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Experimental Investigation on Behaviour of Concrete using Concrete Debris

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Abstract : Concrete is one of the most widely used construction materials in the world. Cement and aggregate, which are the most important constituents used in the concrete production, are the vital materials needed for the construction industry. This inevitably led to a continuous and increasing demand of natural materials used for their production. Parallel to the need for the utilization of the natural resources emerges a growing concern for protecting the environment and a needed to preserve natural resources (such as aggregates) by using alternative materials which are recycled or waste materials. Recycling of concrete debris can make a contribution to reduce the total environmental impact of the building sector. To increase the scope for recycling in the future, aspects of recycling have to be included in the design phase. This experimental study aimed to use concrete debris as a partial replacement for coarse aggregate and fine aggregate. The specimens were produced with constant replacement of coarse debris as 50% and fine debris as 25%, 50%, 75%, 100%. Master Rheobuild 922CC admixture is used. The compressive strength was tested at various ages of 7, 14 & 28 days. Flexural strength and Split tensile was tested at 28days. It was found that (i) Concrete debrisc omparably better strength than conventional concrete.
Keywords : Concrete debris, Aggregates, Strength tests.

Introduction

The debris which we are using is the concrete cube which is thrown after being tested in the lab. The tested cube is broken, crushed and irrelevant materials are removed. The collected concrete debris is now used for new concrete mix.

Concrete is the most used construction material on earth. As the majority of the volume of a concrete mix is composed of aggregate, it is becoming increasing difficult to secure natural coarse and fine aggregates for the production of concrete and this is compounded by the social and environmental impacts associated with unlimited extraction of natural materials. The idea of incorporating RCA in new concrete is not new, it has been around for a number of years. Significant research has been undertaken as regards the general performance of RCA in concrete and its mechanical properties compared to concrete made with virgin aggregates[1,3]. RCA should not have greater than 0.5% brick content[2]. In practice, the usage of RCA in concrete has been mostly limited to non-structural applications such as pavements, earthworks and road construction. It is believed that the primary reasons for the limited use of RCA in higher grade structural concretes is due to perceptions regarding its quality as well as a lack of research, Knowledge and experience, particularly with respect to structural applications[1,4]. The key message is that RCA may perform differently to virgin products with respect to mechanical and structural properties, but if concrete technology allows these properties to be better understood and if appropriate design guidelines can be developed, the use of RCA in concrete will increase and extend more comfortably to structural concrete[1,5].

This paper presents a research findings on the mechanical properties of RCA concrete, including compressive strength, flexural strength, and Split tensile Strength. Behaviour of debris in concrete as an aggregate has been studied in this research work.

Experimental Procedures:

Materials and Mix proportion

Ordinary Portland Cement 53 grade has been used for the entire experimental work.The specific gravity of cement was 3.15 tested in accordance with IS 12269:1987[6].

Locally available crushed granite stone aggregate of 20 mm (maximum) size was used as coarse aggregate. Locally available river sand with fineness modulus of 3.5 was used as fine aggregate. The specific gravity of both coarse and fine aggregate was 2.72 and 2.63, respectively and the water absorption was 0.40 percent and 1.35 percent, respectively. The physical properties were tested in accordance with IS 383-1970[7] and the results are tabulated in Table 1. Portable tap water available in laboratory with pH value 7 and conforming to the requirement of IS 456-2000 was used for mixing concrete and curing the specimen as well[8]. Concrete debris is collected from HITECH CONCRETE SOLUTION PVT. LTD., Ayanambakkam. The concrete debris is crushed for both coarse and fine aggregate manually using a hammer.

Master rheobuild 922cc admixture was used as water reducing agents in order to improve the workabilityAccording to IS 10262-2009[9].

Replacing 50% of blue metals with coarse concrete debris of size less than 20mm for all the Replacement Mixes and also replacing river sand with the fine concrete debris both partially and fully of particle size less than 2.36mm.Mix proportion M1 consists of 25% of fine concrete debris and 75% of river sand, M2 consists of 50% fine concrete debris and 50% river sand, M3 consists of 75% of fine concrete debris and 25% of river sand, M4 consists of 100% of fine concrete debris. Master Rheobuild 922cc admixture has been added as Superplasticizer.Totally 45 Cubes, 10 small Cylinders and 10 Prisms were casted for all the mix proportions including control mix in this research work.

Casting and curing

In the laboratory, we have adopted weigh-batching method. The moulds which are used for testing are cube of size 150mm, cylinder of size 70mm diameter and 150mm height and prism of size 500x100x100 which are made up of cast iron and the inside faces are machined plane.According to the percentage debris is partially replaced with the aggregates and cement were mixed together in the pan mixer thoroughly. Water was then added to the dry materials and the mixing continued till homogenous mixture was obtained. The fresh concrete is then transferred to the moulds and compacted with the help of vibrator. The test specimens after compaction were kept as such for a period of 24 hours. After that period of time the moulds were removed and the specimens were kept in ordinary curing tank and allowed to cure for a period of 28 days.

Tests Conducted:

Compressive strength

Compressive strength of Concrete specimens was determined at 7, 14 and 28 days and tabulated in Table 3. At appropriate ages, specimens kept in water curing were tested using 3000 KN compression testing machine.

Flexural Strength

Flexural strength of concrete specimens was determined at 28 days and tabulated in Table 4. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture.

Split Tensile Strength

Tensile strength of concrete specimens was determined at 28 days and tabulated in Table 5**.**

Results and Discussions:

The effect of various parameters such as partial replacement of fine and coarse aggregates using concrete debris, Slump test, Compressive strength, Flexural strength and Split tensile strength testsare discussed in the following sections.

Partial Replacement of Fine and Coarse aggregates using Concrete debris: Coarse concrete debris is replaced to a constant of 50% and Fine concrete debris as 25%,50%,75%,100%. Replacing of Concrete Debris to aggregates shows a increases in 25% of fine debris and as constant of 50% inCoarse Debris.

Slump test of concrete debris and control mix, As shown in the Table 3. The slump value of control mix is 90mm and whereas in 25%-75% of fine concrete debris varies from 4-7mm from control mix and 100% fine debris differs till 30mm. Admixtures are added according to its workability. The required slump of concrete is from 50-90mm,Therefore, the slump of the concrete debris mixture passed the required slump for concrete

Table 3 Details of slump value for the various mixtures

Mix proportion	**Admixtu6re added**	**Slump**
CM	0.6	90
M1	0.8	94
M2	0.9	95
M3	1	97
M4	1	120

Compressive Strength: The values shown in Table 4 are the maximum load capacity (KN), and the compression strength (MPa) of each five specimens of equal areas of both standard and concrete debris mixtures. In the 7th day test Mix 1 shows high strength compared to the other mixes.

Table 4 Compressive Strength of Concrete debris Cubes at 7th day test.

Mix Proportion	**Load (kn)**	**Area (mm^2)**	**Compressive strength on 7th day test(Mpa)**
CM	531.9	22500	23.64
Mix 1 (Fine Debris 25%)	820.1	22500	34.84
Mix 2 (Fine Debris 50%)	787.7	22500	33.00
Mix 3 (Fine Debris 75%)	778.7	22500	32.60
Mix 4 (Fine Debris 100%)	647.0	22500	28.76

The values shown in Table 5, This time Mix 1 shows 1.16 times higher than Mix in 7th day test which is cured for 14 days.

Table 5 Compressive Strength of Concrete debris Cubes at 14th day test.

Mix Proportion	Load (kn)	Area (mm^2)	Compressive strength on 14th day test (Mpa)
CM	626.9	22500	27.86
Mix 1 (Fine Debris 25%)	885.0	22500	40.60
Mix 2 (Fine Debris 50%)	913.6	22500	39.33
Mix 3 (Fine Debris 75%)	786.2	22500	34.94
Mix 4 (Fine Debris 100%)	733.8	22500	32.61

The values shown in Table 6 shows that the compressive strength of 28th day strength is comparatively 1.39 times higher than 7th day and 1.19 times higher than the 14th day test. In this it shows that the concrete debris mix with 25% of fine debris shows a good strength compared to the other mixtures.

Table 6 Compressive Strength of Concrete debris Cubes at 28th day test.

Mix Proportion	Load (KN)	Area (mm^2)	Compressive strength on 28th day test (Mpa)
CM	726.7	22500	32.3
Mix 1 (Fine Debris 25%)	1096	22500	48.71
Mix 2 (Fine Debris 50%)	892.8	22500	39.68
Mix 3 (Fine Debris 75%)	951.2	22500	42.27
Mix 4 (Fine Debris 100%)	647.0	22500	28.76

Compressive strength of various ages such as 7th , 14th , 28th days tests shows a higher strength results at early stages compared to that of conventional concrete. Comparatively 28th day strength attained upto 48.71Mpa in the 25% replacement of fine debris and 50% of coarse debris shown in Figure 1.

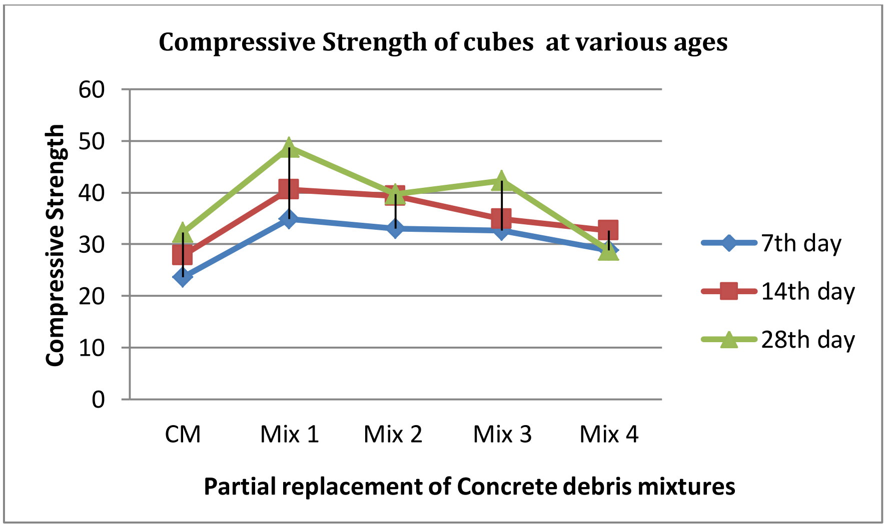

Figure 1: Compressive Strength of Cubes at various ages

Flexural strength Test: The values shown in the Table 7 shows the flexural strength of concrete on 28th day, In this it is shown that Mix 1 shows 1.06,1.08,1.1,2.12 times higher than the other mixtures. Therefore the 25% of fine debris concrete shows a higher strength shown in Figure 2.

Table 7 Flexural Strength of Prism on 28th day test at various mixtures in N/mm^2

Mix Proportion	Load (KN)	Flexural Strength test on 28th day (Mpa)
CM	24.5	12.25
Mix 1 (Fine Debris 25%)	26.10	13.05
Mix 2 (Fine Debris 50%)	24.15	12.08
Mix 3 (Fine Debris 75%)	22.45	11.23
Mix 4 (Fine Debris 100%)	11.95	5.98

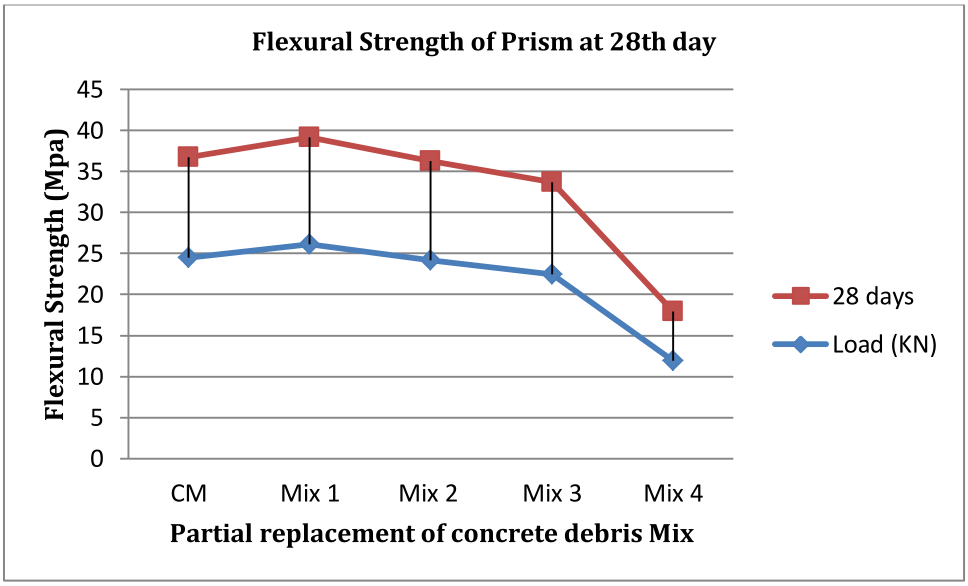

Figure 2: Flexural Strength of Prism at 28th day

Split Tensile Test: The values shown in Table 8 shows the split tensile strength of concrete debris on 28th day, In this it is noted that Mix 1 is 1.03,1.47,1.2 times higher than the other replacement mixtures shown in Figure 3.

Table 8 Split tensile test of cylinders on 28th day test at various mixtures.

Mix Proportion	**Load (KN)**	**Area (mm^2)**	**Flexural Strength test on 28th day (Mpa)**
CM	38.67	3848.45	2.34
Mix 1 (Fine Debris 25%)	50.3	3848.45	3.04
Mix 2 (Fine Debris 50%)	48.4	3848.45	2.93
Mix 3 (Fine Debris 75%)	34.3	3848.45	2.07
Mix 4 (Fine Debris 100%)	7.5	3848.45	0.45

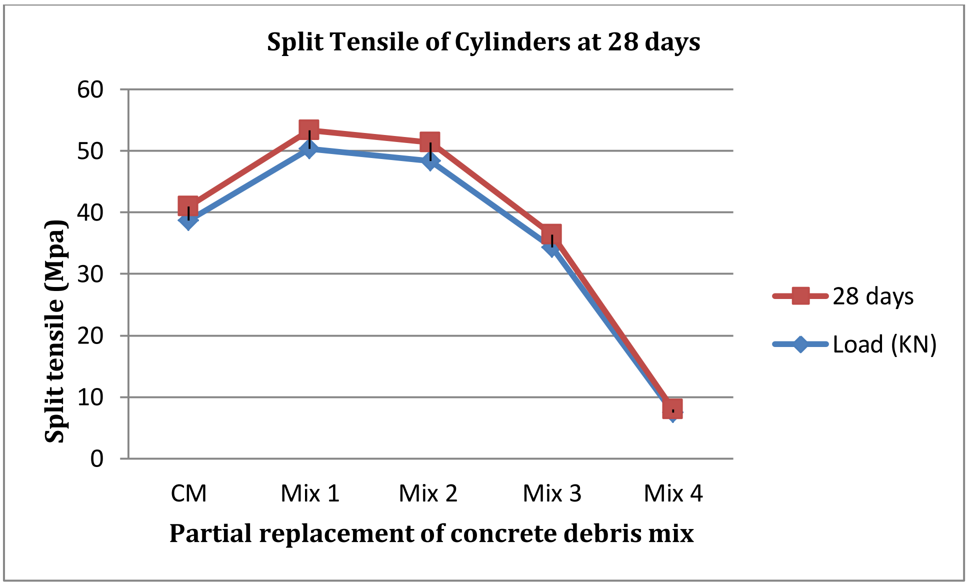

Figure 3: Split Tensile of Cylinders at 28 days

Conclusion:

The workability for the mix proportions is maintained at a same level by increasing the Master Rheobuild 922cc admixture at a linear rate but for M4 the workability is more. In general the water absorption for the concrete debris is more especially for fine concrete debris. The fine concrete debris were collected manually then it is sieved to 2.36mm as more of coarse particles were present.

The Compressive Strength for M1, M2 and M3 mixes is in the range of 35-48 N/mm^{2}andfor the conventional concrete it is in the range of 29 – 33 N/mm^2.

The Flexural Strength for M1, M2 and M3 mixes is in the range of 11 – 13 N/mm^{2}and for the conventional concrete it is in the range of 12 – 13 N/mm^2.

The Split Tensile Strength for M1, M2 and M3 mixes is in the range of 2.07 – 3.04 N/mm^2 and for the conventional concrete it is in the range of 2.3 -2.4N/mm^2.

M4 has lower strength compared to other mixes due to the 100% presence of fine concrete debris and there is no proper binding due to the absence of sand as the fine concrete debris is not fine enough for proper binding and because of which the voids are formed.

M1 has better strengths compared to the other mixes due to the proper mixing of sand and fine concrete debris. The fine concrete debris has some amount of cement residue which enables additional bonding between the fine concrete debris and sand. By analyzing the above results it is to be concluded that except for M4 all other mixes has better results than the conventional concrete.

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