# PREPARATION OF BITUMINOUS CONCRETE MIXES BY USING RECYCLED AGGREGATES FROM CONCRETE

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**Abstract:**

The rapid growth of urbanization and infrastructure development has led to the massive consumption of natural aggregates for road construction, especially in bituminous concrete mixes. At the same time, large quantities of construction and demolition (C&D) waste are being generated worldwide, creating serious environmental and disposal challenges. Among C&D wastes, concrete rubble forms a major portion, which if properly processed, can serve as recycled aggregates for flexible pavement construction. The use of recycled aggregates in bituminous concrete mixes provides a dual advantage—conservation of natural resources and reduction of waste disposal issues. This study aims to prepare and evaluate bituminous concrete mixes using recycled concrete aggregates (RCA) as a partial or full replacement of natural aggregates. Laboratory investigations include Marshall Stability test, flow value, density, voids in mineral aggregates (VMA), voids filled with bitumen (VFB), and indirect tensile strength (ITS). The results are compared with conventional mixes to assess performance. Preliminary findings suggest that mixes incorporating RCA exhibit satisfactory stability and durability, with optimum performance achieved at partial replacement levels. The study concludes that RCA can be effectively used in bituminous mixes for sustainable road construction, reducing costs, conserving natural resources, and promoting eco-friendly practices in line with circular economy principles.

## I.INTRODUCTION

Bituminous concrete (BC) is widely used in flexible pavements due to its high strength, smooth riding surface, and durability against traffic and environmental loads. Traditionally, natural aggregates such as crushed stone, gravel, and sand have been used in bituminous mixes. However, the extensive use of natural aggregates has resulted in environmental degradation, excessive mining, and depletion of natural resources. Simultaneously, urban centers are facing the challenge of managing ever-

increasing construction and demolition (C&D) waste. Concrete waste alone constitutes nearly 50–60% of total C&D waste, and its improper disposal leads to landfills being overburdened, environmental pollution, and health hazards.

Recycling concrete waste into aggregates provides a promising solution to both these problems. Recycled concrete aggregates (RCA), when processed through crushing and sieving, can be used in pavement applications, either as base and sub-base layers or as a replacement for natural aggregates in bituminous mixes. Incorporating RCA into bituminous concrete not only reduces dependency on natural aggregates but also minimizes the need for disposal of concrete debris, thereby conserving land and reducing carbon emissions associated with aggregate quarrying.

In recent years, the concept of sustainable pavements has gained global momentum. Many road authorities and research organizations have been encouraging the adoption of recycled materials to promote circular economy in road construction. The present study focuses on the preparation of bituminous concrete mixes using recycled aggregates derived from demolished concrete structures and evaluates their suitability for use in road construction through laboratory investigations.

## II.RELATED WORKS

The feasibility of using recycled aggregates in bituminous mixes has been explored by several researchers worldwide, showing promising results in terms of performance and sustainability.

- Poon et al. (2002) conducted experiments on recycled concrete aggregates in asphalt mixes and reported that the mechanical properties were comparable to conventional mixes when RCA was used up to a certain percentage. They emphasized that the porous nature of RCA required adjustments in binder content.
- Topçu and Sarıdemir (2008) studied the effect of RCA on asphalt concrete properties and concluded that stability values remained within acceptable limits for partial replacement of natural aggregates. They highlighted that higher absorption of RCA slightly increased binder demand.
- Jain and Jain (2011) focused on the environmental and economic aspects of using recycled materials in pavements. Their study suggested

that RCA not only reduced construction costs but also contributed to sustainable development by reducing landfill needs.

- Khalid et al. (2016) explored the durability and fatigue resistance of RCA-based asphalt mixtures. They observed that while there was a slight reduction in rutting resistance, the fatigue life of the mix improved due to better binder-aggregate interaction.
- Silva et al. (2019) carried out durability studies on asphalt mixtures with RCA and demonstrated that proper mix design and quality control could mitigate potential weaknesses of recycled aggregates.
- Indian Road Congress (IRC, 2020) has also published guidelines encouraging the use of recycled materials in road construction under the Green Highway Policy, highlighting sustainability as a key criterion.
- More recently, Arulrajah et al. (2021) investigated the long-term performance of recycled aggregate asphalt pavements through field trials and confirmed that RCA mixes provided acceptable strength, durability, and service life under real traffic conditions.

From these studies, it is evident that recycled concrete aggregates can serve as a viable substitute for natural aggregates in bituminous concrete mixes. While minor modifications in binder content and mix design may be necessary due to the higher porosity and angularity of RCA, the overall mechanical performance, durability, and sustainability benefits make them suitable for pavement construction.

## III. MATERIAL USED

The preparation of bituminous concrete mixes requires several essential materials. For this study, the following materials are used:

1. **Bitumen (Binder):**

Bitumen acts as a binding material in flexible pavements. For this study, VG-30 grade bitumen is commonly used, as it provides adequate binding strength and resistance to rutting under Indian climatic conditions. The properties of bitumen such as penetration value, softening point, ductility, viscosity, and specific gravity are tested as per IS:73 and IS:1203-1208.

2. **Recycled Concrete Aggregates (RCA):**

Recycled aggregates are obtained from crushed and processed demolished concrete waste. The aggregates are sieved into different sizes as per the gradation requirements of bituminous concrete mix (as per MoRTH specifications). RCA typically has rougher surface texture, angular shape, and slightly higher water absorption compared to natural aggregates.

3. **Natural Aggregates (NA):**

Conventional aggregates such as crushed granite are used as control material for comparison. They are partially replaced by RCA at different proportions (0%, 25%, 50%, 75%, and 100%).

**4. Filler Material:**

Mineral fillers such as stone dust, cement, or lime are used to fill voids in the mix and improve the binding between bitumen and aggregates. They also help in improving the strength and stiffness of the mix.

5. **Additives (Optional):**

In some cases, anti-stripping agents or hydrated lime may be added to improve the moisture resistance of the mix when RCA is used, since RCA tends to absorb more water.

## IV. RECYCLED CONCRETE AGGREGATES IN PRODUCTION

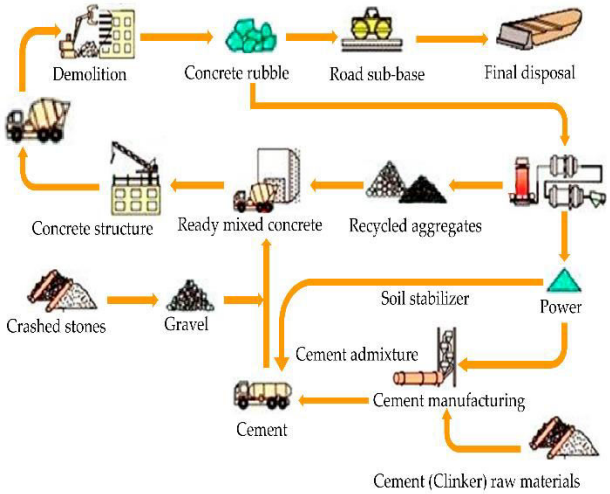


**Fig 4.1 Recycled Concrete Aggregates in Production**

The flowchart clearly illustrates the lifecycle of concrete materials and their potential for recycling in construction and pavement applications. The process begins with the demolition of existing concrete structures, which generates concrete rubble as waste material. Traditionally, such rubble is either disposed of in landfills or used in low-value applications such as road sub-base construction, ultimately leading to final disposal. However, instead of discarding this material, it can be processed into recycled aggregates, thereby extending its utility and minimizing environmental impact.

The concrete rubble collected from demolition is crushed, sieved, and transformed into recycled aggregates. These

aggregates can be reused in different ways, such as being combined with cement admixtures to produce ready-mixed concrete or incorporated into bituminous concrete mixes for road construction. The inclusion of recycled aggregates helps reduce the dependency on natural aggregates like gravel and crushed stones, whose excessive quarrying poses a threat to the environment.

Furthermore, the diagram emphasizes the role of cement manufacturing and the integration of soil stabilizers and power resources in recycling. Cement clinker raw materials undergo processing to produce cement, which is then used with both natural and recycled aggregates in new construction. The loop is completed when these materials return to the cycle through demolition and recycling, reflecting the principle of a circular economy in construction.

The use of recycled aggregates in pavement construction, especially in bituminous concrete mixes, aligns with the goals of sustainable development by conserving natural resources, reducing carbon emissions, and minimizing landfill requirements. It also supports energy efficiency since the reuse of concrete waste reduces the energy required for quarrying and transporting new aggregates. Thus, the diagram highlights how concrete waste, instead of being discarded, can be transformed into valuable resources that contribute to eco-friendly and cost-effective infrastructure development.

## V. METHODOLOGY

The methodology adopted for the preparation and testing of bituminous concrete mixes with recycled aggregates includes the following steps:

**1. Collection and Processing of Materials:**

Demolished concrete waste is collected from construction and demolition sites. The waste is crushed in a jaw crusher, sieved, and separated into required sizes. Dust and unwanted particles are removed to ensure proper gradation. Natural aggregates and bitumen are also collected and tested for quality.

**2. Characterization of Materials:**

Tests on RCA and natural aggregates are conducted to determine physical properties such as specific gravity, aggregate crushing value (ACV), impact value, water absorption, and Los Angeles abrasion value. Bitumen properties are tested for penetration, ductility, softening point, and viscosity to ensure suitability for use in pavement mixes.

3. **Gradation of Aggregates:**

The combined gradation of coarse, fine aggregates, and fillers is prepared as per MoRTH (Ministry of Road Transport and Highways) or IRC (Indian Roads Congress)

specifications for Bituminous Concrete (BC Grade I or II).

4. **Preparation of Mixes:**

Different mix proportions are prepared with varying percentages of RCA (0%, 25%, 50%, 75%, and 100%) replacing natural aggregates. Bitumen content is varied in increments (e.g., 4.0%, 4.5%, 5.0%, 5.5%, and 6.0% by weight of aggregates) to determine the Optimum Binder Content (OBC).

5. **Mixing and Compaction:**

- Aggregates are heated to mixing temperature (150–160°C), while bitumen is heated separately to 160–170°C.
- The heated aggregates and filler are mixed with hot bitumen to form a homogeneous mix.
- The mix is placed in a mold and compacted using the Marshall compactor with 75 blows on each side.

**6. Laboratory Testing (Marshall Stability Method):**

- The prepared samples are subjected to the Marshall Stability and Flow test as per ASTM D1559/IS:1201.
- Parameters such as Stability value, Flow value, Bulk density, Air voids (Va), Voids in Mineral Aggregates (VMA), and Voids Filled with Bitumen (VFB) are determined.

**7. Comparison of Results:**

- The performance of RCA mixes is compared with conventional mixes in terms of stability, durability, density, and optimum binder content.
- The suitability of recycled aggregates is assessed based on whether the values fall within MoRTH/IRC specifications for bituminous concrete.

**8. Analysis and Discussion:**

- The effect of RCA replacement on mix performance is analyzed.
- The optimum replacement level is identified, balancing strength, durability, and economic benefits.

## VI.CONCLUSION

The study highlights the potential of using recycled concrete aggregates (RCA) in the preparation of bituminous concrete mixes for sustainable pavement construction. With rapid urbanization and the increasing demand for natural aggregates, there is a pressing

need to adopt alternative materials that not only reduce environmental impacts but also provide cost-effective solutions. The recycling of demolished concrete into aggregates contributes significantly to waste reduction, conservation of natural resources, and minimization of landfill requirements. Laboratory investigations such as Marshall Stability, density, flow value, and void analysis indicate that RCA can partially or fully replace natural aggregates without significant loss of performance.

However, the use of RCA may require slight adjustments in bitumen content due to higher porosity and water absorption. Optimal performance is often achieved when RCA is used in partial replacement, balancing strength, durability, and workability. The circular flow of materials, as represented in the lifecycle diagram, reinforces the concept of sustainable construction practices by converting waste into valuable resources.

Overall, the incorporation of RCA in bituminous mixes is a technically feasible, environmentally sustainable, and economically viable approach. Future research should focus on long-term field performance, moisture susceptibility, and the development of mix design standards to further encourage large-scale adoption. This approach supports the goals of green highways and the circular economy, ensuring that road construction aligns with sustainability and resource conservation objectives.

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