile strength, flexure strength, and abrasion values. The impact of increasing the RCA percentage and adding fly ash (10% by weight of cement) on the performance of paver blocks are studied in this research. This study has shown that up to 40% RCA would be the ideal substitute for natural coarse aggregates. Shyam Prakash Koganti et al. (2017) have used several industrial waste products, including quarry dust, glass powder, ceramic dust, and coal dust, are used as a partial replacement for fine aggregate. After replacing it with waste materials, strength standards were assessed. It says that quarry dust could be replaced up to 20%, and the observed strength variation is not particularly noticeable.

Shivkumar Hallale et al. (2017) in their study discussed the concept of using concrete waste to produce interlocking paver blocks with coir fiber was examined. For casting paver blocks, concrete grade M-35 was utilized. The aggregates formed from waste concrete had an impact value and crushing value of 14.6% and 13.25%, respectively. The interlocking paver blocks maximum compression strength was found to be 30.33 MPa after 28 days. The total percentage of waste materials used in such blocks was 40%. The flexure strength attained was 4.57 MPa when the replacement percentage was 50%. S. Vanitha et al. (2015) made a study using recycled plastics to partially substitute coarse aggregate in M20 concrete. Aggregates were substituted in different percentages and tests such as tensile strength and compressive strength tests were conducted to study the performance of the blocks. The results show that the compressive strength of M 20 concrete with waste plastics for paver blocks is within the acceptable level and can be used for road construction.

A comparison of compressive strength, flexural strength, split tensile strength, dry density and water absorption of paver blocks made with different types of materials i.e. recycled aggregate, reclaimed ashphalt pavement, tire crumb ruber, stone crusher dust and crushed clay brick, as observed by different researchers, is shown in Figure 3, 4, 5, 6 and 7, respectively. The following inferences can be made from the figures:

a. From Figure 3, it can be seen that the compressive strength of the blocks made with different recycled materials is close to compressive strength of paver block made with conventional materials.
b. Similar to compressive strength, flexural strength of paver blocks made with different recycled

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materials is comparable to that of conventional material (Figure 4). The highest flexural strength was reported by Fabiana et al., that used TCR in the paver block.

c. The split tensile strength of paver block made with different recycled materials is close to that of paver block made with conventional material (Figure 5). Attri et al., reported the highest split tensile strength, where the authors used SCD as the construction material.

d. A comparison of dry density of paver block made with RA, RA2, RAP and GGBS is shown in Figure 6. The dry density values of these different recycled materials is close to that of conventional materials.

e. The percentage of water absorbed by paver blocks made with different recycled materials is close to that of paver block made with conventional material as seen in Figure 7.

Given that compressive strength, flexural strength, split tensile strength, dry density values and percentage of water absorbed of paver block made with different recycled materials is close to that of conventional aggregates, hence, it can be suggested that these materials can be used as partial replacements to the conventional materials.

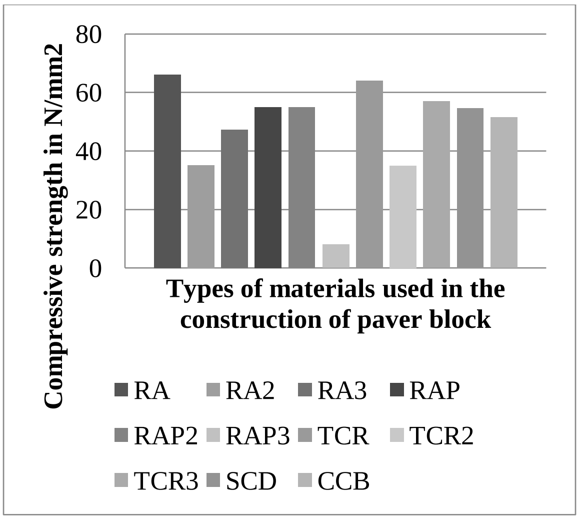

Fig 3: Comparison between compressive strength of the paver block with material using RA, RAP, TCR, SCD & CCB

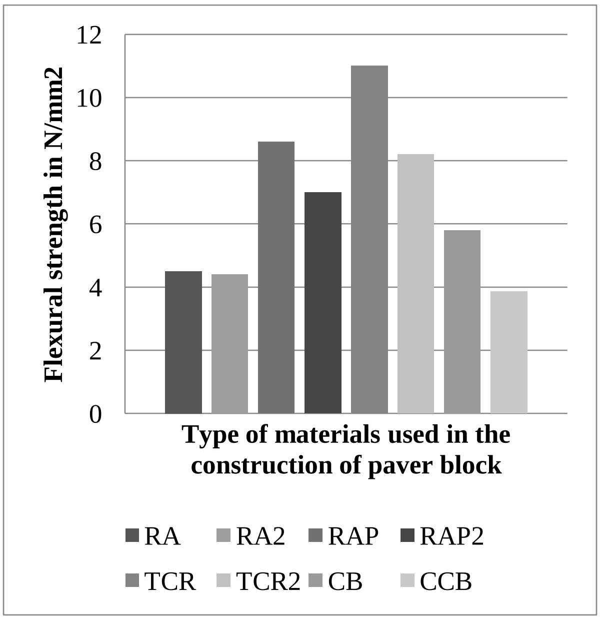

Fig 4: Comparison between Flexural strength of the paver block with material using RA, RAP, TCR, CB & CCB

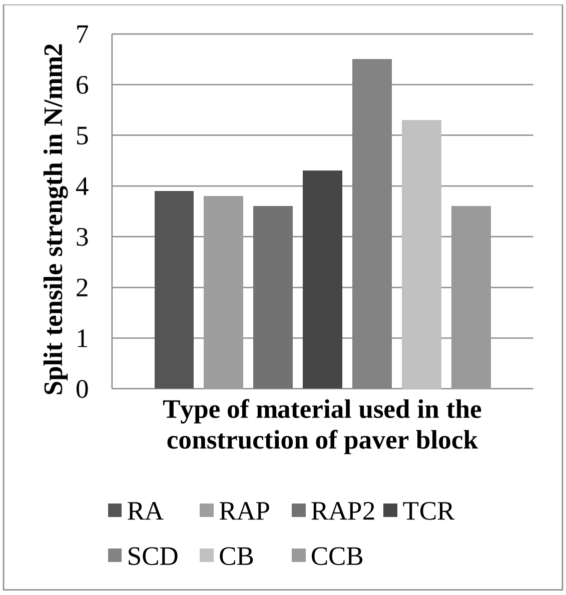

Fig 5: Comparison between Split Tensile strength of the paver block with material using RA, RAP, TCR, CB & CCB

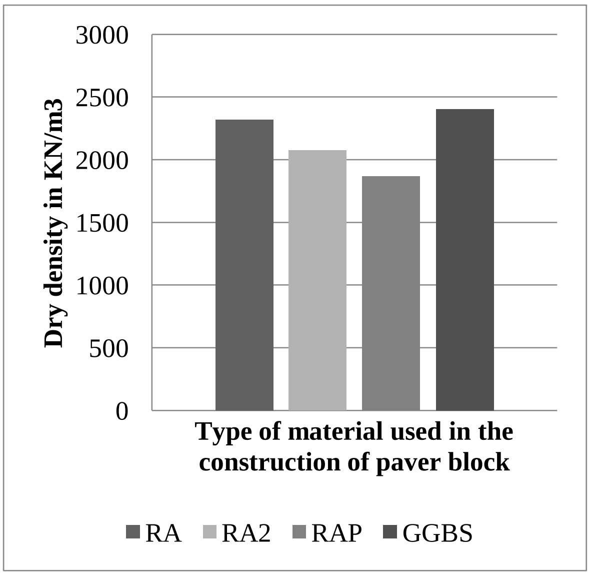

Fig 6: Comparison between Dry density of the paver block with material using RA, RA2, RAP & GGBS

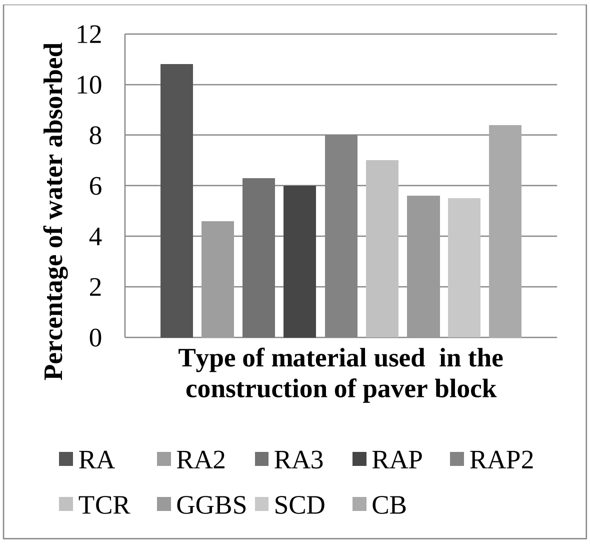

Fig 7: Comparison between water Absorption of the paver block with material using RA, RAP, TCR, GGBS, SCD & CB

III. CLOSING REMARKS

The review of the literature in this paper has focused on the experimental analysis of the paver blocks constructed with demolition wastes. The experiments performed by the researchers such as compressive strength, workability, flexural strength, water absorption, impact value, and crushing value test have shown that the paver blocks made with demolition wastes perform well under different conditions. Further studies have also shown that the use of construction & demolition waste materials in making paver blocks are cost-effective compared to conventional concrete paver blocks. A few of the important findings are given below:

- Most of the research has suggested a replacement of natural aggregate up to 50% by demolition wastes to reach the desired performance level of paver blocks.
- The studies have focused primarily on M20, M25, and M35 grades of concrete for making paver blocks.
- The paver blocks made by using demolition wastes could be used in streets for high volume traffic

provided the blocks were overlaid on adequately designed base and sub-base layers.

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