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Use of Recycled Concrete for Pavement Construction

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Abstract— **Natural aggregate is being used faster than it is being produced, creating a shortage in the future. Despite this, the demand of recycled concrete for use as recycled concrete aggregate (RCA) is increasing. Using this recycled waste concrete as RCA conserves natural aggregate, reduces the effect on landfills, lowers energy consumption and save cost. However, there is still many doubts on the use of RCA in concrete pavements. This research shows the many technical and cost-effective concerns regarding the use of RCA in concrete pavements by deciding concrete mixture and proportioning designs suitable for concrete pavements; using varying amounts of recycled coarse aggregates; monitoring performance through testing. Five mixes were prepared using the various proportions of recycled coarse aggregates i.e. 0%, 10%, 20%, 30%, 40%., keeping the other ingredients constant. Super plasticizer (0.6% of cement) is used to reduce water cement ratio to 0.38 . At 28-days, all of the five mixes exceed the 48MPadesign compressive strength. Quality assurance and quality control (QA/QC) testing showed that the mixes containing RCA showed similar or improved performance when compared to the conventional concrete for compressive and flexural strength. Flexural strength development followed a similar trend as compressive strength. Life cycle cost analysis (LCCA) illustrated the savings that can be expected using RCA as are placement aggregate source as the cost of natural aggregate increase as the sources becomes depleted.**

I. INTRODUCTION

There is a shortage of natural aggregate and an increment of recycled concrete. The current usage of concrete is not sustainable due the increased shortage of natural aggregates in urban area. It is estimated that the construction industry in India generates about 10-12million tons of waste annually. Projections for building material requirement of the housing sector indicate a shortage of aggregates to the extent of about 55,000million m^3. An additional 750 million m^3 aggregates would be required for achieving the targets of the road sector. Recycling of aggregate material from construction and demolition waste may reduce the demand-supply gap in both these sectors. Concrete structures that are designed to have service lives of at least 50 years have to be recycled after 20 or 30 years because of early deterioration. The cost of quality aggregate has increased above the inflation rate and it is projected that this trend will continue as further restrictions are placed on this resource in the future. RCA use is based on economics, including the cost of transporting C&Dwaste and virgin aggregate, the cost of C&D disposal, and government intervention on tipping fees and mandatory usage through legislation. Here is great adverse impact on environment. Not only is there the environmental impact of transporting the waste concrete but the waste concrete also fills up valuable space in landfills. Due to ill effects of waste concrete with space and cost, traditional disposal of concrete in landfills is no longer an acceptable choice. Use of RCA, saves the cost in the transportation of aggregate and waste products, and in waste disposal. There are some barriers also in using RCA. Highways require quality material that meets engineering, economic and environmental considerations. However, where high-performance concrete is not required, RCA can be used and virgin aggregate conserved. The use of material specifications are a barrier to the use of RCA. A performance-based or end result specification would allow more RCA use. However, specific standards on how to use RCA in new concrete are not currently available

II. OBJECTIVES OF THE STUDY

The study of use of recycled concrete in pavement construction consists of making laboratory investigations on cement concrete prepared by using recycled concrete to judge its suitability for pavement construction. The main objectives of study are:

1 To highlight the current issues associated with using RCA.

2 To prepare mix design for M40 concrete with varying proportions of recycled aggregates.

3 To determine the compressive strength of the samples at the end of 7, 28 and 90 days.

4 To determine the flexural strength of the samples at the end of 7,28 and 90 days

5 To demonstrate advantages of using a performance based specification as compared to a prescriptive specification for both the conventional concrete and the concrete with recycled concrete aggregates

6 The purpose of this research is to study the behavior of RPCC aggregates when it is included in Plain cement concrete. Slump tests are to be performed on freshly mixed concrete, and compression tests are to be performed on hardened concrete. 135 samples of concrete are to be prepared with RPCC and natural aggregate, changing their mixture design parameters, including coarse aggregate proportions

III. METHODOLOGY

A concrete mix M40 is designed as per the physical properties of aggregates. Physical properties of aggregates are given in table 1.

Table 1 Physical Property of Aggregates

Properties	Natural aggregates		Recycled aggregates
	Coarse	Fine	Coarse
Shape and texture	100% crushed faces	100%crushed faces	100 % crushed faces
Specific gravity	2.68	2.65	2.5
Water absorption	0.9	1.85	1.5
Fineness modulus	7.3	3.1	6.8

Using these physical properties of aggregates M40 mix is designed as per IS 10262. Water cement ratio is decreased to 0.38 after using super plasticizer (0.6% of cement). Mix design components are summarized in table 2. The values are in kg/m^3

Table 2 Mix Design Components

Water	Cement	Fine aggregates	Coarse aggregates	Super plasticizer
177	467	574	1176	2.8

The mix design ratio comes out to be 1:1.23:2.52 for cement, fine aggregates and coarse aggregates respectively. After this five batches are prepared with varying proportion of recycled coarse aggregates with increasing amount of 10% in each batch. They are designated as m0, m1, m2 ,m3 and m4 with RCA proportion of 0%, 10%, 20% , 30% and 40% respectively. All other components of concrete are kept constant in each batch

Tests performed:

Before going to compressive and flexural strengths, workability of concrete is checked by slump test and compaction factor test. Workability is decreased as proportion of RCA is increased. Slump value and compaction factor value is decreased due to higher water absorption in case of RCA concrete. Table 4 gives the detailed comparison of slump values and compaction factor values.

Table 3: Slump value and Compation factor

Mix	w/c	Superplisticizer (%of cement)	Slump value(mm)	Compaction factor
Mo	0.38	0.6	42	0.842
m1	0.38	0.6	43	0.865
m2	0.38	0.6	40	0.843
m3	0.38	0.6	38	0.828
m4	0.38	0.6	40	0.826

1. Compressive strength : compressive strength checked at 7,28and 90 days. Concrete cubes of 150*150*150 mm^3 are prepared and compressive strength is checked at the end of 7,28and 90 days .
2. Flexural strength: flexural strength is checked at the end of 7,28 and 90 days. Concrete beams of 100*100*500 $mm^3$are prepared and strength is checked.

The strengths of recycled aggregate concrete is to be compared with strengths of natural aggregates concrete. After comparing these strengths, suitable proportion of recycled aggregates is to be selected to be used in concrete

IV. RESULTS

Compressive strength results are presented for each of the five coarse RCA contents in Figure 1. The results presented are based on the average results of three cubes. All test mixes reached the design strength by28-days. Most of mixes exceeded the target strength i.e 48.25MPa. Mix mo was taken as control mix whose compressive strength came out as 50.06 MPa . strength of all other four mixes is compared with this control mix. There is a slight fluctuation in compressive strength of various mixes. There is slight increase in strength from mo to m1. Then after there is slight decrease in strength from m1 to m3.then after the mix m4 showed a sudden increase in compressive strength. So the results of compressive strength do not followed a regular pattern. The compressive strengths at days and at 28 days do not vary at same ratio. The results of compressive strengths are shown in table 4.

Table 4: compressive and flexural strengths

mix	Slump (mm)	Compressive strength(MPa)		Flexural strength(MPa)	
		7 days	28 days	7 days	28 days
Mo	42	42.38	50.10	4.1	5.22
M1	43	42.47	50.40	4.21	5.62
M2	40	41.45	50.4	4.11	5.45
M3	38	42.8	49.10	4.19	5.28
M4	40	40.45	53.80	4.29	5.45

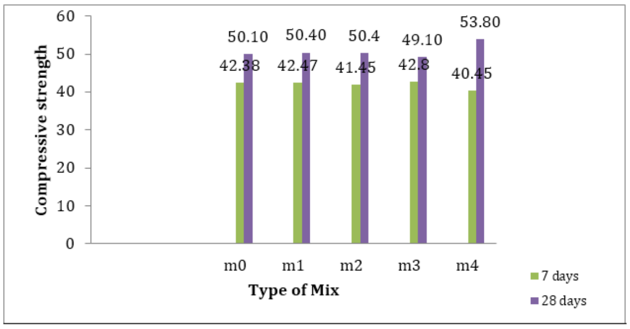

Figure 1

Flexural strengths results for each of five coarse RCA contents are presented in figure 2. The results presented are results of single beam of mix. Flexural strength also followed the pattern of compressive strength. It does not increased or decreased in a uniform manner. At 7 days, it is the mix m1 which exceeded the strength of control mix m0. All other mixes had slightly less flexural strength than control mix. At 28 days, flexural strength of all the mixes with RCA exceeded slightly the flexural strength of control mix m0. The results of flexural strengths are shown in table 4 along with slump value and compressive strength. Figure 2 shows a comparison of flexural strength at 7 days and 28 days for different mixes.

VII. CONCLUSION

This study examined the compressive and flexural strengths of RCA concrete at 7 and 28 days and compared the strength with control mix with natural aggregates. The strengths showed a very less fluctuation between the mixes.

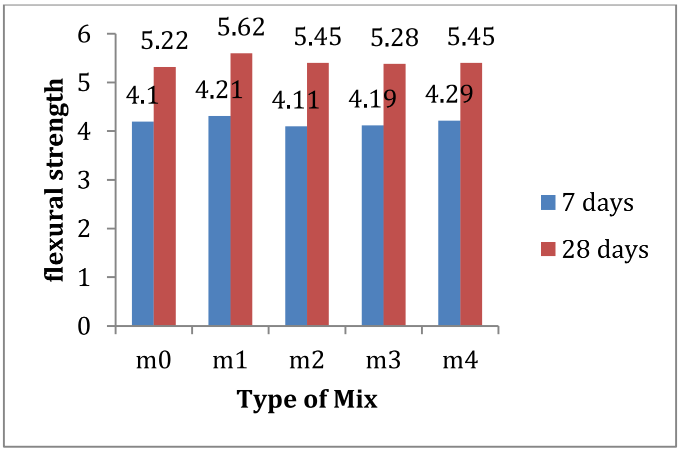

Figure 2

The compressive strengths of all mixes exceeded the target strengths at 28 days. The compressive strength was maximum in case of m4 i.e 40%RCA and 60% natural coarse aggregates. All four of the coarse RCA mixes showed increases in strength compared to the conventional concrete . Same was followed in case of flexural strength. It indicated that RCA can be a good and viable source for concrete pavements.

V.RECOMMENDATIONS

Consistent and predictable results need to be obtained for RCA to use as raw material for concrete pavements. Further study is required in the cases of aggregate properties, mixture design and proportioning, performance, testing, and modeling. It is to be examined that how much deleterious material that can be included without affecting the performance of the concrete. RCA concrete from different sources is to be compared for better results Comparing concrete mixes with different sources of RCA including sources of RCA that are clean, contaminated, and cured differently. RCA concrete mixes are to compared to get the maximum amount of RCA that can be used to have best results.

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