BRCORP
TECHNOLOGY | INNOVATION | INDUSTRY

International Journal of
Advanced Structures and Geotechnical Engineering
ISSN 2319-5347, Vol. 04, No. 04, October 2015

Performance evaluation of waste PVC modified bitumen

USMAN GHANI, WAQAS ARSHAD TANOLI
Department of Civil Engineering, University of Engineering & Technology, Peshawar, Pakistan
Email: dr_waqi@yahoo.com, usmanghani969@gmail.com

Abstract: Bitumen is currently one of the most widely used binding materials in road pavement. The reasons due to which bitumen is mostly used as a binding material are 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 etc. These modifiers are costly and not easily available, so research is focused on waste polymers instead. The waste polyvinyl chloride (PVC) is used as a modifier.

Waste PVC that has been used previously as a part of sewerage system, bottles, and credit cards is a non-biodegradable material and has undesirable impact on the environment. This study presents results of the waste PVC pipes which have been used as a modifier by an amount of 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, and stripping value were studied and compared with those of unmodified bitumen. The performance characteristic of the bituminous mix made up of these 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 in a warmer region from the standpoint of stability and flow characteristics.

Keywords: *Polymers, Crumb Rubber, Bitumen, Distresses, Polyvinyl Chloride*

1. Introduction:

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. 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.

Salient features of the polymer-waste-bitumen mix road (Bale 2011, Vasudevan 2006, Mauskar 2008) are:

- road strength is twice stronger than normal roads
- resistance towards water stagnation, plastic in bitumen provides impermeability to the mix
- less bleeding during summer
- 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
- it helps in protecting our environment from waste plastic

Objective:

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

Compare the bitumen modified mix with conventional HMA (hot mix asphalt)

2. Materials:

The materials used during the experimental program of this research were coarse aggregate (crush), fine aggregate (sand), bitumen, PVC, filler (stone dust).

3. Experimental Program:

Waste PVC pipes were obtained from local recycler. The bitumen was also obtained from local market and various tests were performed to find out their properties.

3.1 Penetration test:

The apparatus used for this test is known as penetrometer. This test is performed to measure the hardness and consistency of bitumen.

Figure 1: *Penetrometer*

Table I : Record of observation

	Test 1	Test 2	Test 3	Mean
Penetration value	73	70	67	70

Penetration value = 70

3.2. Softening point test:

Ball and ring apparatus is used to perform this test. The softening point is the temperature at which the substance attains a particular degree of softening. This test helps to know the temperature up to which the bituminous binder should be heated for various applications of road.

Figure 2: *Ball and ring apparatus*

Table 2: *Record of Observations*

	Ball 1	Ball 2	Average
Temperature at which the ball touches the bottom	39°C	41°C	40°C

Softening point of the bituminous material = 40°C

3.3. Flash and Fire point:

The flash point of a material is the lowest temperature at which the application of test flame causes the vapors from the material momentarily catches fire in the form of a flash under specified conditions of test.

The fire point is the lowest temperature at which the application of test flame causes the material to ignite and burn at least for 5 seconds under specified conditions of test.

Figure 3: *Flash and Fire point apparatus*

Record of observation:

Flash point = 243

Fire point = 251

3.4 Tests on Aggregate:

The coarse aggregate and filler material in the form of stone dust were obtained from the River Kurram and various tests were performed to find their properties which are given in the table below.

Table 3: *Properties of Aggregate*

Properties	**Value**
Los Angeles Abrasion Value	15.8%
Aggregate Impact Value	8.5%
Specific Gravity	2.7

3.5 Preparation of Blends:

Mixing of waste PVC with bitumen was performed in laboratory. The waste PVC was thoroughly washed and dried at 60°C. After washing the waste PVC was treated with fire for homogeneous dispersion into bitumen. Treated PVC waste material at two different percentages, 4% and 6% by weight of bitumen was used to modify bitumen. The blends were stored at room temperature for further work. The physical properties of bitumen with different percentages of PVC were then measured.

Table 4: *Properties of modified PVC bitumen*

Properties	**4% PVC**	**6% PVC**
Penetration value	62	56
Softening point	43°	48°
Stripping value	<2%	<2%
Flash point	253°	259°
Fire point	261°	265°

3.5 Gradation of Aggregate:

The aggregate used to make the bituminous concrete sample were selected in accordance with the specified gradation.

Figure 4: *Gradation of aggregate*

Table 5: *Specified Gradation of aggregate for bituminous concrete surface course*

Sieve size, mm	Specified % passing by wt	Adopted % passing by wt
20	100	100
12.5	80 – 100	90
10.00	70 – 90	80
4.750	50 – 70	60
2.360	35 – 50	42.5
0.600	18 – 29	23.5
0.300	13 – 23	18
0.150	8 – 16	12
0.075	4 – 10	7

3.5 Specimen Preparation:

Marshall Mix design is used to prepare different specimen. Marshall method is one of the conventional techniques for the design of asphalt mixes and adopted world widely. The proportion of mineral aggregate and asphalt should be in accordance with ASTM D 2172 or ASTM PS 90-97. When the specimens are compacted with 75 blows on either side, the designed bituminous concrete mix should full fill the following requirements.

For wearing course

1. Marshall stability value (Kg) min 700
2. Marshall flow value (mm) 2 – 4
3. Voids in total mix (%) 3 – 5

Marshall Samples were prepared for different binder content at temperature of 139° - 163° to determine the optimum binder content of the mix. Marshall Parameters at various percentages of binder content are given in Table 6.

Figure 5: *Preparation of samples*

Table 6: *Marshall Parameters at various binder content*

% by wt of mix	Bulk density G_{mb} (gm/cc)	Max. specific gravity G_{mm} (gm/cc)	Stability (Kg)	Flow (mm)	% Air voids (%)
4.1	2.37	2.503	1230	2.54	5.43
4.56	2.38	2.5	1271	2.85	4.76
5.12	2.41	2.498	1347	3.39	3.78
5.6	2.43	2.495	1168.5	4.20	2.61

For OBC measurement the graphs drawn are;

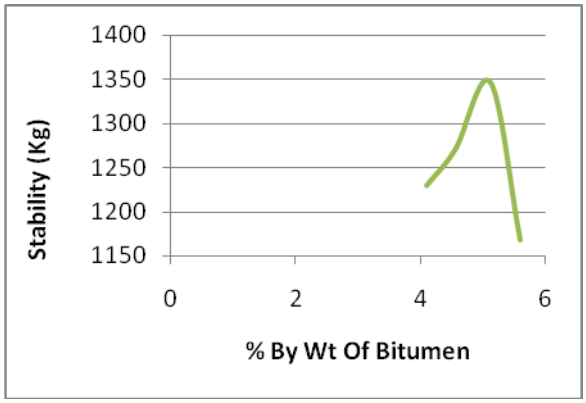

Figure 6: *Effect of binder weight on stability*

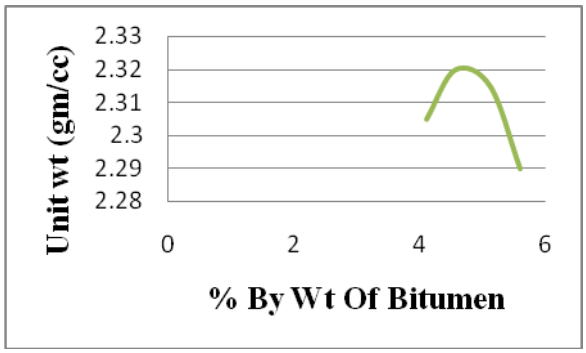

Figure 7: *Effect of binder weight on unit weight*

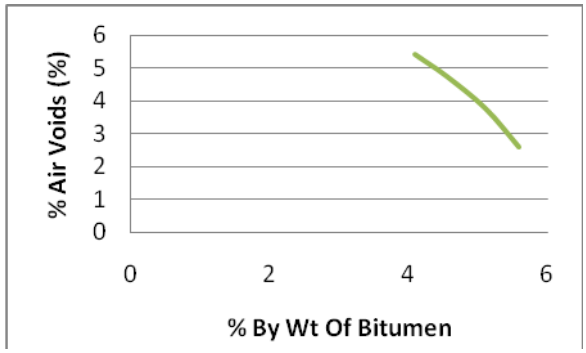

Figure 8: *Effect of binder weight on air voids*

The optimum binder content was calculated to be 5%. The Marshall parameters for samples prepared with waste PVC modified bitumen are then measured and are given in Table 7.

Table 7: *Marshall Parameters of PVC modified bituminous mixes*

% PVC	Binder % by wt of mix	Stability (Kg)	Flow (mm)	G_{mm} (gm/cc)	G_{mb} (gm/cc)	% Air voids (%)
0	5	1332.5	3.35	2.498	2.41	3.523
4	5	1373.5	3.67	2.498	2.42	3.125
6	5	1406.3	3.81	2.498	2.421	3.083

Results:

The results of different tests performed indicate that by using waste PVC as modifier the properties of simple bitumen were improved up to certain amount. Marshall Parameters of PVC modified bituminous mixes were improved and also fulfilled the requirements given in Table 6. Different properties like softening point, stripping value, penetration value and flash, fire point were improved by using the waste PVC as modifier.

Conclusion:

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

1. Waste PVC pipe can be successfully used as modifier with bitumen.
2. The addition of waste PVC increases the softening point and decreases the penetration value which will prove beneficial in hot climate areas and also helpful to overcome the bleeding problems.
3. By using the waste PVC the stability and % air voids of the bituminous mixes were improved that enable it to withstand larger stresses imposed on it by moving wheel loads without sustaining substantial permanent deformation.

Recommendations for future work:

This research is not a full-stop in this area. It is recommended to study the drawbacks of adding PVC to the binder while keeping in mind its plus points and if there are any, further research should be carried out to eliminate that. Also a comparative study of pure mix and PVC modified binder mix for various distresses should be made to decide the ground for its practical use in pavement surfaces. In addition it is recommended to study the effects of greater percentage of PVC on the binder properties. Being the main objective of every engineering project, the cost analysis should be made to decide its economical feasibility.

References:

[1] Ambikabehl, P.K Jain and Girish Sharma (2012), study on waste polyvinyl chloride bitumen for paving applications, CSIR India

[2] H .M Rasel, M.N Rahman and T.U Ahmed (2011), study of effects of waste PVC on the properties of bituminous mixes

[3] Bale, A.S. (2011), potential reuse of plastic waste in road construction: a review, Eco-web India

[4] Mauskar J.M (2008), study on performance evaluation of polymer coated bitumen built roads, I.A.S CPCB India

[5] Vasudevan, R. (2006), utilization of waste plastics for flexible pavement, Indian high ways (Indian Road Congress), July (2006)