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Study on RAP mix using industrial byproducts

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Abstract - *Using Reclaimed Asphalt Pavement (RAP) as a highway material is becoming more popular in India. The use of RAP not only reduces the project's cost but also assures that all materials are properly used. The goal of this research is to learn more about the importance of RAP in the development of bituminous pavements. Milling produces RAP materials, which are reclaimed asphalt pavement. This study included the collection and testing of RAP samples for their suitability for usage in flexible pavements. For both economic and environmental grounds, reclaimed asphalt pavement (RAP) materials are increasingly being employed in the pavement construction industry. Since incorporating RAP into HMA mixtures is a relatively new concept in India, little information is available on the mechanical properties of HMA mixtures and the methodologies used in their creation. In this study, the mechanical reaction of Bituminous Concrete mixes was evaluated as a function of the percentage of aggregates replaced by RAP. The study's goal is to determine the impact of RAP as a coarse aggregate replacement on the flexible pavement parameters, such as stability, flow, unit weight, void filled bitumen (VFB), and the percentage of air voids. (Percent Air Voids) (Vv). The study's findings suggest that using reclaimed asphalt pavement (RAP) as a filler and replacing 1 percent of the bitumen content with industrial glass waste results in the highest flow and stability ratings.*

Key Words: **Reclaimed Asphalt pavement, Bituminous concrete, Optimum Binder Content**

1. INTRODUCTION

According to the projected traffic volume and local environment, the specifications for the various layers of pavement materials should be as cost-effective as possible. To the maximum extent feasible, local materials should be utilised, which are less costly and need less shipping. Garbage generated by industry is a big problem in today's world. Due to the non-biodegradability of many of these materials, they damage the environment in which they are used. Roads in developing countries have recently been constructed using industrial waste. The use of these materials in road building is driven by technical, economic, and environmental factors. Given the scarcity of traditional road materials as well as the need to protect the environment, it is imperative that these materials be thoroughly analysed. Many more factories will be built in India in the near future, and the country already has a vast network of them. There is a great deal of industrial waste created in these businesses. These ingredients include soil, stone aggregates, sand and bitumen as well as cement and asphalt. Time is taking a toll on the supply of natural resources, which are limited. Furthermore, extraction of high-quality natural resources is getting more costly. Scientists are looking at alternative materials for roadway construction, including industrial trash. These materials may be used in a manner that reduces pollution and waste disposal concerns. Since there are no other destinations for these solid wastes, they've taken up a lot of space near companies around the country. Tests to determine how these wastes may be better used in road building, where higher rates of return may be possible, were seen as convenient in light of the country's need for broad use of these materials. Many remote and low-volume roads around the country might benefit from the use of these materials, and this should be investigated. There should be an effort made to employ solid wastes in the road pavement as efficiently as possible, according to the applicable criteria.

1.1 Objectives of Study

- To study the mechanical properties of locally available RAP mix.
- Studying the strength behaviour of bitumen concrete produced using RAP.
- Develop economical pavement design using newly developed RAP.
- Arriving an economical pavement design composition using developed mix through modified IRC 37 guidelines.

1.2 Scope of project

- "Reclaimed asphalt pavement" refers to asphalt and aggregate-containing pavement materials that have been removed and/or reprocessed (RAP). They are created when asphalt pavements are torn up to make way for new construction, resurfacing or access to the underground utility

network. With adequate crushing and screening, RAP is composed of aggregates of excellent quality that have been coated with asphalt cement. Milling or full-depth removal of asphalt pavement is the most common method of removing it. These 50-millimeter-thick-in-one-pass milling machines are transferred to a central processing facility, where they are decommissioned. Crushing, screening, conveying, and stacking the RAP are all part of the process at this factory.

- But RAP may also serve as an additional asphalt cement binder, reducing the need for asphalt cement in new or recycled asphalt mixes that include RAP. Once the old pavement is demolished, it is carried to a storage area or asphalt/concrete factory where it is treated before being sent to its ultimate destination for paving. Due to lower demand for building materials, lower asphalt content, and lower construction costs resulting from RAP use, there are several environmental benefits.

- In road construction, RAP, or recycled asphalt pavement, is a more ecologically friendly alternative to virgin asphalt. Efforts to recycle Reclaimed Asphalt Material (RAP) from asphalt plants address the diminishing availability of fresh aggregate and RAP.

2. MATERAIL USED

Reclaimed asphalt pavement materials are pavement materials that have been removed and/or reprocessed using asphalt-coated aggregates. These materials are formed when asphalt pavement is destroyed for the purpose of rebuilding, resurfacing, or gaining access to subsurface utilities. High-quality, well-graded aggregates are layered on top of asphalt that has been thoroughly crushed and screened. Reclaimed Asphalt Pavement (RAP) is a byproduct of road construction and maintenance (RAP).

2.1 Binder

Almost all crude petroleum contains some asphalt as a byproduct. Distillation is the process by which crude oil from oil wells is divided into its various fractions in a refinery. A sample of VG 30 bitumen from a bitumen refinery was gathered. Flexible pavements in India are often constructed using VG- 30 binder, which we utilised.

2.2 Industrial Glass waste

Filler was replaced with industrial glass waste supplied by "Belgium Glass." Before utilising it as a filler substitute, we crushed the glass debris to a fine powder.

3. CHARACTERIZATION OF BASIC MATERIALS

Bituminous materials may be evaluated using a wide range of assays. Bituminous materials may be tested for a variety of attributes using the following methods. Depending on the mix and structure, the desired qualities of bitumen may be altered. The following characteristics are ideal for bitumen.

3.1 Determination of Softening point

It is possible to determine the temperature at which bitumen softens to a certain degree by performing various tests on it. The Ring and Ball apparatus is used to administer the test. In a metal ring, a bitumen sample is kept submerged in water or glycerin at a certain temperature. With a steel ball in situ, the liquid medium is heated to 5 degrees Celsius per minute, keeping the bitumen sample stable. Once the softened bitumen comes in contact with the metal plate, the temperature is recorded. Because of their lower temperature sensitivity, higher softening points tend to be preferred in hotter environments than lower ones.

Table – 1: Determination of softening point

Description	Ball No 1	Ball No 2	Softening Point Mean Value
Temperature at which sample touches the bottom Plate	56	54	55

3.2 Penetration Value of Bitumen

Standard loaded needles may be used to assess hardness or softness by inserting them into bitumen and waiting five seconds before making this conclusion. The equipment and testing processes have been standardised by the BIS (British Industrial Standards). You must first remove the needle component, which weights 100g, before you may release and lock the penetrometer in any position. Bitumen is mixed well before being poured into containers at a depth of at least 15 millimetres higher than the expected penetration depth when the bitumen is soft enough to pour. During the test, a constant temperature of 25 degrees Celsius should be maintained. The penetration value is greatly affected by any inconsistencies in the pouring temperature, needle size, weight on the needle, and the test temperature. The penetration value of bitumen with a grade of 40/50 is between 40 and 50 when measured under normal conditions. Lower penetration levels are needed in warmer climates.

Table – 2: Penetration Value

SL No	Dial Reading		Penetration	Average Penetration
	Initial	Final	(in 1/10th mm)	(in 1/10th mm)
01	0	55	55	56
02	0	57	57	

3.3 Specific Gravity of Bitumen

At a particular temperature, it is the mass of the material divided by the mass of an equivalent amount of water. Specific gravity is a key property of bitumen, which is determined by the Specific Gravity Test of Bitumen. Classifying bitumen binders for use in pavement construction is therefore possible. Bitumen binder origin may also be determined using this method. Bitumen specimens may also be identified by using this method. Mineral impurities cause the specific gravity to rise. This is crucial for removing bitumen binder contaminants.

3.4 Aggregate Impact Value Test

During the aggregate impact test, a variety of weights are placed on the aggregates to see how they react to the pressures. The capacity of aggregates to sustain sudden or impact loading is measured using the need impact value test. For this reason, determining the aggregate's ability to withstand impact loads is critical to its service life. After the speed breaker, aggregates, for example, will be exposed to impact on the undulating road.

Table – 3 Impact Value

Description	Trial No 1	Trial No 2
Weight of Surface dry sample passing 12.5mm andretained on 10 mm IS sieves, (W1)	351	349
Weight of fraction passing 2.36 mm IS sieve, afterimpact, (W2)	43	41
Weight of fraction retained on 2.36 mm IS sieve,after the test, (W3)	308	308
A.I.V. = (W2/W1) *100	12.25	11.75
Average value of A.I.V.	12	
Specification Limits, Max (%)	30%	

3.5 Specific gravity

Measurements were made to assess the density of discarded glass powder. During the experiment, we utilised a density bottle with stopper, funnel, spatula, and a weighing scale.

Table – 4: Specific Gravity

Description	Trial No 1	Trial No 2
Weight of empty Cylinder	13.6	13.6
Weight of empty cylinder + Sample	68.1	68.2
Weight of empty cylinder + Water + Sample	117.9	118.2
Weight of empty cylinder + Water	84.8	84.7
Specific Gravity	2.55	2.59
Average Specific Gravity	2.59	

3.6 Bitumen extraction test

In the Bitumen Extraction Test, a cold solvent extraction method is used to assess the asphaltic pavement's bitumen concentration. The amount of bitumen used to build the pavement has a significant impact on the features of flexible pavement, including its durability, compatibility, and resistance to bleeding, ravelling, and ageing.

Table – 5: Bitumen Extraction

SL No	Description	Trial No 1	Trial No 2
1	Weight of mix	945	949
2	Initial weight of filter paper	6.03	6.03
3	Weight of aggregate after extraction	900	903
4	Weight of filter paper after extraction	6.73	6.82
5	Increase in weight of filter paper	0.70	0.79
6	Weight of binder	44.3	45.21
7	Binder content in %	4.68	4.76
8	Average binder content	4.72	4.72

4. FINAL RESULTS

Keeping 1% Optimum bitumen content we replace the filler material to glass to an extent of 25%, 50%, and 100% and conduct the Marshall stability strength tests.

- The Marshall mix design technique relies on the Marshall stability and flow test to anticipate the mix's performance.
- Test specimens are subjected to a 50.8 mm/minute loading rate for the stability phase of the test.
- The specimen is subjected to increasing loads until it breaks, and the highest possible load is used to determine stability.
- A dial gauge connected to the specimen monitors its plastic flow (deformation) as the loading proceeds.
- When the maximum load is measured, the flow rate is also measured in millimetres.

Table – 6: Marshal stability

SL No	Sample No	% Replacement	Load (KN)	Displacement (mm)
1	1	25	19.6	5.69
	2	25	21.81	5.67
	3	25	24.45	4.86
2	1	50	31.65	6.19
	2	50	15.96	7.36
	3	50	22.95	3.25
3	1	100	19.88	7.75
	2	100	21	7.96
	3	100	22.92	-3.24

The table clearly Depicts that 50% Filler Replacement yields Maximum Strengths

- We can infer from the graphs and obtained values that 1% bitumen yielding a Marshall stability strength of 25.81KN, as optimum bitumen content.
- Keeping 1% Optimum bitumen content when we replaced the filler material to glass to an extent of 25%, 50%, and 100%, at 50% filler replacement yielded a Marshall stability strength of 23.52 KN.

5. CONCLUSIONS

Suitability of the locally available RAP as the surface course material in the pavement construction is possible for village roads with aggregate replacement of Reclaimed Asphalt Pavement (RAP) mix combined with a binder content of 1% Viscosity Grade 30 (VG-30) which yielded a Marshall Stability Strength of 25.81KN. Suitability of industrial waste products in enhancing performance of RAP is possible for village roads with aggregate replacement with Reclaimed Asphalt Pavement (RAP) mix combined with a binder content of 1% Viscosity Grade 30 (VG-30) and with filler replacement of finely powdered industrial glass waste to be used as 50% Filler replacement which yielded a Marshall Stability Strength of 23.52KN.

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