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STRENGTHENING OF FLEXIBLE PAVEMENT BY ADDING RECRON FIBRE

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Abstract. Now-a-days, there is dire necessity for roads which are more stable and stronger. Due to weathering conditions and heavy traffic, the pavement surfaces are getting deteriorated by rutting, pot holes etc. With the addition of this Recron fiber, there is an improvement in the properties of bitumen like increase in stability value and decrease in the flow value, % of air voids etc. Recron fiber is an artificial material obtained from the polyester and which is also used as a secondary reinforcement for attaining tensile strength. It helps to resist the cracks obtained by the improper laying of pavement surface and heavy loaded vehicles.

In the present study, various proportions of Recron fiber such as 3%, 6%, 9% and 12% are added to Bitumen to prevent the deterioration of pavement surface and various tests are performed on aggregate and bitumen. From the results, it is found that, the flow value and % of air voids decrease and stability value increases. Hence, it is proved that, it protects the pavement surface from the effect of fatigue, cracking and deformation.

The obtained results show that 9% is the optimum percentage of Recron fiber to be added to the bitumen. For nominal bitumen mix, the maximum stability value is 12.07 kN and for modified bitumen (Recron added) mix the maximum stability value is 16.79 kN.

Key words. Modified Bitumen, Flexible Pavement, Polyester [Recron 3s] Fiber.

1. Introduction

Generally, roads are basic requirement for transportation facilities. The pavement should be stronger and more stable. But flexible pavements are generally affected to heavy traffic, weathering and geological conditions of the pavement. In order to overcome from these effects like rutting, pot holes, shrinkage cracks etc., properties of bitumen are improved with addition of fiber. One of such fibers is Polyester (Recron-3S) Fiber. This is an artificial material obtained from polyester. This Fiber helps to resist the cracks obtained by heavy loaded vehicles and any changes occurred due to varying temperatures. This also helps to increase in flexural strength and tensile strength to the pavement. Bitumen is viscous fluid material which consists of binding and adhesive property (which binds all the components in it without any changes in their properties and it is insoluble and acts as a sealant).

During the construction of flexible pavements, the bitumen binder is added to increase the life span of the pavement surface. While laying of road, the bitumen and coarse aggregate are mixed together providing good bonding and friction between vehicle wheels and road surface. But the major problem in the bitumen pavements is due to rising high temperatures, the volatile compounds present in the bitumen are evaporated and the bitumen will become hard. Due to this, when the traffic loads are heavy, the pavement will get deteriorated. During winter rainy seasons, due to presence of moisture content, the pavement may be damaged. To prevent this, Polyester (Recron-3S) Fiber is added at certain proportions (3%, 6%, 9%, 12%) to the bitumen mix. Generally, asphalt pavements can absorb water and lose its strength. But, with the addition of this Fiber to these pavements, the strength is not



decreased even with the absorption of water and also it withstands to abrasion. Polyester (Recron-3S) Fiber in bitumen protects from the fatigue, flow value, cracking and deformation on flexible pavements.

1.1 General

Vangari Manikanta, Gopi Sai Reddy (2018), states that, the permeable Asphalt Pavements are suited for environment in order to percolate the water into the ground for raising the ground water table which is suited for India. In this process, the pavement loses its strength. Further, it is mentioned that, In such cases, addition of fibers to asphalt mix may give the efficient results like additional strength, resistance to shrinkage splits and stability to the pavement.

P. Rajendhra Kumar & P. Archana (2017), got good results on the performance of expansive soils while adding the Recron-3s fiber. By adding this fiber, there is a reduction in maximum dry density & optimum moisture content and increase in the tensile strength.

G. Pradeep Reddy, G. Tarun Krishna (2017), presented a paper giving clear information about the nature of bitumen with the addition of Recron fibers. And they show the comparison of nominal bitumen and bitumen with Recron fiber based on strength, flow value, voids filled with mineral aggregates, bulk density and unit weight.

G. Jenitha, M. Shenbagavalli (2016), in their work gave the clear information about properties of Recron fiber and advantages. They analyzed that with the addition of Recron, there is a change in strength and workability of concrete.

Muhammad Nawazish Husain, Praveen Agarwal (2015), explained about the effect of adding recron fiber to the silty soils which is situated in Kurukshetra. By adding 0.15% of Recron fiber, the CBR value had increased by 3.5% to 20.2% and with further addition of Recron fiber of 0.3%, 0.4%, and 0.6%, there is a little improvement in CBR value. With 0.15% fiber the UC value also has been increased.

Farhad Zafari, Mohammed Rahi (2014), exposed their results about by adding Nano silica to the asphalt pavement. This improves the resistance of pavement by the effect of rutting and rheological properties of asphalt binder.

Kishan Khunt (2013), concluded about the strength of the soil which may increase to certain extent by using additive materials. Especially, Recron-3s mixed with soil & fly ash mixture gave a wonderful result. Fiber absorbs everything and keeps the road surface intact and many problems are solved like pot holes, cracking and failure of pavement. Fiber plays an important role in increasing the efficiency of pavement and helps to bind the soil under the road.

2. OBJECTIVES

- ❖ To study the properties of bitumen by adding different proportions of Polyester (Recron-3S).
- ❖ To modify the strength of the bitumen mix by using Polyester (Recron-3S) Fiber.
- ❖ To obtain the optimum value of Recron fiber to be mixed with the nominal bitumen.

3. Materials Used

3.1. Aggregate

It is a term for the mineral materials, for example, sand, rock and pulverized stone that are utilized with a coupling medium for such as water, bitumen, Portland Concrete, lime and so forth to shape compound materials. The properties of the aggregates are shown in the Table: 1

Table 1. Aggregate Test Results & Accepted Values

S.No.	Test	Results	Acceptable Value
1	Aggregate crushing value	17.95%	30% (maximum)

2	Impact value	12.725	10-20(strong) 20-30(good)
3	Specific gravity	2.91	2.5-3.0

3.2. Polyester (Recron-3S) Fiber

Recron Fiber is a modified polyester Fiber and helpsto resist the micro shrinkage cracks caused due to hydration in the bitumen pavement. It also helps to increase flexural strength of the pavement.

Properties

- ❖ Tensile Strength: 4000 – 6000kg/cm²
- ❖ Cut Length: 6mm or 12mm
- ❖ Melting Point: >250°C
- ❖ Color: White
- ❖ Source: Reliance Industries
- ❖ Cross section: Triangle
- ❖ Diameter: 35-40 micron
- ❖ Ignition temperature: >450⁰ C

Advantages

- ❖ Improves homogeneity of the concrete by reducing segregation of aggregates.
- ❖ Reduces shrinkage cracks/micro cracks
- ❖ Abrasion resistance increases by more than 25%.
- ❖ Impact and shatter resistance increase by 100%.
- ❖ Increases ductility, compressive, flexural and tensile strength.
- ❖ Reduces water permeability which helps to prevent correction of primary steel.
- ❖ Increases energy absorption capability of concrete.
- ❖ Replaces or reduces non-structural steel in floors, roads and pavement.

3.3. Bitumen

The bitumen used in this study is 80/100. This grade is mainly used for good flexible pavements design mixes with chips. This bitumen type has good properties. The main property of this grade is that this has more viscosity as compared to other grades.

Table 2. Bitumen Test Results & Accepted Values

S.No.	Tests	Results	Acceptable Values
1	Ductility	74	65(min)
2	Softening point	47	46(min)
3	Penetration	80/100	80/100
4	Fire	325	235(min)
5	Flash	315	205(min)

4. Methodology

The Polyester (Recron-3S) Fiber is collected and made into pieces of 2cm length. Then aggregate properties are obtained by conducting various tests such as crushing test, impact test, specific gravity, water absorption and abrasion test.

4.1. Aggregate Impact Test

The aggregates that pass through 12.5 mm and 10 mm with pan below the sieves are taken and the aggregate which retained on 10 mm sieve is collected. 1/3rd of the cylinder is filled with aggregate and tamped with tamper rod for 25 times. Again the cylinder is filled up to 2/3rd level with aggregate and tamped. The cylinder is placed at the bottom of the impact machine and hammer is lifted up to 300 mm and it was dropped freely until 15 blows. After this, the aggregate is passed through 2.36mm sieve and readings are noted.

4.2. Crushing Test

Aggregates which retain on 10 mm sieve are collected and the cylinder is filled by 1/3 proportion giving tamping of 25 times. Then it is placed in the crushing machine and the load of 50 tonnes, 5 tonnes per minute is applied. Then, the aggregates are sieved on 2.36mm sieve and readings are noted.

4.3. Specific Gravity

Aggregates are collected and placed in the wire basket and the aggregates are immersed into water and kept for 24 hours. After that, the aggregates are cleaned by using cloth and readings are noted.

4.4. Penetration Test

The bitumen sample is heated and then cooled for 24 hours. The bitumen mould is placed on the bottom base of penetration machine and the time is set. The reading is noted from the instrument.

4.5. Softening Point

The bitumen is placed in the rings and fixed well and the ball is placed and the whole apparatus is put in to the water bath and temperature is switched on. At certain temperature, the ball penetrates through the bitumen and touches the bottom the lid.

4.6. Marshall Mix Design

Marshall Mix design is used to find the optimum binder content of the bitumen, Stability, flow value and bulk density for the bitumen content.

- ❖ Different types of aggregates are selected for grading by using MORTH table.
- ❖ First, we need to assemble the mould with a base plate and we need to apply sum lubricate.
- ❖ Before that we need to sieve the aggregate as per the MORTH table.
- ❖ Then, sample of aggregate is taken as per the MORTH table and heated up to certain temperature by using pan.
- ❖ The bitumen content is added to the sample and mixed thoroughly and taken into the mould immediately.
- ❖ 75 blows are given on both sides of the sample mechanically or manually.
- ❖ The sample is ideally put for 24 hours and then removed from the mould.
- ❖ The water bath is taken at 60 degrees for the sample and the surface of the sample is cleaned.
- ❖ Then Marshall stability test is done and readings are noted down

5. Results & Discussions

5.1. Nominal Mix

With the utilization of various proportions of aggregates of various sizes, the voids in the mix got reduced giving more stability to the mixture. The various sieve sizes taken for getting the required quantity of aggregate and weights are as follows: e.g.: for 5% of bitumen.

Table 3. Sieve Sizes & Aggregates.

Sieve Sizes (mm)	Aggregates Weight Taken		
	5% of Bitumen	5.5% of Bitumen	6% of Bitumen
10	60	120	60
8	120	120	120
6.3	240	180	120
4.75	240	180	240
2.36	300	300	360
Filler	240	300	300
Total weight	1200	1200	1200

5.2. Weights of Material

The bitumen content is taken as per the total weight of the aggregate 1200 grams.

5% of Bitumen = $(1200 \times 5) / 100 = 60$ grams.

5.5% of Bitumen = $(1200 \times 5.5) / 100 = 66$ grams.

6% of Bitumen = $(1200 \times 6) / 100 = 72$ grams.

The fiber % is taken as per the total bitumen for each sample that is:

Table 4. Fiber % and weights taken

S. No.	Bitumen (%)	Fiber (%)	Weight of fiber taken(gms.)
1.	5	3	1.80
		6	3.60
		9	5.40
		12	7.20
2.	5.5	3	1.98
		6	3.96
		9	5.94
		12	7.92
3.	6	3	2.16
		6	4.32
		9	6.48
		12	8.64

5.3. Marshal Tests on Various Mixes

Various Mix types, their proportions and the obtained values of unit weight, stability, flow, percentage of air voids and percentage of voids filled by bitumen are as follows

Table 5. Mix Types and the Values Obtained

Mix	Bitumen (%)	Flow (mm)	Marshal stability (KN)	Unit wt. (g/cm ²)	% of Air Voids	% of voids filled
C	5	4	10.35	2.56	5.72	68.39
	5.5	3.9	12.07	2.57	5.5	76.46
	6	4.1	11.65	2.56	5.64	71.73
M1	5	3.9	13.36	2.54	4.9	71.59
	5.5	3.6	14.58	2.56	4.2	80.07
	6	3.7	12.76	2.54	4	78.21
M2	5	3.5	11.73	2.53	4	75.68
	5.5	3.3	13.57	2.54	3.8	80.32
	6	3.5	12.67	2.53	3.9	76
M3	5	3.2	15.66	2.5	3.01	80.7
	5.5	3	16.79	2.52	2.66	86.79
	6	3.1	16.16	2.47	2.9	83.83
M4	5	4	14.76	2.52	3.4	78.68
	5.5	3.7	15.33	2.54	3.2	83
	6	4.2	13.2	2.53	3.3	81.13

5.4. Graphical Representation of Marshall Test on Various Mixes

Comparison of nominal bitumen and fiber added bitumen with various % (i.e., 3%, 6%, 9%, and 12%) are presented in figs 5.4 (a) to 5.4 (e).

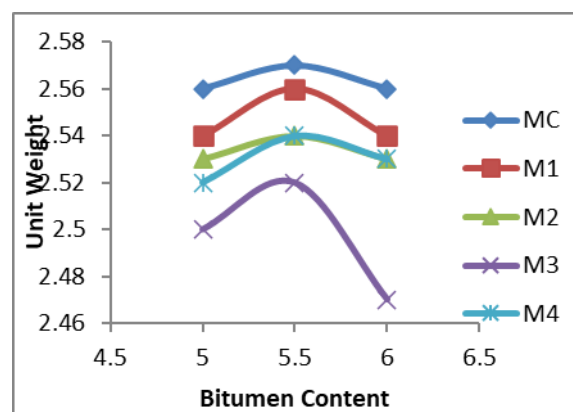


Figure 5.4(a). Unit Weight Vs Bitumen Content

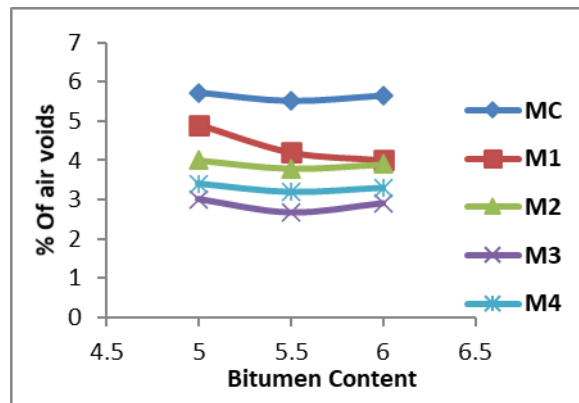


Figure 5.4(b). % of Air Voids Vs Bitumen Content

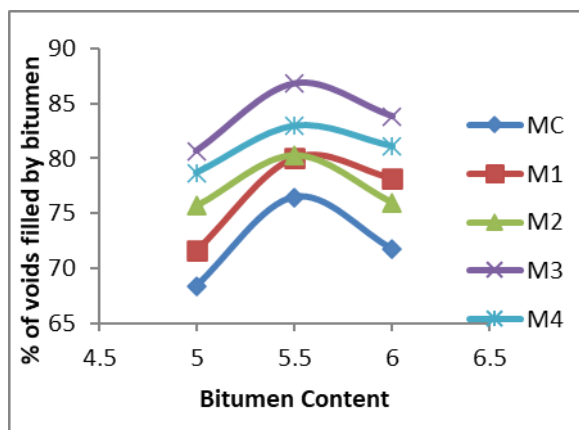


Figure 5.4(c). % of Voids Filled by Bitumen Vs Bitumen Content

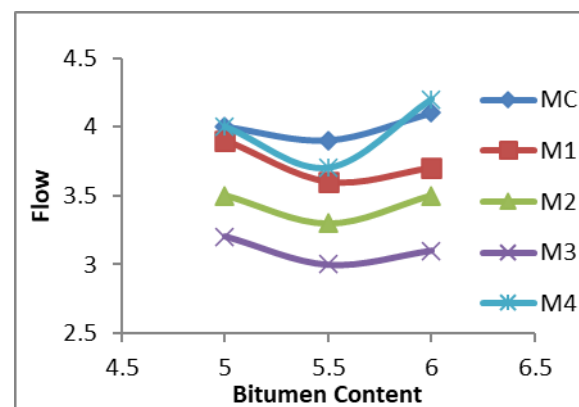


Figure 5.4(d). Flow Vs Bitumen Content

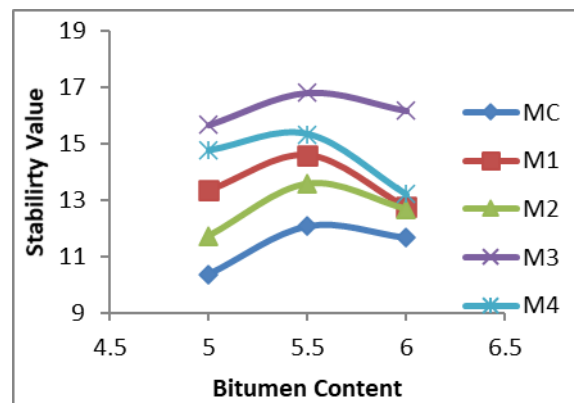


Figure 5.4(e). Stability Vs Bitumen Content

6. CONCLUSIONS

1. The unit weight is more for nominal mix as compared to the modified bitumen whereas inmodified bitumen, the unit weight is least for the mix-3 proportion.
2. The void percentage is more for the nominal bitumen mix when compared to the modifiedbitumen mix. The least percentage value of voids is 2.66%.
3. Void in the nominal mix is mostly filled by bitumen where as in modified bitumen; the voids are filled by bitumen and fiber. Hence, the bitumen percentage for filling voids is less when compared to nominal mix.
4. The flow value is more for the nominal mix whereas the modified bitumen is having much lesser flow value. In nominal mix, the maximum flow value is 4.1mm where as in modified bitumen mix flow value is 3.1mm.
5. The stability value is higher for the Mix-3 proportion than others. The maximum stability value for modified Bitumen is 16.79 kN,whereas for nominal mix the maximum value is 12.07kN.

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