"USE OF WASTE PLASTIC IN CONSTRUCTION OF BITUMINOUS ROAD"

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***Abstract*—The waste plastic and its disposal is a major threat to the environment, which results in pollution and global warming. The utilization of plastic waste in bituminous mixes enhances its properties and also its strength. In addition it will also be a solution to plastic disposal. The waste plastic used are poly-ethylene. The waste plastic is shredded & coated over aggregate & mixed with hot bitumen and resulted mix is used for pavement construction. This will not only strengthen the pavement but also increases its durability. The titanium-dioxide is used as a smoke absorbent material, which will absorb the smoke from the vehicles. This innovative technology will be boon for Indian hot-humid climate. It's economical and eco-friendly. In this paper, we have discussed about the soil properties to be considered in design of pavement, pavement design,process of construction flexible. Therefore, it is excepted that this study will be helpful for minimizing pollution caused due to plastic and thus to develop a technology which is eco-friendly.**

Keywords: Plastic waste, Flexible pavement, Strength.

INTRODUCTION

India generates 1, 88,000 tons garbage every day. Plastic Waste in different formsis found to be almost 9% to 12% in municipal solid waste, which istoxic in nature. Non-biodegradability of plastic in the environment has created numerous challenges for both urban and rural India. Common problems are choking of drains, stagnation of water, and release of toxic gases upon open incineration. Research experiments in the public and private sector have been undertaken to address the growing environmental challenge. Now-a-days disposal of different wastes produced from different Industries is a great problem. These materials pose environmental pollution in the nearby locality because many of them are non-biodegradable. Traditionally soil, stone aggregates, sand, bitumen, cement etc. are used for road construction. Natural materials being exhaustible in nature, its quantity is declining gradually. Also, cost of extracting good quality of natural material is increasing. Concerned about this, the scientists are looking for alternative materials for highway construction, and industrial wastes product is one such category. If these materials can be suitably utilized in highway construction, the pollution and disposal problems may be partly reduced. In the absence of other outlets, these solid wastes have occupied several acres of land around plants throughout the country. Keeping in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of these industrial wastes in road making, in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low volume roads in different parts of our country. The necessary specifications should be formulated and attempts are to be made to maximize the use of solid wastes in different layers of the road pavement. Post construction pavement performance studies are to be done for these waste materials for construction of low volume roads with twofold benefits: (a) it will help clear valuable land of huge dumps of wastes; (b) it will also help to preserve the natural reserves of aggregates, thus protecting the environment. Plastics are user friendly but not eco-friendly as they are non-biodegradable generally, it is disposed by way of land filling or incineration of materials which are hazardous. Plastic is versatile material and a friend to common man becomes a problem to the environment after its use. The better binding property of plastics in its molten state has helped in finding out a method of safe disposal of waste plastics. Road surface with neat bitumen can cause bleeding in hot climate, may develop cracks in cold climate, possess fewer loads bearing capacity and can cause serious damages because of higher axle load in present conditions due to rapid infrastructure development. Useful life of bituminous overlays has reportedly declined 7- 8 from average life of 5-6 years in the past to about 3-4 years at present as compared to average pavement life (5-6 years) in abroad. India has to raise transportation system to a higher level both in terms of length and quality. This study presents the use of waste in hot bituminous mixes to enhance pavement performance, protect environment and provide low cost roads. Polymer and plastic modified bitumen, often abbreviated as modified bitumen is obtained with the incorporation of selected thermoplastics and shredded plastic from discarded waste, natural plastic or any other suitable elastomers in bitumen.

OBJECTIVE

- To find the strength of bitumen after mixing plastic waste.
- To compare ordinary and modified bitumen.
- To compare the estimate of overall cost of both bitumen.
- To understand administrative processes involved in usage of plastic waste in road Construction
- To assess the process followed in incorporating the relevant guidelines and rules of the Indian Roads Congress regarding use of plastic in road various types of road constructions
- To identify any challenging concerns
- To highlight implementation cost involved in execution
- Evaluate coordination methods between urban bodies dealing with disposal of plastic waste and road construction departments using waste in the road building.

- Assess the extent to which the innovation could address the issue of best possible disposal of solid waste (of plastic) faced by urban governing bodies.
- Recognize need for media role in creating public awareness in replication of this innovation.

SCOPE OF WORK

- Assessment of durability of plastic as compared to other materials comparing the use and on a limited scale the performance.
- Assessment would be selective to highlight best practice and operational parameters.
- Assessment of plastics such as polyethylene, polypropylene, polystyrene among others mentioned in the IRC standard SP-98.

METHODOLOGY

- Primary Research:

Primary research involved field visits and interacting with operational participants and stakeholders involved in plastic road construction. The goal of primary research was to collect data qualitative and quantitative along with supporting documents. This was conducted with a view to improve service deliver and enhance replication prospects elsewhere in the country.

Primary Research was critical in developing a nuanced understanding of implementation of plastic roads. In the event of not being able to meet field operatives, telephonic interviews were conducted. Field visits assisted in developing observations of use by beneficiaries and semi-structured interviews of key stakeholders.

- Secondary Desktop Research:

Secondary research involved desktop analysis of technical, administrative, regulatory and organizational aspects of the project. The scope of these references varied from global, regional and local. Secondary research scope of sources included:

Journal papers, patents, government reports, working papers, and case studies for developing a holistic understanding of the context and need for the innovation.

- Focus Group Discussion:

Focus group discussions were used as a qualitative research tool to bring out understanding, opinions and perceptions of the stakeholders in a semi-structured discussion. Focus group meetings were held on the key issues and analytical questions with implementing agencies, contractor, self –help group, societal beneficiaries, policy makers. Small focus group meetings were also held between functional groups to get a better understanding of working dynamics and implementation challenges. Limited scale focus group discussions were also held with beneficiaries. The focus group discussions held in formulating the case study have been mentioned. Qualitative analysis of the discussion outcomes have been included in the case study and distilled to reflect in the roll out strategy for other states.

LITERATURE REVIEW

- **Dr.R.Vasudevan (2007)** -

Stated that the polymer bitumen blend is a better binder compared to plain bitumen. Blend has increased softening point and decreased Penetration value with a suitable ductility.

- **Zahra Niloofar Kalantar (2012)** –

Many researches on PMA mixture have been conducted for the past two decades. Although addition of virgin polymers to asphalt for the purpose of enhancing the properties of asphalt over a wide temperature range in paving applications was contemplated quite some time ago, recycled polymer added to asphalt have also shown almost the same result in improving the road pavement performance as compared to virgin polymers. This paper is a review of the use of polymers in asphalt pavement. In this study, a critical review on the history and benefits of using waste and virgin polymer in asphalt is presented.

- **R.Manju et al** /International Journal of ChemTech Research, 2017,10(8): 804-811. 806 followed by a review of general studies on using polymers in asphalt in order to improve the properties of pavement.

- **Amit Gawande (2012)**-

The quantum of plastic waste in municipal solid waste (MSW) is increasing due to increase in population, urbanization, development activities and changes in life style which leading widespread littering on the landscape. Thus disposal of waste plastic is a menace and become a serious problem globally due to their non-biodegradability and un aesthetic view. Since these are not disposed scientifically & possibility to create ground and water pollution. This waste plastic partially replaced the conventional material to improve desired mechanical characteristics for particular road mix. In conventional road making process bitumen is used as binder. Such bitumen can be modified with waste plastic pieces and bitumen mix is made which can be used as a top layer coat of flexible pavement11. This waste plastic modified bitumen mix show better binding property, stability, density and more resistant to water.

- **Sunil J. Kulkarni (2015)**-

Minimization of waste material is important aspect of the modern growth and development initiatives4. Plastic is used in various domestic and industrial applications. Use of plastic bags and bottles is very common. The disposal of plastic waste is major problem due to non-biodegradable nature of plastic. The plastic can be used

as feedstock for ethanol like products. It can be used for road construction and other construction related activities. The current review summarizes the research on use of waste plastic.

- **Rishi Singh Chhabra (2014)** -

In the highway infrastructure, a large number of originates materials and technologies have been invented to determine their suitability for the design, construction and maintenance of these pavements. Plastics and rubbers are one of them. Also considering the environmental approach, due to excessive use of polythene in day to day business, the pollution to the environment is enormous. The use of plastic materials such as carry bags, cups, etc. is constantly increasing day by day10. Since the polythene are not biodegradable, the need of the current hour is to use the waste polythene in some beneficial purposes. The use of these materials as a road construction proves eco- friendly, economical and use of plastic gives strength in the sub-base course of the pavement.

- **Prof.C.E.G. Justo**-

States that addition of 8.0 % by weight of processed plastic for the preparation of modified bitumen results in a saving of 0.4 % bitumen by weight of the mix or about 9.6 kg bitumen per cubic meter (m 3) of BC mix. Modified Bitumen improves the stability or strength, life and other desirable properties of bituminous concrete mix forms.

- **V.S. Punith, (2001)**-

Some encouraging results were reported in this study that there is possibility to improve the performance of bituminous mixes of road pavements. Waste plastics (polythene carry bags, etc.) on heating soften at around 130°C. Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Softened plastics have a binding property. Hence, it can be used as a binder for road construction.

TECHNOLOGY

The quantum of plastic waste is estimated to be roughly 10 thousand tons per day (TPD). The two major categories of plastics are (i) Thermoplastics and (ii) Thermosetting plastics. The Thermoplastics include Polyethylene Terephthalate (PET), Low Density Poly Ethylene (LDPE), Poly Vinyl Chloride (PVC), High Density Poly Ethylene (HDPE), Polypropylene (PP), Polystyrene (PS) *etc.* and are recyclable. Thermosetting plastics constitute alkyd, epoxy, ester, melamine formaldehyde, phenolic formaldehyde, silicon, urea formaldehyde, polyurethane, metallized and multilayer plastics etc. A mismanagement of plastics waste is a threat to the environment in the following ways (1):

1. Drains are choked and public places become filthy due to the littered plastics.
2. The emission of polluting gases due to burning of garbage containing plastics may cause air pollution.
3. Garbage mixed with plastics hinders the waste processing facilities may be a cause of issues in landfill operations.
4. Some unhygienic hazards to the environment are being caused by recycling industries operating in non-conforming areas.

One of the ways of managing waste plastic is by using it in construction material for pavements and roads which serves the dual purposes of imparting stability and durability to the roads and resolving the issue of environmental hazard due to ever increasing waste plastics. To understand the role of plastics in construction material, one must be familiar with the material specific properties and the processes used in laying roads. Having said this, further discussion details the use of each component and the processes involved in creating construction material.

PLASTIC MODIFIED BITUMINOUS ROAD VERSUS CONVENTIONALBITUMINOUS ROAD

Table provides an insight on various aspects of pavements constructed using bituminous concrete mixes with and without plastic waste. It is evident that plastic modified bituminous roads offer more stability, durability and cost effectiveness in comparison to conventional bituminous roads.

Comparison between ordinary bituminous roads and waste plastic bituminous roads:

S.No.	Properties	Plastic Road	Ordinary Road
1.	MARSHALL STABILITY VALUE	MORE	LESS
2.	BINDING PROPERTY	BETTER	GOOD
3.	SOFTENING POINT	LESS	MORE
4.	PENETRATION VALUE	MORE	LESS
5.	TENSILE STRENGTH	HIGH	LESS
6.	RUTTING	LESS	MORE
7.	STRIPPING(POT HOLES)	LESS	MORE
8.	SEEPAGE OF WATER	VERY LESS	PRESENT
9	DURABILITY OF THE ROADS	BETTER	GOOD
10.	COST OF PAVEMENT	LESS	NORMAL
11.	MAINTENANCE COST	ALMOST NIL	MORE
12.	ENVIRONMENT FRIENDLY	YES	NO

TABLE 1.
(Comparison between ordinary bituminous road and plastic bituminous road on basis of properties)

Criteria	Bituminous roads	Plastic Modified Bituminous roads
Technology	Expensive method	• Dry process can be practiced under all climatic conditions. • % of plastic can be varied to modify the process to suit different climatic conditions and topographical conditions • Cost effective as 10-15% less bitumen is used and waste plastic is consumed thereby reducing carbon footprint
Cost (1Km x 3.75 m road)	₹ 3,93,750	₹ 3,67,875
Maintenance	5 years	Nil up to 10 years
Fatigue resistance (or Indirect Tensile Strength, MPa)	1.42	1.83
Rutting	Yes	No
Roughness	More bumps 5200	Less Bump <4000
Stripping	5% in 24 h	NIL if plastic content is > 6%
Moisture	4%	0-2%

TABLE 2.
(comparison between ordinary bituminous road and plastic bituminous road on basis of criteria)

GUIDELINES OF INDIAN ROAD CONGRESS

The Indian Road Congress is the highest body of highway engineersin the country. The society was set-up by the recommendations of the government of India. The organization over the years has been contributing to enhancement of the roads and bridges in India. IRC had in the H-2 committee meeting of members on the 15th of June 2012 had decided to formulate guidelines for utilizing waste plastic with bitumen in road construction. The guidelines formulated by the committee were approved by theCouncil of IRC in August 2013.

Technology/Material	Sub-category	IRC Guideline
Waste plastic	Type	• LDPE, HDPE, PU, PET permissible • Black coloured plastic waste, PVC must not be used
	Properties	• Size 2.36 mm • Dust and other impurities should not be more than
Bitumen		1%. • The melt-flow value of plastic-binder mix shall be tested as per ASTM D 1238-2010 (permissible values for LDPE: 0.14-58 gm/10 min; HDPE: 0.02-9.0 gm/10 min)
		• The Indian Standard Specifications for viscosity graded paving bitumen (VGPB) IS 73 • IRC: 111-2009 (for grade of VGPB)
Aggregates		• IRC: 111-2009 (for dense graded mixes) • IRC: 14-2004, IRC: SP: 78-2008 and IRC: 110-2005 (open graded mixes)
Filler		• IRC: 111-2009 (dense graded mixes)
Technology		Plastic must not be heated beyond 180°C as it may cause release of harmful gases
Manufacturing of bitumen-plastic mix	Open graded mixes	Waste plastic at 6-8% of weight of bitumen can be used
	Dry process	1. Collection of waste plastic 2. Cleaning and shredding of waste plastic 3. Shredding machine 4. Mixing of shredded waste plastic, aggregate and bitumen in central mixing plant
Construction	Dense graded mixes	IRC: 111-2009, IRC: 14-2004; IRC: 110-2005
	Open graded mixes	IRC:SP: 78-2008
Controls	Dense graded mixes	IRC: 111-2009, IRC: 14-2004; IRC: 110-2005
	Open graded mixes	IRC:SP: 78-2008
	Waste plastic	• Shall be examined for impurity and melt flow value • Three samples be tested for each day work or when there is change in the source of plastic

TABLE 3.

(Guidelines of Indian road congress)

CHARACTERIZATION OF PLASTIC WASTE BITUMEN MIXES.

The employment of plastic waste as modifier is successful only if it coats the aggregate well and the aggregate becomes non-wetting with enhanced mechanical properties. In order to check for the inclusion of plastic in the aggregate bitumen mix, various characterization techniques have been used and listed here:

- **Stripping test (IS: 6241-1971):**

  PCA bitumen mix made by dry process is immersed in water for long hours. Absence of stripping of the plastic material from aggregate mix ensures good resistance towards water due to excellent coating of plastic waste over aggregate making it Use of Plastics in Road Construction Centre for Innovations in Public Systems non-wetting. Further, this would also ensure better binding of bitumen with the aggregate through the plastic layers.

- **Marshall Stability Test:**

Effective binding of bitumen with the aggregate mix through plastic layers would have a positive effect on the stability of the bitumen-aggregate mix. Marshal stability values determined for PMB mixes are generally much higher than pure bitumen mix.

- **Water absorption test:**

Aggregate mix is dried, weighed and then immersed in water for a dayand dried again. The weight was determined to check for the amount of water absorbed by aggregate mix. Then a known amount of aggregate mix is heated and coated with plastic and the plastic coated aggregate mix is immersed in water, removed, dried and weighed. The process is repeated three times for each sample. The same experiment was carried out for aggregates coated with different amounts of plastics. The water absorption decreases with the coating of plastic over aggregate.

- **Extraction of bitumen:**

Bitumen is extracted from aggregate coated with bitumen only, plastic coated aggregate mix (using Dry process) and aggregate mixed with plastic waste blended bitumen (Wet process) using benzene as a solvent. Removal of bitumen is difficult in case of plastic waste coated aggregate mix (Dry process) than plastic waste blended bitumen mix. This confirms that the dry process is better than the wet process

MATERIALS

BITUMIN

"Bitumen is a hydrocarbon material of natural or pyrogenous origin,which is in a gaseous, liquid, semi-solid, or solid state, and which is completely solublein carbon di sulphide (CS2)." Of course, bitumen is found to be soluble to a large extentin carbon tetrachloride (CCl4) also.
Bitumen is a complex organic compound and occurseither as such in nature or can be obtained during the distillation of petroleum; it is generally non-volatile and resistant to most acids, alkalis and salts.
Bitumen occurring in nature as rock intrusions invariably contains inert inorganic materials or minerals; in such a case it is called asphalt. It is also found in lakes (as in Trinidad), in which case it is called lake asphalt. However, in American terminology, bitumen itself is termed asphalt, irrespective of whether it contains inorganic/mineral matter or not. In India, the British terminology is used for the terms bitumen and asphalt.

- **Important Properties of Bitumen:**

1. Predominantly hydrocarbons, with small quantities of sulphur, nitrogen and metals.
2. Mostly (up to 99.9%) soluble in carbon disulphide (CS2), and insoluble in water.
3. Softens on heating and gets hardened on cooling.
4. Highly impermeable to water.
5. Chemically inert and unaffected by most acids, alkalis and salts.
6. No specific boiling point, melting point or freezing point; a form of 'softeningpoint' is used in their characterisation.
7. Although generally hydrophobic (water repellent), they may be made hydrophilic (water liking) by the addition of a small quantity of surface-active agent.
8. Mostly bitumen is colloidal in nature.
9. Desirable Properties of Bitumen as a Road Material:
10. Workability – Bitumen should be fluid enough at the time of mixing so that the aggregates are fully coated by the binder. Fluidity is achieved either by heating or by cutting back with a thin flux or by emulsifying the bitumen.
11. Durability – There should be little change in viscosity within the usual range of temperatures in the locality.
12. Volatile constituents in bitumen should not be lost excessively at higher temperatures to ensure durability.
13. It should have enough ductility to avoid brittleness and cracking.
14. Strength and adhesion – The bitumen should have good affinity to the aggregates and should not be stripped off in the continued presence of water.
15. Cost-effectiveness.

- **Requirements of Bituminous Mixes:**

i. Stability:

This is the resistance to deformation under traffic loads; it is a function of inter- particle friction and cohesion offered by the bitumen binder. It is related to the density of the mix which is dependent on the voids content. The more the density, the more stable the mix; however, minimum voids content are necessary to allow for volume changes which cannot be fully prevented.

ii. Durability:

This is the resistance to weathering action and abrasion from traffic. Spalling, stripping and formation of pits, corrugations and potholes can

result from weathering and traffic. Excessive strain may cause cracking or plastic failure.

iii. Flexibility:

This is a measure of the resistance to long-term deformations and shapes of the road base, sub-base and subgrade; this depends on the flexural or bending strength of the pavement.

iv. Skid Resistance:

The resistance of the surface of the pavement laid with the bituminous mix to skidding of the tyres of vehicles is called skid resistance. The surface texture should be such as to provide grip or friction even under wet conditions. This is important in the prevention of accidents.

v. Workability:

This is the ease with which the mix can be placed in position and compacted. It depends on the aggregate characteristics like the size, shape texture and gradation, bitumen content and nature of the bituminous material.

vi. Economy:

The overall cost in achieving the desired qualities of the mix and the pavement should be a minimum, consistent with quality.

The desired qualities of the bituminous mixes, therefore, have to be achieved by:

1. Using good quality aggregate, which is hydrophobic and has rough surface texture, with appropriate grading and voids content.
2. Using bituminous binder of the correct quality and consistency based on the specific purpose for which the pairing mix is intended.
3. Controlling the voids content and the bitumen content to achieve the desirable qualities listed above.

AGGREGATES

Stone aggregate, or mineral aggregate, as it is called, is the most important component of the materials used in the construction of roads. These aggregates are derived from rocks, which are formed by the cementation of minerals the forces of nature. Stone aggregates are invariably derived by breaking the naturally occurring rocks to the required sizes. They are used for granular bases, sub-bases, as part of bituminous mixes and cement concrete; they are also the primary component of a relatively cheaper road, called water-bound macadam. A study of the types of aggregates, their properties, and the tests to determine their suitability for a specific purpose is of utmost importance to a highway engineer.
Properties such as strength and durability of aggregates are generally influenced by their origin of occurrence, mineral constituents and the nature of the bond between the constituents.

PLASTIC

The plastics involved in building these roads consists mainly of common post-consumer products such as product packaging. Some of the most common plastics used in packaging are polyethylene terephthalate (PET or PETE), polypropylene (PP), and high- and low-density polyethylene (HDPE and LDPE). These materials are first sorted from plastic waste. After sorting, the material is cleaned, dried, and shredded. The shredded plastic is mixed and melted at around 170 °C.

EQUIPMENTS

- BOILER CANS:

  Boilers are used to soften the bitumen by heating it to certain temperature for its easy application. Boilers range from small mobile units to large permanent plant. The most common types are:

- Mobile boilers: Mounted on a steel chassis and towed from place to place. The furnace at the base of the boiler is either gas or oil-fired.

- Static heating and storage tanks: These are heated by oil-fired burners and are available for high outputs as they can have capacities of up to 18,000 litres. They will usually be transported on a low loader.

FIGURE 1. (Boiler can)

- MIXING TRAYS:

These trays are used in order to mix different kind of material. Light in weight andsmall size this range can be carried easily.

FIGURE 2. (Mixing tray)

- THERMOMETER:

This digital thermometer can be used for various field and laboratory applications in road and concrete testing. Dual range, high resolution, housedin a rugged ABS case. Memory functions: simply press a button and the meter will recall the highest and lowest temperatures measured in the test cycle. Read both °C and °F. Itis supplied without probes that has to be ordered separately conforming to the applications. For asphalt temperature measurements we recommend the followingprobes:

- 82-D1229/1 Penetration probe 120 mm long
- 82-D1229/2 Surface probe
- 82-D1229/5 Penetration probe 220 mm long
- 82-D1229/6 T bar probe 650 mm long to BS 594

FIGURE 3. (Thermometer)

- BURNER:

Burner is a kind of gas burner used as laboratory equipment; it produces a single open gas flame, and is used for heating, sterilization, and combustion.

The gas can be natural gas (which is mainly methane) or a liquefied petroleum gas, such as propane, butane, or a mixture.

FIGURE 4. (Burner)

FIGURE 5. (Stove)

- STIRRER:

Stirrers are used to mix bitumen and plastic while they boiling.

Figure 6. (Stirrer)

APPRATUS

PENETROMETER:

Bitumen Penetrometer is used to examine the penetration of bituminous samples under a constant load, time and temperature. The Penetrometer consists of a cast iron base with coarse and fine levelling screws, a penetration timer unit, and a penetration measurement gauge.

Penetrometer is supplied complete with; Penetration Needle, 2, 5g,pieces Transfer Dish Sample Cup Ø 55x35 mm, 3 pieces, stainless steel.

Figure 7. (Penetrometer)

DUCTILITY TESTING MACHINE

Ductility Testing Machine is used to determine the ductility of bituminous materials in a briquette mould by measuring the breaking elongation at a constant speed of 50 mm/min. It is designed for testing 3 specimens simultaneously. The Internal tank is made of stainless steel. The bath is fitted with an immersion heater in order to obtain (in normal conditions), the 25°C test temperature. Each machine comprises speed control and water circulator to maintain the homogenous water temperature. The apparatus consists of a Water bath with a thermostatic heater, and a circulating pump to maintain uniform water temperature. One half of the briquette moulds is fixed on a fixed plate in the water bath, the other half of the briquette mould is fixed to a carrier which slides over a rotating threaded shaft with a clutch. The motor and gears to rotate the shaft are housed in a cabinet fixed above the other end of the bath. A pointer fixed to the carrier moves over a scale graduated from 0-110 cm x 1mm fixed on the bath with "0" (zero) of the scale towards the fixed plate side. The rotating shaft has 2 speeds of travel for the bracket, 5cm/min and 1 cm/min., selected by a clutch. Water bath inside is aluminium, it is an insulated water bath. Water bath is provided with a drain. A heater with thermostatic control is fixed inside the water bath. Control switches for motor, stirrer, heater and indicator lamps are fixed at a convenient place on the water bath, complete with three briquette moulds and one base plate, all made of brass. Operates on 230 volts A.C. single phase.

SALIENT FEATURES

- Stainless steel bath
- Temperature controller (Thermostatic/Digital)
- Immersion electric heater
- Constant speed Pump cum stirrer
- Carriage holding up to three standard briquette moulds
- Electric motor with gear mechanism
- Stainless steel scale and pointer
- Control Panel
- Accessories:
  1. Thermometer IP 38 C, range 23ºC to 27ºC.
  2. Briquette mould with base- plate.

Figure 8. (Ductility testing machine)

RING AND BALL APPRATUS

Used for determining the softening point of bituminous materials.

Comprising:

- Brass rings (2 pieces)
- Steel balls 9.5 mm dia. (2 pieces)
- Ball Centring guide (2 pieces)
- Glass vessel
- Pouring plate
- Ring holder/assembly

- Glass thermometer, -2 +80°C

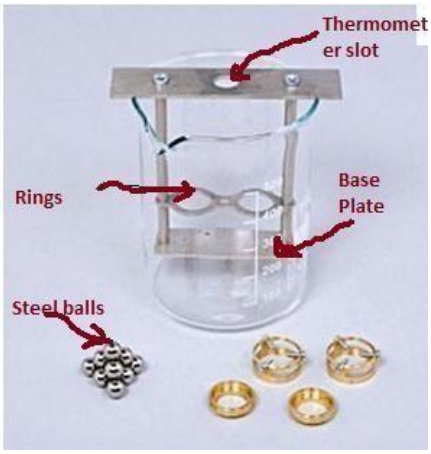

Figure 9. (Ring and ball apparatus)

VISCOMETER

Viscometer- The viscometer, illustrated in Figure 10.6.1 shall be constructed entirely of corrosion resistant metal, conforming to dimensional requirements shown in Figure 10.6.1. The orifice tip, Universal or Furol may be constructed as a replaceable unit in the viscometer. Provide a nut at the lower end of theviscometer for fastening it in the bath. Mount vertically in the bath and test the alignmentwith a spirit level on the plan test; a small chain or cord may be attached to the cork to facilitate rapid removal. Bath- The bath serves both as a support to hold the viscometerin a vertical position as well as the container for the bath medium. Equip the bath effective insulation and with an efficient stirring device provide the bath with a coil for heating and cooling and with thermostatically controlled heaters capable on maintainingthe bath within the functional precision given in Table 10.6.2.
The heaters and coil should be located at least 3 in. (75 mm) from the viscometer. Provide a means for maintaining the bath medium at least 6 mm (0.25 in.) above the overflow rim. The bathmedia are given in Table 10.6.2. b) Withdrawal Tube, as shown in Figure 10.6.2 or othersuitable device. c) Thermometer Support. One suitable design is shown in Figure 10.6.3

d) Say bolt Viscosity Thermometers, as listed in Table 10.6.1. e) Bath Thermometers - Say bolt Viscosity thermometers, or any other temperature indicating means of equivalent accuracy. f) Filter Funnel, as shown in Figure 10.6.4 equipped with interchangeable 850 mm (N0. 20), 150mm (N0. 100) and 75mm (N0. 200) wire-cloth inserts meeting the requirements of M 92 with respect to the wire cloth Filter funnels of a suitable alternate design may be used. g) Receiving Flask, as shown in Figure 10.6.5

h) Timer, graduated in tenths of a second, and accurate to within 0.1% when tested over a 60min interval. Electric timers are acceptable if operated on a controlled frequency circuit.

Figure 10. (Viscometer)

PENSKY-MARTENS FLASH POINT TESTER

The Pensky-Martens Flash Point Tester consists of a closed-cup test arrangement that contains any vapors produced and essentially simulates the situation in which a potential source of ignition is accidentally introduced into a container. For this test, a test portion is introduced into a cup and a close-fitting lid is fitted to the top of the cup. The cup and test portion are heated and stirred, apertures are then opened in the lid to allow air into the cup and also the ignition source to be dipped into the vapours to test for a flash. The closed-cup test like the Pensky-Martens predominates in product specification and regulations due to its greater precision and its ability to detect contaminants.

A brass test cup of specified dimensions, filled to the inside markwith test specimen and fitted with a cover of specified dimensions, is heated and the specimen stirred at specified rates, using one of three defined procedures (A, B, or C).

An ignition source is directed into the test cup at regular intervals with simultaneous interruption of the stirring until a flash is detected. The flash point is reported as defined as the lowest temperature corrected to a barometric pressure of 101.3 kPa at which application of an ignition source causes the vapors of a specimen of the sample to igniteunder specified conditions of test.

Figure 11. (pensky-martens flash point tester)

TESTS

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. 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 25 C. 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. A grade of 40/50 bitumen means the penetration value is in the range 40 to 50 at standard test conditions. In hot climates, a lower penetration grade is preferred. Figure 0.1 shows a schematic Penetration Test setup. Penetration test is to determine the hardness of the bitumen. The penetration of a bitumen is the distance in tenths of millimetre that a standard needle will penetrate into the bitumen under a load of gm applied for seconds at c. penetration value indicates the softness of bitumen higher the penetration softer is the bitumen).

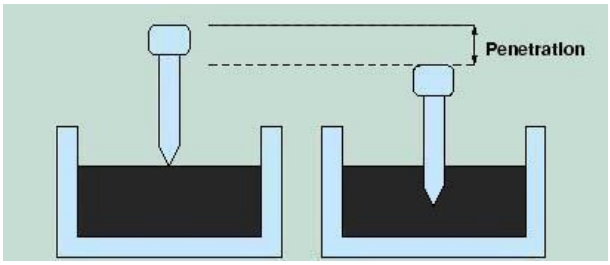

Figure 12. (Pictorial representation of penetration)

Figure 13. (Calibration of penetrometer in laboratory)

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. The 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 the water bath at 27 C temperature. The excess bitumen is cut and the surface is leveled using a hot knife. Then the mould with the assembly containing sample is kept in the 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 the 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, the rate of pulling etc. A minimum ductility value of 75 cm has been specified by the BIS. Figure 0.1 shows ductility moulds to be filled with bitumen.

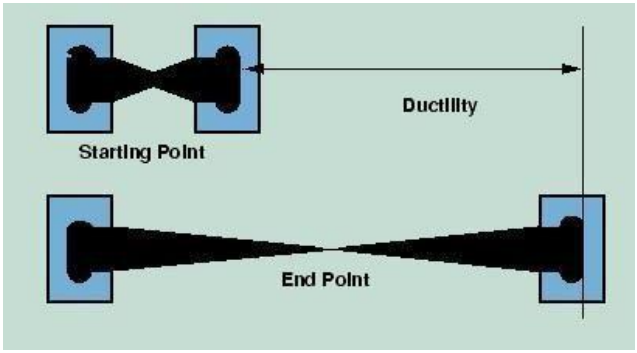

Figure 14. (Elongation of bitumen)

Figure 15. (Actual photograph of elongation from laboratory)

SOFTENING POINT TEST

The principle behind this test is that softening point is the temperature at which the substance attains a particular degree of softening under specified condition of the test. Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the

specifications of this test. The test is conducted by ring and ball apparatus. A brass ring containing test sample of bitumen issuspended in liquid like water or glycerine at a given temperature. A steel ball isplaced upon the bitumen sample and the liquid medium is heated at a rate of 5^oC minute. Temperature is noted when the softened bitumen touches the metal platewhich is at a specified distance below. Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates.

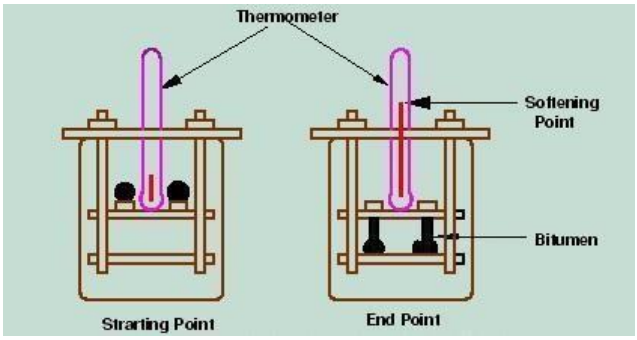

Figure 16. (Ring and ball apparatus)

Figure 17. (Actual softening of modified bitumen at 58°c)

SPECIFIC GRAVITY TEST

The standard specific gravity test is carried out at a temperature of 250C. However, if cooling facilities are not available, a temperature of 350C may be used, although this must be clearly stated in the result. For some purposes the specific gravity at elevated temperatures is required, as it is not possible to measure this directly an approximate value may be obtained by calculation using the value determined at a lower temperature.

The clean, dry pycnometer, complete with stopper, should be weighed to the nearest 0.001 gram., weight A. b) A 600 ml glass beaker should be partly filled with freshly boiled distilled water which has been allowed to cool in a stoppered flask. The beaker should then be immersed to a depth of at least 100mm. in a water bath which is maintained at the required temperature ± 0.10C for a period of at least 30 minutes. The top of the beaker should be above the level of the water in the bath. c) The weighed pycnometer should then be filled with the boiled distilled water and the stopper placed loosely in position, taking care to expel all air from the pycnometer. The pycnometer should then be submerged in the beaker of water to a depth above the stopper of at least 40mm and the stopper firmly pushed into position. The beaker and pycnometer must remain in the water bath for at least 30 minutes after which the pycnometer is removed. The top of the pycnometer should first be dried with one stroke of a dry clean cloth and the remainder of the pycnometer is then dried asquickly as possible prior to weighing, weight B. Note that if a droplet of water forms on the stopper after drying, the stopper should not be re-dried, the volume of water in the pycnometer on immediately, leaving the water is the required value, any subsequent changes should not affect the result. On completion of weighing the pycnometer should be thoroughly dried. d) The pycnometer is then filled about threequarters full with the sample of bitumen. The bitumen should be carefully poured into the pycnometer ensuring that no air becomes trapped below the bitumen and there are no air bubbles in the sample. The sample should be poured into the center of the pycnometer so that the sides or neck of the pycnometer above the level of the bitumen are not contaminated. The pycnometer and bitumen should then be allowedto cool in air for a period of at least 40 minutes, after which the weight is determined, weight C. e) The pycnometer is then topped up with the boiled distilled water and the stopper loosely placed in position, taking care to expel all air from the pycnometer. The pycnometer should then be submerged in the beaker of water to adepth above the stopper of at least 40mm and the stopper firmly pushed into position. The beaker and pycnometer must remain in the water bath for at least 30 minutes after which the top and sides of the pycnometer are dried as before, prior to weighing, weight D. f) At least two separate determinations should be made.

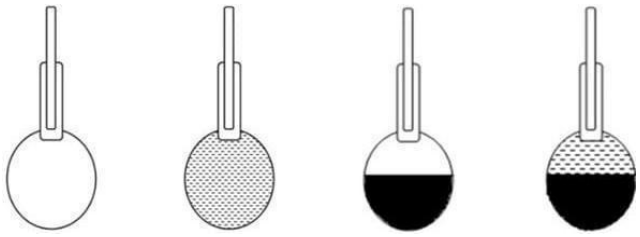

Figure 18. (Specific gravity computation)

VISCOSITY TEST.

Viscosity is reverse of fluidity. It is a measure of the resistance to flow. Higher the viscosity of liquid bitumen, the more nearly it approaches a semi-solid state in consistency. Thick liquid is said to be more viscous than a thin liquid of the road pavement. The bitumen binders of low viscosity, simply lubricate the aggregate particles instead of providing a uniform thin film for binding action, similarly high viscosity does not allow full compaction and the resulting mix exhibits heterogeneous character and thus low stability values. Saybolt Furol viscosity test is used to determine viscosity of liquid bitumen.

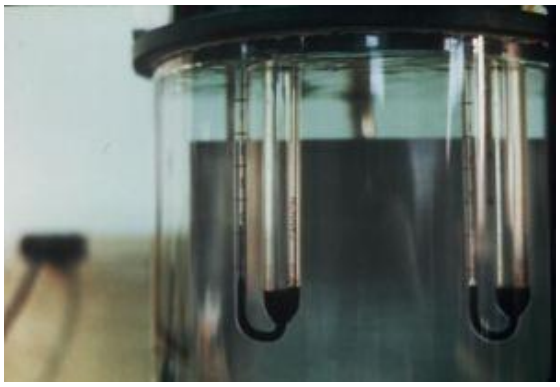

Figure 19. (Viscous flow of modified bitumen)

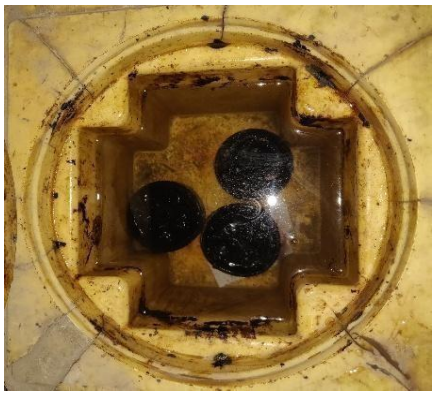

Figure 20. (Moulds kept for cooling)

FLASH AND FIRE POINT TEST

At high temperatures depending upon the grades of bitumen, materials leave out volatiles. And these volatiles catches fire which is very hazardous and therefore it is essential to qualify this temperature for each bitumen grade. BIS defined the flash point as the temperature at which the vapour of bitumen momentarily catches fire in the form of flash 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.

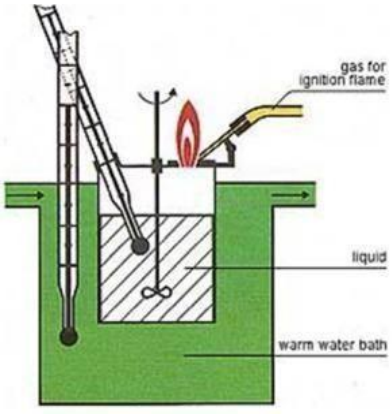

Figure 21. (Flash and fire point test)

FLOAT TEST

a) The brass collar is placed with the smaller end down on the plate which has been previously coated with a suitable release agent.

Note 1. Mixtures of glycerine and dextrine or talc (3 grams glycerine to about 5 grams

dextrine or talc has been used satisfactorily), Dow-Corning Silicone Stop-Cock Grease, or castor oil-Versamid 900 [100:1 mixture by weight heated to 204 to 232 0C (400 to 450 0F) and stirred until Homogeneous] have proven suitable. Other release agents maybe used provided results obtained are comparable to those obtained when using one of the above.

b) The sample shall be completely melted at the lowest possible temperature that will bring it to a sufficiently fluid condition for easy pouring, excepting creosote-oil residues, which shall be mixed and poured at a temperature of 100 to 125 0C. Stir the sample thoroughly until it is homogeneous and free from air bubbles then pour it into the collar in any convenient manner until slightly more than level with the top.

c) Asphalt and Asphalt Products - Asphalt and asphalt products are cooled to room temperature for 15 to 60 min. then place them for 5 min in the water bath at 5 0C, after which trim the surplus material flush with the top of the collar by means of a spatula or steel knife that has been slightly heated. Then the collar and plate are placed in the water bath at 5 0C and leave them in this bath for not less than 15 nor more than 30 min.

d) The water is heated in the testing bath to the temperature at which the test is to be made. This temperature shall be accurately maintained without stirring, and shall at no time throughout the test be allowed to very

more than 0.5 0C from the temperature specified. The temperature shall be determined by immersing the thermometer with the bottom of the bulb at a depth of 40 ± 2 mm below the water surface.

e) After the material to be tested has been kept in the water bath at 5 0C for not less than15 nor more than 30 min remove the collar with its contents from the plate and screw into the aluminum float. The assembly is completely immersed for 1 min in the water bath at 5 0C. Then the water is removed inside of the float and immediately float the assembly on the testing bath. Lateral drift of the assembly shall be permitted, but no spinning motion shall be intentionally imparted thereto.As the plug of material becomeswarm and fluid, it is forced upward and out of the collar until the water gains entrance into the saucer and causes it to sink.

f) The time, in seconds, between placing the apparatus in the water and the water breaking through the material shall be determined by means of a stop watch or other timer, and shall be taken as a measure of the consistency of the material under examination.

RESULTS AND DISCUSSION

1. PENETRATION TEST

SR NO.	Penetration Value (mm) Plain Bitumen	Penetration Value (mm) Modified Bitumen (10% PlasticReplaced)
1	54	19
2	67	14

TABLE 4

(READINGS OF PENETRATION AT 24.6°C)

2. DUCTILITY TEST

SR NO.	SPEED (mm/min)	DUCTILITY (cm) VG40	DUCTILITY (cm) Modified Bitumen (10% Plastic Replaced)
1	50	6	15

TABLE 5

(RESULT OF DUCTILITY)

3. SOFTNING POINT

SR NO.	Softening point(°C) (plain bitumen)	Softening point(0C) 10% bitumen replaced by plastic
1	69.2	60.3
2	70	57.2

TABLE 6

(RESULT OF SOFTENING POINT)

4. MARSHALL STABILITY TEST

S.No	Bitumen Content (%)	Weight of mix(g)	Weight in air(g)	Weight in water (g)	Stability of bitumen Stability of modified		Flow (mm)	Diame -ter (cm)	height (cm)
					Plain bitumen	Modified bitumen			
1	4.5	1255.5	1256.5	733	14.7	17.95	1.99	10	6.3
2	5	1253	1255.5	734	19.47	23.44	2.38	10	6.4
3	5.5	1257	1259	736	13.46	18.21	2.88	10	6.5
4	6	1268	1270	748	8.9	13.10	2.59	10	6.4

TABLE 7

(RESULTS OF MARSHALL STABILITY TEST)

DISCUSSIONS

- The penetration value of bitumen is less than the bitumen mixed with the plastic.
- The bitumen softens less than the bitumen replaced with plastic.
- The stability of modified bitumen (10% bitumen replaced by plastic) is higherthan the normal bitumen.
- Modified bitumen is much flexible than convectional bitumen.

ADVANTAGES AND DISADVANTAGES

1) ADVANTAGES
   - Reduce the need of bitumen by around 10%.
   - Develop a technology which is eco-friendly.
   - Improvements in fatigue life of roads.
   - Increase the strength and better performance of the road.
   - Use higher percentage of plastic waste.
   - The gases released during traffic conditions are absorbed by smoke absorbent.

2) DISADVANTAGES
   - Toxic present in the co-mingled plastic wastes would start leaching.
   - But the presence of chlorine will definitely release HCL gas.

CONCLUSION

- The addition of waste plastic modifies the properties of bitumen.
- The modified bitumen shows good result when compared to standard results.
- The optimum content of waste plastic to be used is between the ranges of 5% to 10%.
- The problems like bleeding are reduce in hot temperature region.
- Plastic has property of absorbing sound, which also help in reducing the sound pollution of heavy traffic.
- The waste plastics thus can be put to use and it ultimately improves the quality and performance of road.
- Total material cost of the project is reduced by 7.99%
- This results in the reduction of ruts and there is no pothole formation.
- The plastic pavement can withstand heavy traffic and are durable than flexible pavement.

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