LABORATORY INVESTIGATION ON UTILIZATION OF PLASTIC IN BITUMINOUS MIXES

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Abstract:

Bituminous mixes are most commonly used all over the world in flexible pavementconstruction. It consists of asphalt or bitumen (used as a binder) and mineral aggregate whichare mixed together, laid down in layers and then compacted. Under normal circumstances, conventional bituminous pavements if designed and executed properly perform quitesatisfactorily but the performance of bituminous mixes is very poor under various situations. Today's asphaltic concrete pavements are expected to perform better as they are experiencingincreased volume of traffic, increased loads and increased variations in daily or seasonaltemperature over what has been experienced in the past. In addition, the performance ofbituminous pavements is found to be very poor in moisture induced situations. Consideringthis a lot of work has been done on use of additives in bituminous mixtures and as well as onmodification of bitumen. Research has indicated that the addition of polymers to asphaltbinders helps to increase the interfacial cohesiveness of the bond between the aggregate andthe binder which can enhance many properties of the asphalt pavements to help meet these increased demands. However, the additive that is to be used for modification of mix or bindershould satisfy both the strength requirements as well as economical aspects. Plastics are everywhere in today's lifestyle and are growing rapidly throughout particularly ina developing country like India. As these are non-biodegradable there is a major problem posed to the society with regard to the management of these solid wastes. Low density polyethylene (LDPE) has been found to be a good modifier of bitumen. Even, the reclaimed polyethylene originally made of LDPE has been observed to modify bitumen. In the present study, an attempt has been made to use reclaimed polyethylene which has been obtained fromplastic packets used in packaging of milk , in dry form with the aggregates like a fibre in a bituminous mix. Detailed study on the effects of these locally waste polyethylene on engineering properties of Bituminous concrete (BC), mixes, has been made in this study. The present locally available polyethylene used as stabilizer in Bituminous Concrete(BC) mixes to fulfil the present requirements of paving mixes. Optimum binder content (OBC) andoptimum polyethylene content (OPC) have been derived by using Marshall Procedure. The OBCs have been found to be 5.8% for Bituminous Concrete by using stone dust as filler.After replacement of some gradation of fine aggregate with filler and considering fly ash as filler the OPCs have been found to be 12% of polyethylene for all types of mixes. Then considering OBC and OPC for Bituminous concrete(BC) mixes have been prepared and different performance tests like Drain down test, Static indirect tensile Strength Test and Static Creep test have been carried out to evaluate the effects of vi polyethylene as an stabilizer on mix properties. It is concluded from present investigation that addition of

Polyethylene to mixes improve the mix properties like Marshall Stability, Drain down characteristics and indirect tensile strength. Key Words: Bituminous concrete (BC), Stone Mix Asphalt (SMA), Marshall Properties, Polyethelene.

INTRODUCTION:

General :

A material that contains one or more organic polymers of large molecular weight, solid in its finished state and at some state while manufacturing or processing into finished articles, can be shaped by its flow, is called as 'Plastic'. Plastics are durable and degrade very slowly; the chemical bonds that make plastic so durable make it equally resistant to natural processes of degradation. Plastics can be divided in to two major categories: thermoses and thermoplastics. A thermoset solidifies or "sets" irreversibly when heated. They are useful for their durability andstrength, and are therefore used primarily in automobiles and construction applications.These plastics are polyethylene, polypropylene, polyamide, polyoxymethylene, polytetrafluorethylene,and polyethylene terephthalate. A thermoplastic softens when exposed to heat and returns to original condition at room temperature. Thermoplastics can easily be shaped and molded into products such as milk jugs, floor coverings, credit cards, and carpet fibers These plastic types areknown as phenolic, melamine, unsaturated polyester, epoxy resin, silicone, and polyurethane. According to recent studies, plastics can stay unchanged fo ras long as 4500 years on earth with increase in the global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily by each household. Plastic in different forms is found to be almost 5% in municipal solid waste, which is toxic in nature. It is a common sight in both urban and rural areas as well as drains. Due to its biodegradability, it creates stagnation of water and associated hygiene problems. In order to contain this problem experiments have been carried out whether this waste plastic can be reused productively. The experimentation at several institutes indicated that the waste plastic, when added to hot aggregatewill form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength, higher resistance to water and better performance over aperiod of time. Waste plastic such as carry bags, disposable cups and laminated pouches like chips, aluminum foil and packaging material used for biscuits, chocolates, milk and grocery items can be used for surfacing roads. Use of plastic along with bitumen in construction of roads not only increases its life and 2 smoothness but also makes it economically sound and environment friendly. Plastic waste is used as modifier of bitumen to improve some of bitumen properties Roads that are constructed using plastic waste are known as Plastic Roadsand are found to perform better compared to those constructed with conventional bitumen.

Fig.1 plastic roads

OBJECTIVE:

1. Optimum bitumen content to ensure a durable pavement,
2. Sufficient strength to resist shear deformation under traffic at higher temperature,
3. Optimum bitumen content to ensure a durable pavement,
4. Sufficient strength to resist shear deformation under traffic at higher temperature,
5. Proper amount of air voids in the compacted bitumen to allow for additional compaction done by traffic,
6. Sufficient workability, and
7.Sufficient flexibility to avoid cracking due to repeated traffic load.

MATERIAL AND METHODS USED:

Preparation of Design Mix

Plain Bituminous Mix Bitumen is a black, oily, viscous material that is a naturally-occurring organic by product of decomposed organic materials. Also known as asphalt or tar, bitumen was mixed with other materials throughout prehistory and throughout the world for use as a sealant, adhesive, building mortar, incense, and decorative application on pots, buildings, or human skin. The material was also useful in waterproofing canoes and other water transport. A good design of bituminous mix is expected to result in a mix which is adequately
(i) strong (ii) durable (iii) resistive to fatigue and permanent deformation (iv) Environment friendly (v) economical and so on. 3.1.2.Selection of mix constituents Binder and aggregates are the two main constituents of bituminous mix: 3.1.2.1.Binder Generally binders are selected based on some simple tests and other site-specific requirements. These tests could be different depending of the type of binder viz. penetration grade, cutback, emulsion, modified binder etc. For most of these tests, the test conditions are pre-fixed in the specifications. Temperature is an important parameter which affectsthe modulus as well astheaging of binder. Super pave specifications [Super pave 1997, 2001] suggest that these acceptability tests are to be carried out at the prevalent field temperatures, not in a laboratory specified temperature. This is an important consideration because, binder from two different sources may show same physical properties at a particular temperature, but their performances may vary drastically at other temperatures. In Super pave specifications, therefore, only the acceptable test values are recommended, and not the test temperatures. The temperature valuesare found out from the most prevalent maximum and minimum temperatures at the field at a given probability level. 21 3.1.2.2.Aggregate Number of tests is recommended in the specifications to judge the properties of the aggregates, e.g. strength, hardness, toughness, durability, angularity, shape factors, clay content, adhesion to binder etc. Angularity ensures adequate shear strength due to aggregate interlocking, and limiting flakiness ensures that aggregates will not break during compaction and handling. Theoretically, it is difficult [Senov 1987, Aberg 1996] to predict the aggregate volumetric parameters, even the resultant void ratio, when the gradation curve is known. The Fuller’s experimental study for minimum void distribution [Fuller and Thompson 1907] still forms the basis of these exercises. Strategic Highway Research Program (SHRP), USA formula 14 member expert task group for evolution of appropriate aggregate gradation to be used for super pave. The group, after several rounds of discussions decided to use 0.45 power Fuller’s gradation as the reference gradation, with certain restricted zones and control points.

Various mix design approaches There is no unified approach towards bituminous mix design, rather there are a number of approaches, and each has some merits are demerits. summarizes [RILEM 17 1998]
some of the important bituminous mix design approaches are as follows:

➢ Mix design method
➢ Recipe method
➢ Empirical mix design method
➢ Analytical method
➢ Volumetric method
➢ Performance related approach
➢ Performance based The recent emphasis on bituminous mix design is on performance related and performance based approaches.

The requirement of a good mix design has changed from time to time. Gives some idea of how mix design requirements have changed from past to present.Some of the above requirements are sometimes mutually 22 conflicting. For, example, the higher is the bitumen content; the better is the fatigue life, provided all the other parameters are kept unchanged. But with the increase of bitumen content, the resistance to rutting may decreases.

EXPERIMENTAL WORK:

Determination of physical properties of Aggregate:

a)Aggregate:

There are various types of mineral aggregates used to manufacture bituminous mixes can be obtained from different natural sources such as glacial deposits or mines and can be used with or without further processing. The aggregates can be further processed and finished to achieve good performance characteristics. Industrial by-products such as steel slag, blast furnace slag, fly ash etc. sometimes used by replacing natural aggregates to enhance the performance characteristics of the mix. Aggregate contributes up to 90-95 % of the mixture weight and contributes to most of the load bearing & strength characteristics of the mixture .Hence, the quality and physical properties of the aggregates should be controlled to ensure a good pavement. Aggregates are of 3 types; Coarse aggregates The aggregates retained on 4.75 mm sieve are called as coarse aggregates. Coarse aggregate should be screened crushed rock, angular in shape, free from dust particles, clay, vegetations and organic matters which offer compressive and shear strength and shows good interlocking properties. In present study, stone chips are used as coarse aggregate with specific gravity 2.75.

Fig.2 Graded coarse aggregate

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AGGREGATE GRADING FOR BITUMINOUS CONCRETE AS PER MORTH,2009
Nominal aggregate size – 19mm

Table.1. Aggregate gradation for bituminous concrete

IS Sieve (mm)	Cumulative by weight of the total aggregate passing (recommended)
19	100
13.2	79-100
9.5	70-88
4.75	53-71
2.36	42-58
1.18	34-48
0.6	26-38
0.3	18-28
0.15	12-20
0.075	4-10

Filler Aggregate passing through 0.075 mm IS sieve is called as filler. It fills the voids, stiffens the binder and offers permeability. In this study, stone and fly ash are used as filler whose specific gravity has been found to be 2.7 and 2.3.

Fig.3 Grading of Fine Aggregate

Aggregate impact value test: The test is used to determine the aggregate's resistance to fracturing. It measures the ability of the road to resist impact or to measure how tough the road is. Continuous movement of heavy vehicles on the road subjects them to nonstop impact causing it to disintegrate. Often, to begin with, it resembles a crocodile skin before completely breaking down. In order to measure this a sample of the mixture is taken and hit with a 14 kg hammer 15 times. The % of mass that becomes powdered should not exceed 30%. The powdered mass will be identified as the mass passing through a 2.36mm sieve.

Fig. 4 Aggregate impact value test in progress.

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RESULTS:

This chapter deals with test results and analysis carried out in previous chapter. This chapter is divided into four sections. First section is deals with parameter used for analysis of different test results. Second section deals with calculation and comparison of optimum binder content (OBC) and optimum polyethylene content (OPC) of Bituminous Concrete (Dense Bitumen) mixes with and without polyethylene with stone dust used as filler. Third section deals with calculation and comparison of Optimum binder Content (OBC) and Optimum polyethylene content (OPC) of Bituminous concrete mixes with or without polyethylene by replacing some gradation of fine aggregate with filler. Fourth section deals with analysis of test results of drain down test, static indirect tensile and static creep test at different test temperature. Prior to these experiments, the specific gravity of polythene used was calculated as per the guidelines provided in ASTM D792-08. 5.1.1 Determination of specific gravity of polythene The procedure adopted is given below: 1) The weight of the polythene in air was measured by a balance. Let it be denoted by “a”. 2) An immersion vessel full of water was kept below the balance. 3) A piece of iron wire was attached to the balance such that it is suspended about 25 mm above the vessel support. 4) The polythene was then tied with a sink by the iron wire and allowed to submerge in the vessel and the weight was measured. Let it be denoted as “b”. 5) Then polythene was removed and the weight of the wire and the sink was measured by submerging them inside water. Let it be denoted as “w”. The specific gravity is given by where: a = apparent mass of specimen, without wire or sinker, in air b = apparent mass of specimen and of sinker completely immersed and of the wire partially immersed in liquid. s = a / (a + w - b) 55 w = apparent mass of totally immersed sinker and of partially immersed wire. From the experiment, it was found that a = 19 gm b = 24 gm w = 26 gm => s = 19 / (19+26-24) = 19/21 =0.90476 Take s = 0.905.

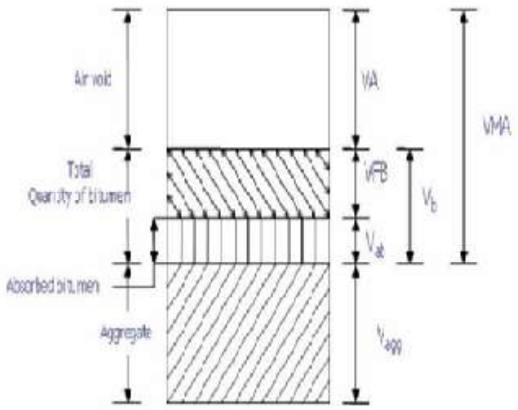

Fig.-5 Phase diagram of bituminous mix

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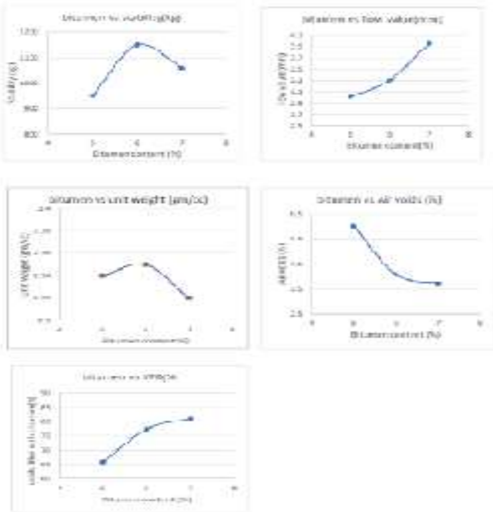
Bitumen content (%)	plastic content (%)	Stability (kg)	Flow value (mm)	Air Voids (%)	Bulk Density (gm/cc)	VMA	voids filled with bitumen (VFB) (%)
5	0	950	3.00	6.02	2.34	17.6	65.8
6	0	1150	3.30	4.08	2.35	18.04	77.36
7	0	1060	3.95	3.73	2.32	19.83	81.17
5	3	1493	2.88	3.65	2.31	17.77	67.14
6	3	1730	3.10	3.76	2.34	17.77	83.0
7	3	1547	3.30	3.17	2.324	19.24	83.52
5	6	2066	2.50	5.28	2.32	18.78	68.53
6	6	2445	2.7	3.30	2.36	16.59	81.74
7	6	2238	3.00	2.54	2.33	19.30	84.47
5	9	2565	2.00	4.99	2.32	16.37	70.13
6	9	3150	2.25	2.5	2.34	16.31	84.69
7	9	2690	2.8	2.42	2.33	18.46	85.59
5	12	2150	2.12	4.75	2.305	16.12	70.68
6	12	2732	2.30	2.3	2.32	16.28	84.60
7	12	2400	3.1	2.34	2.25	17.84	86.24
5	15	1630	2.2	4.40	2.30	16.05	70.90
6	15	2370	2.40	2.45	2.31	16.11	85.06
7	15	2000	3.25	2.61	2.275	17.25	86.54

Table :2.Optimum Binder Content of Bituminous Concrete

Plastic content (%)	Optimum Bitumen Content (%)	Stability (kg)	Flow value (mm)	Air Voids (%)	Voids filled with Bitumen (%)
0	6.02	1155	3.31	3.88	77.32
3	5.89	1724	3.06	3.54	79.48
6	5.83	2441	2.68	3.20	80.02
9	5.80	3094	2.19	2.84	82.30
12	5.76	2640	2.25	2.98	81.25
15	5.69	2238	2.38	3.08	80.77

Table:-3



CONCLUSIONS:

Penetration

The results of the penetration test are shown in Table The variation in the penetration value of bitumen with waste plastic fiber addition is shown in Fig. 4.12. The graph shows that the penetration value of bitumen decreases with the addition of waste plastic fibers. The highest value of penetration is 95 when no waste plastic is added to bitumen and it is 48 when 12 % plastic is added to bitumen. The decrease in the penetration value shows that the addition of plastic fibers increases the hardness of bitumen. 6.2.SofteningPoint Softening point is the temperature at which the substance attains a particular degree of softening under specified conditions of test. The softening point of bitumen is determined by performing ring and ball test. The test results are shown in Table 5.3.6 . The variation of softening point is shown in Fig. 4.13. The softening point is 50 °C when there is no addition of waste plastic fibers in bitumen and it increases to 77 ° C when 12 % waste plastic fibers are added to bitumen. The influence over the softening point is dependent on the chemical nature of the waste plastic fiber added. 6.3.Ductility The ductility is expressed as the distance in centimeters to which a standard briquette of bitumen can be stretched before the thread breaks. To find out this property of bitumen, ductility test is carried out. The test results are shown in table 5.3.5. The variation in ductility values is shown in Fig. 4.14. The ductility value is decreased from 107cms to 31cms when the percentage of plastic fibers added to bitumen increases from 0-12 %(By weight of bitumen). The decrease in ductility value may be due the physical interlocking of the material. 6.4.Stripping When plastic fiber was not added to bitumen, the stripping was found to be 10 10% after 24 hours. When plastic fiber was added to the hot bitumen, there was no 71 stripping when mix checked after 24 hrs. Even after 72 hrs there was no stripping.

FUTURE SCOPE:

➢ Many properties of Bituminous Concrete and other characteristics have been studied in this investigation by using only VG 30 penetration grade bitumen and polyethylene. However, some of the properties such as fatigue properties, resistance to rutting, dynamic indirect tensile strength characteristics and dynamic creep behavior needed to be investigated.

➢ In present study polyethylene is added to them mix in dry mixing process. Polyethylene can also be used for bitumen modification by wet mixing process and comparisons made.

➢ Microstructure of modified bituminous mixture should be observed by using appropriate technique to ascertain the degree of homogeneity. Combination of paving mixes formed with other types of plastic wastes which are largely available, wastes to replace conventional fine aggregates and filler an different types of binders including modified binders, should be tried to explore enough scopeof finding suitable materials for paving mixes in the event of present demanding situation

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