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ENHANCING CONCRETE PAVEMENTS WITH RECLAIMED ASPHALT PAVEMENT AGGREGATES: STRENGTH AND DURABILITY ANALYSIS

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ABSTRACT

Concrete remains the fundamental material in construction, with coarse aggregates comprising more than 50% of the mix. However, the depletion of natural aggregate sources and environmental concerns have made their procurement increasingly difficult. To address this challenge, Reclaimed Asphalt Pavement (RAP) aggregates have emerged as a viable alternative. RAP aggregates are widely available due to the replacement of flexible pavements with rigid pavements in India. Their incorporation in concrete mixtures not only reduces reliance on natural aggregates but also promotes efficient waste utilization, making them an economical and environmentally responsible choice. This study examines the effects of RAP aggregates on the strength and durability of concrete pavements. The primary objective is to evaluate variations in compressive and flexural strength when RAP aggregates partially replace natural aggregates in different proportions. Concrete cubes and beams are cast and tested, with RAP replacements set at 10%, 20%, 30%, 40%, and 50%. The RAP aggregates used in this research are sourced from the transportation laboratory of the college. The experimental results highlight the potential of RAP aggregates in pavement construction. The findings indicate that up to an optimal replacement level, RAP-incorporated concrete maintains satisfactory mechanical properties. However, beyond a certain percentage, a reduction in strength is observed due to the aged and processed nature of RAP materials. Despite this, RAP-modified concrete remains structurally stable, making it a feasible alternative for pavement applications, particularly in low to medium traffic roads where durability requirements are moderate. The use of RAP aggregates offers multiple advantages, including cost reduction, conservation of natural resources, and minimizing environmental impact. Additionally, it helps in addressing the growing problem of asphalt waste disposal by repurposing it effectively. This study underscores the importance of optimizing RAP content to ensure a balance between structural performance and environmental benefits. Future research could focus on assessing the long-term durability of RAP-based concrete under real-world conditions, including exposure to traffic loads and weathering effects.

Keywords: Reclaimed Asphalt Pavement (RAP), Flexural Strength, Waste Utilization, Construction Materials

1. INTRODUCTION

Now a days the importance of the pavement and its maintenance has been rapidly increasing due to the globalization and industrialization. But the increasing demand is not been met with the supply in an efficient manner due to the non sustainability of the resources. In India the network of roads is managed by the various government agencies under “Ministry of Road Transport and Highways”

(MORTH). India's road network is gigantic and said to be only after the United States of America. But one of the striking underlying facts is the condition of the roads. It has been the case since 30 years. Most of the roads were designed as single lane and quality of construction was also poor due to lack of supervision. The traffic volumes on the primary road system have seen tremendous increases over the last 20 years, leading to earlier-than-expected failures of highway pavements. The distressed pavements are left unmanaged and there is a need to rehabilitate the roads by using the environmental sustainable techniques so as to develop it for future generations. The rehabilitation techniques can be developed by studying the types of distresses, material conditions and environment conditions.

The Recycling of existing bituminous mixes are the only alternatives, through the reuse of aggregates and bitumen. Pavement rehabilitation is a logical and practical way to conserve our diminishing supply of construction materials and to help reduce the cost of preserving our existing pavement network.

3. LITERATURE SURVEY

Delwar, Fahmy and Taha (1997) of the University of Washington and Sultan Qaboos University performed one of the first studies on this “green” concrete in 1997. The main goals of their research entailed an investigation on the feasibility of using RAP as aggregate in Portland cement concrete (PCC), and the determination of key material properties and characteristics of the alternative material. RAP millings for use in the concrete test mixtures were obtained from an asphalt producer in Spokane, Washington. The research team processed the material through a set of sieves, removing any aggregate larger than ¾-inch and fractionating the material on the No. 4 sieve. Standard concrete sand and gravel, as well as type I/II cement were purchased from a company in Moscow for use in the study. Mixes containing 10 different aggregate arrangements with two different water &cement (w/c) ratios were tested for compressive strength and stress-strain characteristics. Data on the slump, air content, and unit weight of the wet concrete were also recorded.

Huang, Shu, and Li (2005) of the University of Tennessee and Louisiana State University expanded the available information on concrete containing RAP with their work in 2005. The objective of their study was to further research the effect of the inclusion of RAP aggregates on the toughness and brittle failure behavior of Portland cement concrete. The study hypothesized that the fine layer of asphalt coating the individual pieces of aggregate protects the particles from breakage and facilitates the increased dissipation of energy in the event of a crack.

Huang and Shu (2005) performed additional testing on specimens that included admixtures to help improve the performance of the material (Huang, Shu, & Li, 2005). Both silica fume and a high-range water reducing agent (HRWRA) were added to help reduce the loss of strength accrued by the use of the RAP aggregate. As in prior studies, several mix designs using different percentages of

coarse and/or fine RAP aggregate (10, 30, 50, or 100 percent by weight) were used as a replacement for virgin aggregate.

Hossiney (2008) from the University of Florida worked with the Florida Department of Transportation (FDOT) to study the performance of RAP concrete used in a rigid pavement application. In their study, four concrete mixtures containing reclaimed asphalt pavement were evaluated in a laboratory setting. The tested material properties were then used to create a finite element model to assess how the concretes would behave as a pavement under typical Florida roadway conditions. The natural aggregate for the mixing experiment consisted of a porous limestone coarse rock and a standard silica sand fine material. The mixtures evaluated in the study included mix designs containing 0, 10, 20, and 40 percent RAP aggregate. Laboratory test results indicated that the compressive strength, splitting tensile strength, flexural strength, and elastic modulus of the hardened material were inversely related to the amount of RAP in the mix; these material properties all decreased as the RAP replacement rate was increased.

3. PROPOSED SYSTEM

3.1 Objective

The objective of the project deals with the identification of the distressed pavement and developing the rehabilitation technique utilizing RAP material so that the fatigue life of the road increases in an economic way. The methodology involved in the achievement of this objective is

i) To develop mix design methodology for mix 20 MPa
ii) To study the effect of adding different percentages (0% - 50%) of RAP Aggregates by the weight of fine and coarse aggregates in the preparation of concrete mix.
iii) To determine the workability of freshly prepared concrete by Slump test & compaction factor test.
iv) To determine the compressive strength of cubes at 7, 14, 28 days.
v) To determine the Flexural strength of beams at 28 days.

3.2 Methodology

1. Collect the RAP wastage and dry it.
2. Extract the aggregates and bitumen from RAP. Clean the aggregate thoroughly and oven dry it. Perform the sieve analysis on RAP aggregate.
3. Physical properties of cement, fine aggregate, coarse aggregate and RAP aggregate.
4. Find out the mix design M20 grade of concrete. The concrete, coarse aggregate is replaced with RAP aggregate with various percentages 0%, 10%, 20%, 30%, 40% & 50%.
5. Preparation of Concrete cubes and beams based on mix proportions. Find out the Compressive strength for cubes and flexural strength for beams.
6. Results & discussions

3.3 Laboratory Tests on RAP

Bitumen is a mixture of organic liquids that is black, highly viscous, sticky product used for paving roads, waterproofing products (used in sealing roofs). There are many tests which are conducted to check the quality of bitumen. Bitumen is very important component of many construction sites like

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roads, highways. To check the properties of the RAP sample collected, many tests are conducted to ensure the quality of bitumen such as Binder Content, Gradation.

4. RESULTS AND DISCUSSIONS

The results obtained are shown below in tabular form

4.1 Compressive Strength of Concrete (in N/mm^2)

The 7, 14, 28 days compressive strength was studied and the values of 3 samples studied are shown in the tabular form. Table 5.1 shows the data of 7, 14, 28 days compressive strength obtained. Below tables gives the 7, 14, 28 days compressive strength of concrete with maximum nominal size of aggregates 20mm.

Table : 4.1 Compressive strength of concrete

RAP (%)	Avg Compressive strength (N/mm2)		
	7days	14days	28days
0	14.6	19.6	23.1
10	15.3	20.2	24.2
20	16.3	22.43	25.7
30	14.3	19.45	22.9
40	13.78	18.91	22.3
50	13.1	18.5	20.4

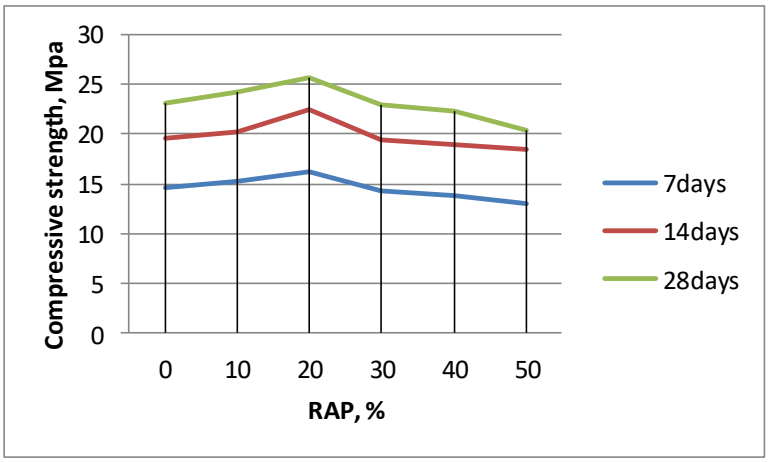

Figure 4.1 Effect of RAP on 7, 14 and 28 days compressive strength

4.2 Flexural Strength Test

The Flexural test was performed on the beams of size 50 x 10 x 10 cm to check the flexural strength of the concrete and the results obtained while performing the flexural test on UTM are given in

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Table 4.2. The beam specimens were tested on universal testing machine for two-point loading to create a pure bending. The bearing surface of machine was wiped off clean and sand or other material is removed from the surface of the specimen. The two point bending load applied was increased continuously at a constant rate until the specimen breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. The modulus of rupture depends on where the specimen breaks along the span. Beam dimensions are 500mm×100mm×100mm. if the specimen breaks at the middle third of the span then the modulus of rupture is given by

$$f_{rup} = \frac{Pl}{bd^2}$$

Where; P = load,

d = depth of the beam,

b = width of the beam

Table 4.2: Result of flexural strength

S.No	% of RAP	Flexural Strength for 28 days (N/mm^2)
1	0	2.12
2	10	2.32
3	20	2.4
4	30	2.05
5	40	1.87
6	50	1.74

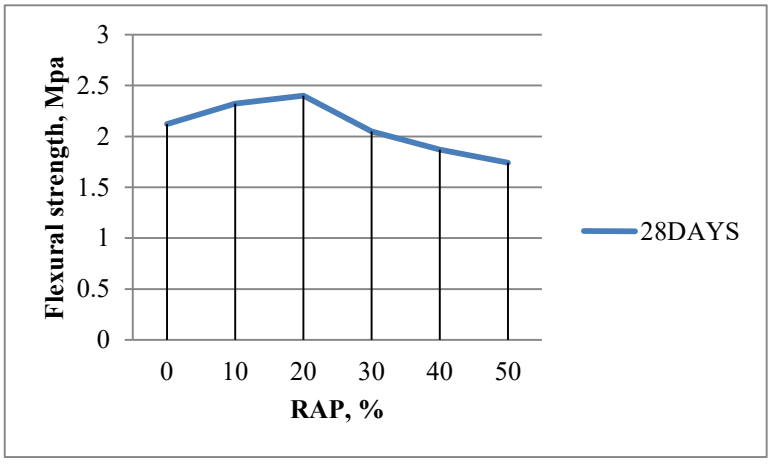

Fig 4.2: Flexural strength v/s % of MSWA

4.3 Workability of concrete (Slump cone test)

Table 4.3: Result of slump test

S. No	% of RAP	Slump (mm)
1	0	90
2	10	94
3	20	97
4	30	100
5	40	102
6	50	105

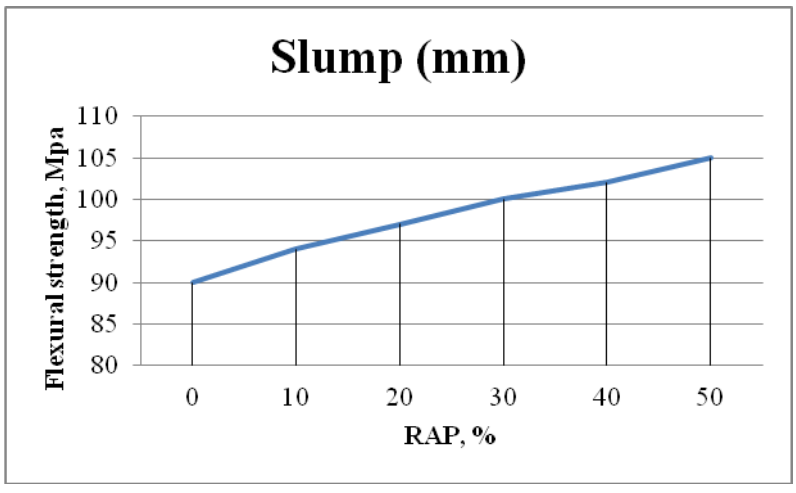

Fig 4.3 : Slump test results

The above figure shows the slump results. It was observed that, the slumps increases as the RAP content were increased in the mix.

5. CONCLUSIONS

The findings of this study highlight the potential of Reclaimed Asphalt Pavement (RAP) aggregates as a viable alternative to natural aggregates in concrete pavement construction. The results indicate

that replacing natural aggregates with 20% RAP yields the highest compressive strength among all tested replacement levels, even surpassing the strength of conventional concrete. However, when evaluating flexural strength, the normal concrete mix demonstrates the highest values compared to RAP-incorporated mixes. Despite this, the 20% RAP replacement mix exhibits flexural strength very close to that of the control mix, making it a promising alternative for practical applications. Beyond strength characteristics, several additional benefits support the use of RAP in concrete pavement construction. One major advantage is the cost-effectiveness of utilizing RAP aggregates, as they can be directly sourced from demolished flexible pavements, reducing transportation expenses and dependency on newly mined natural aggregates. This approach not only conserves natural resources but also mitigates the increasing demand for aggregates in road construction. Furthermore, incorporating RAP aggregates plays a significant role in reducing environmental degradation. The excessive extraction of natural aggregates from quarries leads to ecosystem imbalances, habitat destruction, and increased pollution. By repurposing RAP, the burden on natural resources is alleviated, contributing to sustainable construction practices and waste management solutions.

REFERENCES

[1] International Journal of scientific research and management (IJSRM) ||Volume||2||Issue||8||Pages||1271 1278||2014||Website: www.ijsrm.in ISSN (e): 2321- 3418

[2] Delwar, M., Fahmy, M., &Taha, R. (1997),Use of Reclaimed Asphalt Pavement as an Aggregatein Portland Cement Concrete. ACI Materials Journal (May - June 1997), 251-256.

[3] Huang, B., Shu, X., & Li, G. (2005), Laboratory Investigation of Portland Cement Concrete Containing Recycled Asphalt Pavements. Cement and Concrete Research , 2008-2013.

[4] Huang, B., &Shu, X. (2005),Experimental Study on Properties of Portland Cement Concrete Containing Recycled Asphalt Pavements. Innovations for Concrete Pavement: Technology Transfer for the Next Generation (pp. 485-499). Colorado Springs: International Society for Concrete Pavements.

[5] Hossiney, N. J. (2008), Evaluation of Concrete Containing RAP for use in Concrete Pavement,Civil Engineering, Gainesville: University of Florida.

[6] Concrete Technology (Theory and Practices) by M.S. SHETTY. S.Chand& Company Pvt.LtdPublications.

[7] Highway Engineering by S.K.Khanna and C.E.G.Justo, Nem Chand & Bros, Roorkee,U.K.,India (Ninth Edition 2011).

[8] Principles and Practices of Highway Engineering – by Dr. L R Kadyali, Dr. N B Lal. [9] IRC: 15-2011, Standard Specifications and code of practice for Construction ofConcrete Roads, 4 thRevision, Indian Roads Congress, New Delhi.

[10] IRC: 44-2011, Guidelines for cement concrete mix design for pavements, IndianRoads Congress, New Delhi.

[11] IS: 10262-2009, Indian Standard CONCRETE MIX PROPORTIONING –GUIDELINE (First Revision)