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An Experimental Investigation on CMA

Manoj Sheoran[1], Ms. Shivani[2]

[1]M Tech Scholar, [2]Assistant Professor,
[1,2]Sat Priya Group of Institutions, Rohtak, Haryana, India

ABSTRACT

There are various roadway construction activities and plans that involve the use of flexible pavement having hot mix technique. This hot mix technique is a traditional method for the construction of road that has fulfilled the performance evaluation from infrastructure point of view throughout the past years. The various processes which are involved in this technique are: providing heat to the aggregate and binder, proper mixing, provision of tack coat as per the specifications, laying of the mixed, the process of compaction. The cold mixed technique having use of bitumen emulsion on large scale should be epicenter of the study such that this technology may advance its application in present as well as future with proper specifications, testing throughout. The Hot mixed based techniques have gone through the significant advancements with time. The Cold mixed based technology is somewhere lagging in terms of applications which might be observed in the developing countries. In the present study, it has been the primary motivation that underlies the selection of cold mixed technique.

KEYWORDS: *Hot Mix Technique, Flexible Pavement, Bitumen, Emulsion*

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GENERAL

The hot mix technique is a traditional method for the construction of road that has fulfilled the performance evaluation from infrastructure point of view throughout the past years. The various processes which are involved in this technique are: providing heat to the aggregate and binder, proper mixing, provision of tack coat as per the specifications, laying of the mixed, the process of compaction. All these processes usually takes place at higher range of temperature having variations between 120ºC to 165ºC. This technique is considered to be the most suitable one for the formation of pavements as per the performance point of view but it always said that every good thing has some consequences. The major drawbacks involved in this technique are like higher consumption of energy, degradation of environment, rapid growth of footprints of carbon, limited period of construction available per annum, oxidation of binder during its hardening, health problems to labours, safety hazards (Pundhir et al., 2012). Apart from this, some parts of India like J & K, North-East states, Himachal Pradesh, Uttrakhand and others consist of large number of projects involving rural roads having investment in millions. As far as the mountainous terrain is concerned, the area has huge constraints in terms of weather, rainfalls, etc. and as a result, it becomes very hard to with the hot mix technique / technology. Eventually, it becomes inadvertently essential or mandatory to determine the most appropriate alternative of this technique. The cold mix technique is based upon the use of emulsions. It involves the use of wetting of aggregates prior to work, often termed as pre-wetting phenomenon followed by the use of emulsions to the aggregates, mix production, laying of mix and process of compaction. All the above said processes are usually performed at room temperature (25º ± 2 º C). Moreover, it has already been proved that this cold mixes may be produced easily by the use of hot mix plants and these laid in the similar fashion too. It is also considered to be the labor friendly technique.

PAST STUDIES ON BITUMINOUS EMULSION IN COLD MIX ASPHALT

As per TRB (2006), A circular named as “Asphalt Emulsion Technology” under the category of transportation research provided the essential information related to the bitumen based emulsions. Emulsion is defined as the dispersion of tiny droplets

of one medium (specifically liquid) into the other one. It may be formed by the mixing of any two immiscible liquids; however, in most of the cases of emulsions, one of the two phases is liquid. The Bituminous emulsion is considered to be the product available in the liquid state which contains the considerable given quantity of bitumen when suspended in water in form of the finely divided product in the presence of a specific emulsifier. The size of bitumen droplets varies from 0.1 micron to 20 micron. A standard type of bitumen emulsion consists of a liquid brown in colour having bitumen in the range of 40 to 75 % by weight, water in the range of 25 to 60 % by weight, emulsifier in the range of 0.1 to 2.5 % along with some minor compounds.

A study had been conducted in 1993 by Uemura and Nakamori in laboratory as well as field based on the use of cold mixes. It was concluded that the use of cold mix is very highly eco-friendly in nature due to no involvement policy dust and zero level emission of gases. It was also observed that there is no need to try off the aggregates and asphalt before its use and the performance of cold mix is found to be very satisfactory.

Dittmar (2011) considered that the self repairing of cracks takes place with time only in cold mixed asphalt based pavement. This study also recommends that the surfaces formed by cold mixed asphalt are more stable and flexible, as it may retain the comparative longer life on the roads having low traffic volume.

It was also concluded that the cold mixed asphalt production has very wide range of differential applications. The cold mixes may be primarily used in base courses, wearing courses or binders, etc. These asphalt mixes may be implemented on roads by the numerous methods such as by grader applications, pavers applications, self contained laying plants, etc. As per the suggestion of Oke (2010), there have been a wide range of methods of compaction but the most appropriate method is the use of steel rollers. For commercial scale purposes, the pneumatic tyred rollers are used initially and then, finished the steel rollers.

There have been so many studies conducted by various researchers (Needham 1996, Ibrahim 1998, Thanaya 2003, Thom 2008) that concluded in the favour of use of cold mixed asphalt as compared to the hot mixed asphalt in terms of saving of energy, use efficiency, durability, etc. It was also concluded that these cold mixes based asphalts are found to be satisfactory globally for the traffic conditions varying from low volume to medium volume range, for the pavement construction in the remote areas, etc.

Categorization and Designation of Bituminous Emulsion: There are large numbers of emulsifiers available in market on the basis of which nature of emulsion is determined in terms of anionic or cationic. The anionic emulsion contains some droplets of bitumen having some negative charge. The cationic emulsion consists of some droplets of bitumen having some positive charge. On the basis of their rate of settlement, both the kinds of emulsions such as cationic and anionic emulsions are divided into three categories i.e., slow setting (SS), medium setting (MS) and rapid/fast setting (RS). The rate of settlement may be controlled by use of emulsifier, its type and concentration. The prime difference lies between cationic and anionic emulsions is the faster giving up of water by cationic emulsions as compared to that of anionic emulsions. As per ASTM-D977 & ASTM-D2397, the emulsion nomenclature states the cationic emulsions into subcategories as CRS (cationic rapid setting), CMS (cationic medium setting), CSS (cationic slow setting). The emulsion nomenclature states anionic emulsions into subcategories as RS (anionic rapid setting), MS (anionic medium setting), SS (anionic slow setting). All of the above said types of emulsions are followed by a number among 1 & 2 and a text which indicates the viscosity of emulsion and their residual properties. The numbers 1 & 2 represents lower level viscosity and higher level viscosity respectively. The text H represents the high grade of asphalt residue. For example, CRS-2H can be named as rapid-setting (representing lower rate of reactivity) cationic emulsion with higher viscosity and high grade of asphalt residue. The quick setting emulsions whether cationic or anionic in nature are included in the intermediate range of reactivity that lies between SS and MS. These emulsions do not require passing any cement-mix test. These are used mainly slurry based surface finishing applications. The local vendors mainly form their own schemes of classification that relates the emulsions with some particular characteristics. The above nomenclature is further followed by some other letters which have their own meaning. For example, PM represents polymer - modified asphalt emulsion, LM represents latex – modified emulsion, S represents the higher solvent concentration. Based on their uses, AEP shows the asphalt emulsion prime, ERA indicates the recycling agent emulsion and PEP shows the penetrating emulsion prime.

Mechanism of Breaking: Most of the emulsions are found to be inadvertently highly unstable in nature. During larger time span in terms of years, the phase of asphalt eventually gets separated from its solvent. The asphalt is considered to highly insoluble in water and as a result, the breaking of emulsion includes the

droplets fusion which is termed as coalescence. The small drops of emulsion contain small charge value and emulsifier along with some ionisable compound is found to be the prime source of charge. The small charged droplets act as the electrostatic barrier towards their closer approach with respect to each other. But, the enough level of energy is attained by the droplets to overcome the electrostatic barrier and moves towards each other those results into formation of some flocculates. With the passage of some time span, the layer of water between the drops in the form of flocculate gets shrunk and the droplet gets coalesce. The factors responsible for bringing the droplets together are vaporization process, sedimentation process, freezing, shearing, etc. All these factors may accelerate the process of flocculation as well as coalescence.

In 1994, Leech stated that the emulsions formed by the cationic bitumen are proved to be heavily compatible with most of the aggregates. The type of bitumen, level of emulsifier, temperature, cement content and pressure applied are major factors that affect the droplets of emulsion coalescence [Brown and Needham (2000)]. Pouliot et al. (2003) concluded that the mortars made up of the cationic rapid setting emulsion (CRS-1) gave the higher strength value and higher value of elastic modulus as compared to the mortars made up of the anionic rapid setting emulsion (RS-1). Song et al. (2006) considered determining the spontaneity and feasibility for the use and benefits of the given asphalt based emulsion in the form of a polymeric admixture. It was concluded that proofing against water dampness, resistance to carbonation attack and resistance to the chloride-ion penetration of modified mortars of asphalt were considerably improved with rise in the value of polymer-cement ratio. However, the value of compressive strength and adhesion bond between substrates of mortar gets decreased with rise in the value of polymer-cement ratio.

Another research study was conducted in which the type of aggregate had impacts to determine the nature of emulsion in terms of anionic or cationic. The rate of reaction of aggregates completely depends upon the proportion of negative charge and its random distribution. E.g. the aggregates constituted of higher silica content are found to be acidic in nature and has evenly distribution of negative charges on their surfaces. Even, these charges are proved to be responsible for the strong adhesive bonding between the cationic emulsions and aggregates **[Oruc et al. (2007)].**

METHOD OF COLD MIX DESIGN

The binders of bitumen which are primarily utilized in the cold mix are essentially to be emulsified in nature which indirectly represents the liquid form of the binder. Therefore, it may be implemented at comparatively low value of temperatures as compared with that of hot mixed based asphalt. Although, the cold mix mainly manufactured/produced at ambient level of temperatures, even some of the processes might utilize the emulsion asphalts heated to about 60° ± 5°C.

There is no proper method for the design of cold mix based design and hence there is no specific method or rule that should be followed. In addition to this, there is no specification issued by Indian Standard and no general equipment for the cold mix based emulsion. However, all of the above said parameters are pre-defined for hot mixes. There is only one method namely; Marshall method that has been frequently used for these design mixes. Now a days, compaction from this method is replaced with the gyratory compaction to overcome or reduce the compaction problems which inertly improves the physical characteristics of the mixes.

MORTH (Ministry of Road Transport and Highways, 2001) introduced the complete phenomenon for the bituminous cold mixes during its fourth revision. The guidelines for the design process were defined in Manual series No.-14 (MS-14) issued by the Asphalt Institute. During the background study and analysis, it was also observed that there are some very useful tips and tricks which might be used for the preparation of cold mixed based asphalt design [Thanaya (2007)]. The major difference between the analytical process issued by Thanaya and MS-14 is the calculation process of use of optimum total liquid concentration (OTLC) and optimum residual asphalt concentration (ORAC). To find the value of ORAC, Thanaya gave the idea to conduct the stability test in soaked stage only while MS-14 gave the idea to conduct the stability test in dry stage as well as soaked stage at every residual asphalt content (RAC). Among both the study, the former study is proved to more effective, economic and highly efficient, but it does not include determination of OTLC for the design preparation. As a result, this process is considered to be highly suitable for the field only. The complete design steps involved and design specifications required as per MORTH guidelines are given in table 2.1 and 2.2 respectively.

Table 1: Difference between the Study for MS 14 and Thanaya CMA design procedure

Asphalt Institute MS 14 (1997)	Thanaya (2007)

Calculation of	Determination of
➢ Gradation of aggregate based on specifications ➢ IEC & IRAC (Based on formula) ➢ Optimum Pre-wetting Water Content (OPWC) – Coating test ➢ Optimum Total Liquid Content (OTLC) – Stability Test in Dried State ➢ Optimum Residual Asphalt Content (ORAC) - Stability Test for both RAC in Dried State and Soaked State	➢ Gradation of aggregate based on specifications ➢ IEC & IRAC (Based on formula specified by MS-14) ➢ Optimum Pre-wetting Water Content (OPWC) – Coating test ➢ Optimum compaction to attain the desired value of porosity followed by Stability Test in Dried State ➢ Optimum Residual Asphalt Content (ORAC) - Stability Test for Soaked State only ➢ Retained Stability (Dry Stability Test), AFT (As per formula) and Ultimate strength (fully cured mix) at ORAC

CONCLUSION

From the above study, the following conclusions are drawn:

- The cold mixes may be primarily used in base courses, wearing courses or binders, etc. These asphalt mixes may be implemented on roads by the numerous methods such as by grader applications, pavers applications, self contained laying plants, etc.
- The aggregates constituted of higher silica content are found to be acidic in nature and has evenly distribution of negative charges on their surfaces. Even, these charges are proved to be responsible for the strong adhesive bonding between the cationic emulsions and aggregates
- The proofing against water dampness, resistance to carbonation attack and resistance to the chloride-ion penetration of modified mortars of asphalt were considerably improved with rise in the value of polymer-cement ratio.
- Among both the study i.e. Manual series No.-14 (MS-14) and Thanaya (2007), the former study is proved to more effective, economic and highly efficient, but it does not include determination of OTLC for the design preparation. As a result, this process is considered to be highly suitable for the field only

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