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Investigation on Recycled Concrete Aggregate for Bitiminous Mixture

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Abstract – The growing demand for sustainable construction materials has led to increased intrest in the use of recycled concrete aggregates (RCA) in various application. This study investigates the feasibility and performance of in corporating recycled concrete aggregates into bituminous mixture for load construction. Their characteristics like AIV, ACV ,Specific gravity, flakiness, Elongation, loss abration,water absorption were determined and compared with standard specifications. The present study is with evaluation of marshall stability, deformation and moisture damage resistance values of HMA which is mixed with RCA in varying portion. The Marshall mix design method was adopted in this study to determine the optimum binder content (OBC) for the asphalt mixes containing five aggregate combination with RCA contents of 0, 10, 20, 30 percent was found to be 5, 5.5, 6 percent which is optimum respectively. KEYWORDS: Bituminous mixture, Marshall mix design, Recycled concrete aggregates

1. INTRODUCTION

The rapid growth of infrastructure development across the world has led to an exponential rise in the consumption of natural resources, particularly aggregates used in road construction. Conventional bituminous pavements rely heavily on natural coarse and fine aggregates obtained from quarries and riverbeds. However, the continued extraction of these natural materials raises concerns related to resource depletion, environmental degradation, and increased project costs. At the same time, construction and demolition (C&D) waste generation has increased significantly due to urban expansion, redevelopment projects, and aging infrastructure. Among the various types of construction waste, waste concrete constitutes a major proportion and often ends up in landfills, contributing to environmental pollution and land scarcity issues. These growing challenges have motivated researchers and highway agencies to explore sustainable, cost-effective, and environmentally responsible alternatives. Recycled Concrete Aggregate (RCA), derived from the crushing and processing of waste concrete, has emerged as a promising substitute for natural aggregates. RCA primarily consists of crushed concrete particles coated with residual cement paste and may contain small quantities of mortar and natural aggregates. Its use in structural applications has been studied extensively, but its potential in pavement engineering—especially within bituminous mixtures—has gained momentum only in recent years.

2. LITERATURE REVIEW

1.D. Prasad Published in: Journal/Conference (Review paper), 2022 Summary: Comprehensive review synthesizing laboratory and limited field studies on the use of RCA in hot- and cold-mix bituminous pavements. The paper surveys RCA pre treatments (washing, emulsion coating, polymer impregnation), mix-design adjustments (increased binder to offset absorption), and performance tests (Marshall, ITS, rutting, moisture susceptibility). Conclusions indicate RCA is feasible at partial replacement levels (commonly up to ~30–50%) when source control and pre-treatment are applied; emphasizes lack of long-term field data and the need for standardized protocols.

2. D. El-Tahan Published in: ASCE / Journal conference paper, 2024 Summary: Experimental evaluation of combining Warm-Mix Asphalt (WMA) technology with RCA substitution. WMA lowered production temperatures and improved compactability of RCA mixes; certain WMA additives enhanced coating and reduced apparent binder absorption by RCA. Result: WMA can enable higher RCA usage while saving energy, but additive selection/dosing is critical and field validation is necessary.

3. Abdelhalim Azam et al. Published in: Case Studies in Construction Materials (Elsevier), 2024 Summary: LCA comparing environmental impacts of using recycled C&D aggregates

(including RCA) versus virgin materials in pavement layers. Results: RCA reduces embodied energy and GHG emissions notably (with reductions depending on transport distances and landfill avoidance); combined with WMA, environmental benefits increase. Emphasizes sensitivity of outcomes to transport and processing assumptions.

OBJECTIVES

1. To study the physical and mechanical properties of Recycled Concrete Aggregate (RCA) for bituminous applications.
2. To analyse the suitability of RCA as a replacement for natural aggregates in asphalt mixes.
3. To conduct laboratory tests on aggregates and bitumen, including specific gravity, impact value, crushing value, and penetration value.

3. MATERIALS AND METHODOLOGY

3.1 MATERIALS

3.1.1 Aggregates

Aggregates are mainly used in building constructions and road pavements.material used for mixing with cement,bituminous, lime ,gypsum or other pourposes. in pavements the amount of aggregates in asphalt pavement mixtures is generally 90-95 percent by weight and 75 - 85 percent by volume. Aggregates are primarly responsible for load supporting capacity of a pavement.these are divided into following categories:.

3.1.2 Bitimen

Bitumen, also known as asphalt in the United States, is a substance produced through the distillation of crude oil that is known for its waterproofing and adhesive properties. Bituminous materials are used for road construction, roofing, waterproofing, and other appli- cations as required grade such as VG-10,VG-20,VG-30,VG-40..

3.1.3 Recycled concrete Aggregates

Recycled concrete aggregate(RCA) are aggregates obtained by recycling clean concrete waste from processing of demolition renovation of buildings , highways, bridges etc..where content of other concrete waste must be very low. RCA are produced in stationary recycling plants. It can be used in flexible pavements base layers.

3.2 METHODOLOGY

3.2.1 Collection of Source Material

Demolished concrete waste was collected from identified construction and demolition sites.The waste concrete was free from harmful contaminants such as wood, plastics, glass, soil, and organic matter.The collected material was transported to the laboratory for further processing.

3.2.2. Processing of Recycled Concrete Aggregates

1. The demolished concrete was crushed manually or using a jaw crusher to obtain aggregates of required sizes.
2. Crushing was carried out in stages to minimize excessive breakage of aggregates.
3. The crushed material was sieved to separate coarse aggregates (20 mm and 10 mm) as per IS: 383.
4. Adhered old mortar was retained to represent realistic recycled aggregate conditions.

3.2.3 Physical characterization Of RCA

The following physical properties were determined:

a) Specific Gravity and Water Absorption

- Tested using wire basket method as per IS: 2386 (Part III).
- Three trials were conducted and average values were reported.
- Higher water absorption of RCA compared to natural aggregates was noted due to adhered mortar.

b) Aggregate Crushing Value

- Conducted as per IS: 2386 (Part IV) to evaluate resistance to crushing under compressive load.

c) Aggregate Impact Value

- Performed as per IS: 2386 (Part IV) to assess toughness of aggregates.

d) Los Angeles Abrasion Test

- Conducted as per IS: 2386 (Part IV) to determine resistance to abrasion and wear.

e) Shape Tests

- Flakiness Index and Elongation Index **were** determined as per IS: 2386 (Part I)**.**

3.2.4 Gradation Analysis.

1. Sieve analysis was carried out in accordance with IS: 2386 (Part I).
2. Particle size distribution curves were plotted for RCA and compared with natural aggregates.
3. Grading requirements were checked as per IS: 383.

3.2.5 Mix Proportioning

1. Concrete mixes were designed using IS: 10262 method**.**
2. RCA replaced natural coarse aggregates at different percentages (0%, 25%, 50%, 75%, and 100%).
3. Constant water-cement ratio was maintained, with additional water adjustments made to account for RCA absorption.

3.2.6 Mechanical Properties of Concrete

The following tests were conducted:

1. Compressive Strength Test **as per** IS: 516
2. Split Tensile Strength Test **as per** IS: 5816
3. Flexural Strength Test **as per** IS: 516

3.2.7 Durability Studies (Optional)

1. Water absorption and sorptivity tests
2. Acid resistance and sulphate attack tests
3. Rapid chloride penetration test (RCPT), if facilities permit

3.2.8 **Comparative Analysis**

1. Test results of RCA concrete were compared with control mixes containing natural aggregates.
2. Strength reduction, durability performance, and workability variations were evaluated.
3. Optimum replacement level of RCA was identified based on performance criteria.

3.2.9Conclusion and Recommendations

1. Based on experimental results, conclusions were drawn regarding suitability of RCA for structural and non-structural applications.
2. Recommendations were made for practical implementation and future research

4. Tests on aggregate

4.1 Flakiness index test

Sieve Size (mm)	Mass Retained (g)	Flaky Particles (g)	Trial 1
20–16	500	90	18%
16–12.5	450	72	16%
12.5–10	400	64	16%

4.2 Elongation Index

Sieve Size (mm)	Mass Retained (g)	Elongated Particles (g)	Trial 1
20–16	500	110	22%
16–12.5	450	94	20.8%
12.5–10	400	80	20%

4.3 Specific gravity

Sl. No.	Description	Trial 1 (g)
1	Weight of empty wire basket in water (W_1)	450
2	Weight of basket + aggregates in water (W_2)	1250
3	**Weight of aggregates in water = $W_2 - W_1$ (W_3)**	800
4	Surface-dry aggregates + basket in water after removal (W_4)	500
5	**SSD aggregates in air = W_5**	1600
6	**Oven-dry aggregates in air = W_6**	1540

CONCLUSION

Recycled concrete aggregates obtained from demolished concrete can be effectively processed and reused as coarse aggregates in concrete, contributing to sustainable construction practices and reduction of construction and demolition waste.he physical properties of recycled concrete aggregates, such as specific gravity and bulk density, were found to be lower than those of natural aggregates, while water absorption values were higher due to the presence of adhered old mortar.

Strength-related properties including aggregate crushing value, impact value, and Los Angeles abrasion value of RCA were slightly higher compared to natural aggregates, indicating comparatively lower resistance. However, the values remained within permissible limits as per IS: 383, making RCA suitable for use in concrete.

Shape characteristics such as flakiness and elongation indices of RCA were marginally higher, which may affect workability, but can be controlled through proper processing and grading.

At higher replacement percentages, a reduction in strength was observed, mainly due to increased porosity and weaker interfacial transition zones caused by adhered mortar.Proper mix design adjustments, such as **pre-soaking of RCA** or **use of water-reducing admixtures**, significantly improved workability and strength performance.

From both technical and environmental perspectives, the use of RCA reduces dependency on natural aggregates, conserves natural resources, and lowers landfill disposal of concrete waste.

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