AN EXPERIMENTAL STUDY ON THE BEHAVIOUR OF BITUMEN BY PARTIALLY REPLACING WITH FOOTWEAR WASTE

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ABSTRACT

Nowadays the emerging problem is the disposal of the footwear waste that is produced due to the increasing in population, this footwear waste is disposed in land fill, which leads to soil pollution, infertility of the soil, may affect the ground water table. In order to reduce the disposal of the footwear waste we want to use it as partial replacement of bitumen, which may also improve the strength of the bitumen which we will conclude after the experimentation. In literature survey we studied about bitumen, replacements (polymers) of bitumen, and properties of bitumen. We understood that usage of polymers in bitumen at different percentage of different materials will improve the properties of bitumen like strength, etc. Several test are to be conducted on bitumen after adding of footwear waste those are, penetration test which is conducted to know the consistency and stability of the bitumen, ductility test is conducted to measure the ability of specimen to undergo plastic deformation before breaking, softening point test is conducted to know up to which temperature bitumen should be heated for various pavements, viscosity test is conducted to measure fluidity of bitumen at particular temperature, flash and fire point test is conducted to measure the extreme temperature the bitumen should be exposed to or it can bear. This footwear waste is adding in different percentages and optimum percentage will be the conclusive result. Adding of footwear was temayal so decrease the occurrence of Pothholes as they are caused due to of the penetration of rain water into the pavement, the polymers present in footwear may add more impermeability to the pavement as these polymers are adhesives. Thus, in this experiment we will study the behavior of bitumen after adding the polymer (footwear) waste into bitumen.

Keywords–*Bitumen, Footwear waste, Penetration test, Ductility, Softening point, Viscosity.*

I. INTRODUCTION

Civil engineering is the art of development and maintenance of both the constructed and the naturally built environment. Some of Constructed structures are roads, bridges, dams, buildings etc. This study is about development ofsuch construction structure by using a waste that is produced. A major waste that is produced throughout the world is used to develop an important and majorly using civil structure "Pavement" (road). Roads are majorly used form of transportation to travel from one place to another place. There are different types of roads bitumen road, concrete road, asphalt road, water bound macdom road etc. Above this entire bitumen pavement is mostly used in India as it is affordable compared to concrete pavements and it also contributes good strength to resist the loads of vehicles. As one of the major wastes that is produced through the world is 'Footwear waste' that is about 32 crore pairs of footwear waste is discarded every year according to world health organization. These discarded wastes end up in landfills and oceans causing environment pollution. The concept of Partially replacement of bitumen is used to overcome this problem up to an extent. This may improve the properties of bitumen. So, this study is to evaluate the properties and characteristics of the Bitumen mix using (Footwear waste) foam clogs.

Bitumen:

Bitumen is known as asphalt it is a sticky black and highly viscous solid or semi-solid form of by-product of crude oil. The primary use of bitumen is in road construction, where it is used as the glue or binder mixed with aggregate particles to create bitumen concrete. It is also used for water proofing and sealing of flat roofs

S.NO	PARAMETER	SPECIFICATION	STD.METHOD	TYPICAL QUALITY
1	Penetration at 25^0 C,100g,5s,0.1mm	35, Min	IS:1203	65
2	Softening point (R&B) deg.C,	50, Min	IS:1205	49
3	Viscosity ratio at 60^{0}C	4.0, max	IS:1206(part 2)	2.5
4	Durability at 25^{0}C, cm, after thin film oven test	40, Min	IS:1208	More than 150
5	Flash point (COC) Deg. C,	220 Min	IS:1209	275

Table 1 Properties of bitumen

Footwear:

Footwear refers to garments worn on the feet, which originally serves to purpose of protection against adversities of the environment, usually regarding

ground textures and temperature. Footwear in the manner of shoes therefore primarily serves the purpose to ease the locomotion and prevent injuries. Secondly footwear can also be used for fashion and adornment as well as to indicate the status or rank of the person within a social structure.

Types of footwear Boots:

Boots: Combat boots, Cowboy boots, Derby boots, Fashion boots, Go-go boots, Hiking boots, Kinky boots, Motorcycle boots, Mukluk, Platform boots, Riding boots, Russian boots, Sailing boots, Sea boots, Tabiboots, Ugg boots, Valenki, Wellington boots,Winklepickers

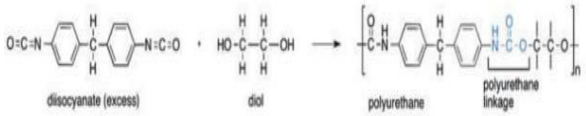
.

Shoes: Athletic shoes, Ballet flats, Brothel creepers, Court shoes, Diabeticshoes, Espadrilles, Galoshes, Kitten heels, Lace-up sholes, High –tops, Loafs,Platform shoes, Schoolshoes, Skate shoes, Sneakers, Tap shoes, Toe shoes.

Sandals: Kolhapur chappals, Peshawari chappal, Flip-flops, Slides, foam clogs, Worishofer, Avarca.

Foam Clogs:

Foam is a soft plastic with air bubbles trapped inside. The properties of different foams are determined by the composition of plastics, the size of the bubbles, and their form.



II. OBJECTIVE:

- To mix the footwear to the bitumen of grade VG 30 and made a homogeneous mixture.
- To incorporate the footwear (sandals) with bitumen to improve bonding and reduces the damage in roads.
- To find its utility in bituminous mixes for road construction laboratory performance studies were conducted on bituminous mixes.
- Improvement in properties of bituminous mix provides the solution for disposal in an useful way
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III. LITERATURE REVIEW

[1] ***"The Use of Waste Polymers to Modify bitumen", F. J. Navarrodomínguezm. Garcia-Morales*** Universidad de Huelva, Spain, 27 March 2014. This chapter deals with the modification of petroleum bitumen with different types of waste polymers: EVA, EVA/LDPE blend, PE, PP, crumb tire rubber (CTR) and ABS, all of them coming from recycling plants of waste plastic materials. In addition, the influence of processing conditions (temperature, mixing device, etc.) on the rheological properties and microstructure is also summarized. Regarding the processing conditions, the mixing device used (low or high shear) strongly affects the mechanical behavior and microstructure of the blend obtained, especially in the case of polyolefin's. For modified bitumen with CTR, no influence of the processing device was observed at temperatures equal to or below 180°C, since the processing conditions used are not able to break up the cross linked network of the rubber.

[2] ***"Utilization of waste polyethylene terephthalate (PET) as partial replacement of bitumen in stone as mastic asphalt, LameckLugeiyamu, MaKunlinElvis, BS.K.Mensahn, AhmadFaraz, China, Tanzania, 4 October 2021.*** Stone mastic asphalt (SMA) is known for its superior performance and durability compared to other forms of asphalt concrete mixtures. However, it requires high asphalt binder, typically 6–7% of the dry mix weight and the modified binder is always essential for further improvement of its performance. Unmodified asphalt binder was used, and its optimum content (OBC) was established by marshal design method, and appropriate PET value to partially replace part of OBC without jeopardizing the mix performance properties was established. The mix with PET was further evaluated against moisture damage, rutting and fatigue failure. After the extensive mix laboratory testing, the results show that 10% of PET by weight of the binder can replace the binder without affecting the mix performance requirements.Moreover, the SMA mix with 10% of PET by binder weight shows satisfactory resistance against moisture damage. Similarly, the well-compacted mix shows a long fatigue life. Dynamic modulus test shows a promising performance at low to medium temperatures and high loading frequency. However, it shows a poor performance against rutting at high temperature and low loading frequency, highlighting the necessity of a modified binder.

[3] ***An experimental investigation on partial replacement of bitumen using rubber tyre",A.Rangaraj, P.Mukesh , 31 may 2019.*** Bitumen is most widely used in the world for road construction. In India, bitumen demand was expected to reach 122 million tonnes by the analysis made in 2018, so we want some alternatives for future use. This research is based on partial replacement of bitumen by using waste rubber tyre chips as a percentage of 0%, 5%,

10%, 15% respectively. The properties of partially replaced 8 bitumen can be analyzed from the tests such as penetration test, softening point test, viscosity test and ductility test, we conclude that, better properties in 15% have efficient result while comparing to other proportion used.

[4] ***"Use of waste cooking oil, tire rubber powder and palm oil fuel ash in partial replacement of bitumen" ,Md TareqRahma, Mohd RosliHainin, Wan Azelee Wan Abubakar Faculty of Civil Engineering , UniversitiTeknologi Malaysia, Johor, Malaysia , .*** Bitumen is a heavy hydrocarbon sourced from petroleum refineries as by-product which is widely used as binder for flexible pavement. Bitumen is non-hazardous at room temperature but when heated to 165–200 °C to coat all the aggregates it generates hazardous fume which is severely detrimental to health. Laboratory investigations based on AASHTO and ASTM standard were performed to check physical and rheological properties of modified binders. Results were compared with neat bitumen as control sample to assess the feasibility of new mixture to be used in industrial scale. Outcome from this research shows that up to 15% replacement of bitumen is possible and this could produce equal or better performance in terms of stability, flow and rutting resistance. This work contributes directly to the field of transportation and highway in development of alternative binder for flexible pavement by introducing improved modified binder compositions using waste materials.

[5] ***"Influence of pandemic waste face mask on rheological, physical and chemical properties of bitumen", ErkutYalcin, AhmetMunirOzdemir, B.VuralKok,MehmetYilmaz, BahadirYilmaz, University of Firat, Elazig, Turkey, 16 April 2022.*** Recently, COVID-19 has appeared as an international pandemic, leading to serious risks for humans. Using face masks is one of the most common measures in a wide-ranging prevention program that could control the COVID-19 dissemination. In the present study, disposable face masks, the use of which has increased due to the Covid-19 pandemic throughout the world and which cause environmental pollution, were divided into very small pieces and utilized as a modifier in the bitumen binder. Therefore, this study aimed to provide a solution to such a significant environmental problem. Five different ratios of waste mask and the single ratio of styrene–butadiene styrene (SBS) were added to the pure binder and the rheological, physical, and chemical properties of the modified binders were compared. As a result, it has been determined that binders containing more than 2% waste mask have better performance characteristics than binders containing 3% SBS in terms of physical and rheological properties.

[6] ***"Lili,Maaikaterinivarveri, Ruxinjing, Corkasbergen, Sandraerkens, Thermodynamics And Kinetics Of Moisture Transport In Bitumen", 2 August 2022.*** Moisture in bitumen and at the bitumen-aggregate interface affects the cohesive and adhesive properties of asphalt mixtures, which are critical for the service performance and durability of pavements. This paper aims to investigate the kinetics and thermodynamics of moisture transport in bitumen at various temperatures and relative humidity for different bitumen types. The diffusion coefficient, cluster size and activation energy were determined and were found to be linked to the bitumen chemical and structural properties. The transport kinetics and thermodynamics are expected to contribute to a comprehensive understanding of moisture transport behavior in bitumen and further of pavement moisture damage at complex and interacting environmental conditions.

[7] ***"Characterization of asphalt bitumens and asphalt concretes modified with carbon powder", YerikAmirbayev,AidosYelshibayev,AsselNugmanova, 10 October 2022.*** Nowadays more attention is paid to nanomaterials‘ use in pavement engineering, as it is already established that asphalt concretes modified by nonmaterial can provide sound performance in terms of enduring heavy traffic loads and climate change conditions. Moreover, a comparative analysis of conventional bitumen and conventional asphalt concretes with nano-modified bitumen and nano modified asphalt concretes is presented in this research study. Comparison analysis includes conduction of Kazakhstani standards tests for bitumen, Bending Beam Rheometer test, Dynamic Shear Rheometer test, Performance Grade test, and also Kazakhstani standard tests for asphalt concretes, Elastic Modulus tests, Tensile Strength tests at a temperature range of − 30 °C to + 20 °C, Fatigue Strength test, Rutting test, Low temperature Cracking test.

[8] ***"Characterization of various bitumen exposed to environmental chemicals",XuemeiZhang, 20 January 2022*** As a necessary element of asphalt concrete, bitumen plays a decisive role in influencing the durability and lifespan of asphalt pavement. Environmental chemicals, such as de-icing salt and acid rain, have negative effects on asphalt pavement. However, different bitumen might react differently to environmental chemicals. The purpose of this research is to investigate the influence of environmental chemicals on various bitumen. To achieve this goal, three types of bitumen, base bitumen, polymer

modified bitumen, and rejuvenated bitumen, were submerged in three environmental chemicals (sodium chloride, calcium chloride, and acid). The micro-surface, physical properties (penetration, softening point, and dynamic viscosity), low-temperature

[9] ***"Preparation and properties of a novel high-viscosity modified bitumen", Zengping Zhang,16 June 2022.*** To develop a high-performance binder for open-graded porous asphalt mixtures, a novel high-viscosity modified bitumen (N-HVA) was prepared by melt blending base bitumen, terpene- styrene resin (TSR), styrene–butadiene styrene block copolymer (SBS), compatibilizer, and stabilizer, the optimal dosage of each modifier was determined. Properties and microstructure of the N-HVA were explored. Two commercially high-viscosity modified bitumen, T PS-HVA and SINOTPS-HVA, were adopted for comparison. The test results show that the appropriate dosage of modifiers is 7 wt% SBS, 4 wt% TSR, 3 wt% compatibilizer, and 0.2 wt% stabilizer.

[10] ***"Use of plastic scrap in asphalt mixtures added by dry method as a partial substitute for bitumen",D.Movilla-Quesada, University Austral of Chile.*** In recent decades, the generation of plastic waste has increased substantially worldwide, with the result that more of such waste is introduced into the environment. Currently, most polymers (polyethylene terephthalate, polyethylene, polyvinyl chloride, and others) are recycled. However, some are rejected for recycling in the primary separation processes due to their physical condition, contamination, or size. These materials are called plastic scrap.

[11] ***"Investigating aging properties of bitumen modified with polyethylene-terephthalate waste plastic",SandAldagariSkFaisalKabirElhamH.FiniArizona State University, 660 S. College Avenue, Tempe, AZ, 85287, USA. 3 June 2021*** This paper examines the merits of using recycled polyethylene terephthalate (PET) in bitumen to improve short and long-term aging of bituminous composites used in roadway constructions. A concern with PET is its low compatibility with bitumen leading to its segregation; here, we functionalized PET with waste cooking oil to enhance its compatibility with bitumen. We then studied the efficacy of functionalized PET to delay aging in bituminous composites.

[12] ***"Utilization of Plastic waste in Bitumen Mixes for Flexible Pavement", S.L.Hake Dr.[1]R.M.DamgirDr.[1*]P.R.Awsarmal[2]Associate Professor, Government College.*** The situation of present way of life an entire restriction on the utilization of waste plastic can't be put, in spite of the fact that the waste plastic taking the substance of a demon for the present and the future age. In this way transfer of waste plastic is a difficult issue all-inclusive due to their non-biodegradability and unaesthetic view. Since these are not arranged logically and probability to make ground and water contamination. This waste plastic in part supplanted the regular material to enhance wanted mechanical qualities for specific street blend.

[13] ***"Major application and impact after modified bituminous with Nitrile rubber and Thermoset: Analysis" AvaniChopra, SandeepSingh, Chandigarh University.2 July 2021.*** India is emerging as an automobile hub and has adequate production capacity of nitrile to cater to the present demand. However, with the passage of time huge waste of nitrile is likely to be created which may become a major problem for its disposal. Nitrile has certain unique properties which are suitable for the road surface viz. resistant to oil, resistant to fuels, resistant to acids, high tensile strength etc. Some research has been carried out using nitrile in bitumen and the results have been encouraging. So far research has only been carried out using Nitrile rubber with different grades of bitumen.

[14] ***"Improving Quality and Durability of Bitumen and Asphalt Concrete by Modification Using Recycled Polyethylene Based Polymer Composition", VasylNagaychuk, ArtemBezuglyi. Kyiv, Ukraine. 13 July 2016.*** Bitumen is a component of asphalt binder that combines gravel, sand and mineral powder in the monolith.Bitumen performs this function due to adhesive properties and ability to become liquid when heated, and becomes solid when cooling.At the same thermos plasticity and low strength makes bitumen the most sensitive of all the components of asphalt to the effects of traffic loads and climatic factors.

[15] ***"An experimental investigation on the use of rice straw in an bituminous concrete" , PawandeepSingh, VijayKumar, UpainKumar Bhatia. Amritsar, Punjab, India.***

15 September 2022 Rice is the most important food crop produced in Asia. Throughout the world, 90 % of rice is produced. During the production of rice, many stable wastes like straw, husk, bran, and broken rice are generated.

[16] ***"Experimental investigation of modified bituminous concrete mix using nitrile butadiene rubber (NBR)", AvaniChopra, SandeepSingh, Gharuan, Mohali, India. 18 June 2020.*** Bitumen is the most widely used constituent in the construction of roads in India, but due to high vehicular traffic and variation of climatic conditions along the length and

breadth of the country, the longevity of such road surfaces is always under criticism. The aim of the present study was to explore the possible use of Nitrile Butadiene Rubber as a partial replacement of bitumen in road construction. Characterizations tests on plain bitumen (i.e. VG30) and bitumen blended with NBR were conducted and the change in properties were observed.

[17] ***"Experimental investigation on the properties of bitumen added with industrial waste (cast iron)", M.Kalpana, BRamesh, JakkulaSai. Chennai, Tamilnadu, India. 15 December 2019.*** Bitumen pavements or flexible pavements are the most commonly used type of pavements in India. Because of high temperature roads that are laid, especially in water prone areas are highly getting damaged due to heavy traffic and deteriorating before their life span. Decrease these damages and In order to avoid cracking of the pavement and improve its stability several measures such as, use of quality materials, and improving the roadway design.

[18] ***"Evaluation of modified bituminous concrete mix developed using rubber and plastic waste materials", ShubhamBansal, AnilKumar, MisraPurnimaBajpai. Haryana, India. 20 August 2017.*** Disposal of huge amount of discarded waste materials like plastic, polythene bags, bottles, rubber tyresetc, which are generated in huge quantity and causes environmental hazards after their disposal. Present study attempts to utilize these waste materials as partial replacement of bitumen to develop a modified binder, for making bituminous concrete mix.

[19] ***Development of methods improving storage stability of bitumen modified with ground tire rubber: A review", MaciejSienkiewicz, KajaBorzędowska-Labuda, ArturWojtkiewicz, HelenaJanik. Gdansk, Poland. 31 January 2017.*** The paper presents an overview of methods for improving the storage stability at high temperature of rubber modified bitumen. The storage stability of the rubber modified bitumen can be improved by using a various type of modifiers that form the bonds between the components of these binders.

[20] ***"An experimental investigation on partial replacement of bitumen using rubber tyre", A.Rangaraj, P.Mukesh. Karur, Tamil Nadu, India. 18 July 2019.*** Bitumen is most widely used in the world for road construction. In India, bitumen demand was expected to reach 122 million tonnes by the analysis made in 2018, so we want some alternatives for future use. This research is based on partial replacement of bitumen by using waste rubber tyre chips as a percentage of 0%, 5%, 10%, 15% respectively.

[21] ***"Strength evaluation of Bitumen mix impregnated with Septage Ash", Prabhanjan Neduri, Prem Kumar B, Department of Civil Engineering, SR University, Warangal, Telangana, 16 November 2022.*** The construction of pavement requires a large number of raw materials like Coarse Aggregate, Fine Aggregate, Filler and Bitumen. Normally these pavements were constructed based on Traffic, soil conditions and economy.

[22] ***"Healing characterisations of waste-derived bitumen based on crack length" Laboratory and Modelling, Linglin Li, Yang Yang, Department of Civil Engineering, Aston University, Birmingham, UK, 17 July 2021.*** Petroleum-derived bitumen, the residue from crude oil refining, is used as a binder in asphalt concrete for constructing and maintaining over 95% of the UK's transport infrastructures, such as roads (Lvel et al., 2020), highways (Li et al., 2015), airport runways (Li et al., 2018, Li et al., 2018a, Li et al., 2018b) and car parks (Azam et al., 2018).

[23] ***"Unravelling the efficient use of waste lignin as a bitumen modifier for sustainable roads", Eyram Norgbey, Jingyu Huang, Civil Department, Kwame Nkrumah University of Science and Technology, Ghana, 23 September 2019.*** The high cost and the environmental impact associated with using petroleum bitumen in pavement construction is a problem facing the asphalt industry

[24] ***"Experimental investigation on modification of rheological parameters of bitumen by using waste plastic bottles", Sudheer Ponnada, Vamsi Krishna K, Department of Civil Engineering, MVGR College of Engineering(A), Vizianagaram, India, 4 November 2020.*** Bitumen is the most popular binding material in road construction. Nowadays due to rapid infrastructure growth and increasing in the number of vehicles it is necessary to build the roads which can sustain adverse traffic loading and extreme weather conditions. Also, disposal of waste plastic is a big problem nowadays. Studies have found that, effective use of plastic in the bitumen to improve its original properties. Plastic added to bitumen by two ways first is dry process and another is wet process

[25] ***"Characterization of rheological properties and aging performance of bitumen modified by bio-oil from bamboo charcoal production", Haotong Lin, Qi Chen, Zhejiang University, Hangzhou, China,1 February 2022.*** As a waste stream from charcoal production, the liquid bio-oil has not been properly

used, leading to both environmental and economic issues. In this study, this deleterious waste was explored as a promising additive for petroleum-based bitumen. Raw bio-oil was pretreated through distillation under different temperature to remove undesirable components. The resulting medium and heavy bio-oil fractions were blended with petroleum-based bitumen by weight ratios up to 12% to obtain bio-bitumen.

III. METHODOLOGY

The purpose of the methodology is to represent the flow of work that is going to be done. It is also a chart the work done and to be done in brief. The following is the methodology that this project is to done.

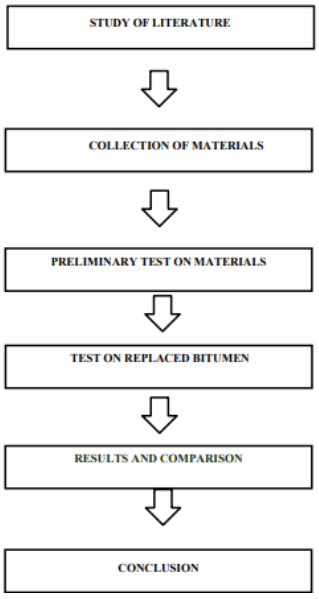


Figure 1 Flowchart methodology

IV.MATERIALS USED

A detail account of properties of material used for this study, mixing proportions of footwear bitumen and their experimental investigation is carried out and presented in this context.

Bitumen

Bitumen is a non-crystalline viscous material, black or dark brown, which is substantially soluble in carbon disulphide (CS2), possessing adhesive and water proofing qualities. It consists essentially of hydrocarbons and would typically comprise at least 80% carbon and 15% hydrogen, remaining is oxygen, Sulphur, nitrogen and traces of various metals. Bitumen of grade 60/70 is used for testing. The physical properties of bitumen used in this study evaluated by standard tests.

Figure 2 Bitumen

Foam clogs

Foam clogs are an open type of footwear, consisting of a sole held to the wearer‘s foot by straps going over the instep and sometimes, Around the ankle. Sandals can also have a heel. While the distinction between sandals and other types of footwear can sometimes be blurry, the common understanding is that a sandal leaves all or most of the foot exposed.

Figure 3 Foam Clogs

People may choose to wear sandals for several reasons among them comfort in warm weather, economy and as a fashion choice. Usually, people wear sandals in warmer climates or during warmer parts of the year in order to keep their feet cool and dry. The risk of developing athlete‘s foot is lower than with enclosed shoes and the wearing of sandals may be part of the treatment regimen for such as infection.

V. TESTS ON BITUMEN

Various tests are conducted on bitumen to assess its consistency, gradation, temperature susceptibility, and safety. There are number of tests to assess the properties of bituminous materials. The following tests are usually conducted to evaluate different properties of bituminous materials.

Penetration Test:

It measures the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds. BIS had standardized the equipment and test procedure. The penetrometer consists of a needle

assembly with a total weight of 100g and a device for releasing and locking in any position.

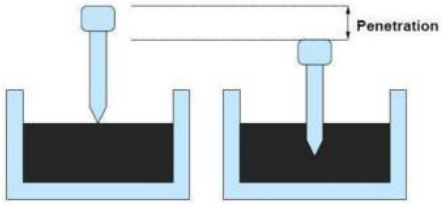


Figure 4 schematic Penetration

The bitumen is softened to a pouring consistency, stirred thoroughly and poured into containers at a depth at least 15 mm in excess of the expected penetration. The test should be conducted at a specified temperature of 250C. It may be noted that penetration value is largely influenced by any inaccuracy with regards to pouring temperature, size of the needle, weight placed on the needle and the test temperature. In hot climates, a lower penetration grade is preferred.

Figure 5 Test setup.

Ductility Test:

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 270C temperature.

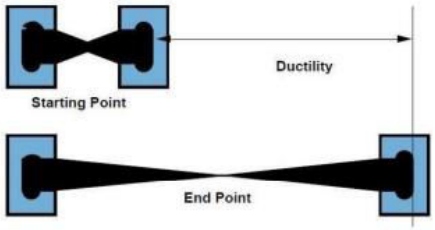


Figure 6 ductility schematic layout

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

Figure 7 ductility Test Process

Softening Point Test:

Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specified condition of test. 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.

Figure 8 Softening Point test setup

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

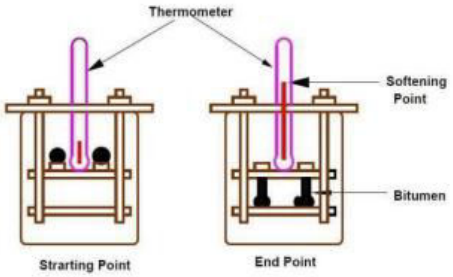


Figure 9 Softening Point schematic layout test setup

Flash and fire point test:

At high temperatures depending upon the grades of bitumen materials leave out volatiles. And these volatiles catch fire which is very hazardous and therefore it is essential to qualify this temperature for each bitumen grade.

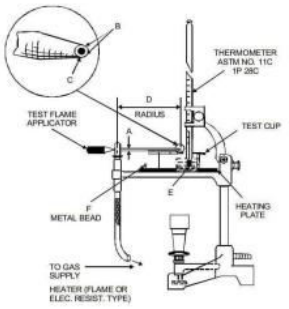


Figure 10 flash Point schematic layout

BIS defined the ash point as the temperature at which the vapor of bitumen momentarily catches fire in the form of ash under specified test conditions. The fire point is defined as the lowest temperature under specified test conditions at which the bituminous material gets ignited and burns.

Figure 11 flash Point test setup

VI. RESULTS AND DISCUSSION

In this chapter results of penetration test, ductility, softening point and Flash point of bitumen without and with adding of footwear waste at different percentages are discussed. The bitumen which is used in these experiments is of grade VG40. VG refers to Viscosity Grade and 40 refer the viscosity of the bitumen.

Penetration test:

This test represents the hardness and consistency of bitumen. The harder the bitumen the more resistance to shear and heavy loads.

Percentage of Footwear waste added	Value in mm	Minimum Value as per IS 73: 2013 (in mm)
0%	100	35
4%	68.3	
8%	43.33	
12%	38.4	

Table 2 Penetration Test

Ductility Test:

This test represents the ability of bitumen to resist cracking and deformation under tensile stress, which is important in applications where the material is subjected to repeated loading and thermal stresses in road paving.

Percentage of Footwear waste added	Value in cm	Minimum Value as per IS 73: 2013 (in cm)
0%	65.5	25
4%	48	
8%	37	
12%	29.8	

Table 3 Ductility Test

Softening Point:

This represents the temperature at which bitumen softens and begins to flow under the influence of heat. it is an important property that is used to determine the suitability of bitumen at different applications.

Percentage of Footwear waste added	Value in °C	Minimum Value as per IS 73: 2013 (in °C)
0%	44.3	50
4%	44.5	
8%	44.7	
12%	45.3	

Table 4 Softening Point Test

Flash and Fire Point:

This test represents the flammability and safety of bitumen when being handled or transported, which can help reduce the risk of accidents and fires.

Percentage of Footwear waste added	Value in °C	Minimum Value as per IS 73: 2013 (in °C)
0%	220	220
4%	230	
8%	235	
12%	238	

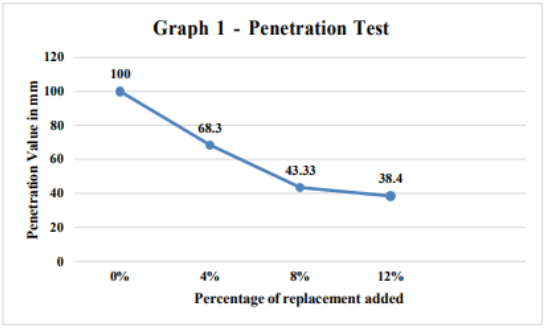
Table 5 Flash & Fire Point Test Table

Figure 12 Experiment Photos

VII. GRAPHS

Penetration test Graph:

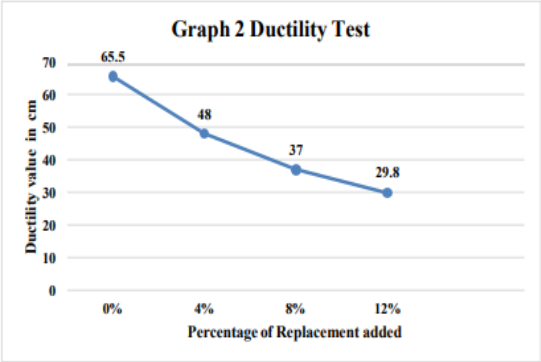
Different percentages 0%, 4%, 8% & 12% of footwear was added into the bitumen and penetration test was performed. The results of these tests are represented in the Table and Graph It is observed that addition of footwear waste into bitumen decreases penetration of needle into bitumen as the footwear waste resists the needle. As the penetration value decreases the hardness of the bitumen increases. Hence it is concluded that addition of footwear waste into bitumen increases the hardness of the bitumen.



Graph 1 penetration test

Ductile test Graph:

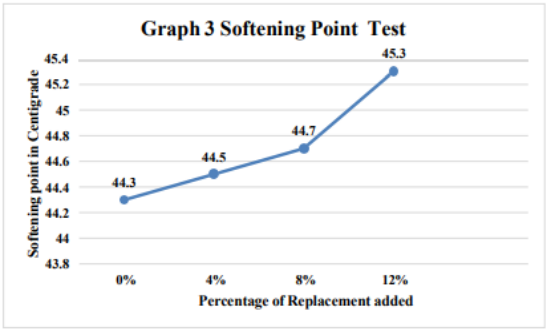
Different percentages 0%, 4%, 8% & 12% of footwear was added into the bitumen and Ductility test was performed. The results of these tests are represented in the Table 6.2 and Graph 6.2. It is observed that addition of footwear waste into bitumen decreases the ductility of bitumen as the footwear waste resists deformation. However, as the ductility decreases the ability of the bitumen to deform under load decreases but the material becomes brittle and will fracture under tensile load. Hence it is concluded that addition of footwear waste into bitumen decreases the deformation but should be added at optimum percentage.



Graph 2 Ductile test

Softening point Test Graph:

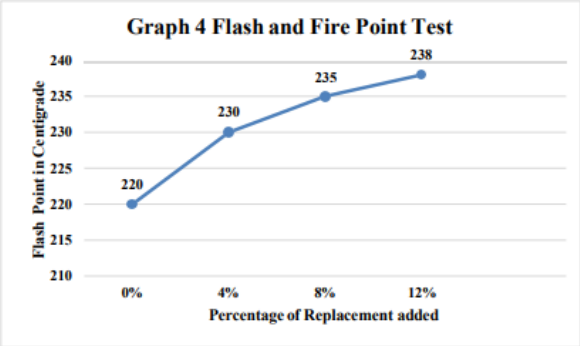
Different percentages 0%, 4%, 8% & 12% of footwear was added into the bitumen and Softening point test was performed. The results of these tests are represented in the Table 6.3 and Graph 6.3. It is observed that addition of footwear waste into bitumen increases the softness of bitumen as footwear waste resists heat and the ability to melt. However, increase in softening point will increase the energy consumption to melt the bitumen. Hence it is concluded that addition of footwear waste into bitumen increases the softening point but should be added at optimum percentage so that more energy consumption will not be economical



Graph 3 Softening point Test

Flash point test Graph:

Different percentages 0%, 4%, 8% & 12% of footwear waste was added into the bitumen and Flash point test was performed. The results of these tests are represented in the Table 6.4 and Graph 6.4. It is observed that addition of footwear waste into bitumen increases the flashpoint of bitumen as the footwear waste resists heat and the ability to melt. However, increase in flash point will increase the energy consumption to melt the bitumen but, in the areas where the temperature will be high it will resists softening of wearing course that it may stick to the tires of the vehicles moving on the pavement also will minimize the damage of wearing course. Hence it is concluded that addition of footwear waste into bitumen increases the flashpoint but should be added at optimum percentage so that more energy consumption will not be economical.



Graph Flash point test

VIII. CONCLUSION

Footwear waste can be used in the construction of the road and it can economize the cost of construction of road and at the same time reduces the environmental damage by waste disposal. Penetration value and softening point of mix with Footwear waste proves better resistance to thermal susceptibility in contradiction of conventional mix, thus result in better pavement life and performance for long term of usage. Based on trials conducted it is possible to get about much-increased service life for roads surface at a comparatively lower cost. There is very likelihood of reduced maintenance when compared to that of bituminous roads. Due to better road surface fuel savings can also be achieved and the carbon prints can also be reduced as this being environment-friendly. The utilization of footwear waste with the bitumen which leads to the pollution free environment and also make a durable and eco-friendly road. It will relieve the earth from all types of footwear waste. This Study solves two major problems, minimizing use of bitumen in binder mixture and use of waste materials in the construction of roads and highway. Foam Clogs waste has been incorporated in the mixture to replace up to 12% of bitumen successfully. The optimum waste that can be introduced to the bitumen is 8%. This idea can introduce an efficient, economic and environment friendly alternative in pavement industry.

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