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OPTIMIZING THE PLASTIC CONTENT IN THE INNOVATIVE PLAST-BIT ROADS

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Abstract : Now a day the quantity of plastic waste in Municipal as well as in Industrial waste is increasing due to increase in population, developmental activities andchanges in life style. Due to non-biodegradability, the disposal of plastic waste is agreat problem in India. Therefore the utilization of plastic waste helps toenvironmental management as well as bitumen road construction. The mainobjective of this research study is to improve the properties of bitumen by addingsome percentage of plastic waste to hot bitumen. This plastic waste increases thepenetration value, softening point and viscosity of bitumen. Thus we can saythat plastic waste improves the performance of bitumen road construction. Generating disposable plastic is becoming a major problemin manycountries. As these are non-biodegradable there is a major problemposed tothesociety with regard to the management of these solid wastes. Using waste plasticasa secondary material in construction projects would be a solution to overcome thecrisis of producing large amount of waste plastics in one hand and improvingthestructure's characteristics such as resistance against cracking on the other hand. This study aimed to investigate the effects of adding plastic in road pavement. Inthis research work waste plastic (Low Density Polyethylene) is used as modifier toprepare samples required for tests to determine the properties of the modifiedbitumen. Other objectives of the research were to analyze the effect of waste plasticmodified bitumen on road quality. The study results conclude that rheological properties like penetration, ductility of bitumen is improved after addition of LDP. It is expected that using the output of this research, the waste plastic materials canbe used in bituminous roads works, resulting in minimization of the frequencyof rehabilitation work and thereby providing an economic solution. It is also expectedto substantially reduce volume of environmentally hazardous plastic andenvironmental pollution.

I. INTRODUCTION

Roadway is a route Constructed on land portion of earth for achievingsafe, smooth and fast movement of large volume of passengers and goods traffic fromdestination to destination through all season at reasonable cost. It contributes totheeconomic, social and cultural development of country. It is cultural representativeof the country. Growth and status of the country can be measured in terms of lengthof transportation network in that country. For the construction of new Road there is large amount of Fund is required, hence we have to find Economical and Sustainable Roads by using newtechnology. In the new Technology of road Construction plastic material is introducedwithbituminous. Bitumen is a black viscous mixture of hydrocarbons obtained naturallyor as a residue from petroleum distillation or purification. A material that contain one or more organic polymer of large molecular weight, solid in its finished state, can be shaped by its flow is called as "plastic".

The durability of plastic is high and it degrades very slowly. The environmental issues with waste plastic are known to all of us. To cater to these issues manyresearchers from different fields are continuously working on different options of efficient re-use of different forms of plastic. Plastic content bituminous roads usingwaste plastic in the wearing course and are now widely used in India. WiththeIndian Road Congress (IRC) bringing out a code of specifications on plastic roads, many agencies are coming forward to implement plasticroads in India as it is a sustainable method and also the need of the hour. TheMinistry of Road Transport & highways, India has embarked upon a missionfor utilizing waste plastic in a big way. India already has over 100,000 kmof roadsmade of waste plastic, with more regions getting engulfed in this with time.

Roadways serve as vital lifelines for societies, ensuring the seamlessmovement of people and goods, thereby fostering economic growth and societal connectivity. As nations strive to expand their transportation networks, thechallenge lies in constructing new roads economically and sustainably. Innovationsin road construction, such as integrating plastic materials with bituminouscompounds, offer promising solutions to address these challenges. Plastic, known for its durability and slow degradation, has emergedas apotential candidate for enhancing road construction materials. However, theenvironmental repercussions of plastic

waste necessitate innovative approaches for its efficient reuse. In India, the adoption of plastic-modified bituminous roads hasgained momentum, with the Indian Road Congress setting specifications for theseroads. This sustainable method has garnered interest from various agencies andaligns with the government's mission to leverage waste plastic in infrastructuredevelopment.

II. LITERATURE SURVEY

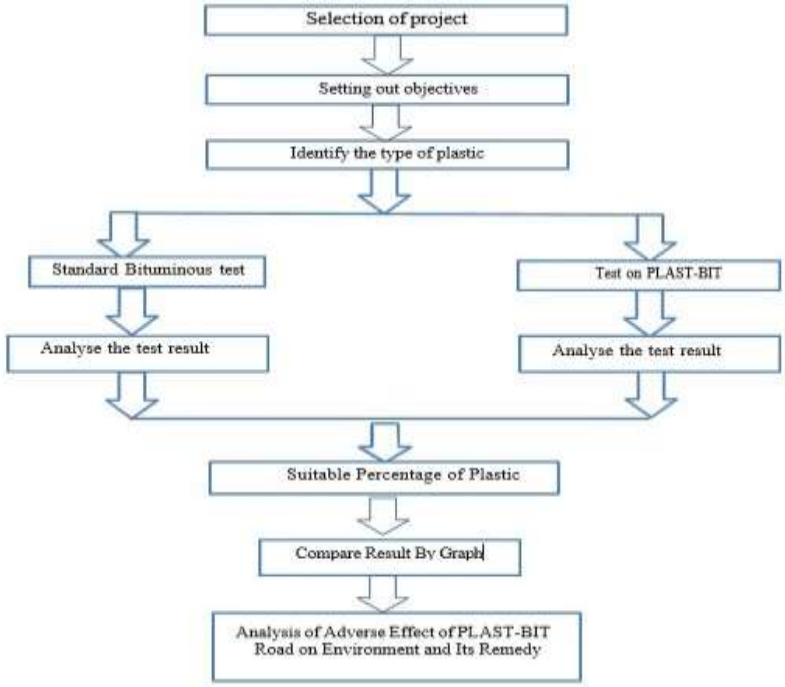
Shamim, & A. Vikram, (2023). Experimental study on usage of (PET) wasteplastic incorporating with (TIO2) titanium dioxide for the constructionof plastic roads. . By utilizing waste plastic in road construction, not only canwepotentially reduce the amount of plastic ending up in landfills or polluting natural ecosystems, but we can also improve the performance and longevity of roads. Thisapproach aligns with the principles of a circular economy, where resources arereused and recycled, contributing to a more sustainable and resilient infrastructure.However, as you mentioned, the successful deployment of wasteplastic in road construction depends on various factors including economicfeasibility, ecological considerations, and technical requirements. It's essential toensure that the incorporation of waste plastic does not compromise the qualityor safety standards of roads and pavements.Developing clear policies and guidelinesfor the use of waste plastic in road construction is crucial to ensure responsible andeffective implementation. These policies should address aspects such as qualitycontrol, material standards, procurement practices, and environmental impact assessments. Collaboration between government agencies, industry stakeholders, researchers, and communities will be essential to develop and implement suchpolicies effectively.Overall, research in this area provides valuable insights intothe potential benefits and challenges of utilizing waste plastic in infrastructureprojects, offering opportunities to move towards a more sustainable and circular economy.

Bansal, S. S. Kushwah, A. Garg, & K. Sharma. (2023). Utilization of plasticwaste in construction industry in India–A review. s The study aims to reviewthe current state of utilizing plastic waste in the construction industry withinthecontext of India. This likely involves examining existing literature, research, andpractices related to incorporating plastic waste into construction materials andprocesses.The researchers likely conduct a comprehensive reviewof existingliterature on the subject. This review would encompass studies, reports, articles, and other sources discussing various aspects of utilizing plastic waste inconstruction, such as material properties, technological advancements, environmental impact, and policy considerations The study may explore the latest technological developments and innovations in the field of using plastic wasteinconstruction materials. This could include advancements in recycling technologies, novel methods for incorporating plastic waste into concrete or other buildingmaterials, and innovative construction techniques.Bansal et al. may assess theenvironmental and economic implications of utilizing plastic waste intheconstruction industry. This analysis could involve evaluating factors suchasresource efficiency, carbon footprint, waste reduction, cost-effectiveness, andpotential market opportunities for recycled plastic materials.

Suchithra,S.Oviya,S.R.Rethinam, & P. Monisha. (2022). Production of paverblock using construction demolition waste and plastic waste–Acritical review. Materials Today: Proceedings The researchers probably conduct acomprehensive review of existing literature on the production of paver blocksusing CDW and plastic waste. This review would include studies, reports, andarticles discussing various aspects such as material composition, manufacturingtechniques, mechanical properties, and environmental considerations.Material Characterization: Suchithra et al. may analyze the physical, chemical, andmechanical properties of both the construction demolition waste and the plasticwaste. This characterization is essential to understand the suitability of thesematerials for paver block production and to determine the optimal blend ratios.thisresearch contributes to the development of sustainable construction practices byexploring innovative ways to reuse waste materials in the production of functional.

Amena. (2022). Utilizing solid plastic wastes in subgrade pavement layers toreduce plastic environmental pollution. Cleaner Engineering and Technology, 7, 100438;The research conducted by S. Amena, published in "Cleaner Engineering and Technology" in 2022, focuses on the utilization of solid plasticwastes in subgrade pavement layers with the aim of reducing plasticenvironmental pollution.The research conducted by S. Amena, publishedin"Cleaner Engineering and Technology" in 2022, focuses on the utilization of solidplastic wastes in subgrade pavement layers with the aim of reducing plasticenvironmental pollution.The research conducted by S. Amena, publishedin"Cleaner Engineering and Technology" in 2022, focuses on the utilization of solidplastic wastes in subgrade pavement layers with the aim of reducing plasticenvironmental pollution.Amena may develop a subgrade pavement designthat incorporates solid plastic wastes as a partial replacement for traditional materialssuch as soil or aggregates. This design process involves considering factors suchas load-bearing capacity, drainage, frost susceptibility, and long-termdurability.hestudy likely includes laboratory testing to evaluate the engineering properties of the plastic-waste-modified subgrade materials. This testing may involve assessingparameters such as compaction characteristics, permeability, shear strength, andresilience under cyclic loading conditions.Amena may conduct field trials or pilot projects to validate the performance of the plastic-waste-modified subgradepavement layers under real-world conditions.

III. METHODOLOGY



Polyethylene Terephthalate (PET):
PET is the most used thermoplastic polyester. PET is an acronym for polyethylene terephthalate, which is a long-chain polymer belonging to the generic group of polyesters. Polyethylene terephthalate (PET) is a semi-crystalline, thermoplastic polyester. PET is one of the polyesters which formed by a polymerization reaction between an acid and alcohol. PET is a polymer which easy to handle and also durable and strong, has low gas permeability, thermally stable and chemically. With it good properties, PET was used widely in the form of the automobile part, lighting product, food packaging, electronics, sports tools, x-ray sheets, house ware, textile, power tools and photographic applications. There are 60% of PET productions in term of bottles synthetic fibers.

Sources of PET Waste:
Sources of PET Wastes Waste PET source can be subdivided into three which are foils, bottle, and cord from tires. Foils have two small problems with material recycling which is related to utilization of additive in production and molecular weight of PET. The bottle also has the same problem with foils, and it also has another one problem which is impurities problem. The cord from tires has big material recycling problem which is pollution of ground tire rubber and metals. Most of this waste is used as alternative fuel.

Composition	Weight Percent %
Polyethylene therephthalate (PET)	77.6
Polyamide (PA)	18.7
Polypropylene (PP)	3.7

IV. ANALYSIS & TESTING

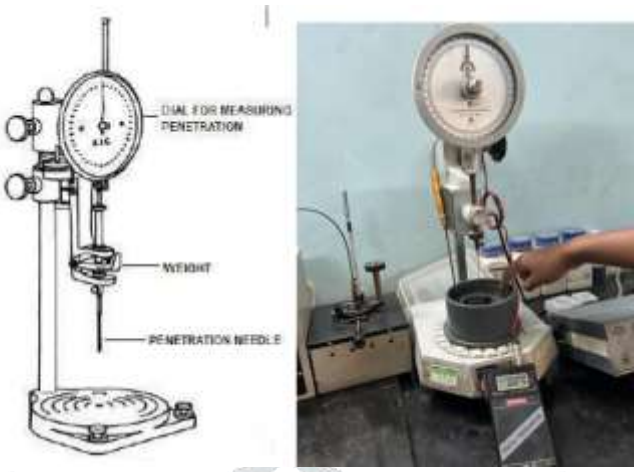
4.1 Penetration Test:
Objective: To determine the consistency of bituminous material and assess its suitability for use under different climate condition and type of construction
Reference: Indian Standard method for and bitumen. Determination of penetration IS 1203 Indian standard institution
Theory: Penetration is the measurement of hardness or of consistency of bitumen. It is the vertical distance penetrated by a point of a standard needle into bitumen material under specific condition of bad, time and temperature. The distance is measured in a 1/10th of mm this test is used for compacting consistency of bituminous material.

Apparatus:

- Container: - it is a flat bottom cylindrical metallic dishes 55 mm diameter and 35 mm deep. If penetration is of the order 225 or deep, dish of 70mm dia. and 45 mm depth is required.
- Needle: - a straight highly polished, hard cylindrical steel rod as shown in figure.
- Water Bath: - it is maintained at 25 +/- 0.2° C containing water not less than 10 liters and supported on a perforated shelf less than 50 mm from bottom of water bath
- Transfer Dish: - it should provide support to the container and should not rock it; it should be of such a capacity as to completely immerse into the container.

- Penetrometer: - it is an apparatus which allows the needle assembly of gross weight 100gm to penetrate without appreciable function for the desired duration.

1. Thermometer: - range 0- 44° C and readable up to 0.2° C
2. Time Measuring Device: - with an accuracy of +/- 0.1 sec



Precautions:

- There should be no movement of container while needle is penetrating into the sample.
- The sample should be free from any extraneous matter.
- The needle should be cleaned with benzene and dried before each penetration.

Observation Table:

Name Of Test	Unit	Test Results: Add % plastic Bottle Scrap in Bitumen	Test Results: Average In mm	Min Requirements for Paving Grades (IS 73:2013): VG30	Test Method
Penetration test	mm	0%	54	45	IS 1203:2022
		2%	51		
		4%	50		
		6%	48		
		8%	45		
		9%	40		

Remark:-

1. For 0% Plastic- The penetration test on VG 30 bitumen found as for test 1 it is 50mm ,test 2 it is 48mm and for test 3 it is 52mm. The average of all test is found to be 50mm.
2. For 2%Plastic- The penetration test on VG 30 bitumen found as for test 1it is 53,test 2 it is 54mm and test 3 is 55mm,The average of all test is found to be 54mm.
3. For 4% Plastic- The penetration test on VG 30 bitumen found as for test 1 it is 47mm ,test 2 it is 50mm and for test 3 it is 5mm. The average of all test is found to be 50mm.
4. For 6% Plastic- The penetration test on VG 30 bitumen found as for test 1 it is 50mm ,test 2 it is 46mm and for test 3 it is 48mm. The average of all test is found to be 48mm
5. For 8% Plastic- The penetration test on VG 30 bitumen found as for test 1 it is 48mm ,test 2 it is 42mm and for test 3 it is 45mm. The average of all test is found to be 45mm.
6. For9 % Plastic- The penetration test on VG 30 bitumen found as for test 1 it is 40mm ,test 2 it is 37mm and for test 3 it is 43mm. The average of all test is found to be 40mm

4.2 Ductility Test:

Objectives :

1. To determine the ductility of a givem sample of the bitumen.
2. To determine the suitability of bitumen for its use in the road construction.

Reference: Indian Standard Method for tar and bitumen determination of ductility; IS1203: Indian Standard Institution Indian Standard Specification for paving bitumen IS 73:1961, Indian Standard Institution.

Theory: The ductility gives a measure of adhesive property of bitumen and its ability to stretch. In a flexible pavement design it is necessary that the binder should form a thin ductile film around the aggregate, so that physical interlocking of the aggregate is imposed. Binder material having insufficient ductility gets cracked when subjected to repeated traffic loads and provides pervious pavement surface. Ductility of bituminous material is measured by the distance in centimeters to which it will elongate before breaking when two ends of a standard mould of material are pulled apart at a specific temperature.

Apparatus:
The apparatus for the standard ductility test as per IS1208:1978 consist of the following: Briquette mould.

Total length	75 ± 5mm
Distance between the clips	30 ± 0.3mm
Width of mouth of clips	20 ± 0.1mm
Cross-section at minimum width	10 ± 0.1mm
Thickness throughout	10 ± 0.1mm

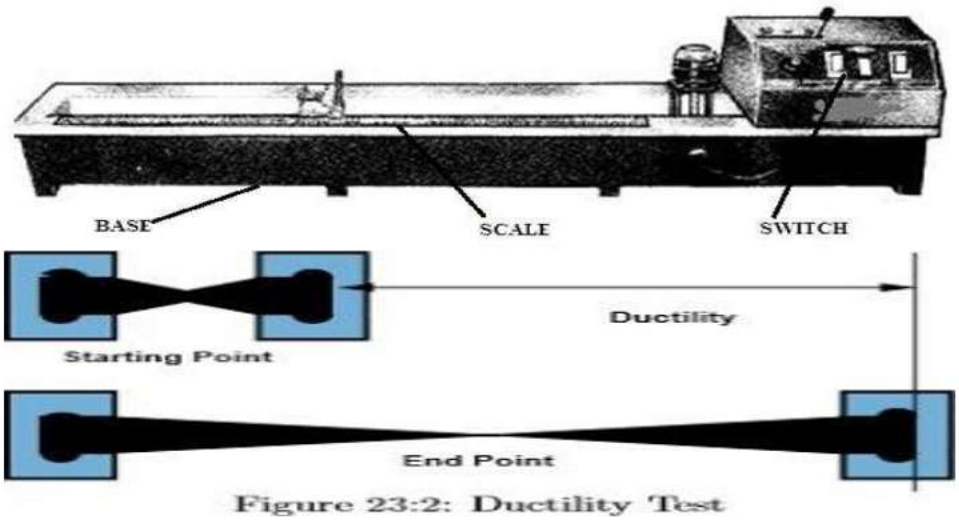


Figure 23:2: Ductility Test

Observations:

Name Of Test	Unit	Test Results		Min Requirements for Paving Grades (IS 73:2013)	Test Method
		Add % plastic Bottle Scrap in Bitumen	Average In cm	VG30	
Ductility Test	cm	0%	98	40	IS 1208:1978 (RA2019)
		2%	72		
		4%	65		
		6%	52		
		8%	48		
		9%	30		

Remark:-

- For 0% Plastic- The Ductility test on VG 30 bitumen found as for test 1 it is 101cm ,test 2 it is 98cm and for test 3 it is 95cm. The average of all test is found to be 98cm.
- For 2%Plastic- The Ductility test on VG 30 bitumen found as for test 1it is 75cm,test 2 it is 69mm and test 3 is 72cm,The average of all test is found to be 72cm.
- For 4% Plastic- The Ductility test on VG 30 bitumen found as for test 1 it is 66cm ,test 2 it is 64cm and for test 3 it is 65cm. The average of all test is found to be 65cm.
- For 6% Plastic- The Ductility test on VG 30 bitumen found as for test 1 it is 49cm ,test 2 it is 55cm and for test 3 it is 52cm. The average of all test is found to be 52mm.
- For 8% Plastic- The Ductility test on VG 30 bitumen found as for test 1 it is 48cm ,test 2 it is 45cm and for test 3 it is 51cm. The average of all test is found to be 48cm.
- For 9 % Plastic- The Ductility test on VG 30 bitumen found as for test 1 it is 25cm ,test 2 it is 30.7cm and for test 34.6 it is cm. The average of all test is found to be 30cm

4.3 SOFTENING POINT OF BITUMEN:

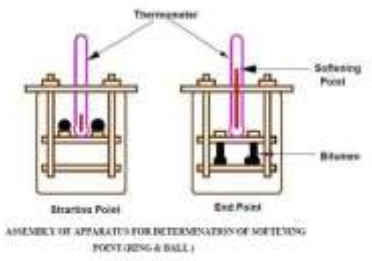
Objective: To determination the softening point of bitumen or tar.

References: Indian standard method for tar and bitumen, Determination of softening point, IS: 1205, Indian Standard Institution.

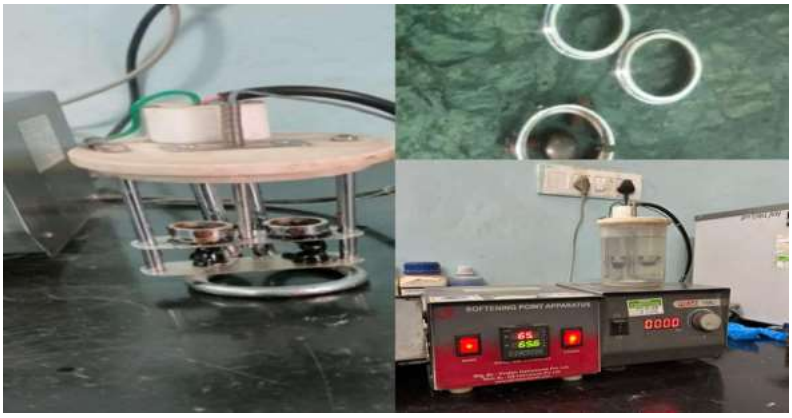
Theory: The softening point of bitumen or tar is the temperature at which the substance attains a particulars degree of softening. As per IS 334-1982, it is the temperature in degree celcious at which a standard ball passes through a height of 2-5cm, when heated under water or glycerin at specified condition of the test. The binder should have sufficient fluidity before its application in road uses. The determination of softening point helps to know the temperature, upto which a bituminous binder should be heated for various road use applications.

Apparatus: The ring and ball apparatus consist of following:

1. Steel Ball: Two numbers each of 9.5mm dia.
2. Brass Ring: two numbers, each having a depth of 6.4mm. The inside diameter of bottom and top is 15.9mm and 17.5mm resp.
3. Ball Guides: To guides the moment of steel balls contactly.
4. Support: That can hold ring in position and also allow for suspension of a thermometer. The distance between the bottom of the ring and the top surface of the bottom plate of the support is 25mm.
5. Thermometer: That can read upto 100° C with an accuracy of 0.02 °C.
6. Bath: A heat resistance glass beaker not less than 85mm in diameter and 120mm in depth.



ASSEMBLY OF APPARATUS FOR DETERMINATION OF SOFTENING POINT (RING & BALL)



Observations:

Name Of Test	Unit	Test Results		Min Requirements for Paving Grades (IS 73:2013)	Test Method
		Add % plastic Bottle Scrap in Bitumen	Average In °C	VG30	
Softening point	°C	0%	49	47°C	IS 1205:2022
		2%	50		
		4%	52		
		6%	53		
		8%	55		
		9%	68.1		

4.4 FLASH AND FIRE POINT OF BITUMEN:

Objective: To determine flash and fire point of bituminous material. References:

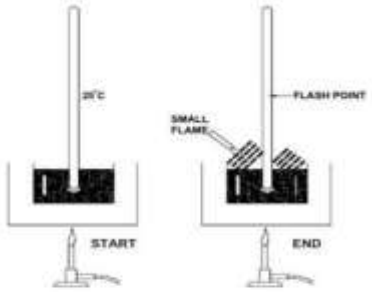
Indian standard methods for testing tar and bitumen, determination of flash and fire point IS1209, Indian standard institution, Indian standard specification for cutback bitumen IS217, Indian standard institution.

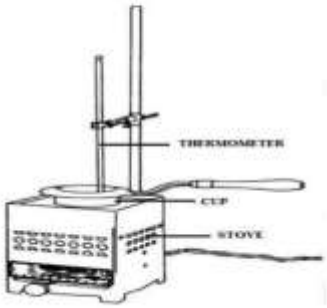
Theory:

The flash point of a material is lowest material at which the application of test film causes vapor from sample material, momentarily catch fire in the form of a flash under specified condition of test. The fire point is lowest temperature at which the application of test flame causes the material to ignite and burn at least for '5' sec. Under specified condition of test. At high temperature bituminous material emits hydrocarbon vapors, which are susceptible to catch fire. Therefore the heating of bituminous material can be safely heated.

Apparatus: The apparatus as per IS 1209-1978 consist of open cup pensky mortens closed tester with following parts;

1. Cup – it is made of brass the inside of cup may be turned to a slightly larger diameter above the filling mark and outer may be tapered above the flange is about 12 mm. in width and approximate 3mm thick it is equipped with device for locating position of the lid on the cup and the cup itself in the store A handle is attached to the large of the cup.
2. Lid- it includes a stirring device shutter flame exposure device and cover proper.
3. Stirring Device – it consists of a vertical steel shaft 2.5 to 3.5 mm diameter and mounted in the center of the carries two propeller.
4. Shutter- 2.5 mm thick and made of brass it is so shaped and mounted that it rotate on the axis of the horizontal center of the lid on one extreme position the opening A,B,C of are completely opened.
5. Flame Exposure Device – it has a tip on opening 0.7 to 0.8 mm in diameter. The device is equipped with an opening mechanism which when the shutter if in the open position. Depresses the upper surfaces of the lid proper. A pilot flame should be provided.
6. Cover Proper- it is made up of brass and its outside the closely. It has openings opening the cup closely .it has 4 openings .opening 'A' has one area defined by two concentric circle opening B & C Are of equal areas and approximately half the angular width of opening 'A' opening 'D' is provided to grip of thermometer and collar.
7. Stove- it consist of an air bath and a top plate on which the flange of the cup rest air bath has cylindrical interior 41.3 to 42.2 mm in depth .The air bath may be either a flame heated metal casing or electric resistant element The top plates is made of metal and it can be attached to the air bath with the help of 3 secures in such a manner to leave an air gap.
8. Thermometer- For low range values it has measurement range from 7 to 110°C and readable to 0.5°C for expected higher value of flash and fire point, thermometer having range of 90 to 370°C readable to 2°C.

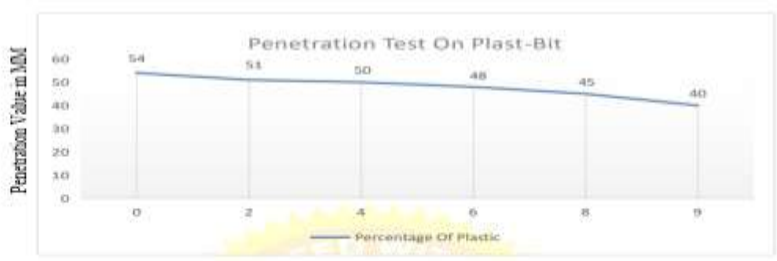




Observations

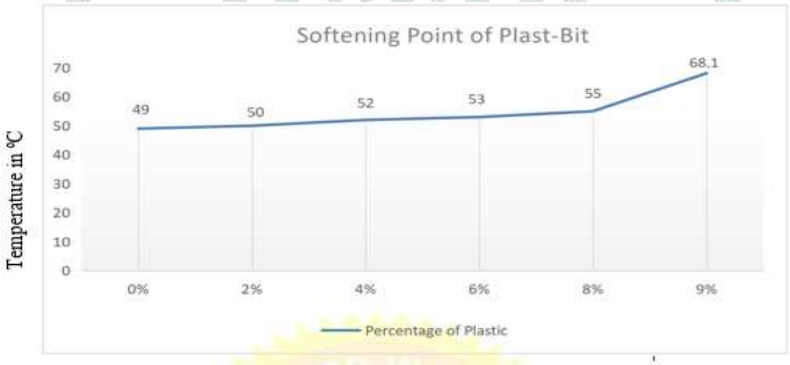
Name Of Test	Unit	Test Results		Min Requirements for Paving Grades (IS 73:2013)	Test Method
		Add % plastic Bottle Scrap in Bitumen	Average In °C	VG30	
Flash Point	°C	0%	232	22°C	IS 1209:2021
		2%	240		
		4%	248		
		6%	265		
		8%	278		
		9%	280.5		

V. RESULT

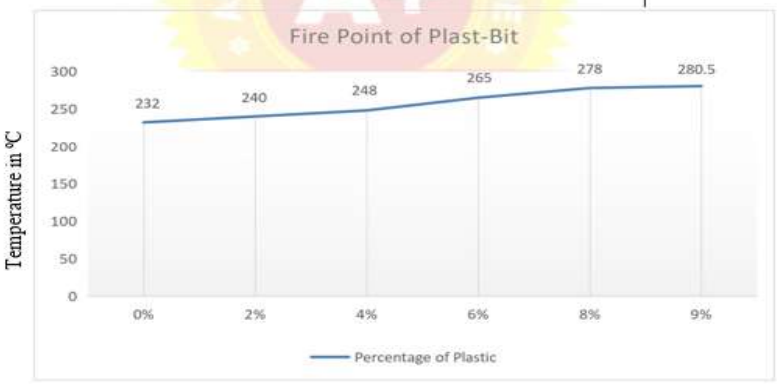


GRAPH NO.1

GRAPH NO.2



GRAPH NO.3



GRAPH NO.4

GRAPH N0.5

VI. CONCLUSION

After performing the various test on bitumen with adding plast bit from 0%,2%,4%,6%,8% & 9% following conclusion were made.

- It is found that for 0% of plast-bit mix bitumen the average penetration value is 54
- mm. As the plast-bit percentage added by 2%,4%,6%,8% and 9%. The average percentage value is found for 2%, 4%, 6%, 8% is 54,50,48, 45 respectively, Which is within limit 50 mm as per IS 1203-2022 and For 9% is found 40 mm which is less than as per(IS73:2013)
- It is found that for 0% of plast-bit mix bitumen the average ductility value is 98
- mm. As the plast-bit percentage added by 2%,4%,6%,8% and 9%. The average percentage value is found for 2%, 4%,6%,8% is 72,65,52,48 respectively, which is within limit 40 cm as per IS 1203-2022 and For 9% is found 30 cm which is less than as per (IS73:2013).
- It is found that for 0% of plast-bit mix bitumen the average softening point value is 49 mm. As the plast-bit percentage added by 2%,4%,6%,8% and 9%. The average percentage value is found for 2%, 4%,6%,8%, 9% is 49,50,52,53,55,68.1°C respectively, which is within limit 47°C as per (IS73:2013).
- It is found that for 0% of plast-bit mix bitumen the average Flash point value is 232 ^{O}C. As the plast-bit percentage added by 2%,4%,6%,8% and 9%. The average percentage value is found for 2%, 4%,6%,8%, 9% is 240,248,265,278,280.5 respectively, which is within limit 220 ^{O}C as per IS 1209-2021.

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