Experimental Case Study of Recycled Aggregate Concrete Using Bituminous Pavement Wastes

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Abstract:- *In general, aggregate make up 60-75% of concrete volume, so their selection is important, also they control concrete properties. Aggregate provide strength and wear resistance in these applications. Hence, the selection and proportioning of aggregate should be given careful attention. The aggregate is generally coarse gravel or crushed rocks such as limestone, or granite, along with a fine aggregate such as sand or stone dust. Bulk of pavement structure is formed by aggregate. This paper presents a review on the use of bituminous pavement wastes in cement concrete. This will help in achieving economy in road construction as well as saving environmental degradation in term of reduced mining and less pollution.*

Key Words: **Aggregate, Wear Resistance, Crushed Rocks, Pavement, Degradation**

1. INTRODUCTION

Concrete is a composite construction material composed primarily of aggregate, cement and water, In general, aggregate make up 60%-75% of total concrete volume, so their selection is important, also they control concrete properties, Aggregate provide bulk, strength and wear resistance in these application. Hence, the selection and proportioning of aggregate should be given careful attention. The aggregate is generally coarse gravel or crushed rocks such as limestone, or granite, along with a fine aggregate such as sand or stone dust. Bulk of pavement structure is formed by aggregate.

Recycled asphalt pavement (RAP) is the removed and reprocessed pavement material containing asphalt and aggregate. The use of recycled asphalt pavement has become a common practice in the construction of new and reconstruction of new, and reconstruction of old, hot mix asphalt pavements. But little research has been done to examine to potential of incorporating RAP into cement concrete. In the present study, the physical and mechanical properties of cement concrete comprising of RAP, in different proportions, are investigated through laboratory experiments. Recycled asphalt pavement used in the present study is obtained from the debris of dismantled asphalt road

1.1 Importance of Study

The topic "Use of bituminous pavement waste in cement concrete" has been selected for the present study to examine the physical and the mechanical properties of RAP incorporated in cement concrete.

The aim of this project is to determine the strength characteristic of RAP for application in high strength concrete, which will give a better understanding on the properties of concrete with RAP as an alternative material to fresh coarse aggregate in concrete. This will help in achieving economy in road construction as well as saving environmental degradation in term of reduced mining and less pollution. Use of RAP will also conserves resources, landfill space and will generate profit for the recyclers.

2. OBJECTIVE OF STUDY

The primary goal of this project is to develop and characterize an environment friendly concrete suitable for transportation-related applications. The objectives of the study include:

1. Collection of study material.
2. To study the various properties of selected material like specific gravity, water absorption, crushing value, impact value and gradation to determine the suitability for high strength concrete.
3. Mix Design of M30 grade cement concrete based on IS code and IRC: 44-2008.
4. Check for compressive strength as well as flexural strength.
5. Comparison study between the followings:

   i. RAP aggregate and fresh coarse aggregate.

   ii. Fresh aggregate concrete and recycled asphalt

   Pavement concrete

3. SCOPE OF THE STUDY

In this project, the mix design of M30 grade of cement concrete is developed at water cement ratio 0.45 using virgin coarse aggregate (CA). In order to study the potential of RAP in the mix design of M30 grade cement concrete, different percentage of RAP aggregate are used in mix with coarse aggregate and their corresponding compressive and flexural strength are studied. A total of five batches are considered in which the percentage of RAP and fresh coarse aggregate are as follows:

1. 0% RAP and 100%CA
2. 25% RAP and75% CA

3 50% RAP and 50% CA

4. 75% RAP and 25% CA

5. 100% and 0% CA

Water cement ratio in total of five batches of concrete mix has kept constant as 0.45.

4. LITERATURE REVIEW

Mashed Delwar et al. (1997)

According to this research paper, the author investigated the use of combinations of coarse and fine RAP aggregate in normal concrete mixes and compared the results of compressive strength to conventional mixes with 0.4 and 0.5 water cement ratios. Compressive strength values were found to decrease with the increase in RAP content.

Baoshan Huang, et al (2005)

According to this research paper, the author found that RAP could be incorporated into Portland cement concrete without any modification to tube conventional equipment or procedures. Without any treatment, there was a systematic reduction in compressive and split tensile strength with the incorporation RAP in concrete.

Salim Al-oaimi, et a1. (2007)

According to this research paper, the author used RAP as a coarse aggregate, substitute in two different normal Concrete mixes having 28 days cube compressive strengths of 33 and 50 MPa. RAP was used with 25, 50, 75,100% replacement of coarse aggregate. According to test result, the slump decreased with the increase RAP content .The compressive and flexural strength decreased with the increase in RAP content. The surface absorption was not significantly affected by the addition of RAP the result indicated the viability of RAP as an aggregate in non-structural concrete applications.

5. RESEARCH METHODOLOGY

Methodology of the study for the present research work describe the procurement of the material and to carry out different test as per IS codes and ASTM 2172.

A series of test were conducted on fresh aggregate and recycled asphalt pavement,

Test on Fresh Coarse Aggregate

(1) Gradation

(2) Specific gravity

(3) Water absorption

(4) Aggregate crushing value

(5) Aggregate impact value

Test on Recycled Asphalt Pavement

(1) Gradation

(2) Specific gravity

(3) Water absorption

(4) Aggregate crushing value

(5) Aggregate impact value

(6) Bitumen content

Test on Fine Aggregate

(1) Gradation

(2) Specific gravity

(3) Water absorption

Two groups of concrete mixes, fresh aggregate concrete (FAC) and recycled asphalt pavement concrete (RAPC) are prepared using fresh sand. Fresh aggregate concrete are produced by using fully fresh coarse aggregate in concrete mix. Whereas in recycled asphalt pavement concrete mixes are prepared by using recycled asphalt pavement aggregate as partially or fully replacement of fresh coarse aggregate. These mixes are designed according to IS code and IRC 44-2008. These combination of concrete mixes here after are called as mix A mix B mix C, mix D and mix E as shown in tables below, shows the quantities variation amount these mixes

Table 1:- Series of Mix Proportion

Mix	Series	Natural Aggregate	Recycled Asphalt Aggregate (%)
A	RAP00	100	0
B	RAP25	75	25
C	RAP50	50	50
D	RAP75	25	75
E	RAP100	0	100

6. FINDINGS OF THE STUDY

A series of tests are conducted in the laboratory for evaluation of various properties of material, relevant for the study. All test have been conducted as per the guidelines of IS codes and ASTM 2172 recommendation. Test results are summarized in tabular form

Table 2:- Result of Specific Gravity and Water and Water Absorption Test on coarse Aggregate and Rap (Size B/W 20mm to 4.75 mm)

Weight of sand	0.5 kg
Weight of pycnometer or gas jar containing sand and filled with water	1.932 kg
Weigh of pycnometer or gas jar filled with water only	1.613 kg
Weigh of oven dried sand	0.491 kg
Specific gravity	2.71 kg
Apparent specific gravity	2.85
Water absorption (percent of dry weight)	1.83%

Table 3:- Result Specific Gravity and Water Absorption Test on Fine Aggregate

Sample	10 mm	20 mm	RAP
Weight of the aggregate	1 Kg	1 Kg	1 Kg
Weight of the aggregate in water	0.630 kg	1.002 kg	1.003 kg
The weight of the aggregate in air after the aggregate is immersed in water for a period of 24 hours and then wiped by dry cloth	1.003 kg	1.002 kg	1.003 kg
The weight of the aggregate after, the aggregate is placed in oven dry for a period of 2 hours at temperature 100 to 110. C	0.998 kg	0.997 kg	0.990 kg
Specific gravity	2.68	2.69	2.456
Apparent specific gravity	2.712	2.724	2.554
Water absorption (percent of dry weight)	0.5 %	0.5 %	1.3%

Table 4:- Result of Aggregate Impact Value Test on Coarse Aggregate (20mm) and RAP

Sample	Coarse aggregate (20mm)	RAP
Weight of the aggregate	0.374 kg	0.342 kg
Weight of the aggregate retained on sieve 2.36 mm after hammering the sample by 15 blows	0.33 kg	0.288 kg
Weight of the aggregate fraction passing the appropriate IS sieve 2.36 mm	0.044 kg	0.054 kg
Aggregate impact value(Percent of dry weight)	11.76%	15.79%

Table 5:- Result of Aggregate Crushing Value Test on Coarse Aggregate (20mm) and RAP

Sample	Coarse Aggregate	RAP
Weight of the aggregate	kg	2.534 kg
Weight of the aggregates ration on IS sieve 2.36 mm after place In compression testing machine	2.255 kg	2.094kg
Weight of the aggregate fraction asking the appropriate is sieve 2.36 mm	0.465k g	0.44 kg
Aggregate crushing value (percent of dry weight)	17.09%	17.36

Table 6:- Result of Bitumen Content test on Recycled Asphalt Pavement (Size Lies B/W 20 to 4.75mm) and RAP (Size below 4.75mm)

Sample	RAP (size lies b/w 20 to 4.75mm)	RAP (size below 4.75mm)
Weight of sample (RAP) place in centrifuge extractor	200gm	200gm
Weight of the extracted sample (RAP)	196gm	190gm
Bitumen content (percent of extracted sample)	2.04%	5.263%

7. RESULTS AND CONCLUSIONS

Test results of compressive strength of beam and flexural tensile strength of beam are presented in tabular form below:-

Table7:- Summary of compressive strength of different Mixes after 7 and 28 days

	Mix design	Compressive strength after 7 days and 28 days(N/mm2)		Percentage variation with respect to average compressive strength after 28 days curing
		Average compressive strength after 7 days curing	Average compressive strength after 28 days curing	
1	Mix A (0% RAP)	26.95	38.36	70.25%
2	Mix B (25% RAP)	24.14	35.70	67.62%
3	Mix C (50% RAP)	17.03	31.42	54.20%
4	Mix D (75% RAP)	16.60	29.19	56.89%
5	Mix E (100% RAP)	16.30	25.78	63.23%

Table 8:- Results of Flexural tensile strength test on concrete Beam

S. No.	Mix design	Weight of concrete cube (Kg)	Compressive strength after 7 days (N/mm²)		Percentage variation with respect to mix design Mix M30
			Individual specimen	Average of three cubes	
1	Mix A (0% RAP)	12.10	6.953	6.32	-
2		11.80	6.008		
3		11.90	6.008		
4	Mix B (25% RAP)	11.75	5.636	6.06	4.12%
5		12.00	6.548		
6		11.80	6.008		
7	Mix C (50% RAP)	11.65	5.936	5.80	8.23%
8		11.90	6.548		
9		11.50	4.928		
10	Mix D (75% RAP)	12.00	4.928	5.12	18.98%
11		11.50	4.928		
12		11.75	5.498		
13	Mix E (100% RAP)	11.90	5.143	4.48	29.11%
14		11.70	4.928		
15		11.40	3.375		

CONCLUSIONS:-

Based on the test results, the following conclusions are drawn:

Based on the Properties of aggregates

1. Presently RAP aggregate is treated as waste material and is economical than fresh aggregate. Therefore concrete made up of RAP aggregate will natural be economical.

2. It is observed that specific gravity of fresh aggregate is in the range of 2.69 to 2.68 and that of RAP is 2.49, which is less than 8.2% than fresh aggregate.

3. It is observed that the water absorption of fresh aggregate is 0.5 and that of RAP is 1.3. This indicates that the workability of concrete mix will reduce at

same water cement ratio, as the percentage of RAP aggregate in cement concrete increases.

4. It is observed that the gradation of recycled asphalt pavement aggregate satisfied the desired graduation requirement specified by IS code: 383-1970. This means that fresh coarse aggregate of size 20mm and 10mm can be partially/fully replaced by recycled asphalt pavement aggregate.

5. It is observed that the crushing value of RAP and fresh aggregate are 17.36% and 17.09% respectively. Indicating in no significant difference between the two.

6. It is also observed that the value of all the properties of RAP aggregate except bitumen content, does not exceed to the permissible limits for mix designs specified by IS code: 383-1970. Thus the recycled asphalt pavement aggregate used in present study is suitable for concrete mix designs.

Based on the Compressive strength of concrete

7. It is observed that the compressive strength of the recycled asphalt pavement concrete mixes i.e. mix B, mix C, mix D, and mix E as compare to fresh concrete mix M30 (mix A), after 7day, is laser by 10.4%, 36.8%, 38.4% and 39.5% respectively. This indicates that there is a gradually reduction in the compressive strength of concrete mix (M30) (after 7 days) as percentage of RAP content increase. It is also found that the minimum compressive strength of the concrete mix (M30) made of a RAP aggregate after 7 days is approximately 60% to that of the fresh aggregate concrete mix (M30).

8. It is observed that the compressive strength of recycled asphalt pavement concrete mixes I.e. mix B, mix C, mix D, and mix E as compare to fresh concrete mix M30 (mix A), after 28 days is lesser by 6.9%, 18.1%,23.9% and 32.8% respectively. This indicates that there is a gradually reduction in the compressive strength of concrete mix (M30) (after 28 days) as percentage of RAP content increases. It is also found that the minimum compressive strength of the concrete mix (M30) made up of RAP aggregate after 28 days is approximately 67% to that of the fresh concrete mix (M30).

9. It is observed that mixing of RAP reduces the rate of gain of compressive strength as compared to fresh aggregate.

Based on the flexural strength of concrete

10. It is observed that the flexural tensile strength of recycled asphalt pavement concrete mixes i.e. mix B, mix C, mix D and mix E as compare to fresh concrete mix M30 (mix A), after 28 days is lesser by 4.1%, 8.2%, 19.0% and 29.1% respectively. This indicates that there is a gradual reduction in the flexural tensile strength of concrete mix (M30) after 28 days as percentage of RAP content increases. It is found that the minimum flexural strength of the concrete mix (M30) made up of RAP aggregate after 28 days is approximately 70% to that of the fresh concrete mix (M30).

11. From the results it is observed that inclusion of RAP affects the compressive strength more than the flexural strength.

Hence, at locations where low strength of concrete is required, the recycled asphalt pavement aggregate may be used as an alternative material for fresh coarse aggregate.

8. REFERENCES

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