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Strength Analysis of Concrete made from Construction and Demolition Waste Recycled aggregates.

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Abstract —*This paper describes the process which deals with the effect of replacing natural coarse aggregate by recycled aggregate which is carried out by processing field demolished concrete. The natural coarse aggregate (NA) in concrete was replaced by recycled coarse aggregate (RA) at different percentages such as 20%, 40%, 60%, 80%, 100% by weight of aggregate of M20 concrete & the compressive test is carried out. Test results showed that the compressive strength of recycled concrete up to 80% coarse aggregate replacement (C. A. R.) by demolished waste at the end of 28 days has been found to be comparable to the conventional concrete. The result of the study concludes that, the strength of concrete from recycled aggregates decreases on replacement of RA with NA.*

Keywords-*Construction and Demolition (C&D) waste; Recycling; Natural coarse aggregate (NA); Recycled coarse aggregate (RA); Compressive strength; Aggregates.*

I. INTRODUCTION

The construction industry is growing rapidly due to increasing population, IT sector, industrialization and new infrastructural projects. Due to which the demand for construction materials is huge for the construction activities which results in the generation of huge amount of construction waste. There is need of management of Construction and Demolition (C&D) wastes, which is a relatively new subject in India.

Construction and demolition (C and D) waste is defined as the solid waste generated by the construction, remodeling, renovation, repair, alteration or demolition of residential, commercial, government or institutional buildings, industrial, commercial facilities and infrastructures such as roads, bridges, dams, tunnels, railways and airports. Construction and demolition waste is considered as high volume, low risk.

II. LITERATURE REVIEW

[3]Gayakwad & Sasane (2015), give information on Construction and Demolition Waste Management in India. As report prepared by the MoEF (Ministry of Environment and Forest) in 2008 estimated that 0.53 million tonnes/day of waste is generated in the country. On that basis the 210 million tonnes of MSW is produced annually.

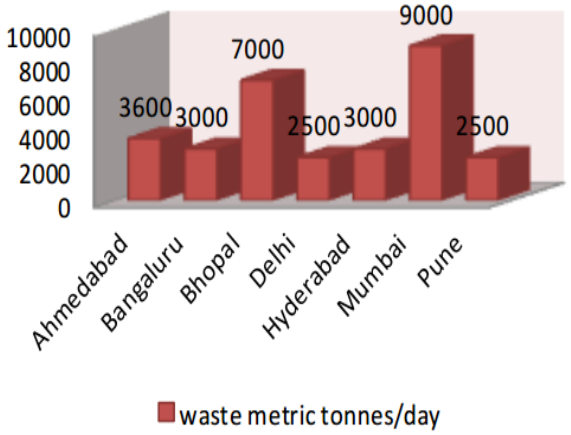

Figure 1: Graphical representation shows C&D waste production per day in Indian cities. [3]

[3]Gayakwad & Sasane (2015) also conclude that, separation of C & D waste should be promoted at source and an institutional mechanism for waste collection should be established involving informal sector who can be trained to separate the waste into categories and also do some amount of use, reuse and reprocessing like making tiles from crushed construction debris.[4]Ishtiyaq Gull(2011) gives results of studies undertaken to assess suitability of construction

demolition as coarse aggregate in new concrete production. Three sets of concrete materials considered are fresh concrete FCM, waste concrete WCM, and waste concrete strengthened with admixtures SWCM. Various mixes were prepared for carrying out the research by varying the proportions of cement, sand, and aggregates. All mixes were designed for characteristic strength *f*ck of M20. The compressive strength of concretes was tested in laboratory. The influence of admixtures on the strength of waste concrete was examined. The compressive strengths of FCM, WCM, and SWCM are compared and the results show that there is not much difference in the strengths of FCM and SWCM after 28 days.[5]Sonawane & Dr.Pimplikar**,** concludes that Use of recycled aggregate up to 30% does not affect the functional requirements of the structure as per the findings of the test results ,Various tests conducted on recycled aggregates and results compared with natural aggregates are satisfactory as per IS 2386,Due to use of recycled aggregate in construction, energy & cost of transportation of natural resources & excavation is significantly saved. This in turn directly reduces the impact of waste material on environment. Testing has been taken for M30 and M40 grade of concrete. There is replacement of NA by RA at 0%,10%,20%,30%.

[2]Schuur (2000),has determined the suitability of crushed building and demolition waste as a raw material for the production of calcium silicate products. Therefore, calcium silicate bricks have been produced by replacing the natural sand with crushed building and demolition waste of different sources. He insists that the mechanical properties of the bricks made with these wastes are comparable or, in some cases, even better than those of bricks with natural sand. The green shear strength of the bricks is higher. The amount of quartz and reactive SiO2 in the waste materials is high enough for the formation of tobermorite as a cementitious material between the grains. He concludes that Replacing natural sand by crushed building and demolition waste for the manufacturing of calcium silicate products can produce products with mechanical properties that are comparable or even better than the original products.

III. OBJECTIVES

1. To reduce impact of waste materials on environment by recycling it.
2. To find out physical properties of RA.
3. To compare cube compressive strength of concrete using recycled aggregate by 20%, 40%, 60%, 80%, 100% by weight of aggregate of M20 concrete.

IV. MATERIALS & METHODOLOGY

4.1. Cement

The cement used for concrete is Ordinary Portland Cement of 53 Grade (Birla Super Cement) conforming to IS: 8112-1989.

4.2. Natural Aggregates(NA)

The coarse natural aggregates from Local Basalt rock crusher, conforming to IS:383 were used. The nominal size of aggregate was 20mm.

4.3. Recycled Aggregates(RA)

The C&D waste was collected from 2 different demolished sites of Residential buildings (figure 2&3) available in local area. The physical properties of NA & RA are listed below in Table 1. The conversion of waste concrete into aggregates was carried out in plant situated at village Mulkhed Tal. Haveli District. Pune, with the similar machineries used for production of crushed aggregate from natural rock as shown in figure 4. The crushed product was screened and sizes below 4.75mm were rejected. The recycled coarse aggregates used in the experimental study were 20 mm down size. The recycled coarse aggregate was standardized to satisfy the grading requirements as per Indian standard I.S.383-1970. All the tests performed for physical properties of NA and RA as depicted in Table 1 are carried out as per IS codes.

4.4. Fine Aggregates

Locally available river sand is used as a Fine aggregates passing through 4.75mm sieve. The fineness modulus of river sand was 2.68 and specific gravity was 6.34.

4.5. Water

Water used for concrete mixing was potable water. For curing of concrete cubes, same water is used. The source of water was tap water.

Figure 2: C&D waste collection Site 1-Vasant Vihar at Kothrud, Pune

Figure 3: C&D waste collection Site 2 –Bhumkar Chowk Narhe Pune

Figure 4: Recycling of C&D waste concrete

Table 1: Physical properties of natural coarse aggregates and recycled coarse aggregates.

Properties	Natural coarse aggregates	Recycled coarse aggregates
Fineness modulus	7.70	7.72
Specific gravity	2.74	2.38
Water absorption (percentage)	0.40	0.91
Bulk density in loose state (kg/m3)	1612	1437
Bulk density in compacted state (kg/m3)	1776	1498
Impact value (percentage)	6.61	12.10
Crushing value (percentage)	25.61	31.43
Los Angles abrasion value (percentage)	7.84	15.66

V. MIX DESIGN

The experimental investigation was based on a reference concrete mix of grade M20 using natural aggregates. On the basis of the material properties, the proportioning of concrete mix was carried out in accordance to IS 456-2000 and as per the guidelines of IS 10262:2009. The mix proportion of reference mix was 0.5(water):1(cement):1.5(sand):3.0(coarse agg.) for M20 grade of concrete.

VI.CASTING

The recycled aggregate concrete (RAC), was obtained by replacing natural aggregate in the reference mix. With the control concrete, i.e.0%, 20%, 40%, 60% and 100% of the natural aggregate is replaced with the recycled aggregates. Three cube samples were cast on the mould of size 150 mm for each 1:1.5:3.0 concrete mix with partial replacement of coarse aggregate with w/c ratio as 0.50 in the college departmental laboratory as shown in figure 5. After about 24 h the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7 and 28 days for compressive strength. To determine the strength characteristics, specimens for each variation for the various tests were cast and cured for 28 days. Concrete cubes of size 150 mm were tested for compressive strength as per IS: 516-1959. The standard practice prescribed by BS 1881: part 3:1970 is followed to fill mould in 3 layers.

Figure 5: Cube casting of concrete

Figure 6: Natural aggregates and recycled aggregates

VII. TESTING

Compressive strength tests were performed on compression testing machine using cube samples at college departmental laboratory as shown in figure 7. Three samples per batch were tested with the average strength values reported in this paper. In the compression tests, the cube is placed with cast faces in contact with the plates of the testing machine, i.e., the position of the cube when tested is at right angles to that as cast, as shown in figure 7. According to BS: 1881: part 4:1970, the load on the cube should be applied at the constant rate of stress equal to 15 MPa/min.

Figure 7: Lab testing of cube specimen

VIII. RESULT & DISCUSSION

The table 2 and 3 below give the overall results of compressive strength of concrete with different percentage replacement of natural coarse aggregates by recycled aggregates. Table also gives the percentage decrease of compressive strength with respect to the reference mix. Variation of compressive strength at different percentage replacement of natural coarse aggregates by recycled aggregates can be depicted in the form of graph in Figure 8 and 9.

Table 2: Results of compressive strength at 7 days

Percentage replacement of natural aggregates by recycled aggregates	Compressive strength (MPa)	Percentage decrease of compressive strength with respect to reference mix
0 (Ref.mix)	13.54	0.00
20	13.02	3.84
40	12.47	7.90
60	12.76	5.76
80	12.51	7.61
100	12.42	8.27

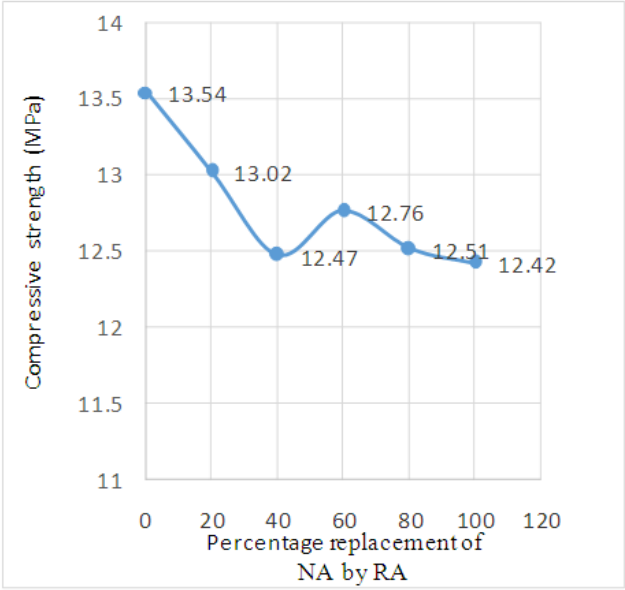

Figure 8: Cube compressive strength at 7-days.

Table 3: Results of compressive strength at 28 days.

Percentage replacement of natural aggregates by recycled aggregates	Compressive strength (MPa)	Percentage decrease of compressive strength with respect to reference mix
0 (Ref.mix)	20.00	0
20	18.62	6.9
40	18.91	5.45
60	18.24	8.8
80	17.86	10.7
100	17.09	14.55

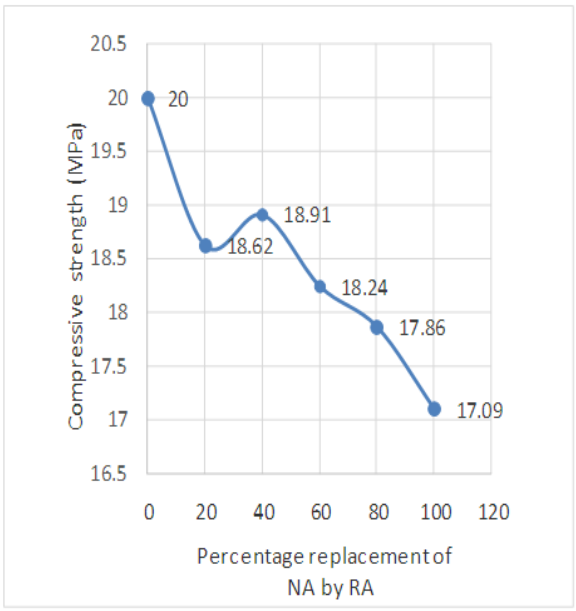

Figure 9: Cube compressive strength at 28-days.

IX.CONCLUSION

Following conclusion may be drawn based on the test results,

1) All the physical properties of RA are well within acceptable limits as per IS code.
2) There is a reduction in compressive strength of concrete with increase in the percentage replacement of natural coarse aggregates by recycled aggregates.
3) Recycled aggregates cannot be used for concreting of structural members as strength is not within permissible limits.

DIRECTIONS FOR FUTURE RESEARCH

Further study of this research can focus on the following:

1. Financial analysis of recycled waste concrete and products; and
2. Potential environmental benefits gained through the promotion of sustainable waste concrete management.

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