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An Experimental Study On Bitumen Properties By Using Medical Plastic Waste

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Abstract —: *The Bituminous concrete (BC) is a composite material mostly used in the construction projects like road surfacing, parking lots ,airports etc. It consists of the Asphalt or bitumen (used as a binder)and the mineral Aggregate which are mixed together and laid down in layers and then compacted. Now a day, the steady increment in the high Traffic intensity in terms of commercial vehicles, and also a significant variation in the daily and seasonal temperature put us in an demanding situation to think of some alternatives for improvisation of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strengths as well as economical aspects. Also considering all of the environmental approach due to excessive use of medical waste plastic in day to day ,the pollution in environment is enormous. Since the medical waste plastic is not the biodegradable, the need of the current hour is to use the medical waste plastic in some beneficial purposes. This paper presents a research conducted over to study the behavior of BC mix modified with bio medical waste plastic. Various percentages of plastic waste are used for preparation of mixes with selected aggregate grading as given in MORTH(Ministry of Road Transportation Of Highway)/IRC(Indian Road Congress)code. The important role of waste Plastic in the mixture is studied for various engineering properties by preparing Marshall samples of BC mixtures with and without polymer.The Marshall properties results are such as stability ,flow rate,air voids,unit weight which are used to determine optimum polythene content for the given grade of bitumen(60/70).*

Keywords: *Bituminous concrete (BC),Marshall stability, Flow value ,Optimum medical plastic waste content.*

I. INTRODUCTION

Mainly the Transportation plays important role not only to the economic but also industrial, social, and cultural development of any country in economical development of any region since every commodity produced even it is food, clothing, industrial products or medicine needs transport at all stages from production to distribution, production stages, transportation is required for carrying raw materials like seeds, manure, coal, steel etc.,during the transportation is required from the production centers viz.; farms and factories to the marketing centers and later to the retailer and the consumer for distribution. Meanwhile it is having of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade.the role of pavement should

be able to provide not only adequate skid resistance, surface acceptable riding quality but also favorable light reflecting characteristics, and low noise pollution. the main target is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the sub-grade. Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements. it shows an overview of pavement types, layers, and their functions, and pavement failures. the Improper designation of pavements results to early failure of pavements affecting the riding quality. On the contrary, in rigid pavements, wheel loads are transferred to sub-grade soil by flexural strength of the pavement and the pavement acts like a rigid plate (e.g. cement concrete roads).

furthermore composite pavements are also available.the main thin layer of flexible pavement over rigid pavement is an ideal pavement with most desirable characteristics. mostly such pavements are rarely used in new construction because of high cost and complex analysis required. things used in construction have been used in flexible pavement:

•Conventional layered flexible pavement,

•Full - depth asphalt pavement, and

•Contained rock asphalt mat (CRAM).

Construction of highway involves a huge outlay of investment. a perfect engineering design can save considerable investment; as well, a reliable performance of the highway, can be achieved. this design aims to estimate the proportions of bitumen, filler material, fine aggregates, coarse aggregates & polythene to produce a mix which should have

• Sufficient workability so that there is no segregation under load.

• sufficient strength to survive heavy wheel loads & tyre pressures.

• Sufficient durability.

• Should be economical.

Plastics are durable & non-biodegradable the chemical bonds make plastic very durable and resistant to normal natural processes of degradation. since 1950s, tons of plastic have been discarded, and they may persist for hundreds or even, thousands of years.mainly when it gets mixed with water, doesn't disintegrate, and takes in use of small pallets which causes the death of fishes and many other aquatic animals who mistake them as food materials.

mainly during of the plastic wastes is enormous, as the plastic materials have become the part and parcel, of our daily life. whether mixed with the Municipal Solid Waste or thrown over a land area. If they are not recycled, their present disposal may be by land filling or it may be by incineration. Both the processes have significant impacts on the environment. If they are incinerated, they pollute the air and if they are dumped into some place, they cause soil & water pollution. Under these circumstances, an alternate use for these plastic wastes is required.

Modification of BC, with the synthetic polymer binder can be considered as a solution to overcome the problems, arising because of the rapid increase in wheel loads and change in climatic conditions. Polymer modification can be considered as one of the solution to improvise the fatigue life, reduce the rutting & thermal cracking in the pavement. when added blended with the polymer, forms a multiphase system, containing abundant asphalt most significantly it will be conducted to explore the idea about use of waste material in bituminous concrete with detailed laboratory Investigation will be carry out to find whether it is viable to use or not in terms of suitability, economically and environmentally. at now it will focus basically on these following points:

1. about the basic physical and mechanical properties of waste plastic in order to contribute a better knowledge of its properties.
2. based on the effect on Marshall Stability of bituminous mix with the addition of waste plastic.
3. minimization of the bitumen content by the addition of Waste plastic in bituminous mix.

From the investigations on the bituminous mix have been carried out as per the Indian Standards used for the road construction. The field application is out of the scope of work.

II. MATERIALS USED

The materials used are as follows.

i. Aggregates

ii. Bituminous Binder

iii. Mineral Filler

iv. Medical plastic waste

At first the aggregates produces the granular part in bituminous concrete mixtures which contributes up to 90-95 % of the mixture weight and contributes to most of the load bearing & strength characteristics of the mixture. finally the quality and physical properties of the aggregates should be controlled to ensure a good pavement. The properties that aggregates should have to be used in pavement are shown below

1.Aggregates should have minimal plasticity. due to availability of clay fines in bituminous mix can result in problems like swelling and adhesion of bitumen to the rock which may cause stripping problems. Clay lumps and friable particles should be limited to almost 1%.

2.Durability or resistance to weathering should be measured by sulphate soundness testing.

3. The ratio of dust to asphalt cement, by mass should be a maximum of 1.2 and a minimum of 0.6.

4. It is recommended AASHTO (American Association of State Highway and Transportation Officials) T-209 to be used for determining the maximum specific gravity of bituminous concrete mixes.

5. Aggregates are of 2 types.

a) Coarse Aggregate (CA)

b) Fine Aggregate (FA)

So the aggregates of different grades were sieved through different IS Sieves and they were Kept in different containers with proper marking.

Specific Gravity of Coarse aggregate = 2.6

Specific Gravity of Fine aggregate= 2.03

III. BITUMEN

These are used for roadway construction, primarily because of their excellent binding characteristics and water proofing properties and relatively low cost. it consists of bitumen which is a black or dark coloured solid or viscous cementations substances consists chiefly high molecular weight hydrocarbons derived from distillation of petroleum has adhesive properties, and is soluble in carbon disulphide. Tars are residues from the destructive distillation of organic substances such as coal, wood, or petroleum and are temperature sensitive than bitumen Bitumen is the residue or by-product when the crude petroleum is refined. A vast sources of refinery processes, such as the straight distillation process, solvent extraction process etc. also used to produce bitumen of different consistency and other desirable proportionately sources and characteristics of the crude oils and on the properties of bitumen required, more than one processing method may be employed. addition of additives called as bitumen modifiers can improve properties of Bitumen and bituminous mixes. Bitumen treated with these modifiers is known as modified bitumen.mainly the Polymer modified bitumen (PMB)/ crumb rubber modified bitumen (CRMB) should be used should be used only in wearing course depending upon the requirements of extreme climatic. specification requirements for each property except specific gravity.

(i) Penetration

(ii) Ductility

(iii) Softening point

(iv) Flash & fire point

The bitumen used in preparing Marshall Samples was of 60/70 Penetration Grade.

Specific Gravity bitumen = 0.99

IV. MEDICAL PLASTIC WASTE

In order to grab the town planners, environmental activists and civic administrators, there is yet lack of concern for some special sources of waste and its management. merely such waste is bio-medical waste generated primarily from health care establishments, including hospitals, nursing homes, veterinary hospitals, clinics and general practitioners, dispensaries, blood banks, animal houses and research institutes. extra sources of biomedical waste are the following:

•Households

•Industries, education institutes and research centres

•Blood banks and clinical laboratories

The waste plastic like these syringes, saline bottles was used as raw material for preparation of the samples. These plastic bottles were collected; they were washed and cleaned by putting them in hot water for 3-4 hours. They were then dried.

Specific Gravity of waste plastic is = 0.905

The bio-medical syringe plastic waste needed for the work was collected from a private organization. The following tests on aggregates were done on aggregate

• Aggregate crushing value test

• Aggregate impact value test

• Specific gravity test

• Water absorption test

• Los Angeles abrasion test

Normal Marshall Mix specimens were prepared with bitumen contents of 5 percent, 5.5 percent 6 percent, 6.5 percent, and 7 percent.the content of Optimum Bitumen Content (OBC) was found out using Marshall Test. Plastic modified mix specimens with plastic contents of 5 percent, 7.5 percent, 10 percent and 12.5 percent by weight of bitumen were prepared through dry process by adding plastic to heated aggregates. the main marshall test was conducted on plastic modified mix specimens to find out the Optimum Plastic Content.

V. TEST ON AGGREGATES

Aggregate plays an important role in pavement construction. they are the load transfer capability of pavements. they should be checked and tested before using for construction.they should be strong and durable, they should also possess proper shape and size to make the pavement act monolithic ally. these are tested for strength, toughness, hardness, shape, and water absorption.
mainly used in pavement construction, following tests are carried out:

Crushing strength test
Abrasion test
Impact test
Shape test
Attrition test

most subjecting matter of aggregate in standard mould to a compression test under standard load conditions.mainly dry aggregates passing through 12.5 mm sieves and retained 10 mm sieves are filled in measure of 11.5 mm diameter and 18 cm height in three layers. foremost is tamped 25 times with at standard tamping rod.and sample is weighed and

placed in the test cylinder in three layers each layer being tamped again.that mixture is subjected to load of 40 tonnes gradually applied at the rate of 4 tonnes per minute. grinded into pieces aggregates are then sieved through 2.36 mm sieve and weight of passing material (w_2) is expressed as percentage of the weight of the total sample (w_1) which is the aggregate crushing value.
Aggregate Crushing Value (%) = w_1/w_2 *100
mixture lessthan of 10% signifies an exceptionally strong aggregate while above 35% would normally be regarded as weak aggregates.
this abrasion test based on los angles principals is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge.
which consists of circular drum of internal diameter 700 mm and length 520 mm mounted on horizontal axis enabling it to be rotated.

Specific gravity of bitumen,Gb = (w_3-w_1)/({(w_2-w_1)–(w_4-w_(3))})

VI. MARSHALL MIX DESIGN

this method to measure the load and flow rate of asphalt specimens, beginning with compaction into molds using manual or automated Marshall Compactors, and conditioned in a Water Bath at the specified temperature.

This wet mix determines the optimum bitumen content. There are many methods available for mix designs which vary in the size of the test specimen, compaction, and other test specifications. this mix design is the most popular one and is discussed below.

This Marshall Stability and flow test provides the performance prediction measure for the Marshall Mix design method. The test of stability measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute. when Load is applied to the specimen till failure, and the maximum load is designated as stability. and attached dial gauge measures the specimen's plastic flow (deformation) due to the loading. most flow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded. That involved in marshal mix design are summarized next.

That mix is designed in the laboratory considering the following requirements:

(a) The stability of the mix corresponding to the design binder content to be more than minimum specified value.

(b) Flexibility or deformation at failure to be within the specified range.

(c) Durability of the mix under stagnant water to be assessed by water sensitivity test

are proportioned by one of the method such as

(1) Analytical method.

(2) Graphical method.

(3) Trial and error method.

Generally it is attempted to obtain midpoint of the difference ranges are specified for the respective sizes vide IRC or MORTH specification.

The the bulk specific gravity of the mix Gm, percent air voids Vv , percent volume of bitumen, Vb ,and percent voids filled with bitumen VFBand VMA. These calculations are discussed next..

Theoretical specific gravity of the mix (Gt)

it is the specific gravity without considering air voids, and is given by:

$$G_t = \frac{W_1+W_2+W_3+W_b}{\frac{W_1}{G_1}+\frac{W_2}{G_2}+\frac{W_3}{G_3}+\frac{W_b}{G_b}}$$

where, W1is the weight of coarse aggregate in the total mix, W2 is the weight of fine aggregate in the total mix, W3 is the weight of filler in the total mix, Wb is the weight of bitumen in the total mix, G1 is the apparent specific gravity of coarse aggregate, G2 is the apparent specific gravity of fine aggregate, and G3 is the apparent specific gravity of filler and Gb is the apparent specific gravity of bitumen,

Bulk specific gravity of mix (G_m)

it is the actual specific gravity of the mix Gm is the specific gravity considering air voids and is found out by:

$$G_m = \frac{W_m}{W_m - W_w}$$

Where, is the weight of mix in air Wm, is the weight of mix in water Ww, Note that Wm-Ww gives the volume of the mix. the accurate bulk specific gravity, the specimen is coated with thin film of paraffin wax, when weight is taken in the water. This however requires considering the weight and volume of wax in the calculations.

Air voids percent (V_v)

Air voids is the percent of air voids by volume in the specimen and is given by:

$$V_v = \frac{(G_t - G_m)}{G_t} * 100$$

Where is the theoretical specific gravity(G_t)of the mix, and is the bulk or actual specific gravity (G_m) of the mix.

Percent volume of bitumen (V_b)

$$V_b = \frac{\frac{W_b}{G_b}}{\frac{W_1+W_2+W_3+W_b}{G_m}}$$

where,W_1 is the weight of coarse aggregate in the total mix, W_2 is the weight of fine aggregate in the total mix,W_3 is the weight of filler in the total mix, W_b is the weight of bitumen in the total mix, G_t is the apparent specific gravity of bitumen, and G_m is the bulk specific gravity of mix.

Voids in Mineral Aggregate(VMA)

Voids in mineral aggregate (VMA) is the volume of voids in the aggregates, and is the sum of air voids and volume of bitumen, and is calculated from

$$VMA = V_v + V_b$$

Where, V_v is the percent air voids in the mix and V_b is percent bitumen content in the mix.

Voids filled with bitumen VFB

Voids filled with bitumen VFB is the voids in the mineral aggregate frame work filled with the bitumen, and is calculated as:

$$\text{VFB} = \frac{V_b}{VMA} * 100$$

Where, V_b is percent bitumen content in the mix and VMA is the percent voids in the mineral aggregate.

VII. CALCULATIONS

Marshall Properties for nominal bitumen mix samples of **bitumencontent of 5 percent** by weight of total mass.

Total mass of MarshallSample = 1200±5 gm

Weight of bitumen, W_b = 60 gm (5 percent)

Weight of coarse aggregate, W_1= 434 gm

Weight of fine aggregate, W_2 = 629 gm

Weight of filler, W_3 = 80 gm

Apparent specific gravity of coarse aggregate, G_1 =2.6

Apparent specific gravity of fine aggregate, G_2 = 2.03

Apparent specific gravity of filler, G_3 = 1.78

Apparent specific gravity of bitumen,G_b = 0.99

Weight of mix in air, Wm = 1152 gm

Weight of mix in water,W_w = 558 gm

Theoretical specific gravity of the mix,G_t

$$G_t = \frac{W_1+W_2+W_3+W_b}{\frac{W_1}{G_1}+\frac{W_2}{G_2}+\frac{W_3}{G_3}+\frac{W_b}{G_b}} = \frac{434+629+80+60}{\frac{434}{2.6}+\frac{629}{2.03}+\frac{80}{1.78}+\frac{60}{0.99}}$$

= 2.065

- Bulk specific gravity of mix,G_m

$$G_m = \frac{W_m}{W_m - W_w} = \frac{1152}{1152-558}$$

= 1.94

- Air voids percent, V_v

$$V_v = \frac{(G_t - G_m)}{G_t} * 100$$

$$= \frac{(2.065-1.94)}{2.065} * 100$$

= 6.05 %

- Percent volume of bitumen, V_b

$$V_b = \frac{\frac{W_b}{G_b}}{\frac{W_1+W_2+W_3+W_b}{G_m}} = \frac{\frac{60}{0.99}}{\frac{1203}{1.94}}$$

=9.77 %

- Voids in mineral aggregate VMA

$$VMA = V_v + V_b$$

= 6.05 + 9.77

= 15.82 %

- Voids filled with bitumen VFB

$$\text{VFB} = \frac{V_b}{VMA} * 100$$

$$= \frac{9.77}{15.82} * 100$$

= 61.75 %

The same procedure is applied for all bitumen percentages (5 – 7) and results are shown in the Table-1

Marshall Properties for plastic modified bituminous mix samples of **bitumen content of 6 percent** by weight of total mass and **5 percent of plastic by weight of bitumen.**

Total mass of Marshall Sample = 1200 gm

Weight of bitumen = 60 gm (5 percent)
Weight of plastic = 3.2 gm (5 percent by weight of bitumen)
Weight of bitumen after adding plastic, W_b = 68.4 gm
Weight of coarse aggregate, W_1= 431 gm
Weight of fine aggregate, W_2 = 620 gm
Weight of filler, W_3 = 80 gm

Apparent specific gravity of coarse aggregate, G_1 =2.6
Apparent specific gravity of fine aggregate, G_2 = 2.03
Apparent specific gravity of filler, G_3 = 1.78
Apparent specific gravity of bitumen,G_b = 0.99
Weight of mix in air, W_m = 1154 gm
Weight of mix in water, W_w = 565 gm

- Theoretical specific gravity of the mix, G_t

$$G_t = \frac{W_1+W_2+W_3+W_b}{\frac{W_1}{G_1}+\frac{W_2}{G_2}+\frac{W_3}{G_3}+\frac{W_b}{G_b}}$$

$$= \frac{(431+620+80+68.4)}{\frac{431}{2.6}+\frac{620}{2.03}+\frac{80}{1.78}+\frac{68.4}{0.99}}$$

= 2.05

- Bulk specific gravity of mix G_m

$$G_m = \frac{W_m}{W_m - W_w}$$

$$= \frac{1154}{(1154-565)}$$

= 1.96

- Air voids percent V_v

$$V_v = \frac{(G_t - G_m)}{G_t} * 100$$

$$= \frac{(2.05-1.96)}{2.05} * 100$$

= 4.4 %

- Percent volume of bitumen V_b

$$V_b = \frac{\frac{W_b}{G_b}}{\frac{W_1+W_2+W_3+W_b}{G_m}}$$

$$= \frac{\frac{68.4}{0.99}}{\frac{1199.4}{196}}$$

=11.3 %

- Voids in mineral aggregate VMA

$$VMA = V_v + V_b$$

= 4.4+11.3
= 15.7 %

- Voids filled with bitumen VFB

$$\text{VFB} = \frac{V_b}{VMA} * 100$$

$$= \frac{11.3}{15.7} * 100$$

= 71.97%

VIII. RESULTSAND DISCUSSIONS

PLOTTING CURVES

Curves are plotted for the results obtained from Marshall Tests conducted on nominal bitumen mix and plastic modified bituminous mix to get the optimum contents of bitumen and plastic. The both contents are obtained from Marshall Stability curves, that which gives higher stability value.

Marshall Test results of bitumen for nominal mix:

The results of the Marshall test of Marshall Properties of specimens prepared for nominal mix with varying percentage of bitumen contents have been presented in ***Table 1***

Table-.1 Marshall Properties of nominal bitumin

S. no	% of bitumen	Weight in air (gm)	Weight in water (gm)	Bulk specific gravity (G_m)	Theoretical specific gravity (G_t)	Stability (Kg)	Flow (mm)	Air voids (V_v) (%)	VMA (%)	VFB (%)
1	5	1152	558	1.94	2.065	853	2.5	6.05	15.82	61.75
2	5.5	1145	560	1.95	2.051	1004	2.6	4.1	15.28	71.1
3	6	1135	557	1.968	2.038	1420	2.78	3.48	15.43	76.5
4	6.5	1121	548	1.954	2.029	998	2.98	3.5	16.12	78.25
5	7	1112	540	1.944	2.018	912	3.1	3.68	17.28	79

Fig-.1: Variation of Bulk specific gravity with bitumen content

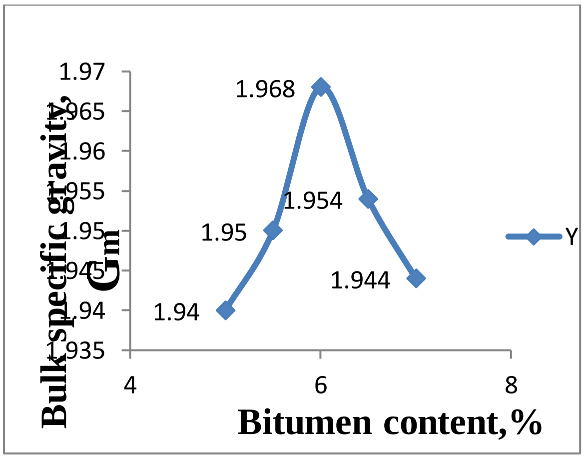


Fig-.1 Shows the variation of Marshall Bulk specific gravity value with % of bitumen content where it is seen that usually an increasing trend is followed with increase in bitumen content after reach maximum point it is decreased.

Table-2: Marshall Results for stability

Bitumen Content %	Stability Kg
5	937
5.5	1004
6	1421
6.5	998
7	945

Variation of stability with bitumen content

Fig.1Shows the variation of Marshall Stability with bitumen content where it is seen that as usual the stability value increases with bitumen content initially and then decreases. Maximum stability value of 14.21kn (1420.65) is observed at 6% bitumen content.

Table-3 Marshall results for flow:

Bitumen Content %	Flow, mm
5	2.50
5.5	2.60
6	2.78
6.5	2.98
7	3.10

Figure.3 variation of bitumen content with respect to stability

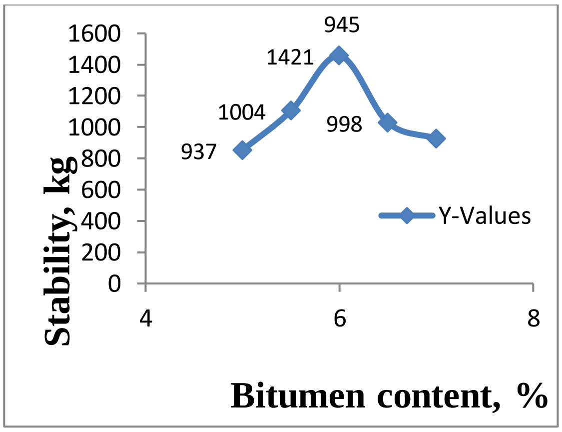
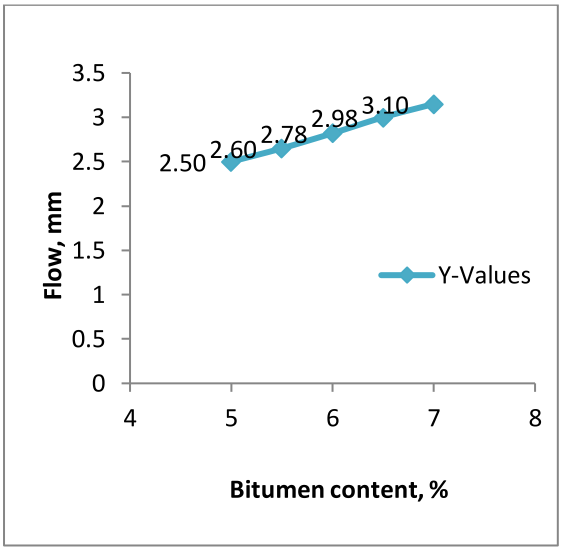


Table-4: Marshall Results for Volume of voids in mineral aggregate

Bitumen Content %	Volume of voids in mineral aggregate % (VMA)
5	15.82
5.5	15.28
6	15.43
6.5	16.12
7	17.28

Fig-4: Variation of flow with bitumen content



It Shows the variation of Marshall Flow value with % of bitumen content where it is seen that usually an increasing trend is followed with increase in bitumen content.

Fig-5: Variation of VMA with bitumen content

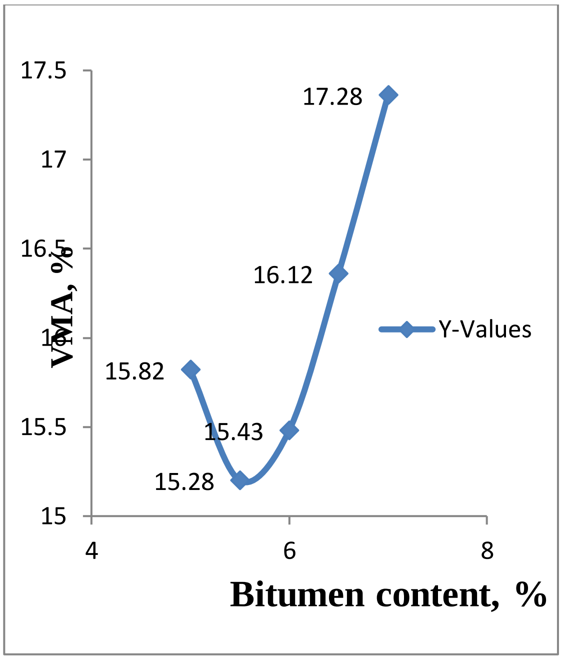
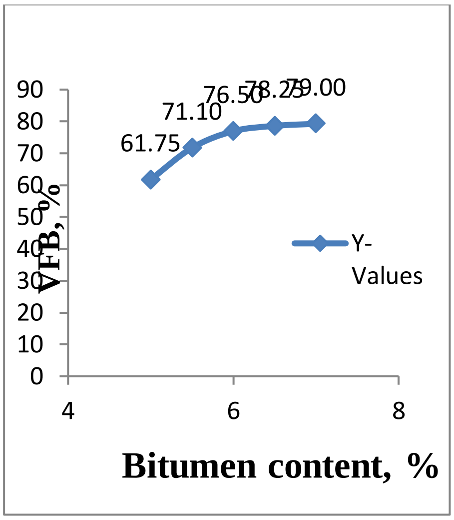


Fig-5Shows the variation of VMA with variation in percentage of bitumen content with the minimumpercentage of 15.28 %VMA being obtained at 5.5%bitumen content

Table-5: Marshall Results for Volume of voids filled with bitumen

Bitumen Content %	Volume of voids filled with bitumen % (VFB)
5	61.75
5.5	71.1
6	76.5
6.5	78.25
7	79

Fig-6: Variation of VFB with bitumen content



with % of bitumen content where it is seen that usually an increasingtrend with increase in bitumen content.

Table-6: Marshall ResultsAir voids

Bitumen Content %	**Air voids (V_v)%**
5	6.05
5.5	4.1
6	3.48
6.5	3.5
7	3.68

Fig-7: Variation of air voids with bitumen content

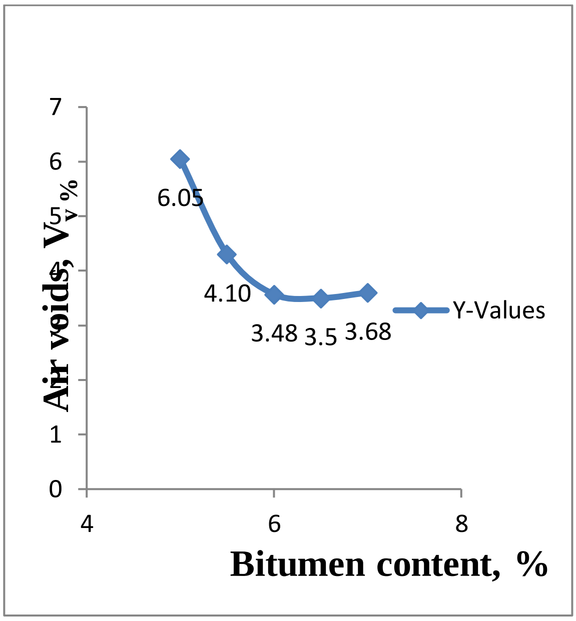


Fig-7 Shows the variation of air voids with % of bitumen content where it is seen that usually an decreasing trend is followed with increase in bitumen content

Byobserving the above graphs, it is clear that the maximum stability value obtained at the bitumen content of 6%. Hence it is proved that the OPTIMUM BITUMEN CONTENT (OBC) is 6%.

Now, plastic modified mix is prepared in such a way that, taken the bitumen content from 5 percent, 5.5

S. no	plastic % at OBC 6%	Weight in air (W_m)	Weight in water (W_w)	Bulk specific gravity (G_m)	Theoretical specific gravity (G_t)	Stability (Kg)	Flow (mm)	Air voids (v_v) (%)	VMA (%)	VFB (%)
1	5	1154	565	1.96	2.05	1195	2.7	4.4	15.7	71.97
2	7.5	1149	569	1.99	2.052	1833	3.3	3.2	14.55	75.9
3	10	1134	560	1.969	2.055	1802	2.9	4.02	14.87	72.4
4	12.5	1127	549	1.944	2.058	1011	2.56	5.56	15.79	65.56

percentages as 5 percent, 7.5 percent, 10 percent, 12.5

percent. Conducts the Marshall test on the sample prepared as mentioned above and draw the graphs for Marshall Properties and find out the OPTIMUM PLASTIC CONTENT (O.P.C).

percent, 6 percent and changing in the plastic

Curves for modified bituminous mix with medical plastic

By conducting the marshal test on the plastic modified bituminous mix and the Marshall stability values are shown in the below table.

Marshall Stability values for bitumen plastic samples

Bitumen content %	Plastic content %	Stability value kg
6	5	1195
	7.5	1833
	10	1802
	12.5	1011
5.5	5	1306
	7.5	1733
	10	1604
	12.5	927
5	5	1133
	7.5	1538
	10	1647
	12.5	895

By observing the above values, it is clear that the maximum stability value is obtained at the bitumen content of 6 percent that is optimum bitumen content and for plastic of 7.5 percent. Hence the OPTIMUM PLASTIC CONTENT (O.P.C) is 7.5 percent of plastic.

The results of the Marshall test of Marshall Properties of specimens prepared with plastic content from percent and bitumen content of 6 percent, have been presented in table

Table-9: Marshall Properties of plastic modified samples:

Plastic Content %	Bulk specific gravity
5	1.96
7.5	1.983
10	1.969
12.5	1.972

Figure.9 variation of plastic content with bulk specific

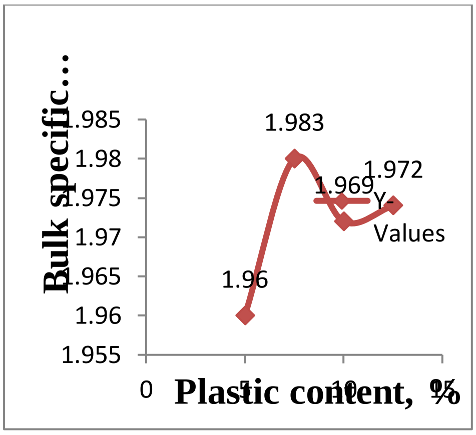


Table-10: Marshall Results for Bulk specific gravity at OBC at 6%:

Plastic Content %	Stability Kg
5	1195
7.5	1833
10	1802
12.5	1011

Fig-9 shows the variation of bulk specific gravitywith % plastic content where it is seen that usually an increasing trend is followed with increase in plastic content.

Table-10: Marshall Results for stability at OBC 6%

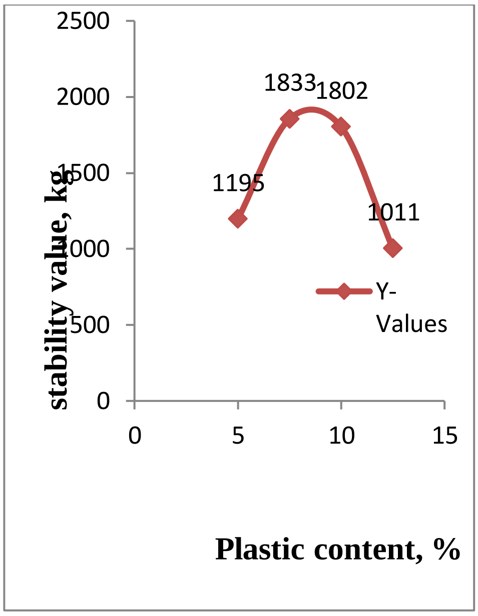


Fig-10 Variation of stability with plastic content

Graph-5.8 Shows the variation of Marshall Stability with plastic content, where it is seen that as usual the stability value increases with plastic content initially and then decreases. Maximum stability value of 1833 is observed at 7.5% plastic content.

Table10: Marshall Results for flow at OBC 6%

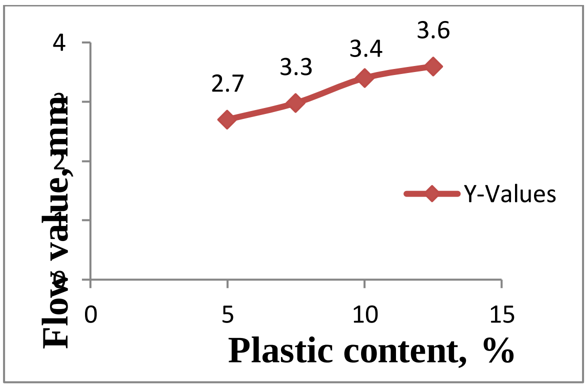


Fig-11: Variation of flow with plastic conte

Fig-12 Shows the variation of flow value with % of plastic content where it is seen that usually anincreasing trend is followed with increase in plastic content.

Table-12: Marshall Results for Volume of voids in mineral aggregate VMA, % at OBC 6%

Plastic Content%	Volume of voids in mineral aggregate (VMA) %
5	15.7
7.5	14.55
10	14.87
12.5	15.79

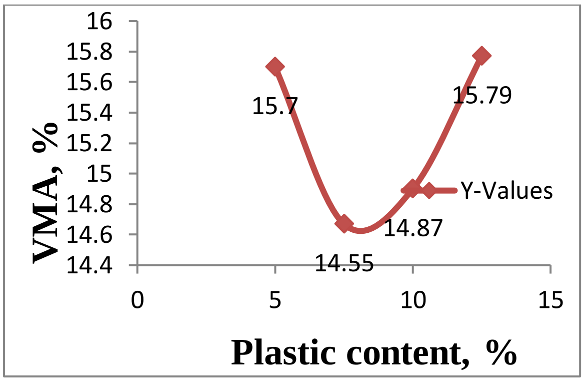


Fig-12: Variation of VMA with plastic content

Fig-12 Shows the variation of Marshall VMA value with % of plastic content where it is seen that initially decreasing trend is followed with increase in bitumen content and after increasing with increase in plastic content.

Table-14: Marshall Results for Volume of voids filled with bitumen VFB % at OBC 6%

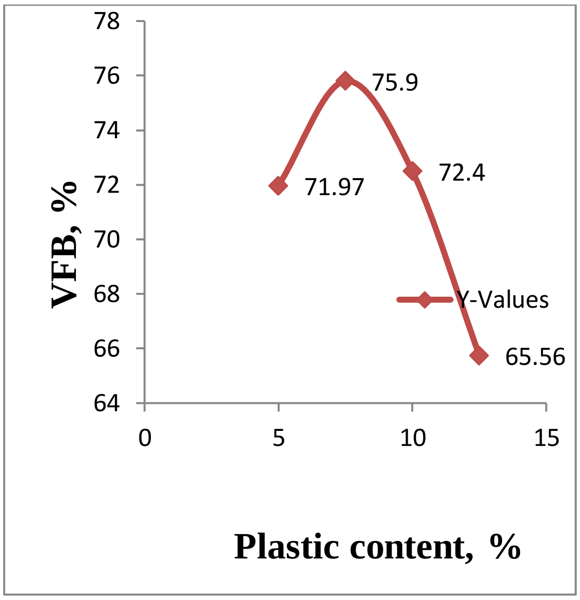


Fig-13: Variation of VFB with plastic content

Fig-13 Shows the variation of VFB value with % of plastic content where it is seen that usually a decreasing trend is followed with increase in plastic content.

Table14: Marshall Results for Air voids at OBC 6%

Plastic Content %	Air Voids,%
5	4.4
7.5	3.2
10	4.02
12.5	5.56

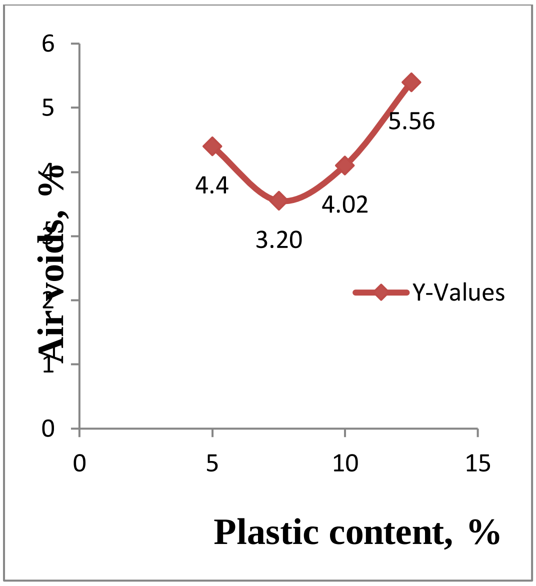


Fig14: Variation of air voids with plastic content

Fig-14 Shows the variation of air voids with % of plastic content where it is seen that increasing trend with is followed with increase in plastic content.

VIII. CONCLUSIONS

The following conclusions are drawn from the study:

- Optimum Bitumen Content (OBC) obtained was 6 percent by weight of total mass.
- Optimum Plastic Content (OPC) was obtained is 7.5 percent at which Optimum Bitumen Content was obtained as 6%.
- The Marshall Stability value of plastic modified mix was found to be 27 percent more than that for the nominal mix.
- Through the work conducted, it was found that the bitumen usage (quantity) could be partially reduced without compromising the strength and workability of bitumen.

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