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Comparative Study of Mechanical Properties between Recycled Aggregate Concrete and Natural Aggregate Concrete

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ABSTRACT:

The objective of this analysis is to explore the viability of appropriating reused coarse aggregate as a substitute for unaffected aggregate in concrete mixtures. The main goal is to ascertain the highest percentage of recycled coarse aggregate that can be employed while maintaining the concrete's strength and integrity. The investigation entails a comparison of specific gravity, water consumption, and particle size distribution between recycled and unaffected coarse aggregates. Furthermore, the conduct of recycled aggregate concrete is assessed across multiple replacement percentages, encompassing 0%, 10%, 20%, 25%, 30%, and 35%. By means of experimental inquiry, this analysis aims to evaluate the accomplishment of recycled aggregate concrete, focusing on allure substance and overall action. Additionally, the project involves calculations of the compressive strength, stiffness, and flexural strength of the concrete.

Objectives: Concrete coarse aggregate can be demolished and reused to help decrease construction solid waste. Pollution and expenses can be reduced.

1. Introduction

The utilization of concrete as the primary construction material is ubiquitous, with its constituents comprising binding material (cement), fine aggregate, coarse aggregate, and water. Concrete's indispensability in countless applications remains unparalleled, as it underpins the very existence of communities and societies. Consequently, extensive research endeavors are underway to develop new varieties of concrete that are both cost-effective and exhibit enhanced strength. Given the heavy reliance on concrete globally, there's a surging demand for construction aggregates, exacerbating the depletion of naturally occurring resources due to over exploitation. To address this challenge, there's a growing trend toward substituting natural resources with recycled alternatives, such as demolished concrete. Construction and demolition waste, a significant contributor to global waste generation, is estimated to range from 40 kg to 60 kg per square meter during construction and renovation activities. Among these waste streams, demolition waste stands out as the most substantial. Presently, India generates approximately 23.75 million tons of construction and demolition (C&D) waste annually, with projections indicating a potential doubling of these figures within the next seven years. The construction industry is one of the largest contributors to global waste generation, with concrete being one of the most abundant materials utilized in building projects worldwide. The disposal of demolished concrete waste presents significant environmental challenges, including increased landfill pressure and the depletion of natural resources due to the demand for virgin aggregate. In recent years, there has been a growing emphasis on sustainable construction practices and the adoption of circular economy principles within the industry. One promising approach to addressing the issue of concrete waste is the utilization of demolished concrete as a partial replacement for coarse aggregate in new concrete mixes. This introduction sets the stage for discussing the

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benefits, challenges, and potential of incorporating demolished concrete waste into concrete mixes. By exploring this innovative approach, we can better understand its implications for sustainable construction and resource management. In the subsequent sections, we will delve into the environmental, economic, and technical aspects of using recycled concrete aggregates, examining their impact on construction practices and the built environment. Additionally, the various factors influencing the successful integration of demolished concrete waste in concrete mixes, including quality control measures, mix design optimization, and performance evaluation criteria, were explored. This comprehensive overview aims to provide insights into the utilization of demolished concrete waste as a valuable resource in the construction industry, contributing to the advancement of sustainable building practices and the conservation of natural resources.

2. Materials Used For Recycled Aggregate Concrete

Various tests are administered on the materials used in concrete to assess their properties and ascertain their suitability for use in concrete.

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Recycled aggregate
5. Admixture – Super plasticizer
6. Water

2.1 Cement

Cement is produced by heating a well-proportioned mixture of materials, such as rock-formed sediment and clay, at extremely high temperatures. It carries sticking and cohesive characteristics and is, to a degree, a binding material for mineral, brick, and construction blocks. The cement utilized for the test specimens is OPC 53 grade, in compliance accompanying IS 12269:1987, as outlined in

Table 1.

Table 1 Properties of Cement

S. No	Properties	Values
1	Specific gravity	3.18
2	Fineness	4.5%
3	Standard Consistency	31%
4	Initial setting time	30 mins

2.2 Fine Aggregate

When rocks are crushed and sized in a quarry, the primary objective is typically to make coarse aggregates and road construction materials that meet specific requirements. However, this process also generates a significant amount of fine material with changeable properties, usually more delicate than 5 mm in size. Premixed concrete manufacturing has long recognized the potential to utilize this material if appropriately processed and selected from acceptable sources, potentially replacing sand to meet high-quality concrete specifications. Manufactured sand refers to purpose-created crushed fine aggregate created from suitable source materials. In a few instances, instinctive sand cannot meet quality principles, as its characteristic often changes significantly contingent upon its inception. Hence, it becomes necessary to moderately or completely replace natural sand in concrete with an alternative material. The properties of these materials are detailed in Table 2.

Table 2 Properties of Manufactured Sand

S. No	Property	Value
1	Specific gravity	2.57
2	Fineness modulus (by sieve analysis)	4.45
3	Water absorption	6.2%
4	Surface texture	Smooth

2.3 Coarse aggregate

The coarse aggregate stands out as the most robust and least absorbent component of concrete, characterized by its chemical stability. When selecting coarse aggregate for concrete, various properties such as crushing resistance, durability, modulus of elasticity, maximum capacity, gradation, shape, surface consistency, percentage of harmful substances, as well as flakiness

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and elongation indices, require careful consideration. It is imperative that the aggregate is sound, reduces deleterious matters, and retains a crushing substance that is not completely 1.5 times that of concrete, as detailed in Table 3.1. Coarse aggregate must be clean and empty of contamination.2. The coarse aggregate secondhand in the work is of the capacity of 20mm.

Table 3 Properties of Coarse Aggregate

S. No	Properties	Values
1	Specific gravity	2.74
2	Fineness modulus (by sieve analysis)	7.05
3	Surface Moisture	0.08%
4	Water absorption	1.02%
5	Bulk density	1652.45 Kg/m^3

2.4 Recycled Coarse Aggregate

To validate the utilization of destroyed waste as coarse aggregates in concrete that is currently built, various mechanical characteristics of the recycled aggregate were examined. These include distinguishing importance, water incorporation, scrape opposition, aggregate crushing value (ACV), and aggregate impact value (AIV), as defined in Table 4.

Table 4 Properties of Recycled Aggregate

S. No	Properties	Values
1	Specific gravity	2.69
2	Fineness modulus (by sieve analysis)	7.25
3	Surface Moisture	0.08%
4	Water absorption	1.8%
5	Bulk density	1552.45 Kg/m^3

2.5 Admixture

Conplast SP 430, a super plasticizer, promotes excellent early strength development. By reducing the amount of water, the cement paste will have a bigger bulk, which results in a stronger adhesive condition.

3 Mix Proportion

The study involved designing a concrete mix adhering to IS 10262:1986 standards with the aim of achieving a target compressive strength of 30 MPa. Subsequently, tests were administered on the casted cubes to evaluate their compressive substance, split stiffness, and flexural substance intermittently for 7, 14, and 28 days. with the mix proportions of 1:1.94:2.47 with a 0.43w/c ratio of conventional concrete and for reused aggregate

4 Testing of Specimens

4.1 Workability

Workability refers to the characteristic of plastic concrete mixture that determines its ease of placement and resistance to segregation for achieving entire compaction. Workability was determined utilizing the slump cone test, a property directly impacting strength, quality, and appearance. A concrete mix with favorable workability balances several attributes, resulting in a quality product. The test involves filling a slump cone with the concrete mixture on a level, non-absorbent surface, and compacting it into three equal layers by tamping each layer 25 times with a standard rod. Adequate workability is indicated by slump values ranging from 75 to 100mm. The workability data for two together conventional and reused aggregate concrete is given in Table 5

Table 5 Workability Test Result

S. No	Type of concrete	Slump value (mm)
1	Conventional concrete	75
2	RCA 10%	85
3	RCA 20%	95
4	RCA 30%	100

4.2 Compressive Strength

The compression test is the most normally attended test on hardened concrete cause many of its attractive characteristics are closely connected to its compressive strength. Compressive strength is typically determined experimentally through a compression test. During a compression test, skilled is an uninterrupted domain where the material trails Hooke's Law. Top of Form. Above this point, the material behaves plastically and

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will not resume the original distance before the load is distant. The example was established in the condensation testing tool as if the load were used on the cast surface. The load was used at a uniform rate as long as the sample was abandoned. The compressive strength results of normal and reused concrete are given in Table 6.

Table 6 Compressive Strength Test Results

S. No	Percentage of replacement	Compressive Strength (N/mm^2)		
		7 Days	14 Days	28 Days
1	0%	16.86	26.75	33.51
2	10%	15.83	25.94	32.86
3	20%	16.35	27.34	32.60
4	30%	18.24	28.62	34.57

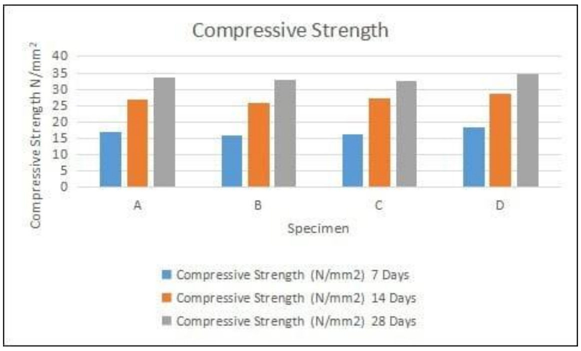

Fig 1. Compressive Strength

4.3 Split tensile Strength

The determination of tensile strength involves estimating the load at which concrete members may experience cracking. Due to the difficulty of transporting a direct tension test on concrete, an unintended system, to a degree, the "Splitting Tension Test," is employed. This test assesses the splitting stiffness of cylindrical concrete examples containing formed cylinders and drilled cores. Splitting tensile strength is primarily indicative of direct tensile properties and is lower than flexural strength (modulus of rupture).The split tensile results of normal and reused concrete are given in Table 7.

Table 7 Split Tensile Strength Test Results

S. No	Percentage of replacement	Split Tensile Strength (N/mm^2)		
		7 Days	14 Days	28 Days
1	0%	2.90	3.25	3.82
2	10%	2.71	3.26	3.75
3	20%	2.65	3.20	3.65
4	30%	2.87	3.34	3.86

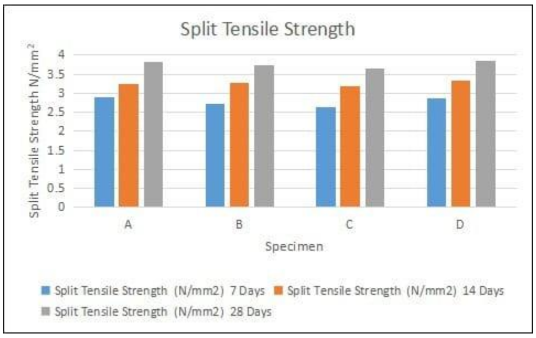

Fig 2. Split Tensile Strength

4.4 Flexural Strength

The purpose of flexural testing is to ascertain a material's torsional or bending properties. Samples undergo experiment in accordance with IS: 516-2004 guidelines. The modulus of dissolution (ultimate fiber stress in bending) value is contingent upon the method of loading. The loading methods include

1. Central point load
2. Symmetrical two point load

In centre point loading, the maximum fibre stresses occur directly beneath the point of application, place the bending importance is at its peak. In well-proportioned two-position loading, detracting cracks may manifest at any division ahead the example.In contrast to center point loading, it is anticipated that two-point loading will have a less impact on the modulus of rupture.The Flexural substance test consequences for both normal concrete and reused aggregate concrete are presented in Table 8.

Table 8 Flexural Strength Test Results

S. No	Percentage of replacement	Flexural Strength (N/mm^2)		
		7 Days	14 Days	28 Days
1	0%	2.5	2.93	3.2
2	10%	2.30	2.5	2.96

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3	20%	2.45	2.71	3.13
4	30%	2.53	2.95	3.28

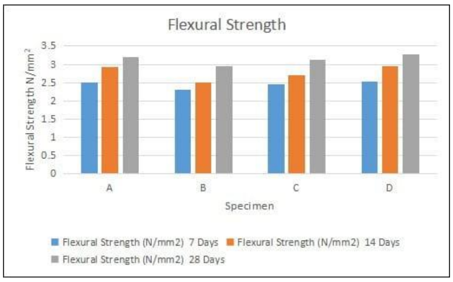

Fig 3. Flexural Strength

5. Conclusion

The results indicate a noticeable decrease in strength as the portion of natural aggregate replaced by reused coarse aggregate increases. Specifically, at 10% replacement, the compressive strength is measured at 32.86 MPa, while at 20% replacement, it decreases slightly to 32.60 MPa, representing a reduction of 2.79%. However, at 30% replacement,compressive substance expansions to 34.57 MPa. Additionally, the stiffness and flexural substance of the concrete at 30% replacement are recorded at 3.86 MPa and 3.28 MPa, respectively. These findings suggest that replacement can be extended up to 30%, beyond which the required compressive strength may not be achieved. Nevertheless, with proper segregation of aggregates, higher percentages of replacement could potentially meet the required strength criteria.

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