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CHARACTERISTICS AND APPLICATIONS OF POLYMER MODIFIED BITUMEN IN RECYCLED ASPHALT PAVEMENT

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ABSTRACT
In the present scenario, the cost of Flexible pavement in construction is high and its Life Span is less. Strengthen the pavement by partial replacement of Recycled asphalt pavement (RAP) in Hot Mix Asphalt and also Polymer modification of Bitumen binders has been increasingly become the industrial vogue in designing the optimally performing pavements, particularly in the recent past to enhance the engineering properties of the bituminous mixes in order to suit the Global Standards of Construction**.** In this paper, different laboratory tests are conducted by replacing bitumen with both polymers target is polypropylene and polyethylene, and RAP material. Aggregate tests are also followed to know the strength of the aggregates. The results are compared with virgin materials and the required optimum percentages are known.
Index terms: recycled asphalt pavement (RAP), hot mix asphalt, polypropylene, polyethylene, Flexible Pavement

1. INTRODUCTION

India has a network of 3.93 million longest roads including National Highway, Regional Highway, Regional Highway, other district roads, and rural roads. Many of these roads have bituminous pavements that need to be repaired regularly. In addition to the above, the government has an excellent road development program. All of these activities require a lot of road construction materials especially paved stones. However, the availability of natural resources is limited. This leads to a system of looking at other building materials. After all, large quantities of existing bituminous concrete are usually processed/removed during re-installation, renovation, and/or reconstruction operations. Road traffic is carried by the pavement, which in engineering terms is a horizontal structure supported by in situ natural material**. Pavement** in civil engineering is a durable surfacing of a road, airstrip, or similar area. The essential capacity of asphalt is to communicate burdens to the sub-base and fundamental soil. There are three types of pavements Flexible pavement, Rigid Pavement, and Composite Pavement. New technology is necessary to alleviate the adverse repercussions of the cement trade [1], [2], [3], [4]. Because of their better characteristics, alkali-activated binders can aid with this. Concrete binders include

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inorganic binders (such as gypsum, lime, and cement), organic binders (such as emulsions and epoxy resins), and mineral binders (such as rice husk ash, red mud, silicon dioxide fume, metakaolin, GGBS, and fly ash) (such as rice husk ash, red mud, silicon dioxide fume, metakaolin, GGBS, and fly ash). Ceramic powder is created from high calcium content tiles and has higher structural properties than concrete [5]. Concrete has a stronger compression zone than a weaker tension zone. Although concrete is reinforced with a variety of fibers [6], [7], aggregate texture substantially affects its strength. The concrete's fire resistance should be evaluated at various temperatures [8]. Every stable form will degrade a little due to shrinkage and strain.

LAYERS OF PAVEMENT

- Subgrade or roadbed
- Sub-base course
- Base Course
- Surface course or wearing course

SUBGRADE OR ROADBED:

Subgrade natural soil is compacted under paved layers and is a finished or compacted area where the road is laid. They are also known as textures and serve as the basis for the pavement layers

SUB-BASE

The sub-base course divides the base course into a subgrade. The material utilized for this layer will fulfill the details regarding degree, strength, and plastic attributes.

BASE COURSE

The base course is a layer or layers of indicated or select material of planned thickness put on a subbase or subgrade (in the event that a subbase isn't utilized) to give a uniform and stable help for fastener and surface courses. Great quality squashed totals in accordance with specialized determinations must be utilized.

SURFACE COURSE OR WEARING COURSE

Surface course is multiple layers of pavement structure where the top layer is directly exposed to traffic. The surface course is also known as the wearing course. The wearing course reduces the percolation of water and provides an antiskid and abrasion-resistant riding surface.

2. MATERIALS USED

- Bitumen
- Coarse Aggregate
- Fine Aggregate
- Polymers

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- Reclaimed Asphalt Pavement (RAP).

BITUMEN

Bitumen is made out of complicated hydrocarbons and contains components like calcium, iron, sulfur, and oxygen. The nature of material and simplicity of creation relies upon the source and sort of unrefined petroleum it is gotten from. Bitumen penetration grade 60/70, is the most common grade of bitumen. This grade has a thermoplastic property that causes the material to soften at high temperatures and garden at lower temperatures.

COARSE AGGREGATE

Aggregates are a very important ingredient in the construction of roads, it plays a major role in the distribution of a load of top layers. These are used layers to overcome the stress action caused by traffic wheel load, squeeze, and wear and tear. Aggregates carry specific sizes with a collection of cubical, angular, rounded, and flaky or elongation. Flaky and elongation aggregate have less strength and durability when compared to other types.

FINE AGGREGATE

Fine aggregates are basically won sand or crushed stone with most particles passing through a 4.75mm sieve. Fine aggregates are used in a rigid pavement for filling the gap or voids of coarse aggregate and fine aggregates are used in a top second layer (Base course) out of four layers.

POLYMERS

The polymer mixed with subgrade soils decreases the brittleness of the road and prevents it from breaking and cracking because of heavy use. The blend likewise diminishes how much rutting, the formation of notches, or the sinking of the street surface due to the section of the vehicles. Polymers are generally classified based upon the source of origin, structure and molecular forces.

Polymers make up a significant number of the materials in living creatures, including, for instance, proteins, cellulose, and nucleic acids. The polymers used for the testing are:

POLYPROPYLENE

A sort of polymer mellows past a particular temperature permitting it to be shaped and on cooling it sets. One of the important families of polyolefin resins, polypropylene is moulded into many plastic materials. Perfectly isotactic PP has a melting point of 171 °C (340 °F).

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POLYETHENE

It is the most common type of plastic found around us. Mostly used in packaging from plastic bags to plastic bottles. There are different types of polyethylene but their common formula is $(C_2H_4)_n$. *Its melting point is approximately 110 °C (230 °F).*

RECYCLED ASPHALT PAVEMENT

In this modern-day RAP is highly growing pavement in the countryside and metropolitan areas. Recycled aggregates are collected from the olden days (up to 10-15 years old pavement). Once removed and processed, these old pavement materials become reclaimed asphalt pavement (RAP) and are available for use in new pavement construction. Very high-quality uniform RAP is generally preferred for the production of hot mix asphalt (HMA).

3. BITUMEN TESTS

SOFTENING POINT TEST:

The conditioning point shows the temperature at which the bitumen acquires a specific level of mellowing under the details of the test. This test is carried out by using the ring and ball apparatus. The softening point help to determine the temperature up to which can be heated for different road use applications. It is also known as the Ring and Ball Test. The results of the softening point are shown in table 1

TABLE 1: SOFTENING POINT

% of polymer used	0%	2%	4%	6%	8%
Polypropylene	51.7ºC	56ºC	58ºC	58.8ºC	52.2ºC
Polyethylene	51.7ºC	54ºC	56ºC	56 ºC	51ºC

PENETRATION TEST

The penetration test of Bitumen decides the hardness or non-abrasiveness of bitumen by estimating the profundity in millimeters to which a standard stacked needle will enter upward in five seconds while the temperature of the bitumen test is kept up at 25ºC. This test is applied only to bitumen. The results of the penetration test are shown in Table 2

TABLE 2: PENETRATION TEST RESULTS

% of polymer used	0	2	4	6	8
Polypropylene	90mm	82.30mm	78.30mm	70.60mm	66.30mm
Polyethylene	90 mm	85.60mm	80.60mm	75.30mm	71.30mm

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DUCTILITY TEST

The property of bitumen that allows it to undergo deformation or elongation is called ductility of bitumen. The ductility of bitumen is measured by the distance in Cm (centimeter, to which the bitumen sample will elongate before breaking when it is pulled by a standard specimen at a specified speed and temperature. The results of the ductility are shown in table 3

Table 3: DUCTILITY TEST RESULTS

% of polymer used	0%	2%	4%	6%	8%
Polypropylene	73.2cm	69.7cm	57cm	50.2cm	49.2cm
Polyethylene	73.2cm	69cm	54cm	40.2cm	37.8cm

AGGREGATE AND RAP MATERIAL TESTS

IMPACT VALUE TEST

Weight of dry sample taken = W1 gm
Weight of fraction passing 2.36 mm sieve= W2 gmAggregate Impact Value = W_2/W_1100
The results of the impact value are shown in table 4

Table 4: IMPACT VALUE

Type	Trail 1	Trail 2	Trail 3	Average
Aggregate	18.21	17.56	19.06	18.27%
RAP	10.91	9.7	11.56	10.7%

Result: The average impact value for Virgin Aggregate is 18.27% andRAP is 10.7%.

CRUSHING VALUE TEST

Weight of dry sample taken = W1gm
Weight of the portion of crushed material passing 2.36 mm IS sieve= W2gm
Aggregate Crushing Value = W_2/W_1100
The limits and the results of the crushing value are shown in table 5 and table 6

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Table 5: CRUSHING VALUE LIMITS

Types of Roads/ Pavements	Aggregate Crushing Value Limit
Water bound macadam	40
Bituminous macadam	40

Table 6: CRUSHING VALUE

Type	Trail 1	Trail 2	Trail 3	Average
Aggregate	19.42	18.3	18.6	18.77%
RAP	15.1	14.86	14.23	14.73%

Result: The average Aggregate crushing value for Aggregate is 18.77%and for RAP is 14.73%.

SHAPE TEST

FLAKINESS INDEX

Flakiness Index = $((w1 + w2 + w3 + \ ))/ ((W1 + W2 + W3+)) \ x \ 100$

The limits and the results of the flakiness index are shown in table 7 and table 8

Table 7: FLAKINESS INDEX LIMITS

S. No.	Type of Pavement	Maximum limit of flakiness index in %
1	Bituminous carpet	30
2	Bituminous concrete	25
3 (i)	Bituminous Macadam	
(ii)	WBM base course and surface course	15

Table 8: FLAKINESS INDEX RESULTS

Type	Flakiness Index
Aggregate	18.2%
RAP	12.28%

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Result: The Flakiness Index for Aggregate is 18.2% and for RAP Material is 12.28%.

ELONGATION INDEX

Elongation Index =" x1 + *x*2 + *x*3 +"/" *W*1 + *W*2 + *W*3 +" x100

The limits and the results of the elongation index are shown in table 9 and table 10

TABLE 9: LIMITS OF ELONGATION INDEX FOR DIFFERENT TYPES OF PAVEMENTS (SOURCE:MORTH)

S. No.	Type of pavement	Maximum limits of elongation index, %
1	Bituminous concrete	25
2	Water Bound Macadam	15

Table 10: Test Results

Type	Elongation Index
Aggregate	13.6%
RAP	8.92%

Result: The elongation index for aggregate is 13.6% and RAP Is 8.92%.

4. CONCLUSIONS

1. From all the test results it was revealed that PE modified bitumen shows the least variation in penetration, softening point, and ductility.
2. This is due to the formation of a thermodynamically stable structure which may offer resistance in terms of rutting, fatigue, and temperature susceptibility.
3. The decrease in the penetration value of virgin bitumen concentration of polymer in the blend shows that even at low concentrations of the polymer in the blend, it rapidly enhances the hardness of the polymer-modified bitumen.
4. Bitumen was strongly influenced by polymer concentration, temperature, and

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penetration grade.

5. RAP is a valuable, high-quality material that can replace more expensive virgin aggregates.
6. RAP and Virgin aggregate materials test values are within the permissible limit. So, it can be used for the construction of pavement.
7. Reduction of bitumen is caused for more economical.

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