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Effect of Mix Parameters Performance and Design of Cold Mix

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ABSTRACT

This project describes laboratory experiments and presents results for the performances of cold-mix, cold-lay emulsion mixtures. The main objective of the experiments was to evaluate and improve the properties of the cold mixtures. The mixture properties evaluated were: volumetric properties, indirect tensile stiffness modulus (ITSM), repeated load axial creep and fatigue. These properties were compared with conventional hot asphalt mixtures not containing any waste/recycled materials. To optimize the performances of the mixtures, a target of ITSM value of 2000 MPa was selected. At full curing conditions, the stiffness of the cold mixes was found to be very similar to that of hot mixtures of the same penetration grade base bitumen (100 pen). Test results also show that the addition of 1–2% cement significantly improved the mechanical performance of the mixes and significantly accelerated their strength gain. The fatigue behavior of the cold mixes that incorporated cement was comparable with that of the hot mixtures.

There is an increasing trend for using cold mix design with bitumen emulsion all over the world because of several advantages such as elimination of heating of binder and aggregate while producing mixes, this helps in protection of environment and energy conservation. In the present study, the main objective is to study the behavior and effect of pre compaction curing on grade-2 semi dense bituminous concrete (SDBC-2) mix using bituminous emulsions treated mixtures (BETM) by Modified Marshall Method of mix design. The specimen were prepared with and without filler. Comparison was made in terms of dry and wet Marshall Stability, Marshall Flow, Volumetric properties and Indirect Tensile Strength (ITS) on Modified Marshall specimen prepared by cold mix method for SDBC-2 mix. In the present investigation it was found that for mixes with and without filler the Volumetric properties, dry and wet Marshall Stability, Marshall Flow and ITS. Based on this present study it has been found that mix with cement and hydrated lime as filler each 2% both showed better results compared to mix with no filler. It has been seen that mix with 2% cement as filler showed better results compared to hydrated lime and there was no much difference in the properties for six and eight days cured specimen and hence could be concluded that six days curing period can be taken as optimum.

INTRODUCTION

Until now, cold mixes have been considered inferior to hot asphalt mixtures. There are three main concerns
(a) High air-void content of the compacted mixtures

(b) Weak early life strength (caused mainly by the trapped water)
(c) The long curing times (evaporation of water/volatiles content and setting of the emulsion) required to achieve maximum performance.
About 740 million people of India live in rural area. Rural connectivity is being focused for the growth of economy, agricultural development and employment generation to rural people. India is having about 2.65 million km of road under rural road category out of total road network of 3.3 million km according to a statistic of Indian road network of National Highways Authority of India. Efforts are going on by central government and state government through different program like Pradhan Mantri Gram Sadak Yojana (PMGSY) to improve road access to rural people. Still about 40 percent of village people of the country are not connected by all weather roads. Either bituminous mix or concrete is required to make these earthen roads into all weather roads. Concrete is not economical one as a paving mix compared to bituminous mix for rural road construction works. In India majority of road network is occupied by bituminous pavement only in which Hot Mix Asphalt (HMA) is used predominantly as a paving mix from many decades. However this bituminous mix is associated with some limitations.

These include excessive emission of greenhouse gases (e.g. sulfur dioxide, nitrogen oxides, carbon monoxides and volatile organic compounds) from HMA plant, shut down of hot mix plant during rainy season and the laying of HMA is difficult in hilly areas and rural areas having long

hauling distances, cost of putting up HMA plant is high and comparative budgets of small sections of rural road is very less, etc.As, Indian rural road network is developing continuously, paving mix like cold mix asphalt or Warm Mix Asphalt (WMA) should be tried. This mix is started to lay on pavement to reduce the problems associated with HMA. Warm mix asphalt is a very new technology compared to cold mix asphalt. Cold mix asphalt should be tried in India for construction of rural roads in hilly areas having high rainfall and difficult terrain.

LITERATURE REVIEW

Studies by Chevron Research Company in California concluded that full curing of cold bituminous mixtures on site may occur between 2 and 24 months depending on the weather conditions.1In the UK, the publication of Specification for Reinstatement of Openings in Highways2 by the Highway Authority and Utility Committee (HAUC) in 1992 helped to draw attention to cold mix, cold-lay materials (cold mixes). The report allows the use of permanent cold-lay surfacing materials as an alternative to hot-mix asphalts for reinstatement work on low-volume roads and footways. A principal requirement is that these mixes perform adequately for a guaranteed period of 2 years, which has proved a challenge.1 In general, cold mixes are simple to produce and suitable for low-to-medium traffic conditions, work in remote areas and for small-scale jobs (at numerous locations) such as reinstatement work. However, currently there is no 'universally accepted' mix design method. Furthermore, due to a lack of uniformity in the laboratory procedures for cold-mix curing and evaluation of mechanical properties, in particular at an early age, it is difficult to form reliable correlations between the experimental results reported in the literature by different researchers. The cold-mix samples were produced using a simplified (more practical) method previously proposed by the authors.3,4 This investigation presents an into the volumetric properties and mechanical performance of the cold mixes, the effect of storage time on loose cold mixes, and a realistic evaluation of the rate of strength gain of cold mixes cured outdoors. For this investigation, the target compacted mix air void content was5–10%. This air voids target is consistent with the most recent amendment to the HAUC document, which requires that the air voids after compaction of cold mixes used for carriageways is between 2 and 10%. It also agrees with guidance provided within the MPW-RI specification.5 A target minimum indirect tensile stiffness modulus (ITSM) of 2000 MPa was also arequirement.2, 6The investigation used carboniferous limestone as the coarse aggregate. This is widely available in the UK. A by-product of red porphyry stone crushing was used as the fine aggregate. This red porphyry sand (RPS) is produced during the production of decorative red-colored coarse aggregates that are commonly used for chipping applications. The RPS availability fluctuates depending on the demand for the colored coarse aggregates. Currently RPS is mainly used as fill material and for sub-grade formation. Fly ash was used as a filler material. Traditionally, fly ashes have been used in a range of applications, namely as fill materials, for grouting, and soil stabilization.

Brown and Needham (2000) studied the cement modified emulsion mixture. The main objective of their study was to evaluate the beneficial effect of adding Ordinary Portland Cement (OPC) in emulsified mixes.

Seref Oruc et al. (2006) carried out research on the effect of cement on emulsified asphalt mixture. Portland cement was substituted for mineral filler in an increased percent from 0 to 6 percent in their study. Crushed limestone and cationic slow setting emulsion (CSS-1) were used to prepare cold mix.

Chavez Valencia et al. (2007) used polyvinyl acetate to improve compressive strength of cold mix asphalt. In their study polyvinyl acetate emulsion was added to a quick set emulsified asphalt to obtain a modified asphalt emulsion. The compressive strength was improved in 31% relative to unmodified cold mix asphalt [3].Pundhir et al. (2010) used OPC by 2 percent in cold mix design of semi dense bituminous concrete. Delhi quartzite aggregate and slow set types [SS-2] were used to prepare the mixes. One comparison between SDBC samples containing 2 percent cement vs. neat samples without cement was drawn at different curing condition in this study. The cold mix with 2 percent cement showed higher stability value (966Kgf) at 25˚C than the stability (688Kgf) of cold mix without cement at same temperature.

Benedito et al. (2003) conducted research on engineering properties of fiber reinforced cold asphalt mixes to find the effect on mechanical properties due to addition of fibers as additive to cold densely graded emulsified asphalt mixes. The asphalt mixture was treated with 0.10%, 0.25%, and 0.50% staple polypropylene fibers 10 mm, 20 mm, and 40 mm long. The result of the study has shown that the addition of fibers to cold mixtures reduces the dry density and Marshall stability. The study also concludes that the addition of fibers can also lead to reduction of fiber reinforced mixture resilient moduli

COLD MIX: Traditionally, aggregates and bitumen are heated to a temp of 150C for construction of pavements. It is extremely important to maintain stipulated temperatures

at the time of producing the mix, laying and compaction. Failure to adhere to these temperature requirements could lead to reduced durability for the pavements. There are enormous challenges to maintain these temperature requirements in high rainfall areas as intermittent rain throughout the year affect production and laying of mixes high attitude or snow-bound areas as mix gets solidified quickly winter conditions long transit distance between the hot mix plant and the project site undue delay in laying the mix These challenges lead to wide spread usage of Cold Mix technology.

Cold mix Applications: We work in close collaboration with contractors and owners to develop proven pavement systems that are both safe and offer the best possible long term cost over the life cycle. Our in depth knowledge and experience of the bitumen market enables us to pass on our expertise to contractors, creating durable products We provide sustainable solutions to our infrastructure customers. Our solutions are designed to withstand the demands of high volume inter-city road networks, rural roads, heavy duty pavements and highways. With heavy traffic demands, a pavement solution which is durable and quick to lay – thus reducing maintenance downtime – is essential to keeping the traffic flow moving and keeping the roads open. We recognize that a strong road network is a lifeline to rural communities. We offer fit for purpose solutions that provide value for money. Our effective paving solutions help infra customers build durable pavements in an environmental friendly manner.

A tack coat is a thin bituminous liquid bitumen emulsion applied between HMA pavement lifts to promote bonding. Adequate bonding between construction lifts and especially between the existing road surface and an overlay is critical in order for the completed pavement structure to behave as a single unit and provide adequate strength. If adjacent layers do not bond to one another they essentially behave as multiple independent thin layers – none of which are designed to accommodate the anticipated traffic-imposed bending stresses. Inadequate bonding between layers can result in delamination (debonding) followed by longitudinal wheel path cracking, fatigue cracking, potholes, and other distresses such as rutting that greatly reduce pavement life.

Ideally, chip seals should be applied when a road is still in good condition, with only minor surface problems, such as loss of friction, drying surface or very minor cracking.

They may also be applied as a wearing surface over a prepared base on rural roads. Chip seals are an excellent choice for keeping good pavements in good condition. The Strategic Highway Research Program found chip seals, which are a relative low cost treatment, to be one of the most cost-effective pavement preservation treatments

A cape seal is effectively a combination of two separate treatments, a chip seal and a slurry seal. The chip seal is placed first, followed within a few days or weeks by the

slurry seal. This enhances the binding of the chips with the asphalt and prevents loose aggregate from being dislodged. Cape seals provide a new wearing surface and can address more significant deterioration than either of the treatments individually. They can be an effective treatment for pavements where some distress is present, but a more expensive overlay is not required.

MATERIALS AND METHODS: This chapter deals with the details about various materials used for the present study and their test results. The method of testing of self computing concrete, heating of specimen etc. is also mentioned briefly in this chapter. Detailed methods for testing of MATERIALS all practical's are done in Site laboratory of Ms.Dilip Buildcon Limited at Vijayawada to Machilipatnam road project site. An experimental setup for the determination of shear strength (Mode II fracture) of concrete has been fabricated and its details along with test procedure have been presented in this chapter.

Materials: The common ingredients of concrete are cement, coarse and fine aggregates and water. A fourth ingredient called admixture is used to modify certain specific properties of concrete in fresh and hardened stage. The physical and chemical properties of each ingredient has considerable role in the desirable properties of concrete like durability, strength, and workability.

Fly ash has also been used as a replacement for conventional limestone fillers in hot rolled asphalts.8 As fly ash particles tend to be more spherical in shape when compared with limestone, laboratory investigations have shown that fly ashes can enhance the workability of the bituminous mixtures, which is of great benefit particularly during the compaction process. Based on the laboratory results and as part of a resurfacing program on the A689, UK in April 1991, a full-scale 320m length trial section consisting of several hot-rolled asphalt segments containing pulverized fly ash filler was laid and compacted. Subsequently, the road sections were continuously monitored for any signs of distress over a period of 5 years and all trial sections were shown to perform [as expected] adequately.8 Based on the success of the project, a publication was issued by the energy efficiency office of the Department of the Environment, on Future Practice (R&D profile 52) carrying the title The Use of Pulverized Fuel Ash as a Bituminous Filler. The utilization of fly ash in the UK has remained stable for a number of years (at around 50% of production). The amount of fly ash available in stock, in addition to fresh production is estimated to have remained relatively constant at about 250 000 000 t for a number of years.7 The mixtures also incorporated crushed glass. In the UK, the glass manufacturing sector attempts to operate a closed-loop recycling system; however, it has a limited capacity to accept green and mixed colour glass. As glass collection increases (to meet the 2006 packaging targets of 60%)10 an 'excess' (300 000–400 000 t) of green glass is likely, for which alternative high-value, high-volume markets are required. The incorporation of crushed glass, in particular green/mixed glass into bituminous mixtures is not new. Glasphalt hot mixtures incorporating 30% crushed glass (using a 100 pen. bitumen), laid at a trial site in Milton Keynes by RMC Aggregates Ltd. showed an average ITSM value of 1900 MPa. Meanwhile, in the same trial, the control hot mixture (not containing crushed glass) gave 2200 MPa. The average air-void contents for the Glasphalt and the control mixtures on that trial were 4.9 and 4.7%, respectively.11

SCOPE OF THE PRESENT STUDY

In the present study, the binders used are tested in accordance with the standard testing procedures, i.e. emulsion is tested micron sieve, residue by evaporation, coating and demulsibility and SS-2 bitumen is tested for penetration, ductility, specific gravity and softening point.

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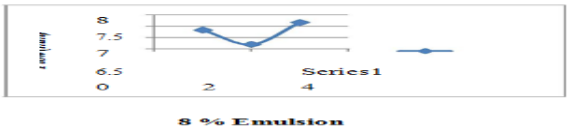
The aggregates are tested for impact value, Los Angeles Abrasion value, combined index, specific gravity, water absorption and crushing value. To prepare the SDBC specimen with and without filler such as cement and hydrated lime each 2% and different percentage of bitumen emulsion at different curing stage of the mix different emulsion contents by conducting dry Marshall Stability, soaked stability and Indirect Tensile strength test.This cold mix design involves optimization of water and bitumen emulsion for aggregates in the mix. The optimum premix water content depends on gradation and physical properties of aggregates. The aggregates are first moistened with water to wet the aggregate surface and then coated with bitumen emulsion. The different sizes of aggregates are blended in different proportions to achieve the gradation of SDBC specification

DESIGN OF COLD MIX: Properties of cold mixes are varied by many parameters like; source of aggregate, curing condition and curing time, etc. Hence there is no universally accepted mix design method for cold mixes. But Marshall Method is popularly used to design emulsified mixes. Marshall Method for emulsified asphalt aggregate design is based on the research conducted at the University of Illinois. This method is applicable to base course mixture for low volume traffic load. Cold mix is used in surface course also for low to medium traffic volume road. The cold mix design is carried out to optimize water and emulsion content for aggregate in the mix. The parameters involved in mix design of cold mix asphalt are;

Aggregates Selection: In India aggregates should conform the physical requirement laid by MoRTH specification (2001). Testing of aggregate like sieve analysis, specific gravity, aggregate impact value and soundness is necessary.

Emulsion Selection: Selection of emulsion depends on aggregate type and aggregate gradation and ability of emulsion to coat the aggregate. According IS 8887:2004 specifications, five grade of emulsion; RS-1, RS-2, MS, SS-1 and SS-2 are used to prepare cold mix. Quality tests should be carried out on the selected emulsion according to IS 8887:2004.



8 % Emulsion

Fig. 4 Flow vs. Emulsion without and with filler

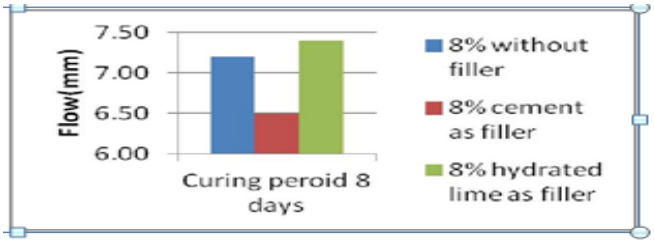


Fig.22 Curing period vs. flow

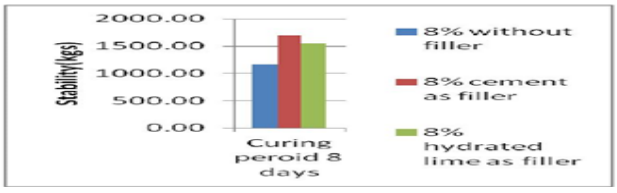


Fig.23. Curing period vs. stability

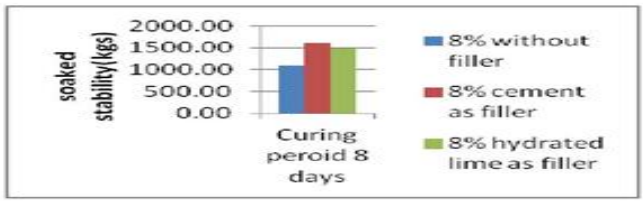
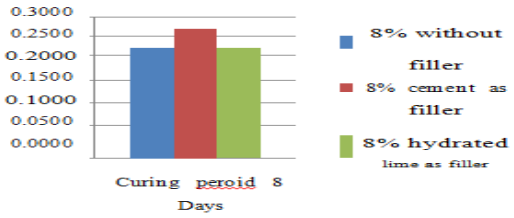


Fig.24 Curing period vs. soaked stability



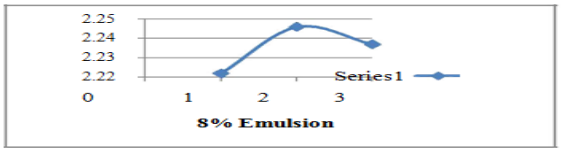


Fig. 1 Bulk density vs. Emulsion without and with filler

CONCLUSIONS

We conclude that, Cold mix can be laid on low to medium volume road as a green paving mix. Mixture can be produced by using conventional plant or by hand. So it can be laid as surface course or bituminous base course for rural road construction. Additive can be used in cold mix to make its properties comparable to the properties of HMA. Curing rate and mechanical properties of cold mix can be improved. Cold mix can be tried for paving mix in north east region of India.

- `The optimum Emulsion content (OEC) is same for three mixes with and without filler such as cement and hydrated lime.
- The bulk density, dry and soaked Marshall Stability, Indirect tensile strength increased with the increase the curing period without and with the addition of 2% cement and hydrated lime as filler.
- Cement as filler provides better results as compared to as filler hydrated lime and without filler.
- Voids in total mix, flow and voids in Mineral aggregates reduced with increase in curing period and with the addition of cement and hydrated lime as filler.
- Six days curing period can be considered as optimum to achieve better properties and results.
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