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Use of emulsion for warm mix asphalt

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ABSTRACT

Due to increase in energy costs and emission problems in hot mix asphalt usually used, it brought a great interest to the researchers to develop the warm mix technology for pavement constructions. Commonly known as warm mix asphalt (WMA), it is a typical method in the bituminous paving technology, which allows production and placement of bituminous mixes at lower temperatures than that used for hot mix asphalt (HMA). The WMA involves an environmental friendly production process that utilises organic additives, chemical additives and water based technologies. The organic and chemical additives are normally very costly and still involve certain amount of environmental issues. These factors motivated the authors to take up this technology using simple, environment friendly and somewhat cost effective procedure. In this study, an attempt has been made to prepare warm mixes by first pre-coating the aggregates with medium setting bitumen emulsion (MS) and then mixing the semi-coated aggregates with VG 30 bitumen at a lower temperature than normally required. After a number of trials it was observed that mostly three mixing temperatures, namely temperatures 110 °C, 120 °C and 130 °C were appropriate to form the bituminous mixes with satisfactory homogeneity and consistency and as such were maintained throughout this study. Marshall samples for paving mixes were prepared using this procedure for dense bituminous macadam (DBM) gradings as per the specifications of Ministry of Road Transport and Highways (MORTH) and subsequently Marshall properties of the resultant mixes were studied with the main objective of deciding the different parameters that were considered for development of appropriate warm mix asphalt. In this study it has been observed that out of three mixing temperatures tried, the mixes prepared at 120 °C with bitumen-emulsion composition of 80B:20E for DBM warm mix, offer highest Marshall stability and highest indirect tensile strength (ITS), while satisfying the other Marshall parameters. It is also seen that the optimum binder contents for warm mixes are 5.1% with 80B:20E bitumen-emulsion composition for warm mix, prepared at 120 °C. The tensile strength ratio and retained stability parameters are also found to be reasonably satisfactory in such warm mixes, thus prepared.

Introduction

Warm mix asphalt (WMA) is a fast emerging technology, now accepted worldwide. The idea for use of lower temperatures to produce bituminous mixes is not new. WMA is defined as the asphalt mixture whose mixing temperature varies

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from 100 °C to 135 °C (Hurley and Prowell, 2005). WMA is produced, placed and compacted at temperature10–40 °C lower than the conventional hot mix (D' Angelo et.al, 2008). It is a technology that allows lowering the production and paving temperature of HMA by reducing the viscosity of binder, which helps in general increasing or at least maintaining the workability of mixture without compromising the performance of bitumen. It reduces energy consumption, carbon dioxide emission, oxidative hardening of bitumen which produced overhead and total costs of the road construction industry by lowering the production temperature thereby creating a better working environment. However, the lower mixing temperatures have raised concerns on the performance of the mixtures. So there is need to thoroughly evaluate and characterize the WMA mixtures to ensure adequate performance. As per Button and Estakhri (2007) WMA mix has less aging of binder during plant mixing and placement, thus improving longevity of pavement service life. Also warm mix reduces thermal segregation and emissions from mixing plants and during placement hence decreases the dust production. The WMA involves an environmental friendly production process that utilizes organic additives, chemical additives and water based technologies. The organic and chemical additives are normally very costly causing higher initial cost of the binder and still involve certain amount of environmental issues. These factors motivated the authors to take up this technology using simple, environment friendly and somewhat cost effective procedure. So in this study, an attempt has been made to prepare warm mixes by first pre-coating the stone chips/ aggregates with medium setting bitumen emulsion (MS) and then mixing the semi-coated aggregates with VG 30 bitumen at a lower temperature than normally required. These two types of bituminous binders have been taken in equal proportions to form the final and actual binder for the bituminous mixes.

Experimental program

Materials used

Aggregates

In this experimental work, the dense bituminous macadam (DBM) gradation is considered for production of warm mix asphalt. For preparing the DBM mixture, the gradation has been selected as per Ministry of road transport and highways (MORTH, 2013) for coarse and fine aggregates with nominal maximum aggregate size (NMAS) of 26.5 mm and the gradation are presented in Table 1. The coarse aggregates and fine aggregates (retained on 0.075 mm IS sieve) inclusive of dust, were collected from a local crusher. The physical properties of aggregates are given in Table 2 and the specific gravity of coarse and fine aggregates are 2.75 and 2.6 respectively.

Filler

The material which passing through 0.075 mm IS sieve is used as filler. Filler helps to fills the voids, stiffens the binder and offers better impermeability. As per MORTH (2013) in DBM mixes, fillers such as stone dust, hydrated lime and cement are used. In the present experimental study, cement has been used as filler. The specific gravity of cement was found in the laboratory to be 3, which has been used in the voids analysis.

Binder

Generally bitumen acts as a binding agent to the aggregates, fines and stabilizers in the bituminous mixtures. Bitumen must be treated as a visco-elastic material as it exhibits both viscous as well as elastic properties at the normal pavement temperature. At low temperature it behaves like an elastic material and at high temperatures its behavior is like a viscous fluid. Conventional VG 30 grade bitumen, collected from local government depot has been used in this research study to prepare the bituminous mixtures. The physical properties of VG 30 bitumen is presented in Table 3.

Bituminous emulsion

An emulsion can be defined as the dispersion of small droplets of one liquid in another. Bituminous emulsions generally belong to oil-in-water type where bitumen is dispersed in water with small quantity of emulsifying agent. Chemically stabilized bituminous emulsion has three necessary components bitumen, water and emulsifying agent. The emulsifying agent is called surfactant which is chemically composed of large molecules. Some of the benefits of bituminous emulsions are

Table 1
DBM gradation as per MORTH, 2013.

Sieve size (mm)	Percentage passing	Adopted percentage passing
37.5	100	100
26.5	90–100	95
19	71–95	83
13.2	56–80	68
4.75	38–54	46
2.36	28–42	35
0.3	7–21	14
0.075	2–8	5