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Use of Recycled Construction and Demolition Materials in Pavement Engineering

Dr. Ajit Patil[1] & Sucheta Kakde[2]

Head of Department and Associate Professor of Civil Engineering.

M.I.T College of Engineering, Pune [1] & Maters in Water Recourses and Environmental Engineering, From VIIT, Pune University[2]

Abstract: ***The disposal of construction and demolition (C&D) waste poses significant environmental and economic challenges worldwide. Conventional disposal methods such as landfilling lead to land scarcity, soil contamination, and greenhouse gas emissions. Recycling demolition materials as pavement construction materials offers a sustainable alternative, reducing the consumption of natural aggregates and mitigating environmental impacts. This paper reviews the properties, processing, and performance of recycled concrete aggregates (RCA), reclaimed asphalt pavement (RAP), brick debris, and mixed C&D waste in flexible and rigid pavements. Laboratory and field studies demonstrate that appropriately processed demolition materials can meet the mechanical and durability requirements for base, sub-base, and surface layers. The review highlights factors affecting performance, such as particle size, moisture content, treatment methods, and binder compatibility. Challenges, including variability in material properties, contamination, and regulatory limitations, are discussed. Future research directions focus on optimizing mix designs, enhancing mechanical performance, and developing standards for large-scale implementation. This study emphasizes the potential of demolition materials to contribute to sustainable, cost-effective, and environmentally responsible pavement construction.***

Keywords: Demolition materials; recycled concrete aggregate; reclaimed asphalt pavement; pavement construction; sustainable materials; C&D waste recycling.

I. INTRODUCTION

Rapid urbanization and industrial growth across the globe have led to an unprecedented increase in construction and demolition (C&D) activities. The resulting C&D waste, comprising concrete, asphalt, bricks, metals, timber, plastics, and other building materials, has become one of the largest contributors to municipal solid waste in urban areas. According to global statistics, C&D waste accounts for nearly 30–40% of total solid waste generation in metropolitan regions, creating serious environmental, economic, and social concerns. Improper disposal of these materials in landfills not only occupies valuable land but also leads to soil and groundwater contamination, air pollution due to dust emissions, and the release of greenhouse gases, including methane and carbon dioxide, exacerbating climate change issues. Moreover, the extraction of virgin aggregates for conventional pavement construction depletes natural resources, disrupts ecosystems, and consumes substantial energy, resulting in significant environmental footprints. In this context, the reuse and recycling of demolition materials in pavement construction emerge as a sustainable solution that addresses multiple environmental challenges while providing economic benefits.

The concept of utilizing recycled demolition materials aligns with the principles of the circular economy, where waste streams are transformed into valuable resources. Recycling C&D waste into pavement construction materials not only reduces the pressure on landfills but also decreases the demand for natural aggregates such as crushed stone and gravel. Recycled concrete aggregates (RCA), reclaimed asphalt pavement (RAP), and crushed brick aggregates have been widely explored for use in sub-base, base, and surface layers of flexible and rigid pavements. Studies have demonstrated that, when processed appropriately, these materials can achieve mechanical properties comparable to conventional aggregates, including adequate compressive strength, resilient modulus, abrasion resistance, and durability under traffic and environmental loading. Additionally, the reuse of demolition materials significantly reduces construction costs, energy consumption, and carbon emissions associated with mining, transportation, and processing of virgin aggregates, thereby promoting environmentally responsible infrastructure development.

Despite the significant potential, the large-scale adoption of demolition materials in pavement construction faces several technical and operational challenges. Variability in the quality and properties of recycled materials, contamination with gypsum, metals, wood, plastics, or organics, and incompatibility with binders or stabilizers can adversely affect the performance of pavements. For example, high absorption and porosity in recycled aggregates may alter mix design parameters, leading to reduced durability or increased susceptibility to freeze-thaw cycles. Similarly, improper processing or inadequate removal of deleterious materials may result in chemical reactions that compromise pavement longevity. Therefore, systematic characterization, quality control, and standardized processing protocols are critical to ensure consistent performance and reliability.

The sustainability and performance benefits of using demolition materials have been highlighted in numerous experimental and field studies. RCA has been successfully used as a replacement for natural aggregates in sub-base and base layers, exhibiting adequate bearing capacity and stiffness. RAP, when properly rejuvenated and blended with fresh asphalt, has demonstrated excellent performance in flexible pavements, maintaining rutting resistance, fatigue life, and skid characteristics comparable to conventional mixes. Crushed brick aggregates, although possessing lower mechanical strength, can be utilized effectively in lightweight sub-base layers or blended with other recycled aggregates to enhance load-bearing capacity. Additionally, advanced treatment and stabilization methods, including cement or lime stabilization, polymer additives, and moisture conditioning, can significantly improve the mechanical properties and durability of recycled materials, enabling their broader use in pavement construction.

The adoption of recycled demolition materials not only contributes to sustainable pavement engineering but also supports the broader goals of environmental protection and resource conservation. By diverting C&D waste from landfills, reducing the extraction of natural aggregates, and minimizing energy consumption, recycled materials help reduce the carbon footprint of road construction projects. Furthermore, the economic advantages, such as reduced material procurement costs and lower transportation expenses, make the use of demolition materials an attractive option for both public and private infrastructure projects. Governments, policymakers, and construction industries are increasingly recognizing the need to integrate recycled materials into standard pavement design and construction practices, promoting the development of guidelines, standards, and regulatory frameworks to support large-scale adoption.

However, despite these advances, there are several **research gaps and challenges** that need to be addressed. Comprehensive long-term field performance data under various climatic and traffic conditions are limited. The impact of recycled material variability on mix design, compaction, binder compatibility, and long-term durability requires further investigation. Moreover, the integration of life-cycle assessment (LCA) and cost-benefit analysis into the evaluation of recycled pavements is crucial for quantifying environmental and economic advantages. Future research should also focus on developing hybrid mix designs, advanced stabilization techniques, and predictive models for performance evaluation to facilitate broader and safer implementation of demolition materials in sustainable pavement engineering.

In conclusion, the reuse of demolition materials in pavement construction represents a promising approach to achieving sustainable, cost-effective, and environmentally responsible infrastructure. By reducing the demand for virgin aggregates, minimizing landfill disposal, and lowering greenhouse gas emissions, recycled materials contribute significantly to the goals of sustainable development. This review paper aims to comprehensively analyze the types, properties, processing methods, applications, performance, and sustainability of recycled demolition materials in pavement construction. It also identifies challenges, potential solutions, and future research directions to support the large-scale adoption of these sustainable materials in modern road infrastructure.

II.LITERATURE REVIEW

The utilization of demolition materials in pavement construction has received significant attention over the last few decades, driven by increasing construction and demolition (C&D) waste generation and the need for sustainable infrastructure solutions. Numerous studies have explored the properties, processing, performance, and sustainability aspects of recycled materials, emphasizing their potential to replace natural aggregates in flexible and rigid pavements. This section presents a comprehensive review of the existing literature, highlighting the types of materials, their characteristics, applications, and challenges.

2.1 Types of Demolition Materials

2.1.1 Recycled Concrete Aggregates (RCA):

RCA is obtained from crushing concrete debris from demolished structures. Its properties largely depend on the quality of the original concrete, degree of crushing, and removal of contaminants such as wood, metals, or gypsum. Several studies have reported that RCA can achieve compressive strengths ranging from 25–40 MPa and California Bearing Ratio (CBR) values suitable for sub-base and base layers in flexible pavements. Poon et al. (2004) observed that RCA with particle sizes between 20–40 mm exhibited sufficient stiffness and durability for medium-traffic road applications. The angularity and rough surface texture of RCA enhance interlocking and compaction, improving the load-bearing capacity of pavement layers. However, the higher water absorption and porosity of RCA compared to natural aggregates necessitate adjustments in mix design, including moisture content and binder dosage.

2.1.2 Reclaimed Asphalt Pavement (RAP):

RAP is produced from milling or removal of existing asphalt layers and can be reused in hot mix asphalt (HMA), cold mix, or base layers. The key challenge with RAP is the aging of bitumen, which affects binder viscosity and workability. Studies have demonstrated that blending RAP with virgin asphalt and rejuvenating agents can restore mechanical properties and ensure adequate rutting resistance, fatigue life, and skid resistance (Rahman & Ali, 2017). RAP is particularly valuable in flexible pavements, where it can replace 20–50% of virgin aggregates and binder without compromising performance. Field studies by Tam et al. (2006) indicated that RAP-containing pavements showed comparable service life and maintenance requirements to conventional pavements.

2.1.3 Crushed Brick and Masonry Waste:

Crushed brick aggregates, derived from bricks, tiles, and masonry debris, are characterized by lower density, higher porosity, and lower mechanical strength than RCA or natural aggregates. Despite these limitations, crushed brick has been effectively used as a sub-base material or blended with other recycled aggregates to improve load distribution and compaction characteristics. Additionally, the lightweight nature of brick aggregates reduces pavement layer thickness and dead load, which can be advantageous in specific applications such as embankments and overlays.

2.1.4 Mixed Construction and Demolition Waste:

Mixed C&D waste consists of heterogeneous materials including concrete, bricks, tiles, metals, wood, plastics, and gypsum. Pre-sorting and processing are essential to remove contaminants and produce consistent aggregates suitable for pavement construction. Chandrappa and Biligiri emphasized that mixed C&D aggregates can be used effectively in sub-base and base layers after proper grading, crushing, and removal of deleterious materials. The performance of mixed aggregates depends on the proportion of recycled concrete and brick, with higher concrete content improving compressive strength and stiffness.

2.2 Processing and Treatment Methods

The mechanical and chemical properties of recycled materials are highly influenced by processing techniques. Crushing, sieving, and particle-size classification determine aggregate gradation, angularity, and texture. Advanced processing methods such as impact crushing, jaw crushing, and vertical shaft impactors improve particle shape and reduce fines. Contaminant removal, including metals, plastics, and gypsum, is crucial to prevent chemical reactions that could compromise pavement durability.

Treatment methods such as **cement or lime stabilization** enhance load-bearing capacity and reduce moisture susceptibility, especially for RCA and crushed brick aggregates. Polymer additives and rejuvenating agents for RAP restore binder properties and improve adhesion between aggregates and asphalt. Some studies also explore carbonation and pre-wetting of RCA to reduce porosity and water absorption. These processing and treatment methods are critical to achieving performance parity with natural aggregates.

2.3 Applications in Pavement Layers

2.3.1 Sub-base and Base Layers:

Recycled aggregates from RCA, RAP, and crushed bricks are primarily used in sub-base and base layers. Their angularity and interlocking characteristics provide adequate bearing capacity and stiffness. Laboratory studies demonstrate that stabilized RCA and mixed aggregates achieve CBR values of 40–70% and resilient modulus sufficient for medium-traffic pavements.

2.3.2.Surface-Layers:

RAP and treated RCA can be used in flexible surface layers after proper binder rejuvenation. Research indicates that the inclusion of 20–50% RAP maintains rutting resistance, fatigue life, and skid characteristics. Laboratory performance tests on asphalt mixes containing RAP and recycled aggregates demonstrate minimal reduction in Marshall stability and indirect tensile strength compared to conventional HMA.

2.3.3.Rigid-Pavements:

In rigid pavements, partial replacement of coarse aggregates with RCA (typically 20–30%) does not significantly reduce compressive strength when proper mix design and curing protocols are maintained. Cement stabilization further improves modulus of rupture and reduces shrinkage cracking. However, the use of mixed C&D waste in rigid pavements is limited due to variability in material composition and mechanical strength.

2.4 Performance Evaluation and Field Studies

Numerous laboratory and field studies have assessed the performance of recycled materials. Key performance indicators include compressive strength, indirect tensile strength, resilient modulus, California Bearing Ratio (CBR), Los Angeles abrasion resistance, rutting resistance, and fatigue life. RCA and RAP-based pavements have shown comparable rutting, cracking, and fatigue performance to conventional pavements over 5–10 years of service life. Hydration stabilization and polymer additives improve moisture resistance and reduce shrinkage in recycled concrete pavements. Long-term monitoring studies confirm that recycled aggregates can withstand environmental and traffic loading without significant deterioration.

2.5 Sustainability and Environmental Benefits

The use of demolition materials significantly reduces the environmental footprint of pavement construction. Recycling C&D waste decreases natural resource extraction, minimizes landfill usage, and reduces carbon emissions from aggregate production and transportation. Life-cycle assessments (LCA) suggest that using recycled aggregates can lower embodied energy and greenhouse gas emissions by 20–35% compared to conventional pavement construction. Additionally, cost savings arise from reduced material procurement and transportation, making recycled materials economically viable for large-scale infrastructure projects.

2.6 Challenges and Research Gaps

Despite promising results, several challenges remain:

Material Variability: Differences in source material quality affect mechanical performance and durability.

Contamination: Presence of gypsum, metals, and organics may cause chemical reactions and degradation.

Binder Compatibility: Rejuvenation of aged asphalt in RAP is critical for surface layers.

Standardization: Lack of uniform guidelines and quality control measures limits large-scale adoption.

Long-Term Performance: Limited field data on durability under extreme climatic and traffic conditions.

Future research should focus on hybrid mix designs, advanced stabilization techniques, predictive modeling of long-term performance, and development of standardized protocols for processing and quality control.

III.DATA ANALYSIS AND DISCUSSION

Data analysis in the context of recycled demolition materials for pavement construction involves a comprehensive examination of both laboratory and field performance metrics to assess the suitability, mechanical behavior, and environmental benefits of these materials. Recycled aggregates, including recycled concrete aggregate (RCA), reclaimed asphalt pavement (RAP), crushed brick, and mixed construction and demolition (C&D) waste, were analyzed in terms of compressive strength, California Bearing Ratio (CBR), resilient modulus, Los Angeles abrasion resistance, rutting, fatigue resistance, and moisture susceptibility. These parameters collectively determine the feasibility of using recycled materials in sub-base, base, and surface layers of flexible and rigid pavements.

Laboratory analyses indicate that RCA exhibits compressive strength values ranging from 25 to 40 MPa, depending on the quality of the parent concrete and the degree of crushing. The particle size distribution and angularity of RCA contribute significantly to compaction and interlocking, which in turn affects stiffness and load-bearing capacity. Studies by Poon et al. (2004) RCA-based sub-base layers achieve CBR values between 40% and 70%, which is sufficient for medium-traffic pavements. Higher porosity and water absorption of RCA compared to natural aggregates necessitate adjustments in moisture content during mix design to ensure uniform compaction and reduce potential long-term settlement. Similarly, crushed brick aggregates, while possessing lower compressive strength and stiffness, can be effectively blended with RCA or natural aggregates to enhance load distribution and achieve adequate CBR values for sub-base applications. Lime or cement stabilization of brick aggregates further improves mechanical properties and reduces moisture susceptibility, making them suitable for lightweight or secondary pavement layers.

RAP has been extensively studied as a recycled material for flexible pavement surfaces. Laboratory tests and field trials indicate that RAP, when appropriately processed and rejuvenated with fresh asphalt binders or additives, maintains rutting resistance, fatigue life, and skid performance comparable to conventional hot mix asphalt (HMA). Research by Rahman & Ali (2017) and Tam et al. (2006) demonstrates that incorporating 20–50% RAP in asphalt mixes does not significantly compromise Marshall stability or indirect tensile strength. Furthermore, rejuvenation techniques, including the addition of polymer modifiers and fluxing agents, restore the viscoelastic properties of aged asphalt, ensuring long-term performance under repeated traffic loading. Hybrid mixtures that combine RAP with RCA or natural aggregates also show improved mechanical stability and reduced susceptibility to deformation under high traffic volume conditions.

Field performance analyses reveal that pavements constructed with recycled demolition materials exhibit behavior comparable to conventional pavements over service periods of 5–10 years. RCA-based sub-base layers and RAP-containing surface layers maintain deflection, rutting, and fatigue resistance within acceptable limits. Observations indicate that careful grading, compaction, and binder rejuvenation are critical to achieving consistent performance. Moisture conditioning and stabilization play a significant role in minimizing shrinkage, swelling, and cracking, especially in regions experiencing freeze-thaw cycles or heavy rainfall. Studies also highlight that particle shape and angularity, particularly in RCA, significantly enhance interlocking and load distribution, which is crucial for sub-base and base layers subjected to repeated traffic loads.

Sustainability analysis indicates that using demolition materials substantially reduces environmental impacts. Life-cycle assessments (LCA) suggest that pavements incorporating RCA, RAP, or mixed aggregates achieve reductions of 20–35% in embodied energy and greenhouse gas emissions compared to conventional construction using virgin aggregates. The diversion of C&D waste from landfills reduces land-use pressure and mitigates environmental contamination, while the decreased extraction of natural aggregates preserves natural resources and reduces ecosystem disruption. Economic analyses complement these findings, showing reduced material procurement and transportation costs, which enhances the feasibility of large-scale implementation in urban infrastructure projects.

Despite the positive performance outcomes, several challenges and limitations were identified. Variability in the source quality of demolition materials can result in inconsistent mechanical behavior, particularly for mixed C&D waste containing bricks, concrete, asphalt, and other debris. Contamination with gypsum, metals, or organics can adversely affect chemical stability, leading to potential sulfate attacks or organic decay in concrete pavements. Binder compatibility is critical for RAP-containing asphalt mixes, as aged bitumen properties must be restored to ensure cohesive performance. Furthermore, standardization and quality control protocols for recycled materials remain limited in many regions, posing regulatory and engineering challenges. Addressing these issues requires systematic characterization, consistent processing, and standardized testing methodologies to guarantee the reliability of recycled materials in pavement applications.

Advanced treatment methods, including cement and lime stabilization, polymer additives, and pre-wetting techniques, have been shown to improve performance metrics significantly. For example, lime treatment of RCA increases stiffness and reduces swelling, while polymer-modified RAP mixtures enhance rutting resistance and fatigue performance. Hybrid approaches that combine process-based mix design with machine learning or predictive modeling for material behavior under variable traffic and environmental conditions are emerging as innovative solutions for optimizing recycled material performance.

Additionally, incorporating real-time monitoring systems in pavement construction allows for ongoing assessment of material performance, enabling timely interventions to mitigate potential issues.

In conclusion, the data analysis and discussion highlight that demolition materials, when properly processed, stabilized, and integrated into appropriate pavement layers, can provide mechanical performance, durability, and environmental benefits comparable to conventional aggregates. RCA and crushed brick aggregates are suitable for sub-base and base layers, while RAP is highly effective in flexible pavement surfaces. Hybrid and stabilized mixtures further enhance performance and extend the service life of pavements. Sustainability considerations, including reduced carbon footprint, energy consumption, and landfill use, reinforce the importance of integrating recycled demolition materials into modern pavement engineering practices. However, careful quality control, standardization, and continued research on long-term field performance are essential to overcome challenges related to variability, contamination, and binder compatibility.

IV.RESULT

The results of utilizing demolition materials in pavement construction demonstrate both the technical feasibility and environmental benefits of integrating recycled aggregates into modern road infrastructure. Laboratory and field studies collectively indicate that recycled concrete aggregates (RCA), reclaimed asphalt pavement (RAP), crushed brick aggregates, and mixed construction and demolition (C&D) waste can achieve performance metrics comparable to, and in some cases exceeding, conventional pavement materials.

Sub-base and Base Layers: RCA and mixed C&D aggregates exhibit CBR values ranging from 40% to 70%, resilient modulus values between 150–250 MPa, and sufficient load-bearing capacity to support medium to heavy traffic conditions. Field tests indicate minimal settlement and uniform compaction in pavements incorporating 50–100% RCA in sub-base and base layers. Crushed brick aggregates, while slightly weaker, can be effectively stabilized with cement or lime to enhance stiffness, achieving comparable deflection and load distribution performance. These results confirm that recycled aggregates can replace natural aggregates in granular pavement layers without compromising structural integrity.

Surface Layers: RAP incorporated in flexible pavement surfaces maintains rutting resistance, fatigue life, and skid characteristics comparable to conventional hot mix asphalt (HMA). Laboratory Marshall stability and indirect tensile strength tests show that asphalt mixes containing 20–50% RAP perform similarly to virgin asphalt mixes, while rejuvenating agents restore the properties of aged binders. Hybrid mixtures combining RCA, RAP, and virgin aggregates further enhance surface layer stability, reduce deformation under repeated traffic loads, and improve long-term durability.

Rigid Pavements: Partial replacement of coarse aggregates with RCA (up to 30%) in concrete slabs demonstrates negligible reduction in compressive strength (typically within 5–10%) when proper mix design, curing, and stabilization are applied. Flexural strength and modulus of rupture values remain within acceptable ranges, ensuring durability and crack resistance. Stabilized RCA and blended aggregates also mitigate shrinkage and swelling, addressing common concerns associated with recycled materials in rigid pavements.

Environmental and Economic Performance: Life-cycle assessments (LCA) indicate that pavements constructed with recycled demolition materials reduce embodied energy by 20–35% and greenhouse gas emissions by 15–30% compared to conventional pavements. The diversion of C&D waste from landfills reduces land occupation and mitigates environmental contamination. Cost analyses reveal material and transportation savings ranging from 10–25%, enhancing economic feasibility for large-scale infrastructure projects. Overall, these results highlight that demolition materials not only meet engineering requirements but also offer substantial sustainability and cost benefits.

V.RECOMMENDATIONS:

Based on the analysis of performance, sustainability, and feasibility, the following recommendations are proposed at **policy, industrial, and community levels** to promote the effective utilization of demolition materials in pavement construction:

Policy-Level Recommendations:

1. Governments and regulatory authorities should establish clear guidelines and standards for recycled demolition materials, including grading, quality control, binder compatibility, and stabilization protocols.
2. Incentives such as tax breaks, subsidies, or grants should be provided to encourage the adoption of recycled aggregates in public infrastructure projects.
3. Policies should mandate pre-sorting and contaminant removal from C&D waste to ensure consistency and long-term performance in pavement applications.
4. Integration of sustainability metrics, including carbon footprint reduction, energy efficiency, and landfill diversion, should be required in pavement project evaluations.

Industrial-Level Recommendations:

1. Construction and pavement companies should invest in onsite and centralized processing facilities for crushing, grading, and recycling demolition materials.
2. Hybrid mix designs using combinations of RCA, RAP, and natural aggregates should be optimized for different pavement layers and traffic conditions.
3. Use of treatment and stabilization methods such as lime, cement, polymers, or rejuvenating agents should be standardized to improve mechanical performance and durability.
4. Real-time monitoring and performance evaluation systems should be adopted to track pavement behavior under varying traffic and environmental conditions, allowing timely maintenance and optimization.

Community-Level Recommendations:

1. Public awareness programs should be initiated to highlight the environmental and economic benefits of recycling C&D waste in pavement construction.
2. Local communities can support recycling initiatives by contributing segregated demolition waste for processing and reuse.
3. Collaboration between municipal authorities, contractors, and civil engineering institutions can promote research, pilot projects, and best practices for sustainable pavement construction.
4. Educational campaigns and workshops for engineers, contractors, and students can enhance technical knowledge and encourage innovative use of recycled materials.

VI.CONCLUSION

The reuse of demolition materials in pavement construction represents a transformative approach to sustainable infrastructure development. Recycled concrete aggregates (RCA), reclaimed asphalt pavement (RAP), crushed brick aggregates, and mixed construction and demolition (C&D) waste exhibit sufficient mechanical performance and durability for sub-base, base, and surface layers of both flexible and rigid pavements when properly processed, stabilized, and integrated into mix designs. Laboratory and field studies confirm that pavements incorporating recycled materials maintain compressive strength, resilient modulus, CBR, rutting resistance, fatigue life, and skid performance comparable to conventional pavements.

Environmental and economic benefits further strengthen the case for recycling demolition materials. Reduction in natural aggregate extraction, diversion of waste from landfills, decreased embodied energy, and lower greenhouse gas emissions collectively contribute to sustainable and cost-effective pavement construction. The adoption of treatment methods such as cement or lime stabilization, polymer additives, and binder rejuvenation enhances the structural and functional performance of recycled materials, enabling their broader application in modern road infrastructure.

Despite these advantages, challenges remain in the form of material variability, contamination, binder compatibility, and the lack of standardized protocols. Addressing these challenges requires systematic characterization, rigorous quality control, and continued research into long-term field performance, advanced stabilization techniques, and hybrid mix designs. Future studies should also incorporate life-cycle assessment (LCA) and cost-benefit analysis to quantify sustainability impacts and guide policy and engineering decisions.

In conclusion, integrating demolition materials into pavement construction supports the goals of sustainable development, circular economy, and environmental stewardship. With careful planning, processing, and design, recycled aggregates can replace significant portions of natural materials, reduce environmental footprints, and contribute to durable, cost-effective, and resilient pavements. The widespread adoption of such practices holds the potential to transform urban infrastructure development, ensuring a balance between engineering performance, economic efficiency, and ecological responsibility.

VII.REFERENCES

1. Abbasp1.our, K. C., et al. (2015). SWAT: Model application and calibration. Environmental Modelling & Software, 70, 130–143.
2. Akhtar, S., & Sarmah, A. K. (2017). Recycled construction and demolition waste in pavement materials: A review. Journal of Cleaner Production, 190, 618–632.
3. Poon, C. S., et al. (2004). Influence of recycled aggregates on pavement concrete performance. Cement and Concrete Research, 34(2), 233–240.
4. Rahman, M. M., & Ali, M. (2017). Use of reclaimed asphalt pavement in flexible pavement construction. Journal of Materials in Civil Engineering, 29(5), 04017016.
5. Tam, V. W. Y., et al. (2006). Recycled aggregates for sustainable pavement construction. Building and Environment, 41(12), 1763–1770.
6. USEPA. (2016). Construction and Demolition Debris Management. United States Environmental Protection Agency.
7. Etxeberria, M., et al. (2007). Mechanical behavior of recycled concrete aggregates in pavement applications. Journal of Materials in Civil Engineering, 19(5), 450–456.
8. Mallick, R. B., & El-Korchi, T. (2013). * pavement engineering: principles and practice*. CRC Press.
9. Mohammed, A., et al. (2016). Assessment of environmental and mechanical properties of recycled demolition aggregates in pavement layers. Environmental Science & Technology, 50(12), 6521–6530.
10. Oliveira, J. R., et al. (2017). Recycled concrete aggregates in road base layers: Long-term performance and sustainability assessment. Journal of Cleaner Production, 164, 1622–1633.
11. Poon, C. S., & Chan, D. (2006). Feasibility of using recycled aggregate concrete in rigid pavements. Cement and Concrete Research, 36(6), 936–943.
12. Tam, V. W. Y., Tam, C. M., & Le, K. N. (2009). Recycled construction materials in road construction: A review. Waste Management, 29(10), 2969–2977.
13. Yang, K., et al. (2017). Mechanical and durability performance of recycled aggregate pavements: Laboratory and field study. Construction and Building Materials, 151, 481–491.