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UTILIZATION OF RECYCLED AGGREGATE IN PAVEMENT QUALITY CONCRETE (PQC) PAVEMENT

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Abstract - ***In recent years, Construction and Demolition Wastes (CDW) are increasing day by day and these are the wastes which influence our natural environment. To reduce the impact of these wastes a remarkable attention has been considered by the researchers to reuse these wastes. Recycled aggregates (RA) are the mostly derived inert materials from the CDW. In general terms CDW comprises of any types of material waste like excavated materials obtained from broken up old roads resulting from road maintenance, broken bricks and broken concrete from the demolition sites, old buildings and industrial wastes, also crushed concrete cubes and beams from material testing laboratory etc. The main purpose of this project was to aim at sustainability by reusing waste demolished concrete or recycled aggregates up to the maximum possible extent without harming the strength of the pavement quality concrete in the coarse sub base layer. We have obtained the recycled aggregates by crushing the old concrete cubes and beams from the laboratory test lab ages up to 3 to 5 years old concrete. This research was implemented to examine the efficiency by utilizing recycled aggregates as a replacement for natural aggregates we have compared the properties at different percentage of replacement (0%, 20%, 40%, 50%, 60%, 80%, 100%) of recycled aggregates. This paper also reports the essential properties of natural and recycled coarse aggregates and also compared these basic properties of recycled aggregates with the natural aggregates. After that other relevant tests were carried out for fresh and hardened concrete at different replacement percentage of recycled aggregate with natural aggregate.***

Keywords - Recycled Aggregate, Natural Aggregate, Compressive Strength, Flexural Strength, RCA, CDW etc.

I. INTRODUCTION

Uncertain waste materials in huge quantities are being accumulated and generated which is causing damage to our natural environment. These waste materials may be classified as the hazardous toxic and non decaying materials which are increasing with the time. Construction and Demolishing waste are the non decaying materials which cause the land filling, dumping and other pollution problems to the natural environment. The Recycling Techniques are being implemented all around the world to overcome the problems of waste materials and many countries has proved the effective use of these waste materials in the construction work without harming the environment and protecting the natural resources. A techno market survey has carried out by TIFAC on 'Use of Waste from Construction Industry' aiming housing /building and road segment. the total amount of waste from construction industry is approximately

12 to 14.7 million tons every year out of which 78 million tons are concrete and brick waste. compatible with discussion of survey, 70% of the respondents has given the justification for not accepting recycling of waste from industry because they are not conscious of the recycling techniques. While remaining 30% have specified that they are not even conscious of recycling possibilities. Furthermore, the other departments and industries admitted that presently, the BIS and other Codal provisions has not provided the provisions for the use of recycled material in the construction projects.

A. *Objectives*

- To study properties of Natural aggregate and Recycled Aggregate.
- To study Compressive strength and Flexural Strength for Pavement Quality Concrete (PQC).
- To study fresh and hardened concrete mix.
- Specimen testing for flexural strength test after 7 days and 28 days For PQC.
- Specimen testing for compressive strength test after 7 days and 28 days for PQC.
- Analyzing the test results to determine and increase optimum percentage of replacement of recycled aggregate.

II. LITERATURE REVIEW

Jung-Ho Kim et.al. (2019)[1] Conducted research on the mechanical and hardness characteristics of concrete using recycled aggregate, after developing equipment to enhance the standard of recycled aggregate to extend the utilization of recycled aggregate for environmental improvements. Zhiming Ma et.al. (2019)[2] examined to analysis the studies on the strength of RAC in China, and so the shrinkage behaviour, chloride permeability, carbonation behaviour, and freeze-thaw resistance of RAC were introduced. Feras Al Adday et.al. (2019)[3] Studied by using of RCA in situ of natural coarse aggregates in concrete mixes. they prepared 90 cubes with different ratio of RCA (0%, 30%, 45%, and 60%) with water cement ratio 0.4 and that they used 0% and 2.5% super plasticizer with different percentages of iron powder in situ of fine aggregate (10%, 15%, and 20%. K.Sabarinathan, R.Ashwathi(2019)[4] investigated the characteristics of Construction waste and obtaining a way out by using its reliable segments such it may be used as a basic material and Conservation the natural recourses like Coarse aggregate. Ammar Ben Nakhi and Jasem M. Alhumoud(2019)[5] studied the chloride diffusion of soaked concrete made with various percentages of recycled aggregate. The results indicate that the density and air content of recent concrete decreased with a rise in recycled aggregates content. Tianyu Xie et.al. (2018)[6] outlined the literature handling the mechanical properties (and the parameters influencing them) of RAC processed using coarse recycled concrete aggregates published between 1978 and 2017. So as to supply a comprehensive understanding of the behaviour of RAC, this review was taken under consideration over 200 published studies. Jagdish Kanungo, Dr. Hemant Sood (2018)[7] A respective evaluation of the experimental solution of the properties of Natural Aggregate Concrete and various replacement ratios of natural aggregates with recycled coarse aggregates was introduced in this paper. Mudasir Liaquat Shah et.al. (2018)[8] investigated the hardness properties of used (recycled) aggregates and Recycled Concrete Aggregate.

III. MATERIAL USED

A. *Fine Aggregate/sand*

River sand was purchased from the local sources and tested for water absorption of .070%, specific gravity was 2.76, free moisture content of .46% and gradation using sieve analysis. Sand use was of zone I sand as per IRC15:2011(Zone I).

Fig. 1 Sand

B. Natural Aggregate

The aggregates were used of nominal size of 10mm and 20mm in the ratio given in the respective code. The aggregates were purchased from the local sources and tested for water absorption, surface moisture content, specific gravity and gradation using sieve analysis.

10mm NA   20mm NA

Fig. 2 Natural Aggregate

C. Recycled Aggregate

We have collected recycled aggregate from material testing laboratory from crushed concrete cubes and beams (aged about 3 to 5 years old). Each of them were undergone a loading (direct compression or combined shear-bending) up to failure and the Source was a mix of concrete contained with various design characteristic strength (ranging from 25 MPa to 30 MPa).The RCA samples were collected reliable with the source and age of the parent concrete. After that we have crushed it in small pieces by crusher and manually then we have done gradation with the help of the sieves and get 10mm & 20mm RA.

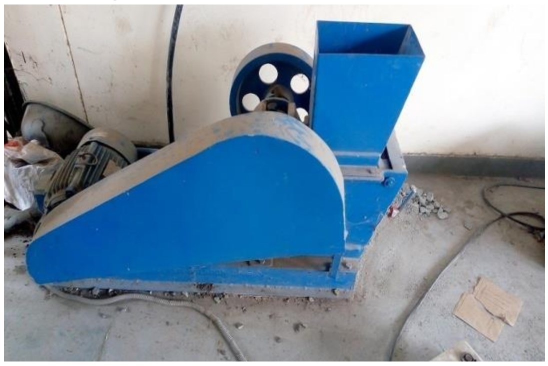

Fig. 3 Crusher used for crushing

10mm RA   20mm RA

Fig. 4 Recycled Aggregate extracted in nominal size

D. Cement

Portland Pozzolana Cement of grade43 (PPC43) was used as per IS: 1489-part-1(1991). Cement tested for specific gravity was 3.25. The brand was Coromandel King Cement.

E. Admixture

Admixture Polycarboxylate ether (PCE) is used to get required workability. Quantity of admixture used is different for different water-cement ratio and it is added by percent weight of cement in this case we have used admixture 2.0% by the weight of cement.

F. Water

Potable water present in lab which is free from any type of impurity was used for casting.

Table I Comparison between the engineering properties of NA and RA

Properties	**IS Code**	**Recycled Aggregate**	**Natural Aggregate**	**Permissible Limit**
Specific Gravity of aggregates	IS:2386 Part III	10mm = 2.50 20mm = 2.68	10mm = 2.78 20mm =2.82	Range 2.5 – 3.0
Aggregate Impact Value of aggregates	IS:2386 Part IV	38.30%	19.22%	30% Max. For (CC)
Aggregate Crushing Value of aggregates	IS:2386 Part IV	30.14%	23.84%	30% Max. For (CC)
Los Angeles Abrasion Value of aggregates	IS:2386 Part IV	21.92%	14.56%	35% Max. For (CC)
Combined Flakiness and Elongation Index	IS: 2386 Part I	29.74%	28.22%	35% Max. For (CC)
Water Absorption Value of aggregates	IS:2386 Part III	10mm = 0.65% 20mm = 0.62%	10mm = 1.55% 20mm = 1.20%	2% Max.

IV. TEST PERFORMED FOR PQC SAMPLES

A. Slump Test

Slump Test was applied as per the rules of IS: 1199-1959. The slump was taken for every mixing of concrete with 0%, 20%, 40%, 50%, 60%, 80% and 100% replacement of RCA. In which he slump results shows that concrete made with natural aggregates has greater value of slump while the slump of concrete made with 100% replacement of RCA has lower value of slump. The low slump in RCA is caused because of high absorption of RCA which absorbs water during the blending process.

Table II Slump value at different % replacement of RA with NA

Sample	**Slump value (mm)**
D0%	87
D20%	81
D40%	73
D50%	66
D60%	57
D80%	43
D100%	31

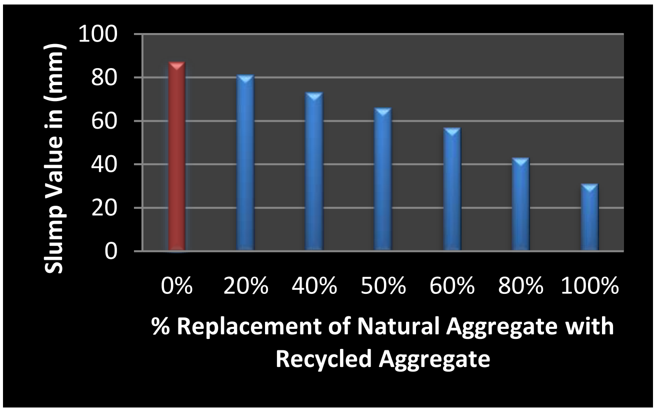

Fig. 5 Graph for Slump value at different % replacement of RA with NA

B. Density of Concrete

Density of hardened concrete is calculated by measuring the difference in weight of empty cube mould and weight of mould filled with fully compacted concrete and divided it with the dimensions (volume) of mould. Here the standard size of mould is 150x150x150mm.

C. Compressive Strength Test

This test is carried out as per IS: 516-1959. In which we find out the compressive strength of concrete cubes after 7 days and 28 days of curing. Minimum of three sample of 150x150x150 mm must be tested for proper average reading. The loading rate per minute should be approximately 140 Kg/cm^2 for the sample of cubes. The compressive strength was determined by using the formula. $F = \frac{P}{A}$

Where, F = Compressive strength of sample (MPa). P = Maximum load applied on the sample (N). A = Cross sectional area of the sample (mm^2).

Fig. 6 Compressive strength testing machine

D. Flexural Strength Test

This test is carried out as per IS: 516-1959. the standard size of beam samples 500x100x100 mm is used. The sample should be placed properly in the machine so that the load may be applied to the uppermost surface as cast in the mould. The load should be applied through the two similar rollers mounted at the supporting span spaced at 133.33 mm centre to centre. The load can be applied at a rate of loading of 400kg/min for the 15.0 cm samples of beam and at a rate of 180kg/min for the 10.0 cm samples of beam. The load is increased till the sample fails and also the maximum load applied to the sample during the test should be noted. The fractured faces of concrete and any different features within the kind of failure should be noted. Flexural Strength (Modulus of Rupture) is determined by using the formula.

$$\text{Modulus of Rupture} = \frac{PL}{BD^2}$$

Where, P = Maximum load applied (N). L= Supported length. B = Width of beam sample. D = Depth of beam sample.

Fig. 7 Flexural strength testing machine

V. TEST RESULTS

A. Strength Test Results for 7 and 28days

Table III Final Table b/w % Replacements and Compressive Strength for 7days

Sample	Compressive Strength @ 7 Days (MPa)
D0%	29.98
D20%	26.37
D40%	23.32
D50%	19.56
D60%	14.81
D80%	10.09
D100%	5.69

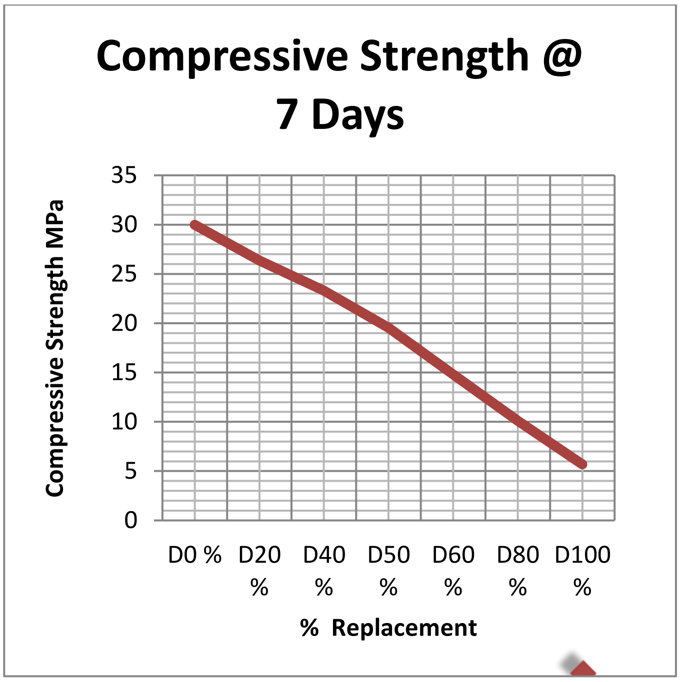

Fig. 8 Graph b/w % Replacement and compressive strength @ 7days

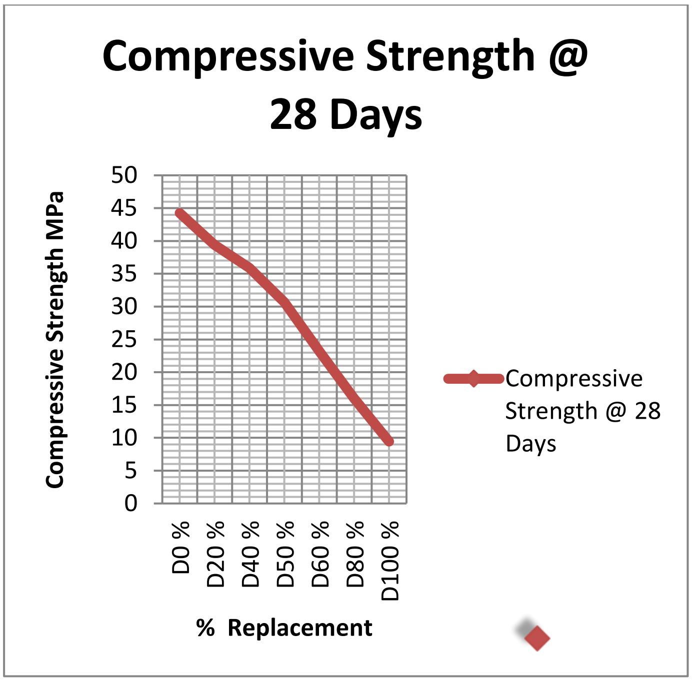

Fig. 9 Graph b/w % Replacement and compressive strength @ 28days

Table 4 Final Table b/w % Replacements and Compressive Strength for 28days

Sample	Compressive Strength @ 28 Days (MPa)
D0%	44.25
D20%	39.39
D40%	35.87
D50%	30.68
D60%	23.22
D80%	16.02
D100%	9.44

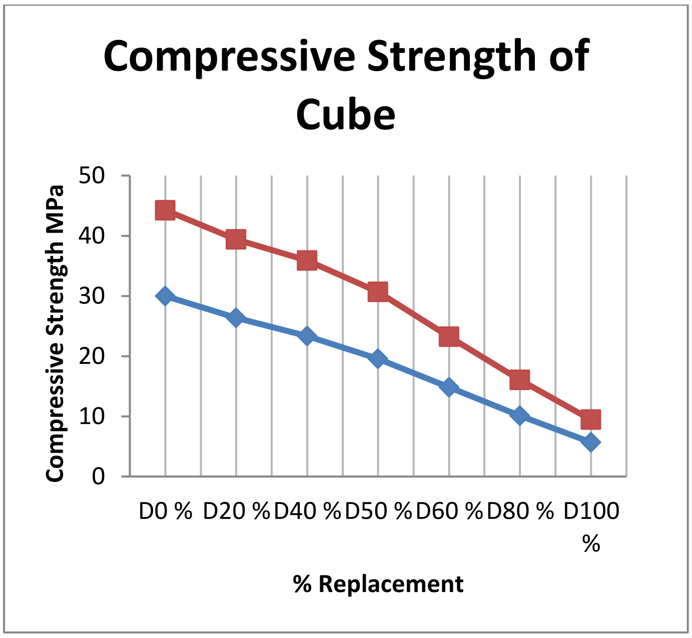

Fig. 10 Graph b/w % Replacement and compressive strength @ 7days and 28 days

B. Flexural Tensile Strength Test Results for 7 and 28days

Table 5 Final Table b/w % Replacements and Flexural Strength for 7days

Sample	Flexural Strength @ 7 Days (MPa)
D0%	3.29
D20%	2.82
D40%	2.56
D50%	2.35
D60%	2.10
D80%	1.89
D100%	1.45

Table 6 Final Table b/w % Replacements and flexural strength for 28days

Sample	Flexural Strength @ 28 Days (MPa)
D0%	4.90
D20%	4.34
D40%	3.91
D50%	3.56
D60%	3.21
D80%	2.84
D100%	2.15

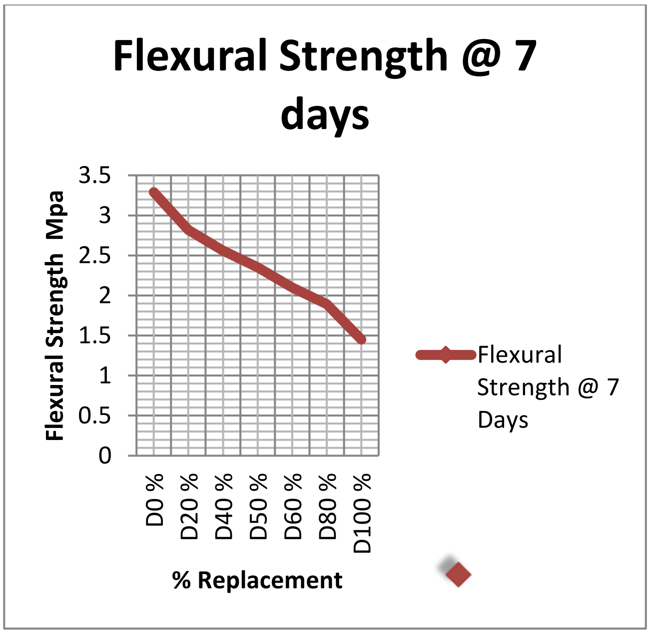

Fig. 11 Graph b/w % Replacement and Flexural strength @ 7days

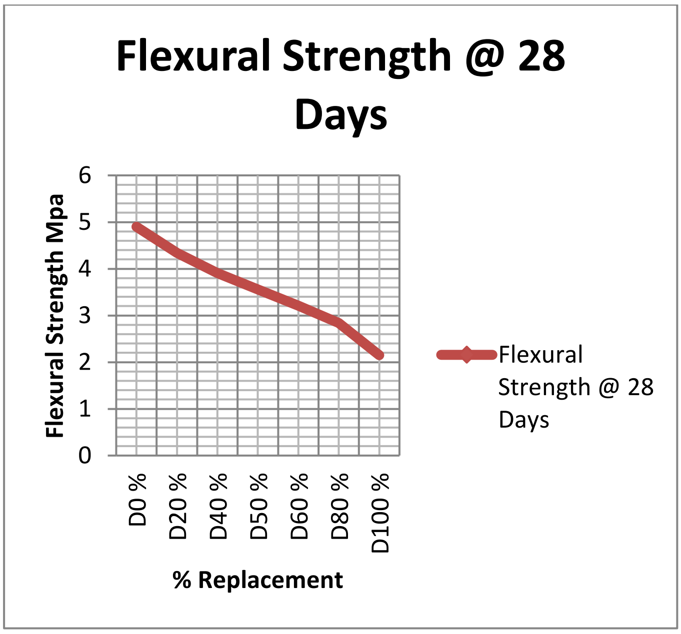

Fig. 12 Graph b/w % Replacement and Flexural strength @ 28days

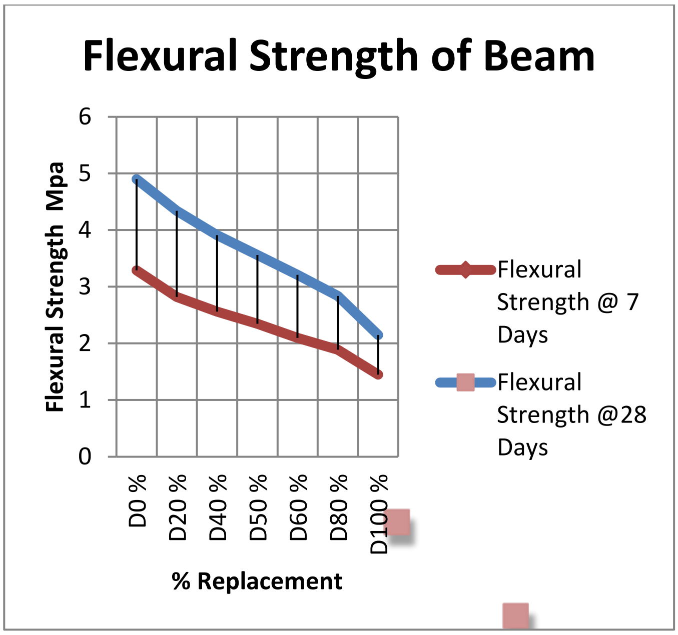

Fig. 13 Graph b/w % Replacement and Flexural strength @ 7days and 28days

VI. CONCLUSION

- The Aim of this project work was set out to work out the extent up to which the natural aggregates can be replaced with recycled aggregates in pavement quality concrete (PQC) for the sub base in Cement Concrete Road. The study has also sought to know the various parameters that are affected by replacement in Recycled Aggregate Concrete (RAC) and what is the behaviour of RAC.

- The main purpose of this project was to aim at sustainability by reusing waste demolished concrete or recycled aggregates up to the maximum possible extent without compromising the strength of the pavement quality concrete sub base. We firstly studied and compared the properties of natural aggregates with the recycled ones and checked whether the satisfy the code recommendations. Then samples were casted at each water content and across various percentages of replacement.

- The conclusions drawn from the above results are that use of up to 40-50% recycled aggregates can be permitted. The 28 days compressive strength remained within limits of average 28 days compressive strength of 3 samples not less than 30 MPa for 50% of recycled aggregates. Further increase in recycled aggregates resulted in a lower 28 days compressive strength and resulted in separation of cement paste from the mix which reduced strength.

- We can Replace Natural Aggregate with Recycled Aggregate up to 40-50% in PQC.

VII. FUTURE SCOPE

- Economy, serviceability and strength of concrete can be improved further by using the different materials at varying percentage of replacement with other natural materials. This may lead to protect the natural resources and other Environmental effects.
- The problems of landfills and dumping of this waste material may also be overcome and reduced.
- This present study work may also be extended for the design of codes required provisions for the recycled aggregate concrete conforming to that of normal concrete.
- The benefits of the use of recycled materials may lead to the reduction in the construction cost of the project and cost analysis may also be studied very well.

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