International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

Rutting Behaviour of Bituminous Concrete by Using Crumb Rubber Modified Bitumen & Plastic Coated Aggregates

BHUPENDRA KUMAR SIRBAIYA
Civil Engineering and Applied Mechanics Department
Shri Govindram Seksaria Institute of Technology and Science, Indore (M.P.)
[An Autonomous Institute affiliated to RGPV, Bhopal]

Abstract

In later past, need of change in execution of adaptable asphalt by utilization of waste material has been felt because of expanding power of troubles and collection of extensive measure of plastic squanders alongside scrap tires. Rutting is one of the upsets in adaptable asphalt which is basic as a result of both its temperament and power watched everywhere throughout the spots. Surface courses in adaptable asphalts are viewed as most essential in handling with rutting.

Rutting is portrayed as the social affair of little measures of unrecoverable strain coming to fruition due to associated weights to the black-top. In sort it is a vertical bitterness found in road in longitudinal configuration. On account of repeated overpowering wheel load, in transit of wheel this demoralization happens longitudinally. IRC 37-2012, recommended that dominatingly rutting happen in surface course and this can be minimized to an uncommonly lesser degree by usage of PMB or CRMB. The Experiment performed in this investigation generally focus to secure changed bituminous mix which minimize rutting without decrement of whatever other quality parameter of bituminous mix.

In past a few looks into perform by adding a few added substances to bituminous mix and got a positive result. Here LDPE (Low Density polyethylene) was utilized as a part of various changing substance, 3%, 6%, and 9% by weight of aggregates along with granulated crumb rubber, 5%, 10%, 15% by weight of bitumen. The bituminous mix is modified by replacing bitumen with CRMB and normal aggregates with LDPE coated aggregates. It was found that stability is greater when 10% of crumb rubber by weight of bitumen as compared with conventional mix. By

use of plastic coated aggregates in place of normal aggregates further increase in stability is observed. CRMB-10 with LDPE-6 coated aggregates is determined as most stable modified bituminous mix. As a result of Grading1 stability of Modified bitumen with 10 % rubber increased 14.8% to conventional mix of VG30. When the conventional mix modified with (CRMB 10%+LDPE6%) the stability increased about 22.22% as compare to the conventional mix For the BC of grading2 the stability of modified with CRMB 10% rubber is increased by 23.8% to the normal conventional mix of VG30. The stability of CBMB10% coated with 6% LDPE is increased 30.8% from the normal mix. Optimum bitumen content in conventional mix is obtained as 5.48% which is reduced to 5.6% in case of CRMB-10 mix and 5.2% in case of CRMB-10 + LDPE-6 mix (For grading 1). Optimum bitumen content in conventional mix is obtained as 5.83% which is reduced to 5.68% in case of CRMB-10 mix and 5.0% in case of CRMB-10 + LDPE-6 mix for grading2.

In the mix of grading 1, percentage increase in rut depth on conventional mix when temperature changes from 40^0C to 60^0C, is 56.3% whereas that for CRMB-10 mix is 47.6% and for CRMB-10 + LDPE-6 mix this value is 28.9%. In the mix of grading 2, percentage increase in rut depth on conventional mix when temperature changes from 40^0C to 60^0C, is 53.2% whereas that for CRMB-10 mix is 41.45% and for CRMB-10 + LDPE-6 mix this value is 13.9%.

In the mix of Grading 1 at 40^0C, 22.05% of decrease in rut depth at 2500 cycles is observed when instead of conventional mix,CRMB-10 mix is adopted and 30.14% of decrease in rut depth is observed when instead of conventional mix CRMB-10 + LDPE-6 mix is adopted. Thus the area where density of vehicle is so high & due to congestion of traffic application of brake increases the chance of distresses in pavement as high rut depth on BC surface course. The modified bituminous mix (having crumb rubber modified bitumen along with plastic coated aggregates) is more suitable than conventional mix due to its high rut resistance. Plastic coated aggregate – crumb rubber modified mix shown negligible increase in rutting even when significant temperature change occurs. Hence such modified mixes could be used in areas having large temperature variations. Thus modified mix with crumb rubber modified bitumen as binder and LDPE coated aggregate, could be used to full replacement of conventional mix for BC, with improvement in performance and environmental betterment.

1.1 General

Rutting is a depression in the direction of length of wheel tracks. The ruts are usually of the width of wheel path. Swerving from a rutted wheel path at high speed can be dangerous. Collection of water in the impressions can cause skidding. Adjacent bulging of the road surface may or may not occur along with rutting which may give some indication of the depth of the source of failure. Rutting is the permanent deformation; it can be defined as the small amounts of unrecoverable strains as a result of applied loading to a pavement. Rutting occurs when the pavement under loading consolidates and or there is a transverse movement of the hot bituminous mix. The transverse movement is a shear failure and mostly occurs in the top portion of the pavement surface. Number of the test procedures has been performed for evaluation to predict rutting in the laboratory. Wheel tracking test simulates traffic loading on pavements. The conditions of the test are same as the pavement conditions in service to obtain ruts under a defined load cycle. The wheel tracking test has a feasible alternative in evaluating the rutting and test results can be used as predictive measures to analyze the result of HMA mixture in road conditions. The major dominant mode of the transport in India is the Road Transport, carrying close to 95% of the passenger traffic &75% of the freight transport. In India, flexible pavement type of construction is chose over the rigid pavement type of construction due to its many advantages such as lower initial cost, maintenance cost etc. Therefore, all the surfaced roads, maximum is the percentage of the bituminous pavements. In spite of the prominence of the surface transport, most of the roads are badly managed and poorly maintained. Bitumen is material which is use as binder & water proofing material for construction of roads, pavements & air field surfacing for several years .The demand of bitumen has increased tremendously because of rapid urbanization in recent years. The objective can be achieved by enhancing the durability of existing road surfacing which will result in reducing maintenance & resurfacing operations. Hence, the modification of bitumen to meet the required performance standards of the pavement appears to be logical & economical approach. Bituminous pavement fails to give the use of crumb rubber in bitumen modification helps in achieving better performance of wearing courses.

1.2 Crumb rubber

Crumb rubber is a term usually applied to recycled rubber from automotive and truck scrap tires. During the recycling process steel and fluff is removed leaving tire rubber with a granular consistency. Continued processing with a granular or and/or cracker mill, possibly with the aid of cryogenics or mechanical means, reduces the size of the particles. The particles are sized and classified based on various criteria including color (black only or black and white).

Sources of crumb rubber

Crumb rubber can be obtained from truck tyres or automobile tyres or both. Truck tyres contain 80 percent more rubber hydrocarbons than automobile tyres and also contain significantly higher amounts of natural rubber. Whole truck tyre contains 18 per cent natural rubber compared to 9 per cent in an automobile tyre and 2 percent in tyre treads. The amount of natural rubber has shown to affect the properties of CR


Figure 1. 1 Waste tyre & Crumb rubber

1.3 CRMB

CRMB is hydrocarbon binder obtained through physical and chemical interaction of crumb rubber (produced by recycling of used tyres) with bitumen and some specific additives. The Flexural range of CRMB offers binders which are stable and easy to handle with enhanced performances. CRMB is suitable for pavements submitted to all sorts of weather conditions, highways, traffic denser roads, junctions, heavy duty and

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

high traffic sea port roads etc. It is a durable and economical solution for new construction and maintenance of wearing courses. In this paper, the properties of CRMB by varying the percentage of rubber ranging from 5% to 25% with an increment of 5% will be studied. Crumb rubber is one of the commonly used asphalt additives for this purpose. Rubber from discarded tyres has been used in various highway applications for over 50 years. Generally, the tyre rubber is ground to a particulate or crumb prior to adding it to bitumen**.**

This form of the tyre rubber is called Crumb Rubber Modifier (CRM5, 10, 15). When CRM is added to bitumen, the resulting product is called Crumb Rubber Modified Bitumen (CRMB)

The advantages of modified bitumen can include one or more of the following for road works.

- Lower susceptibility to daily & seasonal temperature variations.
- Higher resistance to deformation at elevated pavement temperature.
- Better age resistance properties.
- Higher fatigue life of mixes.
- Better adhesion between aggregates & binder.
- Prevention of cracking & reflective cracking.
- Overall improved performance in extreme climatic conditions & under heavy traffic conditions.

3.1 Methodology used

As per the standard test for selection of optimum bitumen content marshal method is appropriate. This method uses standard test specimen. Before start the experimental work, collection of material and their test has been performed. First of all gradation was done. The gradation of aggregate was done according to standard MORTH with IS: 2386 Part1. In my research work, the bituminous concrete is selected as a surface course material. After the proper grading the test specimen was prepared with varying percentage of bitumen and cement content. Preparation of sample was done with different specification as per my research work. The following type of sample with their material was prepared in my experimental work:

1. Normal mix with varying percentage of bitumen.
2. Preparation of CRMB

As per wet process of mix, crumb rubber modified bitumen with different percentage of rubber. In my work, 5%, 10%, 15% of crumb rubber was taken by replacing the bitumen. The 425 micron size of crumb rubber was taken for preparation of sample.

3. CRMB coated with LDPE;

In these sample different percent of rubber used with different proportion of LDPE (3%,6%,9%) . This type of mix was made with both type of process one is dry process and other is wet process. Wet process was done for the crumb rubber and dry process for LDPE. From all result of Marshall Method, optimum binder content was found with their dry density. After the marshal test rutting test was performed for those sample which gave higher stability, the comparisons also made between all the samples.

Normal mixes with different proportion of bitumen.

Modified bitumen with 10% rubber (CRMB).

Modified bitumen with 10%rubber coated with LDPE.

As per my specified test procedure of Wheel Tracking Equipment (WTE) developed for research work. To ascertain the effect of rutting by tracking a hard mould rubber wheel on the bituminous concrete under different applied load. To determine the effects of rutting, by using optimum binder content for plain bitumen VG-30, for modified binders with CRMB using definite proportion of rubber and CRMB coated with LDPE using 6% proportion replacing aggregate concrete surface, to determine the effect of rut depth on the sample with varying temperature and no of passes of wheel.

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

Study of material & their specifications

3.2.1 Bitumen

The bitumen should be viscosity grade paving bitumen as per IS specification IS:73. The type and grade of bitumen used depend upon the climatic conditions & traffic over the pavement. The no of test was performed on laboratory, the results are shown.

Table 3.1 Specification of Test of bitumen

Property tested	Specification	Result
Penetration (100 g, 5 sec at 25**0**C) (1/10**th** of mm)	IS 1203-1978	60
Softening Point , **0**C (Ring & Ball Apparatus)	IS 1205-1978	50
Ductility at 27**0**C (5 cm /min pull), cm	IS 1208-1978	65

Selection for viscosity grade bitumen, depend on highest and lowest daily mean temperature at a particular site are given..

Selection criteria for VG based on climatic condition

Table 3.2 Specifications dependent on Temperature

Lowest daily mean air temperature ^{0}C	Highest Daily Mean Air Temperature, ^{0}C		
	Less than 20^{0}C	20 to 30^{0}C	More than 30^{0}C
More than-10^{0}C	VG-10	VG-20	VG-30
-10^{0}Cor lower	VG-10	VG-10	VG-20

3.2.2 Aggregates

a) Coarse aggregate

The coarse aggregate should be consists of crushed rock, gravel or other hard material retained on 2.36 mm sieve. It should be clean, hard, and durable, except that the aggregate should satisfy the physical requirements and where crushed gravel is proposed for use as aggregate, not less than 95 percent by weight of crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

b) Fine aggregate

Fine aggregates should consist of crushed or naturally occurring material, passing the 2.36 mm sieve and retained on 75 micron sieve.

The plasticity index of fraction passing the 0.425 mm sieve shall not exceed 4.

The gradation of aggregate & binder content as per **MORTH**

3.2.3 Filler

The filler are always free from organic impurity filler should be a finely divided material such as rock dust or cement approved by test.

3.2.4 Waste rubber

Rubber from waste tyres has been used in highway applications for over 40 years. Generally, the rubber is crumbed prior to adding it to bitumen. This powder form of the crumb rubber is called Crumb Rubber Modifier (CRM).

The rubber is collected from lot of wastage of tyre. The size 425 micron is selected for crumb the rubber as our thesis work.

3.2.5 Waste plastic

The waste plastic has been used in highway since 40-50 years. The form of waste plastic is used as PMB in surface course. In my thesis, the main property i.e. coating of plastic play significant role for reducing distresses, specially rutting. We were used LDPE as a coating material, the LDPE mixed with CRMB in dry process.

3.3 Testing of Material

3.3.1 Testing of aggregate

Before start the test all the specifications related to our material was tabulated in previous section. All the test of aggregates was carried in laboratory as per their method given in Manual.

a) Water absorption test

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

Water absorption gives an idea of strength of rock. The stone which are having more water absorption gives higher porosity in nature and are generally consider less suitable based on strength. It also have lesser resistance to impact and hardness.

b) Specific gravity test

The specific gravity of an aggregate is considered to be measure of strength or quality of the material. Stones having low specific are generally weaker than those of higher specific gravity values. The specific gravity of aggregate is used to calculating the void content in compacted bituminous mixes.

The apparatus consist of the following:

1) A balance of 3 kg, to weight accurate of o.5 gm, and such a type to permit weighing of the sample container when suspended in water.

2) A thermostatically controlled oven to maintain temperature of 100^{0}C to 110^{0}C.

3) A container for filling water and suspending the basket.

4) An air tight container of capacity similar to that of the basket.

5) A shallow tray and two dry absorbent clothes, each not less than 75X45 cm. The specific gravity of coarse aggregate normally used in road construction range about 2.5 to 3.2 with an average value of about 2.70.Though higher specific gravity shows higher strength of aggregate. It is not possible to judge the suitability of aggregate without knowing the mechanical property such as impact, abrasion and crushing value.

Water absorption value generally ranges from 0.1 % to 2% for coarse aggregate normally used in road surface course. The IRC and MoRT&H give maximum specific value as 1% for aggregate as surface dressing material. As per the MoRT&H specification the max value of water absorption is 2% for the coarse aggregate used in bituminous concrete, semi dense bituminous concrete and dense bituminous macadam. The results of both the test are shown below.

Table 3.3 Water Absorption and Specific Gravity Test

S No.	Description	Sample No.	
		I	II
1	Weight of sample , gm.	2000	2000

2	Weight of vessel + sample + water (A) , gm.	6744	6748
3	Weight of vessel + water (B) , gm.	5508	5508
4	Weight of saturated and surface dry sample (C), gm.	1980	1984
5	Weight of oven dry sample (D) , gm.	1964	1968
6	Specific Gravity = D/(C-(A-B))	2.639	2.645
7	Apparent specific gravity = D/(D-(A-B))	2.697	2.712
8	Water absorption = (C-D)/(D)*100,%	0.814	0.813
	Mean Apparent specific gravity	2.70	
	Mean water absorption	0.8135 %	

c) Impact value test

The aggregate impact test is used to evaluate the toughness or the resistance of the stones. The aggregate impact test is to be conducted on the specified size of aggregate of size i.e. passing in 12.5mm and retained on the 10 mm sieve.

The specific maximum value of impact as per MoRT&H is 24% for the bituminous concrete surface. The aggregate impact value is expressed as the percentage of the fines passing 2.36 mm sieve shown in terms of the total wt of the sample.

Aggregate impact value = 100X$\mathbf{W_2/W_1}$

Where W_1 is the weight of oven dried sample & W_2 is the weight of broken aggregates passing 2.36 mm sieve after 15 blows of hammer. The impact test results are tabulated in the next page.

Table 3.4 Aggregate Impact Value Test

S. No.	Description	Sample no.	
		I	II
1	Total weight of dry sample taken (P)	322	318
2	Weight of portion passing 2.36 mm sieve (Q)	55.2	57
3	Aggregate impact value = Q/P*100	17.14	17.92
Mean aggregate impact value		17.53	

d) Crushing value test

Crushing strength of road stones may be determined on cylindrical stone specimens cut out of the rocks or by finding the resistance of coarse aggregates under applied load.

e) Aggregate abrasion value test

Due to the movement of the traffic, the road stones used in the surfacing course of pavements are subjected to wearing action at the top surface. Resistance to wear or hardness is hence an essential property of road aggregate specially for the wearing course thus the road stone should be hard enough to resist abrasion due to traffic.

As per the MoRT&H specifications the maximum los Angeles abrasion value for bituminous concrete is 30 percent. The result of crushing value and the abrasion value are tabulated below in sequence:

Table 3.5 Aggregate Crushing Value Test

S. No.	Description	Sample no.	
		I	II
1	Total weight of dry sample taken (P)	3250	3235

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

2	Weight of portion passing 2.36 mm sieve (Q)	565	561
3	Aggregate crushing value = Q/P*100	17.4	17.3 4
Mean aggregate crushing value		17.37	

Table 3.6 Aggregate Abrasion Value Test

S. No.	Description	Sample no.	
		I	II
1	Original weight of the sample (P)	5000	5000
2	Weight of aggregate retaining 1.7mm sieve (Q)	3749	3719
3	Loss of weight = P-Q	1251	1281
4	% wear = (P-Q)/P*100	25.02	25.62
Mean abrasion value		25.32	

e) Combined flakiness & Elongation Index:

The Flakiness index of an aggregate is the percentages by wt of the particles whose least dimension is less than three-fifth of their mean dimension. This test is not applicable to sizes smaller than 6.3 mm.

The Elongation index of an aggregate is the percentage by wt of particles whose greatest dimension is greater than one or four fifth times of their mean dimension. The elongation test is not applicable of size smaller than 6.3 mm

Table 3.7 Combined Flakiness and Elongation Index

Size of aggregate	Correspondin	Weight of	Corresponding	Weight of

Passing through IS sieve	Retained on IS sieve	g Thickness gauge size	Aggregate Passing through thickness gauge		Length gauge size	Aggregate Retained on Length gauge	
1	2	3	4		5	6	
Mm	Mm	Mm	determination		Mm	Determination	
			I	II		I	II
20	16	10.8	68	54	32.4	124	140
16	12.5	8.55	242	210	25.6	286	276
12.5	10	6.75	80	92	20.6	90	81
10	6.3	4.89	28	36	14.7	26	22
Wt of Flaky particle			418	392	Wt to Elongated particle	263	261
Wt of non Flaky particle			2740	2766	**EIc=((263*100/2740)+(261*100/2766))/2=9.51 %**		
FI=((418+392)/2)*100/3158=12.82%				**CFEI=12.82+9.51=22.33**			

3.3.2 Testing of Bitumen

The bitumen used in this study is of viscosity grade 30 (VG30) for conventional as well as for modified mixes as a bituminous binder. Several laboratory tests were conducted. These tests and their results are shown below.

Table 3. 8 Bitumen Ductility Test

S.No.	**Description**	Sample no.		
		I	II	III
1	Initial reading (A)	0	0	0

2	Final reading (B)	76.8	75.8	76.6
3	Ductility = B-A ,cm	76.8	75.8	76.6
Mean ductility value ,cm		76.4		

3.4 Marshall mix Design

3.4.1 Marshall Method

Marshall Test apparatus consist of a cylindrical mould, a hammer, a compression machine. There specifications are, the objectives of the method are unit weight-void analysis and stability-flow test of the sample. The specification of Marshall apparatus as shown.

Table 3.9 Specification of Marshall Mix Design

Apparatus	Value
Mould	
Average internal diameter (cm)	10.12
Hammer	
Mass (Kg)	4.535
Drop Height (cm)	45.7
Blows at each side of specimen depend	50-75

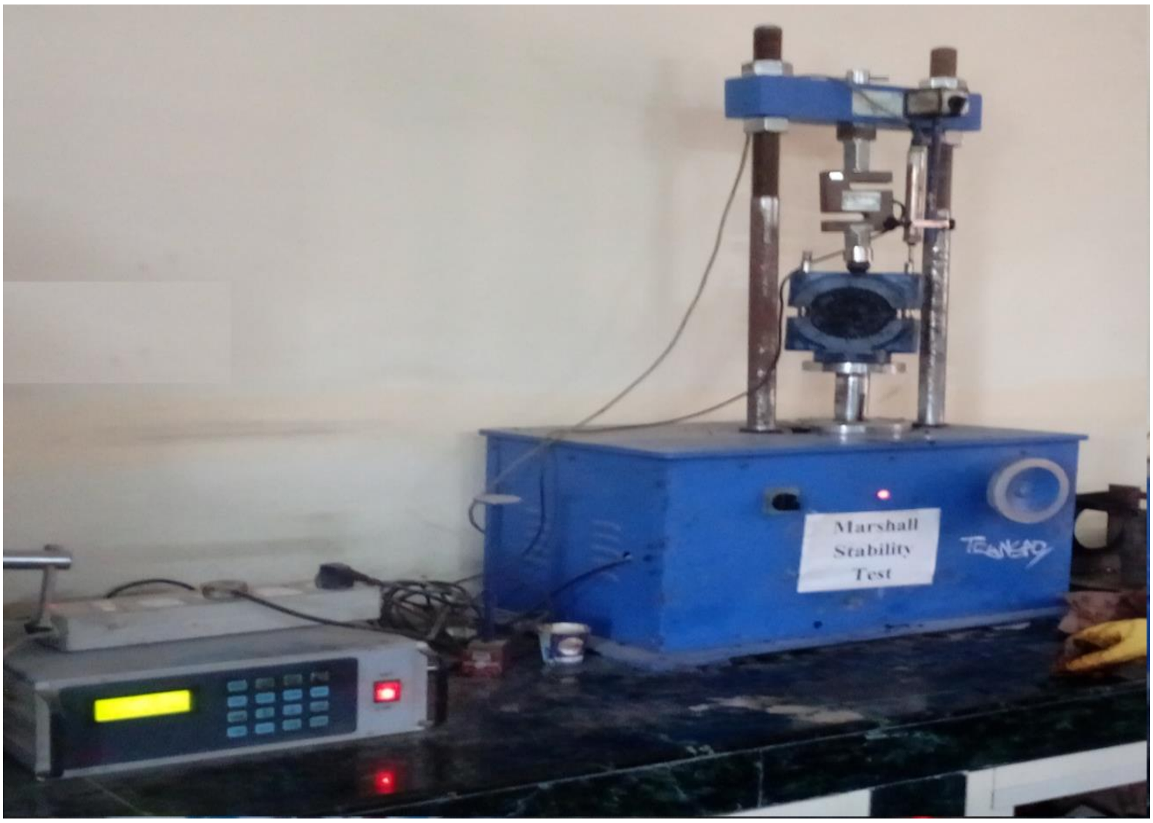


Figure 3.1 Schematic view of Marshall Test apparatus

The Marshall test & rut test are performed in sequence, for both the test some initial steps are follows given below;

3.4.2 Preparation of specimen

The test specimens were prepared with different cement content such that two value lower & two value above the optimum. The proportions of binder content were selected as per our material i.e. bituminous concrete.

The aggregate and bitumen heated at desire temperature separately and mixed them at required temperature. The samples were compacted by giving 75 blows on both faces of the test specimen. All the specification for preparation of specimen was selected as per MoRT&H. All three type of specimen i.e. normal VG30, CRMB, CRMB with LDPE coated, were prepared separately. Five samples were prepared for each type of mix. For CRMB, the wet process was done, the crumb rubber was mixed with bitumen for 30 minute stirred at 700 rpm & for CRMB coated with LDPE, the dry process was done for the coating of aggregate with LDPE, the cutting of polythene was

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

mixed with aggregate at desire temperature. The entire samples were prepared for grading I and grading II.

3.4.3 Testing of specimen

After the preparation of sample, all the sample were kept in a lab for room temperature, then sample were kept on water bath for 30 minutes at 60^0C.

After that we were placed the sample on the mould in sequence and the reading were taken. The Marshall Test give two property of specimen i.e. flow value and stability. The stability is the load just at failure of the specimen. After the test all results were tabulated separately.

Figure 3. 2 Samples of Marshall Test

3.4.4 Determination of weight, volume of sample and void analysis

After the tabulation of the result, the relation between bitumen content and all Marshall Parameters were established, and drawn the plots between them.

The relations between all parameters are given as follows;

1. Unit weight v/s bitumen content.

2. Marshall Stability v/s bitumen content.

3. Percentage voids v/s bitumen content.

4. Flow value v/s bitumen content.

5. Percentage voids in aggregate v/s bitumen content.

After the plotting of graphs between the Marshall parameter and bitumen content, the Optimum bitumen content were determined from the following conditions

1. Point of maximum stability.

2. Point of 4 percent air void in mix.

3. Point of maximum density.

The average bitumen content from those plots was taken as Optimum bitumen content. The OBC were calculated for those samples which gave maximum stability. In the analysis of test result, the mix of 10% of crumb rubber & CRMB coated with 6% LDPE were resulted higher stability among all. After the Marshall test, the evaluation test were done for the higher stable mixes & established the comparisons between virgin BC mix, CRMB & CRMB coated with LDPE.

3.5 Wheel Rut Test

There are two machine are required for perform the test one is wheel rut shaper & another is wheel rut tester.

3.5.1) Wheel rut shaper

Wheel rut shaper consists of hydraulic load hammer with desire temperature to compact the specimen. This apparatus is the new version of researched lab machine used in the highway: equipped with the hydraulic, mechanical and electric power, it has the benefit as smaller in size, higher degree of automation, better functioning and easier to run compared to the other product with same work.

- Pressure: 0-20KN
- Precision <0.1KN
- Height: 30-100mm

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

Main technical index of wheel rut shaper

Table 3.10 Machine specifications

Parameter of shaper	Specification
Sample mode space	300x300x(30-100)
Radius of roller	500 mm
Width of roller	300 mm
Speed of velocity model	6 times round-trip/min
Pressure of roller	20 KN (adjust at desire)
Outer dimension	1750x1216x640
The weight of machine	500 Kg
Worm up temperature	20-200 degree
Hydraulic Power	3 KN

3.5.2) Wheel rut tester

Wheel rut Tester is applied to ascertain the resistance offered by bituminous surface course against permanent defoliation at critical temperatures and under loading similar to what the pavement surface is applied. This test consists of wheel which simulates the traffic load conditions. The wheel rut tester is assembled such that the temperature of the test condition also simulates with the climatic conditions. This rut tester is attached with computer. Wheel track rutting test with the reciprocating motion of loaded wheel on bituminous specimens determine the value of bituminous pavement rutting. This is done by measuring the rut depth scratched over the sample along the tracking of tester's wheel at definite intervals by rut gauge. Desired rut-gauges should have sufficient accuracy at least 0.1 mm. The maximum limit of rut depth measured by wheel rut tester is 20 mm and then the machine turn off.

The specifications of wheel rut tester are given below in tabular form

Table 3.11 Rut Tester Specifications

Machine parameter	Specification
Wheel Rut Tester	
Wheel speed (Passes/minute)	42
Running distance of testing car (mm)	230±1
Pressure between specimen and wheel (Mpa)	0.7±0.05
Mould size(mm) LxBxH	300x300x50
Displacement measuring range(mm)	0-30
Test time (minute)	60
Temperature range (^{0}C)	40-60

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

Figure 3. 3 Wheel tracking device and specimen moulding machine

3.5.3 Preparation & testing of Sample

For the preparation of wheel rut testing specimen, about 11Kg aggregate of required gradation were weighed and heated up to 160-170^{0}C. Bitumen (virgin VG 30) was also heated up separately to 175-190^{0}C and the measured quantity of bitumen is mixed in the container where the aggregates were heated. Then we were mixed Aggregate and bitumen thoroughly in such way that the coating of aggregate was setup properly. The mix was poured into the mould and the mould was placed on the shaper's platform and started the machine for the compaction of the specimen with their desire temperature. After that the sample was kept under normal room temperature for 24 hour. In second day, we were placed the specimen on wheel rut tester, and all the formality of the test were done before started.

Observation tables

4.1 Marshall Test observations

Table 4.1 Grading I Middle; Binder - virgin VG30; Mix type Normal

Properties	% Bitumen Binder				
	5.2	5.4	5.6	5.8	6
Bulk Density(gm/cc)	2.452	2.456	2.462	2.458	2.456
Air Voids(%)	4.76648	3.66889	2.96748	2.73798	2.59186
VMA	17.3961	16.8922	16.7355	16.9851	17.3048
VFB	72.6003	78.2805	82.2683	83.88	85.0223
Stability(KN)	12.16	15.27	13.2	11	9.8
Flow(mm)	2.98	3.35	3.68	3.98	4.8

Table 4. 2 Grading I; Binder-Crumb Rubber Modified VG30 with 5% crumb rubber; Mix type Modified

Properties	% Bitumen Binder (CRMB)				
	5.2	5.4	5.6	5.8	6
Bulk Density(gm/cc)	2.443	2.452	2.462	2.460	2.463
Air Voids(%)	4.48174	3.6838	2.742	2.19483	2.068
VMA	17.2483	16.683	16.3122	16.2861	16.6156
VFB	71.9291	77.98	83.18	86.5042	87.5527
Stability(KN)	12.63	14.72	16.03	13.99	12.33
Flow(mm)	2.99	3.19	3.94	4.8	5.34

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

Table 4.3 Grading I; Binder-Crumb Rubber Modified VG30 with 10% crumb rubber; Mix type Modified

Properties	% Bitumen Binder (CRMB)				
	5.2	5.4	5.6	5.8	6
Bulk Density(gm/cc)	2.458	2.468	2.472	2.466	2.462
Air Voids(%)	4.762	3.368	2.26	2.197	2.068
VMA	17.179	16.409	15.897	16.286	16.6156
VFB	72.279	79.4753	85.779	86.504	87.5553
Stability(KN)	13.26	15.63	17.53	14.72	12.87
Flow(mm)	2.96	3.13	3.73	4.45	5.03

Table 4.4 Grading I; Binder-Crumb Rubber Modified VG30 with 15% crumb rubber; Mix type Modified

Properties	% Bitumen Binder (CRMB)				
	5.2	5.4	5.6	5.8	6
Bulk Density(gm/cc)	2.459	2.467	2.482	2.483	2.478
Air Voids(%)	4.99	3.36	2.585	2.36	2.39
VMA	17.377	16.409	16.017649	16.426	16.8954
VFB	71.283	79.475	84.0187	85.62	85.813
Stability(KN)	13.55	14.79	15.99	13.39	11.89
Flow(mm)	3.01	3.49	3.96	4.82	5.49

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

Table 4.5 Grading I; Binder - Crumb Rubber Modified VG30 with 10% crumb rubber, Aggregates coated with 3% LDPE, Mix type Modified

Properties	% Bitumen Binder (CRMB + LDPE)				
	5.2	5.4	5.6	5.8	6.0
Bulk Density(gm/cc)	2.462	2.469	2.486	2.488	2.462
Air Voids(%)	4.56	3.231	2.201	2.125	2.032
VMA	17.16	16.209	15.561	16.145	16.325
VFB	73.142	80.32	86.52	87.52	88.325
Stability(KN)	13.66	16.21	18.45	15.23	13.45
Flow(mm)	2.86	3.1	3.63	4.23	4.98

Table 4.6 Grading I; Binder - Crumb Rubber Modified VG30 with 10% crumb rubber, Aggregates coated with 6% LDPE, Mix type Modified

Properties	% Bitumen Binder				
	5.2	5.4	5.6	5.8	6
Bulk Density(gm/cc)	2.465	2.472	2.487	2.485	2.465
Air Voids(%)	4.301	3.10	2.16	2.07	2.012
VMA	17.179	16.409	15.897	16.286	16.6156
VFB	73.15	74.66	86.745	87.367	88.938
Stability(KN)	14.02	16.63	18.66	15.98	13.68
Flow(mm)	2.06	2.89	3.40	3.79	4.48

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

Table 4. 7 Grading I; Binder - Crumb Rubber Modified VG30 with 10% crumb rubber, Aggregates coated with 9% LDPE, Mix type Modified

Properties	% Bitumen Binder				
	5.2	5.4	5.6	5.8	6
Bulk Density(gm/cc)	2.471	2.474	2.486	2.487	2.459
Air Voids(%)	4.301	3.10	2.16	2.07	2.012
VMA	17.179	16.409	15.897	16.286	16.6156
VFB	72.13	73.45	87.16	86.59	88.856
Stability(KN)	13.76	15.43	16.86	15.02	12.59
Flow(mm)	2.15	2.98	3.51	3.85	4.87

Table 4.8 Grading II; Binder- virgin VG30; Mix type- Normal

Properties	% Bitumen Binder				
	5.4	5.6	5.8	6	6.2
Bulk Density(gm/cc)	2.47	2.48	2.489	2.485	2.486
Air Void (%)	3.817	2.7939	2.40291	2.2546	2.12331
VMA	17.02	16.5866	16.6932	17.0184	17.35
VFB	77.578	83.1554	85.6106	86.752	87.762
Stability(KN)	14.33	15.03	13.98	11.01	8.89
Flow(mm)	3.6	3.71	3.82	4.19	5.83

Table 4.9 Grading II; Binder-Crumb Rubber Modified VG30 with 5% crumb rubber, Mix type Modified

Properties	% Bitumen Binder				
	5.4	5.6	5.8	6.0	6.2
Bulk Density(gm/cc)	2.471	2.474	2.477	2.462	2.460
Air Void (%)	4.9324	3.30512	2.60195	2.38045	2.25662
VMA	17.23	16.796	16.6319	16.8815	17.2131
VFB	72.231	80.3216	84.3556	85.899	86.8901
Stability(KN)	14.79	16.32	17.02	16.98	13.72
Flow(mm)	3.6	3.81	3.92	4.21	5.23

Table 4.10 Grading II;Binder Crumb Rubber Modified VG30 with 10% rubber, Mix type Modified

Properties	% Bitumen Binder				
	5.4	5.6	5.8	6.0	6.2
Bulk Density(gm/cc)	2.473	2.486	2.493	2.471	2.469
Air Voids(%)	4.153	2.987	1.95596	1.566	1.436
VMA	17.089	16.522	16.0788	16.188	16.518
VFB	75.69	81.8211	87.835	90.324	91.302
Stability(KN)	15.63	17.23	18.61	17.13	14.73

Flow(mm)	3.4	3.56	3.81	4.12	5.01

Table 4.11 Grading II Binder-Crumb Rubber Modified VG30 with15%crumb rubber, Mix type Modified

Properties	% Bitumen Binder				
	5.4	5.6	5.8	6.0	6.2
Bulk Density(gm/cc)	2.457	2.481	2.499	2.497	2.488
Air Voids(%)	4.539146	3.305119	2.279975	2.05448	2.093711
VMA	17.42286	16.79596	16.35629	16.60395	17.07511
VFB	73.94718	80.32194	86.06056	87.62656	87.73823
Stability(KN)	14.29	16.33	17.28	16.83	14.02
Flow(mm)	3.39	3.5	3.82	4.16	4.98

Table 4. 12 Grading II; Binder-Crumb Rubber Modified VG30 with 10% crumb rubber, Aggregates coated with 3% LDPE, Mix type Modified

Properties	% Bitumen Binder				
	5.4	5.6	5.8	6.0	6.2
Bulk Density(gm/cc)	2.494	2.496	2.498	2.482	2.478
Air Voids(%)	4.01	2.75	1.8623	1.456	1.178
VMA	17.045	16.427	16.0745	16.183	16.781
VFB	76.71	82.13	88.41	91.34	91.87

Stability(KN)	16.53	17.86	18.71	17.47	14.71
Flow(mm)	3.1	3.21	3.34	4.01	4.87

Table 4.13 Grading II; Binder - Crumb Rubber Modified VG30 with 10% crumb rubber, Aggregates coated with 6% LDPE, Mix type Modified

Properties	% Bitumen Binder				
	5.4	5.6	5.8	6.0	6.2
Bulk Density(gm/cc)	2.489	2.49	2.497	2.486	2.479
Air Voids(%)	4.01	2.75	1.8623	1.456	1.178
VMA	17.045	16.427	16.0745	16.183	16.781
VFB	76.71	82.13	88.41	91.34	91.87
Stability(KN)	15.76	17.96	19.66	18.03	15.71
Flow(mm)	2.98	3.02	3.14	3.56	4.46

Table 4. 14 Grading II Binder-Crumb Rubber Modified VG30 with 10% crumb rubber, Aggregates coated with 9% LDPE, Mix type Modified

Properties	% Bitumen Binder				
	5.4	5.6	5.8	6.0	6.2
Bulk Density(gm/cc)	2.489	2.491	2.492	2.483	2.479
Air Voids(%)	4.21	2.85	1.98	1.56	1.32

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

VMA	17.045	16.427	16.0745	16.183	16.781
VFB	75.09	81.01	86.41	90.13	90.79
Stability(KN)	14.62	16.56	17.68	17.02	14.89
Flow(mm)	3.02	3.12	3.31	3.76	4.49

4.2 Rut Test Observations

Rut test were performed by wheel rut testing machine on normal and modified mix at different temperatures, results are tabled as below

Table 4. 15 Result showing mix of VG-30 (Grading I)

Number of Passes	Virgin VG-30		
	Rut Depth(mm)		
	40^0c	50^0c	60^0c
0	0	0	0
500	1.46	2.36	2.38
1000	1.78	2.93	2.95
1500	2.1	3.19	3.4
2000	2.46	3.37	3.9
2500	2.726	3.805	4.262

Table 4. 16 Modified with 10% crumb rubber (Grading I)

Number of Passes	VG-30 (Modified by crumb rubber@ 10%)

	Rut Depth(mm)		
	40^0c	50^0c	60^0c
0	0	0	0
500	0.95	1.36	1.65
1000	1.2	1.56	2.1
1500	1.7	1.97	2.5
2000	1.87	2.83	2.96
2500	2.12	3.024	3.73

Table 4. 17 Modified with crumb rubber @10% and 6% plastic coated aggregate (Grading I)

Number of Passes	VG-30(Modified by crumb rubber@10%)and 6% plastic coated aggregate		
	Rut Depth(mm)		
	40^0c	50^0c	60^0c
0	0	0	0
500	0.62	0.84	1.04
1000	1.12	1.24	1.38
1500	1.28	1.4	1.65
2000	1.46	1.54	1.82
2500	1.90	2.15	2.45

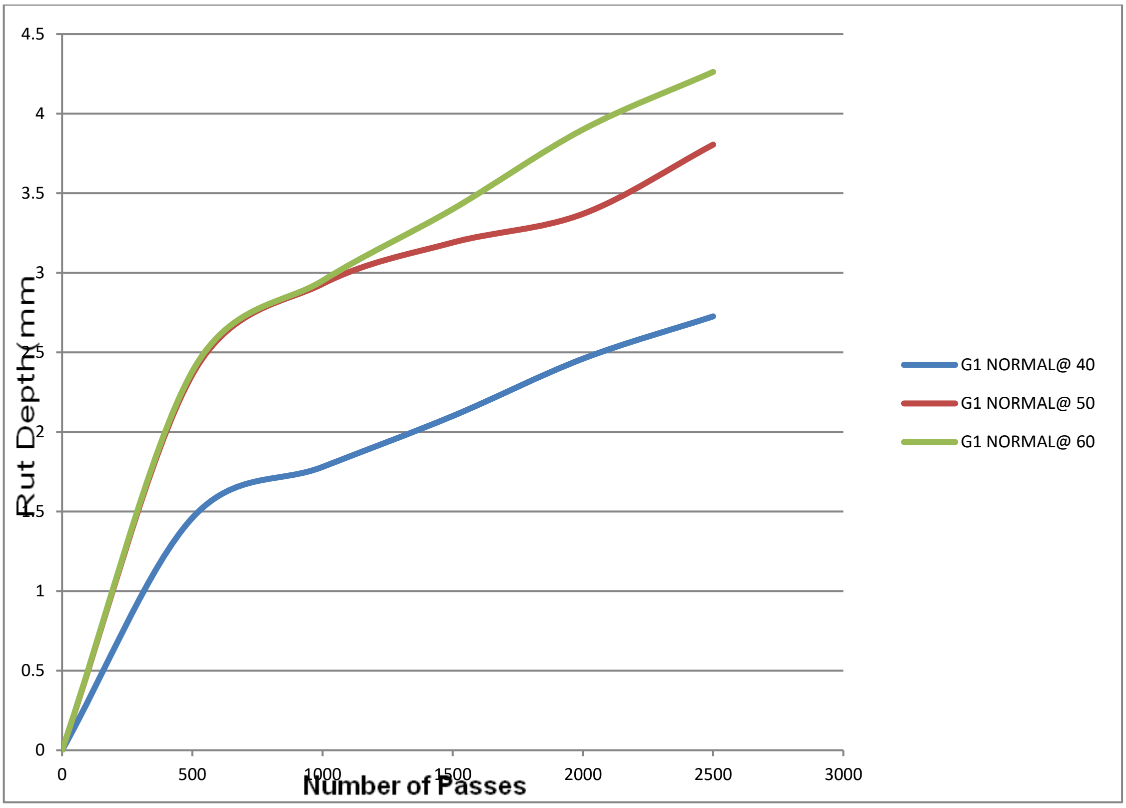


Figure 4. 1 Rut depth variation with no. of passes at diff. temp. for normal mix (G-I)

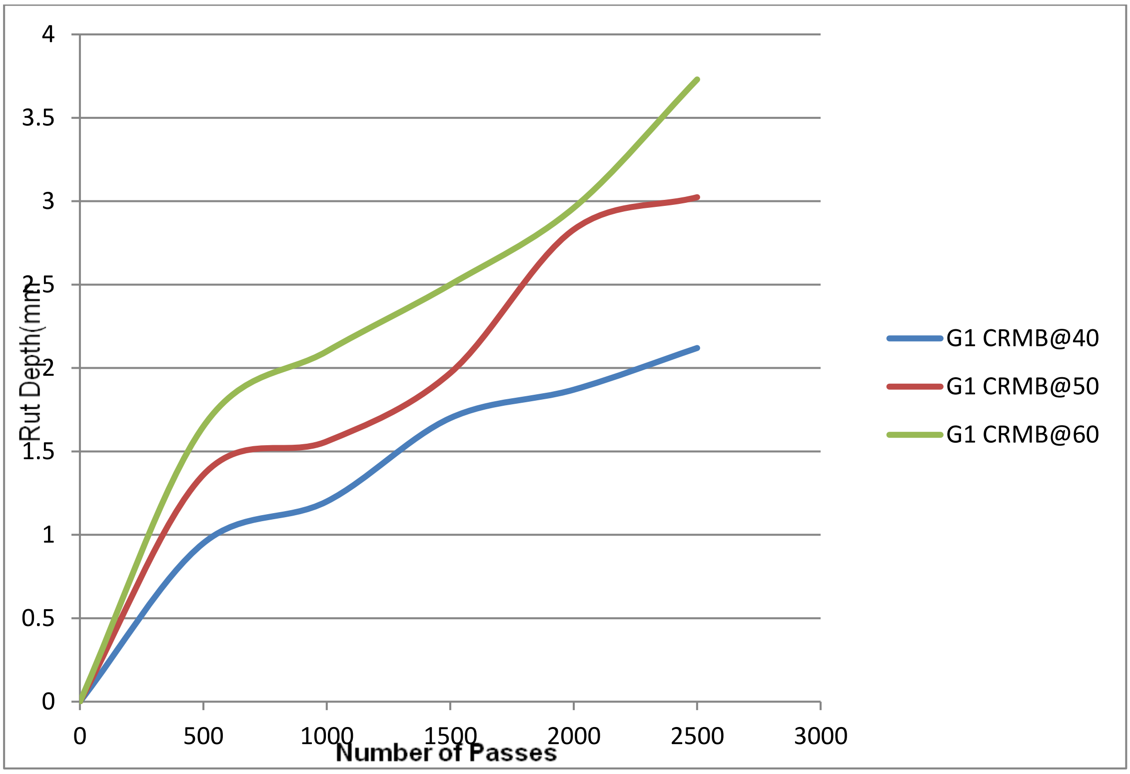
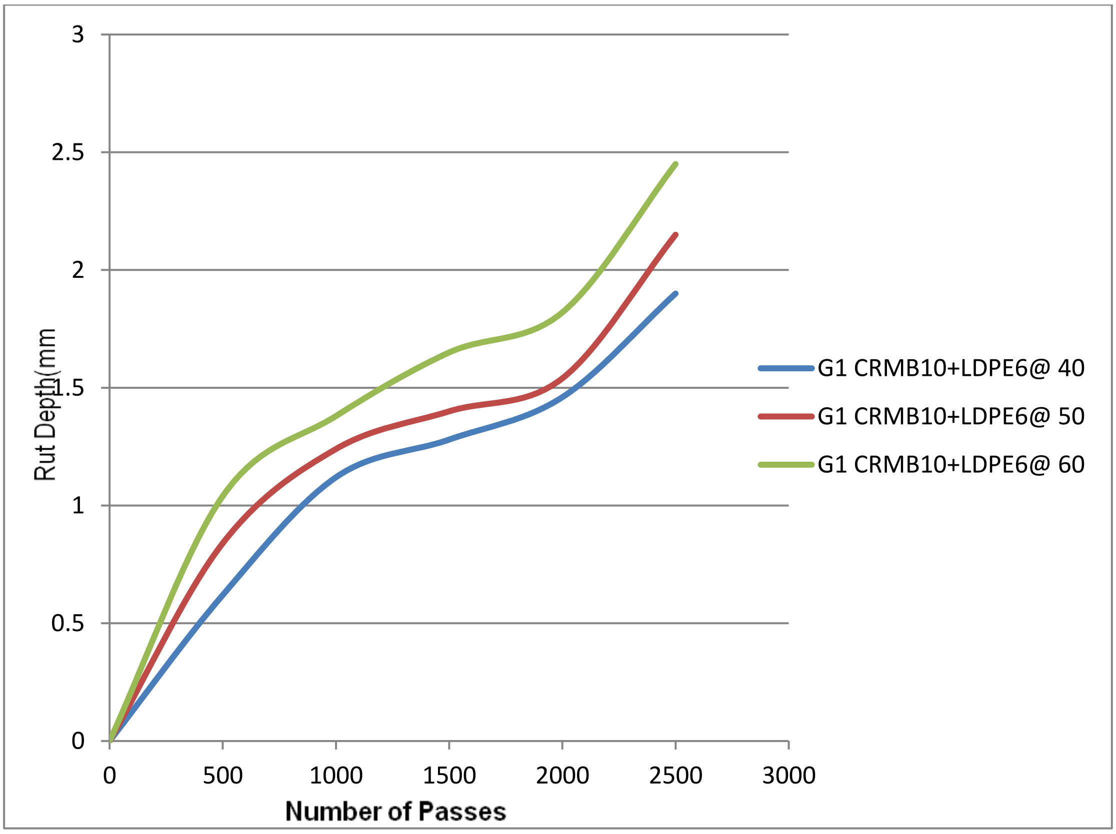


Figure 4. 2 Rut depth variation with no. of passes at diff. temp. for modified mix (G-I) with CRMB-10 as binder



e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

Figure 4.3 Rut depth variation with no. of passes at diff. temp. for modified mix (G1) with CRMB-10 as binder and LDPE-6

Table 4. 18 Grading II virgin mix of VG 30

Number of Passes	VG-30		
	Rut Depth(mm)		
Temperature	40^0c	50^0c	60^0c
0	0	0	0
500	1.32	1.96	2.39
1000	1.75	2.32	2.87
1500	1.96	2.47	3.12
2000	2.01	2.98	3.86
2500	2.56	3.12	3.90

Table 4. 19 Grading II VG-30 mix Modified with Crumb rubber @ 10%

Number of Passes	VG-30(Modified by crumb rubber@ 10%)		
	Rut Depth(mm)		
Temperature	40^0c	50^0c	60^0c
0	0	0	0
500	0.91	1.3	1.18
1000	1.42	1.56	1.58
1500	1.67	1.76	1.82
2000	1.78	1.86	1.99

2500	1.93	2.32	2.73

Table 4. 20 VG-30 Modified by Crumb rubber @ 10% and 6% plastic coated aggregate

Number of Passes	VG-30(Modified by crumb rubber@10%)and 6% plastic coated aggregate		
	Rut Depth(mm)		
Temperature	40^0c	50^0c	60^0c
0	0	0	0
500	0.78	0.93	1.08
1000	1.08	1.32	1.43
1500	1.43	1.57	1.65
2000	1.52	1.75	1.83
2500	1.86	1.99	2.12

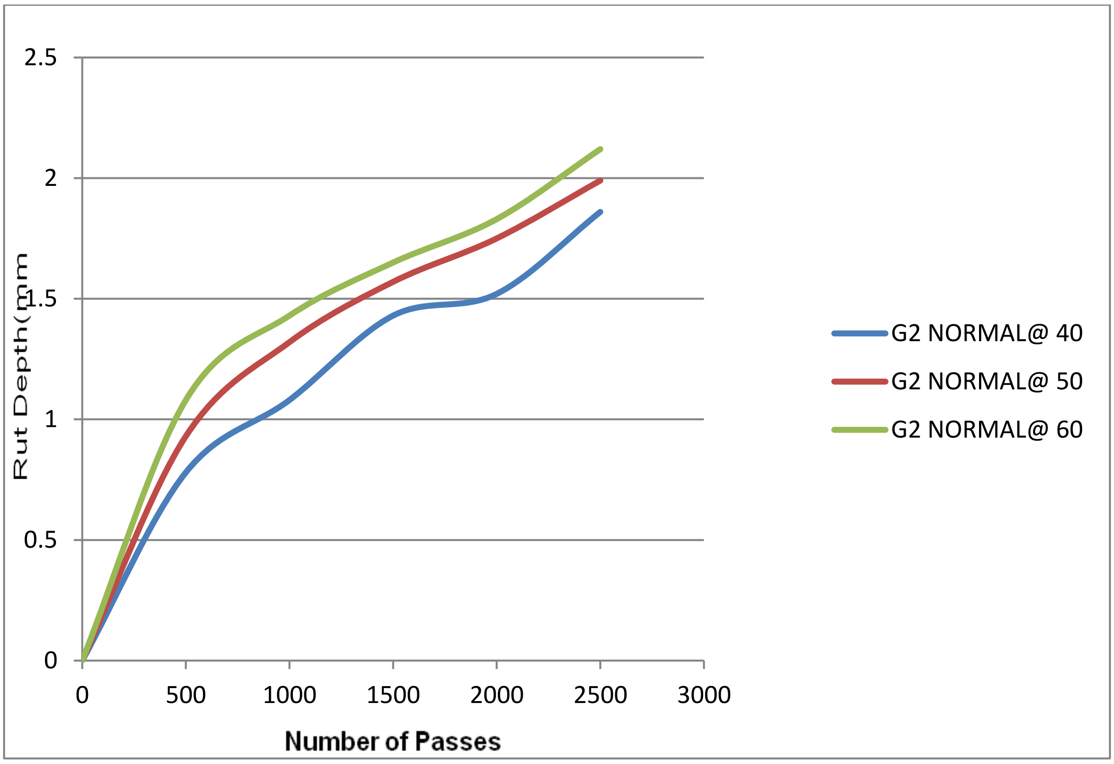


Figure 4. 4 Rut depth variation with no. of passes at diff. temp. for normal mix (G-II)

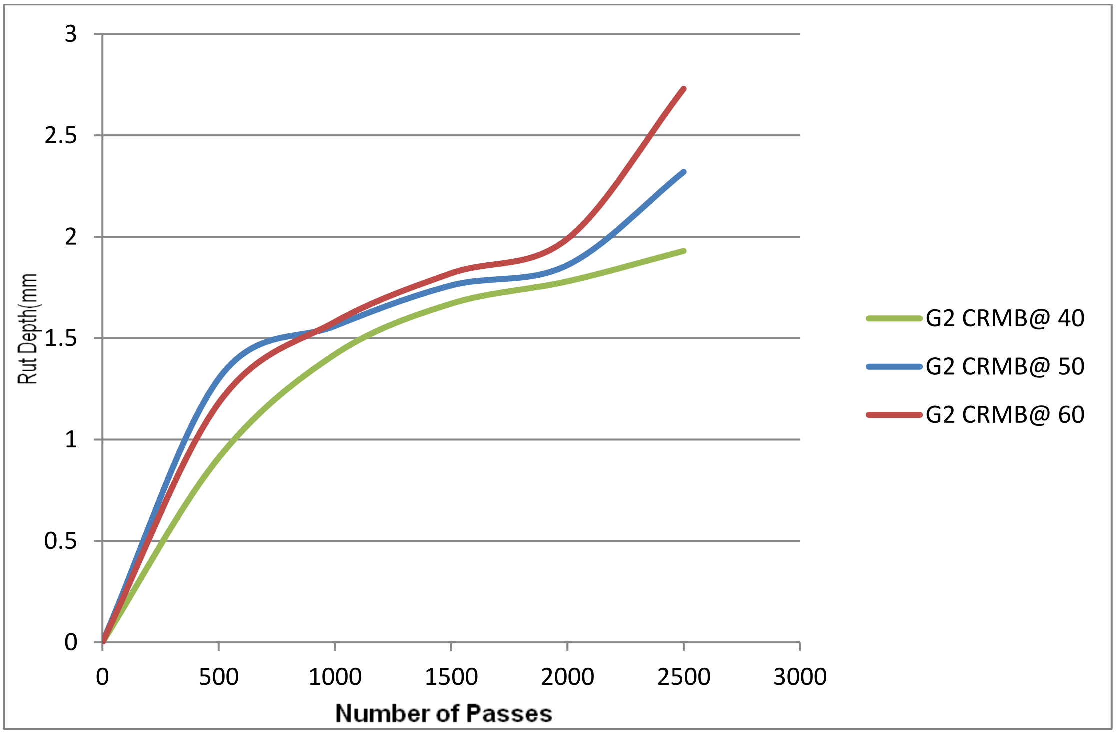


Figure 4. 5 Rut depth variation with no. of passes at diff. temp. for modified mix (G2) with CRMB-10 as binder

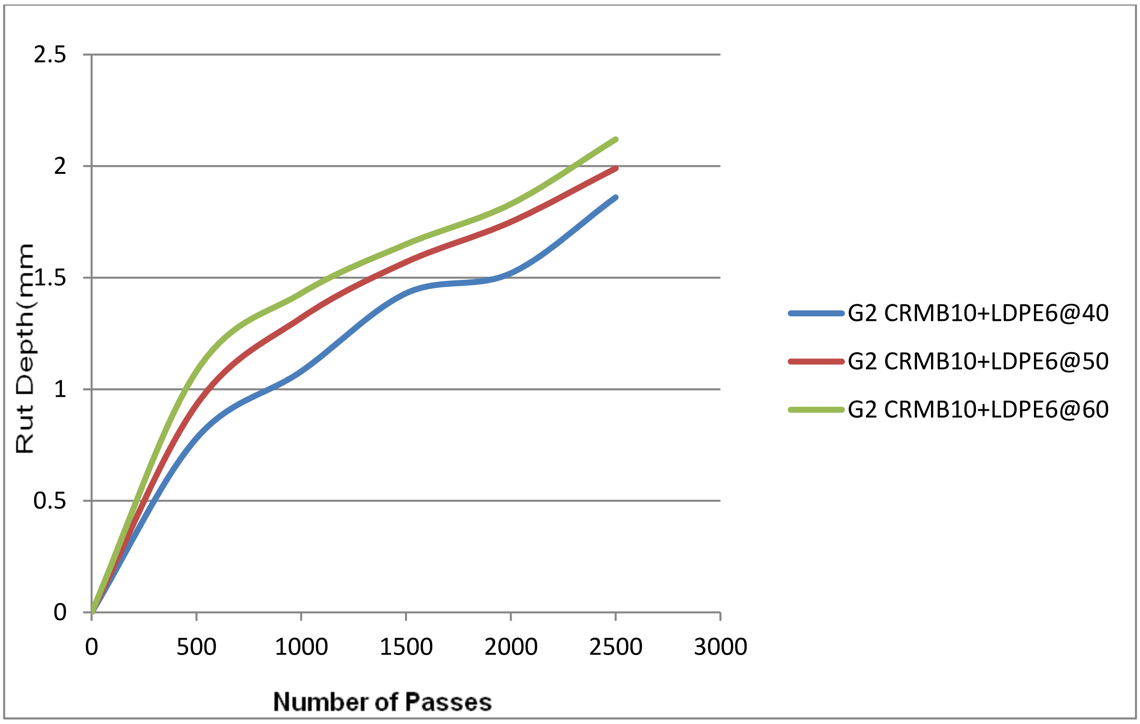


Figure 4.6 Rut depth variation with no. of passes at diff. temp. for modified mix (G1) with CRMB-10 as binder and LDPE-6

Results & Conclusions

- The stability of Modified BC mix with 10% crumb rubber is increased 14.8% as compared to conventional BC mix in Grading l and 22.2% stability increased by using 10%CRMB+LDPE6% in BC mix (Grading-I) as compare to the conventional mix.
- The stability of modified BC mix with 10% crumb rubber is increased by 23.8% as compare to the conventional BC mix in Grading ll. The stability of modified BC mix with CBMB10%+LDPE 6% is increased 30.8% as compared to conventional BC mix.
- The reduction of rut depth is 22.05% in CRMB10% modified BC mix at 40^{0}C as compare to conventional mix and 30.14% of decrease in rut depth when instead of conventional mix; CRMB-10 + LDPE-6 is adopted in grading I.

- The reduction of rut depth is 20.05% in CRMB10% modified mix at 50^{0}C as compare to conventional mix, and 43.4% of decrease in rut depth, when instead of conventional mix CRMB-10 + LDPE-6 mix is adopted in grading I.
- The reduction of rut depth is 12.02 % when CRMB10% modified BC mix is adopted and 42.4% of decrease in rut depth obtained when instead of conventional mix, CRMB-10+LDPE-6 modified BC mix is adopted at 60^{0}C.
- When CRMB10% modified BC mix is used the reduction of rut depth is 32.64% at 40^{0}C, when CRMB-10 modified BC mix is used and 37.6% of decrease in rut depth obtained when CRMB-10 + LDPE-6 mix is used instead of conventional BC mix in grading II
- The reduction of rut depth is 25%, when CRMB-10 modified BC mix used instead of conventional BC mix. and 36.2% of decrease in rut depth obtained when CRMB-10 + LDPE-6 modified BC mix is used instead of conventional BC mix in grading II at 50^{0}C.
- The reduction of rut depth is 30% when instead of conventional mix, CRMB-10 modified BC mix is adopted and 45.6% of decrease in rut depth when instead of conventional mix, CRMB-10+LDPE-6 modified BC mix is used in grading2 at 60^{0}C. Thus we conclude that BC mix modified with crumb rubber improve its property but modified with crumb rubber with LDPE improve its property significantly and the percentage of optimum bitumen content is reduced by using waste crumb rubber or waste plastic.

  It also concludes that the use of crumb rubber modified bitumen coated with LDPE is less susceptible to temperature; means there is a negligible increase in rut depth where the temperature variation is most common. Thus the conventional BC mix fully replaced by the modified BC mix satisfactory, for both the grading specified in the MoRTH i.e. Grading I & Grading ll.

  This analysis has no negative effect to the ecology as it decreases the quantity of rubberized waste; the rubber waste is used beneficially & gives better technology which is eco-friendly.

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 19
August 2018

Reference

- Bhattacharya, K., and Deshmukh, S. (2014).“Study on Rutting and Surface Behavior of Urban Flexible Pavement.”*International Journal of Research and Technology*, 3 (4), 730-735.
- Chakroborty, and Das. “Principles of Transportation Engineering.”*PHI Learning Private limited,* Ninth edition,300-301.
- Ganesh, K., and Kumar, S. (2012).“Studies on Effect of Wheel Configuration-Temperature and Type of Binder on Rutting Characteristics of Bituminous Concrete Mix.”*International Journal of Innovations in Engineering and Technology*, 2 (1),424-434.
- Indian Roads Congress (IRC).(2010). ‘‘Tentative guidelines on use of polymer and rubber modified bitumen in road construction.’’ *SP:53*,New Delhi, India.
- Jain, P. K., Kumar, S., and Sengupta, J. B.(2011).“Mitigation of rutting in bituminous roads by use of waste polymeric packaging materials.”*Indian Journal of Engineering & Materials Sciences*, 18,233-238.
- Khateeb,G., and Basheer, I. (2009).“A three-stage rutting model utilising rutting performance data from the Hamburg Wheel-Tracking Device.”*International Journal of Earth Sciences and Engineering*.4(5), 922-929.
- Indian Roads Congress (IRC).(2012). “Tentative Guidelines for Design of Flexible Pavement.”*IRC:37*, 13-15.
- Kadiyali, L.R.,“Principles and Practices of Highway Engineering.”*Khanna publishers*,Fifth edition,468, 497, 584.
- Kakade, V. B., and Reddy, M. A.(2014).“Effect of Type and Quantity of Binder on Rutting Characteristics of Bituminous Mix.”*Indian highway Journal*, 42 (3), 8-14.
- Khanna, and Justo. “Highway Engineering.”*Nemchand and Brothers*,Ninth Edition,292-294.

- Kumar, D., and Yadav, R. K. (2016).“Effect of Gradation of Aggregates on Marshall Properties of SDBC & BC Mix Design.”*International Journal of Research in Engineering and Technology*, 5 (2);25-30.
- Kumar, K. R., and Mahendran, N. (2014).“Experimental Studies on Modified Bituminous Mixes Using Waste HDPE and Crump Rubber.”*International Journal of Emerging Technology and Advanced Engineering*, 4 (4),587-597.
- Ministry of road transport and highways, (MoRTH) (2001).“Specifications for Road and Bridge Works.”*4th Rev*, 155-158.
- Pasalkar, A., Bajaj, Y., andWagh, A. (2015).“Comprehensive Literature Review on use of Waste Tyres Rubber in Flexible Road Pavement.”*International Journal of Engineering Research & Technology*, 4 (2), 685-689.
- Rokade, S. (2012).“Use of Waste Plastic and Waste Rubber Tyres in Flexible Highway Pavements.”*International Conference on Future Environment and Energy*, 28,105-108.
- Satish, B. K., and Ganesh, K. (2014).“Rutting Studies Of 100 Mm Thick Bituminous Concrete Mix with Plain and Modified Binders at Varying Temperatures.”*Indian highway Journal*, 42 (6), 26-36.
- Rajasekaran, S., Vasudevan, R., and Paulraj, S. (2013). “Reuse of Waste Plastics Coated Aggregates-Bitumen Mix Composite For Road Application.” *American Journal of Engineering Research*, 2 (11), 1-13.
- Shafabakhsh, G. H., Sadeghnejad, M., and Sajed, Y. (2014). “Case study of rutting performance of HMA modified with waste rubber powder.” *Case Studies in Construction Materials, ELSEVIER*, 69–76.