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Energy Conservation using Cold Mix Technology in Road Construction-A Review

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Abstract—*Nowadays, there is a need of energy conservation as there are increasing effects of global warming .There is also a great requirement to implement road construction technology which will conserve more energy during the construction process and maintenance operations. Traditionally, aggregates and bitumen are heated to a temp of 150°C for construction of pavements as hot mix technology was used on a large scale. It is extremely important to maintain stipulated temperatures at the time of producing the mix, laying and compaction. This hot mix technology leads to more fuel consumption and thereby leads to environmental pollution. So, technology has to be implemented which will reduce pollution and it can be done by using cold mix technology for road construction. Cold mix technology helps in energy conservation and maintaining the environmental balance during road construction. Here, the main goal is to carry out road construction by heating the aggregates at ambient temperature which will also give good quality pavement.*

1. INTRODUCTION

The cold mix technology is a highly engineered but simple and effective solution for road construction and maintenance for rural, district and state roads, requiring a durable all-weather surface measuring 2 cm in thickness over the WBM or old bituminous surface with open-graded premix carpeting.Cold Mix eliminates heating of aggregate and binder. This results in energy savings and overall reduced cost as compared to typical hot mix.

1 km long rural road consumes about 1800 litres of fuel in construction of bituminous surface using hot mix technologies presently in practice. The estimated quantity of fuel for PMGSY network is more than 1540 million litres, if only hot mix technologies are used. The estimated quantity of fuel for PMGSY shall be about 132 million liters, if cold mix technology is used for road construction.

Till date cold mix technology has saved 13,396 tonne emissions of CO_2, 0.913 tonne Methane and 183 tonne CO due to reduced consumption of fuel [29].

Cold mixes are prepared by mixing aggregates with bitumen emulsion at ambient temperature compared to the hot mix prepared at 150°C that leads to emission of hydrocarbon and suspended particulate matters thus degrade the environment. Round the clock work can be carried out as cold mix is feasible with cold climates and also during rainfall..The cost and energy saving, protection of environment, decrease in carbon footprint, use of damp aggregates are the advantages of cold mix technology.

2. METHOD FOR DESIGN OF COLD MIXES

Presently, a standard design procedure is not available for design of cold mixed BM or SDBC (Hazlett-2007).

The cold mix design procedure involves optimization of water as well as content of bitumen emulsion for the aggregates in the mix [17]. The aggregates are made moist with water to wet its surface and then coated with cationic bitumen emulsion. The different sizes of aggregates are blended in proportions to achieve the best standard gradation of BM or SDBC.

a) Determination of Aggregate Gradation:

This simply follows standard specifications for aggregate gradation selection.

b) Determination of Initial Residual Asphalt Content (IRAC) and the Initial Emulsion Content (IEC):

Initial Residual Asphalt Content (IRAC) is calculated utilizing an empirical formula:

$$\text{IRAC} = (0.05\,A + 0.1\,B + 0.5\,C) \times (0.7)\ldots \qquad \text{(I)}$$

Where A is the percentage of aggregate retained on sieve 2.36 mm.

B is the percentage of aggregate passing sieve 2.36 mm and retained on 0.075 mm and C is the percentage of aggregate passing 0.075 mm.

IEC is calculated using formula:

$$\text{IEC} = \text{IRAC} / [X \text{ (in \%)}] \ldots\ldots\ldots \qquad \text{(II)}$$

Where IEC is the Initial Emulsion Content by mass of total mixture and X is the asphalt content of the emulsion.

c) Coating Test and Determination of Optimum Pre-wetting Water Content (OPWC):

Using the IEC value coating test is carried out by mixing dry aggregates and filler with varied amount of water. After the pre-wetting of aggregates the asphalt emulsion is added and then mixed for about 2 to 3 minutes until the uniform coating is obtained. The optimum pre-wetting water content (OPWC) that gives the best asphalt coating on the mineral aggregates (in which the mixture was neither too sloppy nor too stiff) is determined. The degree of coating should not be less than 50 % by visual observation.

d) Dry Stability Test and Determination of Optimum Total Liquid Content at Compaction (OTLC):

Utilizing the IEC, the mix is compacted at the predetermined compaction level (50 Marshall blows on each side of the sample). The loose mixtures are compacted at OPWC and then at PWC (pre-wetting water content) with 1 % increasing steps from OPWC. The samples are kept for one day in their moulds after compaction and thereafter extruded and kept for one day in an oven at 40ºC. Then they are removed from the oven and stored at room temperature for one day. After that the samples are tested for Marshall Stability at room temperature and the results obtained are referred as dry stability. This test gives the OTLC at which the dry stability of the sample is maximum. Where OTLC is the summation of liquid content of IEC and pre-wetting water content at maximum dry stability.

e) Soaked Stability Test and Variation of Residual Asphalt Content (RAC):

By maintaining a constant OTLC value, the RAC is varied in a range of 7 to 10 % emulsion content (EC) value with 0.5 % increment in RAC. Specimens are mixed, compacted at each of these RAC values. Then the same curing process is followed up to the completion of the oven curing as explained above in case of dry stability test. The dry samples are then water conditioned (capillary soaking). In this procedure half the thickness of each compacted specimen is soaked in water at room temperature for 24 hour. The specimen is then inverted and the other half is soaked for next 24 hour. The samples are subsequently towel dried and tested for Marshall Stability at room temperature. The Marshall Stability test results obtained are referred as soaked stability. At this condition the samples do not achieve full curing stage as contained some amount of water.

f) Determination of Optimum Residual Asphalt Content (ORAC):

ORAC is determined by optimizing the parameters such as soaked stability, air void, flow value for soaked samples of all residual asphalt content (RAC) variation. The main parameter considered is the maximum soaked stability while all other parameters should meet the CMA design requirement as per MORTH (2001) specification at the proposed ORAC. In case either the soaked stability or the air void result is found to be inadequate, the compaction level should be increased to meet the required target.

g) Determination of Retained Stability:

Retained stability is the ratio of soaked stability to dry stability. Both soaked stability and dry stability are considered at ORAC only. Maintaining the OTLC value, the dry stability of the mixture is determined at ORAC only. The maximum stability loss is 50 %, hence, the minimum retained stability is 50 % at the proposed ORAC.

3. ENERGY EMISSION BY VARIOUS TECHNOLOGIES

The figure given below shows an estimation of the reduction in CO_2 emissions and fuel consumption that can be achieved in the production stage. The savings are highly dependent on the technology applied and on the local conditions i.e. plant type, energy source, weather conditions, recipe, quantity produced. [8]

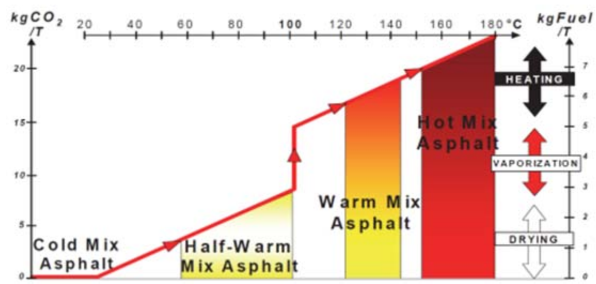

Fig. 01: Emissions by Various Technologies (Orald 2008)[8]

As mentioned above, the basic idea consists in decreasing the production and laying temperature of the asphalt mixture. In order to achieve this, it is crucial to decrease the mixture viscosity in the production and laying temperature domain, this in order to guarantee a sufficient. Workability of the mixture. Various technologies (or processes) can be applied in order to decrease the mixture viscosity (Orald 2008) [8].

The main advantages of these technologies are:

1. The energy savings and reduced CO_2 emissions

2. The simplicity of the production equipment (usually mobile)

3. The possibility to perform in-place recycling (large savings in transport, storage)

The main disadvantages of cold and semi-cold technologies are related to the early life stage after installation and include extended periods required to reach full strength and high sensitivity to rainfall after paving. Performance, when compared to the equivalent HMA, is also a point which requires special attention.

Air Pollution

As the material is not heated, there will be less air pollution during construction. In the use phase, the air pollution will be approximately the same.

Health and Safety:

Decreased odour and smoke from the plants and working sites gives better comfort for asphalt workers and people that live by the construction site. The risk of burning injuries by producing and paving hot asphalt is reduced to zero.

Financial Cost:

The cost of cold asphalt is generally much lower than the cost of HMA, provided that the pavement lifetime is comparable. This is possible for low volume roads without heavy traffic [8] [15].

For contractors who want to apply these techniques, an initial investment is required in new equipment and to train workers and engineers. Therefore, it is necessary to assure a long term security for the volume of contracts requiring these techniques.

Recyclability:

Cold mix asphalt could be recycled using the same techniques as hot mix asphalt [8].

Performance:

The material is less resistant to heavy traffic and is usually not recommended as top layer on high volume roads. The breakdown speed of the emulsion is said to be a critical factor for performance. The mixture has to break down quickly to build up the required internal cohesion, but when the breaking rate is too high, this result in workability problems and poor compaction levels. Void contents of cold mix asphalt concrete are systematically higher than for a hot mix with the same granular composition. However, the void content further decreases in the years following construction, due to curing and post compaction by traffic [27].

4. ENERGY CONSERVATION

In towns, highways become more aesthetically pleasing, and in rural area highways become a more natural part of the environment a such as Conservation and Ecosystem Management, Water Shed Driven Strong Water Management, Life Cycle Energy and Emission Reduction. Conservation of non-renewable resources and energy, together with reduced environmental pollution and working conditions are global issues that are becoming increasingly important to civil engineers [2]

As a result, authorities in various countries are creating legislation and authorities to reduce energy consumption by using cold mix construction. These incentives are bound to shape to development of new processes in the road construction especially in the section where the highest consumption occurs, i.e. in the hot mixes asphalt production. As we know that for hot mix production involves the use of fossil fuel both as a raw material and energy source, hot mix plants vary according to their age and efficiency, on average it takes about 10 cubic meters of the natural gas has about 0.525kg of carbon (Grade 9 science), one tonne of HMA will produce about 5.25 kg of carbon. [2]**.**Using cold mix and cold mix recycling we can stop this carbon emission. Pavement preservation is inherently green owing to its focus on conserving energy and raw materials, and reducing greenhouse gases by keeping good roads good [6].

Microsurfacing's environmental footprint is lower than most common pavement preservation and maintenance treatments [35].Changes in aggregate storing and drying processes can substantially reduce energy consumption in asphalt pavement production.

Fuel savings of about 50% have been achieved in cold mix asphalt road construction [32].Energy conservation may be further increased by using foamed bitumen because aggregates need not be heated and can be mixed with foam while cold or damp [1]**.**

5. CONCLUSIONS

i. It was concluded that cold mix technology is good for health of construction workers as it prevents burns, occurrence of diseases like asthma, cancer and frequent vomiting, etc.

ii. Female construction workers prefer jobs of cold mix technology.

iii. Level of environmental pollution can be decreased and energy conservation is achieved.

iv. Great economical balanced can be achieved as it greatly reduces the fuel consumption.

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