

Effects of Recycled Concrete Dust on the Behaviour of Hot Mix Asphalt

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Abstract.

The increasing demand for sustainable pavement materials has encouraged the utilization of construction and demolition waste in asphalt mixtures. This study investigated the effects of recycled concrete dust (RCD), derived from demolished concrete, on the behaviour and performance of hot mix asphalt (HMA). The RCD was used as a replacement for conventional stone dust filler at proportion of 0%, 25%, 50%, 75%, and 100% using the Marshall mix design method in accordance with relevant ASTM standards. The performance of the mixtures was evaluated in terms of Marshall and volumetric properties, rutting resistance, cracking and moisture damage resistance. Results show that the OBC increased consistently with increasing RCD content due to the lower specific gravity and cementitious nature of RCD, with statistical analysis confirming the significance of this effect. The Marshall and volumetric analysis revealed improved mixture densification up to 75% RCD replacement, as evidenced by higher bulk density, reduced air voids, lower VMA, and increased voids filled with bitumen. Marshall test results indicated that moderate RCD replacement (25–50%) enhanced stability. Flow values decreased with increasing RCD, indicating stiffer mixtures without exceeding specification limits. Rutting resistance, assessed using the Marshall Quotient, improved substantially with increasing RCD content, demonstrating enhanced resistance to permanent deformation. Conversely, indirect tensile strength results showed a reduction in value at higher RCD contents, attributed to increased mixture stiffness. However, moisture susceptibility performance improved with RCD incorporation, with most RCD-modified mixtures exhibiting tensile strength ratio values above 75%, indicating strong resistance to moisture-induced damage. Overall, the findings demonstrate that recycled concrete dust can be effectively used as a sustainable filler in hot mix asphalt. The study supports the adoption of RCD in asphalt pavement construction as a viable approach for enhancing sustainability and reducing environmental impacts. Recycled concrete dust, Tensile strength ratio, rutting resistance, cracking resistance, modified asphalt mixtures, Sustainability.

1. Introduction

Alternative construction materials are being used as a result of the need for sustainable infrastructure (Oyedepo et al., 2021). Using waste materials in construction provides an eco-friendly solution for landfill issues (Mashaan et al., 2025; Oguntayo et al., 2025). Their use and suitability in construction are mostly determined by their relative abundance, acceptability, viability, dependability, and performance. The characterization of seven waste materials as fillers in the HMA mixtures was examined by Choudhary et al. (2020), who discovered that all of the waste-modified mixtures produced an adequate tensile strength, indicating the resistance to cracking.

One of such alternative materials that has gained significant attention is the construction and demolition waste (CDW). Utilization of CDW in construction, especially in asphalt mixtures,

is an extra way to support the initiatives implemented to turn them into useful products (Kareem *et al.*, 2025; Ding *et al.*, 2020). The significant concentration of many potentially valuable components makes it necessary to incorporate these wastes into a circular economy.

Construction and demolition waste (CDW), which is produced in massive quantities by the construction sector nowadays, is frequently dumped in landfills. In addition to losing areas that could be used for other land purposes, their disposal can have a significant negative visual and scenic impact. Uncontrolled CDW landfilling can also contaminate soil and aquifers (Shamsaei *et al.*, 2023; Pérez *et al.*, 2010). One of the promising ways to mitigate the environmental nuance and enhance its economic value is to recycle these materials and incorporate them as alternative material in asphalt pavement (Joumblat *et al.*, 2024; Solouki *et al.*, 2023).

Certain waste products can be substituted for the aggregates, asphalt binders, and/or filler components used in traditional HMA formulations. These waste materials have been divided into three categories: industrial by-products (such as steel slag, bottom ashes, fly ashes, waste plastics, waste tires, and waste glass), building and demolition by-products, and pavement by-products (such as recycled asphalt pavement, recycled concrete pavement). Among these wastes, CDW is gaining significant attention due to its composition with many materials. According to Ding *et al.* (2020), waste concrete and bricks are two main parts occupied for 60% and 20% of the CDW, and they can be processed into aggregates and fillers after crushing and screening. In this regard, in order to contribute to sustainable development, several studies have been conducted dealing with the use of recycled materials from CDW in hot-mix asphalt (HMA). In Oguntayo *et al.* (2023), waste ceramic tiles were utilized as replacement for aggregate in asphalt mixtures. The results obtained indicates the possibility of production of asphalt mixtures with waste ceramic tiles. Pico *et al.* (2025) evaluate the performance of asphalt mixtures using CDW as fillers for light traffic pavement. The findings demonstrated that 1% CDW has comparable characteristics of the conventional asphalt mixtures. Teshome *et al.* (2025) utilized marble waste as fillers in asphalt mixtures. The mixture was modified with 0 % to 50 % marble waste and its effect on the mixture rutting resistance evaluated. The results showed that at 30 % marble waste replacement, there was a reduction in the mixture rut depth. These studies have highlighted the possibility of asphalt mixtures with CDW with improved performance.

Furthermore, beyond the asphalt mixtures performance improvement, the use of CDW as partial replacement of materials in the hot mix asphalt is considered one of the alternatives to reduce the cost of constructing new roads and reduce the produced carbon emissions (Naser *et al.*, 2022; Oguntayo *et al.*, 2023; Ding *et al.*, 2020). In addition, as the growing number of road construction projects has resulted in the demand for large amounts of construction materials, using CDW materials will help reduce the demand for those non-renewable natural materials. The objective of this research therefore is to evaluate the behaviour of HMA containing recycled concrete dust (RCD) as fillers. The research approach is based on the laboratory experimental evaluation of modified asphalt performance parameters that are relevant to field pavement functions.

2. Materials and Methods

2.1 Materials

The materials utilized in this study are commonly used in the Nigeria asphalt paving industry. The aggregate used was granite aggregate and the filler material was a stone dust; all obtained

from quarry site. The RCD was obtained from a demolition site, crushed to powder and used as replacement for stone dust (conventional filler) as filler for asphalt mixture production. The bitumen utilized was 60/70 penetration bitumen. The properties of the aggregate and bitumen are presented in Table 1, the chemical properties of the fillers is reported in Table 2 and the combined aggregate gradation for the mixture is depicted in Figure 1. As seen, the fillers (stone dust and RCD) have highest concentration of SiO₂. This is in consistent with previous studies (Taiwo et al., 2022; Zhao et al., 2020; Etim et al., 2021; Lei et al., 2023; Veera, 2023; Li et al., 2024). Also, the chemical properties of RCD are comparable with the stone dust, indicating RCD as potential replacement for stone dust.

Table 1. Material properties

Parameters	Aggregate		Parameters	Bitumen	
	Value	Specification		Value	Specifications
Specific gravity	2.88	2.5-3.0	Penetration (dmm)	66	60-70
Aggregate impact (%)	19.6	30% Max.	Ductility (mm)	121	100 Minimum
Flakiness index (%)	16.4	30% Max.	Solubility	107	99.5 Minimum
Aggregate crushing (%)	16.8	30% Max.	Viscosity (Pa.s)	2753	2400 Min
Elongation index (%)	14.3	30% Max.	Flash point	287	250 Min
Aggregate abrasion (%)	16.8	40% Max.	Softening point (°C)	56	55-65
Water absorption (%)	0.17	4% max	Specific gravity	1.02	1.01-1.06

Table 2. Properties of Stone dust

Parameters	Stone Dust	RCD
SiO ₂	38.16	46.94
Al ₂ O ₃	22.71	9.07
Fe ₂ O ₃	8.44	6.90
CaO	15.43	14.18
MgO	0.09	-
K ₂ O	0.29	7.33
P ₂ O ₅	-	9.39
MnO	11.14	0.34
SO ₃	-	1.48
TiO ₂	1.57	1.511
Other	2.17	2.87
Specific gravity	2.74	2.62

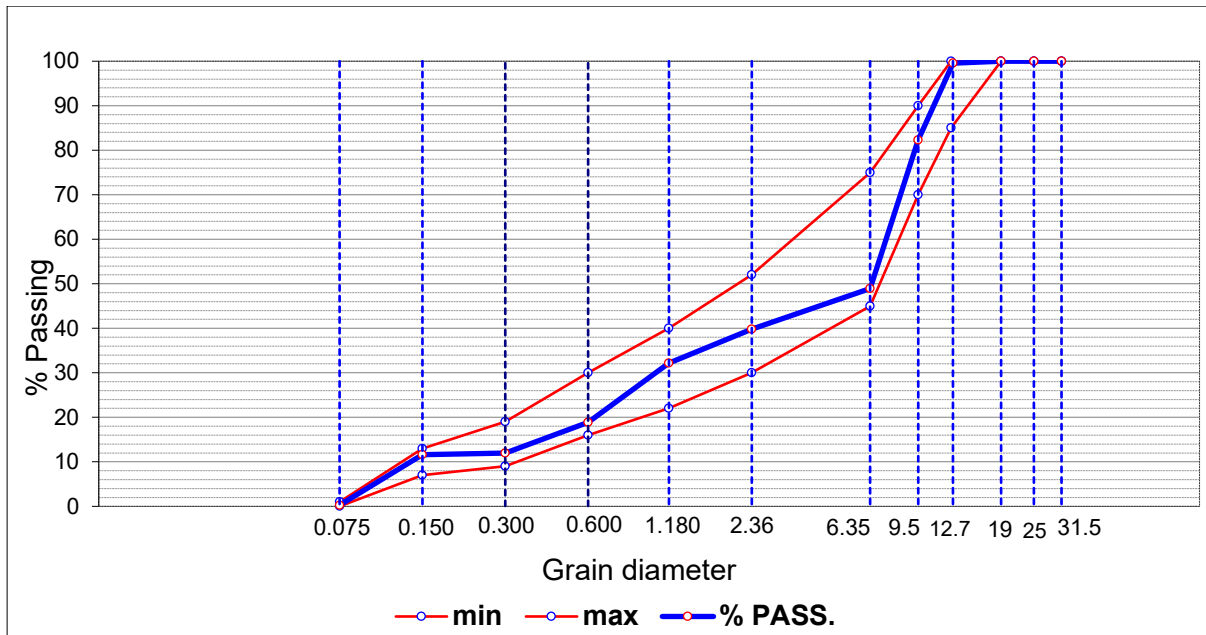


Figure 1. Aggregate gradation for asphalt mixture production

2.2 Asphalt Mixtures Production and Testing

Asphalt mixture that is used for a surface layer, with a nominal aggregate size of 12.5 mm, was selected for investigation in this study (the mixture aggregate gradation is shown in Figure 2). The mixture was prepared in accordance with ASTM D6926 (2010) by varying the proportions of the concrete dust as depicted in Table 3. The proportion of RCD used in this study is in accordance with the study conducted by Lei et al. (2023). The mixture was afterwards subjected to Marshall and volumetric properties testing in accordance with ASTM D6927 (2010) to determine their optimum bitumen content (OBC) at different filler replacement level. The samples were further compacted at their OBC, soaked in a water bath at 60°C for 30 minutes, then the outer surface is dried and placed on the Marshall machine (As shown in Figure 2). The conditioned samples are loaded with a constant rate of 50 mm/min on the Marshall machine until the maximum load is reached and then stability and flow values are recorded. The mixture volumetric properties such as bulk density (Gm), Volume of Voids (Vv), Voids in Mineral Aggregate (VMA), Voids Filled with Bitumen (VFB), and Volume of bitumen (Vb) was also determined on the compacted samples. Furthermore, the Marshall Quotient (MQ) and tensile strength was evaluated on the mixture. The MQ, tensile stress at failure (shown in Figure 2b) and Tensile Strength Ratio (TSR) are computed using equations 1, 2 and 3, respectively. In all the test, three (3) samples were determined and the average reported for each test. This is to ensure repeatability and reproducibility of the experimental results.

$$\text{Marshall Quotient (kN/mm)} = \frac{\text{Stability (kN)}}{\text{Flow (mm)}} \quad (1)$$

$$\text{Tensile Strength (S}_t\text{)} = \frac{2P}{(\pi * H * D)} \left(\frac{N}{\text{mm}^2} \right) \quad (2)$$

Where, S_t is the ITS value; D is the specimen diameter in mm; P is the the measured load value at failure in Newton; and H is the specimen thickness in mm:

$$\text{Tensile Strength Ratio (\%)} = \frac{\text{Tensile Strength}_{Wet}}{\text{Tensile Strength}_{Drt}} \times 100 \quad (3)$$

Table 3. Asphalt Mixture Formulations

Mixture designation	Proportion of RCD (%)
RCD0	0
RCD25	25%
RCD50	50%
RCD75	75%
RCD100	100%

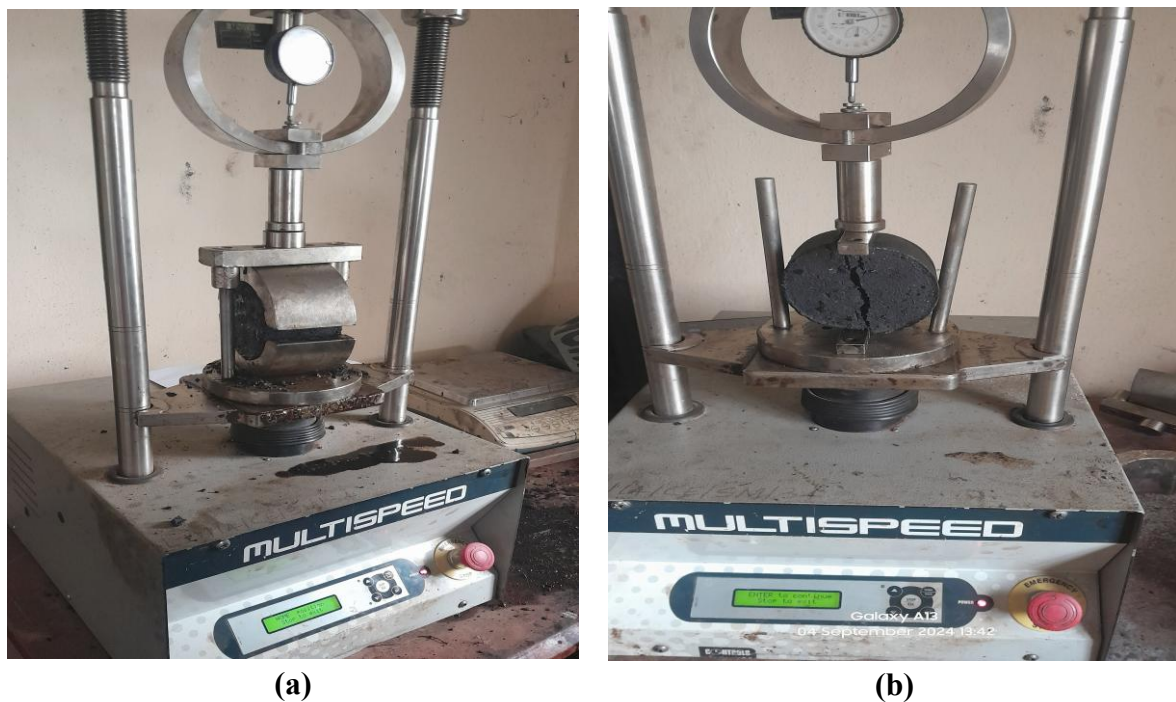


Figure 3. Specimen under Marshall machine for (a) Marshall properties and (b) Indirect Tensile Strength

3. Results and Discussions

3.1 Effects of RCD on the optimum bitumen content of the asphalt mixtures

The production of asphalt mixtures with proper characteristics required the determination of the optimum bitumen content (OBC). The OBC help to ensure balance in the mixture bitumen such that having enough bitumen to coat the aggregates and not too much, which can cause rutting. The OBC was determined for each RCD content replacement using the maximum bulk density, stability and percent air void at 4%. The OBC of the asphalt mixtures at various RCD replacement is shown in Figure 4. As it can be seen, the OBC increases as the proportion of RCD increases in the mixture. The OBC is determined as 5.90, 5.93, 6.20, and 6.30% for RCD proportion of 25, 50, 75 and 100%, respectively. These OBC values are 2.97%, 3.49%, 8.20% and 9.95% more than the OBC of the control mixture. The increase in the OBC as RCD increase could be attributed to the lower specific gravity of RCD as compared to the stone dust and due

to the cement content in the RCD. The increase in OBC as RCD increases was also observed in the study conducted by Dhir et al (2019) using RCA as aggregates. Therefore, to achieve the optimal mixture performance, workability and durability properties with RCD as filler content, more bitumen will be required, leading to an increase in the OBC.

Figure 1 also shows that the error bar is short, implying a little difference in the bitumen content required to reach optimal performance between the RCD modified mixtures. It also indicates the parameters utilized in the OBC determination are stable and not prone to large fluctuations and the RCD as filler is well graded. To determine if the OBC of RCD modified asphalt mixture is significantly different from the control mixture (designated as RCD0), a one-way ANOVA was conducted, and the results is showed in Table 4. The analysis revealed a p-value of 0.037622, which is less than the standard significance level of 0.05, indicating that the RCD proportion on the OBC are statistically significant. This further aligns with the obtained error bar in Figure 4. Conclusively, RCD proportion causes a measurable change in the OBC.

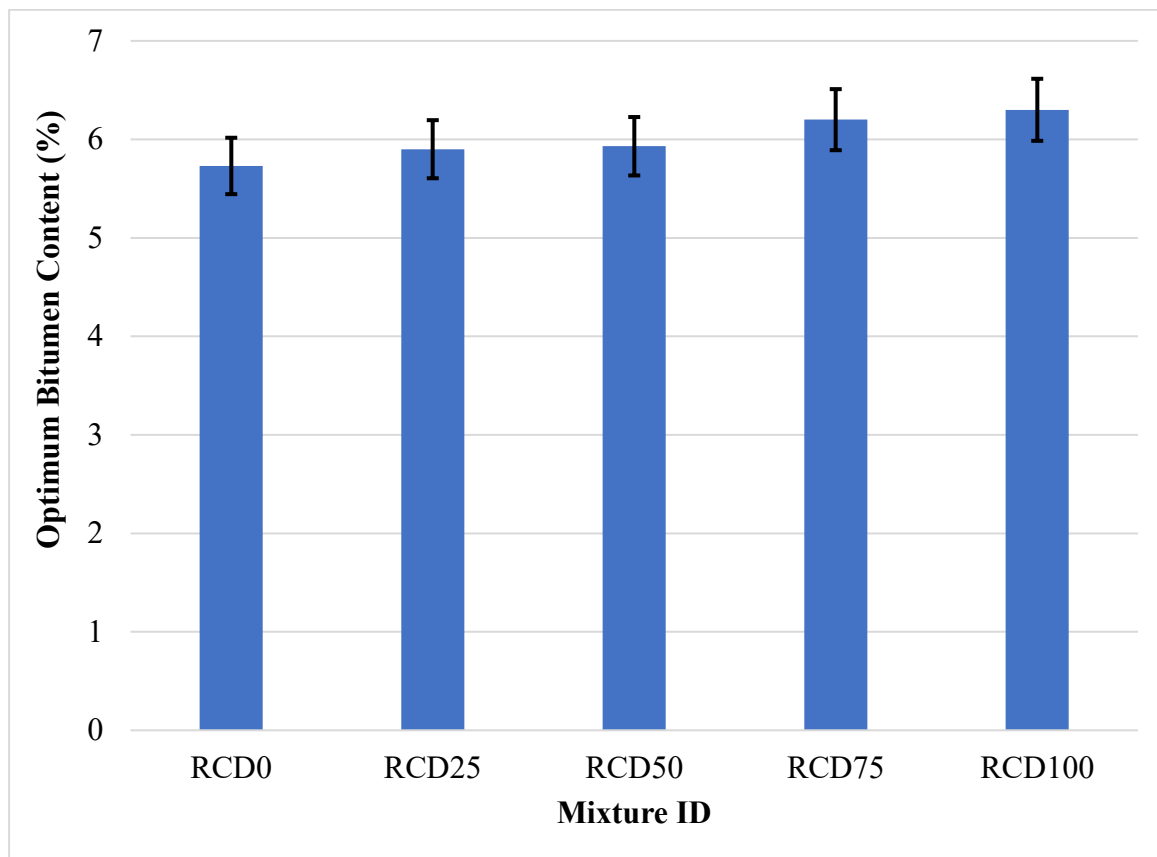


Figure 4. Effects of RCD on the mixture OBC

Table 4. ANOVA for RCD effects on OBC

Summary				
Groups	Count	Sum	Average	Variance
OBC	5	30.06	6.012	0.05427
RCD	5	250	50	1562.5
ANOVA				

Source of variance	SS	Df	MS	F	P-value	F critical
Between Group	4837.36	1	4837.36	6.19606	0.037622	5.317655
Within Group	6250.217	8	781.2771			
Total	11087.58	9				

3.2 Effects of RCD on the asphalt mixtures volumetric properties

Volumetric properties of asphalt mixtures include parameters like bulk density (Gm), Volume of Voids (Vv), Voids in Mineral Aggregate (VMA), Voids Filled with Bitumen (VFB), and Volume of bitumen (Vb), which are crucial for predicting pavement performance. They are fundamental indicators of how well the mixture will resist rutting, moisture damage and fatigue over time. They also guide the mix design process, ensuring the right balance of bitumen, aggregates and air void for road specific conditions and are used in specifications to ensure consistency and quality in produced asphalt.

The effects of RCD on the asphalt mixtures volumetric properties are depicted in Figure 5. As the RCD increases up to 75%, the Gm increases from 2.34% to 2.38% and decreases afterwards to 2.35% at 100% replacement of RCD. Also, only RCD75 is greater than the control (designated a RCD0), suggesting a denser and less porous mixture with improved performance and lower and better permeability and durability, respectively. From Figure 5, the Vv of the mixture ranges from 4.1-2.77%. The lowest Vv value of 2.77% was exhibited by RCD75. This agrees with Gm value, as higher Gm usually implies lower Vv resulting in reduced air and water infiltration with enhanced durability against moisture.

The Vb of the mixtures shows that as the RCD increases, the Vb also increases. This agrees with the obtained OBC, indicating that more bitumen will be needed in RCD modified asphalt mixtures. The VMA is the space between aggregates particles, filled with bitumen and air. The VMA values follows the same trend as the Vv. In all the mixtures, RCD75 has lowest value of 17.74%. This minimum value of VMA suggest that sufficient binder is available to coat aggregates and allow for air voids.

The proportion of VMA that is actually filled with the bitumen is denoted as the VFB. An increase in the RCD up to 75% resulted in an increase in the VFB. The highest VFB value of 84.42% was exhibited by RCD75, which again aggress with other volumetric properties. This VFB means there is enough binder to resist traffic stress, leading to improved cracking resistance. Nonetheless, care must be taken as too much VFB can result to pavement rutting. All the mixtures meet the minimum volumetric properties requirements of wearing course as specified by Nigeria specifications for Road and bridges (FGN, 2013). Furthermore, the volumetric properties of the RCD modified asphalt mixtures is in consistent with the study conducted by Akinleye et al. (2025) and Teshome et al. (2025).

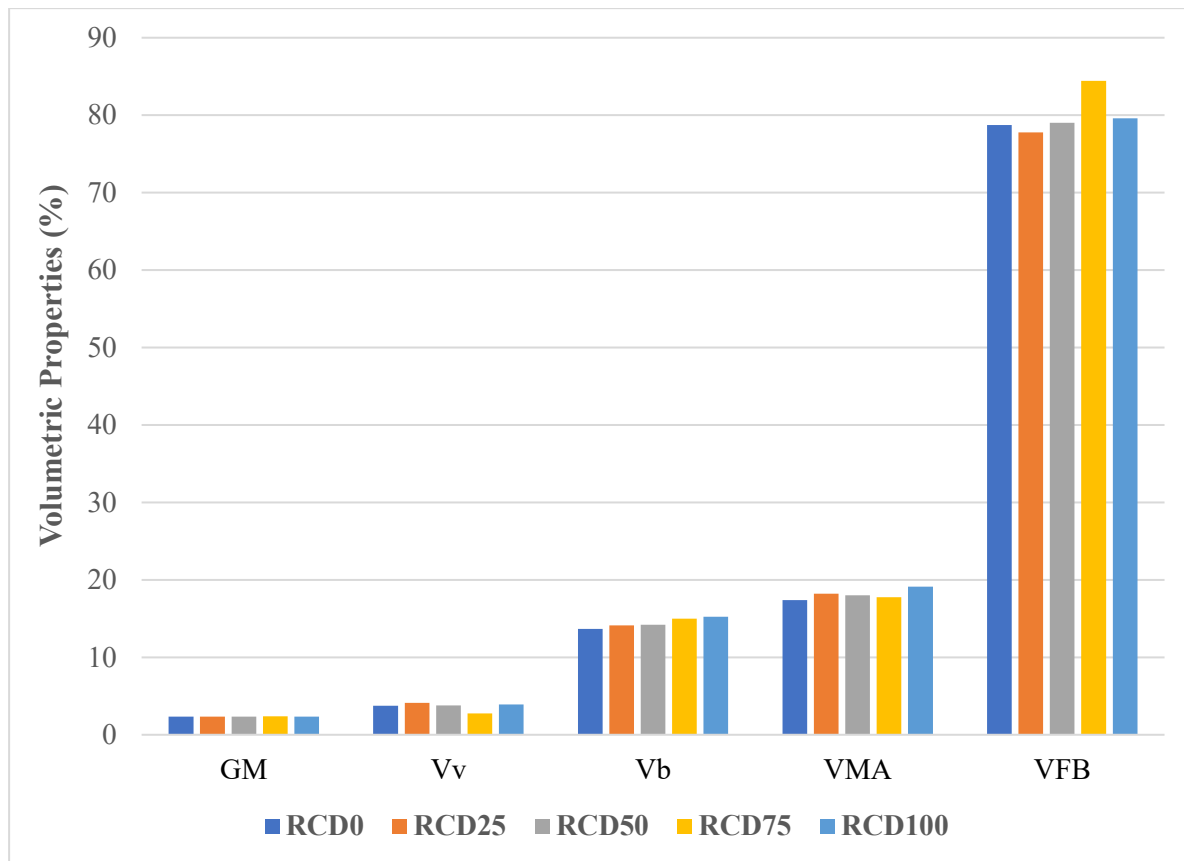


Figure 5. Effects of RCD on the asphalt mixtures volumetric properties

3.3 Effects of RCD on the asphalt mixtures Marshall Properties

The Marshall properties such as Marshall stability and flow for RCD modified asphalt mixtures is shown in Figure 6. A reduction in the stability value was observed as the RCD proportion increases up to 75% and a slight increase in the stability with further increase in the RCD up to 100%. A highest stability of 11.62 kN was exhibited by RCD25, corresponding to 1.13% increase compared to the control (RCD0). The RCD50 has a stability of 11.55 kN, corresponding to 0.53% gain in stability compared to the control. The gain in stability could be as a result of the stiffening effects of the RCD fillers, thereby helping to distribute the applied loads more evenly through the mixture. In Teshome et al. (2025), an increase in mixture stability was also observed as marble waste filler increased up to 30%. The RCD75 and RCD100 has a stability of 11.14 kN and 11.33 kN, indicating a reduction of 3.05% and 1.39%, respectively compared to the control. The reduction in stability maybe due to the excessive bitumen absorption at higher filler content and may suggest a brittle mix. However, all the mixtures exhibited stability value higher than the minimum 3.5 kN specified by the Nigeria specifications for Road and bridges (FGN, 2013), suggesting a good asphalt mixture.

The flow value of RCD modified asphalt mix showed a decrease as the RCD proportion increases. At RCD25, the flow value obtained is 3.6 mm, corresponding to 7.69% reduction compared to the control (RCD0). RCD50, RCD75 and RCD100 has a flow value of 3.3 mm, 3.0 mm and 2.7 mm, corresponding to 15.38%, 23.08%, and 30.77% flow value reduction, respectively. A high stability and specific range of low flow are crucial requirements for the Marshall test. This will ensure the mixture is not too stiff and become brittle. Hence, the reduction in the mixture flow suggests a moderately stiff and more stable mixture. All the

mixture are however within the flow requirement of 2 - 4 mm specified by the Nigeria specifications for Road and bridges (FGN, 2013).

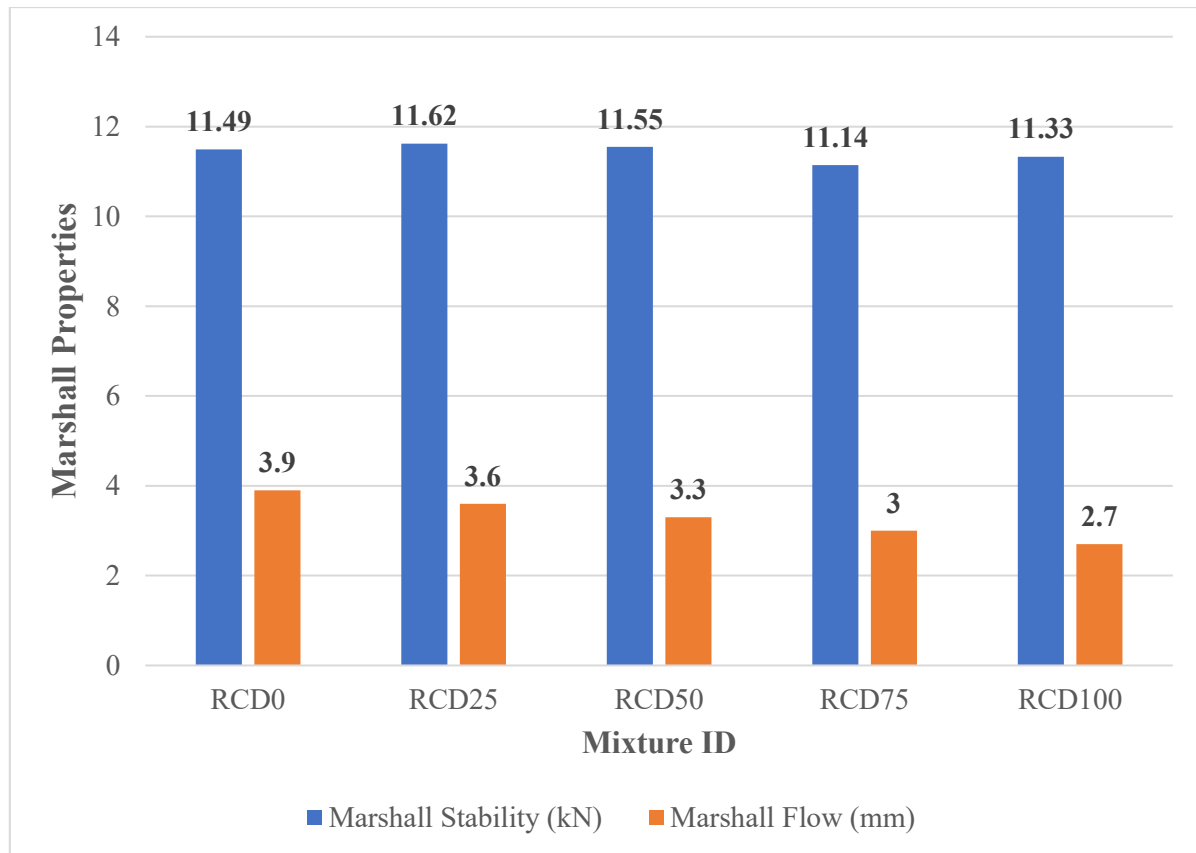


Figure 6. Effects of RCD on the asphalt mixtures Marshall Properties

3.4 Effects of RCD on the asphalt mixtures Rutting resistance

The Marshall Quotient (MQ) is an indication of asphalt mixture's stiffness and resistance to permanent deformation (rutting) under Marshall test conditions (Akinleye et al., 2025). Even though MQ doesn't always correlate well with actual field rutting, it is useful as an initial indicator during the asphalt mix design to balance stability and flexibility. The higher the MQ the better the rutting resistance of the mixture. The MQ of RCD modified asphalt mixture is showed in Figure 7. The results showed that the MQ improved as the proportion of RCD increases. The RCD proportion of 25%, 50%, 75% and 100% has MQ of 3.23 kN/mm, 3.53 kN/mm, 3.73 kN/mm and 4.20 kN/mm. these MQ value has a percentage increase of 8.75%, 18.86%, 25.59% and 41.41%, respectively. The increase in MQ suggests a better rutting performance because it reflects a stiff, stable mix that can resist deformation.

Furthermore, as shown in Figure 7, the error bar is short, implying a high precision and consistency in the mixture. Hence, the addition of RCD produces a predictable and uniform rutting resistance across the RCD proportion. The one-way single factor ANOVA depicted in Table 5 showed that $F > F_{\text{critical}}$, suggesting that the RCD proportion on the mixture rutting resistance are statistically significant.

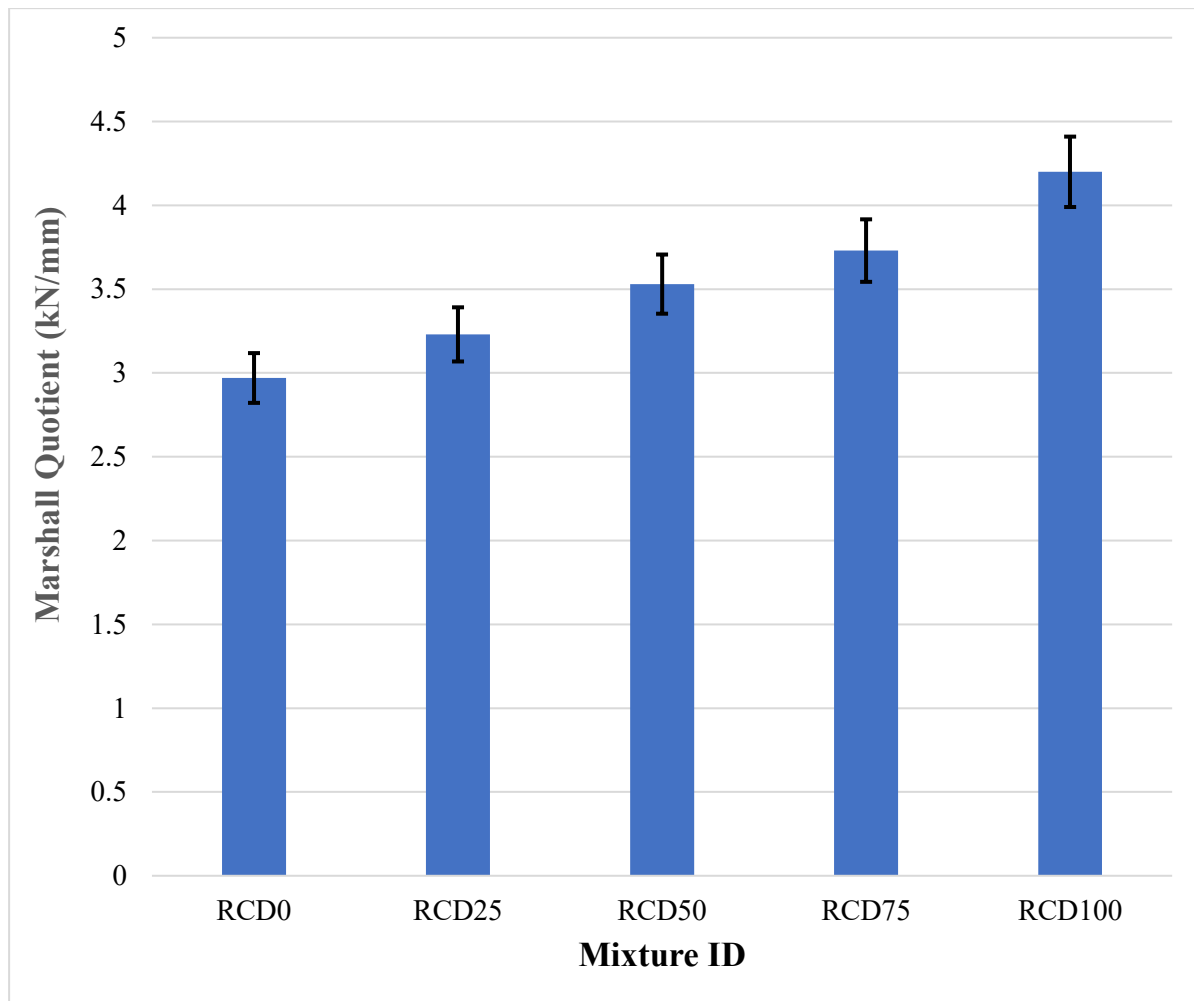


Figure 7. Effects of RCD on the asphalt mixtures Rutting resistance

Table 5. ANOVA for RCD effects on mixture rutting resistance

Groups		Count	Sum	Average	Variance	
MQ		5	17.66	3.532	0.22312	
RCD		5	250	50	1562.5	
Source of variance	SS	Df	MS	F	P – value	F - critical
Between Group	5398.188	1	5398.188	6.90869	0.030251	5.317655
Within Group	6250.892	8	781.3616			
Total	11649.08	9				

3.5 Effects of RCD on the asphalt mixtures cracking resistance and moisture susceptibility

Asphalt mixture cracking resistance is its ability to withstand repeated bending without fracture (Ipekyol et al., 2022). The indirect tensile test was used as asphalt mixture resistance to fatigue and cracking and the results is depicted in Figure 8. The tensile strength (dry) reduces as the proportion of RCD increases up to 75% and slight increase at 100% RCD replacement. As compared with the control with strength of 887.64 kN/m², the RCD proportion of 25%, 50%, 75% and 100% in the mixture has percentage reduction of 7.91%, 29.37%, 35.93% and 26.73%, respectively. The reduction in strength implies adverse fatigue and cracking resistance. Also, the conditioned RCD modified mixtures followed the same trend with the unconditioned (dry)

mixtures and exhibit a lower strength value than unconditioned mixtures. This lower strength is because of diminishing of bitumen and aggregate adhesion and bonding with the water content and curing duration (Amirkhani et al., 2023).

Tensile strength ratio (TSR) is a key parameter for asphalt mixture indicating the material's resistance to moisture damage. A higher TSR suggests better durability against water stripping. It quantifies how much a materials strength degrades when exposed to water. The TSR is shown in Figure 8. All the mixtures except the RCD25 (25% proportion of RCD) had a TSR value of over 75%, suggesting good moisture susceptibility resistance. A further observation shows a variation in the TSR values as the RCD proportion increases. The TSR of RCD modified mixtures at RCD proportion of 50, 75 and 100% are 83.35%, 82.2% and 85.29%, respectively. These values are higher than the control (designated as RCD0) by 8.39%, 6.90%, and 10.92%, respectively. Therefore, it can be deduced that RCD causes increase in the TSR of asphalt mixtures. A finding which was also been reported by Teshome et al. (2025) using marble waste as filler. The increased in the TSR values obtained from the RCD modified mixture implies the mixture can withstand moisture without significant loss of integrity which is crucial for road longevity.

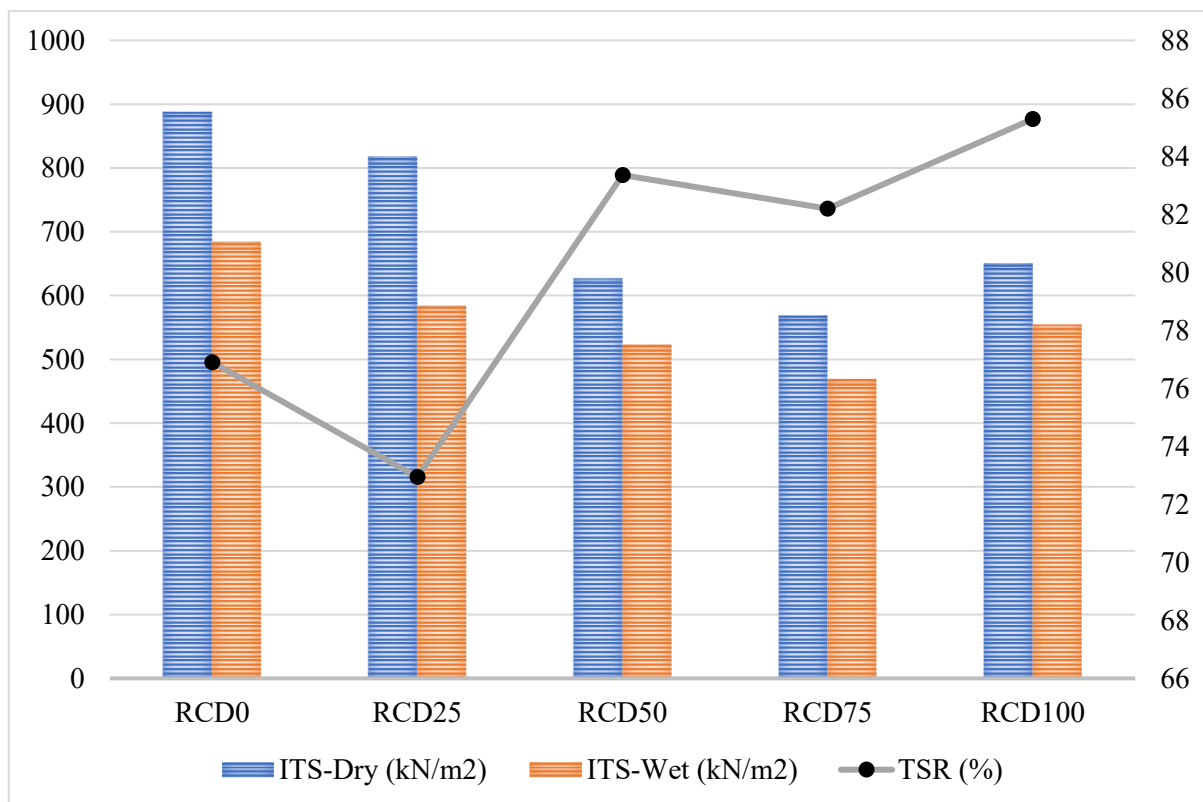


Figure 8. RCD effects on the asphalt mixtures fatigue resistance and moisture resistance

4. Conclusions

Based on the experimental evaluation of hot mix asphalt (HMA) incorporating recycled concrete dust (RCD) as filler, the following conclusions are drawn:

1. The OBC increased progressively with higher RCD replacement levels, reaching 6.30% at 100% RCD compared to the control mixture. This trend is attributed to the lower specific gravity and cementitious nature of RCD, which increased bitumen absorption.

The statistical analysis (ANOVA, $p = 0.0376 < 0.05$) confirms that the effect of RCD on OBC is statistically significant, indicating that RCD content must be carefully considered during mix design.

2. Bulk density (Gm) increased with RCD content up to 75%, while air voids (Vv) and VMA reached their lowest values at RCD75, indicating a denser and less permeable mixture. The increase in VFB up to 84.42% at RCD75 suggests improved binder effectiveness and potential enhancement in durability. All mixtures satisfied the Nigerian wearing course specifications, demonstrating that RCD can be safely incorporated without compromising volumetric requirements.
3. The Marshall Stability and flow results show that moderate RCD replacement (25–50%) improved mixture stability, with RCD25 achieving the highest stability (11.62 kN). Higher RCD contents (75–100%) slightly reduced stability but remained well above the minimum specification limits. Flow values consistently decreased with increasing RCD, indicating stiffer mixtures while still remaining within the acceptable range (2–4 mm). These results confirm that RCD contributes to increased stiffness and load-bearing capacity when used at optimal proportions.
4. Rutting resistance, assessed using the Marshall Quotient (MQ), improved significantly by up to 41.41% at 100% RCD, indicating enhanced resistance to permanent deformation. The ANOVA results ($F > F\text{-critical}$, $p = 0.0303$) further established that the improvement in rutting resistance due to RCD incorporation is statistically significant. This suggests that RCD-modified mixtures are better suited for resisting deformation under traffic loading.
5. The indirect tensile strength (ITS) results indicate a reduction in fatigue resistance with increasing RCD content, particularly up to 75% replacement, due to increased stiffness and reduced flexibility. However, moisture susceptibility performance improved with RCD incorporation. Except for RCD25, all mixtures achieved TSR values above 75%, with RCD100 exhibiting the highest TSR (85.29%). This demonstrates that RCD enhances moisture damage resistance, likely due to improved filler–binder interaction and cementitious bonding.

In this study, Marshall quotient and ITS was used to evaluate RCD modified asphalt mixture's rutting and cracking resistance, though these might not correlate well with actual field performance. Therefore, wheel tracking and bending beam test should be investigated on RCD modified asphalt mixtures. Furthermore, for practical applications of the RCD modified mixture, field correlations using accelerated pavement testing facility and the life cycle analysis should be conducted.

DECLARATIONS

Ethics Approval and consent to participate: Not Applicable

Consent for publication: The authors give their full consent for relevant information, case Figures and Table included in this manuscript to be published in International Journal of Concrete Structures and Materials.

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References

- Naser M., Abdel-Jaber, M., Al-shamayleh R., Louzi N., Ibrahim R. (2022). Evaluating the effects of using reclaimed asphalt pavement and recycled concrete aggregate on the behavior of hot mix asphalts. *Transportation Engineering* 10 (2022) 100140. <https://doi.org/10.1016/j.treng.2022.100140>
- Oguntayo, D., Ogundipe, O., Daikwo J., Adeyemi F., and Aladegboye O. (2023)a. Moisture susceptibility of waste ceramic tiles modified asphalt mixtures. *Research on Engineering Structures & Materials*. <http://dx.doi.org/10.17515/resm2023.798ma0704tn>
- Ding, L., Zhang, J., Feng, B., and Li, B. (2020). Performance Evaluation of Recycled Asphalt Mixtures Containing Construction and Demolition Waste Applicated as Pavement Base. *Advances in Civil Engineering*, Volume 2020, 8875402. <https://doi.org/10.1155/2020/8875402>**Digital Object Identifier (DOI)**
- Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures, ASTM D6927, 2010. 10.1520/D6927-15
- Ipekyol, A., Tortum, A., Rasouli, R., & Yazdani, M. (2022). Evaluating fatigue and crack resistance of asphalt mixture containing zinc tailing aggregates. *Case Studies in Construction Materials*, 17, e01384. <https://doi.org/10.1016/j.cscm.2022.e01384>
- Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus, ASTM D6926, 2010. 10.1520/D6926-04
- Standard Test Method for Indirect Tensile (IDT) Strength of Asphalt Mixtures, ASTM D6931, 2017. 10.1520/D6931-17

- Oguntayo, D., Ogundipe, O., Aladegboye, O., Ogunkunbi, G., Babatunde, Y., & Aransiola, O. (2023)b. Performance Evaluation of Hospital Waste Ash-Modified Asphalt Mixtures. *Advances in Civil Engineering*, 2023. <https://doi.org/10.1155/2023/6880766>
- Mashaan, N. S., Oguntayo, D. O., & Dassanayake, C. (2025). Waste by-products in asphalt concrete pavement construction: a review. *Materials*, 18(17), 4092. <https://doi.org/10.3390/ma18174092>
- Pico, A. A. R., Reyes, R. N. S., & Bonilla, S. E. E. (2025). Analysis of Asphalt Mixtures Using Construction and Demolition Wastes as Filler. In *Advances in Civil Engineering-Sustainable Materials and Resilient Structures*. IntechOpen. 10.5772/intechopen.1007330
- Shamsaei, M., Carter, A., and Vaillancourt, M. (2023). Using Construction and Demolition Waste Materials to Develop Chip Seals for Pavements. *Infrastructures* 2023, 8, 95. <https://doi.org/10.3390/infrastructures8050095>
- Kareem, A. I., Ezzat, E. N., Khaled, T. T., & Al-Hamd, R. (2025). Effects of breakage of construction and demolition waste materials (C&DWMs) at asphalt mixtures. *Al-Qadisiyah Journal for Engineering Sciences*, 18(1), 54-64. <https://doi.org/10.30772/qjes.2024.148821.1202>
- Pérez, I., Gallego, J., Toledano, M., & Taibo, J. (2010, December). Asphalt mixtures with construction and demolition debris. In *Proceedings of the Institution of Civil Engineers-Transport* (Vol. 163, No. 4, pp. 165-174). Thomas Telford Ltd. <https://doi.org/10.1680/tran.2010.163.4.165>
- Dhir, R. K., de Brito, J., Silva, R. V., & Lye, C. Q. (2019). 12-use of recycled aggregates in road pavement applications. *Sustainable Construction Materials*, RK Dhir, J. de Brito, RV Silva, CQ Lye, Editors. Woodhead Publishing, 451-494. [10.1016/B978-0-08-100985-7.00012-1](https://doi.org/10.1016/B978-0-08-100985-7.00012-1)
- Amirkhani, M. J., Fakhri, M., & Amirkhani, A. (2023). Evaluating the use of different fillers and Kaowax additive in warm mix asphalt mixtures. *Case Studies in Construction Materials*, 19, e02489. <https://doi.org/10.1016/j.cscm.2023.e02489>
- Federal Government of Nigeria (2013). *General Specification for road and bridges* -Revised edition (volume ii), Federal Ministry of Works and Housing. Abuja, Nigeria.
- Lei, B., Xiong, Q., Zhao, H., Dong, W., Tam, V. W., Sun, Z., & Li, W. (2023). Performance of asphalt mortar with recycled concrete powder under different filler-to-asphalt weight ratios. *Case Studies in Construction Materials*, 18, e01834. <https://doi.org/10.1016/j.cscm.2023.e01834>
- Taiwo, L. A., Obianyo, I. I., Omoniyi, A. O., Onwualu, A. P., Soboyejo, A. B., & Amu, O. O. (2022). Mechanical behaviour of composite produced with quarry dust and rice husk ash for sustainable building applications. *Case Studies in Construction Materials*, 17, e01157. <https://doi.org/10.1016/j.cscm.2022.e01157>
- Horsakulthai, V. (2021). Effect of recycled concrete powder on strength, electrical resistivity, and water absorption of self-compacting mortars. *Case Studies in Construction Materials*, 15, e00725. <https://doi.org/10.1016/j.cscm.2021.e00725>
- Etim, R. K., Ekpo, D. U., Attah, I. C., & Onyelowe, K. C. (2021). Effect of micro sized quarry dust particle on the compaction and strength properties of cement stabilized lateritic soil. *Cleaner Materials*, 2, 100023. <https://doi.org/10.1016/j.clema.2021.100023>

- Zhao, Y., Qiu, J., Xing, J., & Sun, X. (2020). Recycling of quarry dust for supplementary cementitious materials in low carbon cement. *Construction and Building Materials*, 237, 117608. <https://doi.org/10.1016/j.conbuildmat.2019.117608>
- Li, J., Deng, X., Lu, Z., Li, X., Hou, L., Jiang, J., ... & He, K. (2024). Recycled concrete fines as a supplementary cementitious material: Mechanical performances, hydration, and microstructures in cementitious systems. *Case Studies in Construction Materials*, 21, e03575. <https://doi.org/10.1016/j.cscm.2024.e03575>
- Oguntayo, D. O., Mashaan, N. S., & Shukla, S. K. (2025). Mine Tailings as a Sustainable Filler for Asphalt Binder–Mastics: A Review. *Materials*, 18(21), 4892. <https://doi.org/10.3390/ma18214892>
- Joumbat, R., Kassem, H., Elkordi, A., & Khatib, J. (2024). Use of alternative recycled fillers in bituminous mixtures: A review. *Advance Upcycling of By-Products in Binder and Binder-Based Materials*, 335-356. <https://doi.org/10.1016/B978-0-323-90791-0.00007-X>
- Akinleye, M., Al Kaaf, K., Oyeibisi, S., Tijani, M., Salami, M., & Adeleke, J. (2025). Valorizing waste materials as biomass fillers in the production of asphalt mixtures. *World Journal of Engineering*. <https://doi.org/10.1108/WJE-12-2024-0672>
- Solouki, A., Tataranni, P., Tarsi, G., & Sangiorgi, C. (2023). Waste silt as filler in hot mix asphalt: A laboratory characterization. *Applied Sciences*, 13(6), 3473. <https://doi.org/10.3390/app13063473>
- Teshome, G., Geremew, A., & Fayissa, B. (2025). Rutting Performance Evaluation of Asphalt Mixture Constitutes Waste Marble Powder Filler: An Experimental and Numerical Analysis Approach. *Results in Engineering*, 105550. <https://doi.org/10.1016/j.rineng.2025.105550>
- Oyedepo, O. J., Olukanni, E. O., Alalade, A., Amoko, A., Oluwadare, G., & Ayanda, O. (2021). Evaluation of the Strength Properties of Asphalt Concrete using Natural Fibres as Reinforcing Additives. *Nigerian Journal of technological development*, 18(4), 302-311. <https://doi.org/10.63746/njtd.v18i4.787>