MODIFIED BITUMEN USING WASTE MATERIAL FOR HIGHWAY CONSTRUCTION

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Abstract
The numbers of inhabitants in our nation are expanding quickly and because of its plastic waste is additionally expanding every day because of urbanization, advancement exercises and changes in way of life, which is driving broad climate contamination. Subsequently removal of waste plastic is a danger and has become a major issue universally because of the non-biodegradability and a stylish view. Since these are not arranged logically and possible to make ground and water contamination. This waste plastic halfway supplanted the ordinary material to improve wanted mechanical qualities of street blend. In the current paper created strategies to utilize plastic waste for development reason for streets and adaptable asphalts has assessed. Roads constructed in India mostly includes flexible pavement structure load, these pavements are subjected to different kinds of loading which result in affecting the performance of the pavement. Now a day's waste plastics and widely used in the bitumen as a modifier to increase the performance of pavement. The use of waste plastic for modifying the bitumen properties, which will be used for the road construction, has resulted in the reduction of the construction cost and eco-friendly disposal method of the waste plastic. As use of waste plastics is increasing day by day due to industrialization and increase in population which leads to various environmental problems. Therefore, using waste plastic in the construction of flexible pavement is economical and eco-friendly method for the disposal of waste plastic.

I. Introduction

The Road transport conveys near 90% of traveler traffic and 70% of cargo transport. Examinations in India and nations abroad have uncovered that properties of bitumen and bituminous blends can be improved to meet prerequisites of asphalt with the consolidation of specific added substances or mix of added substances.

These added substances are designated "Bitumen Modifiers" and the bitumen premixed with these modifiers is known as altered bitumen. Adjusted bitumen is In India, it is assessed that more than 33 lakhs kilometers of street exists expected to give higher existence of surfacing (upto100%) contingent on level of alteration and sort of added substances and change measure utilized. Various sorts of modifiers utilized are Polymers (LDPE-low thickness polyethylene), squander tire elastic and reusing of polymers (LDPE) and waste tire elastic. Plastics are easy to use however not Ecoaccommodating as they are non-biodegradable. For the most part, it is arranged by method of land filling or cremation of materials which are risky. The better restricting property of plastics in its liquid state has helped in discovering a strategy for safe removal of waste plastics, by utilizing them in street laying.

By and large, lasting disfigurement (rutting) happens because of hefty pivotal burdens going ahead the sub grade and furthermore rutting shows upon a superficial level because of helpless blending of bitumen and subsequently sub-grade is harmed. The bituminous blend utilized in the surface course ought adequate the necessary quality as well as is needed to have enough interior protection from withstand rehashed substantial burden. Industrially accessible bitumen in the nation needs alteration as they have attributes that can't fulfill the exhibition necessities bringing about untimely disappointment of bitumen surfacing. Bituminous materials with adjusted covers give higher quality and longer lives as the give better protection from rutting, stripping, and show lower pace of enduring. Adaptable asphalts with bituminous surfacing are generally utilized in numerous pieces of the world. The focused energy of traffic as far as business vehicle and overstocking of trucks and critical variety in day by day and occasional temperature of the asphalt have been liable for early advancement of misery indications like undulations, rutting, breaking and potholing of bituminous surface. A factor which causes genuine concern is shifting climatic conditions at various timeframes. Under such conditions, adaptable asphalts will in general become delicate in summer and fragile in winter. The properties of bitumen and bituminous blends can be improved to meet the prerequisites of asphalt with the in-partnership of specific added substances. These added substances are called as bituminous modifiers and bitumen preblended in with these modifiers is known as adjusted bitumen. Roads play a vital role for economic growth and bring important social benefits. It helps in providing employment, health and social services to mankind thus road network is crucial in order to make a nation grow and develop. Extreme climatic condition and increased traffic volume on roads causes necessity to develop feasible and economical road construction in India. Due to hike in price of crude oil, in recent years the cost of bitumen is raised. As highway construction and maintenance involves huge amount of money ,appropriate engineering design and use of waste plastic can save considerable amount of cost.

Waste plastics is mixed with the bitumen and aggregate ,results in enhancing the properties of the bitumen mix. Plastics are feasible but not eco-friendly because they are non-biodegradable. At present in INDIA the plastic consumption is more than 15 M tones, which is 3rd largest plastic consumption in the world. Most of the plastic is used for packaging which are usually dropped and left to litter the surrounding. The scattered plastics get mixed with domestic waste due to which the solid municipal waste disposal becomes difficult. The solid municipal waste is either land filled or burned. Both method of disposal is not the best way to dispose the waste because both method cause soil and air pollution.

Plastic also have a very long lifetime and incinerate under unchecked conditions can cause air pollutants to generations depending upon the polymer type and used additives . Rapid industrialization and very large population growth resulted in increase of different types of waste materials. For the disposal of the waste material considerable measures have been done.

Fig. 1. Polymer Modified Bitumen at Srinagar National Highway

1.1 Classification of road

1. Flexible pavement
2. Rigid pavement

Flexible pavement:

Flexible pavements will transmit wheel load stresses to the lower layers by grain-to-grain transfer through the points of contact in the granular structure. The wheel load acting on the pavement will be distributed to a wider area, and the stress decreases with the depth. Taking advantage of these stress distribution characteristic, flexible pavements normally has many layers. Hence, the design of flexible pavement uses the concept of layered system. Based on this, flexible pavement may be constructed in a number of layers and the top layer has to be of best quality to sustain maximum compressive stress, in addition to wear and tear. The lower layers will experience lesser magnitude of stress and low-quality material can be used. Flexible pavements are constructed using bituminous materials. These can be either in the form of surface treatments (such as bituminous surface treatments generally found on low volume roads) or, asphalt concrete surface courses (generally used on high volume roads such as national highways). Flexible pavement layers reflect the deformation of the lower layers on to the surface layer (e.g., if there is any undulation in sub-grade then it will be transferred to the surface layer). In the case of flexible pavement, the design is based on overall performance of flexible pavement, and the stresses produced should be kept well below the allowable stresses of each pavement layer. The load distribution in flexible pavement as following Fig.1.4.

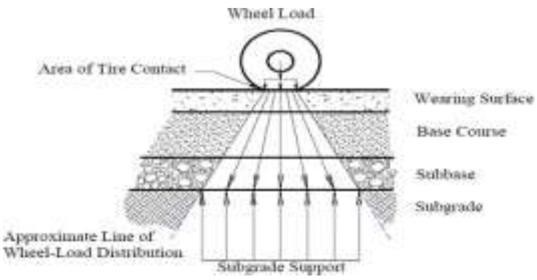


Fig 2. **–**Load Distribution

Rigid pavement:

The rigid characteristic of the pavement is associated with rigidity or flexural strength or slab action so the load is distributed over a wide area of subgrade soil. Rigid pavement is laid in slabs with steel reinforcement. Critical condition of stress in the rigid pavement is the maximum flexural stress occurring

In the slab due to wheel load and the temperature changes. Rigid pavement is designed and analyzed by using the elastic theory.

Table-1 Comparison between Flexible Pavement and Rigid pavement

Flexible Pavement	Rigid Pavement
1. Deformation in the grade Is subtransferred to the upper layers	1. Deformation in the subgrade is not transferred to subsequent layers
2. Design is based on load distributing characteristics of the component layers	2. Design is based on flexural strength or slab action
3. Have low flexural strength	3. Have high flexural strength
4. Load is transferred by grain To contact	4. No such phenomenon of grain to grain load transfer exists
5. Have low completion cost Bu repairing cost is high t	5. Have low repairing cost But completion cost is high
6. Have low life span	6. Lifespan is more as compared to Flexible pavement
7.Surfacing cannot be laid directly on The sub grade but a sub base is needed	7.Surfacing can be directly laid on the Sub grade

II. LITERATURE REVIEW

The developments of project of mix design of bitumen using waste material for the purpose of improving the capacity or condition of exiting pavement. First the mix design of bitumen is use to know about the percentage of binder content (bitumen), Aggregate, dust which is use in DBM & BC layer.

During project waste material like Rubber, Polymer (LDPE, HDPE) and maxing of both is use as a different proportion in Binder content (Bitumen). After that take this mix in design of DBM & BC layer and check the property of mixing (Conventional Bitumen with waste materials) and compare with original limit of conventional bitumen. This section of the project discusses the literature review in order to get the fundamental concept of mix design of bitumen.

Ali Jamshidi (2020) Paved surfaces must reliably bear heavy loads, often under challenging environmental and geotechnical conditions. These requirements are addressed through the use of high-quality, newly produced materials in pavement design. However, in remote locations, newly produced materials are often expensive or unavailable, making waste or alternative materials more attractive. Waste materials can be used in their natural condition but are more commonly stabilized or otherwise improved to meet performance targets. However, this practice can incorporate unwarranted risk into pavement design solutions. The decision to use waste materials in a pavement is a balance between technical risk, maintenance liability, available materials, environmental emissions and capital cost. This study reviews the use of waste materials in pavement design and construction. Reclaimed asphalt pavement (RAP) materials and processed waste plastic for pavement construction are considered. Additionally, blast furnace slag (BFS) and waste glass in pavement construction are evaluated. This review focuses on the effects of alternative materials on the properties of asphalt pavement. The results indicate that RAP is acceptable as an alternative material, while BFS, waste plastic and waste glass can be used under specific condition.

Shivani Singh Dhriyan1 (2017) The use of waste plastic for modifying the bitumen properties, which will be used for the road construction, has resulted in the reduction of the construction cost and eco-friendly disposal method of the waste plastic. As use of waste plastic is increasing day by day due to industrialization and increase in population which leads to various environmental problem. Therefore, using waste plastic in the construction of flexible pavement is economical and ecofriendly method for the disposal of waste plastic. In this paper we will discuss the variation of the properties of bitumen on addition of waste plastic at different percentage.

Azmat Shaikh (2017) Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes. Bituminous Concrete (BC) is a composite material mostly used in construction projects like road surfacing, airports, parking lots etc. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which is mixed together & laid down in layers then compacted. Nowadays, the steady increment in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature putus in a demanding situation to think of some alternatives for the improvisation of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strength as well as economic aspects.

Sk. Wasim Anwar (2014) Based on the results and discussions of experimental investigation carried out on the behavior of Marshall and Modified Marshall specimens, prepared by using Crumb Rubber Modified Bitumen. In this experimental investigation, two types of specimens, i.e., Marshall (100 mm dia) and Modified Marshall (150 mm dia) are prepared by using CRMB. Properties behavior and Static Indirect Tensile Strength of these specimens have been tested at different stress level and temperature. Based on these tests, it is concluded that specimens prepared by Modified Marshall method of mix design gives very good result than Marshall specimens and it can be used in flexible pavement.

Kapil Soni, K.K Punjabi (2013), the results indicated that the consumption of waste polythenes in bituminous concrete mixtures shows improved property of the mixtures thus formed. The waste polythene consumed in the mix will get coated over aggregates of the mixture and reduces porosity, absorption of moisture andimproves binding property. The bitumen modified with 4.5 % Polythene Waste is showing better performance as compared to other mixes. The Marshall Stability which is a strength parameter has shown increasing trend with a maximum increase percent of 35.20% as compared to Conventional mix when modified with 4.5% Polythene Waste.

K.V. Krishna Reddy (2013) in this paper represented the evaluation of rutting resistance of waste tire rubber modified flexible pavement surface test section with laboratory wheel tracking test and an accelerated payment rust tester. Test track with waste tire rubber modified surface course on a clay sub grade along with conventional material was considered for testing. In this he was used waste tire rubber powder for mixing process in 80/100 penetration grade bitumen. Headopts wet mixing process for mixing at 163 and conduct test like penetration, softening point, ductility, loss on heading test and result obtain that 35% improvement in rut resistance.

Rokde (2012), proposed to use plastic and rubber are user friendly but not eco-friendly and non– biodegradable. In this study an attempt has been made to usewaste plastic (LDPE) and crumb rubber. Blend using dry process for LDPE and wet process for CRMB. He takes 60/70 grade bitumen mixing with LDPE and CRMB using dry process and wet process in different proposition and adopted

R. Vesudeven (2007) proposed to various waste such as plastic and tyre waste because of increase in road traffic, the load bearing capacity is increased. In this process the road of 1 km and 3.375 km width consume

10,000 carry bags an road strength increased by 100% and no pot whole formation occurs. Secondly, wastetyre rubber used in flexible pavement, strength is increased.

III. METHODOLOGY

Mix design is the design of various materials which is used in flexible pavement specifically in base course and dense bitumen macadam course. It is the mixing of course aggregate, fine aggregate, filler and bitumen content in different proportional desired temperature at a time of casting the mould. We conduct Marshall Mix Design for proving our project which has same proportion of material as mix design of conventional bitumen. The design of conventional bitumen as follows:

1) Marshall Mould (BC) contains 1200 gm mould which consists of Bitumen, Aggregate (16-12mm, 12-5mm, dust and filler as a lime) in a different proportion.
2) We take different proportion of bitumen in mix starting from 4.5%, 5.0%,5.5%, 6.0%, and 6.5% and conduct Marshall test as per test procedure given in 5.2.8 and check various property of mix.
3) The properties like air voids, stability, flow value, voids filled with bitumen (VFB), Maximum specific gravity (GMM) are coming in 5.0-5.6%bitumen.
4) So we choose as bitumen 5.3% of total material and conduct test on modified bitumen.
5) Following is the design calculation on different proportion of conventional bitumen for choosing best proportion for modifying bitumen.

3.1 Properties of the mix:

The properties that are of interest include the theoretical specific gravity Gt, the bulk specific gravity of the mix Gm, percent air voids Vv, percent volume of bitumen Vb, percent void in mixed aggregate VMA and percent voids filled with bitumen VFB.

3.1.1 Theoretical specific gravity of the mix (Gt)

Theoretical specific gravity Gt is the specific gravity without considering airvoids, and is given by:

Gt= {W1+W2+W3+Wb/[(W1/G1)+(W2/G2)+(W3/G3)+(Wb/Gb)]}

where,W1 is the weight of coarse aggregate in the total mix,W2 is the weight of _ne 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 offine aggregate, G3 is the apparent specific gravity of filler and Gb is the apparent specific gravity of bitumen,

3.1.2 Bulk specific gravity of mix (Gm)

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

Gm={Wm/(Wm -Ww)}

where, Wm is the weight of mixing air, Ww is the weight of mixing water, note that WmWw gives the volume of the mix. Sometimes to get accurate bulk specific gravity, the specimen is coated with thin film of paraffin wax, when weight is taken in the water. This, however requires to consider the weight and volume of wax in the calculations.

3.1.3 Airvoids percent (Vv)

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

Vv=[(Gt-Gm)100/Gt]

Where Gt is the theoretical specific gravity of the mix, given by equation and Gm is the bulk or actual specific gravity of the mix

3.1.4 Percent volume of bitumen (Vb)

The volume of bitumen Vb is the percent of volume of bitumen to the total volume and given by:

Vb=[(Wb/Gb)/(W1+W2+W3+Wb)/Gm]

where, W1 is the weight of coarse aggregate in the total mix, W2 is the weight offine 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, Gb is the apparent specific gravity of bitumen, and Gm is the bulk specific gravity of mix

3.1.5 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, Vv is the percent airvoids in the mix, and Vb is percent bitumen content in the mix,

3.1.6 Voids filled with bitumen (VFB)

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

VFB = (Vb x100/VMA)

where, Vb is percent bitumen content in the mix and VMA is the percent voids in the mineral aggregate

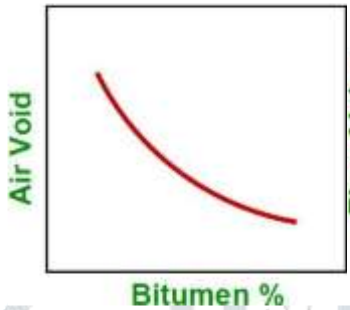
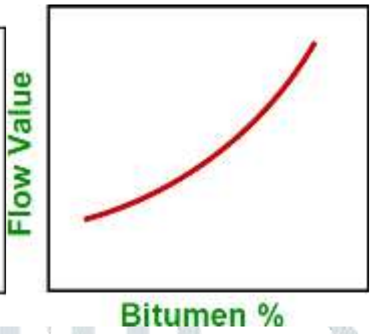


Fig – Bitumen v/s Air voids



Fig–Bitumen v/s Flow

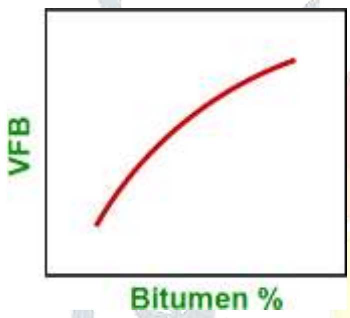


Fig –Bitumen v/s VFB

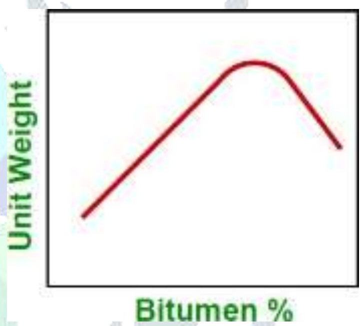


Fig –Bitumen v/s Unit weight

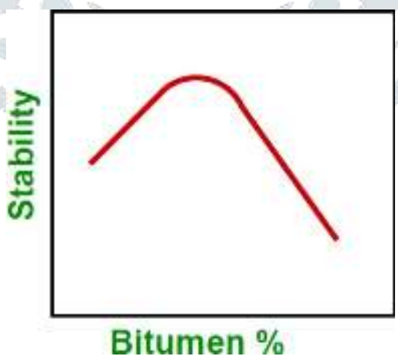


Fig – Bitumen v/s Stability

IV. Tests Conducted on Conventional Bitumen and Modified Bitumen

4.1 Assumptions

The following are the assumption made by us before conduct various test.

- It should be noted that the proportion of crumbed rubber in conventional bitumen is 12% as per IRC.
- It should be noted that the proportion of LDPE in conventional bitumen is 4% and 6% as per IRC.
- Heat and blending of mixing of bitumen and crumbrubberat177°C.
- Heat and blending of mixing of bitumen and LDPE at 164°C.
- Take Bitumen =PMB and CRMB.

V. RESULT AND DISCUSSION

In this chapter the discussion on the test results of modified bitumen are based on the tests such as Aggregate Impact Value Test, Penetration Test which are performed for find out the property of bitumen inflexible pavement. The tests are performed on IS specification.

5.1 Aggregate impact value test

As explained in chapter 5 obtained test results are presented in Table 5.1.Aggregates which are used for the construction of flexible pavement should have property to resist sudden impact and it should be come less than 30% which is as shown in Table 6.1

Table 5.1-Aggregate Impact Value

S. No.	Description	Sample1	Sample2	Sample3
1	Total wt. of oven dried sample (passing 12.5mm- retained on10mm sieve) (W1) gm	363.5	364.0	363.75
2	Wt. of material retained on 2.36 Mm (W2) gm	296.5	295.5	296.0
3	Wt. of material passing on 2.36 Mm (W3) gm	67	68.5	67.75
4	Aggregate Impact Value(%)	18.43%	18.81	18.62
Note: if W4=1gm discard and retest				

5.2 Penetration test [is:1203-1978]

It shows that there is a greater reduction in Penetration of PMB and CRMB than conventional bitumen. It means bitumen become hard with using of 4%, 6% polymer and 12% crumb rubber as additive in bitumen and it should be used in hot climate and Heavy rainfall area.

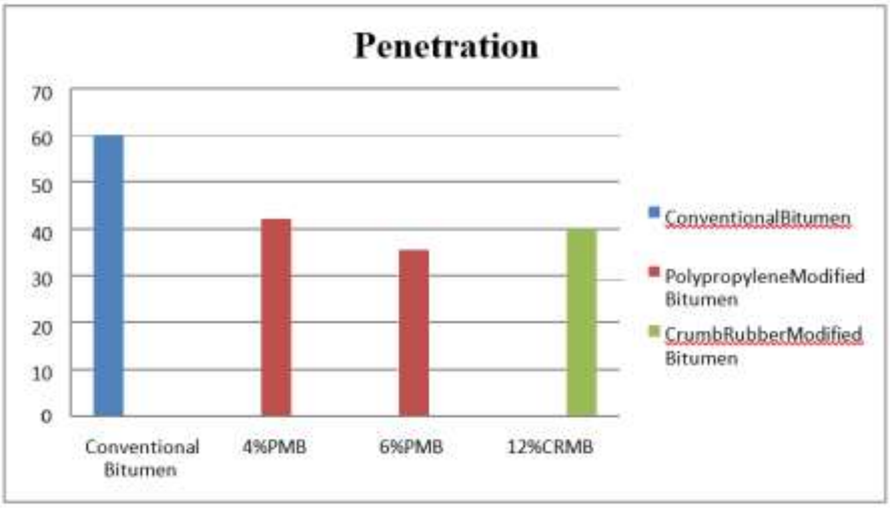


Fig. -Penetration V/s Bitumen, PMB, CRMB

VI. CONCLUSION AND FUTURE SCOPE OF WORK

To produce more environmentally friendly asphalt and concrete mixes, it is recommended to use divergent combinations of waste materials. However, the long-term performance of such pavements is a cause for concern. To address this issue, optimal combinations of various waste materials should be determined through laboratory experimentation. A key factor in determining such a balance is the compatibility between different waste materials types. In other words, synergistic elects between the waste materials, binder and aggregate materials is desirable.

Another challenge for using waste material is the potential production of leachate, which can be hazardous for Eco-systems. Therefore, the chemical composition of leachtes should be investigated. In addition, apertinent question lies in how many times the waste material scan be recycled and reused for pavement construction. The appropriate number of uses depends on the type of waste material, its chemical components, energy feed-stock, environmental emissions and economic justifications. A definitive answer that encompasses every composition is impossible. Therefore, it is necessary for various waste materials to be ranked based on their potential for recyclability.

Studying the ecological impacts of roads is an important area of study in conservation biology and environmental science, as the impacts often extend far beyond the surface of the road itself.

- ★ because all the test result of CRMB is coming in limit of CRMB 60 which is Our modified bitumen made by using crumb rubber is become CRMB-60Given in table 6.27.
- ★ Our modified bitumen made by using Polypropylene is become PMB 40 because all the test result of PMB is in limit of PMB 40 which is given in table 6.26.
- ★ For CRMB 60 and PMB 40 selection criteria are given in table 6.29 so from table we can say that our modified bitumen is use in high temperature area and high rainfall area.

Table 8.1-Selection Criteria for PMB and CRMB based on Atmospheric Temperature

		Maximum Atmospheric Temperature		
		<35	35 to 45	>45
Minimum Pavement Temperature	<-10	PMB120,CRMB -50*	PMB120,CRMB -50*	PMB120,CRMB -50*
	10to -10	PMB120,CRMB -50*	PMB120,CRMB -50*	PMB120,CRMB -50*
	>10	PMB120,CRMB -50*	PMB120,CRMB -50*	PMB120,CRMB -50*
*notbelow-15				

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