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Performance Evaluation of Recycled Aggregate Concrete in Structural Application

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ABSTRACT: The study aims to evaluate the performance of recycled aggregates derived from demolished construction materials by assessing their compressive strength when used in reinforced cement concrete (RCC) structural components such as beams and columns. Crushed debris from demolished structures, with particle sizes ranging from 10 mm to 60 mm, was used as a partial or full replacement for conventional coarse aggregate. A systematic experimental investigation was carried out by replacing natural coarse aggregate with recycled aggregate in varying proportions from 10% to 100% by weight. Concrete mix designs were prepared following Indian Standard (IS) guidelines, and the compressive strength was measured at 28 days. The results revealed that the highest compressive strength was recorded when 60% of the demolished concrete waste aggregate was used. Furthermore, strength values remained comparable to the control mix up to 80% replacement. These findings suggest that recycled demolition waste can be effectively utilized in structural-grade concrete, providing a sustainable and eco-friendly alternative to natural aggregates without significant loss in performance.

KEYWORDS: Recycle aggregate,concrete,test,strength,C & D waste,coarse aggregate ,cement,eco-friendly etc.

I.INTRODUCTION

Recycled aggregates, obtained from demolished concrete structures or industrial waste, serve as an environmentally friendly alternative to natural aggregates in concrete production. Their use helps conserve natural resources and manage construction and demolition waste more effectively, aligning with the goals of sustainable development. To ensure their suitability, it is essential to understand their physical properties and compare them with conventional aggregates. Sieve analysis, guided by IS 383:1970, is used to determine particle size distribution and assess the fineness modulus, which indicates aggregate uniformity. Maintaining consistent particle size is crucial for achieving desired concrete performance. Additionally, properties like specific gravity and water absorption play a vital role in determining concrete density, strength, and workability. These parameters assist in optimizing the concrete mix design. Recycled aggregates are also classified based on their source and characteristics, much like natural aggregates. Aggregates

falling under Natural Zone I are generally suitable for typical construction, while those in Zone II may require additional processing. Despite the many benefits, including reduced environmental impact and improved resource efficiency, recycled aggregates must undergo proper testing and quality control to ensure reliable performance. However, as per [1], using

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recycled aggregates or processed C&D waste for structural or load-bearing elements such as bridges, flyovers, and culverts is not recommended. bearing elements such as bridges, flyovers, and culverts is not recommended.

State wise production and treatment of solid waste:-

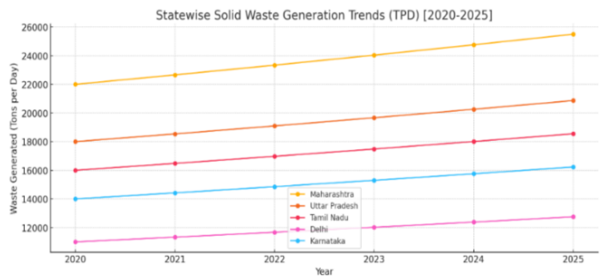


Figure 1 State wise per capita solid waste generation

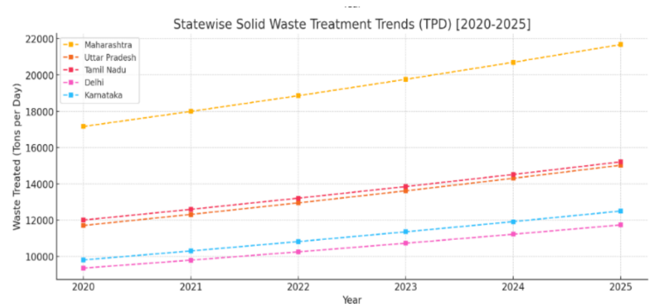
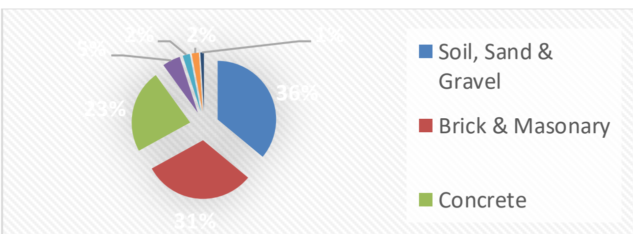
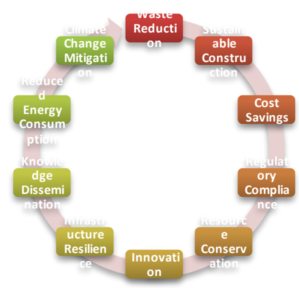


Figure 2 -Percentage of state wise solid waste treatment

1.2 Typical composition of Indian C & D waste

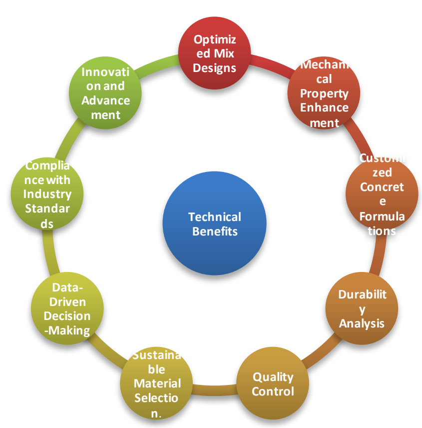


1.3 Importance of Topic

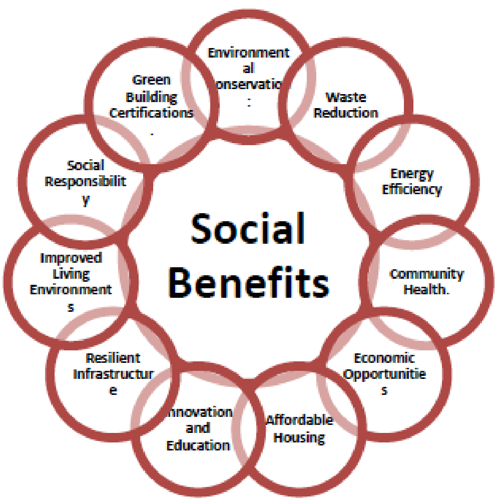


1.4 Benefits of Research

1.5 Technical Benefit

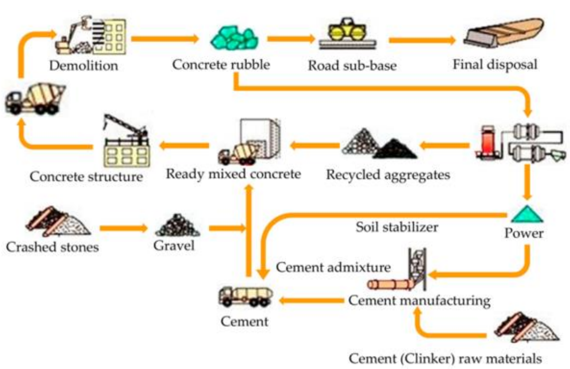


1.6 Social Benefit:-

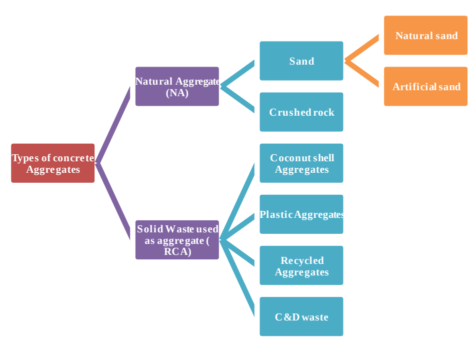


1.7 Environmental Benefits:-

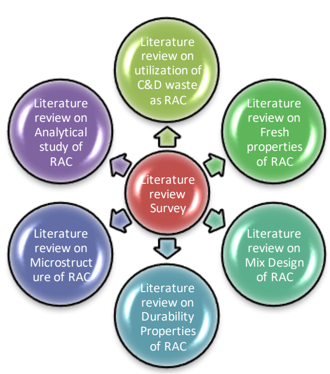
1.8 Process of destroyed buildings wastes production as RCAs



1.9 Types of aggregate



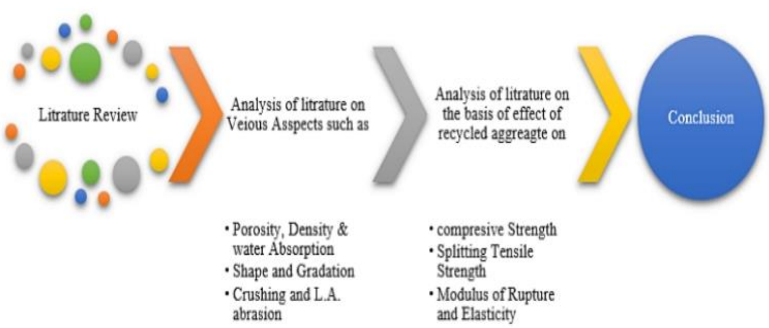
II.LITERATURE REVIEW



Concrete is a fundamental material in the construction industry, playing a crucial role in economic and societal development. Due to globalization and rising population, the demand for concrete has surged, leading to increased construction and demolition (C&D) waste. Proper management and reuse of this waste are key for environmental sustainability. Most C&D waste is currently dumped in landfills, but researchers are exploring ways to repurpose it. Concrete, being the primary construction material, should be optimized for resource conservation and energy efficiency. Using C&D waste as recycled aggregates in concrete is a promising large-scale solution. Around 70% of concrete consists of aggregates, making replacement with waste materials like slag, power plant waste, and mining debris viable. Ongoing research focuses on the structural, economic, and environmental feasibility of this approach. Regional variations in waste characteristics must be considered for effective implementation. Overall, recycled aggregates show potential in maintaining strength and durability in structural concrete.

III.METHODOLOGY OF PROPOSED SURVEY

In order to thoroughly examine all aspects of recycled aggregates in concrete, a thorough literature analysis was done for this review paper[2]. The literature analysis clarifies the importance of porosity, density, and water absorption qualities in sustainable construction methods. Aspects of shape and gradation are also covered in detail, offering important insights into the structural integrity of concrete that contains recycled particles. Additionally, these materials' reactions to crushing and L.A. abrasion are examined.



IV.RESULTS AND DISCUSSION

4.1 Cement Properties

Here is a table comparing the test results to the limits specified in IS 8112:2013 for various properties of cement:

Consistency: The consistency of the cement paste was found to be 27.60%, which should comply with the standard.

- Fineness by 90 Micron Sieve: The percentage of cement particles passing through the 90-micron sieve was 2%, which meets the maximum limit of 10%.
- Setting Time: The initial setting time of the cement paste was 140 minutes, which should be a minimum of 30 minutes. The final setting time was 210 minutes, which should be within 600 minutes.
- Compressive Strength (Avg.): The average compressive strength of the cement at 3 days, 7 days, and 28 days was found to be 24.25 N/mm², 35.10 N/mm², and 44.15 N/mm² respectively, all exceeding the minimum required values.
- Specific Gravity: The specific gravity of the cement was 3.15 g/cc.
- Soundness: The soundness of the cement, determined by the 'Le Chatelier' method, was found to be 1 mm, which is within the maximum limit of 10 mm.

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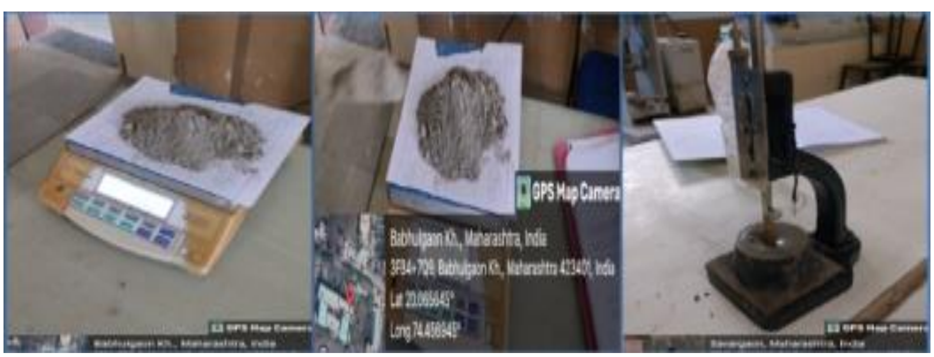
Sl. No.	TYPE OF TEST	RESULT'S	LIMIT AS PER IS 8112 : 2013	
1	Consistency (%)	27.60		
2	Fineness by 90 Micron Sieve %	2	10%	(Max Retain)
3	Setting Time			
(A)	Initial Setting Time (Minutes)	140	30	(Min.)
(B)	Final Setting Time (Minutes)	210	600	(Max.)
4	Compressive Strength (Avg.)			
(A)	3 Days	24.25 N/mm2	23 N/mm^2	(Min.)
(B)	7 Days	35.10 N/mm2	33 N/mm^2	(Min.)
(C)	28 Days	44.15 N/mm2	43 N/mm^2	(Min.)
5	Specific Gravity	3.15 g/cc		
6	Soundness			
(A)	'Le Chatelier' method	1	10 mm	(Max)

Table :-Cement 43 grade Testing Report

Aggregate Testing :- Aggregate properties, including grading, shape and size, specific gravity, absorption, strength, and durability, significantly impact concrete quality. Well-graded aggregates with angular shapes and rough textures improve concrete strength by enhancing interlocking with cement paste. Specific gravity influences concrete density and strength, while absorption affects workability and durability. Strong, durable, and sound aggregates free from impurities ensure long-lasting concrete structures. Controlling these properties through proper selection and testing, following standards like IS 383:1970, is crucial for producing high-quality and durable concrete.



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4.2 Fine Aggregate Properties:-

Properties	Recycled Fine Aggregate	Natural Fine Aggregate	IS Code
Specific Gravity	2.45 – 2.55	2.54	2386-Part-III-1963
Water Absorption	2.10 – 3.50	1.01	2386-Part-III-1963
Fineness Modulus	3.826	2.699	IS 383:1970
Type	Zone II	Natural Zone I	IS 383:1970

4.3 Coarse Aggregate Properties:-

4.3.1 Sieve Size Coarse aggregate

IS Sieve Size (mm)	Recycled Coarse Aggregate	Natural Coarse Aggregate	Limit As per IS383:1970
20	100	100	85-100
16	63.8	56.17	-
12.5	29.1	22.32	-
10	9.4	5.29	0-20
4.75	0	0	0-5

Properties	RCA Values Obtained	NA Values Obtained	IS CODE
Specific Gravity	2.5	2.74	IS 2386-Part-III-1963
Water Absorption	0.04	0.005	IS 2386-Part-III-1963
Type	Crushed	Crushed	IS 383:1970
Shape	Angular	Angular	IS 2386-Part-I-1963
Crushing Value	20.2	15.34	IS 2386-Part-IV-1963
Impact Value	23.4	10.15	IS 2386-Part-IV-1963
Void Ratio(Kg/Lit)	0.81	0.65	IS 2386-Part-III-1963
Soundness	3.6%	2%	IS:2386-Part V-1963

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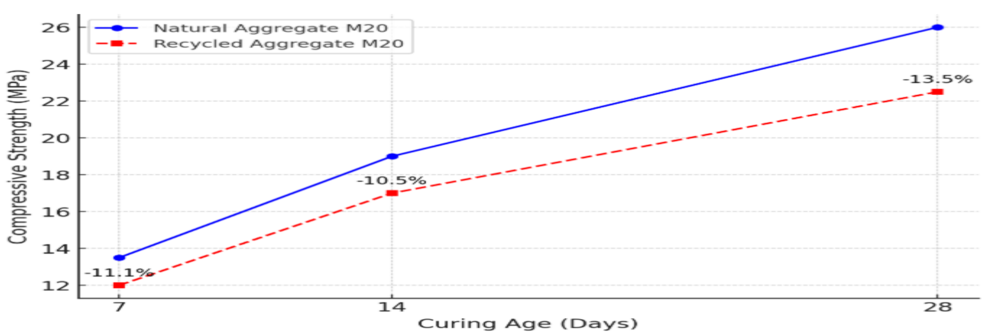
4.4 Coarse Aggregate Properties

Curing Age (Days)	Natural Aggregate (MPa)	Recycled Aggregate (MPa)	Strength Reduction (%)
7	13.5	12.0	11.1%
14	19.0	17.0	10.5%
28	26.0	22.5	13.5%

4.3.2 compressive strenghth of m 20 grade concrete



4.3.4 Spilt Tensile strength

MIX	% RCA in MIX	Modulus of Rupture and Elasticity test results. Compressive strength after 7 days (N/mm^2)	Modulus of Rupture and Elasticity test results. Compressive strength after 28 days (N/mm^2)
M1	0	4.50	29,000
M1	10	4.38	28,300
M3	20	4.25	27,600
M4	30	4.10	26,800
M5	40	3.95	26,000
M6	50	3.80	25,300
M7	60	3.65	24,600
M8	70	3.50	23,800
M9	80	3.35	23,000
M10	90	3.20	22,200
M11	100	3.05	21,500

MIX	% RCA in MIX	Split Tensile test results. Compressive strength after 7 days (N/mm^2)	Split Tensile test results. Compressive strength after 28 days (N/mm^2)
M1	0	2.90	3.75
M2	10	2.85	3.62
M3	20	2.75	3.50
M4	30	2.65	3.38
M5	40	2.55	3.25
M6	50	2.45	3.12
M7	60	2.35	3.00
M8	70	2.25	2.85
M9	80	2.15	2.75
M10	90	2.05	2.55
M11	100	1.95	2.4

4.3.5 Modulus of Rupture and Elasticity

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Aggregate collection

Natural Aggregate

Sieve Analysis

Recycle aggregate

Impact test

oiling

Cube casting

Flakiness and Elongation Index

Abrasion test

Beam casting

Compressive testing

OUTECOMES OF THE EXPERIMENT

Sr No	Aggregate test	Fine Aggregate	Coarse Aggregate	Recycled Aggregate
1.	Fineness Modulus	2.78	7.1	7.5
2.	Density (kg/m3)	1753	1806	1661
3.	Specific Gravity	2.5	2.9	2.74
4.	Water Absorption (%)	0.13	0.29	2.36
5.	Voids Ratio (%)		44.36	48.53
6.	Porosity (%)	37.23	6.3	15
7.	Crushing Value (%)	---	15	20
8.	Abrasion Value (%)	---	16	25
9.	Impact Value (%)	---	14.3	23
10.	Flakiness Index	---	3.6	4.7
11.	Elongation Index	---	7.2	8.4
12.	Angularity Number	---	10.3	13.9

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IV.CONCLUSION AND FUTURE WORK

- Recycled coarse aggregate offers a sustainable solution in construction by reducing the demand for natural aggregates.
- Despite its properties being somewhat inferior to natural aggregates, recycled coarse aggregate still meets the required standards for various construction applications.
- Utilizing recycled coarse aggregate can help minimize environmental impact by decreasing the depletion of natural resources.
- Proper processing and quality control are essential to ensure the performance of recycled coarse aggregate in construction projects.
- The cost-effectiveness and environmental benefits make recycled coarse aggregate a viable alternative for responsible construction practices.Embracing recycled materials in construction contributes to a more eco-friendly and resource-efficient industry, promoting long-term sustainability

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