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Research paper

Contemporary Investigation of Pvc Modified Bitumen

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Abstract:

Bitumen is one of the most used binding materials in road pavement due to its excellent binding characteristics, waterproofing properties and low cost as compared to other binders. However, it is widely known to have various types of distresses and does not perform well in aggressive situations. To counter these shortcomings, bitumen is ordinarily assorted with various forms of modifiers such as polymers, crumb rubber, PVC, etc. Waste PVC that has been used previously as a part of sewerage system. In this project the waste PVC pipes which have been used as a modifier by an amount of 2%, 4% and 6% by weight of bitumen in making bituminous mixture for pavement applications. The different properties of PVC modified bitumen such as softening point, penetration value will be studied. In addition Brick powder is added as a filler to increase the absorption capacity and to increase the strength properties. Performance characteristics of the bituminous mix prepared by modified binder were also studied and compared with conventional bituminous mix. The results indicate that waste PVC pipe can be used efficiently in road construction. Flow and stability of the mix increase after incorporating PVC waste pipe. On the basis of experimental work it is concluded that the asphalt mixtures with waste PVC modifier can be used for flexible pavement construction.

Keywords

1. Introduction

1.1 General

The amount of waste PVC is increasing day by day as the availability of PVC is enormous. Disposal of this waste PVC appears as a challenging problem. They either get mixed with municipal solid waste or thrown over land area. Various attempts have been made for the useful utilization of this waste PVC. The rapid increase in high traffic intensity in addition to significant variations in daily and seasonal temperature demand qualitatively best road characteristic. Especially in under develop countries where proper maintenance of road networks is difficult due to lack of funds and effective machinery. Better infrastructure of road is required which needs less maintenance. Many investigations have found that the strength of paving mixes can be enhanced by using various types of modifiers with bitumen such as crumb rubber, polyethylene, and organic polymers. (Ambika B et al)

Using these modifiers the temperature susceptibility and viscosity characteristics are improved and also helped in elevating certain problem like bleeding of binder during peak summer temperature and stripping of aggregate in moisture prone areas. These polymers besides being costly are not easily available that is why many research have been performed for modification of bitumen by using waste polymers. (Shirish n. nemade)

1.2 Salient Features of Polymer Waste Bitumen

Salient features of the polymer-waste-bitumen mix road are:

- Burning of plastics waste could be avoided
- It doesn't increase cost of road construction
- It helps to reduce the consumption of bituminous mix and reduce cost
- Road strength is twice stronger than normal roads
- Resistance towards water stagnation, plastic in bitumen provides impermeability to the mix
- Less bleeding during summer
- It helps in protecting our environment from waste plastic

1.3 Aim of the Project

- To investigate the strength properties of PVC modified bitumen adding Brick Powder as filler.
- To compare the strength properties of unmodified Bitumen with PVC modified bitumen.

1.4 Objectives

The objectives of this project are

- Use waste PVC as modifier with bitumen
- Study the outcome by mixing the waste PVC with bituminous mix
- To evaluate the performance of the modified bitumen mix by using different tests.

2. Material &methodology

The materials used in this project are,

- Bitumen –Binding material
- Aggregate-Wearing and Base coarse

- Brick powder-filler material
- PVC-Modifier

2.1 Binders

Bitumen is a sticky, black and highly viscous liquid or semi-solid. It is also the residue or by-product of fractional distillation of crude petroleum. A wide variety of refinery process such as straight distillation process, solvent-extraction process, etc., may be used to produce bitumen of different consistency and other desirable products. Based on characteristics of crude oil and on the properties of bitumen required, more than one processing method may be required namely, Vacuum steam distillation of petroleum oils. Bitumen composed primarily of highly condensed polycyclic aromatic hydrocarbons, containing 95% carbon and hydrogen.
Different forms of bitumen:

- Cut-back bitumen
- Bitumen Emulsion
- Bituminous primers
- Modified Bitumen

2.2 Filler

The filler defined as that fraction of an inert mineral dust having particle size less than 75µ in a bituminous mixture can perform several functions. The process of filling voids in coarser aggregates, increases the density, stability, and toughness of a conventional bituminous paving mixture.

2.3 Aggregate

Aggregate plays an important role in the performance of bituminous mix. In bituminous mix, aggregates constitute about 90 to 95 percent by weight and comprise 75to 85 percent by Volume. Aggregate mainly
consisting of both coarse and fine aggregates (coarse aggregate of 14.2 mm to 2.36 mm and fine aggregates of 2.36 mm to 75µ) are used. Coarse aggregates offer compressive and shear strength and shows good interlocking properties and the fine aggregates fills the voids present between the coarse aggregates. The following tests are conducted on coarse aggregates and the results are presented. (Vasudevan.R et al)

2.4 Plastic

The plastic waste constitutes two major categories of plastics, thermoplastics and thermoset plastics. Thermoplastics, constitutes 80% approximately and thermoset constitutes approximately 20 % approximately of total postconsumer plastics waste generated in India .The thermoplastics are recyclable plastics which include, polyethylene terephthalate (PET), low density poly ethylene (LDPE), poly vinyl chloride (PVC), high density poly ethylene (HDPE), polypropylene (PP), polystyrene (PS) etc. However, thermoset plastics contains alkyd, epoxy, ester, melamine formaldehyde, phenolic formaldehyde, silicon, urea formaldehyde, polyurethane, metalized and multilayer plastics etc. Most of thermoplastics on heating soften at temperature between 130-140°C. The analysis of thermoplastics has proven that there is no gas eVolution in the temperature range of 130-180 °C and beyond 180 °C gas eVolution and thermal degradation may occur. (Shirish n. nemade et al)

2.5 Modified Bitumen:

The properties of bitumen and bituminous mixes can be improved with the incorporation of certain additives are blend of activities. These additives are called as modifiers and the bitumen premixed with these modifiers is known as modified bitumen. The use of modifier in the top layer of the
pavement is expected to significantly enhance the life of the surfacing and extend the time of next renewal.
IS15462:2004 classify the polymer and rubber modified bitumen into the following types.

- PMB(P) Plastomeric thermoplastic based
- PMB(E) Elastomeric thermoplastic based
- NRMB Natural rubber and SBR latex based, and d. CRMB Crumb rubber/ treated crumb rubber based.

2.6advantages of Modified Bitumen

- Lower susceptibility to temperature variations.
- Higher resistance to deformation at high pavement temperature.
- Delay of cracking and reflective cracking.
- Better age resistance properties.
- Better adhesion between aggregates and binder.
- Higher fatigue life of mixes.

3. Preparation of Blends

In this Project PVC waste used is plastics which is obtained from food wastes such as plastic boxes, covers, etc.

Bitumen is heated at the temperature of about 180^{o}c and various tests are done according to Codal provisions SP52:1999

Plastic is heated at the temperature of about 160^{o}c and it is blended with hot bitumen.

In this project PVC is used as a modifier by adding 2%, 4% and 6% of plastic waste in the total weight of the bitumen (5.5% of conventional asphalt mix design)(Lekhaz, Mallikarjun.D et al)

For further work the blends were stored at room temperature. With different percentages of PVC, the physical properties of bitumen were then measured.

Fig 3.1: Preparation Of Blends (Pvc+Bitumen)

Experimental tests
The various tests done on aggregates are as follows,

- Gradation of Aggregates
- Impact Test
- Los Angles Abrasion Test
- Water Absorption and Specific Gravity test

3.1 Gradations of Aggregates

Aggregate is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geo synthetic aggregates. They are a component of composite materials such as concrete and asphalt concrete and serve as reinforcement to add strength to over all composite material. They can also be mixed with a binder either to cement to make concrete and used in manufacture of houses, structures and bridges. (Apurva J Chavan et al)
It has three main functions,

- Support
- Filling
- Embellishment

The density and stability are very much dependent on the aggregate and their grain size distribution. The gradation has a profound effect on mix performance. It might be reasonable to believe that best gradation is one of that produces maximum density. This would involve a particle arrangement where smaller particles are packed between larger particles thus reducing the voids space between the particles. These create more particle to particle contact. But in bituminous pavements would increase the stability and reduce water infiltration. However some minimum amount of void space is necessary to:

- Promote rapid drainage.
- Provide adequate Volume for a binder to occupy.
- Provide resistance to frost action for base and sub-base courses

Fig. 3.2: gradation of aggregates

Specified Gradation of Aggregates For BC And WC of 40mm

Sieve size	Weight passing	Weight passing
Mm	Grade 1	Grade 2
20	-	100
12.5	100	80-100
10	80-100	70-90
6	55-75	50-70
4.75	35-50	35-50
0.15	8-18	8-18
0.075	4-10	4-10
Binder*	5-7.5	5-7.5

3.2 Impact Test

The term toughness is the property of a material to resist impact. Because of the movement of vehicles on the road the aggregate are subjected to impact resulting in their breaking down into smaller pieces. The aggregates should therefore have sufficient toughness to resist their disintegration due to impact. This characteristic is measured by impact value test.

Fig 3.3: impact test

The aggregate impact value is a measure of resistance to sudden impact or shock, which may differ from its resistance to gradually applied compressive load. The apparatus as per IS2386:1963-PART-IV.

Table 3.2: impact test results

	Sample 1(12.5mm)			**Sample 2(6mm)**		
	Trial I	**Trial II**	**Mean**	**Trial I**	**Trial II**	**Mean**
Total weight Of dry sample(W1gm)	400	400		300	300	
			16.25			17.49
Weight of portion passing 2.36mm sieve(W2 gm)	63	67		50	55	
Aggregate impact Value (W2/W1)*100 (%)	15.75	16.75		16.66	18.33	

3.3 Los Angles Abrasion Test

Due to the movement of traffic, the aggregate used in the surface course of highway pavements are subjected to wearing When vehicles move on the road the soil particles present between the pneumatic trials and road surface cause abrasion of road aggregates. The steel reamed wheels of animal driven vehicles also caused considerable abrasion of road surfaces. Therefore the road aggregate should be hard enough to resist abrasion. It is determined by using Los Angles testing machine. (The apparatus are as per IS2386:1963-PART-IV)

The working principle of Los Angles Abrasion test is to produce abrasive action by using the standard steel balls which when mixed with aggregates and when rotated in a drum for specific number of revolutions also cause impact on aggregates. The percentage wear on aggregates is due to rubbing with the steel balls is determined and is known as Los Angles Abrasion Value.

Table 3.3: los angles abrasion test results

	Sample 1(12.5mm)	**Sample 2(6mm)**
Original weight of the aggregate (W1gm)	5000	5000
Weight of passing	1175	1317

1.75mm IS sieve (W2 gm)		
Abrasion value (W2/W1)*100 (%)	23.5	26.34

Fig 3.4: los angles abrasion test

3.4 Specific Gravity and Water Absorption Test

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. The stones having low specific gravity are generally weaker than those
with higher specific gravity values. (The test is done as per IS2386-PART3).
Specific gravity = 2.57
Apparent specific gravity = 2.66
Water absorption = 1.5%

3.6 Tests on Bitumen

The Tests done on bitumen are as follows

- Penetration test
- Softening Point test
- Ductility test
- Specific Gravity test
- Marshall Stability test

4. Results and Discussion

4.1 Tests on BitumenPenetration Test

In this table the results of the penetration test is given and it done for un modified bitumen, modified bitumen(2%) , modified bitumen (4%) , modified bitumen (6%) and those values are compared with the codal provision SP 53:2010. Table 4.1 penetration test result

Penetration Value	Unmodified Bitumen	Modified Bitumen (2%)	Modified Bitumen (4%)	Modified Bitumen (6%)	Codal Provision
(25-35°c)					Sp53:2010
Trial 1	67	66	65	63	
					50 to 80
Trial 2	67	65	63	63	
Trial 3	66	67	65	63	
Mean	67	66	65	63	

As the penetration value of Bitumen is between 60-70 it comes under 60/70.So the viscosity value of Bitumen is VG30.

4.2 Softening Point Test

The softening point test is conducted for the un modified bitumen, modified bitumen(2%) , modified bitumen (4%) , modified bitumen (6%) and the following test results are given below. As per the values obtained the temperature of the ball increases by increasing the PVC content in the bitumen.

Table 4.2: softening point test result

Temperature at which the Ball touches the Bottom	UNMODIFIED BITUMEN		MODIFIED BITUMEN (2%)		MODIFIED BITUMEN (4%)		MODIFIED BITUMEN (6%)	
	Ball 1 °c	Ball 2 °c	Ball 1 ℃	Ball 2 ℃	Ball1 °c	Ball 2 °c	Ball 1 °c	Ball 2 °c
Trial 1	48°	47°	49⁰	50⁰	52°	51°	57°	56°
Trial 2	47°	47°	49⁰	51⁰	52°	53°	58°	56°
MEAN	47.5°	47°	49⁰	50⁰	52°	52°	57.5°	56°

The mean value which is obtained from the softening point test of the un modified bitumen, modified bitumen (2%) , modified bitumen (4%) , modified bitumen (6%)are 47°,49°,52°and 57° respectively.

Specific gravity test
The calculated specific gravity values are listed in the table below from those results it is clear that the specific gravity value is increasing as 1.167,1.170,1.176,1.19.

Table 4.3:specific gravity test results

TYPE OF BITUMEN	SPECIFIC GRAVITY
unmodified bitumen	1.167
modified bitumen (2%)	1.170
modified bitumen (4%)	1.176
modified bitumen (6%)	1.19

4.4 Ductility Test

The ductility test thus carried for the following bitumen binder contents are calculated and listed below and those values are below 40 cm as per code SP 53:2010.
The ductility value of the following test shows that the unmodified bitumen as the highest ductility value as 29.

Table 4.5: ductility results

Types of bitumen	Ductility value(cm)
Unmodified bitumen	29
Modified bitumen(2%)	27
Modified bitumen(4%)	24
Modified bitumen(6%)	19.5

4.5 Marshall Stability Test

The Marshall stability test thus conducted on un modified bitumen, modified bitumen (2%) , modified bitumen (4%) , modified bitumen (6%) are calculated and the results are given below

The maximum load carried by the specimen at the standard test temperature of 60*C is the stability and the flow value is the determination that the test specimen undergoes during loading up to the maximum load .flow is measured in 0.25 mm unit. In this, an attempt is made to obtain optimum binder content for the type of aggregate mix used.

Binder Content	**5.5% of total weight**
Aggregate (12mm)	**38%**
Aggregates (6mm)	**60%**
Filler	**2%**

Table no 4.5 mix design for unmodified bitumen

CONCLUSIONS

On the basis of experimental work performed during the project it is concluded that:

Waste PVC pipe can be successfully used as modifier with bitumen having conventional mix of 5.5%. The addition of waste PVC increases the softening point, specific gravity and decreases the penetration value, ductility which will prove beneficial in hot climate areas and also helpful to overcome the bleeding problems. By using the waste PVC the stability and % air voids of the bituminous mixes were improved. Form the test conducted above the PVC is mixed at various % in the bitumen and the stability is checked, as per that the bitumen mix with 6% shows the highest value.

References

[1] Ambika B, Girish Sharma, Gajendra Kumar (2003). A sustainable approach: utilization of waste PVC in asphalting of roads Vol 2-Issue 6 pp 35-55.

[2] Apurva J Chavan (2004).Use of Plastic Waste in Flexible Pavements. Vol 1, Issue no.5 pp 45-56.

[3] Akhtarhusein. A. Tayebali, Joseph L. Goodrich, Jorge B. Sousa and Carl L. Monismith (2008) Relationships between modified asphalt binders rheology and binder aggregate mixture permanent deformation response Vol 3-Issuee 3 pp 24-43.

[4] Aslam.P , Er.Shahan - ur- Rahman, Lecture Engineering, Integral University,Lucknow. (2006)Use of "Waste Plastic in Construction of Flexible Pavement". Vol 5.Issue no.5 pp 32-45.

[5] Ambikabeh .L , P.K Jain and Girish Sharma (2012) Mix Proportioning of Semi Dense Bituminous Concrete Grade-II , study on waste polyvinyl chloride bitumen for paving applications, CSIR India, Volume 1,no.2(2012)

[6] AfrozSultana S.K , K.S.B.Paul (2012) "Utilization of waste Plastic as a Strength Modifier in Surface Course of Flexible and Rigid Pavements".(International Journal of Engineering Research and Applications (IJERA)(Vol. 2, Issue 4, July-August 2012)

[7] Bambang S SUBAGIO, Djunaedi Kosasih et.al.(2005) on "Development of Stiffness Modulus and Plastic Deformation Characteristics of Porous Asphalt Mixture Vol 3,Issue 12 pp 123-156.

[8] Christopher M. Smemoe(1994), has presented a paper on "Stability and Flow by Means of the Marshall Apparatus", to Matthew Church, Highway Materials laboratory Vol 3.no.4 pp-12.

[9] Gayle N. King, Harold, W. Muncy, (2003)Binder's effect on Mix properties.Vol 5.,Issue07,2003 pp-45.

[10] Justo C.G.E and Veeraragavan. A (2002) "Utilisation of waste plastic bags in bituminous mix for improved performance of roads"Vol 3, Issue 6.

[11] Lekhaz, Mallikarjun.D, Mandan Mohan, Vasudevanaidu. The Study of Bituminous Concrete Mix by Using Different Type of Fillers like Cement GGBS and Brick Dust.Vol 6,Issue 2 pp-54.

[12] Llyod D. Coyne and Haultman.D (1987) "Evaluation of polymer modified chip seal coats". Vol 5, Issue 1 pp-65.

[13] Rasel H.M, Rahman and T.U Ahmed (2011), study of effects of waste PVC on the properties of bituminous mixes.Vol 11,Issue 3 pp-10.

[14] Shirish n. nemade and Prashant.v.thorat. (2010)Utilization of polymer waste for modification of bitumen in road construction.Vol 4,no.5 pp54-67.

[15] Tapase .A.B, Andkadam D.B,(2004)Performance Evaluation of Polymer Modified Bitumen In Flexible Pavement Vol 2,no.3,pp 45-55.

[16] Vasudevan.R and Saravanavel.S (2006) "Utilization of waste plastics in construction of flexible pavement" Vol 6,Issue 4 pp 34-46.