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Reuse of Building Demolished Waste Material as a Sustainable Concrete

Komal G. Gaulkar, Yash R. Durge, Prajwal S. Dhawade, Shrutika S. Adhau, Shravani R. Wasu, Prof. M. S. Deshmukh

Department of Civil Engineering

P. R. Pote Patil College of Engineering & Management, Amravati, Maharashtra, India

ABSTRACT:

Construction and demolition (C&D) activities generate substantial quantities of concrete, brick and ceramic-tile waste. Disposal of these materials consumes landfill space and increases demand for virgin aggregates. This study examines the reuse of processed building-demolition waste as aggregate constituents in concrete, together with partial replacement of cement by fly ash. The project considered demolition concrete, crushed brick and tile fractions and four cement-to-fly-ash proportions (100:0, 90:10, 80:20 and 70:30). The demolition-waste aggregate blend consisted of 70% crushed concrete, 20% crushed brick and 10% crushed tile by aggregate proportion, as maintained in the experimental mixes. Concrete cubes of 150 mm size were water-cured for 28 days and tested for compressive strength. Fifteen cube results were recorded, including three conventional control specimens and three specimens for each of four experimental mixes. The calculated mean compressive strengths were 21.85 MPa for the control and 22.62, 18.53, 13.96 and 11.93 MPa for mixes C1–C4, respectively. The highest experimental value was obtained for C1, while strength decreased across the later experimental mixes. Reported aggregate comparison values were specific gravities of 2.70, 2.40 and 2.10 and water absorption values of 0.80%, 5.00% and 13.20% for natural, recycled-concrete and crushed-brick aggregates; the aggregate properties were determined experimentally using laboratory testing procedures, and the obtained values were used for comparative analysis. Estimated material cost per cube decreased from ₹21.61 for conventional concrete to ₹18.82 for the 70:30 cement–fly-ash mix, based on the material cost assumptions considered in this study.

Keywords: Construction and Demolition Waste, Recycled Concrete Aggregate, Crushed Brick Aggregate, Fly Ash, Sustainable Concrete, Compressive Strength.

I. INTRODUCTION

The construction sector relies heavily on natural aggregates and cement, while demolition, renovation and reconstruction generate large quantities of concrete, brick and tile debris. When these materials are dumped without segregation or processing, they occupy disposal areas and may create dust and local environmental impacts. Recovering usable fractions from demolition waste can reduce demand for natural resources and support more circular use of construction materials.

Recycled concrete aggregate (RCA) commonly contains adhered mortar and may show higher porosity and water absorption than natural aggregate. Mixed demolition waste is more variable because it can include concrete, masonry and ceramic constituents. Aggregate quality, grading, moisture condition and replacement proportion therefore influence fresh and hardened concrete properties.

A. Problem Statement

The main challenge is to reuse heterogeneous demolished materials without assuming that they behave identically to natural aggregates. Higher absorption and lower particle density can affect water demand, compaction and strength. This project evaluates selected physical properties of demolition-derived materials and compares compressive strength, density and estimated material cost of concrete mixes incorporating demolition waste and different fly-ash contents.

B. Aim and Objectives

Aim: To investigate the feasibility of reusing building-demolition waste materials in concrete as a sustainable alternative to conventional concrete constituents.

Objectives:

To collect, segregate, crush and prepare demolished concrete, brick and tile materials for possible use as aggregate.

To compare specific gravity and water absorption characteristics of natural and recycled aggregate materials. To prepare concrete mixes with cement-to-fly-ash proportions of 100:0, 90:10, 80:20 and 70:30.

To evaluate concrete cube compressive strength and specimen density and compare the results with conventional concrete.

To evaluate the material-cost implications of using demolition waste and fly ash.

To investigate the potential reuse of building-demolition waste materials as constituents of sustainable concrete.

II. LITERATURE REVIEW AND RESEARCH GAP

Reviews of recycled aggregate concrete report that the properties of recycled aggregates depend strongly on source material, processing and the amount of adhered mortar. These characteristics affect workability, density, compressive strength and durability. A systematic comparison of recycled fine aggregates from concrete, brick, marble and ceramic demolition waste also highlights that different waste streams cannot be treated as a single uniform material.

Mandal and Shiuly (2025) discuss the mechanical behaviour of recycled concrete aggregates and identify aggregate quality, processing and mix design as important factors in sustainable concrete. Chandru et al. (2023) compare recycled fine aggregates from multiple C&D waste sources in OPC and PPC concrete and emphasize the influence of aggregate type on fresh and hardened properties. Braga et al. (2022) similarly report that recycled aggregate composition and quality contribute to variability in concrete performance.

Research Gap: Although previous studies have investigated the use of recycled concrete aggregates and other construction and demolition waste materials in concrete, further investigation is required into the combined utilization of demolished concrete, crushed brick and tile aggregates with different cement–fly ash proportions. The present experimental study evaluates the physical properties of these materials and investigates the compressive strength, density and estimated material cost of concrete incorporating the selected demolition-waste aggregate blend. The study presents experimental observations from laboratory specimens and examines their potential contribution to sustainable concrete production.

III. MATERIALS AND METHODOLOGY

A. Materials

Material	Use / description
Cement	Binder component; proportion varied with fly ash.
Fly ash	Partial cement replacement at 0%, 10%, 20% and 30% of binder.
Natural fine aggregate	Sand used in concrete preparation.
Demolished concrete	Crushed and processed demolition-derived aggregate.
Crushed brick aggregate	Brick waste processed into aggregate fractions.
Tile aggregate	Crushed and processed tile material used as a constituent of the demolition waste aggregate blend.
Water	Used for mixing and 28-day water curing.

The project describes collection, segregation, crushing and sieving of demolition materials before batching. The experimental aggregate blend consisted of demolished concrete, crushed brick and crushed tile in the proportions of 70%, 20% and 10%, respectively. This blend was maintained across the experimental mixes.

B. Mix Design and Specimen Details

Four cement-to-fly-ash proportions were reported. The demolition-waste aggregate blend was kept constant in the specimen schedule. Concrete cubes were cast with nominal dimensions of 150 × 150 × 150 mm and cured in water for 28 days.

Mix schedule ID	Cement (%)	Fly ash (%)	Demolished concrete (%)	Brick (%)	Tile (%)
C1	100	0	70	20	10
C2	90	10	70	20	10
C3	80	20	70	20	10
C4	70	30	70	20	10

The compressive strength of concrete was evaluated after 28 days of water curing using 150 × 150 × 150 mm cube specimens. Three specimens were tested for each mix, and the average compressive strength was calculated from the recorded failure loads. The conventional concrete (control mix) achieved an average compressive strength of 21.85 MPa. Among the experimental mixes, C1 (100% cement and 0% fly ash) recorded the highest average compressive strength of 22.62 MPa, followed by C2 (90% cement and 10% fly ash) with 18.53 MPa, C3 (80% cement and 20% fly ash) with 13.96 MPa, and C4 (70% cement and 30% fly ash) with 11.93 MPa. The results indicate that the compressive strength decreased with increasing fly-ash replacement for the particular mix proportions investigated. C1 showed a 3.34% increase in compressive strength compared with the conventional concrete control mix.

C. Casting, Compaction and Curing

Measured ingredients were dry-mixed to distribute cement, fly ash and aggregates. Water was added gradually and mixing continued until a uniform fresh concrete was obtained. Concrete was placed in cube moulds and compacted to reduce entrapped air. Specimens were allowed to set, demoulded and immersed in water for the intended 28-day curing period.

D. Testing Methods

Aggregate specific gravity and water absorption were evaluated using oven-dry and saturated-surface-dry masses and submerged mass, following the general procedures of IS 2386 (Part 3):1963. Specific gravity was calculated as $G = A/(B-C)$, where A is oven-dry mass in air, B is SSD mass in air and C is apparent submerged mass. Water absorption was calculated as $[(B-A)/A] \times 100$.

Concrete compressive strength was calculated from maximum failure load divided by the loaded face area. For a 150 mm cube, the nominal loaded area is 22,500 mm^2; therefore, strength (MPa) = failure load (kN) × 1000 / 22,500. The density of each concrete cube was calculated by dividing its measured mass by the nominal specimen volume. For a cube measuring 150 × 150 × 150 mm, the volume was 0.003375 m^3. The calculated density was expressed in kg/m^3.

IV. RESULTS AND DISCUSSION

A. Aggregate Specific Gravity and Water Absorption

Aggregate	Specific gravity	Water absorption (%)
Natural aggregate	2.70	0.80
Recycled concrete aggregate	2.40	5.00
Crushed brick aggregate	2.10	13.20

The experimental results indicate that the old bricks had lower specific gravity and compressive strength and higher water absorption than the newly manufactured bricks. The compressive strength of old bricks was 9.10 MPa, compared with 18.60 MPa for new bricks. These observations indicate differences in the physical and mechanical properties of the two brick samples.

B. Comparative Properties of Old and New Bricks

Brick type	Average specific gravity	Average water absorption (%)	Compressive strength (MPa)
Old / reclaimed brick	1.784	16.00	9.10
New brick	1.929	11.98	18.60

The specific gravity and water absorption tests were conducted on old and newly manufactured brick samples to

compare their physical properties. The average specific gravity of old bricks was found to be 1.784, whereas new bricks recorded 1.929. The average water absorption of old bricks was 16.00%, compared with 11.98% for new bricks. The results indicate that old bricks have lower specific gravity and higher water absorption than newly manufactured bricks. These differences show variations in the physical properties of the two types of brick samples.

C. Compressive Strength of Concrete Cubes

Mix	Individual failure loads (kN)	Mean strength (MPa)	Difference vs. control
Control	492, 480, 503	21.85	—
C1	512, 507, 508	22.62	+3.34%
C2	420, 417, 414	18.53	−15.19%
C3	317, 314, 311	13.96	−36.11%
C4	272, 268, 265	11.93	−45.40%

The mean compressive strength of each concrete mix was calculated from the recorded failure loads of three cube specimens. The control mix achieved a mean strength of 21.85 MPa, while experimental mix C1 recorded 22.62 MPa. The remaining mixes C2, C3 and C4 achieved mean strengths of 18.53 MPa, 13.96 MPa and 11.93 MPa, respectively. The results indicate a decrease in 28-day compressive strength with increasing fly-ash replacement for the particular mix proportions investigated.

D. Density of Concrete Cubes

Cube specimen	Mass (kg)	Volume (m^3)	Density (kg/m^3)
1	7.8726	0.003375	2332.62
2	7.4196	0.003375	2198.40
3	6.5643	0.003375	1944.98
4	7.0283	0.003375	2082.46
Average	—	—	2139.62

The measured masses of four concrete cube specimens were used to calculate their respective densities. The calculated values ranged from 1944.98 to 2332.62 kg/m^3, with an average density of 2139.62 kg/m^3. The specimens were weighed under their recorded moisture condition without oven drying. Therefore, the reported values represent density under the moisture condition at the time of measurement.

E. Comparative Material Cost

Concrete mix	Estimated cost per 150 mm cube (₹)	Estimated saving vs. control
Conventional concrete	21.61	—
M1 (100% cement + 0% fly ash)	21.32	1.3%
M2 (90% cement + 10% fly ash)	20.49	5.2%
M3 (80% cement + 20% fly ash)	19.65	9.1%
M4 (70% cement + 30% fly ash)	18.82	12.9%

The estimated material cost per 150 mm cube decreased with increasing fly-ash replacement in the mixes considered. The estimated cost was ₹21.61 for conventional concrete and ₹21.32, ₹20.49, ₹19.65 and ₹18.82 for mixes C1, C2, C3 and C4, respectively. These estimates are based on the material quantities and cost assumptions adopted for the study. Actual costs may vary depending on local material prices, transportation and processing expenses.

F. Environmental significance

The reuse of building demolition waste, such as crushed concrete, bricks and tiles, in concrete production helps reduce the quantity of construction waste disposed of in landfills. It also conserves natural aggregates by reducing the demand for conventional construction materials. Furthermore, the partial replacement of cement with fly ash may help reduce cement consumption. Thus, the proposed approach promotes waste management, resource conservation and sustainable construction. The actual environmental benefits depend on material quality and the collection,

transportation and processing requirements.

G. Practical application

Based on the experimental observations, processed demolition-waste concrete may have potential applications in selected non-structural and construction works, subject to further evaluation of strength, durability and applicable requirements.

Sr. No.	Application	Potential Use
1	Road Construction	Use of recycled concrete aggregates in road sub-base and base layers.
2	Paver Blocks and Footpaths	Manufacturing of paving blocks and construction of pedestrian pathways.
3	Flooring Applications	Use in non-structural flooring and basic floor concrete.
4	Precast Concrete Products	Manufacturing of kerb stones, paving units and other suitable precast products.
5	Landscaping Works	Construction of garden pathways, edging blocks and other landscaping elements.
6	Non-Load-Bearing Concrete Blocks	Production of non-load-bearing blocks after checking their strength and durability.

H. Limitation

The practical application of concrete incorporating building-demolition waste depends on its strength, durability and quality of recycled materials. The suitability of this concrete for different construction applications must be assessed according to the required performance and applicable standards. The experimental results obtained in this study are not sufficient to establish its suitability for structural applications. Therefore, further testing and quality assessment are necessary before its use in actual construction works.

V. CONCLUSION

The project investigates reuse of demolished concrete, brick and tile waste in concrete, together with partial replacement of cement by fly ash. The reported aggregate comparison suggests that recycled concrete and crushed brick have higher water absorption and lower specific gravity than natural aggregate, with crushed brick showing the largest difference. The brick comparison indicates that reclaimed bricks have lower specific gravity, higher water absorption and lower compressive strength than new bricks.

For the concrete cube tests, the control mean strength was 21.85 MPa and the highest calculated experimental mean was 22.62 MPa for C1. C2, C3 and C4 showed progressively lower mean strengths of 18.53, 13.96 and 11.93 MPa. Recorded density values ranged from 1944.98 to 2332.62 kg/m³. Estimated material cost reduced from ₹21.61 to ₹18.82 per cube across conventional and M4 mixes. These results support the potential of processed demolition waste and fly ash in sustainable concrete, but do not by themselves establish compliance with a specified concrete grade or suitability for structural use.

A. Limitations and Future Scope Limitations:

The present investigation was carried out using selected building demolition waste materials, including demolished concrete, crushed bricks and tiles, along with different cement-to-fly-ash proportions. The study was limited to a specific set of mix proportions and laboratory specimens. The physical properties of recycled aggregates may vary depending on their source, composition and processing methods. Higher water absorption of recycled aggregates may influence the water demand, workability and strength of concrete. The investigation primarily focused on aggregate properties, compressive strength, density and material cost. Long-term durability characteristics under different environmental conditions were not evaluated in detail. Therefore, the results obtained from laboratory experiments may differ from the performance of concrete under actual field conditions. Further investigations are required before considering the developed concrete for structural applications.

Future Scope:

Future studies can be carried out by investigating different replacement percentages of demolished concrete, brick and tile aggregates to identify suitable mix proportions. Additional experiments can be performed to evaluate workability, split tensile strength, flexural strength, water absorption and durability characteristics of the developed concrete. Further studies may also include permeability, abrasion resistance, shrinkage and long-term performance under different environmental conditions. The effect of different cement and fly-ash proportions can be investigated to obtain improved concrete performance. A detailed cost analysis, including collection, transportation, crushing, processing and material costs, can also be conducted. These investigations will help determine the suitability of recycled demolition waste concrete for various non-structural and construction applications and promote sustainable construction practices.

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