"A Comparative Study on Stability of Hot and Cold Bituminous Mix prepared using Rap Aggregates and Concrete Waste "

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***Abstract*- In light of this, it is necessary to elevate the road levels at the entrances to these structures, rendering the current pavement materials unnecessary. In order to build a new road, a layer of the current bitumen pavement must first be removed from the existing road. This process occurs on a massive scale every year. It may benefit the environment and the building industry economically and environmentally to use a binding material like reclaimed asphalt pavement to replace some natural aggregates. Additionally, it has become a significant issue to dispose of aggregates and other binder materials because they are often burned, which pollutes the environment. Waste aggregates are used in bituminous mixes, and it has been shown in several studies that these aggregates improve the mix's characteristics as well as address disposal issues. Asphalt's viscoelastic nature means that seasonal changes in temperature and the type of loading they undergo have a big impact on how it behaves. Due to the behaviour of the asphalt binder, there are many different forms of flexible pavement failure and distress, the most prevalent of which are rutting and fatigue cracks. The purpose of the current study is to determine whether these reclaimed asphalt pavement (RAP) materials, also known as redundant pavement materials, are appropriate as potential subbase or base course materials for flexible pavement. Various laboratory experiments will be conducted to analyse the materials' strength and durability factors, and the outcomes of hot and cold bituminous mixes with waste concrete will be compared. Reviewing the experience with RAP throughout the world, identifying common implementation problems, and developing strategies to guarantee a thorough approach to RAP use are all goals of this article.**

***Keywords*—Cold Mix, Hot Mix, RAP, Stability Test, Bitumen, Aggregates.**

INTRODUCTION

The nation's garbage generation is expanding dramatically as a result of the fast urbanisation and population growth. Municipal garbage is now being dumped in landfills since there isn't a strong recycling programme in place, which has an impact on the environment and human health (Sabale and Jose 2022). Using it in the construction of roads and other infrastructure is the most promising option to recycle a portion of this trash, which consists of HDPE, LDPE, and crumb rubber. Contrarily, the majority of flexible pavements collapse before their expected lifespans due to the Kingdom's extreme temperatures, high traffic volumes, and unaltered usage of standard grade bitumen (PG 64-10). In order to recycle this specific form of municipal trash and find ways to change conventional binder from PG 64-10 to higher grades, this research was conducted (Sabale et al. 2023b). The use of these wastes again in various ways has been the subject of several investigations. Transport infrastructure is necessary for the country's economic and social growth (Sabale and Jose 2023). Any nation's transport sector development is closely related to the expansion of its economy. Significant funding has been allocated to the road system to improve the highway system.

According to the Ministry of Transportation in 2013, collaboration between industry, government, and academia is the key to solving the global issue of maintaining appropriate roads. The best available technology (BAT) should be used in road building and asphalt paving maintenance, and the government is in charge of maintaining the most recent regulatory framework.

As a result of their involvement in investments and task execution, business structures help make new technology usable in daily life. The scientific community participates in the advancement of technology and helps the road construction sector expand in an inventive way. The goal of developing new technologies has always been to make them more cost-effective, but recently, environmental concerns have also been taken into account along with economic ones. An example of this is the need to lessen the adverse effects of material production and construction on the environment. Due to several environmental and financial advantages, the use of waste materials in pavement combinations, such as recovered asphalt pavement (RAP), has increased (Sabale et al. 2023a). The benefits of permitting bigger percentages of RAP on the pavement while still upholding the best performance requirements in order to fulfil the rising demands and regulations are continually being evaluated by practitioners throughout the world. The maximum quantity of RAP that may be used in surface layers, certain combination types, and occasionally major or crucial projects has been restricted by several transportation authorities and departments. Initially, less than 15 percent of RAP was often employed in surface layers since there were no clear economic benefits to employing more RAP.

Using a higher percentage of RAP once more became a priority as a result of the substantial rise in asphalt binder costs in 2006 and 2008 as well as the resulting decrease in supply. The binder found in RAP has often aged naturally over years, becoming harder as it does. A modified mix that may also be tougher is produced as a result of adding this old binder to virgin HMA material. This raises serious worries about fatigue cracking and moisture damage performance even though it could improve other performance characteristics, such rutting resistance. Regarding the quantity of RAP binder mobilised at a mixing plant or during the mix design process, there are additional worries regarding RAP mixture design. For conventional asphalt mixtures, complete mobilisation and blending are thought to be unlikely, but it is now understood that a significant amount of mixing does take place. RAP mixes function as a combination of virgin and RAP binders.

Because of these restrictions, bitumen modifiers such rejuvenators and antistripping additives are needed to enhance their rheological characteristics and offer a more consistent performance. Numerous of these commonly employed modifiers are polymeric in nature, and it is well known that adding them to RAP mixtures improves their rheological characteristics. The major goal of this study is to create polymeric additives by incorporating waste plastic into the bituminous mixture comprising RAP and to create reclaimed asphalt pavement (RAP) that replaces natural aggregates and bitumen in building projects that are environmentally friendly. The test results will serve as guides for the required qualities of the materials as they will show various replacement levels of bitumen with waste plastic and natural aggregates with reclaimed asphalt pavement.

Any asphalt-paved road is asphalt pavement. Stone, sand, or gravel make up 95% of Hot Mix Asphalt (HMA), which is held together by asphalt cement made from crude oil. HMA facilities heat aggregate and mix asphalt cement with it. Hot Mix Asphalt is trucked to the paving site. Paving machines' front hoppers receive Hot Mix Asphalt from lorries. After placing the asphalt, a heavy roller compacts it. After the pavement cools, traffic is allowed.

Cold Mix Bitumen

A cold mixture of Mineral aggregate, water, and a binder are the three components that go into making bitumen emulsion. It is typically delivered to customers in bulk packaging or a polybag for the purposes of making transportation and application as efficient as possible. In contrast to hot asphalt, which requires heat for the application process, this product, which is referred to as "cold mix," does not require heat.

Problem Statement

Development of a Bituminous Mix Prepared using RAP aggregates with waste concrete for sustainable construction purposes due to scarcity of natural Aggregates and for economical road construction, results of the test will give guidelines for desired properties of materials stability. As well as to check the Stability of Hot and Cold Bituminous Mix.

Objectives

- To determine the properties of the material used in the bituminous mix.
- To study the effect of Reclaimed Asphalt Pavement on properties of bituminous mix by conducting different laboratory tests on prepared specimens, it is intended to analyses the result.
- To check the stability of bituminous mix after adding waste concrete.
- To compare RAP bituminous mix (Hot and Cold) with the bituminous mix partially replaced by waste concrete.

LITERATURE REVIEW

- **M.T. Tiza, O.N. Mogbo , E.C. Duweni, J.I. Asawa.** "Recycled Asphalt pavement".Journal of Modern Technology and Engineering Vol5,No.3,2020,pp.242-254. The use of infrastructural and industrial wastes has gained attention in every day civil engineering practice. The incorporation of these wastes into civil engineering projects are significantly promoting sustainability in the industry. The fast depletion of natural resources used in the construction of highways will reduce if the construction of highway pavements and other civil engineering structures take advantage of wastes with good engineering properties. This review paper aims to build an insight into the interaction between new and aged asphalt binders in Reclaimed Asphalt Pavement(RAP). The research discusses the review of different properties of asphalt when Reclaimed Asphalt Pavement(RAP) is incorporated as aggregates and also compares the result with the use of natural aggregate. The literature review shows that stability, stiffness, workability, durability, resistance to moisture damage, and fatigue resistance are all affected by gradation.

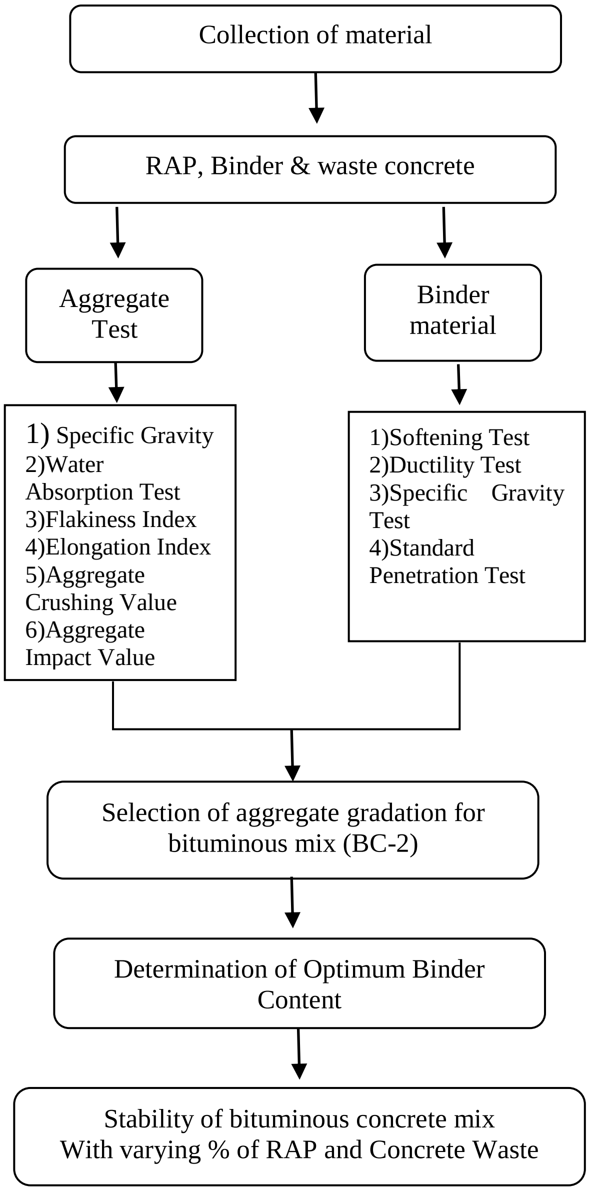
- **Imad L. Al-Qadi, Mostafa Elseifi, Samuel H. Carpenter.**

"Reclaimed Asphalt Pavement ". Civil Engineering Studies Illinois Center for Transportation Series No. 07-001 UILU- ENG-2007-2014 ISSN: 0197-9191. The state of Illinois has been recycling Reclaimed Asphalt Pavement (RAP) material into hot-mix asphalt (HMA) since 1980, there continue to be questions regarding the correct approach to design HMA with RAP. The Illinois Department of Transportation's current method of RAP HMA design provides 100% contribution for the residual asphalt binder from the RAP based on solvent extractions. This means that the amount of virgin asphalt binder is reduced by the full amount of asphalt binder in the RAP for the percentage specified. This has recently been reported to be inaccurate and could result in an erroneous HMA job mix formula and may cause dry HMA. Hence, the HMA may become vulnerable to durability cracking and premature failure. The objective of this research project is to develop an understanding of the interaction between aged and virgin asphalt binders in RAP. Based on this understanding, this study will determine the appropriate level of contribution that should be given to the residual asphalt binder in RAP. The level of interaction between aged and virgin binders will then be used to investigate the influence on the performance and durability of the mixtures as compared to virgin HMA.

- **Gregory J. Schaertl and Tuncer B. Edil.** "Literature Search and Report On Recycled Asphalt Pavement" University of Wisconsin- Madison March 18, 2009. Several important findings were noted in the course of this literature review. Kim et al compared the compaction properties of specimens prepared by typical proctor methods with specimens prepared with a gyratory compactor and found that the OMC and MDD of the specimens compacted via gyratory compactor were found to more closely correlate with field density measurements. Kim also found that at low confining pressures, pure aggregate and 50%/50% blends of RAP and aggregate had an equivalent stiffness, but at high confining pressures the 50%/50% blends had a higher stiffness than the pure aggregate. Bennert et al(3) found that pure specimens of RAP and RCA had higher resilient moduli than pure virgin aggregate specimens. Bennert also found that specimens of pure aggregate had higher shear strength than pure RAP or RCA specimens. This trend is supported in a study by Guthrie et al(6) in which RAP/aggregate blends showed a decrease in shear strength as RAP content increased. In general, RPM seems to show a better response than natural aggregate for similar gradation and compaction in tests that induce relatively smaller strains such as resilient modulus tests than tests that induce large strains such as triaxle compression or CBR tests.

- **Sharanabasappa Kori.** "Effect of Mixing and Compaction Temperatures on The Indirect Tensile Strength and Fatigue Behavior of Bituminous Concrete Mix Prepared Using Polymer Modified Bitumen" International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395- 0056, p-ISSN: 2395-0072, Volume: 04 Issue: 07 | July -2017. Bituminous mixes are used in the surface layer of road and airfield pavements. The mix is composed usually of aggregate and bitumen. The design of bituminous paving mix, as with the design of other engineering materials is largely a matter of selecting and proportioning of constituent materials to obtain the desired properties in the finished pavement structure. In the present study, an attempt is made to evaluate the effects of Mixing and Compaction temperature on the Marshall Properties, Indirect Tensile Strength and Fatigue behavior of Bituminous Concrete Mix prepared using Polymer Modified Bitumen. The present study includes an aggregate gradation of Bituminous Concrete Mix Grading-2 as per MORTH specifications (4th revision), Polymer Modified Bitumen (PMB-70) as binder. The design of Bituminous Concrete Mix prepared using Polymer Modified Bitumen as per IRC SP 53-2002 specifications. Based on the experimental work and analysis carried out in the present study, an ideal mixing temperature of 160oC and compaction temperature of 140oC is suggested for the preparation of Bituminous Concrete Mix prepared using Polymer Modified Bitumen.

Flow chart of Methodology (Test to be studied)



Study Determination of material properties

Various tests will be on the materials used in Flexible Pavement. The following tests will be carried out on materials:

1)Test on RAP Aggregate.

- Specific Gravity [IS 2386]
- Water Absorption Test [IS 2386]
- Flakiness Index [IS 2386]
- Elongation Index [IS 2386]
- Aggregate Crushing Value [IS 2386]
- Aggregate Impact Value [IS 2386]

2) Test on Bitumen.

- Softening Test [IS 1206]
- Ductility Test [IS 1206]
- Specific Gravity Test [IS 1206]
- Standard Penetration Test [IS 1206]

3) Test on Hot and Cold Bituminous Mix (RAP Aggregate with Partial Replacement by Waste Concrete)

- Marshall Stability Test [IS: 73 (1950-62-92)]

Road Technologies

Components of Road

The components of Roads can be classified into two types according to their functional performance and the material and technology used.

1) Earthworks
2) Pavement structure

The earthwork quantities are estimated based on the longitudinal and transverse sections along the alignment of the road. The swelling and shrinkage factors also have to be considered in the exaction and compaction of the earth.

The fundamental purpose of a road pavement is to disperse the applied vehicle loads to the subgrade. Road pavement is a structure made up of layers of processed materials overlaid on the natural soil subgrade. The pavement construction must be able to offer a surface with a good riding quality, sufficient skid resistance, good light-reflecting properties, and low noise pollution. The ultimate goal is to make sure that transmitted stresses from wheel load are suitably decreased so as not to surpass the subgrade's bearing capability..

Experimental Investigation

The main testing program includes the: -

a) Physical characterization of the materials used in this study
b) Grading the material used as per MORTH grading II (Table 500-14)
c) Performing test by using aggregate grading and binder content

When tested in accordance with 18:2386 Part 1 (Wet grading method). the combined grading of the coarse and fine aggregates and filler shall fall within the limits shown in Table 500-17. The grading shall be as specified in the Contract.:

Figure 1: Collection of RAP

Table 1 Composition of Bituminous Concrete Mix

Grading	1
Nominal aggregate size*	13.2mm
IS Sieve(mm)	
45	
37.5	
26.5	
19	100
13.2	90-100
9.5	70-88
4.75	53-71
2.36	42-58
1.18	34-48
0.6	26-38
0.3	18-28
0.15	12-20
0.075	4-10
Bitumen content % by mass of total mix	Min 5.4**

Figure 2: Sieving of Material as per gradation

A.Binder

As shown in Table 1, the bitumen utilised for the current work is 60/70 penetration grade and has been extensively applied to paving. It serves as the binder in the project. At 160–165 °C, bitumen melts.All bitumen tests were carried out in accordance with I.S.-mandated protocol. The results of basic tests on bitumen and modified bitumen show that, when bitumen is replaced with waste plastic to the extent of 4.5% of its weight, penetration and ductility decrease, but softening point and specific gravity rise.

Table 2 Test on Bitumen

Test	**Sample 1**	**Sample 2**	**Result**	**Specification**
Softening Test	53ºc	54ºc	53.5ºc	56ºc Max
Ductility Test	74.5	74	74.25	100 Max
Specific Gravity Test	0.96	0.99	0.97	1.06 Max
Standard Penetration Test	48	50	49	70 Max

Table 3 Test on Emulsion

Sr.no	**Characteristics**	**Results**
1	Residue on 600-micron IS Sieve	0.40
2	Viscosity, seconds at 25ºC	55
3	Storage Stability After 24 hrs.%	3
4	Test on Residue	
	a. Residue by Evaporation %	30
	b. Penetration 25ºC/100g/5sec	90
	c. Ductility 27ºC/cm	110

B.RAP:

Materials used in this experimental study's diverse physical and chemical qualities. Cement, fine and coarse aggregates, and RAP (reclaimed asphalt pavement) are the components. In this study, M-sand was utilized as the fine aggregate, and after grading the RAP into fine and coarse for both cases, testing on the RAP were carried out. All tests were carried out in accordance with Indian requirements. Table 1 lists the findings of several cement test results. Table 2 displays the findings of the M-sand and fine RAP sieve analyses, whereas Table 3 displays the results of the coarse aggregate and coarse RAP sieve analyses. Table 4 displays, respectively, the specific gravity and water absorption of m-sand, coarse aggregate, and fine and coarse RAP..

For coarse aggregate made entirely of recycled asphalt pavement aggregate, crushing strength decreased. Compressive strength was somewhat increased because to the abrasion process. Additionally, abrasion process increased the compressive and flexural strengths compared to concrete with 30% and fully replaced recycled asphalt pavement aggregate. Recycled asphalt pavement aggregate subjected to abrasion at day 28 exhibits higher water absorption. With age, a specimen's weight decreases due to an acid attack. Fully recycled asphalt pavement aggregate concrete demonstrated greater resilience than regular concrete. At 30% higher levels than that without abrasion, recycled asphalt pavement aggregate demonstrated greater resilience to acid attack.

Table 4 Reclaimed Asphalt Pavements (RAP)

Test	**Specification**	**Result**
Specific Gravity Test	_	2.7
Water Absorption Test	2%Max	_

Flakiness Index	15% Max	10.82
Elongation Index	20% Max	11.58
Aggregate Crushing Value	30% Max	16.98
Aggregate Impact Value	30% Max	15.09

Figure 3: Aggregate Crushing Test

C.Determination of OBC.

In the present study determination of OBC for hot bituminous concrete mix by varying bitumen % 5,5.5,6,6.5.
Determination of OBC for cold bituminous concreate mix by varying emulsion % 8,8.5,9,9.5,10,

Table 5 Optimum Binder Content

	OBC
Hot Mix	5.8%
Cold Mix	9.2%

- **Marshal Stability of Bituminous Mix**

Marshal Stability of Hot and cold Bituminous Mix prepared using varying % of RAP (100,95,90,85,80,75) and concrete waste (0,5,10,15,20,25)**.**

Table 6 Marshal Stability of Hot Mix

Rap+Waste concrete	Density	VMA (%)	VFB (%)	Avg Flow	Stability of Hot Mix(KN)
100/0	2.79	12.40	62.50	4.05	10.56
95/5	3.01	10.50	60.50	2.99	10.21
90/10	2.29	10.33	59.22	4.33	9.80
85/15	3.41	8.9	58.41	4.17	9.11
80/20	3.90	8.1	56.10	2.51	8.30
75/25	3.75	7.25	54.99	2.90	7.45

Table 7 Marshal Stability of Cold Mix

Rap+Waste concrete	Density	VMA (%)	VFB (%)	Avg Flow	Stability of Cold Mix(KN)
100/0	2.60	12.53	62.39	4.8	6.22
95/5	2.95	10.60	60.27	5.4	5.64

90/10	2.15	10.44	59.09	3.5	5.13
85/15	3.26	8.99	58.33	4.2	4.67
80/20	3.70	8.22	56.01	5.4	3.33
75/25	3.59	7.36	54.77	5.3	2.96

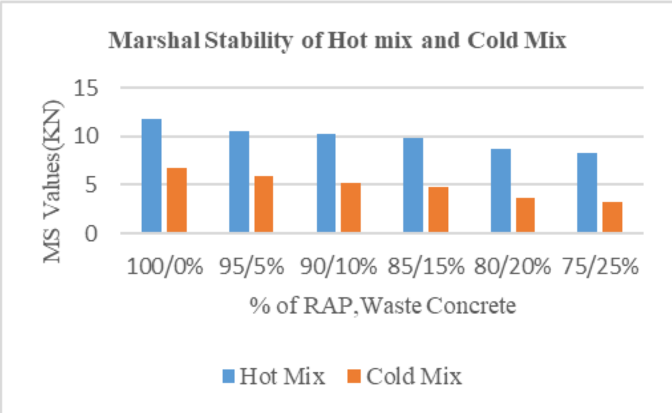


Figure 4: Preparation of Specimen

Figure 5: Marshal Stability Test

CONCLUSION

The physical properties of a rap aggregate, bitumen, and Emulsion satisfies the requirements as per MORTH. We can conclude that the hot bituminous mix is more stable than the cold bituminous mix. After adding Waste Concrete in RAP Aggregate by increasing the Percentage the stability of the Bituminous mix decreases. As per IRC minimum Stability of Hot mix is 9KN and the Cold mix is 4.9KN. Hence we can add waste concrete up to 15% in Hot mix while 10% in Cold mix.

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