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Design, Construction and Performance of Porous and Rubbrised Asphalt Pavement

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ABSTRACT- Moreover, porous asphalts have volumetric and surface characteristics (e.g., acoustic absorption, drain ability, texture, and friction). These characteristics are influenced by both intrinsic (such as gradation and bitumen content) and extrinsic (such as traffic load) variables, and the complex phenomena and processes that give rise to them determine how they change over time. Deterioration, which consequently impacts budget, noise, and safety. Despite the deterioration of so many different and intricate qualities over time, there aren't any standards for synergistically improving the pavement system. So, the goal of this study is to establish and validate a design methodology that, when applied to the most important characteristics of friction courses as a component of a pavement structure, works in concert. The aforementioned method is based on extensive literature analyses as well as experiment conducted in a lab and on-site over a period of time to assess how the major surface and volumetric qualities degrade over time.

KEYWORDS- Road engineering, Surface property, Acoustic absorption, Macro texture, Friction, Porous asphalt

I. INTRODUCTION

India, which has the second-largest road network in the world, with a total length of over 4,689,842 km as of 2013. Its adaptable pavement design, which makes up more than 98% of the entire road network, is its main feature. Due to its size, India has a wide range of temperatures, landscapes, building materials, and traffic conditions, both in terms of loads and volumes. More traffic demands pavements with higher performance due to variables including larger loads, more traffic, and higher tire pressure. Thus, traditional bitumen has to be upgraded in order to reduce damage to the pavement surface and increase the durability of flexible pavement.

The phrase "crumb rubber" is typically used to describe recycled rubber from truck and automobile trash tires. Tire rubber is left with a granular consistency after steel and fluff are removed during the recycling process. The size of the particles is decreased by continuing to process them in a granulator and/or cracker mill, possibly using cryogenics or mechanical methods. Crumb Rubber Modified Bitumen (CRMB) is created when regular bitumen and crumb rubber mix physically and chemically. Its benefits include decreased sensitivity to daily and seasonal temperature variations, increased resistance to deformation at high pavement temperatures, better age resistance properties, higher fatigue life of mixes, better adhesion between aggregate and binder, prevention of cracking and reflective cracking, and overall improved performance in extreme climatic conditions and under heavy traffic conditions.

When a surface is intended to support automotive or pedestrian activity, such as a roader walkway, it is called "pavement." Cobblestone paths were common for animal carts and for foot traffic load in earlier times, before automotive traffic became more frequent, but these surfaces have largely been replaced by bitumen or concrete.

Based on the structural behaviour, pavements are generally classified into two categories

- Flexible pavements
- Rigid pavements

The flexible pavements layers reflect the deformation of sub grade layer on to the surface of the top layer.

Flexible pavement: Flexible pavements behave structurally fairly flexibly under loads and have minimal flexural strength. Asphalt and bitumen roads are two types of flexible pavement.

Rigid pavement: Because of the stiffness, flexural strength, or slab action of the pavement, the load is dispersed over a significant area of sub grade soil. Steel reinforcement is used when laying rigid pavement in slabs. The rigid pavements are constructed with pre-stressed, reinforced, or plan concrete.

Figure 1: Environmental pollution due to waste rubber tires

A. Crumb rubber

Crumb rubber is recycled rubber made from used tyres from cars and trucks. Tire cord (fluff) and steel are taken out of the tire rubber during recycling, leaving behind granular tire rubber. The size of the particles is further decreased through additional processing in a granulator or cracker mill, perhaps with cryogenics or by mechanical means. The size and classification of the particles are based on a number of factors, including color (black only or black and white). The granulate is size-based on a dimension (1/4 inch) or mesh after passing through a screen (holes per inch: 10, 20, etc.). As a cushion, crumb rubber is frequently utilized in fake grass.

II. LITERATURE REVIEW

When crumb rubber is added to bitumen binder, it has an impact on how hard or soft it is; as the rubber content is raised, the penetration reduces. For various rubberized bitumen binder mix conditions, the penetration exhibits lower values as rubber content increases, suggesting that the binder stiffens and becomes more viscous

Mashawn et al, (2011). The qualities of rubberized bitumen created by physically combining bitumen 80/100 penetration grade with various crumb rubber contents and ageing phases were studied by Mahrez (1999). By adding more rubber to the mix, the results of penetration values fell both during and before ageing. The penetration levels of the modified binders are also lower than those of the unmodified binders. The temperature at which bitumen softens to a specific degree is referred to as the softening point. As the amount of rubber crumb used to modify bitumen grows, the softening point and viscosity will also rise (Mahrez, 1999; Mashawn et al, 20011a). According to Mahrez and Rehana (2003), the viscosity and softening point of rubberized bitumen binder exhibit a constant relationship as the material ages.

A study by Lee et al. (2008) found that the enhanced viscosity at 135°C and improved rutting capabilities were caused by the higher crumb rubber content. Also, itwas found that adding more crumb rubber (fine crumb rubber) led to rubberized bitumen having a lesser resilience and higher viscosity.

For every crumb rubber size and asphalt binder, the ideal crumb rubber content still needs to be calculated. It is thought that a physicochemical reaction between the asphalt and the crumb rubber modifies the physical characteristics and effective size of the rubber particle, affecting the performance of the pavement (Huang et al, 2007).

Becker et al. (2001), the amount of crumb rubber added to the bitumen will affect the mix qualities. Increased levels meant that the blend's qualities had changed significantly. Increased viscosity, durability, softening point, and decreased penetration at 25°C are all effects of rising rubber content in general. The mixture performed better in terms of strain value, flexural strength, dynamic stability, and 48-hour residual stability. Rubber with a 0.2- and 0.4-mm size suggested the best experimental results in asphalt (Souza and Weismann, 1994). The physical characteristics of the bituminous rubber blend were impacted by the disruption of crumb rubber particle size. Little differences in particle size typically have no discernible effects on the blend's qualities. Yet the size of the crumb rubber can undoubtedly make a significant difference.

Bahia and Davies (1994) The visco-elastic properties of rubberized bitumen binders were reportedly affected by the particle size effects of CRM on high temperature properties, according to a 2009 study by Sheen et al. When the crumb rubber content was increased, the creep stiffness decreased, resulting in a modified binder with a high shear modulus and a significant amount of thermal cracking resistance. When bitumen components migrate into crumb rubber during high-temperature mixing to create a modified binder (i.e., wet process), the two materials interact, causing the rubber to swell (Bahia and Davies, 1994). Crumb rubber and bitumen initially interact no chemically, with the rubber particles swelling as a result of absorbing the bitumen's aromatic oils.

Hertzman, (1992) Because of the interaction between crumb rubber and base binders, modified bitumen employing crumb rubber performed better for pavements than base binders. The viscosity, physical, and rheological properties of the rubberized bitumen binder are noticeably altered as a result of this interaction, giving pavements a high resistance to rutting.

III. SCOPE OF THE WORK

This research will use extensive laboratory testing to investigate the notion of using waste materials in bituminous concrete. A study will be conducted to determine whether or not it is appropriate to use in terms of appropriateness, economically, and environmentally. The following points will be the main focus of the current study. To investigate the fundamental mechanical and physical characteristics of used tire rubber in order to advance our understanding of these characteristics. To research how adding scrap tire rubber to a bituminous mix affects Marshall Stability. To lower the bitumen content by including used tire rubber into the bituminous mix. According to the Indian Standards used for building roads, laboratory tests on the bituminous mix were conducted.

IV. METHODOLOGY

This study's design for the bituminous concrete mix calls for The apparatus required for test the bitumen are

container, needle, aggregates with a nominal size of 19 mm. Crusher aggregate water bath, tray, Thermometer, Penetration apparatus and stop from a quarry and 60/70 grade bitumen were utilized as the watch etc.
study's binder and aggregate, respectively. First, tests such grain size analysis, aggregate impact value, abrasion test, crushing value test, flakiness and elongation index (combined), water absorption, specific gravity, etc. were performed in the laboratory to determine the physical attributes of aggregate. Also, using sieve analysis, it was determined that the aggregate's grade satisfied MORTH section 509's requirement for a notional aggregate grade of 19 mm for BC designs. Similar to this, the IS:73-2006 criteria were satisfied by the Bitumen Test for VG30, which included Penetration Test at 25 °C, Softening Point Test, Ductility Test at 27 °C, etc. In the second step, samples will be prepared for Marshall mix design, and the optimal bitumen content (OBC) for mix design will be determined.

A. *Materials Used*

- Aggregate - Aggregate of 20mm, 10mm
- Bitumen-VG-30 grade bitumen
- Waste rubber in the shredded less than 4.75mm
- Stone dust and cement as filler material.

Ductility value:

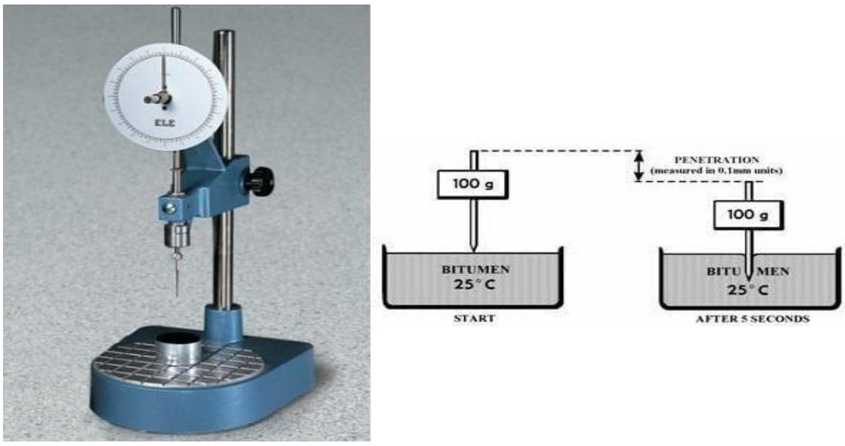

Figure 2: Penetrometer

Laboratory tests on materials: Test on aggregate:
To measure the adhesive property of bitumen and its ability to stretch or ductility of a given sample of bitumen by ductility test. And compare ductility values before adding and after adding
Standard tests on aggregate like aggregate impact, crushing value,bitumen material according to IS: 73-2006.
abrasion value, specific gravity and water absorption values wereThe ductility test measures the bitumen's adhesive and conducted by using appropriate apparatus.

B. *Test on bitumen*

extensibility properties. Binder must provide a thin, ductile layer around aggregates in flexible pavement designs in order to increase the physical interlocking of the aggregates. Bitumen's suitability for various climatic situations and building types is evaluated by grading.
Using the proper equipment, standard tests on bitumen such as penetration, softening point, and ductility were carried out.

C. *Tests on mixes*

The Marshall Stability apparatus was used to test bituminous mixes for stability, bulk density, and the ideal binder content, among other features. The qualities of bituminous mix are primarily influenced by the gradation of the aggregate, the amount of binder, themethod used for compaction, the method used for compaction, and the temperature during compaction.

D. *Penetration Value*

Penetration value is a measure of hardness or consistency of bituminous material. It is the vertical distance traversed or penetrated by the point of a standard needle in to the bituminous material under specific conditions of load, time and temperature.
This distance is measured in one tenths of a millimeter. This test is used for evaluating consistency of bitumen. It is not regarded as suitable for use in connection with the testing of road tar because of the high surface tension exhibited by these materials.

Figure 3: Ductility test apparatus

E. Softening Point Value

To determine the softening point of bitumen by ring and ball apparatus and compare the softening point of bitumen before adding and after adding bitumen material according to IS: 73-2006.

The Softening Point of bitumen is the temperature at which the substance attains particular degree of softening. The binder should have sufficient fluidity before its applications in road uses. The determination of softening point helps to know the temperature up to which a bituminous binder should be heated for various road use applications. The apparatus required for testing the bitumen ring and ball apparatus, thermometer etc.

V. RESULT

A. Penetration Value

Table 1: Observations for penetration test

Penetratio n dial reading	0% crumb rubber	5% crumb Rubber	10% crumb rubber	15% crumb rubber	20% crumb rubber
(a) Initial reading	0	0	.0	0	0
(b) final reading	36	22	20	23.1	23.83
Penetratio n value	36	22	20	23.1	23.83

B. Ductility value

Table 2: Observations for Ductility test

Percentage	**Trail-1**	**Trail-2**	**Trail-3**	**Average**
0%	39.5	34.7	42.8	39
5%	14.6	15.5	20	16.7
10%	1 3	19	20.5	17.5
15%	8.6	9.5	13.6	10.56
20%	7.3	8.9	11.3	9.16

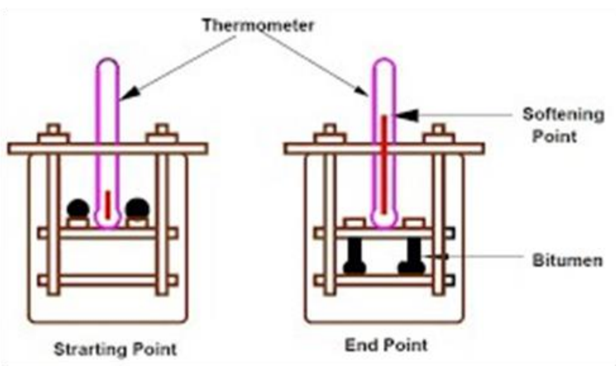

Figure 4: Softening point test apparatus

Figure 5: Marshall stability test apparatus

C. Marshall Stability Test

The purpose of this test was to identify the ideal binder level for BC mixtures. The test takes into account the following characteristics: stability, bulk specific gravity, air spaces, bitumen-filled voids, and voids in mineral aggregate. Marshall Table 9 lists the bituminous mix requirements. The criteria as given in Table 10 must be met by the voids in the mineral aggregate

D. Softening Point Value

Table 3: Observations for Softening point value

	0% crumb rubb er	5% crumb rubbe r	10% crumb rubber	15% crumb rubber	20% crumb rubber
Tempera ture when the ball touches Bottom0C	60.5	52.5	56.1	52.7	57.2

E. Marshall Stability Test

Table 4: Observations for Marshall stability test value

CRMB CONTENT %	UNIT Wt.	STABILITY (mm)	FLOW (mm)	AIRVOIDS %	VMA %	VFB %
4	2.35	1219.18	2.59	6.36	17.06	62.74
4.5	2.41	1290.53	3.15	5.52	16.84	67.21
5	2.38	1370.41	3.57	4.47	16.74	73.31
5.5	2.35	1211.33	4.16	3.87	17.89	78.38
6	2.34	993.60	5.21	3.59	18.86	79.03

VI. CONCLUSION

Porous asphalt concretes' surface characteristics are crucial. They degenerate with time Site permeability, in particular, declines with time due to clogging, and this occurrence depends on a variety of factors, including the type of pavement, position within the lane, lane type, hydrological conditions, and road location. Clogging therefore affects the air void content. It also has an impact on hydraulic conductivity. Both experimental research and a thorough literature review were conducted. A strategy was developed and used. The findings show that.

- The design of a high-performance friction course, such porous asphalt concrete, is a complicated subject that takes into account both the mechanical point of view and a number of functional features.
- The primary functional attributes' real behavior over time does not match suitable intervention limitations in the corresponding. Friction and high-frequency acoustic absorption may experience premature failures.
- Clogging, which alters the number and characteristics of pores, is primarily responsible for the real evolution over time of the primary functional features. It involves both volumetric indications (AV) and other indicators (q2 and RS). Because of this, each attribute has the level of requirement fulfilment changes over time and among the qualities, showing a varied trend. This means that a number of qualities prematurely fail in practice.
- More research is required due to the difficulty in forecasting the primary surface attributes. Building future research programmed can be done from this appropriate starting.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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