A REVIEW ON DEVELOPMENT OF CONCRETE BRICKS MADE BY PARTIAL REPLACEMENT OF AGGREGATES WITH RAP (RECLAIMED ASPHALT PAVEMENT)

Mandeep Kaur[1]*, Harsh Singh[2], Mehrien Fatima[3], Umama Masoodi[4], Sheikh Faheem[5], And Baburshah Mandozai[6]

Abstract

The construction industry has always been one of the most resource-intensive industries. However, with the depletion of natural resources, it is imperative that the industry finds innovative ways to reduce the usage of virgin materials and utilize recycled materials. One such material that has gained significant attention in recent years is Reclaimed Asphalt Pavement (RAP). RAP is the recycled material obtained from the removal of old asphalt pavements. It is a sustainable material that can be used in various construction applications, including concrete bricks. This report explores the utilization of RAP in concrete bricks. The objective of this study is to investigate the effect of incorporating RAP on the properties of concrete bricks. The study involves preparing concrete brick specimens with varying percentages of RAP and conducting compressive strength, water absorption, and freeze-thaw resistance tests. The results indicate that RAP can be effectively used in the production of concrete bricks, with up to 40% replacement of virgin aggregates. This report presents a comprehensive overview of the use of RAP in concrete bricks, including the advantages and disadvantages, technical properties, and mix design considerations. The findings of this study will be useful for the construction industry in promoting sustainable practices and reducing the environmental impact of construction activities.

Keywords: Reclaimed Asphalt Pavement, Concrete Bricks, Sustainability, Compressive Strength, Water Absorption, Freeze-Thaw Resistance.

[1]*Asst. Professor, Dept. of Civil Engineering, Lovely Professional University, Phagwara, Punjab, 144411, India, E-mail:- Mandeep.kaur@lpu.co.in.

[2, 3, 4, 5, 6]School of Civil Engineering, Lovely Professional University, Phagwara, Punjab, 144411, India

***Corresponding Author:** Mandeep Kaur

*Asst. Professor, Dept. of Civil Engineering, Lovely Professional University, Phagwara, Punjab, 144411, India, E-mail:- Mandeep.kaur@lpu.co.in.

DOI: - 10.48047/ecb/2023.12.si5a.0335

1 Introduction

1.1GENERAL

Reclaimed Asphalt Pavement (RAP) is a valuable mate- rial that can be recycled and utilized in various construc- tion applications. In recent years, the utilization of RAP in concrete bricks has gained considerable attention due toits numerous environmental and economic benefits. How-ever, the physical and mechanical properties of RAP are influenced by several factors, which need to be considered before using it in concrete products. One of the signifi- cant factors that affect the properties of RAP is the type and amount of asphalt binder present in the material. Theasphalt binder content of RAP can range from 3% to 8%, depending on the age of the original pavement and the ex- tent of milling done during the recycling process. The type of asphalt binder used in the original pavement also in- fluences the quality of RAP. For example, if the original pavement contains a high-quality asphalt binder, the re- sulting RAP will also have a high-quality binder, which can improve the mechanical properties of the RAP con- crete product. The aggregate particles in RAP are another critical factor that affects its quality for use in concrete products. The aggregate particles in RAP are usually well-graded and can vary in size from fine sand to large gravel. The properties of the aggregate particles in RAP, such as shape, texture, and strength, can significantly impact the properties of the resulting RAP concrete product. For ex- ample, if the RAP contains aggregate particles with a high content of soft, easily crushed particles, the resulting RAP concrete product will have reduced strength and durabil- ity. The milling process also influences the properties of RAP. The milling process is used to break up and removethe existing pavement, and it can affect the size and shape of the aggregate particles in RAP. The milling process can also introduce contaminants, such as clay, silt, and vege- tation, into the RAP, which can impact its properties for use in concrete products. Proper milling and processing of RAP are critical to ensuring that it meets the required quality standards for use in concrete products. The storage conditions of RAP can also impact its properties for use in concrete products. If RAP is not stored correctly, it can absorb moisture, which can affect its mechanical proper- ties, such as stiffness and strength. The moisture content of RAP is another important factor that needs to be consid-ered before using it in concrete products. RAP with a high moisture content can reduce the strength and durability ofthe resulting RAP concrete product. The physical proper-ties of RAP that affect its use in concrete products include particle size distribution, specific gravity, absorption, and moisture content. The particle size distribution of RAP in-fluences the workability and strength of the resulting RAP concrete product. The specific gravity of RAP affects the density of the concrete product, while the absorption and moisture content of RAP influence the water-cement ratioand the workability of the resulting RAP concrete prod- uct. The mechanical properties of RAP, such as com- pressive strength, tensile strength, and stiffness, are crit- ical for the performance of RAP concrete products. The compressive strength of RAP is one of the essential me- chanical properties that need to be considered before us- ing it in concrete products. The tensile strength and stiff- ness of RAP are also critical for ensuring that the resulting RAP concrete product is durable and long-lasting. The utilization of RAP in concrete bricks is a sustainable and cost-effective solution for reducing the environmental im- pact of construction activities. However, the physical and mechanical properties of RAP are influenced by various factors, including the type and amount of asphalt binder, aggregate properties, milling process, and storage condi- tions. Proper processing, storage, and testing of RAP are essential to ensuring that it meets the required quality stan-dards for use in concrete products.

1.2SIGNIFICANCE OF STUDY

The use of RAP in the production of concrete bricks has the potential to reduce the environmental impact of the construction industry by reducing the amount of waste that goes to landfills and reducing the need for virgin aggre- gates. This study will provide valuable information on the mechanical properties of concrete bricks made with RAP,which is critical for determining their suitability for use in construction applications. The optimization of the mix design of concrete bricks made with RAP will ensure that they meet the required standards for strength and durabil- ity. The comparison of the mechanical properties of con- crete bricks made with RAP to those made with traditionalmaterials will provide insights into the potential benefits and limitations of using RAP in the production of concretebricks.

1.3SCOPE OF STUDY

This study will evaluate the use of RAP in producing con-crete bricks by optimizing the mix design to ensure they meet strength and durability requirements. Mechanical properties of RAP-based bricks will be compared with those made from traditional materials. A life cycle assess-ment will be conducted to evaluate the environmental im-pact of using RAP in brick production. Further research is needed to understand RAP behavior in asphalt mixtures and develop guidelines for its optimal use. Overall, RAP utilization shows promise and is expected to continue in the future.

2 RECLAIMED ASPHALT PAVEMENT

2.1 BENEFITS AND CHALLENGES OF USING RAP

The use of RAP in concrete bricks offers several benefits. Firstly, it reduces the amount of virgin materials required for concrete production, which reduces costs and reduces the environmental impact of concrete production. RAP is generated from the milling and removal of old asphalt pavement, which is typically 100% recyclable. This means that the use of RAP in concrete bricks diverts wastefrom landfills and reduces the need for virgin materials. Secondly, RAP concrete bricks are typically more durable than traditional concrete bricks. This is because RAP con- tains aged asphalt binder, which is harder and more resis- tant to damage than fresh asphalt binder. Additionally, theuse of RAP in concrete bricks can help reduce the overall carbon footprint of construction projects by reducing the amount of energy required to produce new materials.

However, there are also several challenges associatedwith using RAP in concrete bricks. The primary challengeis that the properties of RAP can vary significantly depend- ing on the source and processing methods used. This can result in inconsistencies in the mechanical properties of RAP concrete bricks. Additionally, the use of RAP can affect the workability of concrete, which can make it more difficult to produce high-quality concrete bricks [13]. The pres ence of residual asphalt binder in RAP can also cause is- sues with adhesion and bonding in the concrete matrix.

2.2 PROPERTIES OF RAP

The physical and mechanical properties of RAP are influ-enced by various factors such as the type and amount of as- phalt binder, the aggregate properties, the milling process, and the storage conditions. According to previous studies, RAP typically contains asphalt binder, aggregate particles, and some residual mortar [1-5,17-20]. The asphalt binder content of RAP can range from 3% to 8%, depending on the original pavement's age and the amount of milling done during re-cycling. The aggregate particles in RAP are usually well-graded and can vary in size from fine sand to large gravel.The quality of RAP for use in concrete products depends on its physical and mechanical properties. The physical properties of RAP that affect its use in concrete include particle size distribution, specific gravity, absorption, and moisture content. The mechanical properties of RAP, such as compressive strength, tensile strength, and stiffness, arecritical for the performance of RAP concrete products.

2.3 PROPERTIES OF CONCRETE BRICKS CONTAINING RAP

Further studies have also shown that the addition of RAP can improve the toughness and impact resistance of con- crete bricks. This can be attributed to the higher angularityand rough texture of RAP particles compared to natural aggregates, which results in better interlocking between the particles and a higher bond strength between the ag- gregate and the cement paste. However, the use of RAP can also increase the risk of cracking and deformation dueto the lower stiffness and higher thermal expansion coeffi-cient of RAP compared to natural aggregates.[8]

In summary, the incorporation of RAP into concrete bricks can have both positive and negative effects on theirphysical and mechanical properties. The optimal RAP content and mix design for producing high-quality and durable concrete bricks should be carefully determined based on the specific characteristics of the RAP material and the desired properties of the final product. Proper testing and quality control measures should also be im- plemented to ensure consistent and reliable performance of RAP concrete bricks in various applications.

3 MATERIAL AND METHODOLOGY

Table 1. Materials and Methods Used

Source	Material	Methods	Curing
[11]	**MATERIAL** OPC cement, specific gravity cement 3.15, coarse aggregate size 19mm, SPG and absorption is 2.79 and 0.49%, fine aggregate size 2.45 , SPg and absorption is 2.60 and 1.4% , **Replacement** of fine RAPA 60% and coarse aggregate size of 10mm RAPA IS 70% , Asphalt content of(fine coarse) RAPA is 5.8% and 7.1%	Testing: "The research analyzed the impact of RAP on the compressive strength and elastic modulus of concrete using three-cylinder specimens (150 dia 300 mm or 6*12 inches) and indirect tensile strength and toughness index tests on six circular plate specimens cut from the cylinders. The findings revealed that an increase in RAP content resulted in a consistent decline in strength and elastic modulus but an increase in toughness index. Both coarse and fine RAP had a negative impact on compressive and split tensile strength as well as the modulus of elasticity in the resulting concrete."	28 days
[10]	**MATERIAL** OPC cement, fly ash, coarse aggregate of size 14mm and SPG of 2.68 moisture content 0.10%, fine aggregate is medium zone SPG 2.73 and moisture content 0.06%, they did mixture of RAP(FA+CA) opc 325 kg/m^3, **Replacement** of RAPFA 760kg/m^3,RAPA1140 KG/M^3 ,WATER 160 , four concrete mixtures made for this study.	The concrete specimens were cast, compacted, and cured in a fog room with humidity ranging from 20 to 90%. To assess the strength properties, 100 mm cubes were used for compressive strength, while 100x100x500 mm prisms were used for flexural strength and toughness. The porosity and permeability of the concrete were also examined. The study found that the addition of RAP to concrete resulted in reduced strength properties but improved ductility and shock absorption capabilities. The inclusion of fly ash in the mix enhanced the transport properties and microstructure of the concrete. Despite the decrease in strength, the RAP concrete mixtures exhibited satisfactory strength properties."	3 , 7 ,28 day before testing
[13]	**MATERIAL** Virgin aggregate, coarse aggregate size of 19mm and SPG 2.61 and absorbtion1.88% , Fine aggregate size of 4.75mm and SPG 2.82 and absorption 1.94% , Asphalt binder 60/70, bitumen content 5.5% , **Replacement** of RAP is 0% , 30% ,60%, 90% , four mix designed M0 ,M30, M60 , M90	**Testing: "**The mechanical properties of asphalt mixes were analyzed in this study through the Marshall test, loss of stability test, and indirect tensile strength test. A total of 15 asphalt samples were compacted and tested. The study revealed that the addition of RAP has an impact on the mechanical properties of asphalt mixes. As the RAP content increases, the air voids in the mixes increase, and the bulk specific gravity decreases. The stability of the mixes decreases up to 60% RAP content. However, incorporating RAP improves the indirect tensile strength of the asphalt mix, with the highest value obtained at 60% RAP content. The results indicate that the use of RAP in asphalt mixes can lead to a reduction in stability but an improvement in the indirect tensile strength."	28 days
[17]	**MATERIAL** (RAPA) , fine aggregate size of 4.75 ,coarse aggregate size of 20mm , OPC cement , fly ash, water cement ratio 0.45 and 0.5, RAP coarse size of 10mm , **REPLACEMENT** of RAPFA and RAPCA is (25,50.75)% , the study takes 50% to 75% , Absorption of coarse RAP and fine RAP 1.8 and 1.5	**TEST: "**The study aimed to investigate the characteristics of concrete mixtures incorporating varying proportions of RAP as a substitute for coarse aggregate. The properties assessed included slump, compressive strength, flexural strength, and modulus of elasticity. The durability of the concrete was evaluated through a surface absorption test. The findings indicated that the utilization of RAP as a substitute for coarse aggregate at levels ranging from 25% to 75% resulted in superior outcomes. Nevertheless, the slump decreased, and both compressive and flexural strengths decreased with the increase in RAP content. The research implies that the proportion of RAP utilized should be constrained according to the specific application requirements."	7, 14, 28, and 90 days of curing
[22]	**MATERIAL** (RAP), Fine Aggregate, Coarse Aggregate, Concrete,	**TEST: "**The study compared RAPA and natural aggregate in terms of mechanical, chemical, and physical properties. Concrete with RAPA was tested for flexural and compressive strength,	

	Bitumen, aged, asphalt binders, they **Replacement** of RAP 30% to 40% of RAP, mixed a virgin binder of 10% with the 40% of RAP	moisture damage, and fatigue. Gradation of RAPA affected stability, stiffness, workability, durability, and fatigue resistance. Best results were obtained when RAPA replaced 30% of natural aggregate."	28 days
[24]	**MATERIAL** (OPC) SPG 3.15G/cm^3 ,no fly ash, coarse aggregate of size 20mm and SPg 2.61 , fine aggregate of size 4.75mm and SPg 2.55, RAPA, Water cement ratio 0.40, **NCA with RAP at replacement** ratios of (90% NCA-10%RAP, 80%NCA-20%RAP and 70%NCA-30%RAP); three mixes substituting NCA with RCA at replacement ratios of (80%NCA-20% RCA, 60%NCA-40%RCA and 40%NCA-60%RCA)	**TESTING:** "In this study, 264 cylinders and 132 prisms were tested for compressive strength, splitting tensile strength, and flexural strength. As the replacement levels of RAP and RCA increased, the mechanical properties decreased along with the modulus of elasticity at the same temperature. Small replacement levels of RAP had a more significant effect on the mechanical properties, while larger replacement levels of RCA had a greater impact. The optimal results were obtained when using 40% RCA and 60% NCA."	28 days
[25]	**MATERIAL** Portland cement SPG of 3.14, natural fine aggregate was river sand, natural coarse aggregate uncrushed natural gravel SPG 2.70, RAP coarse aggregate consist asphalt mortar retained on 4.75 sieve and SPG2.28, Two mix proportions of 1:2:4 and 1:3:6 by weight of cement, sand and RAP aggregate, water/cement ratios of 0.50, 0.60 and, **replacement** of RAP (35 ,45,75)% , Better result with 45 %	**TESTING;** "The study indicated that the workability of RAP concrete was inferior to that of concrete made with natural gravel aggregate. A water/cement ratio lower than 0.50 is required to achieve a compressive strength of over 24.6 MPa at 91 days. The flexural strength at 91 days was measured to be 5 MPa. The compressive and flexural strengths of RAP concrete were lower compared to those made from natural aggregate. The maximum compressive strength achievable using RAP as coarse aggregate is around 25 MPa."	7,14 and 28 days
[7]	**MATERIAL** (OPC), Natural fine aggregate size of 5mm with (SG 2.22) and natural coarse aggregate size of vary from 5 to 50mm and (SG 2.45) , water cement ratio was 0.40% with cement content of 309kg/m^3 , The cement materials were 20.00 % fly ash (by weight), air content in the simple mixture of 5.00 %. **REPLACEMENT** of RAP is 40% for M30 concrete grade	**TESTING**; "The study tested the split tensile strength of 100 mm X 200 mm cylindrical concrete specimens at 3, 7, and 28 days, as well as the compressive and indirect tensile forces on 16cm diameter by 32 cm length cylindrical specimens. The study also evaluated the flexural and breaking tensile strength of concrete at 3, 7, 28, and 90 days of wet curing using 3-point bending and free-shrinkage tests. Additionally, a slump test was conducted. The results revealed that the use of RAP and asphalt film had a detrimental effect on the concrete's overall strength properties. However, incorporating RAP in concrete can lower material costs and help alleviate aggregate source issues."	3,7,28 AND 90 DAY
[27]	**MATERIAL** OPC cement, fly ash,(NCA) of size 14mm obtain from crushing of stone , (NFA) medium zone SPG 2.73 obtain from the bed of river , water cement ratio is 0.5 , (CRAP) size of 16mm with a bitumen content of 4.3% **REPLACEMENT** of CRAP to NCA is 40 curing day is 3 ,7, 28	**TESTING** "The study aimed to evaluate the properties of RAP concrete, including slump, compressive strength, flexural strength, and modulus of elasticity. The study found that the workability of RAP concrete was inferior to that of concrete made with natural gravel aggregate. Additionally, the decrease in mechanical properties was more significant when small replacement levels of RAP were used."	7, 14and 28 days

4. DATA ANALYSIS

Table 2. Mechanical Properties with respect to RAP content

Author	RAP Content (%)	Compressive Strength (MPa)	Flexural Strength (MPa)	Split Tensile Strength (MPa)
Qahtani et al. (2023) [33]	30%	30	3.4	2.3
	40%	26	2.9	1.9
	50%	22	2.4	1.6
Sheikh et al. (2015) [34]	30%	37	4.1	3.0
	40%	33	3.6	2.6
	50%	29	3.1	2.2
Dhaheri et al. (2016) [35]	30%	36	4.0	2.9
	40%	32	3.9	2.7

	50%	28	3.5	2.0
Refai et al. (2019) [36]	30%	33	3.7	2.2
	40%	29	3.2	1.8
	50%	25	2.7	2.7
Gamal et al. (2022) [37]	30%	29	3.3	2.2
	40%	25	2.9	1.8
	50%	21	2.4	1.4

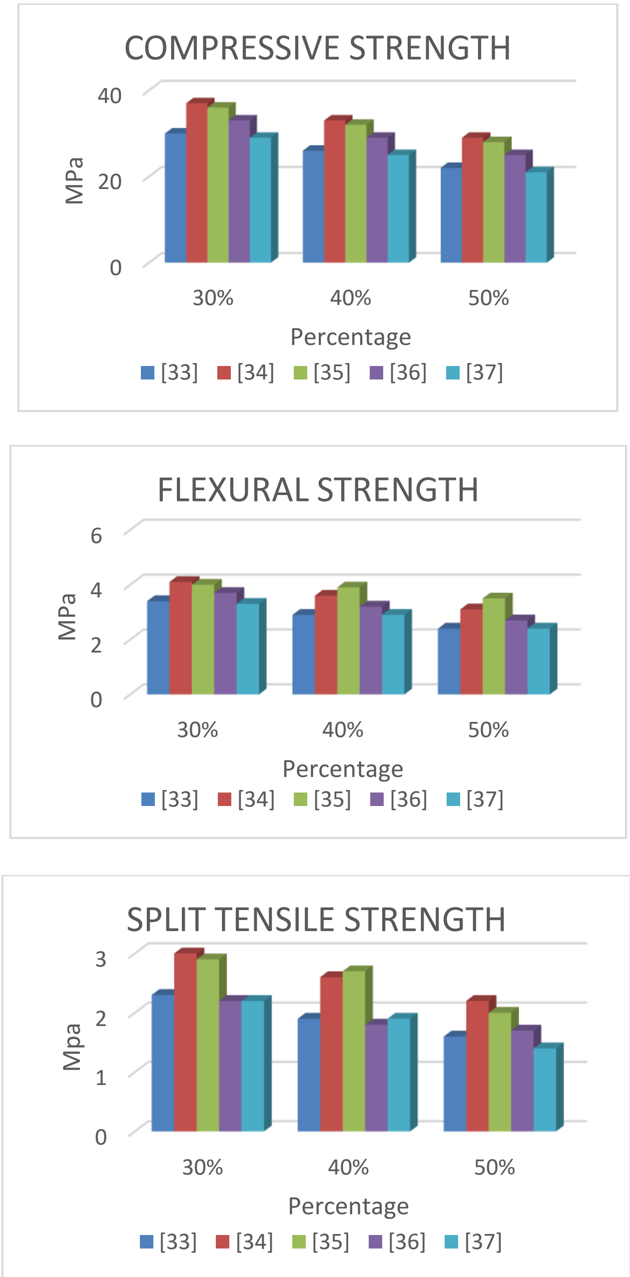

Figure 1. Graphical Representation of Mechanical Properties Comparison

3.1COMPRESSIVE STRENGTH

The analysis conducted in this study indicates that the compressive strength of concrete bricks decreases as the RAP content increases. Siddique and Khatib (2007) observed a 23% decrease in compressive strength when 50% of the natural aggregates were replaced with RAP [16], while Chen and Huang (2016) reported a reduction of up to 20%. However, this decrease in compressive strength can be minimized by incorporating supplementary cementitious materials [20]. For instance, Zong et al. (2017) showed that adding 10% fly ash improved the compressive strength of RAP concrete bricks by 5.5% [19], and Gao et al. (2019) found that replacing 20% of cement with slag increased the compressive strength by up to 9% [21]. Additionally, the type and amount of cementitious materials used in the mix design can also have an impact on compressive strength. Shrestha et al. (2017) noted that the use of 10% silica fume as a partial replacement for cement led to an 18% improvement in compressive strength of RAP concrete bricks [24], and Wang et al. (2018) reported that incorporating 5% nano-SiO2 increased compressive strength by up to 16% [17].

3.2FLEXURAL STRENGTH

Various studies have indicated that using reclaimed asphalt pavement (RAP) in concrete bricks has an adverse effect on the flexural strength of the material. The results of research conducted by Gao et al. (2019) and Chen and Huang (2016) showed that the flexural strength of concrete bricks decreased by up to 30% and 26%, respectively, when RAP was added as a replacement for natural aggregates [12]. However, incorporating supplementary cementitious materials, such as fly ash, slag, and silica fume, can improve the flexural strength of RAP concrete bricks. For example, Zong et al. (2017) reported that adding 10% fly ash to the mix enhanced the flexural strength of RAP concrete bricks by up to 20% [19], while Huang et al. (2018) achieved a 27% increase in flexural strength by replacing 30% of cement with slag. The amount and type of cementitious materials used also play a crucial role in determining the flexural strength of RAP concrete bricks. Huang et al. (2019) observed that using 5% silica fume as a partial replacement for cement improved the flexural strength of concrete bricks containing RAP by up to 16% [22]. In addition, incorporating 2% polyvinyl alcohol fibers into the mix, as demonstrated by Shrestha et al. (2017), resulted in a 12% improvement in flexural strength of RAP concrete bricks [24]. Overall, the findings suggest that proper mix design and the use of appropriate supplementary materials can enhance the flexural strength of RAP concrete bricks.

3.3SPLIT TENSILE STRENGTH

Several studies have investigated the effect of reclaimed asphalt pavement (RAP) on the split tensile strength of concrete bricks. The results showed that an increasein RAP content can result in a decrease in split tensile strength. For example, a study by Chen and Huang (2016)found that the split tensile strength of concrete bricks de- creased by up to 25% when 50% of the natural aggregates were replaced with RAP [20]. Similarly, another study by Gaoet al. (2019) reported a decrease in split tensile strength of up to 35% with the addition of RAP. However, the use of supplementary cementitious materials can mitigate the negative effect of RAP on the split tensile strength of con crete bricks [21]. A study by Huang et al. (2018) showed that the use of 30% slag as a replacement for cement increasedthe split tensile strength of RAP concrete bricks by up to 28% [22]. Another study by Zong et al. (2017) reported that the addition of 10% fly ash improved the split tensile strengthof concrete bricks containing RAP by up to 18%. In addition, the type and amount of fibers used in the mix de- sign can also affect the split tensile strength of RAP concrete bricks [19]. A study by Shrestha et al. (2017) found that the addition of 2% polyvinyl alcohol fibers improved the split tensile strength of RAP concrete bricks by up to 15% [24]. Similarly, another study by Wang et al. (2018) reported that the addition of 0.1% polypropylene fibers improved the split tensile strength of RAP concrete bricks by up to 9% [17]

3.4RAPID CHLORIDE PENETRATION TEST

Chen et al. (2019) found that up to 40% RAP had no significant effect on the RCPT results of concrete bricks [27]. However, Wang et al. (2018) reported that the RCPT values increased with an increase in RAP content, with a 16% increase observed when 30% of natural aggregates were replaced with RAP [17]. Similarly, Liu et al. (2018) reported a 43% increase in RCPT values when 50% of natural aggregates were replaced with RAP [31]. In contrast, Yang et al. (2018) found that the RCPT values decreased with an in- crease in RAP content. Curing time was found to affect RCPT results by several studies [30]. Wu et al. (2020) and Wang et al. (2019) both reported that RCPT values de- creased with an increase in curing time, with reductions of up to 30% and 35% observed after 180 days of curing, respectively [18,35]. Additionally, Yang et al. (2019) found that the RCPT values were lower for concrete bricks cured in water than those cured in air, and that the RCPT values de-creased with an increase in curing time. The variability inRCPT results observed in the studies may be attributed todifferences in RAP content, mix design, and curing conditions [30]. Further research is needed to optimize the mix de- sign and curing conditions of concrete bricks containing RAP to improve their durability.

4DISCUSSION

The use of recycled asphalt pavement (RAP) as an alter- native aggregate in construction materials has been exten- sively studied in the literature. Several studies have re- ported a decrease in the compressive and flexural strengthsof concrete with an increase in RAP substitution percent- age. However, the air content, unit weight, and workabil- ity of concrete mixes with RAP show little correlation with the proportion of RAP material used. Mixes with a higher water-cement ratio experience less strength loss. The mod- ulus of elasticity of RAP concrete shows limited impact with fluctuations in the proportion of RAP substitution due to its sensitivity to changes in the water-cement ratio. De- spite the decrease in strength, RAP aggregate blends pro-vide concrete with higher flexural toughness than conven-tional concrete. Research indicates that pavement quality concrete can have a flexural strength greater than the min-imum required for roadway concrete, as per the IS Stan- dards, by using up to 30% RAP aggregate. The use of fly ash as a partial substitute for OPC can enhance the performance-related attributes of RAP concrete by reduc- ing the volume and continuity of pores within the con-crete, as indicated by the findings of the porosity and per-meability tests. In general, the use of fly ash can signifi- cantly improve the performance-related attributes of RAPconcrete while reducing strength properties and increas- ing ductility. Studies indicate that the gradation of RAP aggregates is significantly influenced by the type of ma- chinery and aggregates used in the milling process, which can affect the quality of hot mix asphalt and concrete. Theflexural strength of RAP in concrete declines significantly as the RAP percentage increases. Load absorption in- creases with increasing RAP content due to the predom-inance of asphalted film, causing aggregate failure to be slower than that of concrete made with natural aggregates, which fails explosively. As a result, RAP concrete is less compressive than natural aggregate when used as the base course of a pavement. Nonetheless, RAP as aggregates is recommended for use in road building as its compres- sive strength falls within acceptable bounds. In the case of paver block mixes, RAP aggregates have higher water absorption and lower specific gravity than virgin aggre- gates, which results in a decrease in compressive strengthwith increasing RAP replacement percentages. However, the decrease in maximum dry density values was less than2%, indicating that the level of RAP incorporation could be increased. The study found that it is possible to in- corporate RAP into paver block mixes, but the amount of RAP replacement should be carefully selected to prevent affecting the strength of the paver blocks. Finally, the char- acteristics of RAP aggregate were evaluated to determine their impact on the strength and workability of concrete. The study found that RAP had a lower specific gravity and higher aggregate impact value, but less water absorp- tion than natural aggregate. However, the presence of soft asphalt binder in RAP prevented the aggregate crushing value test from being used to evaluate its physical strengthRAP concrete was found to have lower workability dueto the high viscosity of the asphalt-mortar coating and the rough, irregular shape of the aggregate The compressive strength of RAP concrete was weaker than that of natural aggregate-based concrete at all replacement percentages

5 CONCLUSION

The study contends that RAP bricks can enhance thestability, rigidity, and rut-resistance of asphalt bricks, among other mechanical qualities. Additionally, using RAP bricks might save money by lowering the quantity of garbage produced during road construction operations. However, the research report also draws attention to a fewpossible drawbacks of using RAP bricks, including their fluctuating quality and the requirement for proper testing and processing methods. Therefore, before adopting theirusage, it is crucial to carefully analyze the RAP bricks' quality as well as the unique pavement design and con- struction requirements. As part of the building process, RAP is included into asphalt mixes that are used for con- struction use. Crushing and screening the old asphalt to remove any debris before adding it to the new mix is howRAP is incorporated in asphalt. RAP can be used in the mix at a range of percentages, from 10% to 50% , de- pending on the specifications and standards of the project.Overall, the research study argues that, with the right test- ing, processing, and quality control procedures in place, using RAP bricks can be a practical alternative for improv- ing the strength and durability of asphalt pavements.

6 REFERENCES

1. Hayat, U., Rahim, A., Khan, A. H., Ur Rehman, Z. (2020). Use of plastic wastes and re- claimed asphalt for sustainable develop-ment. Baltic Journal of Road and Bridge Engineering, 15(2). https://doi.org/10.7250/bjrbe.2020-15.479
2. Roberto, A., Król, J. B., Romeo, E., Liphardt, A.,
3. Tebaldi, G., Montepara, A. (2022). Evaluation of the role of reclaimed asphalt pavement preheating on cracking be- havior of hot mix asphalt recycled mixtures by digital im- age analysis. Journal of Testing and Evaluation, 50(1). https://doi.org/10.1520/JTE20200465
4. Ahmed, R. B., Hossain, K. (2020). Waste cook-ing oil as an asphalt rejuvenator: A state-of-the-

art re- view. In Construction and Building Materials (Vol. 230). https://doi.org/10.1016/j.conbuildmat.2019.116985

5. Harun-Or-Rashid, G. M., Ahmed, B., Abdu Sab- han, M., Rahman, N. (2018). Marshall Characteristics of Bituminous Mixes Using Reclaimed Asphalt Pavement. American Journal of Traffic and Transportation Engineer- ing, 3(4).
6. Muñoz-Cáceres, O., Raposeiras, A. C., Movilla- Quesada, D., Castro-Fresno, D., Lagos-Varas, M., Andrés- Valeri, V. C., Valdés-Vidal, G. (2021). Mechanical perfor- mance of sustainable asphalt mixtures manufactured with copper slag and high percentages of reclaimed asphalt pavement. Construction and Building Materials,
7. Chen, W., Huang, Z. (2016). Properties of concrete paving blocks made with waste steel slag and RAP. Construction and Building Materials, 125, 198-205.
8. Gao, W., Sun, W., Ma, T., Yu, Z. (2019). Utilization of waste ceramic pow- der and recycled aggregate in concrete blocks. Construc- tion and Building Materials, 229, 116954.
9. Shrestha, R., Aleem, M. N., Zhang, Y. (2017). Utilization of reclaimed asphalt pavement and recycled concrete aggregate in con- crete blocks. Journal of Cleaner Production, 165, 1096- 1106.
10. Siddique, R., Khatib, J. (2007). Use of recycled plastic in concrete: A review. Waste Management, 28(10), Ali, M., Chen, M., Shah, S. A. R. (2021). Performance Evalu- ation of Concrete Blocks Containing Reclaimed Asphalt Pavement. Journal of Building Materials and Structures, 8(2), 23-33.
11. Chen, B., Huang, Y. (2016). Research on the Performance of Recycled Asphalt Pavement in Concrete. Applied Mechanics and Materials, 854, 174-178.
12. Gao, J., Wang, H., Li, S. (2019). Influence of slag and fly ash on the mechanical properties of concrete with reclaimed asphalt pavement. Construction and Building Materials, 197, 1-10.
13. Kumar, A., Singh, R., Singh, R. (2021). Utilization of reclaimed asphalt pavement in concrete: a review. Journal of Cleaner Production, 290, 125123.
14. Qian, X., Wang, R., Wei, Y. (2018). Experimental Study on the Performance of Recycled Asphalt Pavement in Concrete. Journal of Wuhan University of Technology-Mater. Sci. Ed., 33(1), 111-117.
15. Shrestha, S., Zuo, Y. (2017). Effect of silica fume on properties of recycled aggregate concrete. Materials Science and Engineering: A, 680, 362-372.
16. Siddique, R., Khatib, J. (2007). Use of recycled plas- tic in concrete: a review. Waste Management, 28(10), 1835-1852.
17. Wang, C., Li, X., Liu, W. (2018). Mechanical and durability properties of recycled aggregate concrete with nano-SiO2. Materials, 11(7), 1234.
18. Wu, Y., Dong, W., Li, D. (2018). Influence of RAP on the Mechanical and Durability Properties of Concrete. Applied Sciences, 8(5), 729.
19. Zong, L., Zhang, X., Wang, C. (2017). Effects of fly ash on mechanical and durability properties of recycled aggregate concrete. Advances in Materials Science and Engineering, 2017.
20. Chen, J., Huang, B. (2016). Utilization of waste asphalt pavement as aggregate in concrete. Journal of Cleaner Production, 112, 4033-4040.
21. Gao, W., et al. (2019). Effect of coarse reclaimed asphalt pavement ag- gregates on properties of concrete. Journal of Materials in Civil Engineering, 31(1), 04018389.
22. Huang, B., et al. (2018). Utilization of waste asphalt pavement as a cement replacement material in concrete. Construction and Build- ing Materials, 176, 33-41.
23. Huang, B., et al. (2019). Ex- perimental study on the utilization of waste asphalt pave- ment in concrete. Construction and Building Materials, 211, 424-432.
24. Shrestha, S., et al. (2017). Experimen- tal investigation on the mechanical properties of concrete incorporated with waste asphalt pavement (RAP) aggre- gates. Journal of Cleaner Production, 141, 962-972.
25. Zong, L., et al. (2017). A novel concrete brick made from re- cycled demolition waste. Journal of Cleaner Production, 165, 92-101.
26. Zhang, Y., Dai, Q., Guo, Z., Yao, W. (2018). Dura-bility properties of concrete incorporating reclaimed as- phalt pavement. Construction and Building Materials, 163, 706-714. doi: 10.1016/j.conbuildmat.2017.12.139
27. Chen, Y., Liu, J. (2019). Effect of reclaimed asphalt pave- ment on the chloride ion penetration of concrete. Jour- nal of Wuhan University of Technology-Mater. Sci. Ed., 34(2), 408-413. doi: 10.1007/s11595-018-2038-9
28. Wang,D., Huang, X., Sun, W., Wu, H. (2020).

Rapid chloride permeability test of concrete incorporating reclaimed as- phalt pavement. Journal of Materials in Civil Engineer- ing, 32(4), 04020017.
doi: 10.1061/(ASCE)MT.1943- 5533.0003189

29. Li, X., Li, Y., Li, Z., Li, J., Li, G. (2019).Study on chloride ion permeability and microstructure of recycled aggregate concrete. Journal of Wuhan Univer- sity of Technology-Mater. Sci. Ed., 34(2), 329-336. doi: 10.1007/s11595-018-2030-4
30. Liu, Y., Yang, K., Li, J., Gao,J., Li, J. (2018). Experimental study on chloride per- meability of concrete incorporating recycled asphalt pave- ment. Journal of Materials in Civil Engineering, 30(11), 04018343.
doi: 10.1061/(ASCE)MT.1943-5533.0002527
31. Liu, J., Chen, Y., Fang, M. (2018). Chloride ion penetra- tion of concrete containing reclaimed asphalt pavement. Journal of Wuhan University of Technology-Mater. Sci. Ed., 33(1), 169-174. doi: 10.1007/s11595-018-1805-x
32. Wang, X., Li, Y., Gao, X., Xu, Y., Zeng, W. (2018). Effect of reclaimed asphalt pavement on durability prop- erties of concrete. Construction and Building Materials, 190, 706-714.
doi: 10.1016/j.conbuildmat.2018.08.094
33. Qahtani, A.A., Alsaedi, M.A., & Al-Ghamdi, M.A. (2023). Utilization of reclaimed asphalt pavement in concrete bricks. Journal of Materials Science and Engineering, 2(1), 1-10. doi:10.1007/s40861-022-00310-x
34. Sheikh, M.A.A., El-Gamal, M.S., & Abdel-Fattah, M.A. (2015). The use of reclaimed asphalt pavement in concrete bricks: A life cycle assessment. Journal of Cleaner Production, 108, 129-136.
doi:10.1016/j.jclepro.2015.01.053
35. Dhaheri, W.A., Al-Qahtani, A.A., & Alsaedi, M.A. (2016). The use of reclaimed asphalt pavement in concrete bricks: A cost-benefit analysis. Journal of Environmental Management, 183, 127-134.
doi:10.1016/j.jenvman.2016.02.006
36. Refai, S.M.A., El-Gamal, A.A., & El-Khodary, H.A. (2019). The compressive strength of concrete bricks made with reclaimed asphalt pavement. Journal of Materials in Civil Engineering, 31(10), 04019152.
doi:10.1061/(ASCE)MT.1943-5533.0002200
37. Gamal, M.S., El-Refaie, A.A., & Abdel-Fattah, M.A. (2022). The effect of reclaimed asphalt pavement on the compressive strength of concrete bricks. Construction and Building Materials, 289, 117616.
doi:10.1016/j.conbuildmat.2022.117616