Recycling Aggregate Use in Dry Lean Concrete (DLC) Pavement

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Abstract- **Every year, India produces a massive amount of debris from construction and destruction. The disposal of garbage has become problematic since these waste products require a huge space to be dumped. Furthermore, the ongoing depletion of natural resources in the manufacturing of traditional concrete raises the price of fine and coarse aggregate and reduces their availability. Thus, there is expanding interest in the potential application of using demolition debris to create coarse aggregate through the recycling building sector. Beyond the environmental benefits of reducing the demand for land for waste disposal, recycling demolition wastes can contribute to the conservation of natural resources. Evaluation of recycled coarse aggregate's mechanical, physical, and long-lasting qualities is crucial when using it in structural concrete. To determine whether to use concrete using recycled coarse aggregate (RCA) as structural concrete, its mechanical and physical qualities must be examined. The goal of the current investigation is to evaluate concrete that has had all its natural coarse aggregates (NCA) completely replaced with RCA. Additionally, the mechanical and durability test results are assessed and contrasted with NCA concrete. The high percentage of water absorption in RCA concrete is the primary issue. Like natural coarse aggregate concrete, RCA has a high compressive strength. This is mostly because the recycled coarse aggregate has a lot of mortar on to its surface and the RCA is highly angular, which results in coarse aggregate of low quality. The experimental investigation results indicate that RCA's high percentage of water absorption property qualifies it for usage as structural concrete in specific applications.**

Keywords– Recycled Coarse Aggregate, Natural Coarse Aggregate, Dry Lean Concrete.

1. INTRODUCTION

The preservation of the environment is one of the main issues facing modern society. The broad utilize of waste products and the decrease in energy consumption and natural resources are some of the crucial components in this regard. [1, 2, 3] These days, sustainable development is giving them a lot of attention. As a result, less space is needed for landfill disposal and natural resources are preserved. Industrialized nations have viewed C&D waste, particularly concrete, as a resource. The emphasis in recycling projects has been on the need for second-generation concrete to meet the necessary compressive strength requirements if old concrete is to be applied. Compressive strength is mainly determined by adhering mortar, water absorption, aggregate size, parent concrete strength, curing age and replacement ratio, moisture condition, contaminants present, and regulated environmental conditions, according to literature. [4, 5, 6, 7]

Research Significance: The current objectives of research to determine the properties of RCA concrete for utilize structural demand. Next, it is mandatory to compare characteristics of natural and recycled coarse aggregate concrete. Its strength and durability properties of RCA concrete are main objectives of the current study. [8, 9] It is investigated whether RCA can completely replace natural coarse aggregate. Research on Dry Lean Concrete Pavement's Use of Recycled Aggregate (DLC M10 Compressive Strength). Additionally, research is being done to determine the compressive strength (M30) with the use of RCA. [10, 11, 12]

Summary of This Work: This study presents the material option, laboratory design, mechanical and durability property tests, findings, discussion, and conclusions of RCA concrete.

2. MATERIALS

2.1 Cement: The experimental inquiry made use of regular Portland cement. The protocols outlined in IS 4031:1988 Part IV, V, I, II, III, and VI [13-18] are followed the conducting tests. According to IS 8112:1989, the characteristics of cement are within allowable bounds. The first setting period for the cement was sixty-five minutes. The cement required 115 minutes to set in its final state. 30% of the cement had a normal consistency.

2.2 Fine Aggregate: The River BANAS in the Tonk area of Rajasthan provided the sand utilized in the experiment. According to IS 383-1970 [19], the fine aggregate is classified as Zone II.

2.3 Water: The laboratory's potable water was used for the mixing and curing processes.

2.4 Coarse Aggregate: For the purpose of the experiment, both recycled and natural aggregate were used as coarse aggregate. In this investigation, the natural coarse aggregate consisted of crushed granite coarse aggregate that was graded 20 mm and 10 mm.

2.5 Recycled Aggregate: 10 mm and 20 mm nominal RA are utilized. It was taken out of the debris left over from demolition.

2.6 Admixture: To achieve the required workability, an poly carboxylic ether (PCE) based Auramix 300 made by Fosroc brand was employed. In this instance, employed admixture was in the range of 0.5% to 1.0% by mass of cement. The amount of admixture used varied based on the water cement ratio and was added as a percentage.

20mm RA **10mm RA**

Figure 1 ***Different types of aggregates***

Table1: *Coarse Aggregate gradation for DLC as per SP49:2014*

S. No.	Sieve	% by mass passing the sieve
1.	26.5 mm	100
2.	19.0 mm	80-100
3.	9.5 mm	55-75
4.	4.75 mm	35-60
5.	600 µ	10-35
6.	75 µ	0-5

Table 2: *FA Gradation as per IRC15:2011(Zone 2)*

S. No.	Sieve	% by mass passing the sieve
1.	10.0 mm	100
2.	4.75 mm	90-100
3.	2.36 mm	75-100
4.	1.18 mm	55-90
5.	600 µ	35-59
6.	300 µ	8-30
7.	150 µ	0-10

Table 3: ***The specific gravity of ingredients***

S. No.	Material	Specific Gravity
1.	Fine aggregate	2.67
2.	NCA (10 mm) IS:2386 (Part-III)-1963 IS:2386 (Part-III)-1963	2.58
3.	NCA (20 mm)	2.60
4.	RCA (10 mm)	2.46
5.	RCA (20 mm)	2. 64
6.	Cement	3.15
7.	Admixture	1.2

Table 4: ***water absorption of materials***

S. No.	Material	% of Water Absorption
1.	Fine Aggregate	1.5
2.	NCA (10 mm)	0.60
3.	NCA (20 mm)	0.57
4.	RCA (10 mm)	0.62
5.	RCA (20 mm)	0.6

Aggregate impact value (AIV):

Fresh Aggregate: AIV = 29.79%

RCA: AIV = 33.78 %

Maximum AIV < 30

Table 5: Aggregate Crushing Value Test

Particular	ACV_1	ACV_2	ACV_{avg}
Fresh Aggregate	22.89%	23.13%	23%
Recycled Aggregate	31.86%	30.10%	30.90%

Table 6: Loss Angles Abrasion Value (LAAV)

Particular	GRADE B 20-12.5 mm & 12.5-10 mm	GRADE C 4.75-2.36 mm & 6.3 - 4.75 mm
NCA LAAV	46.28%	45.61%
RCA LAAV	42.15%	38.20%

Table 7: Flakiness Index (FI)and Elongation Index (EI) for NCA

Sieve Size mm	FI	EI	Combined
10-6.3	13.21	13.79	27.0
12.5 – 10	14.1	15.21	29.31
16 -12.5	16.32	13.2	29.52
20 - 16	18.1	16.2	34.30

Table 8: FI and EI for RCA

Sieve Size mm	FI	EI	Combined
10-6.3	13.57	15.43	29.0
12.5 – 10	15.4	15.77	31.17
16 -12.5	14.42	12.66	27.08
20 - 16	16.16	15.56	31.72

3. CONCRETE MIX DESIGN (DLC)

When using ordinary Portland cement (OPC), the maximum aggregate cement ratio for the concrete mix is 14:1, and when using pozzlanic portland cement (PPC) or Portland slag (PSC), it is 12:1. A minimum of 140 kg/m^3 of cementation ingredients must be present in the concrete. This minimum cementation materials content must be raised as needed if it isn't enough to create concrete with the required strength. According to Clause 3.4, the fly ash or GBFS concentration should be 15–30% or 25–50% by weight of the cementation materials, respectively. (As per Code Reference) [20]. It is necessary to make trial mixes of dry lean concrete with water contents of 5.0, 5.5, 6.0, 6.5, and 7.0 percent by weight of the material overall.

Figure 2: Figure of dry mixing of materials

4. EXPERIMENTAL INVESTIGATION

Compressive Strength For DLC: The test for compressive strength was conducted three and seven days after casting. Five cubes (DLC) with a nominal size of 100 mm are taken for the compressive strength test, and the dimensions of each cube are used to calculate the surface area of each cube.

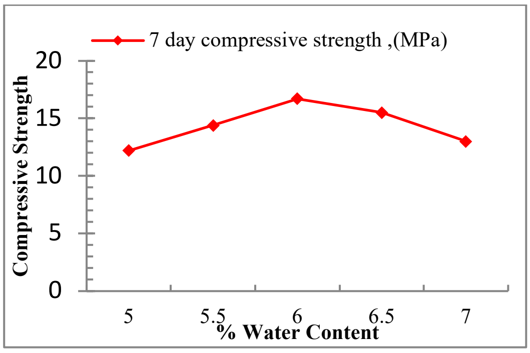
Figure 3: Compressive strength testing machine

Table 9: D0% Sample Test Results

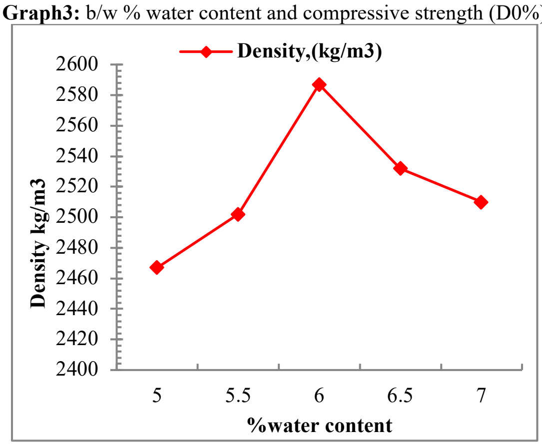
Mix Design	Water content	3-day compressive strength (MPa)	7-day compressive strength (MPa)	Density(kg/m^3)
D 0	5	8.3	12.2	2467
	5.5	9.0	14.4	2502
	6	11.7	16.7	2587
	6.5	9.7	15.5	2532
	7	9.2	13.0	2510

Table 10: D 100% (FULL REPLACEMENT)

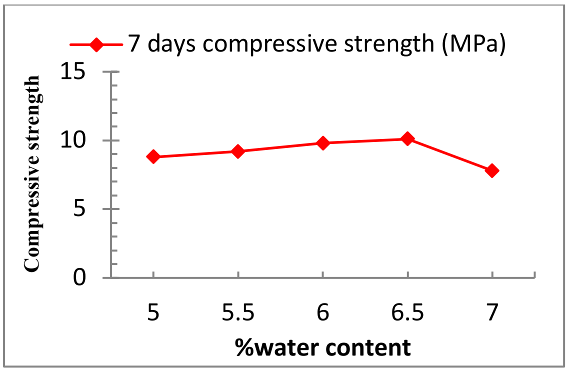
Mix Design	Water Content (%)	3 days compressive strength (MPa)	7 days compressive strength (MPa)	Density (kg/m^3)
D 100	5.0	5.5	8.4	2176
	5.5	5.6	8.6	2182
	6.0	6.3	9.0	2187
	6.5	6.4	9.2	2196
	7.0	5.2	7.4	2191



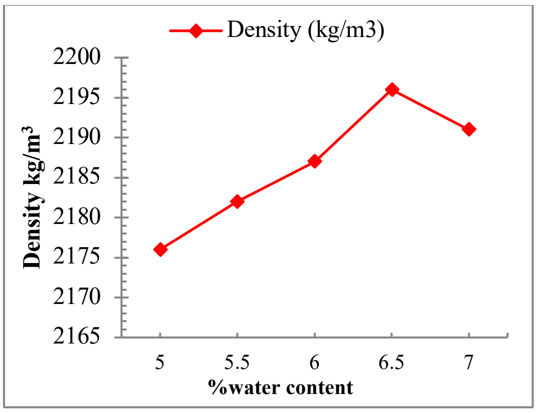
Graph3: b/w % water content and compressive strength (D0%)



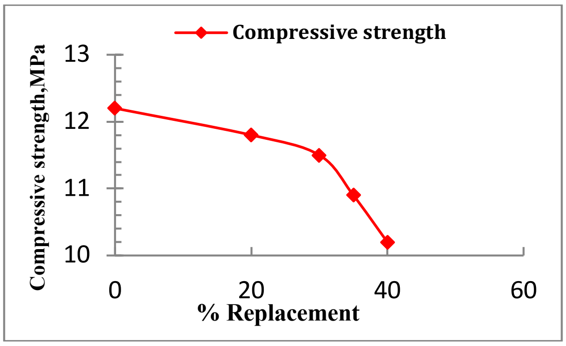
Graph4: Graph b/w % water content and Density (D0%)



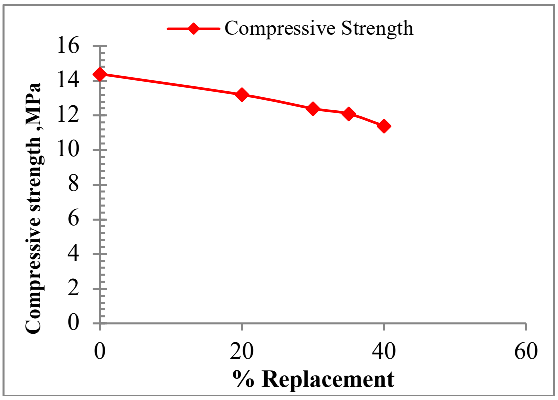
Graph 5: b/w % water content and compressive strength (D100%)



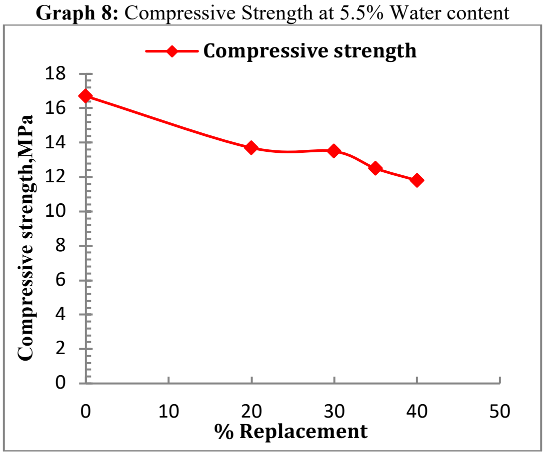
Graph 6: Graph b/w % water content and Density (D100%)



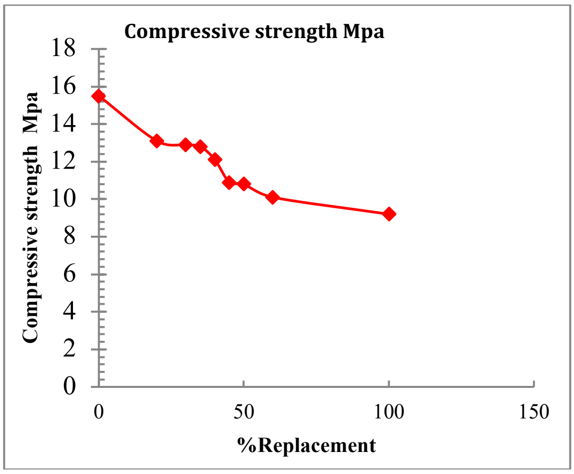
Graph 7: Compressive Strength at 5.0% Water content



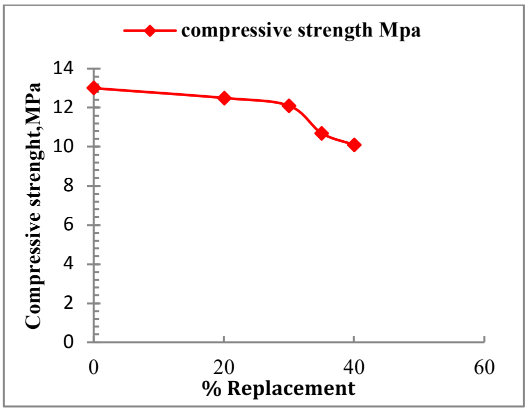
Graph 8: Compressive Strength at 5.5% Water content



Graph 9: Compressive Strength at 6.0% Water content



Graph 10: Compressive Strength at 6.5 % Water content



Compressive Strength at 7.0% Water content

5. CONCLUSIONS

1. It has been noticed that the compressive strength and density has increased in water content till optimum moisture content and is maximum at that water content. This is due to the optimum moisture at 6% and 6.5%which provides maximum strength.

2. The Optimum Moisture Content value is increasing with the increase in percentage of substitution of natural aggregates by RC. This is because of the fact that in higher replacement samples the aggregates have residual portion of used cement already attached to it. It increases the water absorption and so extra water content is required to attain maximum density and hence maximum compressive strength at 7 days.

3. The value of the Optimal Moisture Content increases with a higher percentage of recycling aggregate replacing natural aggregates. This is because of residual part of the cement that was already attached to the aggregates in samples with more replacements. This raises the `absorption rate and therefore, it implies there must be extra water content so as to achieve complete density and maximum compressive strength at seven days.

REFERENCES

[1] TR14 Best Practice guide for the use of RCA.

[2] DHIR R. K., LIMBACHIYA M. C. and LEELAWATT T. Acceptability of recycled concrete aggregate in mixtures that are authorized by BS 5328. Proceedings of the Institution of Civil Engineers, Structures and Buildings, 1999, 134, No. 3, 257–274

[3] DHIR R. K., PAINE K. A., DYER T. D., TANG M. C. and CUI Y. Value added recycling of domestic, industrial and construction a risings as concrete aggregate, Concrete Engineering International, 2004, 8, No. 1, 43–48.

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[6] University of North Carolina at Charlotte, Department of Civil and Environmental Engineering, 9201 University City Blvd, Charlotte, NC 28223

[7] American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-2 pp-06-09

[8] Hansen, T.C. (1992), "Recycling of Demolished Concrete Masonry, Rilem Report No. 6, E&FN Spon, London, Great Britain, pp. 316.

[9] Ferguson, J.; Kermode, O.N.; Nash, C.L.; Sketch, W.A.J. and Huxford, R.P. (1995), "Managing and Minimising Construction Waste," Institution of Civil Engineers, Thomas, Telford Publications, U.K., pp. 160.

[10] Gottfredsen, F.R. and Thogerson,F. (1994), "Recycling of Concrete in Aggressive Environment," Demolition and Reuse of Concrete and Masonry; Rilem Proceeding 23, E & FN Spon, pp. 309317.

[11] Hansen, T.C. (1986) "Recycled Aggregate and Recycled Aggregate Concrete, Seocnd state of Art Report, Development 1945–1985," Rilem TCDRC, Material & Structure, Vol. 19, No. III. pp. 201248.

[12] Hendricks, Ch.F. (1996), "Recycling and Reuse as a Basis of Sustainable Development in Construction Industry," Concrete for Environment, Enhancement and Protection, E&FN Spon, pp. 4354.

[13] BIS 4031 (Part IV), Methods of physical tests for hydraulic cement. Part IVDetermination of consistency of standard cement paste, Bur. Indian Stand. New Delhi. (1988) Reaffirmed in 2005.

[14] BIS 4031 (Part V), Determination of Initial and Final Setting Time, Bur. Indian Stand. New Delhi. 4031 (2002) 3–6.

[15] BIS 4031 (Part I), Method of Physical Tests for Hydraulic Cement Part 1, Determination of Fineness by Dry Sieving, Bur. Indian Stand. New Delhi. (1996).

[16] BIS 4031 (Part II), Determination of Fineness by Blaine Air Permeability Method, Bur. Indian Stand. New Delhi. (1999).

[17] BIS 4031 (Part III), Methods of physical tests for hydraulic cement, Part-3: Determination of Soundness, Bur. Indian Stand. 4031 (1988) 2–7.

[18] BIS 4031 (Part VI), Methods of Physical Tests For Hydraulic Cement Part 6 Determination Of Compressive Strength Of Hydraulic Cement Other Than Masonry Cement (First Revision), Bur. Indian Stand. Delhi. (2005) 1–3. https://ia800400.us. archive.org/0/items/gov.in.is.4031.6.1988/is.4031.6.1988.pdf.

[19] BIS 383, Coarse and Fine Aggregate from Natural Sources for Concrete, Bur. Indian Stand. New Delhi. (1997) 1–20.

[20] IRC:SP:49-2014, GUIDELINES FOR THE USE OF DRY LEAN CONCRETE AS SUB-BASE FOR RIGID PAVEMENT. https://law.resource.org/pub/in/bis/irc/irc.gov.in.sp.049.2014.pdf