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Original Research Paper

Sustainable Dense Bituminous Mixtures using Reclaimed Asphalt Pavement,Construction & Demolition Waste:Performance Comparison of VG-30 and CRMB-55 Binders

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Abstract

The increasing consumption of natural aggregates and bituminous materials, together with the generation of reclaimed asphalt and construction and demolition waste, creates a need for sustainable pavement construction practices. This study experimentally investigates the combined utilization of Reclaimed Asphalt Pavement(RAP) and Processed Construction and Demolition(PCD) waste in Dense Bituminous Macadam DBM) mixtures using VG-30 and Crumb Rubber Modified Bitumen(CRMB-55) binders. The experimental programme included characterization of binders and recycled aggregates, Marshall mix design, determination of optimum RAP and PCD contents, and performance evaluation using Marshall Stability, Flow Value, Indirect Tensile Strength(ITS), Tensile Strength Ratio(TSR), and Retained Stability (RS). DBM Grade-II gradation was maintained for the investigated mixtures to permit comparison of recycled-material combinations and binder types. For VG-30, the Marshall Stability increased from 13.14 kN for the natural-aggregate control mixture to 19.88 kN at 30% RAP, which was selected as the optimum RAP level. Subsequent incorporation of PCD increased optimum binder demand because of the comparatively high absorption of the recycled demolition aggregate. The final sustainable VG-30 mixture containing 30% RAP and the investigated combination of PCD fractions achieved 14.75kN Marshall Stability, approximately 12.25% above the control mixture. Performance evaluation showed that the final VG-30 mixture satisfied the investigated ITS, RS and TSR requirements. In contrast, the corresponding CRMB-55 mixture containing 30% RAP and 33.5% PCD did not satisfy the minimum TSR requirement of 80%. RAP improved ITS and moisture resistance in the VG-30 system, while PCD generally reduced tensile and moisture-related performance. The results indicate that the engineering suitability of high-recycled-content mixtures depends on both recycled-material proportions and binder compatibility. Under the conditions investigated, VG-30 showed better overall compatibility with high RAP and PCD contents than CRMB-55.

Keywords: Reclaimed Asphalt Pavement; Construction and Demolition Waste; Processed C&D Waste; Dense Bituminous Macadam; VG-30; CRMB-55; Marshall Stability; Indirect Tensile Strength; Tensile Strength Ratio; Sustainable Pavement.

1. Introduction

Rapid growth in transportation infrastructure has increased the demand for natural aggregates and bituminous materials. Continuous extraction of virgin aggregates contributes to resource depletion, energy consumption and ecological degradation, while pavement rehabilitation generates large quantities of reclaimed asphalt. In parallel, rapid urban development and demolition activities generate construction and demolition(C&D) waste. Sustainable pavement engineering therefore increasingly emphasizes recycling, resource conservation and reduction of waste sent to disposal facilities.

Reclaimed Asphalt Pavement (RAP) is particularly attractive because it contains aggregate coated with aged bitumen. When appropriately processed and proportioned, RAP can replace part of the virgin aggregate and reduce the requirement for fresh binder. However, aged RAP binder is generally stiffer than virgin binder and can affect mixture workability, stiffness, cracking response and moisture susceptibility. Consequently, the RAP

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replacement level and the properties of the new binder are important design variables.

Processed C&D waste is another potential source of recycled aggregate. Concrete, masonry and mortar-derived particles can be crushed, screened and incorporated into pavement materials. However, PCD particles may have higher water absorption and lower specific gravity than natural aggregate because of adhered mortar and porous masonry constituents. These properties can increase binder demand and influence mixture strength and moisture resistance.

The combined use of RAP and PCD provides an opportunity to increase recycled-material utilization in bituminous mixtures. At the same time, the simultaneous presence of aged RAP binder and porous PCD aggregate may create interactions that differ from those observed when either recycled material is used separately. Binder selection is therefore critical. VG-30 is a conventional viscosity-grade paving binder, while CRMB-55 is a crumb-rubber-modified binder with comparatively higher stiffness and viscosity. Their different rheological characteristics may result in different compatibility with RAP and PCD.

The present investigation evaluates the combined use of RAP and PCD in DBM mixtures and compares the performance of VG-30 and CRMB-55 binders. The study maintains a consistent DBM Grade-II gradation and systematically progresses from material characterization to optimum RAP determination, PCD incorporation, Marshall mix design and performance evaluation. The principal research contribution is the identification of a recycled-material combination and binder system capable of maintaining satisfactory mechanical and moisture-related performance.

1.1 Research Gap

Existing research has established the potential of RAP and recycled C&D materials for pavement applications. However, the simultaneous incorporation of substantial RAP and PCD contents introduces combined effects of aged binder, aggregate absorption, aggregate strength and binder stiffness. A further gap concerns direct comparison of conventional VG-30 and CRMB-55 binders under the same RAP–PCD aggregate combinations. The present study addresses this gap by evaluating the two binders using a common experimental framework and by assessing not only Marshall properties but also tensile strength and moisture susceptibility.

1.2 Objectives

- To characterize VG-30 and CRMB-55 binders using physical and rheological laboratory investigations.
- To evaluate the engineering properties of Natural Aggregate(NA), RAP and Processed Construction and Demolition(PCD) waste.
- To determine the optimum RAP replacement level for DBM mixtures using Marshall mix design.
- To investigate the influence of PCD aggregate proportions and sizes on RAP-containing DBM mixtures.
- To compare VG-30 and CRMB-55 binder systems under recycled-material conditions.
- To evaluate Marshall Stability, Flow Value, ITS, TSR and Retained Stability of selected mixtures.
- To identify a sustainable RAP–PCD mixture with satisfactory engineering performance.

2. Review of Literature

Arbani and Tahami (2017) investigated the suitability of rice husk ash (RHA) as an environmentally sustainable modifier for hot mix asphalt binders. Rice husk ash was incorporated into the base bitumen at replacement levels of **5%, 10%, 15%, and 20%** by weight. The modified binders were evaluated using Rotational Viscometer(RV) and Dynamic Shear Rheometer(DSR), while asphalt mixtures were tested through Marshall stability, stiffness modulus, indirect tensile fatigue, and repeated load axial tests.

The results indicated that the incorporation of rice husk ash significantly enhanced both the rheological characteristics of the binder and the mechanical properties of asphalt mixtures. Marshall stability, stiffness modulus, rutting resistance, and fatigue performance improved considerably with increasing RHA content up to **15%**. Beyond this level, only marginal improvements were observed, indicating that **15% rice husk ash** represents the optimum dosage for achieving balanced engineering performance and sustainability.

Hu et al. (2019) investigated reclaimed asphalt felt waste (RPAF) as a sustainable modifier for asphalt binders and hot mix asphalt. The waste material was pre-treated before being incorporated into virgin binders at **3%, 5%, 7%, and 9%** by weight. The modified binders were assessed through conventional physical, storage stability, and rheological tests, whereas asphalt mixtures were evaluated for cracking, rutting, and moisture resistance. The study concluded that reclaimed asphalt felt waste can serve as an effective and environmentally responsible binder modifier.

Jonia et al. (2019) explored the feasibility of using waste vegetable oil (WVO) and waste engine oil (WEO) as rejuvenating agents for aged bitumen recovered from reclaimed asphalt pavement. The rejuvenators were incorporated separately at **1%, 2%, and 3%** concentrations and evaluated using penetration, ductility, viscosity, softening point, specific gravity, flash point, and FTIR analysis.

The investigation showed that **1% waste vegetable oil** and **3% waste engine oil** successfully restored aged binders to their original penetration grade. Waste vegetable oil demonstrated slightly better rejuvenating capability than waste engine oil, indicating its greater suitability for asphalt recycling applications.

Barati et al. (2020) investigated the combined influence of recycled glass powder(RGP) and carbon nanotubes (CNTs) on asphalt binder and hot mix asphalt performance. Recycled glass powder replaced fine aggregate at different proportions, while carbon nanotubes were added directly to the binder. Marshall Stability testing and economic analysis were performed to evaluate the modified mixtures.

The incorporation of carbon nanotubes significantly improved the mechanical performance of asphalt mixtures, whereas recycled glass powder contributed to sustainable aggregate replacement. Considering both engineering performance and economic feasibility, the combination containing **1% carbon nanotubes and 25% recycled glass powder** was identified as the most effective mixture.

Paul et al. (2021) evaluated the performance of centrifuged natural latex(CENEX) polymer as a modifier for Dense Bituminous Macadam(DBM) and Bituminous Concrete(BC). Different polymer contents ranging from **0% to 8%** were incorporated into VG-30 binder, and the optimum dosage was determined through storage stability testing.

3. Materials and Methodology

3.1 Materials

The study used Natural Aggregate (NA), Reclaimed Asphalt Pavement (RAP), Processed Construction and Demolition (PCD) waste, VG-30 binder and CRMB-55 binder. The PCD material was considered in 40 mm, 20 mm and 10 mm aggregate fractions. These materials are obtained from Vijayawada market.

3.2 Methodology

The methodology involves procuring and characterizing the binder and aggregate materials through standard laboratory tests. DBM mixtures are prepared using the Marshall mix design method with VG-30, RAP, and PCD in different phases. The prepared mixes are evaluated using retained stability, ITS, and TSR tests to determine their performance. The results are compared with CRMB-55 mixes to identify the most effective and suitable DBM mixture**.** IRC:SP:53-2010,IRC:37-2018,IRC:SP:98-2013,IRC:SP:145-2015 and IRC:SP:84-2019 were used in this study**.** This methodology shown in the below Flowchart format as follows:

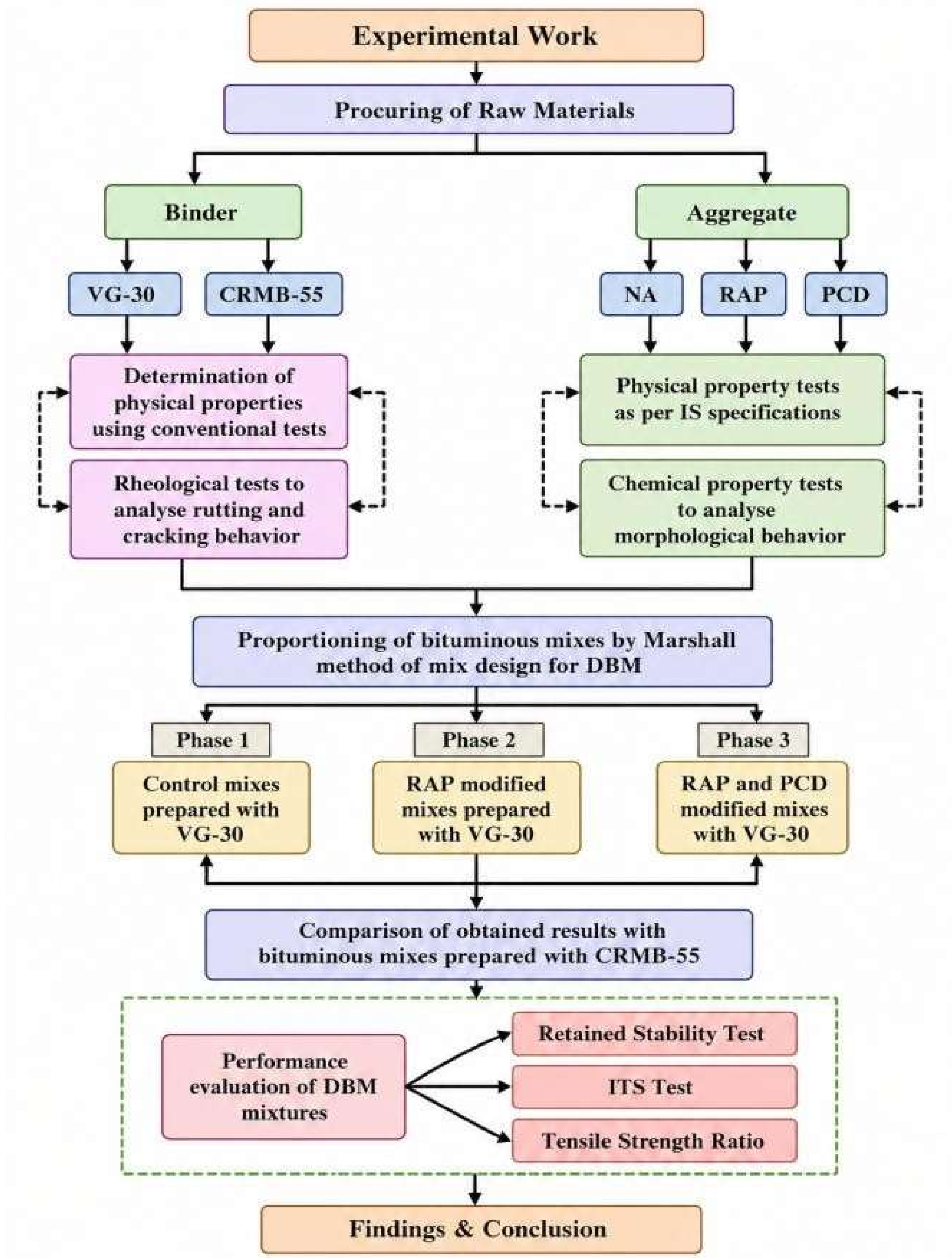


Figure 3.1 : Flowchart of Experimental Methodology

4. Experimental Work

The experimental programme was designed in five stages: binder characterization, aggregate characterization, development of bituminous mixes, comparative evaluation of binder types, and performance evaluation.

4.1 Binder Characterization

VG-30 and CRMB-55 were characterized through conventional physical tests and rheological investigations. The programme included penetration, viscosity, ductility, softening point, specific gravity, elastic recovery, creep stiffness and m-value investigations, together with Dynamic Shear Rheometer-based assessment of high-temperature behaviour. The Bending Beam Rheometer results were used to compare low-

temperature stiffness and stress-relaxation response.

4.2 Aggregate Characterization

Natural Aggregate, RAP and PCD were characterized for gradation, specific gravity, water absorption, Aggregate Impact Value, Aggregate Crushing Value, Los Angeles Abrasion Value, and combined flakiness and elongation characteristics. These tests were used to assess suitability for incorporation into the DBM mixture and to explain subsequent differences in binder demand and mixture performance.

4.3 DBM Gradation and Mix Development

Dense Bituminous Macadam Grade-II was selected for the study. The same aggregate gradation was maintained for the comparative mixtures. A conventional natural-aggregate control mixture was first developed using VG-30. RAP was then introduced at different replacement levels to identify the optimum RAP content. After selecting the optimum RAP level, PCD was introduced using different particle sizes and proportions. Corresponding CRMB-55 mixtures were subsequently produced using the same aggregate combinations to enable direct binder comparison.

4.4 Marshall Mix Design

Marshall specimens were prepared for the control, RAP-modified and RAP–PCD mixtures. Optimum binder content was determined at the adopted design air-void condition. Marshall Stability and Flow Value were measured to evaluate mixture strength and deformation response. The optimum RAP level was selected based on the observed Marshall performance, after which PCD incorporation was investigated.

4.5 Performance Tests

Selected mixtures were evaluated using Indirect Tensile Strength (ITS), Tensile Strength Ratio (TSR) and Retained Stability (RS). ITS was used to evaluate tensile strength. TSR was used to assess moisture susceptibility through comparison of conditioned and unconditioned strength. A minimum TSR requirement of 80% was adopted for the investigated mixtures. Retained Stability was used as an additional indicator of stability retention after conditioning.

Figure 4.1 : Common Rubber and Plastic Waste Materials Used for Bitumen Modification

5. Results and Discussion

5.1 Binder Behavior

CRMB-55 exhibited comparatively greater stiffness than VG-30, while VG-30 showed greater flexibility and stress-relaxation capability. At low temperatures, the BBR results indicated lower creep stiffness for VG-30 at −6 °C and −12 °C, while CRMB-55 showed slightly lower stiffness at −18 °C. The m-values of VG-30 were consistently higher at the investigated temperatures. Both binders satisfied the low-temperature acceptance criteria used in the study. These results indicate that CRMB-55 provides a stiffer binder system, while VG-30 provides a more flexible response.

Table 5.1 Variation of creep stiffness and m-value of VG-30 and CRMB-55 with temperature

Temperature	VG-30 Creep Stiffness (MPa)	VG-30 m-value	CRMB-55 Creep Stiffness (MPa)	CRMB-55 m-value
−6 °C	40.6	0.518	46	0.379

−12 °C	85.4	0.447	131	0.373
−18 °C	284	0.350	269	0.308

5.2 Aggregate Behavior

The aggregate characterization indicated that Natural Aggregate had comparatively low water absorption, whereas PCD showed higher absorption because of porous mortar and masonry constituents. RAP exhibited intermediate characteristics because the aggregate particles were coated with residual aged bitumen. The higher absorption of PCD is important because it increases the binder requirement of mixtures containing larger PCD proportions.

Mix	Aggregate Combination	OBC (%)	Stability (kN)	Flow (mm)
V1	NA (Control)	4.70	13.14	3.10
V2	NA + 25% RAP	4.10	16.95	2.95
V3	NA + 30% RAP	3.95	19.88	2.90
V4	NA + 35% RAP	3.80	17.69	2.78
V5	NA + 30% RAP + 16% PCD40	4.40	18.59	3.35
V6	NA + 30% RAP + 12.5% PCD40	4.25	18.81	3.27
V7	NA + 30% RAP + 10% PCD40	4.25	18.97	3.20
V8	NA + 30% RAP + 15% PCD20	4.40	16.44	3.38
V9	NA + 30% RAP + 12.5% PCD20	4.25	17.49	3.30
V10	NA + 30% RAP + 10% PCD20	4.25	18.02	3.25
V11	NA + 30% RAP + 10% PCD10	4.40	17.04	3.30
V12	NA + 30% RAP + 16% PCD40 + 15% PCD20 + 10% PCD10	5.00	14.75	3.65

Table 5.2 Marshall Characteristics of VG-30 Mixtures

The VG-30 control mixture exhibited 4.70% optimum binder content, 13.14 kN Marshall Stability and 3.10 mm Flow Value. Increasing RAP to 25% increased stability to 16.95 kN, while 30% RAP produced the maximum stability of 19.88 kN at 35% RAP, stability decreased to 17.69 kN. Therefore, 30% RAP was selected as the optimum RAP level in the investigated VG-30 system.

The optimum binder content decreased progressively from 4.70% in the control mixture to 4.10%, 3.95% and 3.80% at 25%, 30% and 35% RAP, respectively. This trend is attributed to the residual aged binder associated with RAP, which reduces the requirement for additional virgin binder.

After 30% RAP was selected, incorporation of PCD increased optimum binder demand. The OBC increased to 4.40% for the 16% PCD40 mixture and to 5.00% for the final multi-size PCD mixture. The increased binder demand is consistent with the higher absorption of PCD. Marshall Stability generally declined with increasing PCD content; however, the final V12 mixture still achieved 14.75 kN, approximately 12.25% above the 13.14 kN control value. The final combination therefore demonstrates the potential for substantial recycled-material utilization without losing the investigated Marshall strength level.

Table 5.3 Marshall Characteristics of CRMB-55 Mixtures

Mix	Aggregate Combination	OBC (%)	Stability (kN)	Flow (mm)
C1	NA (Control)	4.85	15.78	3.30
C2	NA + 30% RAP	4.25	15.68	3.05
C3	NA + 30% RAP + 16% PCD40	4.70	14.02	3.50
C4	NA + 30% RAP + 12.5% PCD40	4.55	14.36	3.42
C5	NA + 30% RAP + 10% PCD40	4.55	14.88	3.32
C6	NA + 30% RAP + 15% PCD20	4.70	13.76	3.56
C7	NA + 30% RAP + 12.5% PCD20	4.55	14.08	3.46
C8	NA + 30% RAP + 10% PCD20	4.55	14.32	3.35
C9	NA + 30% RAP + 10% PCD10	4.70	13.57	3.40
C10	NA + 30% RAP + 16% PCD40 + 15% PCD20 + 10% PCD10	5.30	10.01	4.20
C11	NA + 30% RAP + 12.5% PCD40 + 10% PCD20 + 10% PCD10	5.30	10.67	4.05

C12	NA + 30% RAP + 10% PCD40 + 10% PCD20 + 10% PCD10	5.15	11.43	3.95
C13	NA + 30% RAP + 16% PCD40 + 10% PCD20 + 7.5% PCD10	5.15	12.08	3.80

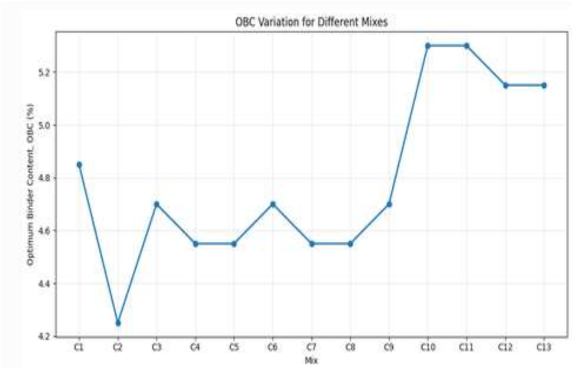
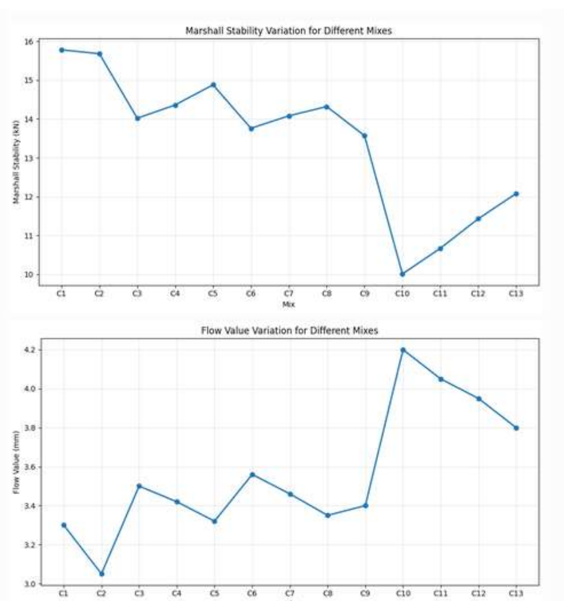


Figure 5.1 OBC Variation for Different Mixes



Figures 5.2 Variation of Marshal stability and Flow values for different mixes

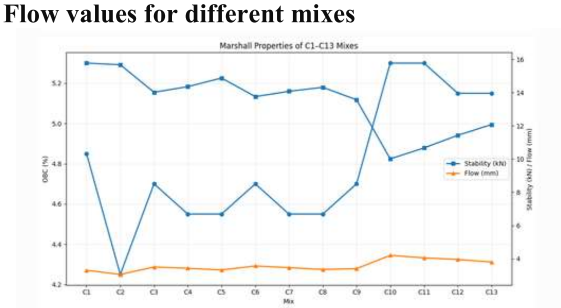


Figure 5.4 Marshal Properties of C1 – C13 mixes

The CRMB-55 control mixture produced 15.78 kN Marshall Stability, higher than the VG-30 control mixture. This reflects the greater stiffness of CRMB-55. However, incorporation of 30% RAP reduced stability slightly to 15.68 kN. Further PCD incorporation generally reduced stability, and the highest multi-size PCD combination produced stability values between 10.01 and 12.08 kN depending on the final blend. The OBC increased to 5.15–5.30% for these mixtures. The results indicate that the higher stiffness of CRMB-55 did not provide a corresponding improvement when high recycled-material contents were introduced.

5.3 Comparison of Binder Systems

Table 5.4 Comparison of binder systems

Performance Indicator	VG-30	CRMB-55	Interpretation
Control Marshall Stability	13.14 kN	15.78 kN	CRMB-55 higher for conventional mix
Optimum RAP level	30%	30% investigated	30% selected for recycled-mixture development
Maximum/selected RAP-stage stability	19.88 kN at 30% RAP	15.68 kN at 30% RAP	VG-30 benefited more from RAP
Final sustainable mixture	30% RAP + 41% PCD	30% RAP + 33.5% PCD	Different optimum recycled-material combinations
Final TSR compliance	Satisfied	Not satisfied	VG-30 showed better moisture resistance
Overall compatibility	Better under investigated conditions	Inferior at high recycled content	Binder–RAP interaction is critical

The binder comparison is one of the main findings of the study. Although CRMB-55 provided greater stability in the conventional control mixture, VG-30 performed better after RAP and PCD were incorporated. The 30% RAP VG-30 mixture reached 19.88 kN, compared with 15.68 kN for the corresponding CRMB-55 mixture. The difference suggests that binder stiffness alone cannot be used as a criterion for selecting the best binder for high recycled-content mixtures. Compatibility with aged RAP binder and the absorption characteristics of PCD are equally important.

5.4 Indirect Tensile Strength

The ITS results reported in the thesis show contrasting responses to RAP for the two binders. In VG-30 mixtures, RAP increased ITS, indicating improved tensile performance. This behaviour is attributed to compatibility between the comparatively softer VG-30 binder and the aged binder coating on RAP particles. In CRMB-55 mixtures, RAP reduced ITS, which is associated with the combination of the stiff modified binder and aged RAP binder. PCD incorporation reduced ITS for both binder systems, consistent with the porous nature, adhered mortar and comparatively lower mechanical strength of PCD. Larger PCD particles showed better ITS performance than smaller particles, and VG-30 mixtures consistently exhibited higher ITS than CRMB-55 mixtures in the investigation.

5.5 Moisture Susceptibility

Moisture susceptibility was evaluated using TSR and Retained Stability. RAP improved both TSR and Retained Stability in the VG-30 mixtures. The improvement is attributed to the relatively low water absorption of RAP and its aged binder coating, which can reduce moisture penetration and enhance aggregate–binder adhesion. In CRMB-55 mixtures, RAP produced comparatively lower TSR and Retained Stability values.

PCD reduced moisture resistance in both binder systems. Its porous structure and higher water absorption provide greater opportunity for moisture ingress and moisture-induced damage. The study adopted a minimum TSR requirement of 80%. The final VG-30 mixture containing 30% RAP and 41% PCD satisfied the investigated ITS, Retained Stability and TSR requirements. The corresponding CRMB-55 mixture containing 30% RAP and 33.5% PCD did not satisfy the minimum TSR requirement. This result indicates that high recycled-material content must be optimized together with binder type and moisture resistance.

5.6 Sustainability and Practical Implications

The results demonstrate that RAP and PCD can be incorporated together into DBM mixtures and can reduce dependence on virgin aggregates. RAP additionally reduces the requirement for fresh binder because of its residual aged binder. PCD provides a route for diverting construction and demolition waste from disposal. However, the results also show that recycled-material utilization should not be based solely on maximizing replacement percentage. Excessive PCD can increase binder demand and reduce tensile and moisture-related performance. The final VG-30 mixture demonstrates a practical balance between recycled-material utilization and the engineering properties investigated in this study.

The findings are laboratory-based and should be interpreted within the material sources, aggregate gradation, binder systems and test conditions used. Field validation, long-term ageing, rutting, fatigue and life-cycle assessment are recommended before large-scale implementation.

6. Conclusions

1. VG-30 and CRMB-55 both satisfied the physical and rheological requirements considered in the study. CRMB-55 showed greater stiffness, whereas VG-30 showed comparatively greater flexibility and stress-relaxation capability.
2. Natural Aggregate, RAP and PCD exhibited different physical characteristics. PCD showed comparatively higher water absorption because of porous mortar and masonry constituents.
3. For VG-30, 30% RAP produced the maximum Marshall Stability of 19.88 kN and was selected as the optimum RAP replacement level.
4. Increasing RAP content reduced optimum binder content because of the residual aged binder associated with RAP.
5. Incorporation of PCD increased optimum binder content because of its higher absorption.
6. The final VG-30 multi-size PCD mixture containing 30% RAP achieved 14.75 kN Marshall Stability, approximately 12.25% above the natural-aggregate control mixture.
7. CRMB-55 provided higher Marshall Stability than VG-30 for the conventional control mixture, but its advantage was not maintained after substantial RAP and PCD incorporation.
8. RAP increased ITS in VG-30 mixtures but reduced ITS in CRMB-55 mixtures, indicating better compatibility of VG-30 with the aged RAP binder under the investigated conditions.
9. PCD reduced ITS for both binder systems; larger PCD particles performed better than smaller particles in the tensile-strength investigation.
10. RAP improved TSR and Retained Stability in VG-30 mixtures, whereas PCD reduced moisture resistance in both binder systems.
11. The final VG-30 mixture containing 30% RAP and 41% PCD satisfied the investigated ITS, TSR and

7. Limitations and Future Research

The present investigation is laboratory-based and uses specific sources of RAP, PCD and binders. The conclusions should therefore be interpreted for the material characteristics and mix conditions investigated. Further work should evaluate long-term ageing, rutting resistance, fatigue performance, resilient modulus, wheel tracking, field compaction and field performance. A life-cycle assessment and life-cycle cost analysis should also be undertaken to quantify environmental and economic benefits. Future studies may additionally investigate rejuvenators for high-RAP mixtures and alternative modified binders to improve compatibility with PCD.

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References

1. Arulrajah, A., Yaghoubi, E., Wong, Y.C., & Horpibulsuk, S. (2017). Recycled plastic granules and demolition wastes as construction materials: Resilient moduli and strength characteristics. Construction and Building Materials, 147, 639–647.
2. Nandal, M., Sood, H., Gupta, P.K., & Haq, M.Z.U. (2022). Morphological and physical characterization of construction and demolition waste. Materials Today: Proceedings.
3. Sharma, A., Ransinchung, G.D., Kumar, P., & Kumar, D.S.N.V.A. (2021). Design Mixture of RAP-HMA Pavements: A Review. IOP Conference Series: Materials Science and Engineering, 1075.
4. Nandal, M., Sood, H., & Gupta, P.K. (2023). Comparative Study on Physical Characterization of Reclaimed Asphalt Pavement and Natural Aggregate in Flexible Pavement. E3S Web of Conferences, 405.
5. Nandal, M., Sood, H., & Gupta, P.K. (2023). A Review Study on Sustainable Utilisation of Waste in Bituminous Layers of Flexible Pavement. Case Studies in Construction Materials.
6. Purohit, S., Panda, M., & Das, A.K. (2022). Performance of waste polyethylene modified bituminous paving mixes containing reclaimed asphalt pavement and recycled concrete aggregate. Construction and Building Materials, 348.
7. Giri, J.P., Panda, M., & Sahoo, U.C. (2018). Performance of Bituminous Mixes Containing Treated Recycled Concrete Aggregates and Modified by Waste Polyethylene. Journal of Materials in Civil Engineering.
8. Xu, W., Li, W., & Ji, Y. (2021). Mechanical behavior investigation of reclaimed asphalt aggregate concrete in a cold region. Materials, 14.
9. Singh, D., & Girimath, S. (2016). Influence of RAP Sources and Proportions on Fracture and Low Temperature Cracking Performance of Polymer Modified Binder. Construction and Building Materials, 120, 10–18.
10. Arulrajah, A., Disfani, M.M., Horpibulsuk, S., Suksiripattanapong, C., & Prongmanee, N. (2014). Physical Properties and Shear Strength Responses of Recycled Construction and Demolition Materials in Unbound Pavement Base/Subbase Applications. Construction and Building Materials, 58, 245–257.
11. Purohit, S., Panda, M., & Chattaraj, U. (2021). Use of Reclaimed Asphalt Pavement and Recycled Concrete Aggregate for Bituminous Paving Mixes: A Simple Approach. Journal of Materials in Civil Engineering, 33.
12. Colbert, B., & You, Z. (2012). The Determination of Mechanical Performance of Laboratory Produced Hot Mix Asphalt Mixtures Using Controlled RAP and Virgin Aggregate Size Fractions. Construction and Building Materials, 26, 655–662.
13. Behl, A., Kumar, G., & Sharma, G. (2013). Performance of Low Energy Crumb Rubber Modified Bituminous Mixes. Procedia – Social and Behavioral Sciences, 104, 49–58.
14. Nanda, H., & Siddagangaiah, A.K. (2024). Effect of RAP Fractionation and Dosage on Design and Mechanical Behaviour of Cold Asphalt Mixes. Construction and Building Materials, 422.