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UTILIZATION OF WASTE PLASTIC AND WASTE RUBBER IN FLEXIBLE PAVEMENT

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Abstract - The use of waste materials like plastics and crumb rubber in road construction is being increasingly encouraged so as to reduce environmental impact. Plastics and crumb rubbers are one of them. The plastic waste quantity in municipal solid waste is increasing due to increase in population and changes in life style. Similarly, most tires, especially those fitted to motor vehicles, are manufactured from synthetic Crumb rubber. Disposal of both is a serious problem. At the same time, continuous increase in number of vehicles emphasizes on need of roads with better quality and engineering design. This waste plastic and crumb rubber can be used to partially replace the conventional material which is bitumen to improve desired mechanical characteristics for particular road mix. In the present study, a comparison is carried out between use of waste plastic like LDPE and Crumb Rubber (1%, 1.5%,2%,and 2.5% by weight of bitumen) in bitumen concrete mixes to analyse which has better ability to modify bitumen so as to use it for road construction.

Keywords: aggregates, Bitumen, Crumb rubber, LDPE, and Marshal Stability Test

1.0 INTRODUCTION

Road network is the mode of transportation which serves as the feeder system as it is the nearest to the people. So the roads are to be maintained in good condition. The quality of roads depends on materials used for construction. Pavements are generally of two types: flexible and rigid pavement. A flexible pavement is the one which has a bitumen coating on top and rigid pavements which are stiffer than flexible ones have PCC or RCC on top. The flexible pavements are built in layers and it is ensured that under application of load none of the layers are overstressed. The maximum intensity of stress occurs at top layer hence they are made from superior material mainly bitumen. The mix design should aim at an economical blend with proper gradation of aggregates and adequate proportion of bitumen so as to fulfil the desired properties of mix which are stability, durability, flexibility, skid resistance and workability. Mix design methods should aim at determining the properties of aggregates and bituminous material which would give a mix with these properties. The design of asphalt paving mixtures is a multi-step process of selecting binders and aggregate materials and proportioning them to provide an appropriate compromise among several variables that affect mixture behaviour, considering external factors such as traffic loading and climate conditions. In the construction of flexible pavements, bitumen plays the role of binding the aggregate together by coating over the aggregate. It also helps to improve the strength of the road. But its resistance towards water is poor. Anti-stripping agents are being used. Bitumen is a sticky, black and highly viscous liquid or semi-solid which can be found in some natural deposits or obtained as by-product of fractional distillation of crude petroleum. It is the heaviest fraction of crude oil, the one with highest boiling point (525°C). Various Grades of Bitumen used for pavement purpose:30/40, 60/70 and 80/100[(1).]

2.0 Objectives

1. To utilize non- degradable plastic, crumb rubber in bitumen.
2. To compare the strength characters of normal bitumen and (waste plastic& crumb rubber) added bitumen 1%, 1.5%, 2% & 2.5%.
3. Disposal of waste plastic and crumb rubber is major problem and burning of these causes environment pollution, so find utility of waste plastics and Rubber in road construction.
4. To know the properties of aggregates and plain bitumen.
5. To study the effect of waste plastic and crumb rubber on strength and stability characteristics of BC mix for 80/100 grade bitumen.

MATERIALS

A. Waste Plastics
B. Waste tires rubber. (Crumb rubber)
C. Bitumen 80/100.
D. Aggregate -20mm down size.

TESTS

a. Ductility Test = 95 mm
b. Specific Gravity Test (Bitumen &aggregate) = (Bitumen 1.02, Aggregate 2.7)
c. Softening Point Test = 56
d. Marshall Stability Test
e. Aggregate.

METHODOLOGY

Collection of plastic waste & crumb rubber—› cleaning and drying of segregated plastic —›shredding of plastic into 2mm-4mm& crumb rubber make powder form —› heating bitumen up to 1600^{o}c —› addition of shredded waste plastic & crumb rubber to hot bitumen —› testing with different % of plastic & crumb rubber added bitumen (1%,1.5%,2%&2.5%) —› comparing test results—› optimum % of plastic & crumb rubber to be added is obtained.

Preparation of Mould for Marshall Tests

•Prepared mix was placed in the preheated apparatus which consist of a cylindrical mould of diameter 10.16 cm and height 6.35cm with base plate and collar. Mix will be compacted on a compaction pedestal using a hammer of 4.54 kg weight with 45.7 cm height of fall, with 75 blows on either side at a temperature of 138^{0}-149^{0} c. The weight of the mixed aggregate taken for the preparation of the specimen was suitably.

•Altered to obtain a compacted thickness of 63.5 +/- 3.0mm.The compacted specimen from the mould is extruded from the sample extractor after cooling 24 hrs. The physical parameters such as diameter, thickness and weight of specimen in air were determined. The bitumen is a complex organic material and it occurs either naturally or may be obtained artificially during the distillation of petroleum. It is chemically a hydrocarbon. It is insoluble in water, but it completely dissolves in carbon bisulphate. It is black or brown in colour and it is obtained in solid or semisolid state. It softens when heated and again solidifies when the temperature is lowered. It contains 85 percent carbon, 12percent hydrogen and 3percent oxygen.

Fig:1 Preparation of Mould for Marshall Tests

Fig. 2 (Bitumen Moulds)

Marshall Stability Test:

Bruce Marshall, formerly bituminous engineer with Mississippi state highway department, UAS formulated Marshall Method for designing bituminous mixes. Marshall's test procedure was later modified and improved upon by U.S. corps of engineers through their extensive research and correlation studies. ASTM vide designation D 1559-62 T has standardised the test procedure. Generally, this stability test is applicable to hot-mix design using bitumen and aggregates with maximum size of 25 mm. In this method, the resistance to plastic deformation of cylindrical specimen of bituminous mixture is measured when the same is loaded at the periphery at 5cm per minute. This test procedure is used in designing and evaluating bituminous paving jobs. There are two major features of the Marshall method of designing mixes namely,

a) Density-voids analysis
b) Stability-flow tests.

The Marshall stability of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature at 60C. The flow value is the deformation of Marshall Test specimen undergoes during the loading, up to the maximum load, in 0.25 mm units in this test an attempt is made to obtain optimum binder content for the type of aggregate mix and traffic intensity.

Fig. 3 (marshal stability test)

RESULT AND DISCUSSION

RESULTS

FOR BITUMEN

Maximum stability=1767kg

At bitumen content=5%

Maximum bulk density=2.410 gm/cc

At bitumen content=5%

Percent air voids=4%

At bitumen content=4.9%

Optimum bitumen content=5% From the above tables and graph the maximum stability and maximum bulk density is attained at 5% of bitumen content. The 4% of air voids is attained at 4.9% of bitumen content. Taking into consideration of all the three properties, the optimum binder content [OBC] of bitumen grade 80/100 is found to be 5%.

FOR PLASTIC

Maximum stability = 1963 kg, @ 2% of waste plastic content

Maximum bulk density = 2.394 gm/cc, @ 2% of waste plastic

From the above table and graphs it is clear that maximum stability of the mix is attained at 2% of Plastic which is add to the mix of bitumen grade 80/100 and waste plastic. The maximum bulk density is also attained at 2% 0f Plastic content.

FOR RUBBER

Maximum Stability = 868.348 kg, @ 2% of Rubber content

Maximum Bulk Density = 2.65 gm/cc, @ 2.5 % 0f rubber

From the above table and graphs it is clear that maximum stability of the mix is attained at

2% of rubber which is add to the mix of bitumen grade 80/100. The maximum bulk density is also attained at 2.5% 0f rubber content.

FOR RUBBER AND PLASTIC

Maximum Stability = 1150.63 kg, @ 1.5% of Rubber and Plastic Content

Maximum Bulk Density = 2.62 gm/cc, @ 1% of Rubber and Plastic Content

From the above table and graphs it is clear that maximum stability of the mix is attained at 1.5% of plastic and rubber which is add to the mix of bitumen grade 80/100. The maximum bulk density is also attained 1% of plastic and rubber.

Discussion

General

Use of waste plastic and rubber has made a good progress in bituminous road construction in recent years. Waste plastic and rubber are used in bituminous course. This investigation is on attempt to evaluate addition of waste plastic and rubber to bituminous concrete wearing course mix of aggregate grade 1 along with plane bitumen 80/100 grade.

Optimum binder content for bituminous concrete mix BC

optimum binder content obtained for bituminous concrete grade 1 mix for 80/100 grade bitumen was 5% as per specification of MORTH standards. The stability obtained for the respective OBC was 1767Kg.

CONCLUSION

Based on the experimental investigation the following conclusions are drawn:

1. By carrying out Marshall Test for control mix samples which was prepared by adding 4%, 4.5%, 5%, 5.5% bitumen by weight of aggregate to form BC mix, OBC was obtained as 5%.

2. Addition of LDPE and Crumb Rubber in 1%, 1.5%, 2% ,2.5% to BC mix samples keeping constant OBC 5%.
3. Since the Marshall stability is higher in case of LDPE 1963 kg @ 2% when compared to Crumb Rubber and LDPE with crumb rubber. LDPE can be regarded as the best modifier among three.
4. Thus, it can be concluded from the study that the modifiers when used in 2% by weight of bitumen can improve the stability of pavement, best among them being LDPE.
5. The use of waste plastic as an asphalt mixture modifier ensue its safe, useful and environmental friendly disposal.

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