IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

FEASIBILITY ANALYSIS OF USING CONSTRUCTION AND DEMOLITION WASTE IN ROAD CONSTRUCTION

Manas Dinesh Sanap[1], Prof. Aarti B. Gaikwad[2], Prof. Swapnil Joshi[3], Prof Amol Saner[4]
M-Tech 2nd Year student, Professor
Civil Engineering Department,
Matoshri College of Engineering & Research Centre, Nashik, India

Abstract: The rapid pace of urbanization and infrastructure development has resulted in the generation of large quantities of construction and demolition (C&D) waste. Improper disposal of this waste creates environmental concerns and increases pressure on landfill sites. At the same time, road construction requires a significant amount of natural aggregates, leading to depletion of natural resources. The use of recycled C&D waste in pavement construction provides a sustainable and eco-friendly alternative. This study evaluates the feasibility of using recycled aggregates obtained from concrete debris, brick waste, and ceramic materials in road construction. Engineering properties such as specific gravity, water absorption, aggregate impact value, aggregate crushing value, and California Bearing Ratio (CBR) are considered to assess their suitability. The study compares the performance of recycled aggregates with conventional natural aggregates and standard specifications recommended by IRC and MORTH. The findings suggest that recycled aggregates can be effectively utilized in pavement sub-base and base layers, contributing to sustainable construction practices and conservation of natural resources.

Index Terms - Construction and Demolition Waste, Recycled Aggregates, Road Construction, Sustainable Materials, Pavement Engineering.

I. INTRODUCTION

Construction and demolition (C&D) waste is one of the fastest growing waste streams worldwide due to rapid urbanization, population growth, and continuous infrastructure development. Large quantities of waste materials are generated during construction, renovation, and demolition of buildings, roads, bridges, and other infrastructure projects. These wastes commonly include concrete debris, bricks, tiles, ceramics, mortar, plaster, and other construction materials. Improper disposal of such waste not only occupies valuable landfill space but also leads to serious environmental problems such as soil pollution, air pollution, and depletion of natural resources.

At the same time, road construction requires a significant quantity of natural aggregates such as crushed stone, gravel, and sand. These materials are extracted from quarries and riverbeds, resulting in environmental degradation and depletion of natural resources. With increasing demand for infrastructure development, the consumption of natural aggregates has increased rapidly. Therefore, there is a growing need to explore alternative materials that can partially or fully replace conventional aggregates in road construction.

Recycling construction and demolition waste offers a sustainable solution to this problem. By processing C&D waste through crushing and screening operations, it can be converted into recycled aggregates that may be used in various layers of road pavements, particularly in sub-base and base layers.

Several studies have indicated that recycled aggregates obtained from concrete and masonry waste possess adequate engineering properties such as strength, durability, and load-bearing capacity when properly processed and graded.

The utilization of recycled C&D waste in road construction not only helps in reducing the environmental burden caused by waste disposal but also contributes to conservation of natural resources and reduction in construction costs. Moreover, it supports the concept of sustainable development and circular economy by promoting reuse and recycling of construction materials.

This study focuses on analysing the feasibility of using construction and demolition waste as recycled aggregates in road construction. The research involves material selection, collection, processing, and evaluation of engineering properties of recycled aggregates obtained from concrete debris, brick waste, and tile or ceramic fragments. The performance of these recycled materials will be compared with conventional natural aggregates and relevant standards such as IRC and MORTH specifications to determine their suitability for pavement applications.

II. FUNDAMENTALS / BACKGROUND

Construction and demolition (C&D) waste refers to the materials generated during the construction, renovation, repair, and demolition of buildings, roads, bridges, and other infrastructure facilities. These wastes typically include concrete debris, brick fragments, ceramic tiles, mortar, plaster, asphalt pavement, and other building components. With rapid urbanization and population growth, the generation of C&D waste has increased substantially across the world. Improper disposal of these materials often leads to environmental degradation, landfill congestion, and inefficient use of valuable natural resources.

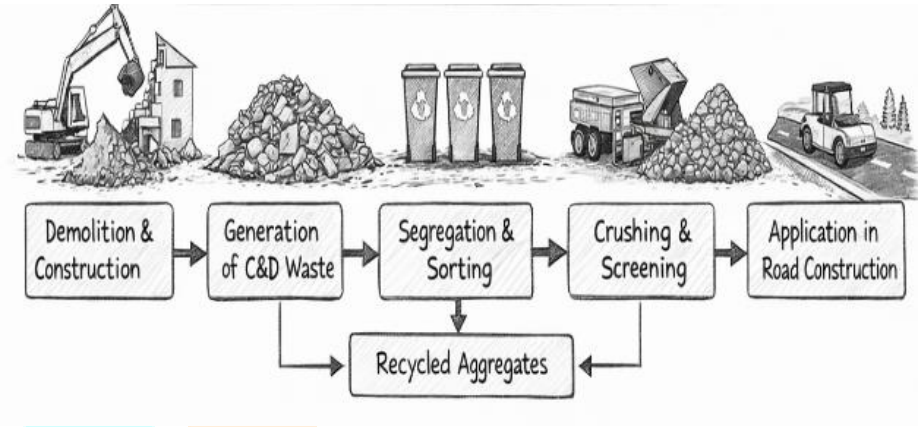
Traditionally, construction and demolition waste has been disposed of in landfills or dumped in open areas without proper treatment. Such practices occupy large areas of land and contribute to environmental pollution through dust generation and contamination of soil and groundwater. At the same time, the construction industry continuously requires large quantities of natural aggregates for road construction. Excessive extraction of these materials from quarries and riverbeds results in environmental impacts including habitat destruction, landscape degradation, and depletion of natural resources.

In recent years, recycling and reuse of construction and demolition waste have gained considerable attention as a sustainable approach to waste management. Through appropriate processing methods such as crushing, screening, and sorting, C&D waste can be converted into recycled aggregates that can be utilized in various construction applications. These recycled materials can potentially replace a portion of natural aggregates used in road construction, thereby reducing the demand for virgin materials and minimizing environmental impact.

Concrete debris is one of the most abundant components of C&D waste. By crushing demolished concrete structures, recycled concrete aggregates can be obtained and used in pavement layers such as sub-base and base courses. Similarly, brick and masonry waste can also be crushed to produce aggregates suitable for road construction. Tile and ceramic waste generated from broken floor tiles and roofing materials possess considerable hardness and abrasion resistance and can contribute to aggregate mixtures when used in controlled proportions. Proper evaluation of their physical and mechanical properties is necessary before incorporating them into pavement construction.

The successful utilization of recycled aggregates depends largely on their engineering characteristics. Laboratory tests such as specific gravity, water absorption, aggregate impact value, aggregate crushing value, and California Bearing Ratio (CBR) are commonly conducted to evaluate their performance. These tests help determine whether recycled materials satisfy the requirements specified by standards such as IRC and MORTH for pavement construction applications.

The use of recycled construction materials in road construction aligns with the principles of sustainable development and circular economy. Instead of treating construction waste as a disposal problem, it can be considered a valuable resource that can be reintroduced into the construction cycle. This approach not only reduces waste generation but also conserves natural resources and lowers construction costs.



1:Construction and demolition waste recycling process.

III. PREVIOUS STUDIES

Research on the reuse of construction and demolition waste has increased significantly in recent years due to growing environmental concerns and the need for sustainable infrastructure development. Numerous studies have investigated the physical and mechanical properties of recycled aggregates and their potential applications in road construction.

Several researchers have explored different sources of recycled aggregates such as demolished concrete, brick masonry, ceramic tiles, and asphalt pavement. These materials have been evaluated for properties such as strength, durability, density, and resistance to abrasion. In many cases, recycled aggregates have demonstrated engineering properties comparable to those of conventional natural aggregates when properly processed.

Table 1: summary of previous studies

Author(s) & Year	Title	Method	Focus	Findings
Poon et al. (2007)	Recycling of Construction Waste as Aggregates	Experimental testing of recycled aggregates	Use of C&D waste in construction materials	Recycled aggregates can be used in pavement layers after proper crushing and grading.
Rao et al. (2010)	Utilization of Recycled Aggregates in Road Construction	Laboratory testing of aggregate properties	Strength and suitability of recycled aggregates	Recycled aggregates showed acceptable strength for use in base and sub-base layers.

Tam et al. (2008)	Sustainable Use of Construction Waste	Case study and environmental analysis	Sustainability and waste management	Recycling construction waste reduces landfill disposal and supports sustainable development.
Katz (2003)	Properties of Concrete with Recycled Aggregates	Experimental investigation	Mechanical properties of recycled concrete aggregates	Recycled aggregates have slightly higher water absorption but adequate strength for construction.
Arulrajah et al. (2013)	Recycled Construction Materials in Pavements	Laboratory and field evaluation	Application of recycled materials in pavement layers	Recycled aggregates performed well in pavement sub-base applications.

Several experimental studies have also investigated the performance of recycled aggregates in pavement layers. Results indicate that these materials can be successfully used in sub-base and base courses of flexible pavements, where the strength requirements are moderate compared to surface layers. However, the presence of attached mortar and higher water absorption in recycled aggregates often requires careful mix design and quality control.

IV. IMPORTANCE OF USING CONSTRUCTION AND DEMOLITION WASTE IN ROAD CONSTRUCTION

The utilization of construction and demolition (C&D) waste in road construction has gained increasing attention in recent years due to its environmental, economic, and engineering benefits. Recycling these materials not only helps manage the large quantity of waste generated from construction activities but also contributes to sustainable infrastructure development.

4.1 Environmental Benefits

One of the major advantages of using recycled construction materials is the reduction of environmental pollution caused by improper waste disposal. Large quantities of C&D waste are often dumped in open areas or landfills, leading to land degradation, dust pollution, and contamination of soil and groundwater. Recycling these materials reduces the burden on landfill sites and promotes environmentally responsible waste management practices.

4.2 Conservation of Natural Resources

Road construction requires significant quantities of natural aggregates such as crushed stone, gravel, and sand. Continuous extraction of these materials from quarries and riverbeds leads to depletion of natural resources and ecological imbalance. The use of recycled aggregates obtained from construction waste reduces the demand for natural aggregates and helps conserve valuable natural resources.

4.3 Economic Benefits

The recycling and reuse of C&D waste can reduce the overall cost of construction projects. Recycled aggregates are often available at lower costs compared to natural aggregates, especially when the waste materials are sourced locally. Reduced transportation and disposal costs further improve the economic feasibility of using recycled materials in road construction.

4.4 Sustainable Infrastructure Development

The use of recycled construction materials supports the concept of sustainable development by promoting reuse of waste materials and minimizing consumption of natural resources. It aligns with environmental policies and sustainability goals aimed at reducing construction waste and encouraging circular economy practices in the construction industry.

4.5 Engineering Performance

Several studies have demonstrated that recycled aggregates derived from concrete debris, brick waste, and ceramic materials possess acceptable engineering properties for use in pavement layers. When properly processed through crushing and screening operations, these materials can provide adequate strength, durability, and load-bearing capacity for applications such as sub-base and base layers in flexible pavements.

V. METHODOLOGY

The methodology adopted in this study focuses on the collection, processing, and evaluation of recycled aggregates obtained from construction and demolition (C&D) waste for potential use in road construction applications. The overall methodology includes material selection, processing of waste materials, laboratory testing, and comparison of results with standard specifications recommended by IRC and MORTH.

5.1 Material Collection

Construction and demolition waste materials were collected from nearby demolition and construction sites. The selected waste materials mainly included concrete debris, brick and masonry waste, mortar waste, and tile and ceramic fragments. Care was taken to ensure that the collected materials were free from hazardous substances such as asbestos, plastic waste, wood, and other organic impurities.

5.2 Material Processing

The collected waste materials were inspected and sorted manually to remove unwanted impurities. Large pieces of debris were broken manually and then crushed into aggregate-sized particles. The crushed materials were sieved into required sizes according to pavement construction requirements. Dust and fine impurities were removed to obtain clean recycled aggregates suitable for laboratory testing. The processed materials were then stored in separate containers for further analysis.

5.3 Material Selection

Different types of recycled materials were selected for the study based on their availability and engineering characteristics. Concrete debris was selected as the primary source of recycled coarse aggregates because of its strength and hardness. Brick and masonry waste were included due to their lightweight and drainage properties, while tile and ceramic waste were considered because of their abrasion resistance and hardness. Natural aggregates were also collected and used as control samples for comparison purposes.

5.4 Laboratory Testing

Laboratory tests were conducted to evaluate the engineering properties of recycled aggregates. Sieve analysis was performed to determine particle size distribution and gradation of aggregates. Specific gravity and water absorption tests were carried out to evaluate density and moisture absorption characteristics.

Aggregate Impact Value (AIV) and Aggregate Crushing Value (ACV) tests were conducted to assess resistance to impact and compressive loads. California Bearing Ratio (CBR) tests were also performed to determine the suitability of recycled aggregates for pavement sub-base and base layers.

5.5 Evaluation of Results

The results obtained from laboratory testing were compared with conventional natural aggregates and standard specifications recommended by IRC and MORTH. Based on the comparison, the suitability and feasibility of using recycled construction and demolition waste in road construction applications were evaluated.

VI. MATERIAL SELECTION

Selection of suitable construction and demolition (C&D) waste materials is an important step in evaluating the feasibility of recycled aggregates for road construction. The materials selected for this study were chosen based on their availability, physical characteristics, engineering properties, and suitability for pavement applications. The selected materials mainly include concrete debris, brick and masonry waste, mortar waste, tile and ceramic waste, and natural aggregates used as control samples.

6.1 Concrete Debris

Concrete debris collected from demolished slabs, beams, columns, and pavements was used as the primary source of recycled coarse aggregates. These materials possess good hardness, compressive strength, and durability, making them suitable for use in pavement layers such as sub-base and base courses. Crushed concrete aggregates are considered one of the most promising recycled materials for road construction applications.

6.2 Brick and Masonry Waste

Brick and masonry waste consisted of crushed bricks, hollow blocks, and masonry units collected from demolition sites. These materials are generally lightweight and porous in nature, which improves drainage characteristics in pavement layers. However, due to higher water absorption, their usage is generally limited to controlled proportions or blended with concrete aggregates.

6.3 Mortar and Plaster Waste

Residual mortar attached to demolished concrete and brick surfaces was also considered in the study. Mortar waste influences the water absorption and gradation characteristics of recycled aggregates. Although excessive mortar content may reduce aggregate strength, controlled quantities can improve particle gradation and filling characteristics in pavement mixtures.

6.4 Tile and Ceramic Waste

Broken floor tiles, ceramic materials, and roofing pieces generated during demolition activities were included as recycled aggregate materials. Tile and ceramic wastes possess high hardness and abrasion resistance, making them potentially suitable for pavement applications. However, due to their brittle nature, these materials were used in limited proportions within the aggregate mixture.

6.5 Natural Aggregates

Natural crushed stone aggregates were used as control samples for comparison with recycled aggregates. These conventional aggregates are widely used in pavement construction and provide a reference for evaluating the engineering performance and feasibility of recycled C&D waste materials.

VII. LABORATORY TESTING OF RECYCLED AGGREGATES

Laboratory testing was carried out to evaluate the engineering properties and suitability of recycled aggregates obtained from construction and demolition (C&D) waste for use in road construction applications. The recycled materials selected for the study included concrete debris aggregates, brick aggregates, and tile and ceramic aggregates. The test results were compared with natural aggregates and standard specifications recommended by IRC and MORTH to determine their applicability in pavement sub-base and base layers.The laboratory investigation included tests such as sieve analysis, specific gravity, water absorption, aggregate impact value, aggregate crushing value, and California Bearing Ratio (CBR). These tests were conducted to evaluate important engineering characteristics including particle size distribution, density, moisture absorption, resistance to impact loads, crushing resistance, and load-bearing capacity of recycled aggregates.

Sieve analysis was performed to determine the gradation and particle size distribution of recycled aggregates. Properly graded aggregates improve compaction characteristics and pavement stability. The processed recycled aggregates were found to exhibit acceptable gradation suitable for pavement applications. Specific gravity and water absorption tests were conducted to determine the density and porosity characteristics of recycled aggregates. Recycled concrete and tile aggregates exhibited satisfactory specific gravity values, whereas brick aggregates showed comparatively higher water absorption because of their porous structure. Higher water absorption in recycled aggregates is mainly attributed to the presence of attached mortar and micro-cracks developed during demolition and crushing operations.

Aggregate Impact Value (AIV) tests were conducted to evaluate the resistance of aggregates against sudden impact loads. Lower impact values indicate better aggregate toughness and suitability for road construction. Concrete debris and tile aggregates showed satisfactory impact resistance, while brick aggregates exhibited comparatively higher values due to their brittle and porous nature. Aggregate Crushing Value (ACV) tests were performed to assess the resistance of recycled aggregates against compressive loads. The results indicated that recycled concrete and tile aggregates possess adequate crushing resistance suitable for pavement sub-base and base layers. Brick aggregates showed slightly higher crushing values but remained within acceptable limits for low to moderate traffic road applications.

California Bearing Ratio (CBR) tests were carried out to evaluate the load-bearing capacity of recycled aggregates for pavement construction. The obtained CBR values indicated that recycled aggregates possess sufficient strength for use in sub-base layers and can potentially replace a significant portion of conventional natural aggregates in road construction.

Table 2: Test Results of Different C&D Waste Materials

Test	Concrete Debris Aggregate	Brick Aggregate	Tile & Ceramic Aggregate	IRC/MORTH Limit	Suitability
Specific Gravity	2.60	2.35	2.50	2.5 – 3.0	Concrete & Tile Suitable
Water Absorption (%)	3.2	6.5	2.8	Max 5%	Brick Aggregate Higher
Aggregate Impact Value (%)	22	30	24	Max 30%	Acceptable
Aggregate Crushing Value (%)	25	32	26	Max 30%	Concrete & Tile Suitable
CBR Value (%)	58	42	55	Min 30%	Suitable for Sub-base
Gradation	Well Graded	Fairly Graded	Well Graded	As per IRC	Acceptable

The overall laboratory test results indicate that recycled aggregates derived from construction and demolition waste possess acceptable engineering properties for pavement applications. Among the tested materials, concrete debris aggregates exhibited the best overall performance in terms of strength and durability, while tile and ceramic aggregates also showed satisfactory characteristics. Brick aggregates demonstrated comparatively higher water absorption and crushing values; however, they can still be utilized effectively in sub-base layers when used in controlled proportions or blended with other aggregates.

VIII. RESULTS AND DISCUSSION

The laboratory test results obtained for recycled aggregates prepared from construction and demolition (C&D) waste were analysed and compared with conventional natural aggregates and standard specifications recommended by IRC and MORTH. The study mainly focused on evaluating the suitability of recycled concrete debris, brick aggregates, and tile and ceramic aggregates for use in pavement sub-base and base layers.

The test results indicated that recycled concrete debris aggregates possess satisfactory engineering properties and show performance characteristics comparable to natural aggregates. The specific gravity value of concrete debris aggregate was found to be within the acceptable range, indicating good density and strength properties. Water absorption values were slightly higher than natural aggregates because of the presence of attached mortar; however, the values remained within permissible limits for pavement applications.

Brick aggregates exhibited lower specific gravity and comparatively higher water absorption due to their porous structure. Although brick aggregates showed slightly lower strength characteristics than concrete debris aggregates, they demonstrated acceptable performance for sub-base applications where moderate strength is sufficient. The higher porosity of brick aggregates may also contribute to improved drainage characteristics within pavement layers.

Tile and ceramic aggregates demonstrated good hardness and abrasion resistance. The aggregate impact value and crushing value results indicated that these materials possess adequate resistance against impact and compressive loads. Their performance was found to be comparable to recycled concrete aggregates in several aspects.

The California Bearing Ratio (CBR) values obtained for recycled aggregates confirmed their suitability for pavement sub-base applications. Concrete debris aggregates exhibited the highest CBR value among the tested materials, indicating superior load-bearing capacity.

Tile and ceramic aggregates also showed satisfactory CBR values, while brick aggregates provided comparatively lower but acceptable results for low to moderate traffic roads.

Table 3: Comparative Test Results of Recycled Aggregates

Property	Concrete Debris	Brick Aggregate	Tile & Ceramic Aggregate	Natural Aggregate
Specific Gravity	2.60	2.35	2.50	2.65
Water Absorption (%)	3.2	6.5	2.8	1.0
Aggregate Impact Value (%)	22	30	24	18
Aggregate Crushing Value (%)	25	32	26	20
CBR Value (%)	58	42	55	65

The overall results suggest that recycled construction and demolition waste materials can be effectively utilized in road construction applications, particularly in pavement sub-base and base layers. Among the tested materials, recycled concrete aggregates showed the best overall engineering performance, followed by tile and ceramic aggregates. Brick aggregates, although more porous, can also be used successfully in controlled proportions or blended with other aggregates.

The findings of the study support the concept of sustainable road construction through recycling and reuse of construction waste materials. Utilization of recycled aggregates not only reduces environmental problems associated with waste disposal but also decreases dependence on natural aggregates and promotes conservation of natural resources.

IX. CONCLUSION

The increasing generation of construction and demolition (C&D) waste has created major environmental and resource management challenges worldwide. At the same time, the growing demand for natural aggregates in road construction has resulted in excessive extraction of natural resources and environmental degradation. Recycling and reusing C&D waste as aggregates in pavement construction offers a sustainable and economical solution to these problems.

This study evaluated the feasibility of utilizing recycled aggregates obtained from concrete debris, brick waste, and tile and ceramic materials for road construction applications. Laboratory investigations were conducted to determine important engineering properties such as specific gravity, water absorption, aggregate impact value, aggregate crushing value, and California Bearing Ratio (CBR). The obtained results were compared with conventional natural aggregates and standard specifications recommended by IRC and MORTH.

The experimental results indicated that recycled concrete debris aggregates possess satisfactory strength, durability, and load-bearing characteristics suitable for pavement sub-base and base layers. Tile and ceramic aggregates also demonstrated good hardness and resistance to impact and crushing loads. Brick aggregates exhibited comparatively higher water absorption and lower strength properties; however, they can still be effectively utilized in sub-base applications when used in controlled proportions or blended with other aggregates.

The study confirms that properly processed construction and demolition waste can serve as a suitable alternative to conventional natural aggregates in road construction. The utilization of recycled aggregates not only reduces landfill disposal and environmental pollution but also conserves natural resources and supports sustainable infrastructure development.

Overall, the use of recycled construction and demolition waste in pavement construction represents an important step toward environmentally responsible and sustainable road engineering practices. Further large-scale field studies and long-term performance evaluations can help increase the practical implementation of recycled aggregates in future road construction projects.

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