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A study on use of waste polythene bituminous paving mixes

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ABSTRACT

Bituminous binders used in pavement construction works include both bitumen and tar. Bitumen is hydrocarbon material of pyrogenous origin, made available as by product of fractional distillation of crude petroleum. Bituminous materials are very commonly used in highway construction because of their binding and their water proofing properties. Plastic has become common man's friend. It finds its use in every field. Nearly 50% of the plastic consumed is used for packing. The most used plastic materials for packing are carry bags, cups, thermocoles and foams. These materials are manufactured using polymers like Polyethylene, polypropylene and polystyrene. The tubes and wires are made of poly vinyl chloride. These materials, once used are either thrown out or littered and ultimately get mixed with Municipal Solid Waste (MSW). As the plastic is non-biodegradable, its disposal is a problem and it causes social problems contributing to environmental pollution. Especially pollution caused by plastic is a very critical problem of the present society. In the present research work, the plastic blended bituminous mix using `Zycothermal` a chemical stabilizer is prepared by replacing optimum bitumen content with 8%, 10%, and 12% of plastic by weight of bitumen and Marshall Stability and flow values are compared with straight run bituminous mix.

INTRODUCTION

A good roadway infrastructure is the backbone of a strong stable economy. Over the years after Independence there has been an extensive development of the road network across the length and breadth of India**.**

PLASTICS & PLASTIC WASTE: Among plastics, Polyethene forms the largest portion followed by Polyethylene Terephthalate (PET). It is obtained in massive quantity from bottles most commonly used for packaging of beverages and drinking water . India approximately produces 40 million tons of solid waste of which 12.3% is plastic which is discarded mainly in form of water bottles. Depending on their physical properties, they may be classified as thermoplastic and thermosetting materials. Thermoplastic materials can be formed into desired shapes under heat and pressure and become solids on cooling. On subjected to the same conditions of heat and pressure, they can be remolded. Thermosetting materials which once shaped cannot be softened/remolded by the application of heat. Table 2 gives the polymer demand in India from 1995 to 2011.The examples of some typical Thermoplastic and Thermosetting materials are tabulated in Table 3. Thermosetting materials are not used in pavement construction.. India has among the lowest per capita consumption of plastics and consequently the plastic waste generation is very low as seen from the Table 4. India has among the lowest per capita consumption of plastics and consequently the plastic waste generation is very low as seen from the Table4. Table5 indicates the various sources of waste plastic generation.

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Properties of Plastic blended bituminous mix

Some fibers have high tensile strength relative to asphalt mixtures. Thus it was found that fibers have the potential to improve the cohesive and tensile strength of bituminous mixes. They are believed to impart physical changes to asphalt mixtures. Plastic can improve effectively mechanics behaviors of asphalt concrete, enhance the tensional and compressive strengths of asphalt concrete, and prolong the fatigue life of asphalt concrete pavements. It is thought that adding plastics to asphalt enhances material strength and fatigue characteristics.

SIGNIFICANCE OF THE STUDY

Plastic is expected to increase the stability, decrease air voids and reduce the flow of the bituminous mix.. Plastic will also help in imparting more elasticity to the bituminous mixes. Hence various percentages of the plastic are used in bituminous mix.

LITERATURE REVIEW

GENERAL: Plastic use in road construction is not new. It is already in use as PVC or HDPE pipe mat crossings built by cabling together PVC (polyvinyl chloride) or HDPE (high-density poly-ethylene) pipes to form plastic mats. The plastic roads include transition mats to ease the passage of tyres up to and down from the crossing. Both options help protect wetland haul roads from rutting by distributing the load across the surface. But the use of plastic-waste has been a concern for scientists and engineers for a quite long time. Recent studies in this direction have shown some hope in terms of using plastic-waste in road construction i.e., Plastic roads. A Bangalore-based firm and a team of engineers from R. V. College of Engineering, Bangalore, have developed a way of using plastic waste for road construction. An initial study was conducted in 1997 by the team to test for strength and durability. Plastic roads mainly use plastic carry-bags, disposable cups and PET bottles that are collected from garbage dumps as an important ingredient of the construction material. When mixed with hot bitumen, plastics melt to form an oily coat over the aggregate and the mixture is laid on the road surface like a normal tar road. In this chapter, a brief review of methods of introduction of plastic, stability, flow ,volumetric properties, of plastic blended bituminous mix are presented .Critical observation based on the work reported so far are also presented in the end of the chapter.

METHOD OF MIXING PLASTIC: Waste plastic is ground and made into powder; required percent of plastic is mixed with the bitumen. The plastic waste is melted and mixed with bitumen in a particular ratio. Normally, blending takes place when temperature reaches 45.5°C but when plastic is mixed, it remains stable even at 55°C. Plastic and bitumen both are melted separately and then mixed. This mixture is then mixed with aggregates in required proportion.

Studies on volumetric properties of plastic blended bituminous mix: The addition of plastic to the bituminous mix increases the Air void and VMA, while bulk specific gravity decreases, and the volume filled with bitumen decreases. Adding fibers to the mixture reduces specific gravity of mixture due to plastics lower density compared to asphalt and aggregate. The air voids and VMA increases because, plastics has higher elastic behavior than asphalt and thus resists compaction efforts and condensing of mixture.

AREA OF STUDY

The Roads and Buildings (R&B) department will identify the roads in rural areas to construct. The department is working on the proposal and will take it up at the earliest. The idea is to find a solution to growing plastic waste menace and also lay quality roads in the State. The new procedure is likely to bring down the expenditure involved in construction of roads. The R&B department maintains more than 50,000 km of roads, including, national highways, state highways, major district roads and rural roads. Of this, the major district roads network is 10,629 km, while other roads 21,053.07 km.When contacted, Special Chief Secretary (R&B) Sumita Dawra said that the government was making earnest efforts to reduce the plastic waste that was posing environmental hazards. Use of plastic waste in laying roads was a solution. It will be an answer to municipal solid waste management apart from laying quality roads. The estimates and plans were being prepared. Very soon the plastic roads would be a reality, she said.

The plastic road process involves shredding of waste plastic to small pieces and mixing it with bitumen. However, there are no firms that are into this kind of business in the State. Neighbouring Tamil Nadu and Karnataka are making strident steps in that direction. The AP would have to purchase the shredded plastic from TN or Karnataka for pilot projects. The government would encourage the village Sarpanches to segregate the plastic waste and take up shredding works. The government is planning to purchase the shredded plastic from native sources with a view to reducing the waste.

Cost effective

The Panchayat Raj department had already laid a 27-km length plastic road in Guntur district on pilot basis. The PR department officials found that the plastic roads were successful. As there are no firms that sell shredded plastic, the officials purchased shredded plastic from units located in Tamil Nadu and on borders of AP.PR department Engineer-in-Chief Sriram Murthy said that cost would come down byRs. 10,000 to Rs. 15,000 per km if plastic waste was used.For every 100 kg of bitumen, 8 kg of shredded plastic is used.

Offers solution

It would cost Rs. 40 to Rs. 45 per kg of shredded plastic, including transportation costs. More than savings, the new technology would be a solution, he said.

INTRODUCTION OF WASTE POLYTHENE

The polythene used in OMFED milk packets was used as raw material for preparation of the samples. These polythene packets were collected; they were washed and cleaned by putting them in hot water for 3-4 hours. They were then dried. Specific Gravity of polythene = 0.905The dried polythene packets were cut into tiny pieces of size 2 mm maximum. This is because when the polythene is to be added with bitumen and aggregate it is to be ensured that the mixing will be proper. The smaller the size of the polythene, the more is the chance of good mixing.

EXPERIMENTAL INVESTIGATIONS

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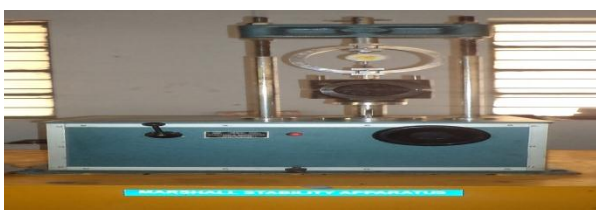
GENERAL In this chapter, characterization of materials used in this study, details of the experimental investigations such as selection of mix, aggregate gradation, selecting the method for proportioning of aggregates and obtaining the stability, flow and volumetric properties by Marshall Method are presented in this study.

MATERIALCHARACTERIZATION: Aggregates are classified as coarse, fine, and filler. The function of the aggregates is to contribute the stability to the bituminous mixture by providing interlocking and frictional resistance between the aggregates. Mineral filler is largely visualized as a void filling agent. Bitumen and plastic provides the binding and reinforcing action.

Aggregates: The coarse aggregate used was a normal weight aggregate with a nominal size of 10 mm and was obtained from the local supplier. The fine aggregates used was a normal weight aggregate with a nominal size of 6 mm and stone dust were obtained from the local supplier. The filler used was hydrated lime obtained from the local supplier. Salient properties of the fine and coarse aggregate determined by standard tests are presented in Table 3.1 and 3.2 respectively.



The procedure for preparation of specimens for the Marshall test is detailed in this section. The weighted aggregates were mixed and heated for 100°C in a pan. Then the plastic was added to the bitumen and mixed well to ensure uniform distribution of plastic(Dry blending method). The entire mixture was heated to a temperature of 140-150°C.The weighed bitumen for the sample was added to the heated mixture. Then mixture was heated to a temperature of 150-160°C and mixed well with the aggregates to get a homogenous mixture. The homogenous mixtures is transferred to the mould for compaction. Compaction was done at a temperature of around 100°C to 150°C. The specimen was compacted with 75 blows to each side of the cylindrical sample mounted on a standard mould assembly by using a standard compactor, that has a circular tamping face and a sliding weight of 4.536 kg with a free fall of 45.7 cm to get the Marshall Compaction Specimen. The compacted specimen was allowed to cool down to room temperature before extraction of the sample of specimen. A steel disc with a diameter not less than 100 mm and a minimum thickness of 13 mm was used for extracting the compacted specimen from the mould by applying a slow gradual force using a hydraulic jack to the face of the specimen and the extracted specimen was shown in figure .

Determination of the volumetric properties : It is necessary to determine the volumetric properties for the specimen such as air voids (VV), voids in mineral aggregate (VMA) and voids filled with bitumen (VFB). In order to calculate those properties the parameters for the specimen like theoretical specific gravity, bulk specific gravity and bulk density are required. The bulk specific gravity was calculated as the weight of the sample in air to the volume of the specimen. The volume of the sample was calculated

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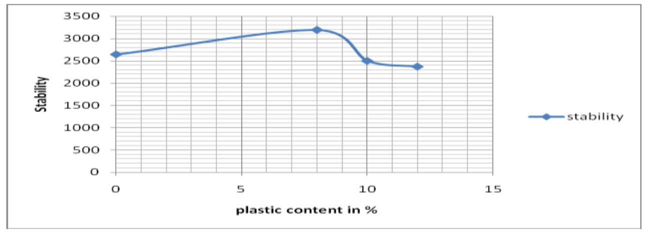
by the difference in the weight of the specimen in air and water .

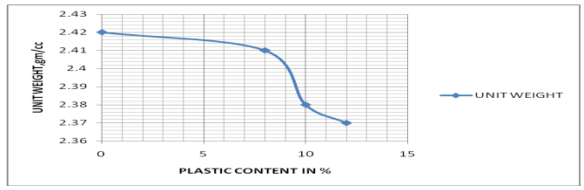
Stability and Flow Value Test: ASTM D 1559 standards prescribe that the bituminous mix specimens must be tested at 60±1°C. To facilitate this, the samples after determination of volumetric properties were kept in a water bath maintained at 60°C for 30- 40 minutes. The guide rods and the entire breaking head setup of the Marshall apparatus were cleaned and lubricated. The specimen was removed from the water bath and placed with its axis horizontal to the test heads. The complete assembly was quickly placed on the base plate of the Marshall Compression machine. The flow dial gauge was placed over the guide rod and the dial gauges of proving ring and flow meter were adjusted to read zero. The machine was set to operation for applying load until the maximum value was reached. The values of maximum load and the corresponding rotation in flow dial gauge were recorded .Then the machine was reversed and the failed specimen removed from the test head

RESULTS

GENERAL: In this chapter, the properties of semi dense bituminous concrete such as stability, flow, air voids (VV), Voids in mineral aggregate (VMA), voids filled with bitumen (VFB), unit weight and bulk specific gravity obtained from Marshall method of mix design were computed, analyzed and presented for both reference mix and plastic blended bituminous mix. Computation of the Optimum Plastic Content using the Marshall procedure is also presented.

BITUMINOUS MIX WITHOUT PLASTIC (REFERENCE MIX): Specimens prepared without plastic were considered as reference specimens. The binder content of 5%(by weight of the mix) was used to prepare Marshall Specimens. Three specimens were prepared with this binder content. Specimens were tested as per ASTM D 1559. Mix properties like stability, flow, air voids (VV), Voids in mineral aggregate (VMA), Voids filled with bitumen (VFB), unit weight and bulk specific gravity were computed and presented in table





It was observed that the air voids and voids in mineral aggregate increases and voids filled with bitumen and the unit weight decreases with the increase in plastic content. This was mainly because of the plastic occupying in between the aggregates thereby creating voids. Mixtures with higher plastic contents were expected to experience lower compact ability (bouncing), leading to higher air void values. As the voids increases the unit weight decreases.

BITUMINOUS CONCRETE PAVEMENT-SPECIFICATIONS

DESCRIPTION: This work shall consist of the construction of a plant mixed bituminous surface(s) of pavement(s) of bituminous concrete on the approved prepared roadbed, base course, or existing surface in accordance with the specifications and contract, and in conformity with the lines, grades, and typical section shown on the plans. The bituminous concrete pavement(s) shall be composed of a mixture of mineral aggregates, mineral filler and bituminous material. The requirements of Sections 401, 402, 405, 406, 407, and 408 under Part IV, "Surface Courses", and Section 306, "Bituminous Base Course" of the Standard Specifications for Road and Bridge Construction, State of Wisconsin, Department of Transportation, latest edition, except as herein-after stipulated, shall be applicable to this work.

MATERIALS: All materials used in the work shall conform to the requirements of Section 401 or 306 as stated above. The aggregate requirements shall conform to Section 401 titled "Materials for Bituminous Mixtures and Surface Treatments" in these specifications. When a Special Wear Course is specified, the aggregates used in the Special Wear Course shall be 100 percent crushed mine trap rock, quartzite or granite; or shall consist of 100 percent crushed natural gravel. The bituminous material to be used in the work shall be asphalt type AC in the penetration grades 60-70, 85-100, 120-150, 200-300. The penetration grade shall be designated by the Engineer in the Special Specifications.

COMPOSITION OF PAVING MIXUTRES:

General: The paving mixtures shall be composed of homogenous mixture of coarse aggregate, fine aggregate, mineral filler, and bituminous material.

Base Course: Aggregates to be used shall conform to the gradation requirements for gradation No. 1 of "Aggregates for Bituminous Road Mix and Plant Mix Surfaces and Pavements" or Gradation No. 1 or Gradation No. 2 of "Aggregates for Bituminous Base Course." Bituminous material in the approximate range of 4% to 7% of the composite mix, and as specifically determined by the Engineer on the basis of laboratory tests, shall be incorporated into the mixture.

Surface Course: The aggregates, including mineral filler, shall conform to the gradation requirements for Gradation No. 3 of "Aggregate Specifications"; except that Gradation No. 4 shall be used when specifically required by the contract; or when the nominal thickness of a given layer or course to be built as a separate operation is less than 1 ¼ inches; or when the characteristics of the material in the deposit are of such a nature as to require crushing to a smaller size in order to obtain 45% or more of particles retained on a No. 4 sieve having at least one surface or face produced by the fracture of a larger particle. The composition of the surface course shall conform to Section 407 of Standard Specifications for Roads and Bridges, State of Wisconsin, and/or as specified on the plans of special specifications Not less than one-half of the material passing the No. 200 sieve shall be mineral filler. Bituminous material in the approximate range of 5% to 8% of the composite mix, and as specifically determined by the Engineer on the basis of laboratory tests, shall be incorporated into the mixture.

EQUIPMENT: The equipment to be used in the work shall conform to the requirements set forth in Section 405 of the Standard Specifications for Road and Bridge Construction, State of Wisconsin.

CONSTRUCTION METHODS: The construction methods shall be as required under Section 405 of the Standard Specifications, State of Wisconsin, for Road and Bridge Construction.

Preparation of Aggregate: The dried and heated aggregates shall be separated into sizes, stored in separate bin compartments, and recombined in the proper proportions in the mixer. Aggregates for the binder course and Gradation No. 2 shall be separated into 3 sizes. Aggregates of Gradation No. 3 shall be separated into 2 sizes (at the Contractor's option, he may separate aggregate No. into 3 sizes).A separate bin and feed shall be used for mineral filler unless the aggregates, as produced, contain stone dust of the required quality and in the amounts necessary to produce a finished mixer of the required composition. The aggregates used in the binder or lower course mixture shall be dried and heated to a temperature not in excess of 375 degrees F. The aggregates shall be heated to such temperatures so that the mixture when discharged from the mixer will be within 15 degrees F., plus or minus, of the temperature specified for the mixture.

Preparation of Asphalt Cement: The asphalt cement shall be heated to a temperature of not less than 250 degrees F. and not more than 350 degrees F. The required temperature within this range will be within 25 degrees F., plus or minus or as designated by the Engineer.

Finished Mixtures: The finished mixtures shall be delivered at a temperature, plus or minus, 20 degrees F. of the temperature designated by the Engineer, but not less than 225 degrees F. for lower or binder course mixtures, and not less than 250 degrees F. for surface course mixtures.

TESTING AND DESIGN MIXES: At least 10 days prior to use, representative samples of the aggregates, sand, and bituminous material to be used shall be furnished by the successful contractor or his suppliers to an independent testing laboratory, such as the Twin City Testing and Engineering Laboratory, for testing purposes and for preparation of design mixes under Sections 306, 405 and 407 of the Standard Specifications, State of Wisconsin, for Road and Bridge Construction. Design mixes shall be prepared by the independent testing laboratory and submitted to the City Engineer for each of the courses (base course, surface course, and/or Wear Course). The cost of the preliminary testing of materials and preliminary design of asphaltic concrete mixtures is to be borne by the Contractor. The City may engage an independent testing laboratory to inspect the project and the plant during the course of the work to verify materials and procedures as to meeting specifications.

TRANSVERSE JOINTS: The placing of any course of bituminous material shall be as continuous as possible, and the roller shall not pass over any unprotected end of freshly laid mixture except where the laying of the course is to be discontinued long enough to become cold. In such cases when laying is discontinued, joints shall be made for proper bond with the new surface for full depth of the course by cutting back on the previous run so as to form a true transverse vertical face. When the laying of the course is resumed, the fresh mixture shall be placed against the joint to form intimate contact with the previous course.

LONGITUDINAL JOINTS: Longitudinal joints for surface courses produced by concurrent paving of adjacent lanes shall be treated to insure a tightly bonded and sealed joint. Such treatment shall be either the painting of the edge of the course in place with hot asphalt cement, or heating the edge with an approved infrared or radiant heating device at the time the abutting course is placed. The longitudinal joints for the surface course shall be on centerline and a minimum of 11 feet either side of centerline so that no joint falls in the center lane of travel. The longitudinal joints in the base course shall not coincide with longitudinal joints in the surface course.

CONCLUSIONS

In this chapter, the salient features of this project work on plastic blended bituminous mixes are examined and conclusions are drawn after a detailed analysis of the results obtained. Based on the study and experimental data for waste plastic modified bituminous concrete mix compared with conventional bituminous concrete mix, the following conclusions can be drawn- The results showed that waste plastic can be conveniently used as a modifier for bituminous concrete mix as it gets coated over the aggregates of the mixture and reduces porosity, absorption of moisture and improves binding property of the mix. The Optimum Bitumen Content (OBC) was found to be 5.43% by weight of aggregates. The Optimum Plastic Content (OPC) to be added as a modifier of bituminous concrete mix was found to be 9.73% weight of Optimum Bitumen Content (OBC) of bituminous concrete mix. Bituminous concrete mix modified with waste plastic coated aggregates showed higher (approximately 21%) Marshall stability and higher flow value as compared to conventional bituminous concrete mix. Marshall stability value increases with plastic content up to 12% and thereafter decreases. Thus the use of higher percentage of waste plastic/ polythene is not preferable. The stiffness of the modified mix was increased but it was with in specified norms.

The volumetric and Marshall properties of conventional and modified bituminous concrete mixes were almost satisfying both MORTH and IRC: 111-2009 specifications. This shows that plastic waste blended bituminous concrete mix is better one and is more suitable for flexible pavement construction. Plastic waste modified mix is strip resistant even when subjected to worst moisture condition. Physical properties like Aggregate Impact Value, Los Angles Abrasion Value , Water Absorption Value and soundness etc. of plastic

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coated aggregates (PCA) were improved appreciably as compared to conventional aggregates (without plastic coating) due to thin plastic coating over aggregates. Plastic waste modified mix consumes less bitumen (OPC= 9.73% by weight of OBC) so it is economical. Hence cost of construction of plastic roads will be less. One can also effectively use the relatively weak stone aggregates by making them comparatively stronger by providing suitable plastic coating over it by Dry Method. The addition of plastic enhances the properties bituminous mixtures by increasing its stability and flow at 8% of plastic. On further increasing of the plastic content upto 12% the stability and flow decreased. Therefore the optimum plastic content to be used is 8%. This makes the semi dense bituminous concrete acquiring the potential to improve structural resistance to distress occurring in flexible road pavement due to traffic loads. The voids increase with the increase in plastic content. The increase in the voids is significant in hot regions where bituminous mix is prone to bleeding .Increase in voids provides more spaces for the binder to move and prevents it from raising to the surface. It is concluded that the use of plastic in Bituminous mix significantly enhance the resistance of bituminous layers to tensile stress. This method is important because it provides a solution to the major environmental problem i.e. usage of plastic by showing an alternative for it. It is more concerned about increasing the road's strength. So using these types of new technologies will help the society to be strong, clean and green.

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