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Development of Paver Block Using Recycled Concrete Aggregate: A Review

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ABSTRACT

Paver block construction uses more natural aggregates, there is a gradual depletion as a result of continued use. Therefore, it is necessary to control the use of natural aggregates and advised to substitute them with alternative materials. The demand for raw materials like cement and aggregate in the construction sectors has surged due to population growth and urbanization. Furthermore, it has been acknowledged that the volume of garbage coming from the construction and demolition industries is significant and keeps growing annually. Using destroyed debris not only solves disposal issues but also conserves natural resources to meet the growing need for aggregates while using less energy. This research focuses on producing concrete paver blocks by substituting natural aggregates with construction and demolition (C&D) waste. This project's primary goals are to motivate contractors to recycle, reuse, and decrease construction and demolition trash. Reusing C&D trash is a widespread practice in several nations. Concrete paver blocks can be made from C&D wastes in place of aggregate. This paper reports on a performance evaluation study of CDW-produced concrete blocks. An experimental campaign was carried out for that reason, along with a characterization of the aggregates utilized. The mixes were created based on whether the aggregate was wet, dry, or saturated. To examine the microstructure of these blocks in more detail, a few more tests were carried out. The mechanical strength and water absorption of these blocks were used to assess their performance. Since there were no discernible changes between the reference sample and the changed concrete blocks, the results were quite encouraging. Therefore, the concrete blocks made with demolition waste can be used.

Key Words: RCA, C&D Wastes, Paver Block, Replacement, Recycling, Strength Property

1. Introduction

By using a specific mixture, curing techniques, and casting techniques, recycled aggregates can also be utilized in structural concrete. The use of recycled aggregate concrete (RCA) in the construction sector is crucial due to the growing challenges associated with obtaining natural coarse aggregates for concrete production, as well as the negative social and environmental effects of unrestricted extraction of natural aggregates. The impact of recycled concrete aggregate as coarse materials in paver block construction is analysed in this review and is further explained using the mechanical, rheological, and performance qualities. As a result, using RCA as a coarse material was shown to improve paver block characteristics and performance in numerous research projects. When making concrete, the two most essential ingredients are cement and aggregates. Due to these factors, there is a constant and rising demand for natural resources. Waste and byproducts are also produced in large amounts, which has negative repercussions. Utilizing RCA to partially substitute aggregates in the production of concrete paver blocks has proven beneficial recently. The usage of recycled aggregate as a building material is becoming more and more popular worldwide these days. An effort is made to replace the coarse aggregates in paver blocks with this recovered aggregate.

Recycled Concrete Aggregates (RCA), which come from construction and demolition (C & D) debris, are one alternative supply of coarse aggregate. Recycled concrete aggregate is created when the leftover concrete from the demolition of any concrete constructions is transported to a recycling facility and crushed into the appropriate sizes. Paving blocks constructed from building and demolition waste gained popularity quickly and are now practically a default option for defectors. Paving blocks are preferred by most construction companies these days over slabs, asphalt, stone, or clay. The cost of paving blocks has decreased due to mass manufacture, making them widely accessible. It is now even easier to finish their laying.

Construction materials are becoming scarcer and more expensive due to the rapid growth of infrastructure and rising demand. The majority of the waste materials generated by demolished buildings are dumped as land fill. The lack of dumping sites in metropolitan areas is a result of waste being dumped on land. In order to conserve the environment, money, and energy, demolition concrete waste must be recycled and reused. One method of transforming a waste product into a resource is recycling. It may increase the sustainability of our natural resource development, lengthen the life of natural resources, and lessen environmental disturbance around building sites. Looking at the possibility of using RCA in related construction projects including building highways, casting paver blocks, filling plinths, etc. In order to use this RCA in paving blocks, an attempt has been undertaken.

In the process of making paver blocks, the compressive, flexural, and tensile strengths of concrete are studied while taking into account different ratios of recycled aggregate to partially replace natural aggregates and replace cement with a constant weight of fly ash or GGBS. The properties of RCA namely Specific gravity, particle size distribution, moisture content, water absorption, impact value, crushing value, flakiness, and elongation index are among the characteristics of RCA that are examined. The necessary samples of paver blocks of each type are cast and tested for compression, tensile, flexure, and abrasion values in accordance with the guidelines of IS 15658-2006 code. To further study the microstructure of these blocks, a few more tests were carried out. The mixes were created based on the aggregate's state (soaked, washed, or dry). An in-depth analysis is done on the changes in the characteristics of paver blocks when the percentage of RCA increases and fly ash or GGBS replaces some of the cement. The best way to utilize RCA is discussed, along with the financial, environmental, and practical advantages of substituting RCA for traditional coarse aggregates.

2. Literature Review

1. **Anusha et al. (2021)** in order to reduce the amount of plastics disposed of, which leads to a waste management issue (waste Bakelite), this study assists in developing a waste Bakelite for fine and coarse aggregate. It was determined that a 20% replacement was a more suitable mix percentage with a better compressive strength than a standard one. However, leftover bakelite mortar is not as useful for plastering in the building industry; instead, it can be used to make bricks, pavers, blocks, and other materials (figure 1).

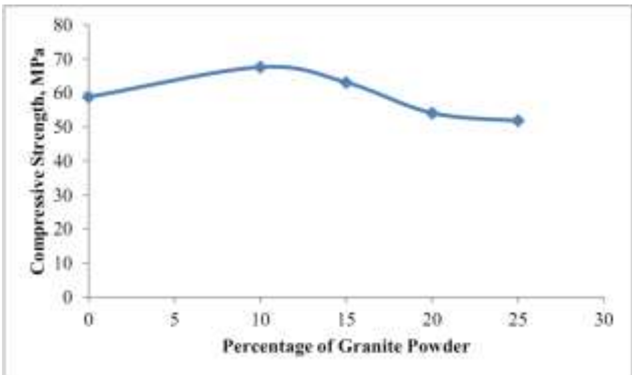

Figure 1Compressive strength graphical representation

2. **Yeole and Varma (2019)** had addressed every construction technique uses a significant amount of concrete, which is the primary material. This report presents parametric experimental research that uses waste steel aggregates to produce paving blocks. Different percentages of waste steel bearings are added to the concrete used in paver blocks. Below the paver stones, rubber pads are also utilized. The impact strength of paver blocks is examined when rubber pads are used and different amounts of waste steel aggregates are added. According to test results, adding different percentages of discarded steel aggregates to paver blocks along with rubber pads might increase impact strength by up to 50% compared to standard paver blocks. As the percentage of steel aggregate increases, paver block density rises as well. When paver blocks with rubber pads are used in an impact test, the impact value increases five to seven times compared to paver blocks without rubber pads. As density rises, paver block impact strength rises as well.

3. **Talati and Talati (2019)** had addressed the current situation, where the daily consumption of paver blocks is growing. Because such material trash may contain hazardous compounds that could harm the environment, disposing of it is a big concern. The study's goal is to make paver blocks more affordable without sacrificing strength parameters by using material waste in their manufacturing process. Fly ash, foundry sand, abrasive waste, and silica fumes are used in place of sand. According to the findings, the fly ash paving block's compressive strength is just marginally lower than that of regular brick. Similar to fly ash, using foundry sand increases compressive strength over regular block by only a small amount. Small economies can be made and waste can be used to prevent non-biodegradable material from being dumped on the soil. The two other waste materials are abrasive waste and silica fume. Compared to a standard block, abrasive waste has a higher compressive strength.

4. **Hastuty and Sembiring (2018)** it is researched to produce paving blocks using crusher dust. Crusher dust is used to replace paving blocks in different proportions; its characteristics have also been investigated. (Dust from crushers). The findings indicate that using crusher dust in place of sand has a negligible impact on weight and improves the economy. Using crusher dust can lessen environmental pollution because it is being dumped in numerous locations and sand supply is decreasing these days.

5. **Kaviya et al. (2017)** this investigation's primary goals are to recycle plastic trash into pavers and examine its qualities in light of current changes in industry requirements. Pet bottles are the substance used. All of the test blocks melt again at temperatures over 140 OC, but the block with an equal proportion of quarry dust and plastic waste has a higher compressive strength than the other mixes. Because of their low compressive strength, these blocks are suitable for use in walking pavements without significant loads.

6. **Koli (2016)** assessing the impact of coarse aggregate on the mechanical and physical characteristics of Low-Density Polyethylene (LDPE) melted paving blocks. The compressive strength of LDPE plastic and aggregate paving blocks is about equal to that of a standard C20 concrete paving block. Concrete paving blocks are less resistant to the abrasive effects of water than LDPE plastic waste paving blocks.

7. **Poonam and Ramesh (2016)** used polyethylene (PE) and high-density polyethylene (HDPE) bags in different proportions with sand and aggregate to create paver blocks utilizing discarded plastic. Materials used include sand, fly ash, red oxide, and waste plastics in varying proportions (1:2, 1:3, 1:4, 1:5, and 1:6) for plastic and river sand, respectively. Comparing the mix ratio of 1:4 to a typical block, it has been demonstrated that the former has greater compressive strength and improved fire resistance. Additionally, the rate at which water absorbs drops as the amount of waste plastic increases.

8. **Jain and Garg (2015)** has carried out an experiment on this topic that involved laboratory investigations for the manufacture of M-35 grade concrete paving blocks from 25 to 100% level by weight utilizing recycled coarse and fine aggregates in place of natural aggregates. The findings were compared with control. The test findings for the blocks demonstrated that the compressive strength fell beyond these levels and was not significantly affected by substituting recycled aggregates for natural aggregates up to a 25% level. When recycled aggregates were used instead of natural aggregates, the flexural strength of the paving blocks increased. With cleaned recycled coarse aggregates, the durability performance of the blocks such as their density, abrasion resistance, and water absorption was further enhanced (Figure 2, 3 and 4). When the percentage of recycled aggregates is increased from 25% to 100%, the density drops by up to 7% when compared to the control specimens. On the other hand, paving blocks made with cleaned recycled aggregates have a 2–4% increase in density compared to those made with unwashed recycled aggregates.

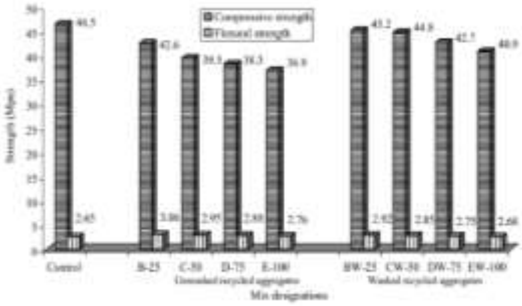

Figure 2 Mechanical strength of pavers block at the age of 28 days

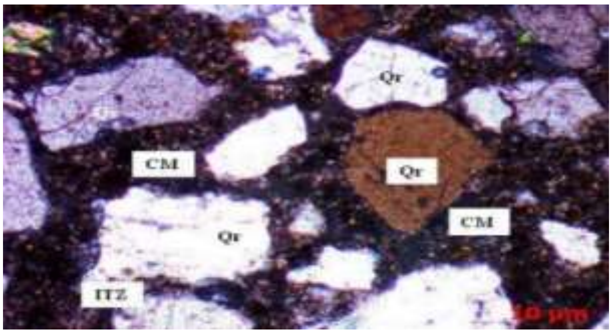

Figure 3 Petrographic image of concrete containing natural aggregates (CM-cement mortar; Qr-quartz; ITZ-inter transition zone)

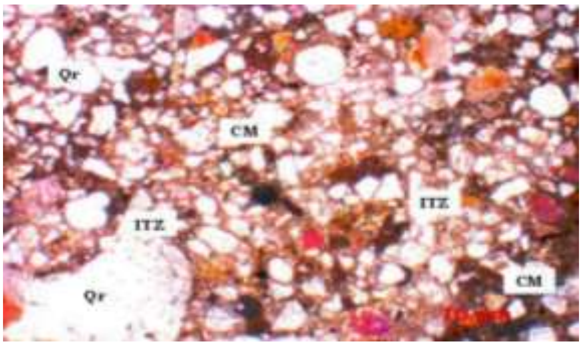

Figure 3: Petrographic image of concrete containing washed recycled coarse aggregates (CM-cement mortar; Qr-quartz; ITZ-inter transition zones).

9. **Vanitha et al. (2015)** has conducted research on the use of waste plastics in M20 concrete as a partial replacement of coarse aggregate. Waste plastics were gradually added in increments of 0%, 2%, 4%, 6%, 8%, and 10% to replace the same quantity of aggregates. Tests

were performed on waste plastics, cement, fine and coarse aggregate, and waste plastics to ascertain their physical qualities. For 7, 14, and 28 days, 200 mm by 150 mm by 60 mm paver blocks were cast and tested. According to the test results, adding waste plastics in concrete blocks is permissible as the compression value of the concrete mix dropped when more than 4% of waste plastic was added. This will facilitate the recycling of plastic in concrete blocks. Construction costs will go down, and it will also assist avoid the common methods of disposing of waste plastics, which include land filling and cremation, which have an adverse effect on the environment. Utilizing used plastics lessens the impact on the environment.

10. **Ganjian et al. (2014)** has investigated the use of mineral waste in lowering cement content. Conventional paver block manufacture typically requires the use of at least 210 kg of cement per m3. This study explores the use of waste and by-product materials to lower the cement content of paving blocks, including run-of-station ash (ROSA), basic oxygen slag (BOS), ground granulated blast furnace slag (GGBS), plasterboard gypsum (PG), and bypass dust (BPD). It has been confirmed that Portland cement can be replaced with cementations mixes containing ROSA up to 60%, GGBS up to 55%, BPD up to 25%, and PG up to 5% by weight without significantly affecting the strength of the blocks. However, the results of the water absorption test ought to indicate a value of less than 6%.

11. **Bansal and Singh (2014)** had addressed the sustainable method for handling C and D waste. The circumstances have compelled us to investigate aggregation from alternative sources. Finding and separating an increasing amount of recyclable materials from trash is crucial. The work in this paper has clarified the various C and D waste products' possibilities for recycling and reuse (Figure 5). To turn a reused item into a valuable product, no more processing is needed. The paving block's added C and D waste may also result in an enhancement in its strength properties. By using the demolition trash in the paving blocks, the cost of building will also go down. It's time for recycled aggregate to be accepted for use in concrete projects.

Figure 4 Recycled Aggregates

12. **Ohemeng et al. (2014)** had carried out the experiment using a paver block and low density polyethylene. This study's primary goal was to determine whether discarded low-density polyethylene might partially replace sand in the process of making concrete pavement blocks. In percentage terms, the plastic was utilized to replace the sand at 0%,10%,20%,30%,40%,50%, and 60%. Density, splitting tensile strength, flexural strength, and compressive strength were found to decrease with increasing plastic content. On the other hand, as the amount of plastic increased, so did the water absorption. The volume of plastic waste that is accumulating worldwide made disposal of it quite difficult. Their effects can be lessened by using them in concrete pavement blocks.

13. **Sgorlon et al. (2014)** had used electroplating waste to analyze the paver block. The aim of this work was to investigate the macro structural characteristics of concrete paving blocks that were made by partially substituting cement. The composition of blasting dust comprises a significant amount of silica, according to the data. According to the results, blasting dust may be used to make concrete paving blocks by stabilizing and solidifying the debris within the cement matrix. But in order to properly reuse this waste, academia, the interlocking block industry, and the electroplating industry must work together. Only then can society use the technologies developed in academia to achieve not only financial gains but also, and primarily, environmental benefits.

14. **Deva et al. (2014)** has researched fly ash in paver blocks. In order to report Fly Ash Concrete's appropriateness for concrete paver blocks, this paper discusses the findings of an experimental investigation that was done on the material. The study's conclusion is that, for all mixtures with the same degree of workability, the ratio of water to cementation material decreases. Comparing all four mix designs with varying fly ash proportions to the control mix without fly ash, it is discovered that the cube compressive strengths at seven and twenty-eight days showed a modest drop. In comparison to the control mix that contains no fly ash, the cube compressive strength at 90 days increased marginally for all four of the mixes with varying fly ash contents.Their findings demonstrate how readily and affordably a high proportion of fly ash may be utilized to make paver blocks for use in pavement and other comparable applications.

15. **Santos et al. (2013)** had tested coal waste in paving blocks in an experiment. Studying the use of coal waste to make concrete pavement blocks is the goal of this endeavor. It is believed that the south of Brazil is home to over 300 million tons of coal waste, which has an adverse effect on the environment and is expensive. Environmental damage could result from sand extraction from riverbeds. According to the outcome, coal waste can be processed. In place of river sand, concrete pavement blocks made from 25% and 50% recovered coal waste are manufactured. Coal waste has both technical and environmental advantages when used as fine aggregate in the production of

concrete blocks and pavement. It is possible to reduce the amount of coal waste deposits by using some of the coal tailing and minimizing the demand from sand deposits.

16. **Gencel et al. (2012)** had addressed the marble waste used in the production of paver blocks. In this study, cement, or fine aggregate, serves as a partial substitute for marbles in the paving block. On the blocks, mechanical and physical tests were conducted. According to the test results, the combinations' water requirements rise as the marble content does. The marble content has a distinct impact on the block's dry density. After 28 days, if the marble concentration in the mixture reduces, the blocks' compressive strength will be sufficient (Figure 6, 7 and 8). The marble content has a significant impact on the paver block's abrasive resistance. The type of cement has a greater impact on the concrete's elasticity modulus than marble aggregate. Ultimately, they draw the conclusion that adding marble waste results in concrete pavement blocks of adequate quality.

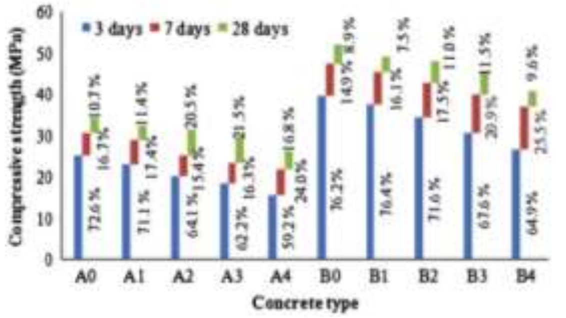

Figure 5 Compressive strength values for the blocks

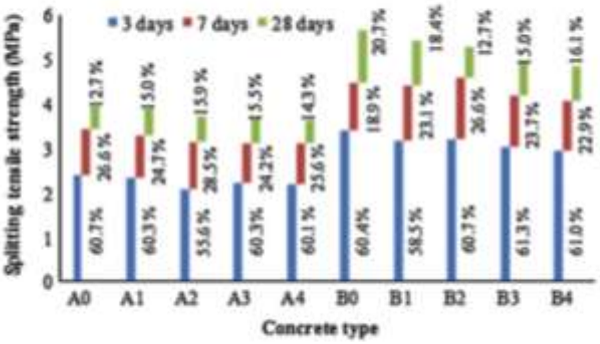

Figure 6 Splitting tensile strengths of the blocks

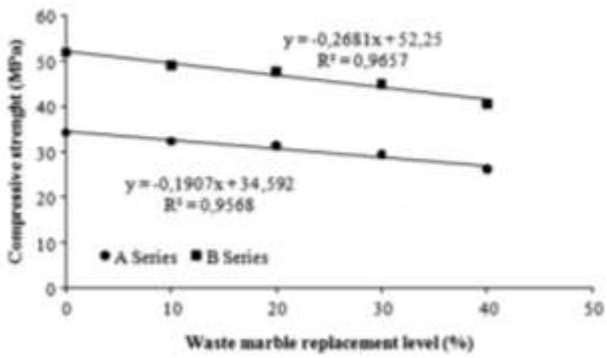

Figure 7 Relationship between 28-day compressive strength and waste marble content

3. Conclusion

After undergoing strength and durability tests, this study has demonstrated that recycled concrete aggregate is a valuable resource that can be used to produce high-strength or high-performance paver blocks. These blocks have been shown to perform satisfactorily and similarly to concrete containing virgin aggregate. It is anticipated that the results of this study would increase the amount of recycled concrete aggregate used and divert it from landfills.

When all of the testing were finished, it was discovered that adding construction and demolition (C&D) debris improved the mechanical qualities of paver blocks, cubes, and cylinders. Also observed were the paver blocks' microstructural characteristics, such as water absorption. All properties showed higher outcomes for blocks made with washed recycled aggregates. Increased compressive strength resulted from the powdery material being removed. As RCA's fraction in the mix rises, abrasive wear is seen to diminish.

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