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A STUDY ON BEHAVIOR OF STRUCTURAL ELEMENTS PREPARED USING RECYCLED COARSE AGGREGATE

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Abstract: The construction industry faces challenges in meeting the escalating demand for construction materials, especially concrete aggregates while managing the surge in construction and demolition waste. Recycling demolished concrete into recycled concrete aggregates (RCA) offers a sustainable solution, conserving resources and promoting circular economy principles. However, RCA's attached mortar leads to drawbacks, such as increased porosity and reduced performance. This study investigates the potential of pre-treated cement slurry to enhance RCA's mechanical properties and structural performance. Flexure tests on beams revealed remarkable improvements in load-carrying capacities and crack resistance. Pre-treatment a in Cement Slurry-Coated Recycled Aggregate Concrete (CRAC) achieved a notable 17.97% and 9.04% increase in flexural strengths, respectively, compared to Recycled Aggregate Concrete (RAC). This research highlights the significance of these tech- inquest in advancing the structural capabilities of sustainable concrete.

Keywords: recycled concrete aggregates, pre-treatment, cement slurry mechanical properties, structural performance, flexural test.

1.0INTRODUCTION

The construction industry in the twenty-first century has the challenges of full- filling increased demand for construction materials, particularly concrete aggre- gates, as well as managing the increasing generation of construction and demolition waste .With billions of tonnes of new aggregates required each year and a large quantity of trash created, more sustainable solutions are urgently needed. One promising option is recycling demolished concrete into recycled aggregate aggre- gates (RCA). This practice redirects building waste from landfills, saves natural resources, lowers energy consumption, and encourages a circular economy. The building industry can address these difficulties while also advancing towards a more ecologically friendly and resource-efficient future by embracing the usage of RCA (Arezoumandi et al., 2018). According to the Building Material and Tech- neology Promotion Council (BMTPC), India generates about 150 million tonnes of Construction and demolition (C&D) waste every year but recycles just one per- cent of its C&D waste. The rest of the C&D waste is disposed of in landfills. Countries such as Denmark, Netherlands, Japan, and Germany have successfully implemented sustainable construction with a recycling rate of 80%, 75%, 65%, and 40-60% respectively. India still has a lower recycling rate Recycled concrete aggre- gates (RCA) are obtained from the destruction of concrete structures during civil construction activities. RCA is made up of concrete particles that include different percentages of natural aggregates (NA) and cement. However, due to the presence of attached mortar on its surface.

2.0 NEED OF THE STUDY.

- Water Pollution: Stone crushing activities can lead to contamination of nearby water sources such as rivers and streams with fine particles and chemicals from the mining process.
- Health Risks to Workers in stone crushing units are exposed to high levels of dust and pollutants, which can cause respiratory diseases such as silicosis, tuberculosis, and lung cancer.
- These impacts underscore the importance of implementing effective environmental management practices and regulations to minimize the adverse effects of stone crushing on the environment and human health.

3.0 METHODOLOGY

3.1Material required

The materials required for the research are described below:

- Recycled coarse aggregate

Coarse aggregate

1. Fine aggregates
2. Cement
3. Superplasticizer

Recycled coarse aggregate

Collection of material

1.Demolished old Rcc building
2.Life span: 50 years
3.Location: vishrambag (Sangli,Maharashtra)

3.2 Mix Design

The proportions of the different ingredients must be set to give the strength and durability qualities required for the design of an M25 grade concrete mix. A concrete mix that normally possesses a compressive strength of 25 (MPa) after 28 days of curing is referred to as M25 grade concrete. This is a general overview of the M25 grade concrete mix design procedure. It is significant to remember that mix design procedures can change depending on regional norms, the availability of resources, and particular project needs. Ensuring the successful design of M25 grade concrete mixes can be achieved by consulting pertinent codes and guidelines and getting advice from knowledgeable concrete technologists.

Table 3.1: Mix design NCA for M25

Description	Cement kg/m^3	Fine aggregate kg/m^3	Coarse Aggregate kg/m^3	Water kg/m^3	Admixture kg/m^3
For 1 m^3	300	875.54	1258.65	158.1	1.44
Proportion	1	2.91	4.19	0.527	0.0048

Table 3.1: Mix design RCA for M25

Description	Cement *kg/m3*	Fine aggregate *kg/m3*	Coarse Aggregate *kg/m3*	Water *kg/m3*	Admixture *kg/m3*
For 1 m^3	300	875.54	1138.99	158.1	1.44
Proportion	1	2.91	3.79	0.527	0.0048

Table 3.1: Mix design CRCA for M25

Description	Cement *kg/m^3*	Fine aggregate *kg/m^3*	Coarse aggregate *kg/m^3*	Water *kg/m^3*	Admixture *kg/m^3*
For 1 m^3	300	875.54	1192.17	158.1	1.44
Proportion	1	2.91	3.97	0.527	0.0048

3.3 Casting

The two-stage mixing process is a specialized method used in concrete production, particularly when dealing with challenging materials like recycled aggregates. In this present study, the mixing of ingredients is split into two stages for better performance and improved concrete properties. Initially, the coarse and fine ag- gregales are mixed together for about 60 seconds to achieve a homogenous blend. Subsequently, 50% water is added to form a cement slurry layer on the coarse aggregates, enhancing their bond with the cement mortar and filling voids in the recycled aggregates shown in Fig. 5.15. In the second stage, cement is added and mixed for an additional 30 seconds to ensure proper dispersion. Finally, the remaining 50% of water is introduced to complete the process shown in Fig. 5.16, resulting in a durable and strong concrete mix flow chart similar to Fig. 5.14. The two-stage mixing process enhances the overall workability, strength, and durability of the concrete. Later, cubes are cast by filling molds with concrete, and these cubes undergo a curing process for a duration of 28 days.

4.0 Laboratory Experiments:

4.1 Test on fresh concrete

The slump cone test and other experimental tests on freshly mixed concrete are essential for determining the consistency and workability of concrete mixtures. Here are some additional experimental tests commonly conducted alongside or instead of the slump cone test. To guarantee that concrete mixes fulfil required performance standards in terms of workability, strength, durability, and other attributes, these experimental investigations are helpful to concrete producers, engineers, and contractors. To att ain the intended results in a variety of building projects, they are essential in optimizing concrete mix designs and construction techniques.

4.2 Test on hardened concrete

Testing hardened concrete is essential for assessing its mechanical properties. Here are details on some common tests, including flexural, compression, and split tensile tests. These tests help ensure the structural integrity and durability of concrete in construction applications. Always follow standard procedures and safety protocols during testing.

The compressive strength test was conducted in accordance with IS 516:1979 guidelines. Concrete specimens were cast in 150 x 150 x 150 mm steel molds and cured for 7 and 28 days. After curing, the specimens were removed, cleaned, and their weight and dimensions recorded. The compressive strength test was performed using a universal testing machine, which applied increasing load until the specimen failed. The compressive strength (fc) was calculated by dividing the maximum load supported by the specimen (Pmax) by the cross-sectional area of the cube (A), using the formula: Fc = Pmax / A. This calculation provides a measure of the concrete's ability to withstand compressive forces, which is essential for evaluating its structural integrity and durability.

4.2.1 Flexural test procedure:

The test procedure followed IS 516:1979 guidelines. The specimen's concrete mixture was filled into 150 x 150 x 150 mm steel moulds. After that, the concrete was allowed to cure for seven and twenty-eight days in a curing tank. After the healing period, the specimen was taken out of the healing tank and cleaned. The weight and size of the sample were accurately noted. The specimen area (A) has been calculated based on its dimensions. The test is typically conducted using a compression testing machine, also known as a universal testing machine (CTM) or a concrete testing machine. This machine compresses a cylindrical or cubic object till it breaks.

Calculations: The compressive strength (fc) is calculated by dividing the total load supported by the specimen (Pmax) by the area of its cube cross-section (A).

$$Fc = A / Pmax$$

Flexural Stress = $WL/ BD2$

Were,

W = load applied

B = Width of the beam

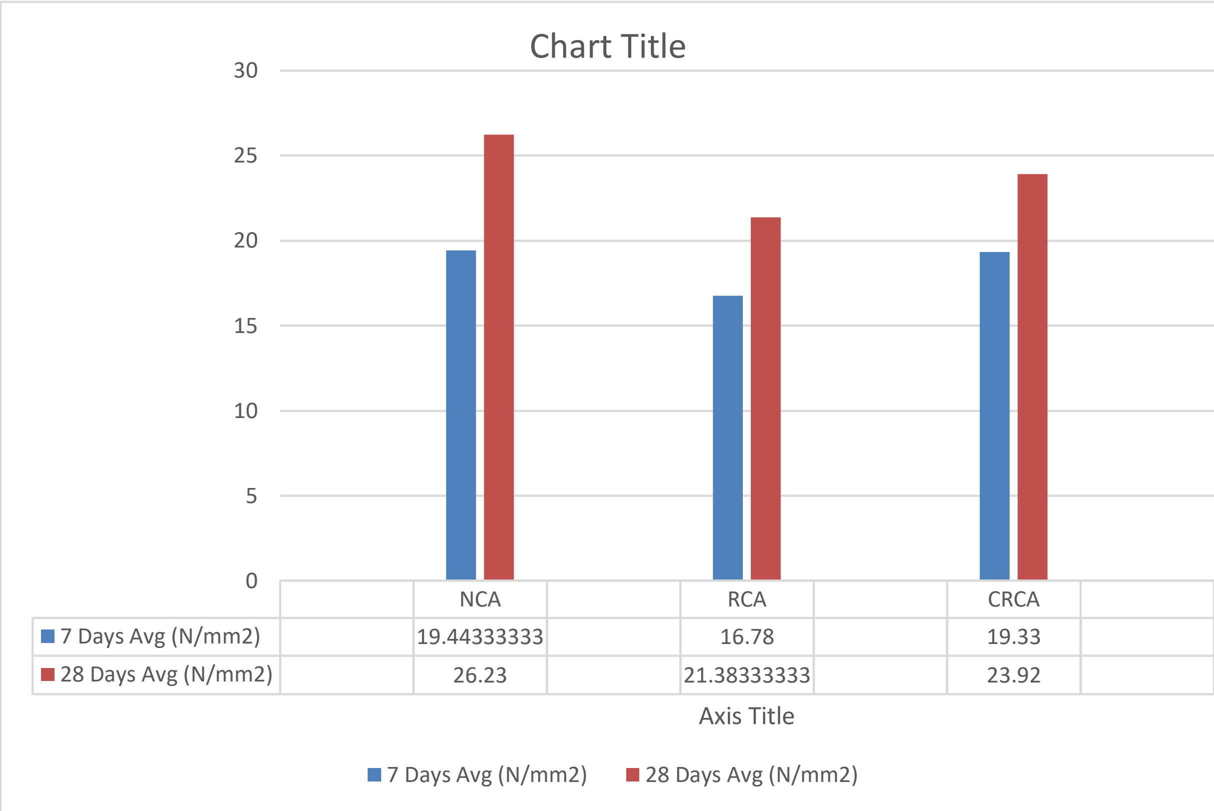
D = beam depth

L= beam length.

5.0 Results and discussion:

Compressive strength

Sr.No.	Type of concrete	7 Days (N/mm2)	7 Days Avg (N/mm2)	28Days (N/mm2)	28 Days Avg (N/mm2)
1	NCA	18.4	19.44	26.5	26.23
2		19.5		25	
3		19.83		25.5	
4		18.83		26	
5		20.1		26.9	
6		20		27.5	
1	RCA	16.5	16.75	21.50	21.38
2		18.7		22	
3		15.9		21.20	
4		15.5		20	
5		17.05		21.9	
6		17		21.7	
1	CRCA	18.4	19.33	23	23.91
2		19.23		24	
3		19.4		23.5	
4		19.8		23.7	
5		20.1		24.2	
6		19.05		25.1	



Flexural strength Beam

Sr.NO	Type Of concrete	Load carried (KN)	28Day MPA	Average flexural strength n/mm2
1	NCA	9.33	1.86	1.55 MPA
2		8.01	1.60	
3		7.01	1.402	
4		7.9	1.58	
5		7.4	1.48	
6		6.7	1.4	

Flexural Strength on the RCA beam

Table 5.2 Flexural Strength on the RCA beam

Sr.NO	Type Of concrete	Load carried (KN)	28Day MPA	Average flexural strength n/mm2
1	RCA	5.5	1.1	1.14MPA
2		5.7	1.14	
3		5.9	1.18	
4		5.4	1.08	
5		5.9	1.18	
6		6	1.2	

Flexural Strength on the CRCA beam

Sr.NO	Type Of concrete	Load carried (KN)	28Day MPA	Average flexural strength n/mm2
1	CRCA	6.5	1.3	1.41MPA
2		6.8	1.36	
3		8	1.6	
4		7.5	1.5	
5		6.7	1.34	
6		7	1.4	

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6.0 Conclusion

The pre-treatment of cement slurry fills the microcrack in RCA and improves its mechanical properties. When compared to RCA, CRCA reduces water absorption by 45.45%, aggregate impact value by 15.53%, aggregate crushing value by 16.69%, and los angeles abrasion value by 14.18%. Which is within the permissible limit IS 383-2016.

Pre-treatment of aggregate and cement addition in CRAC enhances its compressive strength. When compared with RAC, the compressive strength of CRAC improved by 8.37% than RAC but NAC shows similar results at 31.9.

The utilization of pre-treated aggregate and the addition of cement in CRAC increases flexural carrying capacity respectively, when compared to RAC

The observed enhanced crack resistance further highlights the valuable con- tribution of pre-treatment in enhancing the flexural carrying capacity of the structural member.

By focusing on these objectives, operators can significantly reduce the environmental footprint of crushing activities and contribute to a more sustainable and responsible industry.

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