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PERFORMANCE OF ASPHALT MODIFIED BY BITUMEN AND DE-SULFURIZED RUBBER MATERIAL

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ABSTRACT

The thesis describes the performance of bitumen added with de-sulfurized rubber asphalt binder. The main parameters that are considered for comparative study of the bitumen is the performance of de-sulfurized rubber asphalt binder bitumen. The main objectives of the study are as: 1. To examine and analyze the performance of bitumen when added with de-sulfurized rubber. 2. To investigate the tensile strength of bitumen when mixed with de-sulfurized rubber. 3. To investigate the stability of the mixture of de-sulfurized rubber and bitumen.

***KEYWORDS**: Bitumen, De-Sulfurized, Rubber, Material*

I.INTRODUCTION

There are distinctive methods for transportation, but street transport is one of the crucial means and the most generally used for transport of merchandize and ventures all throughout the world. In Ancient circumstances Romans firstly executed the idea of planning and development of streets that later changed to black-top innovation. This change from ease to cutting edge prompts to the development of agreeable streets all through the world. Extensively Asphalt can be separated into two i.e. Adaptable and unbending asphalts. Adaptable asphalt involves different layers which are sub-base, street base and wearing course. These layers are comprised of bitumen and totals while unbending asphalts are normally built with strengthened cement and are not used for transportation reasons often. Surface roads are more often constructed with bitumen asphalt. The reason for using bitumen at large is that it is the material of choice and meets the majority of the requirements for example low initial cost, phased development and readily available. With the rapid progress in every aspect it becomes necessary to extend road network to even difficult environs. Due to increasing of heavy load traffics, Engineer's all around the world have become aware to upgrade the bituminous binder. Modification of binders is done to overcome various problems regarding flexible pavements. Some of the usual and common problems faced are mentioned below:

To restrain these types of failures different types of modified binders are needed. To minimize these daily rising problems to a large extent and to have most durable pavements we need to use different modification of binders. Since 1970s the search and study with sustainable options the asphalt industry has introduced various recycled techniques to reduce waste from energy consumption and road construction costs. It is now a days a common practice to use reclaimed asphalt pavement and the good example of this is the use of rubber into asphalt binder for construction of pavements. Recycled Rubber tire is made from end of life tire. Since disposal of waste tires is a major environment concern due to many reasons, but using of rubber in asphalt binder as a modifier is one of the promising solutions that protects the environment and provides better road performance. Modified rubber asphalt binder mixture have been found with less traffic sound, less costs of maintenance, better abrasion, rutting, skid resistance and cracking resistance. The elastic property could be partially recovered from scanned electronic microscopic images of rubber pre-blended demonstration. So there is more interest in using rubber binder in hot mix asphalt mixture due to more advantages. Some studies have also found that the performance of the resulting mixture can be slightly affected by the rubber content, particle size and types, mixing conditions and technology for modifying processing, etc. Rubber binder research's started in 1980s in China and first came in Jiangsu and Sichuan provinces. In 2004, a standard provision on application of rubber binder was adopted for many major highways.

Asphalt which is also known as asphalt concrete which is also sometimes known as flexible pavement because it easily distributes the loads and it is being used since 1920. Asphalt concrete having the properties of plastic deformation form repetitive loading which is known as fatigue which is common failure mechanism due to over time loading. Asphalt can be added with polypropylene and polyester geosynthetics this type of material is used to reduce or resist the flexible pavement from penetration of frost in subgrade layer of pavement. Asphalt is categorized as hot mix asphalt, warm mix asphalt and cold mix asphalt. Hot, warm and cold denotes the temperature of mixing and lying on the top layer of flexible pavement. Hot bituminous mix has temperature more than 300-degree Fahrenheit and warm mix bituminous mix has temperature of 200-250-degree Fahrenheit. Warm mix has the advantage of less heat requirement and less emissions also. Cold mix bituminous mix has the advantage that it can be applied in rural roads because if hot mix is applied then it will cool too much when transporting from plant to site of construction. Bituminous mix can absorb traffic loads of up to 3000 vehicles per day. Bituminous mix is not able to resist too much hot weather as it becomes sticky and it cannot resist hydrocarbon contaminated soil and groundwater or polluted water drain in pavement

In pavement construction some of the aggregates are water loving in nature which makes bad effect over the whole pavement. Bitumen and rubber are the water hating materials and thus the addition of the rubber which is hydrophobic can produce a good quality material which is durable for the pavement work. Rubber is added in hot mixture and thus the mixture produced is laid over the road surface. For preventing the cracking and improving fatigue life, polymers are added in it. Thus properties of the mixtures are increased. It can't only produce durable surface for the pavements.

II.OBJECTIVES

The thesis describes the performance of bitumen added with de-sulfurized rubber asphalt binder. The main parameters that is considered for comparative study of the bitumen is the performance of de-sulfurized rubber asphalt binder bitumen. The main objectives of the study are as:

- To examine and analyze the performance of bitumen when added with de-sulfurized rubber.
- To investigate the tensile strength of bitumen when mixed with de-sulfurized rubber.
- To investigate the stability of the mixture of de-sulfurized rubber and bitumen.

III.LITRATURE REVIEW

1. Ma et al. 2016 had investigated the method for adjustment of the desulphurized rubber asphalt and its quality was contrasted with that of the crumb rubber asphalt.. Using electron microscope, material analysis, and infrared analysis, the micro structures of the two was established. Performance testing of these asphalts was conducted by the Conventional and Strategic Highway Research Program (SHRP). Mixture quality tests were also taken out just to describe the high temperature rutting resistance, low temperature cracking resistance, humidity tolerance and fatigue life of the desulfurized rubber asphalt mixture and crumb rubber asphalt mixture. It was identified that desulfurized rubber asphalt and crumb rubber asphalt modification mechanisms are different. It was found that both can improve the performance but de-sulfurized rubber has low viscosity and good stability than the other. Also the processing temperature of de-sulfurized asphalt can lowered by 10°C to 20°C compared to the crumb rubber asphalt mixture. Moreover, without the interference of solid rubber particles, the desulfurized rubber asphalt can be used in dense-graded asphalt mixture while crumb rubber asphalt mixture tends to use gap gradation with high asphalt content. This study investigated the modification mechanism and the performance of rubber modified asphalt and mixture. By comparison between crumb rubber asphalt and desulfurized rubber asphalt, the following conclusions can be summarized:

1. The modification mechanism of crumb rubber asphalt and desulfurized rubber asphalt is different. The desulfurized rubber asphalt can integrate into asphalt while the crumb rubber mainly exists incompatibly in asphalt.

This is the key reason for the performance difference between crumb rubber asphalt and desulfurized rubber asphalt.

2. Both crumb rubber and desulfurized rubber can improve the performance of virgin asphalt, shown as better high-temperature and low-temperature performance grade. The network formed by solid crumb rubber particles enhances the performance of asphalt, which results in high viscosity and easy separation from the crumb rubber asphalt. Although the integration and reaction between desulfurized rubber and asphalt decreases the high-temperature performance of desulfurized rubber asphalt compared to the crumb rubber asphalt, it reduces the viscosity and improves the storage stability of asphalt rubber as well.

3. Although the performances of crumb rubber asphalt mixture and desulfurized rubber asphalt mixture are different with each other, all of the performances of the two asphalt rubber mixtures are much better than virgin asphalt mixture, and can meet the performance requirements for modified asphalt mixture by Chinese technical specification. Although the preparing temperature of desulfurized rubber asphalt mixture is still higher than virgin asphalt mixture, it is 10~20°C less than that of the crumb rubber asphalt mixture. More importantly, desulfurized rubber asphalt can be used in dense graded mixture, which is the most commonly used mixture type in the current field projects, while the crumb rubber asphalt mixture has to use a gap gradation with high asphalt content.

4. The desulfurized rubber asphalt technology remedies a series of critical drawbacks of the asphalt rubber technology, including the high viscosity and production temperature, poor storage stability, gradation interference, and high asphalt content. Meanwhile, the production cost of desulfurized rubber asphalt is similar to the conventional modified asphalt such as SBS modified asphalt. Therefore, it provides a promising way to apply the asphalt rubber technology to the field projects.

2. Wu, Chen, Zhang, & Zhang, 2017 studied compliance with both the shear spring was accepted to put on bonding conditions in between semi-rigid base and asphalt base layer. Compressive stress, shear stress under separate interlayer bonding conditions are analyzed by orthogonal method. The impact on shear stress, tensile stress, of various interlayer bonding conditions and asphalt layer thicknesses have been further examined. When horizontal force affects the pavement structure, the pavement mechanics index is responsive to the thickness of the asphalt surface and 11 cm is the opposed thickness of the pavement for mechanical action. The shear mutation value of the top of semi-rigid base and asphalt layer bottom increases significantly, tensile stress of asphalt layer bottom becomes gradually from compressive stress to tensile stress, and the interlayer shear is also increasing with the interlayer contact conditions between asphalt layer and semi- rigid base layer changing from the bonding or half bonding to full slipping. The asphalt layer thickness of 12 cm is adverse in actual asphalt pavement structures and the change of tensile stress of asphalt layer bottom is most markedly with half interlayer bonding condition.

3. Zou, Xu, & Wu, 2017. In this study rutting has been one of the major distresses observed on asphalt pavement, due to increasing traffic volume, heavy axle load, continuous hot weather, etc., especially in long-steep-slope section, bus stops, etc. Many factors would affect rutting resistance of asphalt pavement, including material properties, climatic condition, traffic volumes, speed, and axle types, and construction quality.The orthogonal experimental design method was used in this study to reduce the number of tests required, without comprising the validity of the test results. The testing variables and their levels were selected according to investigations and field test results. Effects of various factors on asphalt pavement rutting performance were evaluated, including the asphalt binders, mixture type (aggregate gradation), axle load, vehicle speed and temperature. In this study, the wheel tracking test was used to evaluate rutting performance, as represented by the parameter Dynamic Stability (DS), of the various asphalt mixes. Test results were analyzed using range analysis and analysis of variance (ANOVA). All four factors evaluated in this study had significant effects on pavement rutting performance. The ranking of the significance was asphalt mixture type, temperature, loading frequency, and tire-pavement contact pressure. Asphalt mixture type was the most important factor that affects rutting resistance. Within the asphalt mixtures, asphalt binder had significant effects on rutting performance of mixes more than aggregate gradation. Rutting resistance of SBS modified asphalt mixes was significantly better than neat asphalt mixes, and skeleton dense structure mixes were better than suspended dense structure mixes. The conclusion of this study was, the rankings of the effects of the factors were: type of asphalt mixture > temperature > loading frequency > loading magnitude. The use of SBS modified asphalt binder improved the rutting performance compared to the mixtures with neat asphalt binder. With the same SBS modified asphalt binder, stone matrix asphalt exhibited better rutting performance than dense graded asphalt mixtures, and the effects of type of asphalt binder were prominent. Temperature was the second most important in affecting the rutting performance of the asphalt mixture. As temperature increased the DS value decreased.

4. Hakimzadeh, Behnia, Buttlar, & Reis, 2017, In this work, three different asphalt binders were studied to assess their fracture behavior at low temperatures. Fracture properties of asphalt materials were obtained through conducting the compact tension [C (T)] and indirect tensile [ID(T)] strength tests. Mechanical fracture tests were followed by performing acoustic emissions test to determine the ‘‘embrittlement temperature” of binders which was used in evaluation of thermally induced micro damages in binders. Results showed that both nondestructive and mechanical testing approaches could successfully capture low-temperature cracking behavior of asphalt materials. It was also observed that using GTR as the binder modifier significantly improved thermal cracking resistance of PG64-22 binder. The overall trends of AE test results were consistent with those of mechanical tests. Both mechanical performance tests and the acoustic emission approach showed that using Ground Tire Rubber (GTR) as the asphalt binder modifier would significantly improve low-temperature cracking resistance of asphalt binder, as GTR-modified PG64-22 binder exhibited higher tensile strength, higher fracture energy and fracture tough- ness and lower embrittlement temperature as compared to those of unmodified binder. It was also observed that bin- der modification system was sensitive to the testing temperature. At lower temperatures, GTR-modified binder exhibited superior fracture properties as compared to other binders. The AE embrittlement temperature was found to be a good indicator of low-temperature cracking performance of asphalt binders. The overall trends of embrittlement temperature of different binders were consistent with the ID (T) and C (T) test results. This provides more confidence in the use of these tests as screening tools to quickly assess the cracking resistance of asphalt materials. One major difference between the AE technique and mechanical bulk fracture testing is the response scale within the material. In the case of AE, it yields results that are at the local scale of the material response while in the mechanical tests, results are a measure of the response of the whole specimen (as a structure) and thus it is difficult to extract local properties. Both mechanical tests and AE techniques are highly recommended for complete evaluation of cracking resistance of asphalt binders

5. Ma, Wang, He, Zhao, & Huang, 2017, studied that characterize the process and performance of various modified asphalt crumb rubber including desulphurized asphalt crumb rubber and typical crumb rubber asphalt. In order to reveal the quality mechanism of specific crumb rubber asphalt, component analysis and Gel Permeation Chromatography test were used. Superpave experiments were carried out to determine the performance at low and high temperatures of different crumb rubber asphalt. To assess the processing strength of specific crumb rubber asphalt, separation test was conducted. Mix models and reliability trials are carried out to determine the high temperature rutting resistance, low temperature cracking resistance, humidity tolerance and fatigue life of various rubber asphalt mixtures. The results show that crumb rubber exists mainly separately in asphalt while most desulfurized rubber can be digested into asphalt and partially altered asphalt components and microstructure

6. Wang, Zhang, & Li, 2020, found that in order to comprehensively understand the quality and viability of desulfurized rubber asphalt (DRA), performance of road, viscosity and temperature characteristics, etc. of DRA were investigated and compared with ordinary rubber asphalt. DRA has the same resistance to fatigue as RRA. The temperature during construction of DRA can be reduced by approximately 25°C compared to RRA, which means DRA is more workable. DRA's performance grade (PG) has been classified as PG 76-34. Therefore, DRA's toxic gas emissions are smaller than RRA's, making DRA more environmentally friendly. Therefore, to expand its application, we need to modify DRA by using compound methodologies.

7. Tao Xu, Yu Feng, Zhifeng Wang and Zhihua Hu, 2016, in this paper the author studied the process of reclaimed rubber producing, the desulfurization is an important link of waste rubber recycling. It is directly affect the quality of the recycling reclaimed rubber. At present, there is no good desulfurization way for industrialization. Therefore, how to carry on the desulphurization in the process of industrialization has become a problem to be solved immediately. In this paper, a reclaimed rubber desulphurization technology based on the expert system is proposed. In order to meet the increasing material performance requirements, the development of rubber is towards to the direction of high strength, wear resistance, stability and ageing resistance. But it brings a problem that is the waste rubber can't realize the natural degradation after a long time. Worse a lot of waste rubbers cause the black pollution and the treatment of this pollution is much more difficult than that of plastic pollution. Meanwhile it is a waste of precious rubber source. All over the world, every year there are tens of millions of tons of waste rubbers produced, there into, in recent years, the quantity of waste rubbers in our country is more than ten millions of tons per year. It is a huge number. How to efficiently solve the problem has caused wide attention around the world. Ever the mountain of waste rubber products is burned as fuel. Since 1910, scientists from all over the world began to research more effective regeneration treatment technology of waste rubber. In fact, the essence of which is under a series of chemical and physical actions such as heat, oxygen, regenerative agent and mechanical action, the vulcanized rubber network damages degradation, and makes the rubber changed from elastic state into plastic and sticky state, so that it can be vulcanized again. The manufacture of reclaimed rubber mainly includes three parts, such as crushing, desulphurization and refining. There into crushing and refining belong to the mechanical processing, and desulfurization is a chemical treatment. In the manufacture of reclaimed rubber, the key working procedure is desulfurization. Under the action of mechanical, the rubber is processed into the powder particles. When the size of the powder particles is less than 1.5 millimeter, we call it as the vulcanized rubber powder.

8. Guangming Jiang, Suhe Zhao, Jingyuan Luo, Yaqin Wang, Wangyang Yu, Cuiru Zhang, 2009. This study concentrated on microbial desulfurization for NR ground rubber by Thiobacillus ferrooxidans with sulfur oxidizing capacity. NR ground rubber was desulfurized in the modified 9K medium during the cultivation of T. ferrooxidans. FTIR–ATR and XPS spectra and the increase of SO2 4 in the medium indicated that the main chains of the polymer were not broken by T. ferrooxidans, and SAS linkages on the surface of ground rubber were partly oxidized to sulfoxide and sulfone, and at last partly oxidized to SO_4^{2-}. Cumulative sulfur convention of ground rubber was 16% (w/w), which means 16% of sulfur has been fully oxidized to SO2 4 after 20 days' incubation. A sulfur oxidative scheme was proposed to explain the microbial desulfurization by T. ferrooxidans. Physical properties were determined on carbon black enforced SBR vulcanizates compounded with desulfurizated ground rubber of 40 phr loading. Preferable tensile strength and elongation at break were obtained for SBR vulcanizates filled with desulfurizated ground rubber if compared with that one obtained using ground rubber without modification. Scanning electron microscope photographs and DMA results suggested good interface coherence between desulfurizated ground rubber and SBR matrix. T.ferrooxidans was grown better in the modified 9K medium with higher Fe^{2+} concentration. The FTIR– ATR analysis and S element peak position and area in XPS spectra of desulfurizated NR indicated main chains of polymer could not oxidized to break and crosslinking sulfur was oxidized to form sufoxide and sulfone groups by T.ferrooxidans. The concentration of SO_4^{2-} in the medium increased.

9. Yuanhu Li, Suhe Zhao, Yaqin Wang, 2009. This study focused on the microbial desulfurization of ground tire rubber (GTR) by Sphingomonas sp. that was selected from coal mine soil and had sulphur oxidizing capacity. GTR was immersed in the medium co-cultured with the Sphingomonas sp. for 20 days. The growth curve of Sphingomonas sp. during co-cultured desulfurization with GTR was measured and the surface chemical groups of GTR before and after desulfurization were analyzed. The crosslink density, mechanical properties, dynamic mechanical properties, and morphology of fracture surface of SBR composites filled with GTR or DGTR were studied to evaluate the microbial desulfurization effect. The results showed that GTR had low toxicity to Sphingomonas sp., so Sphingomonas sp. was able to maintain a high biomass. After desulfurization, not only a rupture of conjugated C=C bonds, but also a reduction of sulfur content had happened to GTR. The sol fraction of GTR increased from its original 4.69–8.68% after desulfurization. Desulfurated ground tire rubber (DGTR) sheets had better physical properties, and higher swelling values than GTR sheets. The DMA results showed that SBR/ DGTR composite had a reduction of molecular chain friction resistance during glass transition region and a decrease of glass transition temperature. SEM photograph further indicated a good coherency interface between DGTR and the rubber matrix. Sphingomonas sp. with biological activity towards sulfur could be used for GTR desulfurization and maintained good growth when co-cultured desulfurization with GTR. Sphingomonas sp. could cause the breakage of conjugated C=C in waste rubber and decreased sulfur content by 22.9% on the surface of GTR. After desulfurization, crosslinked sulfur bonds could be partly cleaved and sulfur converted to sulfite or oxygen-containing sulfur-based groups. The sol fraction of GTR increased from its original 4.69–8.68% after desulfurization. SBR/DGTR composites had significantly higher mechanical properties and lower crosslink density than SBR/GTR composites at the same loading. DMA and SEM studies indicated that lower internal friction losses of SBR/DGTR composites were found and better interface coherence were formed between DGTR and the matrix compared with SBR/GTR composites. On the basis of these results, Sphingomonas sp. had good desulfurization effect on GTR.

IV. MATERIALS AND METHODS

For this study neat bitumen VG30 from unknown source and aggregates with maximum size of 20mm are used. De-sulfurized rubber in crushed form is used as a modifier binder with different percentages.

Constituents of mix

Asphalt mix is a mixture consist of continuous graded aggregates, size less than twenty five millimeter (<25mm). Appropriate amount of asphalt is added in this mix so resulting mixture which is compacted will be impervious as well as acceptable elastic property.

RAW MATERIALS USED

- Aggregates (coarse, fine)
- Binder (Bitumen)
- Desulfurized Rubber
- Crusher Dust

3.2.1 AGGREGATES

Many types of aggregates are used in the construction and preparation of the bitumen mix. These aggregates are generated from natural resources like mines or glacial deposit. These are processed from different phases to achieve its desirable properties for e.g. Big stones are break into small angular pieces. This aggregate constitutes at least 92-95 percent of whole mixture. Aggregates will provide the whole strength or load bearing capacity to the pavement. It has an very important role in pavement design. They are of three types:

a) **Coarse:** Aggregates which will not pass through 4 no. sieve (4.75 mm) or retain on 4 no. sieve those aggregates are called coarse aggregates. These are generally obtained from the crushing of rocks, there shape is angular. These angular aggregates have good interlocking properties.

b) **Fine:** The aggregates passing through 4 no. sieve and retain on 200 no. sieve (.075 mm) sieve are known as fine aggregates. They are produced during the crushing of rocks, very small particles are generated during the processing of coarse aggregates they should free from the organic matter, clay etc.

c) **Filler:** Passing through 200 no. sieve all particles comes under the filler categories. They act as filler in coarse aggregates and increase the stiffness of the binder also.

Table 3.1: Aggregate Gradation for BC

Sieve Size (mm)	% Passing
19	100
13	75-100
9.5	70-90
4.75	50-70
2.3	40-55
1.18	30-45
.6	25-35
.3	15-20
.15	10-15
75µ	5-10

3.2.2 BINDER

Bitumen used as a binder in the flexible pavements. It is a bi product of petroleum. It will bind up all the aggregates in flexible pavements. There are many types of bitumen or we can say that different type of grades is there which are used as per specifications and based on the climatic conditions.

In this research work VG 30 grade of bitumen is used.

BITUMEN

It is a non-crystalline hydro carbon in solid or liquid state possessing properties of adhesion. It is obtained by artificial or natural distillation of crude petroleum. Rather than in water, it is soluble in carbon disulphide. Properties of bitumen not only depends on its source from which it is extracted but also on preparation methods. In North America it is nick named as asphaltic cement or asphalt. Naturally occurring bitumen is called with the name of rock asphalt or natural asphalt. It is a product of petroleum which is in solid and semisolid form. It's also black in color. It is obtained both manually and naturally from various sources. Its properties are affected by the temperature, which indicates there is a fixed range where viscosity allows an adequate compaction by allowing lubrication between particles during compaction method. The movement of aggregate particles is stopped by lowering the temperature and the achievement of required density is not possible

Types of Bitumen

There are different types of bitumen present today. Some of these are as follows:

1 Based upon Penetration Grade:

Based upon penetration grade, bitumen is of the following grades:

- 80/100: This grade of bitumen is suitable for the areas where traffic volume is quite low. Properties of this grade confirm to that of S90 grade of IS 73-1992.
- 60/100: This is harder than the above one. It can withstand quite higher traffic loads. Its properties does resemble to that of S65 grade of IS 73-1992. At present this grade is commonly used in manufacturing of state highways and national highways.
- 30/40: Among all these grades this grade is harder one and can withstand against very high and heavy traffic loads. Properties of this grade resemble to that of S35 grades of IS 73-1992. Mainly it is used in construction of runways and roads where traffic volume is more.

2. Cutback

At normal room temperature cutback bitumen flows like a liquid and is obtained with the help of fluxing bitumen with appropriate solvents. By addition of kerosene viscosity gets reduced in bitumen. It is one of the most important applications in the tack coat.

3. Bitumen Emulsion

At ample temperature bitumen emulsion is free flowing liquid. Proper quality emulsifier is important to make it sure that it has stability over the period of time and most importantly it breaks and sets while its application on road aggregates.

4. Modified Bitumen

Various additives or mixes of additives called as modified bitumen can enhance properties of bitumen to a great extent. Bitumen treated using these modifiers is commonly called as modified bitumen. Commonly used modifiers are SBS, EVA, LDPE, HDPE and Rubber.

3.2.3. DESULFURISED RUBBER

3.3. METHODOLOGY

The various tests which were conducted are as follows

3.3.1. PENETRATION TEST

Apparatus Used:

- Needle: It consists of a steel needle as per IS specification needed for the penetration test of bitumen.
- Water Bath: The capacity of this is not less than 10 liters.
- Penetrometer: It is the main apparatus of the test and is having a gauge that measures the reading in unit of one tenth of a millimeter.

Theory: This test is done in order to find out or predict the hardness as well as softness of the bitumen. In this the depth is being measured in tenth or (0.01) mm. The standard needle is being used and is allowed to penetrate vertically in about 5 seconds. This is done by using penetrometer and it consists of needle assembly and in this the weight of bar is 100gm. The consistency is being determined in this process. Scope. This is a basic test for determining the grades of bitumen. In effect, the test is an indirect determination of high temperature viscosity and low temperature stiffness. The scope of this is to provide a method for determining the consistency of semi-solid and solid bituminous materials in which the sole or major constituent is either bitumen or tar pitch.

IS Code: The code used for the penetration test of bitumen is IS 203-1978.

Procedure:

- The bitumen is softened to a paving consistency between 75^0 C and 100^0C above the approximate temp at which bitumen softens.
- The sample material is thoroughly stirred to make it homogeneous and free from air bubbles and water.
- The sample containers are cooled in atmosphere of temperature not lower than 13°C for one hour. Then they are placed in temperature controlled water bath at a temperature of 25°C for a Period of one hour.
- The weight of needle, shaft and additional weight are checked. The total weight of this assembly should be 100 g.
- Using the adjusting screw, the needle assembly is lowered and the tip of the needle is made to just touch the top surface of the sample.
- The needle assembly is clamped in this position. The contact of the tip of the needle is checked using the mirror placed on the rear of the needle.
- The initial reading of the penetrometer dial is either adjusted to zero or the initial reading is noted.
- Then the needle is released by pressing a button and a stop watch is started. The needle is released exactly for a period of 5.0 secs.
- At least 3 measurements are made on this sample by testing at distance of not less than 100 mm apart.

In this test, mainly the penetration value of the bitumen lies between 20 to 25. If the bitumen is having 80/100 grade it shows the range of penetration of bitumen is 80-100. Lesser the penetration value, the harder the bitumen is.

Conditions of test: The test is normally carried out at a temperature of 250C with the total weight of the needle, spindle and added weights being 100 grams, the needle is released for a period of 5 seconds. If it is not possible to obtain these conditions or if there are special circumstances, one of the following alternative conditions may be used.

Temperature	Total Sliding	Time
□	weights, grams	Seconds
0	200	60
4	200	60
46.1	50	5

Figure 3.1: Penetration Test Apparatus.

Figure 1.2: Bitumen Samples for Penetration Test.

Calculation

The penetration is given by: Penetration = (Initial dial gauge reading (mm) - Final dial gauge reading (mm)) x 10

The three penetration values obtained on the sample must agree to within the following limits:-

Penetration	0 to 49	50 to 149	150 to 249	250
Maximum difference between highest and lowest determination	2	4	6	8

If the differences exceed the above values, the results are ignored and the test must be repeated on the second sample. If the differences are again exceeded by the second sample, the results must be ignored and the test completely repeated. If the determinations are within the above tolerances, the penetration is quoted as the average of the individual results.

Safety & Precautions:

- Use hand gloves, apron while removing containers from hot plate after switching off the hot plate.
- No disturbance occurs at time of penetration.
- Use safety shoes & Apron at the time of test.
- Equipment should be cleaned thoroughly before testing & after testing.

Testing of sample:

Bring the specimen at the base of penetrometer. Take needle and clean it with benzene and place it. The needle assembly should have free movement. Place sample below the needle and bring needle in contact with the top surface of sample. Be sure needle will be in just contact with sample and does not penetrate initially. Now allow needle to penetrate for five second. Initial reading is noted down and after five second final reading is noted down by taking readings from the dial. For each sample we have done at least three test at different locations. From this I have get three values and average is taken of these values which is the penetration value of the bitumen.

Table 3.2 Penetration Values without Rubber

Penetrometer Dial Reading	**Test 1**	**Test 2**	**Test 3**
Initial Reading	94	165	230
Final Reading	165	230	291
Penetration Value	71	65	61

Mean penetration Value is 65.6

Table 3.3 Penetration values with Rubber

% of Rubber Used	Penetration values
0	65.6
1	64.3
2	63.1
3	60.4
5	57.3

As per IS 73:2006 penetration limit lies between 50-70 so that these values lies in limit after the addition of plastic. Method of test, IS 1203.

3.3.2. DUCTILITY TEST

Apparatus Used:

Ductility Machine, Briquette Mould in which the distance of clips should be 30 mm, width of mould clips should be 20 mm and thickness should be 10 mm.

Theory: The ductility test gives the measure regarding the tensile properties of the bitumen. The tensile properties means the ability of the bitumen to deform under the loading. When the ductility value is not good, and then crack is likely to occur. Ductility is measured in distance in centimeters to which standard briquette can stretch before it starts to break. Ductility is the property of bitumen that permits it to undergo great deformation or elongation. Ductility is defined as the distance in cm, to which a standard sample or briquette of the material will be elongated without breaking. Dimension of the briquette thus formed is exactly 1 cm square. The bitumen sample is heated and poured in the mould assembly placed on a plate. These samples with moulds are cooled in the air and then in water bath at 27^0C temperature. The excess bitumen is cut and the surface is leveled using a hot knife. Then the mould with assembly containing sample is kept in water bath of the ductility machine for about 90 minutes. The sides of the moulds are removed, the clips are hooked on the machine and the machine is operated. The distance up to the point of breaking of thread is the ductility value which is reported in cm.

The ductility value gets affected by factors such as pouring temperature, test temperature, rate of pulling etc.

A minimum ductility value of 75 cm has been specified by the BIS

IS Code: The code used for ductility test is IS 1208-1978.

Procedure:

- First the bitumen is heated up.
- The bitumen is now poured into the mould kind of assembly.
- The temperature of bitumen is being decreased in air in a water bath at 27°C.
- Then size of the mould is being removed and the clips hooked and the pointer is then set to zero.
- Then the two clips are pulled apart at the rate of 50mm per min.
- Then the ductility value is calculated.
- The ductility value is the distance up till the time where the thread tends to break.

Safety & Precautions:

- Use hand gloves while removing containers from oven after switching off the oven.
- Carefully fill the mould avoid air pocket with right arrangement.
- Use glycerin for easily remove bitumen from the container.
- Use safety shoes & Apron at the time of test.
- Equipment should be cleaned thoroughly before testing & after testing.

Table 3.4: Recommended values of ductility test.

Paving Bitumen	Lowest Ductility Value
Assam Petroleum A25	5
A35	10
A45	12
A65, A90, A100	15
Bitumen from source other than Assam Petroleum S35	50
S45, S60, S90	75

Figure 3.3: Ductility Test Apparatus.

Testing Of Sample:

A side of the moulds is removed and assembly is put in the machine. Switch on the machine and put it on appropriate gear. It runs at the speed of 50 mm per minute. One end of the assembly is remaining fixed and other is pulled apart. Distance is noted at which the bitumen thread breaks and value is noted down of all tem samples. Average of these values is taken as the ductility value of the bitumen.

Table 3.5 Comparison between the Standard and Practical values

% of Rubber	Practical Values	Standard Values
0	82	75
3	34.1	17
5	18.6	11

Measurements are in centimeters. As per IS:1208-1978.

3.3.3. SOFTENING POINT TEST

Apparatus Used:

Ring and ball apparatus, metallic support, water bath, heating device.

Theory: Softening point is defined as the temperature at which a particular degree of softness is being attained under given set of conditions. In this higher is the softening point, low is the temperature susceptibility. Mainly the softening point of bitumen is 25 to 75. The test is conducted by using Ring and Ball apparatus. A brass ring containing test sample of bitumen is suspended in liquid like water or glycerin at a given temperature. A steel ball is placed upon the bitumen sample and the liquid medium is heated at a rate of 5^0C per minute. Temperature is noted when the softened bitumen touches the metal plate which is at a specified distance below.

Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates.

IS Code: The code used for softening point is IS 1205-1978.

Procedure:

- In the brass ring, bitumen sample is suspended in the liquid.
- The temperature is increased at the rate 5□ per min.
- Then the temperature is noted where the softened bitumen touches the metal which is being placed just below the ring.
- This temperature will be called as softening point of the bitumen.

Safety & Precautions:

- Use hand gloves, apron while removing containers from hot plate after switching off the hotplate.
- Use glycerin for remove of bitumen from the container.
- Use distilled water in test for accuracy result.
- Use safety shoes & Apron at the time of test.
- Equipment should be cleaned thoroughly before testing & after testing.

Testing of sample:

Distilled water is taken in the beaker. Assemble the ring and ball and place it on the metallic frame. Frame is placed in beaker filled with water. Whole assembly is placed on the hot plate and stirrer is fixed and thermometer is inserted in the slot made. Rate of heating is five degree per minute .As temperature is risen bitumen becomes soften and steel ball start falling down. Temperature is noted down when ball touches the bottom surface of the plate. Average of both values is taken which is the softening value or point of a particular bitumen.

Table 3.6: Values of Softening point Test

% of plastic	Sample	Temperature
0	1	48
0	2	50
1	1	50
1	2	51
3	1	53
3	2	55
5	1	59
5	2	62

Method of test IS 1205. As per IS 73:2006 minimum value of temperature should be 47 degree.

3.3.4 AGGREGATE CRUSHING VALUE

To determine the crushing value of the aggregate.

Preparation of sample

At the first step sample is selected then sampling and sieving is done on 25 sieves. The aggregate passing on 12.5 mm sieve and retained on 10 mm sieve is collected. Collect 6.5 kg of this sample for 2 test trials. To avoid any error due to moisture, the aggregate is heated in oven at 100 degree Celsius and is then cooled room temperature before testing. The cylinder is then filled in 3 equal depths. After putting each layer, 25 temping are given by round edge of temping rod. The top surface of aggregate in cylindrical measure is planned off straight edge of temping rod. The total aggregate in cylindrical is weighed and is recorded. these aggregates are now tempered in test cylinder with base plate. This is also done in similar manner of putting aggregates in three layers and giving 25 temping after every layer.

Testing of sample

Now, test cylinder with plunger at top is placed in CTM. Load of 40 tones is applied now at rate of 4 tones per minute. now the crushed material is transferred on 2.36 mm sieve. The fine particles collected after sieving is collected and weighed and recorded.

Table 3.7: Practical values of crushing test

	Sample(a) gm	Sample(b)gm
Wt. of dry sample(A1)	3000	3000
Wt. of crushing's passing 2.36 mm(A2)	718	709
Percentage(A2/A1)X100	23.933	23.633

Mean or crushing values= 23.783 %

Recommended maximum values of crushing test by BIS and IRC is 30 percent.

3.3.5 AGGREGATE IMPACT VALUE

Impact value of the aggregates is determined.

Preparation of sample

Oven dried material is sieved through 12.5 mm and 10 mm sieves. The material retained on 10 mm sieve and passing through 12.5 mm sieve compress the test sample. The cylindrical measure and note its weight. Fill it with upto one third depth with material. Now compact it with 25 gentle blows. In the similar manner, fill other two layers. The aggregate in cylindrical measure comprises the test sample. Fix the cup firmly in position on machine. Transfer the aggregate in the cup in a single layer and compacted by 25 gentle blows.

Testing of sample

Remove the lock and raise the hammer of machine. Lift it to give 15 similar fashioned blows. The internal between successive blows shouldn't be less than 1 sec. lock the hammer after its done and remove the crushed material from cup and collect it in plate. Pass the crushed material through 2.36 mm sieve. Weigh the fraction passing through the accuracy of 1 gram.

Table 3.8: Practical values of impact test

	Sample(a)gm	**Sample(b) gm**
Wt. of dry sample (A1)	500	500
Wt. of crushing's passing 2.36 mm(A2)	76	85
Percentage(A2/A1)x100	15.2	17

Mean or impact value of aggregate is 16.1

IRC has recommended that if the impact value lies between 20-30 percent it will be satisfactory for the surfacing of roads and less than 20 percent considered as extremely strong.

3.3.7. VISCOSITY TEST

Apparatus used: Stopwatch, Tall graduated kind of cylinder, Steel balls.

Theory: Viscosity is defined as the inverse of fluidity. It is defined as the measurement of the flow. The property allows the bitumen to spread, penetrate into the voids and also for coating purpose. For the orifice meter is used to find the viscosity of binder like the bitumen. Also various viscometer are used for the measurement of viscosity purpose. Viscosity has basically four grades VG10, VG20, VG30 and VG40.

IS Code: The code used for viscosity test is IS 1209-1978.

Procedure:

- In this the tar cup is properly leveled.
- Then after leveling, bitumen is heated in a water bath upto the testing temperature.
- Then again material is heated upto 29 after the testing temperature is attained.
- The cooling is allowed and stirring is done continuously.
- When the temperature reaches upto 40□ , it is poured into the viscometer and leveling peg is inserted.
- Then a receiving plate is placed under the orifice.
- Bitumen starts to come down and the time is noted by using the stop watch.

Requirement Criterion:

As per IS: 8887 -2004, the acceptance limits of viscosity for different types of emulsion are as follow.

Type of Emulsion	Acceptance Limits at 50^0C
Rapid Setting (RS-1)	20 – 100
Rapid Setting (RS-2)	100 – 300
Medium Setting (MS)	50 – 400
Slow Setting (SS-1)	20 – 100
Slow Setting (SS-2)	30 – 150

Figure 3.7: Ring and Ball Apparatus.

Figure 3.8: Viscosity Test Apparatus

3.3.8 SPECIFIC GRAVITY TEST

Procedure:

Weight of polythene was measured in air with the help of weight balance denote this by "A". Vessel immersed in water was kept under the balance. Iron wire piece ties to balance in a way that it will suspended 25mm above the vessel support. After this polythene was tied with sink and allow to submerge in the vessel full of water now weight the polythene denote this by "B". Now remove polythene and weight the sink and wire in submerged position denoted by "W".

Specific Gravity given by:

$$S = A / (A + W - B)$$

A = Apparent specimen mass in air.

B = Apparent specimen mass in water (sink completely immersed and wire partially)

W = Apparent specimen mass of sink and wire in water.

A = 18gm

B = 22gm

W = 24gm

S = 18 / (18 + 24 -22)

S = 0.9

IS Code: The code used for determining the specific gravity is IS 1202-1978.

Safety & Precautions:

- It is necessary that all precautions are taken in making the specific gravity bottles thoroughly cleaned and dried in the first weighting.
- The surface of the specific gravity bottle should be cleaned dry after filling with water, before weighing.
- The test temperature should be firmly adhered to.
- Inaccurate balance would never give reproducible results

Figure 3.9: Pycnometer Bottle

1.2. SCOPE OF STUDY

The main motive of this research is to analyze the performance of the bitumen when mixed with de-sulfurized rubber. By doing so we will be able to reduce the most of the failures of flexible pavement like rutting, fatigue, cracking, etc. Since these are the major problems mostly with the flexible pavement, the major cause behind these is the heavy traffic load and high tire pressure. To overcome these problems we need the modified binder which can be added to bitumen so as to enhance the overall properties of the bitumen with higher stiffness and adequate elasticity at high temperature. Therefore the future scope depends on how much these modified binders reduce problems in construction of pavements. Which not only leads to long life span of pavement but also becomes economical project. This study involves the use of de-sulfurized rubber asphalt binder with bitumen with extensive laboratory testing.

In the introduction we study about the use of rubber in bituminous concrete, need for modifying the bituminous concrete, material (desulfurized rubber) used in the modification.In the literature review we will collect some data about the project that we are going to do experiments and their suggestions. Generally the data is of two types primary and secondary, primary means related to the experience that have been experienced in the site or job and the secondary data is related to the collection of data through journals, publications , internet , newspapers and so on. After all this our methodology of experimentation starts by collecting the data and doing experimentations. In the experimentations we will study about the different tests to be conducted on the bitumen, type of bitumen. Type of bitumen is very important for the mixing of the admixtures. In the experimentation we will take different percentages of admixture in the bitumen and test the sample. In the experimentations the following test are conducted

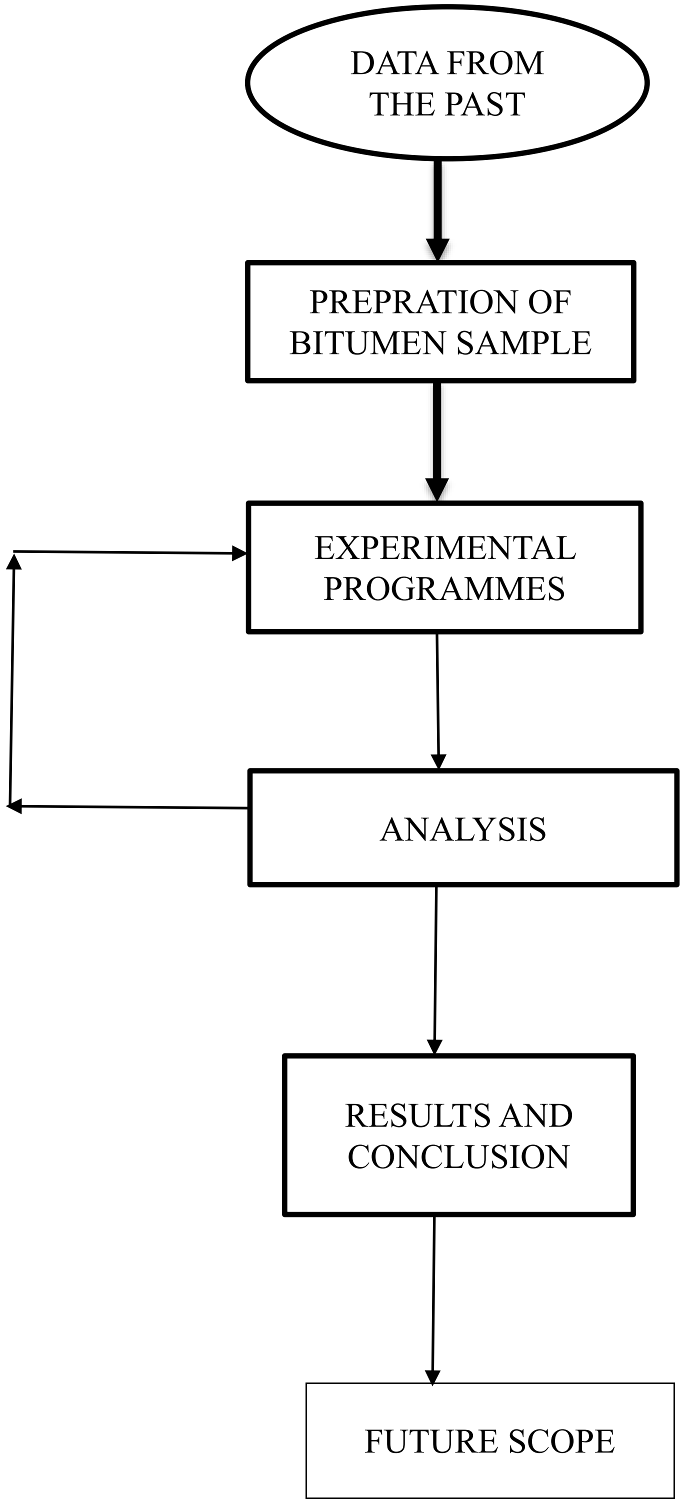

Figure 2: Flow chart of Methodology

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