A REVIEW ON DEVELOPMENT OF PAVING TILES FOR LOW VOLUME ROADS MADE WITH PARTIAL REPLACEMENT BY RAP (RECLAIMED ASPHALT PAVEMENT)

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Abstract.
The construction industry is constantly seeking alternative solutions for sustainable road construction. In this context, the use of Reclaimed Asphalt Pavement (RAP) as a partial replacement material in the production of paving tiles is gaining popularity due to its potential for eco-friendly and cost-effective solutions. This review paper focuses on the development of paving tiles for low volume roads made by partial replacement by RAP, with a specific emphasis on the replacement of coarse aggregate with recycled aggregate from bituminous pavements. The paper provides a literature review of relevant studies and research, as well as a detailed discussion of the design considerations for paving tiles using RAP for low volume roads. The laboratory tests used to evaluate the structural properties, including strength, hardness, and durability, and the accelerated weathering tests used to evaluate sustainability and recycling are also discussed. The paper concludes with a critical analysis of the findings, emphasizing the potential for cost-efficiency and reduced environmental impact. The use of paving tiles for low volume roads made by partial replacement by RAP with recycled aggregate can lead to a more sustainable and eco-friendly approach to road construction.

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1. Introduction

1.1 GENERAL

Virgin aggregates, which are made up of crushed stone or gravel and sand, are the most important basic raw materials used in concrete. It makes up 70 to 80% of the volume of concrete mixtures. Although virgin aggregate is widely used, it has limited resources. The current state of urbanization and construction industry expansion necessitates the use of more virgin aggregate. The extraction of virgin aggregates from their quarries has an impact on the environment. It is more important to exercise caution when utilizing these resources. An attempt has to be made to develop or adopt alternative technologies for road construction and maintenance to reduce consumption of fuel and aggregates [1], [2]. The disposal of construction waste in landfills is being investigated. The potential solutions to this problem are intertwined, and using construction debris in concrete instead of virgin aggregates is a novel way to use waste efficiently. Recycled materials derived from various sources replace virgin aggregates. Incorporating recycled asphalt pavement (RAP) from a variety of sources can reduce costs, energy consumption, and environmental impact. Recycling reduces the amount of waste disposed of in landfills. It also reduces the need for the construction of new aggregate quarries. Concrete pavement is 100% recyclable. The use of RAP in concrete, on the other hand, may alter its properties and, as a result, its performance.

The compressive strength, elastic modulus, splitting tensile strength, and flexural strength of concrete are reported to decrease as the RAP replacement percentage increases. RAP frequently has lower absorption and specific gravity values than virgin aggregate. Many old buildings were demolished, and new buildings were built in their place. The demolished building materials polluted the environment. To avoid using all of these demolished waste materials as landfills. Demolished construction materials such as aggregate, bricks, ceramic tiles, steel, and so on can be reused as building materials. Recycled aggregates are used in the construction of buildings, recycled aggregates are used as pavement construction material. Aggregates, bitumen, and soil are the most commonly used materials in the construction of a pavement or road. Strength, hardness, toughness, durability, aggregate shape, and bitumen adhesion are desirable properties of road aggregates. In this context, the reclaimed asphalt pavement (RAP) is one of the most recycled materials in the world [3].

1.2Current Scenario Regarding RAP

The use of reclaimed asphalt pavement (RAP) has gained popularity in recent years due to its economic and environmental benefits. RAP is obtained from milling and crushing of old asphalt pavements, and it can be reused as a raw material in the production of new asphalt mixtures. The utilization of RAP in asphalt mixtures has increased significantly over the past decade. However, the degree of utilization varies depending on the region and the availability of RAP. In some countries, such as the United States and Canada, the use of RAP is common practice, and it can account for up to 30% of the total asphalt mixture [5]. In contrast, in some other countries, the utilization of RAP is still limited due to the lack of regulatory support and technical knowledge. Despite the advantages of using RAP, there are some challenges associated with its utilization. One of the main challenges is the variability of the properties of RAP, which can affect the performance of the asphalt mixture. Therefore, it is essential to consider the characteristics of RAP when designing asphalt mixtures.

Overall, the current situation of RAP utilization is promising, and the trend is expected to continue in the future. Further this research is needed to better understand the behaviour of RAP in asphalt mixtures and to develop guidelines for the optimal utilization of RAP.

2 Significance and scope of study incorporating RAP in paving tiles

2.1OVERVIEW

The studies related to any kind of recycling or reuse can help in reducing the environmental impact of construction activities by reusing waste materials and reducing the amount of new resources required. This can also help in conserving natural resources and reducing the carbon footprint associated with construction activities.

Secondly, using recycled materials in construction can potentially lower the cost of construction, as recycled materials are often cheaper than new materials.

Research on incorporating RAP in construction materials can lead to the development of new and improved construction materials that have better properties and performance than traditional materials. This can lead to more durable and sustainable infrastructure that requires less maintenance and repair over its lifespan.

2.2SCOPE

- This study aims to make a Review of the current state of research on the use of RAP in paving tiles for low volume roads.
- Analysis of the mechanical and durability properties of paving tiles made by partial replacement of RAP.
- Examination of the economic feasibility of using RAP in the production of paving tiles.
- Evaluation of the environmental benefits and sustainability of using RAP in paving tiles.
- Identification of the challenges and limitations of using RAP in paving tiles.

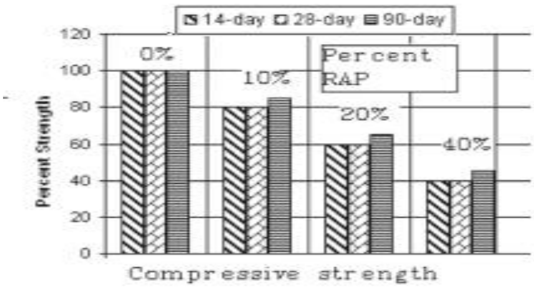
2.3LIMILATIONS

- The study will be limited to the use of RAP in paving tiles for low volume roads only by comparing the structural and mechanical properties of test specimens against a control group set of specimens.
- The availability and quality of RAP in different regions may affect the outcomes of the study.
- The study will not cover the design and construction aspects of low volume roads.
- The study will not cover the long-term performance of paving tiles made with RAP.
- The study will not include an experimental investigation, but will rely on the analysis of previously published literature.

3 Properties of Concrete Specimens containing RAP

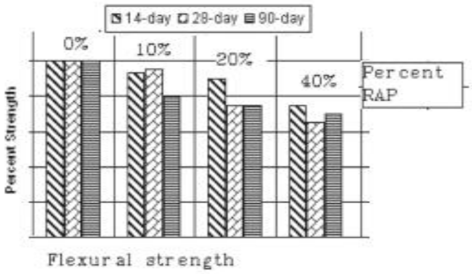
3.1COMPRESSIVE STRENGTH

The compressive strength test is a fundamental and crucial method to evaluate the quality of concrete mix in terms of its strength. Numerous research studies have demonstrated that the strength of concrete decreases as the RAP replacement increases. [25] [26] [27]This phenomenon is caused by the poor bonding between the aggregate and the cement paste due to the presence of an asphalt film on the surface of the aggregate. The soft asphalt film can lead to stress concentration, resulting in micro cracks around the aggregate and a reduction in strength [5] [6]. Research studies “K.E. Hassan et al.” research study also found that concrete containing RAP has lower compressive strength compared to control concrete mix with natural aggregates. The study showed that concrete with coarse RAP had more satisfactory results than concrete with both coarse and fine RAP replacing natural aggregates. The reduction in strength was observed to be 65% in concrete with coarse RAP and 80% in concrete with both coarse and fine RAP compared to control concrete mix at the age of 28 days. Various research studies have also shown that concrete specimens containing RAP exhibit fewer cracks during compressive loading compared to the control mix with natural aggregates. This behaviour is mainly due to the asphalt motor coating around the aggregate. Additionally, some research studies have demonstrated that concrete containing both coarse and fine RAP resulted in a strength of less than 44 MPa at 28 days of curing. [4] [16] [24] [26] [28] [29] [30]



3.2FLEXURAL STRENGTH

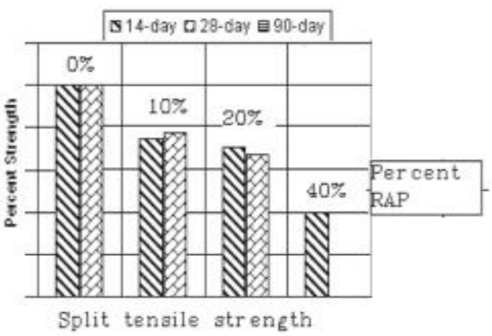
All the strength parameters are falling in line with the studies that show strength reduction after addition of RAP [1] [44]. Consequently, flexural strength also exhibits a similar pattern as the compressive strength, showing a reduction in strength as the RAP content in the concrete mix increases. However, RAP aggregates perform better in terms of load absorption compared to natural aggregates, which can be a good thing for pedestrian sidewalks and low volume roads [2] [24] [26]. Concrete with coarse RAP had a strength reduction of up to 35% compared to control concrete, while concrete with both coarse and fine RAP had a reduction in strength of over 45%. Research findings on the flexural behavior of concrete specimens containing RAP indicate that the specimens with natural aggregates exhibit a sudden fail, while those with RAP fail slowly, which could be attributed to the asphalt film present in RAP aggregates. The asphalt film decreases the elastic modulus of concrete with RAP, allowing the specimens to absorb more loads than concrete with natural aggregates. Although load absorption has increased, the strength reduction findings make it unsuitable for high-volume roads. Various research studies support these findings. [2] [16] [23] [24] [26] [28]



3.3SPLIT TENSILE STRENGTH

The split tensile test is an indirect method used to determine the tensile strength of concrete specimens. And as expected, this test also reveals a trend of reduction in the tensile strength of concrete mixes with an increase in RAP content, similar to the compressive strength test [27]. However, the tensile strength values of RAP inclusive concrete are much lower than its compressive strength, indicating that the RAP content in concrete mixes has a greater impact on tensile strength. Many research studies have focused on investigating the effect of RAP on concrete tensile strength and have found that concrete containing coarse RAP performs better than those containing both coarse and fine RAP or fine RAP alone [2] [4] [5] [6] [16] [24] [26] [28] [29] [30].

Overall, it has been observed that the reduction in tensile strength of RAP inclusive concrete is directly proportional to the percentage of RAP content in the concrete mix. The weak bond between the RAP aggregates and the cement paste, caused by the asphalt film present on the surface of the RAP aggregates, leads to stress concentration and micro-cracking around the aggregates. This results in a decrease in the tensile strength and ultimately Split tensile Strength of the concrete specimens [5] [6]. However, the presence of the asphalt film around the RAP aggregates also increases the energy absorption capacity of the concrete, which could be attributed to the ability of the asphalt film to reduce the elastic modulus of the concrete [2].



3.4TOUGHNESS

The property of toughness is crucial in concrete applications like pedestrian sidewalks and low volume roads where cyclic and impacting loads are expected (perfectly represented by the bicycles and the pedestrians) [2] [16] [19]. It has been noted by numerous research studies that the inclusion of RAP in concrete results in improved toughness compared to concrete with natural aggregates. Additionally, the toughness value of RAP concrete was found to increase proportionally with the increase in RAP content. This suggests that higher RAP content leads to higher toughness values. Furthermore, testing has shown that concrete specimens with RAP aggregates have fewer and smaller cracks than those without RAP when subjected to compressive load; lets identify them as micro-cracking [5] [6]. This implies that the asphalt film surrounding the RAP aggregates enhances the concrete's ability to withstand higher strains and is particularly beneficial in applications as suggested above. When comparing the impact of coarse and fine RAP on toughness, it was found that the concrete containing only fine RAP had similar results to that of natural aggregate concrete, while the concrete mixes containing coarse RAP showed higher load absorption. This is because the fine RAP contains more dust particles, leading to lower toughness values. However, additional research is necessary to confirm these findings and identify any other factors that may contribute to differences in toughness between coarse and fine RAP concrete.

3.5RCPT

As RAP is incorporated into concrete paving blocks, it is crucial to assess its impact on the durability of the resulting structures, pavements. One important aspect of durability is the resistance of concrete to chloride ion penetration, which can cause deterioration of pavers in the long run. In this review, we examine various studies that have investigated the Rapid Chloride Permeability Test (RCPT) on concrete containing RAP to evaluate its resistance against chloride ingress.

Nabil Hossiney, Guangming Wang, Mang Tia, Michael Bergin. "Evaluation of Concrete Containing Recycled Asphalt Pavement for Use in Concrete Pavement." Transportation Research Board 87th Annual Meeting Transportation Research Board, Issue 08-2711. RCPT was conducted to evaluate the chloride permeability of concrete containing RAP. The results showed that the incorporation of RAP up to 40% replacement level had a minimal effect on the chloride permeability of concrete.

Mang Tia, Nabil Hossiney, Yu-Min Su, Yu Chen, Tu Anh Do. "Use of reclaimed asphalt pavement in concrete pavement slabs." Tallahassee, Volume 321. The RCPT was performed to assess the chloride permeability of concrete incorporating RAP. The study revealed that concrete with RAP content exhibited similar or slightly higher chloride permeability compared to conventional concrete.

Sawssen El Euch Ben Said, Saloua El EuchKhay, and Amara Louliz. "Experimental Investigation of PCC Incorporating RAP." International Journal of Concrete Structures and Materials, December 2018, volume 12, article 8. The RCPT was utilized to evaluate the chloride permeability of concrete incorporating RAP. The findings indicated that the addition of RAP up to 50% replacement level did not significantly affect the chloride permeability of concrete.

Vincent Mathias, Thierry Sedran & François de Larrard. "Modelling of Mechanical Properties of Cement Concrete Incorporating Reclaimed Asphalt Pavement." Road Materials and Pavement Design, Volume 10, 2009 – Issue 1. RCPT was employed to assess the chloride permeability of concrete incorporating RAP. The study demonstrated that concrete with RAP exhibited comparable or slightly higher chloride permeability compared to conventional concrete.

Sengupta, S., Roy, S., Kumar, A., & Bhattacharjee, B. "Strength properties of concrete incorporating reclaimed asphalt pavement." International Journal of Civil Engineering and Technology, 8(4), 1344-1354. was conducted to evaluate the chloride permeability of concrete incorporating RAP. The results indicated that the addition of RAP up to a certain replacement level had minimal impact on the chloride permeability of concrete.

In conclusion, the review of studies on the RCPT conducted on concrete incorporating RAP reveals that the addition of RAP up to a certain replacement level does not significantly affect the chloride permeability of concrete. This suggests that concrete containing RAP can exhibit comparable or slightly higher chloride permeability compared to conventional concrete. However, it is important to consider the specific mix proportions, curing conditions, and RAP characteristics when assessing the chloride permeability of RAP inclusive concrete. Further research is warranted to explore the long-term performance and durability of concrete containing RAP in various environmental conditions.

4 CONCLUSION

In conclusion, the review on the development of paving tiles for low-volume roads made by partial replacement with RAP (Reclaimed Asphalt Pavement) highlights several key findings. The utilization of RAP in the production of paving tiles offers numerous benefits and has been a subject of extensive research in recent years.

The reviewed studies have demonstrated that incorporating RAP in the production of paving tiles can result in improved sustainability, reduced environmental impact, and enhanced resource utilization. The use of RAP helps in recycling and reusing waste materials, thereby reducing landfill waste and conserving natural resources. Furthermore, the incorporation of RAP can lead to improved mechanical properties, such as increased compressive strength and enhanced durability, making the paving tiles suitable for low-volume road applications.

The research findings also indicate that the addition of RAP can influence the physical and mechanical properties of the paving tiles. Factors such as the percentage of RAP replacement, processing techniques, and curing conditions play a significant role in determining the performance of the tiles. Therefore, careful mix design and optimization are crucial to ensure the desired properties and performance of the paving tiles.

However, it is important to note that the utilization of RAP in paving tiles has certain limitations and challenges. These include variations in RAP properties, potential presence of contaminants, and the need for proper quality control measures during production. Addressing these challenges through rigorous testing, quality assurance, and proper manufacturing practices is essential to ensure the consistent performance of the paving tiles.

Overall, the reviewed studies provide valuable insights into the development of paving tiles using RAP, highlighting the potential benefits and challenges associated with this approach. Further research and experimentation are warranted to explore the long-term performance, durability, and economic feasibility of RAP-based paving tiles for low-volume roads. This review serves as a foundation for future studies and contributes to the advancement of sustainable and cost-effective road construction practices.

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