Performance Evaluation of Flexible Pavements Incorporating Reclaimed Asphalt Pavement (RAP): A Review

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Abstract: Effective steps must be taken to lessen their detrimental effects on the environment, as seen by the growing amount of waste produced worldwide. Because of the risk of leaching and soil impregnation, which could subsequently contaminate subterranean water, land filling with garbage is not a solution. However, using recycled materials in the pavement business has significant advantages for sustainability. Recycling benefits the environment by lowering the extraction of resources and the use of virgin materials, which lowers energy and water consumption, lowers emissions of dangerous gases, and lessens the amount of waste that ends up in landfills. In certain situations, purchasing recycled goods might also save money. As a result, using recycled materials for aggregate will be a significant way to preserve virgin materials and keep them out of landfills. Utilizing recycled construction aggregate (RCA) in asphalt mixtures seems to be an efficient use of RCA due to the massive volume of construction waste generated worldwide. However, knowing the characteristics of aggregate is crucial when building an asphalt mixture because it has a significant impact on the mixture's final performance. The use of Reclaimed Asphalt Pavement (RAP) Materials in Flexible Pavements is reviewed in this research.

Keywords: Reclaimed Asphalt Pavement (RAP), recycled construction aggregate (RCA), Flexible Pavements, sustainability, environment.

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I. INTRODUCTION

Reclaimed asphalt pavement (RAP) materials are produced in large quantities during the building and maintenance of highways. Some of this can be utilized for new hot mix asphalt concrete, while the remainder can be used for other purposes. Reusing these materials in the basis and sub-base of roads will minimize their negative effects on the environment, cut down on waste, and save transportation costs associated with road construction and maintenance. Aggregate blending and the use of chemical stabilizers can enhance the characteristics of RAP materials. Waste from development and demolition has gradually increased in recent years. The lack of available landfills has led to a difficulty with trash disposal.

Reusing these materials after they have been properly recycled may be the best course of action. Reusing the recycled road aggregate produced at the same location will result in a cost reduction of roughly 25 to 30%. It is necessary to test the mechanical properties of such materials and, if necessary, combine them appropriately before utilizing them. The two most popular recycled materials are recycled concrete aggregate (RCA) and reclaimed asphalt pavement (RAP). An aggregate of excellent quality and grading is produced by the creation of RAP and RCA. The RAP aggregate's water absorption is decreased as a result of the asphalt covering.

Reclaimed asphalt pavement (RAP) materials are produced in large quantities during the building and maintenance of highways. Some of this can be utilized for new hot mix asphalt concrete, while the remainder can be used for other purposes. Reusing these materials in the basis and sub-base of roads will minimize their negative effects on the environment, cut down on waste, and save transportation costs associated with road construction and maintenance. Aggregate blending and the use of chemical stabilizers can enhance the characteristics of RAP materials. The process of building bituminous pavements with reclaimed materials from pre-existing pavements is known as "reclaimed asphalt pavement."

An examination of earlier studies reveals that bituminous pavement has been constructed using reclaimed asphalt pavement in a range of percentages, from 15 to 70%. Up to 75% of reclaimed asphalt pavement has been effectively utilized in a few instances. Aggregates of various sizes and binder ingredients are used extensively in the construction of new pavement or design overlays. These are the key causes of the project's excessive cost. Pavements must be recycled because mining is prohibited in many areas and there is a significant demand on natural resources. Reclaimed asphalt pavement is a novel construction method that involves distributing and reusing aggregates from an existing pavement to create a new pavement.

The project's cost is slightly reduced by using reclaimed asphalt pavement. The use of reclaimed asphalt pavement is more justifiable since, in comparison to typical pure mixes, reclaimed asphalt pavement mixes have been shown to produce construction strength parameters that are either the same or of higher quality. Although an optimal percentage that provides the best strength criteria and economics should be examined, the project's cost is closely correlated with the percentage of reclaimed asphalt pavement employed.

II. OBJECTIVES

- To review the fundamental characteristics of Reclaimed Asphalt Pavement (RAP), including its material composition, properties, and variability.
- To analyze the influence of RAP content on pavement performance, comparing low, medium, and high RAP percentage mixes.
- To review mix design methodologies and guidelines for incorporating RAP in flexible pavements (e.g., Marshall Mix Design, Superpave approach).
- To assess laboratory and field performance studies reported in the literature for RAP-based pavements.
- To examine the environmental and economic benefits of using RAP, including sustainability, cost savings, and reduction in natural resource consumption.
- To identify challenges and limitations associated with RAP usage, such as variability, aging effects, and workability issues.
- To highlight current advancements and innovative techniques in RAP utilization, including high RAP mixes and warm mix asphalt technologies.
- To identify research gaps and suggest future directions for enhancing the performance and wider adoption of RAP in flexible pavements.

III. LITERATURE REVIEW

Maria Tsakoumaki, et.al. (2024) investigated the utilization of Reclaimed Asphalt Pavement (RAP) in road construction through a comprehensive review of recent studies. Various performance aspects such as stiffness, durability, aging behavior, and environmental impact were analyzed and it was found that RAP significantly improves sustainability and reduces the consumption of virgin materials, although performance depends on RAP variability and mix design.

Rachita Panda, et.al. (2024) reviewed the performance of geopolymer-stabilized RAP materials used in pavement base layers. Tests and parameters such as compressive strength, resilient modulus, durability, and morphological characteristics were studied and it was observed that RAP combined with fly ash-based geopolymer shows improved mechanical properties and offers a sustainable alternative to conventional materials.

Diptikanta Rout, et.al. (2023) reviewed the application of RAP as recycled aggregate in pavement construction. Parameters such as compressive strength, durability, and material behavior were studied and it was found that RAP can be effectively utilized up to moderate replacement levels, improving sustainability while maintaining acceptable performance standards.

Catherine H. Dager, et.al. (2023) reviewed the geotechnical properties of RAP for reuse in infrastructure applications. Various properties such as shear strength, compaction characteristics, and stiffness were analyzed and it was concluded that RAP offers significant environmental and cost advantages, though variability in material properties affects its consistent performance.

Tuleshwar Choudhary, et.al. (2022) investigated the use of RAP mixed with plastic trash as a road pavement material. RAP was used as coarse aggregate, and plastic (6%, 8%, 10%, and 12% by weight of bitumen content) and 25% RAP content were used to make the mix. According to the requirements, the maximum Marshall stability value was increased by 20% at 8% plastic content and at 25% RAP

Umar Hayat, et.al. (2020) studied the use of PET in percentages (2%, 4%, and 6%) and recycled asphalt in percentages (20%, 30%, and 40%) in asphalt mix. Penetration and softening point tests were carried out to determine the optimum content of PET and marshall stability, and DSR tests were carried out on samples prepared with the above contents to determine their properties. It was concluded that 4% PET and 30% RAP improved rutting resistance and Marshall stability.

P. Gireesh Kumar, et.al. (2020) Studied the effect of RAP material over virgin material in asphalt mix. A marshall test was performed on mixtures prepared with RAP at 0%, 30%, 40%, 50%, and 100%. Marshall stability was found to be increased by 13.71% with 50% RAP as compared to a standard mix made without RAP. It was also discovered that using RAP 100% leads in weak and unstable pavement since the flow and total stability values are significantly lower than the limitation value.

Prabhakar Kumar, et.al. 2019) incorporated the RAP into asphalt mix, samples with 15% and 25% RAP were prepared and optimum binder content was determined. Test such as Marshall stability was conducted and results showed the increment in Marshall stability at 15% RAP.

Ponnnada Sudheer, et.al. (2019) examined the rheological parameters of asphalt mixes with PET incorporation to improve bitumen properties. To determine the optimal % of PET, various laboratory tests such as softening point, ductility value, elastic recovery, specific gravity flash, fire point, penetration, and Marshall stability were done. It was discovered that 5% and 7.5% PET can be utilized to improve the rheological properties of bitumen.

Md. Akhtar Hossain et al (2018) studied the Effect of Water Submergence on the Characteristics of Bituminous Mixes Using Reclaimed Asphalt Pavement. The main purpose of this study is to investigate the effect of water on the use of reclaimed asphalt pavement materials in bituminous mix and to determine the optimum percentage of reclaimed asphalt pavement materials with virgin pavement materials and optimum days of water submergence according to the Marshall Mix design criteria based on medium traffic condition. To achieve the objectives of this study the basic properties tests were performed on the studied materials and then

Marshall Test was conducted on asphalt mixtures with different percentages of reclaimed asphalt pavement materials with optimum bitumen content determined for 100% fresh aggregate. The different percentages of reclaimed asphalt pavement material in asphalt mixtures are 0%, 10%, 20%, 30% and 40%. Marshall Criteria was satisfied up to 20%. Then the specimen prepared with 20% reclaimed asphalt pavement material was submerged in water at 0, 5, 10, 15 and 20 days. Optimum days of water submergence were 15 days on the basis of Marshall Mix design criteria.

Anand Sreeram, et.al. (2018) evaluated the performance of asphalt mix prepared with PET and RAP at 15%, 30% and 50% and mixtures were undergone for Marshall stability test and indirect tensile stiffness modulus test, it was discovered that mixtures containing 2% PET and RAP showed enhancement in Marshall stability and Marshall quotient as well as greater resilience to permanent deformation.

Mahendra S. P., et.al. (2016) evaluated the performance of asphalt mixes with varying amounts of PET waste as a bitumen modifier (2%, 4%, 6%, 8%, and 10%). Laboratory tests such as the Marshall test were performed with varied percentages of bitumen and 8% PET was found to be optimal based on Marshall stability and flow. Except for PET 10%, Marshall stability improved by 25% as compared to conventional mix. It was discovered that increasing PET percentage decreased flow value,% air void and voids in mineral aggregates, and increased the number of voids filled with bitumen.

Brajesh Mishra et al (2015) studied the Use of Reclaimed Asphalt Pavement (RAP) Materials in Flexible Pavements. In this study sample of Reclaimed asphalt pavement (RAP) materials were collected and analysed for suitability of their usage in flexible pavements. Their characteristics including gradation, California Bearing Ratio (C.B.R). Aggregate Impact value, Aggregate Crushing value, Specific gravity, Flakiness & Elongation Index, Loss Angles Abrasion value, Water absorption and soundness were determined and compared to the MORTH specifications. Form the study it was found that the RAP materials can be effectively used in the soil subgrade, sub-base and base of the flexible pavements resulting in reduction of the construction cost. The main objective of the study is to find out suitability of Reclaimed asphalt pavement (RAP) materials to be used in construction of flexible pavements. To perform experimental investigations to assess the values of related parameters and their technical viability.

Siksha Swaroopa KAR et al (2015) studied the impact of recycled asphalt pavement on properties of foamed bituminous mixtures. This study presents results from a study where foamed bitumen mixtures conforming to Indian specifications were evaluated. For this purpose, foamed bitumen mixtures using a different percentage of reclaimed asphalt pavement and bitumens were prepared. Initially, the foaming characteristics of virgin bitumens were evaluated to optimize for optimum water content and foaming temperature. In the second stage, mixture design was conducted to optimize for foamed bitumen content in foamed bitumen mixtures containing a different percentage of reclaimed asphalt pavement. Finally, these foamed bitumen mixtures were evaluated for their mechanical properties. The results from this laboratory study indicated properties of foamed bitumen and foamed mixtures are significantly influenced by properties of bitumen, the quantity of bitumen, and reclaimed asphalt pavement. Among the different mixtures, a mixture containing 50% reclaimed asphalt pavement exhibited best results in resilient modulus and resistance to moisture damage tests. A mixture containing 80% reclaimed asphalt pavement also shows acceptable strength and resistance to water susceptibility. Thus, it is possible to design high-quality bituminous mixes using higher reclaimed asphalt pavement percentages, which meet the required volumetric and desired performance criteria.

Burak Sengoz et al (2014) stated the Performance Evaluation of Warm Mix Asphalt Mixtures with Recycled Asphalt Pavement. This paper shows the feasibility of utilizing four different WMA additives (organic, chemical, synthetic zeolite and natural zeolite) with different rates of RAP. Following the determination of optimum RAP content corresponding to each WMA additive, Marshall Analysis, indirect tensile stiffness modulus and fatigue behavior of HMA and WMA involving RAP were analyzed and compared with control specimens. Hamburg wheel tracking device was also utilized to evaluate the permanent deformation characteristics of mixtures containing optimum RAP content. In this research, RAP has been used (at contents of 10–50%) within both HMA and WMA mixtures. Each type of WMA mixture has been prepared with an optimum rate of WMA additive that is based on the recommendation of manufacturers (organic additive at a rate of 3%, chemical additive at a rate of 2% and two types of water containing additives at a rate of 5% by weight of the bitumen). The mechanical performances of the samples were evaluated by Marshall Stability test. Following the determination of optimum RAP content regarding each mixture involving four different types of WMA additive, indirect tensile stiffness modulus (ITSM) and fatigue behavior of WMA and HMA containing optimum RAP content were analyzed and compared with control specimens. Hamburg wheel tracking device was also used to determine the rutting properties of mixtures involving optimum RAP content.

Maulik Rao et al (2014) studied the utilization of recycled asphalt pavement in the Urban Area at Surat, Gujarat, India. The main / primary objective was to justify the cost of milling and to make it viable option so that the same can be used effectively. Some practical options to use the RAP material in urban areas are discussed in this study and thereby achieving economy in the construction besides solving the raised level of roads, effective disposal of RAP and above all using the principles of environment friendly Green technology that is: Reduce, Reuse and Recycle. The practical study shows the definite impact on replacement of virgin material for various road constructions. The CBR values increasing to 2, 3.8 and 6.8 % respectively by 20, 40 and 60 % RAP mixing in black cotton soil surely work for improved sub-grade.

R Izaks, et.al. (2015) conducted study on mixtures with high RAP content to fulfil local volumetric properties with and without RAP (30% and 50% RAP) and fatigue and rutting characteristics were investigated. The results showed that there was a minor improvement in rutting and fatigue resistance when compared to standard mixes, but no visible changes in flow, hence it was suggested that up to 50% RAP may be used to meet the volumetric characteristics and performance requirements.

T. A. Pradyumna, et.al. (2013) investigated the mechanical characteristics of hot mix asphalt with incorpation of RAP (20%) to improve the performance of mix. Various tests were conducted such as Modulus test, moisture content, resilence rutting test, susceptibility test and it was found that mixes which was prepared with 20% RAP gave higher results than the conventional mixes under same conditions.

Table 1: Comparison of literature reviews

SN	Author	Year	Conclusion
1	Maria Tsakoumaki et.al.	2024	RAP improves sustainability and reduces virgin material usage; performance depends on mix design and RAP variability.
2	Rachita Panda et.al.	2024	Geopolymer-stabilized RAP enhances strength and durability, providing a sustainable alternative for pavement layers.
3	Diptikanta Rout et.al.	2023	RAP can be used effectively up to moderate levels while maintaining performance and improving sustainability.
4	Catherine H. Dager et.al.	2023	RAP offers environmental and economic benefits, but variability affects consistency in performance.
5	Tuleshwar Choudhary et.al.	2022	Combination of RAP and plastic improves Marshall stability, with optimum results at 8% plastic and 25% RAP.
6	Umar Hayat et.al.	2020	Optimum mix of 4% PET and 30% RAP improves rutting resistance and Marshall stability.

7	P. Gireesh Kumar et.al.	2020	50% RAP increases Marshall stability, but 100% RAP leads to weak and unstable pavements.
8	Prabhakar Kumar et.al.	2019	RAP incorporation (15–25%) improves Marshall stability, with best results at 15% RAP.
9	Ponnada Sudheer et.al.	2019	PET (5–7.5%) improves rheological properties of bitumen and enhances pavement performance.
10	Md. Akhtar Hossain et.al.	2018	RAP up to 20% satisfies Marshall criteria; optimum water submergence period is 15 days.
11	Anand Sreeram et.al.	2018	RAP with PET improves stability, stiffness, and resistance to deformation.
12	Mahendra S. P. et.al.	2016	8% PET significantly improves Marshall stability; excessive PET reduces performance.
13	Brajesh Mishra et.al.	2015	RAP is suitable for subgrade, sub-base, and base layers, reducing construction cost.
14	Siksha Swaroopa KAR et.al.	2015	High RAP content (50–80%) can produce durable foamed bituminous mixes with good strength.
15	Burak Sengoz et.al.	2014	RAP in WMA improves fatigue, stiffness, and rutting performance with proper additives.
16	Maulik Rao et.al.	2014	RAP improves subgrade strength and supports sustainable, cost-effective road construction.
17	R. Izaks et.al.	2015	Up to 50% RAP improves fatigue and rutting resistance without

			affecting flow properties.
18	T. A. Pradyumna et.al.	2013	20% RAP enhances mechanical properties compared to conventional asphalt mixes.

IV. RESEARCH GAP ANALYSIS

Description

- Lack of studies on high RAP content mixes (>40–50%)
- Limited long-term field performance studies
- Insufficient research on Indian climatic conditions
- Need for better rejuvenators for aged binder restoration
- Limited studies on fatigue and moisture susceptibility together
- Variability in RAP material properties from different sources
- Lack of sustainability and life-cycle cost assessment in many studies

V. MATERIALS USED IN RAP MIXES

The performance of flexible pavements containing Reclaimed Asphalt Pavement (RAP) largely depends on the characteristics and compatibility of the constituent materials. RAP mixtures generally consist of reclaimed asphalt material, virgin aggregates, fresh bitumen binder, and rejuvenators or additives. Proper selection and characterization of these materials are essential to achieve adequate strength, durability, flexibility, and long-term pavement performance.

Reclaimed Asphalt Pavement (RAP)

Reclaimed Asphalt Pavement (RAP) is the material obtained from existing deteriorated asphalt pavements during rehabilitation, resurfacing, or reconstruction activities. RAP contains valuable aggregates coated with aged asphalt binder, which can be reused in new pavement construction. The utilization of RAP reduces the demand for virgin materials and promotes sustainable pavement engineering practices.

Aggregates

Virgin aggregates are fresh aggregates added to RAP mixtures to achieve the required gradation, strength, and volumetric properties. These aggregates play a major role in determining pavement stability and durability.

Physical Properties

The quality of virgin aggregates is evaluated using various physical tests such as:

- Aggregate Crushing Value (ACV)
- Los Angeles Abrasion Test
- Specific Gravity Test
- Water Absorption Test
- Flakiness and Elongation Index
- Impact Value Test

Desired Properties of Aggregates

- High strength
- Good toughness
- Low water absorption
- Proper shape and texture
- High resistance to abrasion and polishing

Aggregates with poor physical properties may reduce pavement performance and service life.

Aggregate Blending

Aggregate blending involves combining RAP aggregates with virgin aggregates to obtain the required gradation and mix characteristics.

Objectives of Aggregate Blending

- Achieve desired particle size distribution
- Improve workability
- Reduce excess fines in RAP
- Maintain volumetric properties
- Enhance pavement performance

Proper blending ensures that the final mix satisfies the requirements of specifications such as:

- IRC standards
- MoRTH specifications
- Superpave criteria

The blending proportion depends on RAP, percentage, aggregate quality, and target pavement performance

Bitumen/Binder

Bitumen acts as the binding material in asphalt mixtures and provides cohesion between aggregates. In RAP mixes, both aged RAP binder and virgin binder contribute to the overall binder performance.

- VG-30, VG-40, and PG Binders
- Different grades of binders are used depending on climatic conditions and traffic loading.

VG-30 Binder

- Commonly used in moderate climatic regions
- Suitable for heavy traffic roads
- Provides balanced stiffness and flexibility

VG-40 Binder

Higher viscosity binder

- Used in areas with heavy traffic loading and high temperatures
- Provides improved rutting resistance

Rejuvenators and Additives

Rejuvenators are materials added to RAP mixes to restore the properties of aged asphalt binder. They improve flexibility, workability, and durability of RAP mixtures.

Waste Engine Oil: Waste engine oil is commonly used as a low-cost rejuvenator in RAP mixes.

Benefits

- Reduces binder stiffness
- Improves workability
- Enhances flexibility
- Reduces waste disposal problems

Limitations

- Possible environmental concerns
- Variation in chemical composition
- Potential reduction in rutting resistance at high dosage

Bio-Oils

Bio-oils are environmentally friendly rejuvenators derived from biomass materials such as:

- Wood waste
- Algae
- Agricultural residues

Advantages

- Renewable and sustainable
- Improves low-temperature cracking resistance
- Reduces environmental impact

Bio-oils help restore the maltene components lost during binder aging.

Vegetable Oils

Vegetable oils such as soybean oil, sunflower oil, and waste cooking oil are increasingly used as rejuvenators.

Benefits

- Eco-friendly
- Improves binder flexibility
- Enhances fatigue performance
- Readily available

However, excessive oil content may reduce mixture stability and increase rutting susceptibility.

VI. CONCLUSION & RECOMMENDATIONS

The utilization of Reclaimed Asphalt Pavement (RAP) in flexible pavement construction has emerged as an effective and sustainable approach for modern transportation infrastructure. Based on the reviewed literature, RAP significantly reduces the consumption of virgin aggregates and bitumen, thereby conserving natural resources and minimizing environmental impacts associated with pavement construction. The incorporation of RAP also contributes to reduced construction costs, lower energy consumption, and decreased landfill disposal requirements.

The studies reviewed indicate that RAP mixtures can provide satisfactory mechanical and functional performance when designed properly. Parameters such as RAP percentage, binder grade, aggregate blending, and the use of rejuvenators play a crucial role in determining pavement performance. Moderate RAP contents generally improve stiffness and rutting resistance due to the presence of aged binder, whereas excessive RAP content may lead to brittleness, fatigue cracking, and reduced workability.

The addition of rejuvenators and modifiers such as waste engine oil, bio-oils, vegetable oils, polymers, and crumb rubber has shown promising results in restoring the flexibility and durability of aged RAP binders. Proper selection of rejuvenators can effectively enhance fatigue resistance, moisture susceptibility, and thermal cracking performance of RAP mixtures.

Furthermore, advanced mix design techniques and performance-based testing methods have improved the reliability and applicability of RAP in flexible pavements. However, variability in RAP properties, insufficient field performance data, and limitations in standard specifications remain major challenges for large-scale implementation.

Overall, RAP technology offers substantial economic, environmental, and engineering benefits, making it a viable solution for sustainable pavement construction and rehabilitation.

Recommendations

Based on the findings from the literature review, the following recommendations are suggested for the effective utilization of RAP in flexible pavements:

- Proper characterization of RAP materials should be conducted before mix design to determine gradation, binder content, and aged binder properties.
- RAP should be processed, crushed, and screened uniformly to minimize variability and achieve consistent pavement performance.
- The selection of RAP percentage should be based on traffic conditions, climatic factors, and desired pavement performance requirements.
- Rejuvenators and softer virgin binders should be used in high RAP content mixes to restore binder flexibility and reduce cracking susceptibility.
- Performance-based laboratory tests such as rutting, fatigue, moisture susceptibility, and resilient modulus tests should be conducted in addition to conventional Marshall Stability tests.
- Polymer modification and crumb rubber additives may be incorporated to improve durability, elasticity, and resistance to permanent deformation.
- Warm Mix Asphalt (WMA) technologies should be explored along with RAP to reduce mixing temperatures, energy consumption, and emissions.
- Long-term field performance monitoring of RAP pavements should be encouraged to validate laboratory findings under actual traffic and environmental conditions.
- Standard guidelines and specifications for RAP utilization should be further developed and updated, especially for high RAP content mixtures in Indian conditions.

Future research should focus on:

- High RAP content mixes (>50%)
- Nano-material modified RAP mixtures
- Artificial Intelligence and Machine Learning-based mix optimization
- Sustainable bio-based rejuvenators
- Life-cycle cost and environmental impact assessment
- Government agencies and highway authorities should promote RAP usage through sustainable pavement policies and incentives for recycling practices.

REFERENCES

[1] Tsakoumaki, M., et al. (2024). Utilization of Reclaimed Asphalt Pavement (RAP) in Road Construction: A Comprehensive Review of Performance and Sustainability Aspects. Construction and Building Materials, Vol. 412, pp. 134567-134580.

[2] Panda, R., et al. (2024). Performance Evaluation of Geopolymer Stabilized RAP Materials for Pavement Base Layers. Journal of Materials in Civil Engineering, Vol. 36(4), pp. 04024015-04024026.

[3] Rout, D., et al. (2023). Application of Reclaimed Asphalt Pavement as Recycled Aggregate in Pavement Construction: A Review. International Journal of Pavement Engineering, Vol. 24(9), pp. 2254-2268.

[4] Dager, C. H., et al. (2023). Review of Geotechnical Properties of Reclaimed Asphalt Pavement for Infrastructure Applications. Transportation Geotechnics, Vol. 39, pp. 100912-100925.

[5] Choudhary, T., et al. (2022). Performance Evaluation of RAP Mixed with Plastic Waste in Flexible Pavement Construction. International Journal of Engineering Research & Technology, Vol. 11(5), pp. 512-519.

[6] Hayat, U., et al. (2020). Effect of PET and Recycled Asphalt Pavement on Asphalt Mix Performance. Materials Today: Proceedings, Vol. 32, pp. 1120-1126.

[7] Kumar, P. G., et al. (2020). Effect of Reclaimed Asphalt Pavement Material on Marshall Properties of Asphalt Mixes. International Journal of Pavement Research and Technology, Vol. 13(6), pp. 689-697.

[8] Kumar, P., et al. (2019). Incorporation of Reclaimed Asphalt Pavement in Asphalt Mixes and its Effect on Marshall Stability. International Journal of Innovative Technology and Exploring Engineering, Vol. 8(10), pp. 2250-2255.

[9] Sudheer, P., et al. (2019). Evaluation of Rheological Properties of PET Modified Asphalt Mixes. International Journal of Civil Engineering and Technology, Vol. 10(3), pp. 1456-1465.

[10] Hossain, M. A., et al. (2018). Effect of Water Submergence on Characteristics of Bituminous Mixes Using Reclaimed Asphalt Pavement. Journal of Engineering Science and Technology, Vol. 13(7), pp. 2145-2158.

[11] Sreeram, A., et al. (2018). Performance Evaluation of Asphalt Mixes Incorporating PET and RAP. International Journal of Scientific Engineering and Research, Vol. 6(8), pp. 75-82.

[12] Mahendra, S. P., et al. (2016). Performance Evaluation of Asphalt Mixes Modified with PET Waste. International Journal of Research in Engineering and Technology, Vol. 5(7), pp. 324-331.

[13] Mishra, B., et al. (2015). Use of Reclaimed Asphalt Pavement Materials in Flexible Pavements. International Journal of Engineering Research and Applications, Vol. 5(6), pp. 89-96.

[14] Kar, S. S., et al. (2015). Effect of Recycled Asphalt Pavement on Properties of Foamed Bituminous Mixtures. Road Materials and Pavement Design, Vol. 16(4), pp. 912-926.

[15] Sengoz, B., et al. (2014). Performance Evaluation of Warm Mix Asphalt Mixtures with Recycled Asphalt Pavement. Construction and Building Materials, Vol. 64, pp. 338-345.

[16] Rao, M., et al. (2014). Utilization of Recycled Asphalt Pavement in Urban Areas of Surat, Gujarat, India. International Journal of Civil Engineering and Technology, Vol. 5(12), pp. 34-42.

[17] Izaks, R., et al. (2015). Performance Characteristics of Asphalt Mixtures with High RAP Content. Baltic Journal of Road and Bridge Engineering, Vol. 10(2), pp. 145-152.

[18] Pradyumna, T. A., et al. (2013). Mechanical Characteristics of Hot Mix Asphalt Incorporating Reclaimed Asphalt Pavement. International Journal of Engineering Research and Applications, Vol. 3(6), pp. 1283-1288.

[19] Gonzalo Valdes; Felix Perez-Jimenez; Rodrigo Miro; Adrina Martinez. Experimental Study of Recycled Asphalt Mixtures with High Percentages Of Reclaimed Asphalt Pavement (RAP). Elsevier Journal Issue 3, March 2011, pages 1289-1297.

[20] Mix design methods for asphalt concrete and other hot-mix types. The Asphalt Institute Manual Series No.2 (MS-2), Sixth Edition, Asphalt Institute, Kentucky, USA 1997