International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 5, July-August 2021 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

A Result Paper on Experimental Investigation on CMA

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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*

How to cite this paper: Manoj Sheoran | Ms. Shivani "A Result Paper on Experimental Investigation on CMA" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-5, August 2021, pp.1677-1683, URL: www.ijtsrd.com/papers/ijtsrd45179.pdf

IJTSRD45179

1. INTRODUCTION

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. 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 & 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.

2. LITERATURE REVIEW

Borhan Muhamad Nazri, et al. (2009) conducted experimental study to observe the outcome of fly ash on the mechanical properties of bituminous mixtures. It was also evaluated the significant effect of using fly ash in improving performance characteristics and modifying pavement distress. In this study, four types of specimens with various percentage of fly ash fractions were studied. The properties such as permanent deformation, resilient modulus, creep and fatigue were calculated at three different temperatures. Moisture induced damage tests were also carried out to assess moisture induced damage. The pavement performance was predicted by VESYS model. Results indicated that fly ash as mineral filler can be used to increase resilient modulus characteristics and stripping resistance. The addition of fly ash did not reduce field performance of asphalt concrete mix in terms of rut depth and serviceability index but with the increase in temperature the sum of surface cracking is also increased in the pavement.

Asi I., and Assaad A. (2005) conducted Laboratory study on a special type of carbon fiber grid which was placed at different depth in asphalt pavements. The purpose of the study was to obtain the design information about the position of the grid which will give optimum result. Two different types of asphalt pavements were examined (a) asphalt concrete and (b) mastic asphalt. This study reveals that with addition of carbon grid stiffness, failure strain and stress, and resistance against low temperature cracking increased. However, during rutting tests with Model Mobile traffic Load Simulator (MMLS) it was found that the grid was not able to improve resistance against flow value in the mastic asphalt layer.

3. FRAMEWORK AND MATERIAL USED

In this study, two types of cold mixes are considered i.e. Bituminous Concrete (BC) in the form of dense mix and stone mixed asphalt (SMA) in the form of gap graded mix. The materials used and gradation of aggregates is selected as the specifications mentioned in the table . The compaction of both the types of cold mixes is done by gyratory compaction method and Marshall compaction method. As per the MORTH specifications (2001), Manual series No. 14 from Asphalt Institute and guidelines from the concept of Thanaya (2007), the complete procedure of cold mixed based design is done. Both the compaction methods along with the impacts of additives used in various forms like lime, cement or fly ash were observed to produce the effects on the characteristics of cold mixed based designs. There are total 6 gradations of modified aggregates are to be designed for the study for BC and SMA types of cold mixes. All the gradations must be in the range of gradation limits adopted initially. All of these gradations are designed by the combination of lowest and highest values of coarse aggregate ratio and by the combination of lowest, middle and highest values of quantities of filler. The entire framework of this experimental study is briefly elaborated by the use of block diagram in figure.

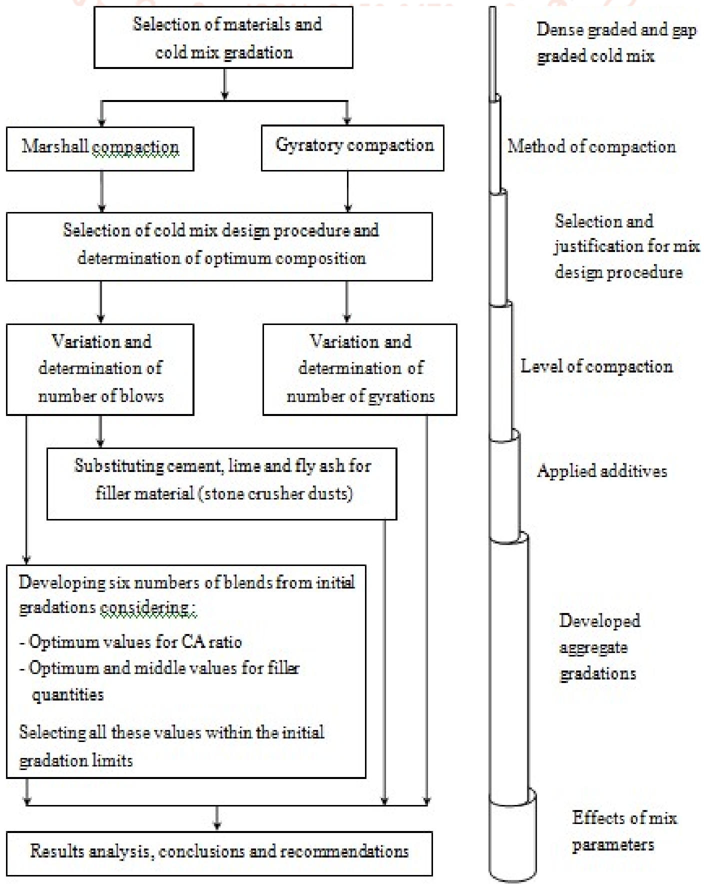


Fig: : Framework of Experiment

4. RESULTS AND DISCUSSIONS

The results obtained for compacted samples to analyse the effect of test parameters are discussed in this chapter. Attempt has been taken to justify the adopted design procedure and ORAC value is found out. The effects of additives, method and level of compaction on the performance of cold mixes have been studied. After constructing a spreadsheet the existing aggregate gradations are improved by using Bailey concept for aggregate packing. The performance of all the developed gradations has been observed and compared with the initial gradations.

DETERMINATION OF ORAC

Samples were compacted by Marshall method after mixing the coarse aggregate, fine aggregate and crusher dust as filler material according to the adopted aggregate gradation given in table 3.2 and table 3.3 to produce dense graded and gap graded cold mix respectively. For both types of cold mix two IRAC values were considered. One value was chosen according to the empirical formula and another value was taken arbitrarily. By using these two IRAC values two sets of mixes were produced for each gradation.

DENSE GRADED COLD MIXES

As per the adopted design procedure given in table Samples were produced by Marshall Compaction. The test results are summarized in table and illustrated in figure .

Table : Optimum Compositions of Dense Graded Cold Mixes

IRAC by Empirical formula	IRAC by arbitrary value
IRAC = 6 %	IRAC = 4 %
IEC = 9.17 %	IEC = 6 %
OPWC = 3 %	OPWC = 4 %
OTLC = 6.17 %	OTLC = 7.07 %
ORAC = 5.6 %	ORAC = 5.6 %
Soaked Stability = 5.88 kN	Soaked Stability = 3.19 kN
Dry Stability = 6.28 kN	Dry Stability = 3.45 kN

It should be noted that both the results of dry stability and soaked stability given were the values obtained at ORAC value.

Determination of OTLC values:

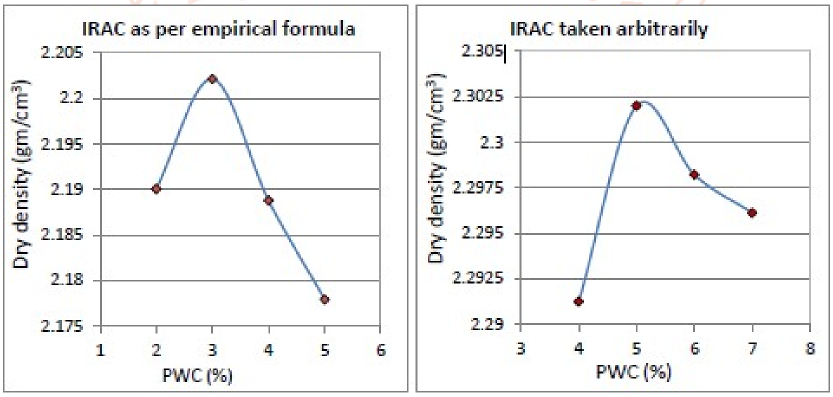


Fig. : Determination of OTLC for Gap Graded Mixes

Determination of ORAC Value:

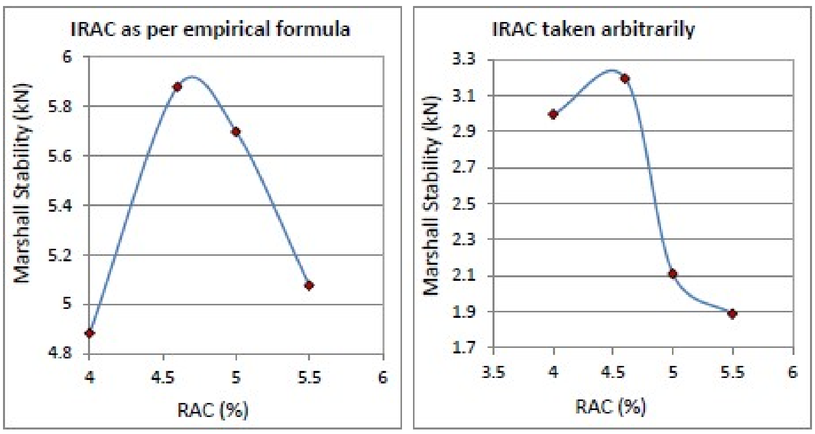


Fig. : Determination of ORAC for Dense Graded Mixes

Considering the results obtained shown in figure it was observed that the maximum stability was achieved at RAC of 5.6 % for both types of dense graded cold mix. But the Marshall Stability was found to be greater for dense graded mix having IRAC as per empirical formula. Hence its OTLC and ORAC values were refferred for further analysis and it was presented as Cold Mix D in further study. The other design parameters for Cold Mix D were checked at ORAC only. The flow value, air void, VMA and stability loss were found to be 3.3 mm, 8.32 %, 15.83 % and 6.35 % respectively and the test results are shown in figure 5.3.

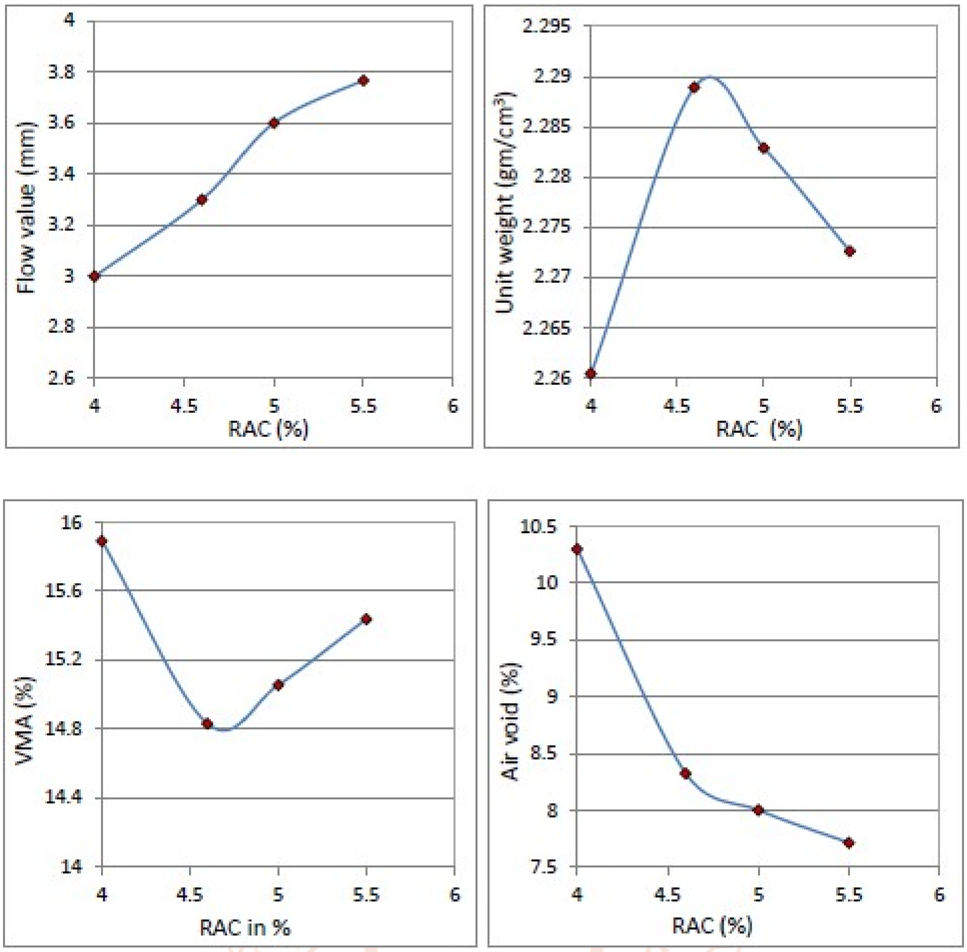


Fig. : Results of Flow Value, Density, Voids in Mineral Aggregates and Air Voids for Dense Graded Bituminous Mix

GAP GRADED COLD DESIGN MIXES

The test results for gap graded cold mixes are summarized in table and illustrated in figure . It should be noted that both the results of dry stability and soaked stability given were the values obtained at ORAC value.

Table Optimum compositions of gap graded cold mixes

IRAC by Empirical formula	IRAC by Arbitrary value
IRAC = 7 %	IRAC = 5.6 %
IEC = 10.7 %	IEC = 6.5 %
OPWC = 3 %	OPWC = 5 %
OTLC = 8.7 %	OTLC = 9.25 %
ORAC = 5.5 %	ORAC = 5.5 %
Soaked Stability = 3.46 kN	Soaked Stability = 3.1 kN
Dry Stability = 3.67 kN	Dry Stability = 3.21 kN

Determination of OTLC Values:

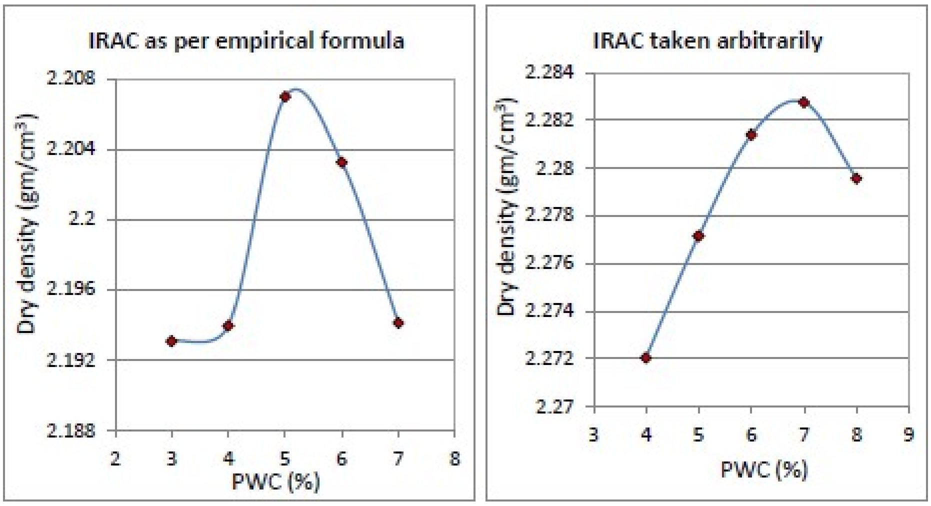


Figure : OTLC Determination for Gap Graded Cold Mixes

Determination of ORAC values:

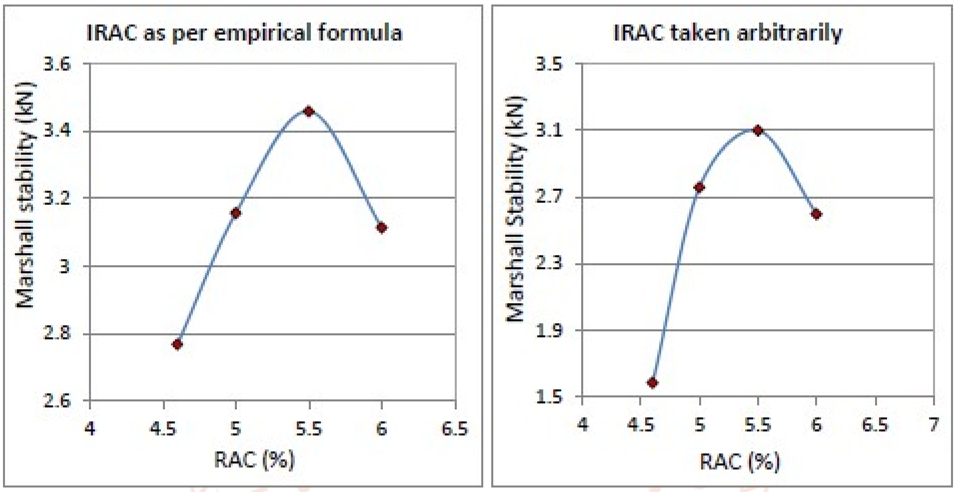
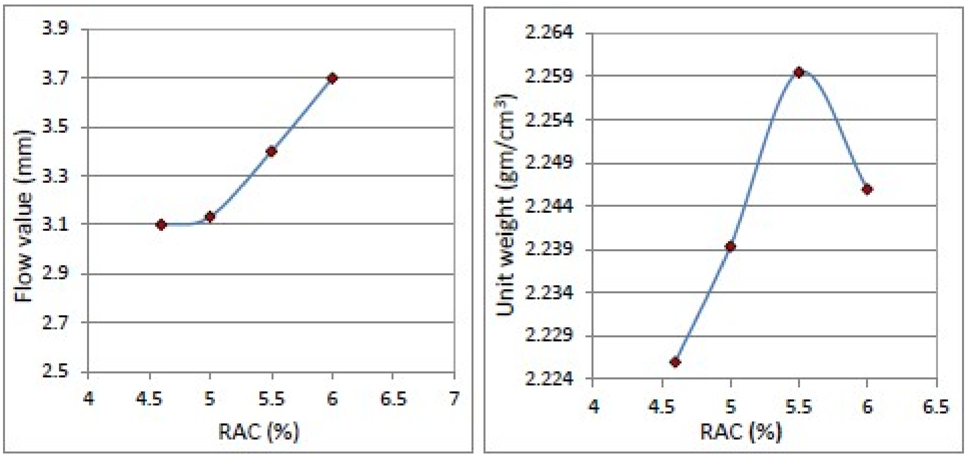


Figure : ORAC Determination for Gap Graded Cold Mixes Considering the results obtained shown in figure , it was

observed that the maximum stability was achieved at RAC of 5.5 % for both types of gap graded cold mix. But the Marshall Stability was found to be greater for gap graded mix having IRAC as per empirical formula. Hence its OTLC and ORAC values were refferred for further analysis and it was presented as Cold Mix G in further study. The other design parameters for Cold Mix G were checked at ORAC only. The flow value, air void, VMA and stability loss were found to be 3.4 mm, 9.22 %, 16.95 % and 5.87 % respectively and the test results are shown in figure.



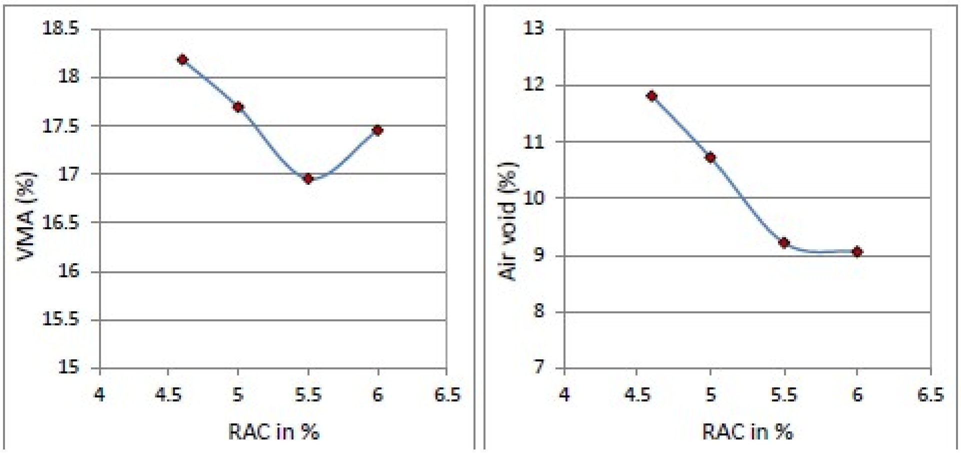


Fig. : Results of Flow Value, Density, Voids in Mineral Aggregates and Air Voids for Gap Graded Bituminous Mix

Based on the above studies and the test results summary from table and table some conclusions were made which were presented below.

- ORAC values are found to be same for cold mixes having same aggregate gradation which indicates that ORAC is not affected by the IRAC and OTLC factors rather it depends on the aggregate gradation.
- Though for the same aggregate gradation ORAC is found same for both mixes produced with IRAC as per empirical formula and IRAC taken arbitrarily, it has been observed that the soaked stability of the mix having IRAC value as per empirical formula is higher. Hence it indicates that the IRAC determined by the empirical formula is more efficient in comparison to IRAC taken arbitrarily.
- It has been felt that initial stability of the mix depends on OTLC values. At same binder content higher the total liquid content, greater would be the curing time to obtain full strength of the mix. So, for laboratory procedures we should determine the OTLC value to avoid delay in work process. This concept has supported the adopted design procedure of the present study.
- While analysing the results for stability values at each ORAC, it has been observed that the dry stability value is greater than the soaked stability value for all types of cold mixes. So, in case the soaked stability has satisfied the minimum stability requirement (2.2 kN), the dry stability would also satisfy the same requirement. Hence it would be more economic to determine ORAC value on basis of soaked stability test only and the dry stability should be found out at ORAC only to check the stability loss. This supports the concept provided by Thanaya (2007).
- It should be noted that all the above conclusions has been made on basis of very limited study. Hence these hypothesis need further analysis for developing more suitable design procedures.

COMPARATIVE STUDY BETWEEN DENSE AND GAP GRADED COLD MIX

It was observed that performance of dense graded mix (Cold Mix D) was superior than gap graded mix (Cold Mix G) in every aspect except in case of the stability loss value which was lesser for Cold Mix G.

Table : Design parameters of Cold Mixes at 50 Blows of Compaction

Design parameters	Dense graded mix (Cold Mix D)	Gap graded mix (Cold Mix G)	Design requirement
Marshall Stability	5.88 kN	3.46 kN	Min. 2.2 kN
Flow value	3.3 mm	3.4 mm	Min. 2 mm
Stability loss	6.36 %	5.87 %	Max. 50 %
Emulsion content	7% (5.6% ORAC)	8.4% (5.5% ORAC)	7 - 10 %
Air void	8.32 %	9.22 %	3 - 5 %
VMA	15.83 %	16.95 %	Cold Mix D: Min. 14 % Cold Mix G: Min. 15 %

5. CONCLUSION

From the above study following conclusions are drawn based on performance of the cold mix.

- From the limited study it is observed that initial stability of the mix is dependent on optimum total liquid content (OTLC) of the compacted mix. At same binder content higher the total liquid content, greater is the curing time to obtain full strength of the mix. Although achieving OTLC is difficult for field application, it may be applied for laboratory procedures to avoid delay in work process. This concept has supported the adopted design procedure of the present study.
- Increment in the compaction level is found not to be much effective in decreasing the air voids in cold mixes rather it increased the stability loss value in the gap graded mix (SMA) which may be resulted due to the destruction of stone-to-stone contact skeleton at higher compaction level. Besides, higher is the compaction level, greater may be the difficulty in field applications.
- Increase in number of gyrations has resulted in the increased stability and reduced air void content of compacted cold mixes. 40 numbers of gyration has been found to be suitable as at higher level of compaction bleeding phenomenon of binder occurred which may affect the durability of the mix.
- Among the additives, though the stability value has been found to be improved by fly ash, lime and cement, performance of cement modified mix is observed to be superior in every aspect. Comparing lime and fly ash as substituted for filler, greater stability but higher air void content is noticed in case of cold mixes modified with lime.
- The Bailey method for gradation selection has been found to be effective for improving the stability of both dense and gap graded cold mixes even without addition of cement.
- In between dense and gap graded cold mixes, though the dense graded mixes has resulted in higher stability value, it has showed lesser indirect tensile strength and higher deformation in comparison to gap graded mix.
- Considering all the selected mix parameters it is noticed that only in case of gyratory compaction the adequate air void range (3 to 5 %) in cold mixes has been achieved. Besides, though each and every parameter has contributed to increase the Marshall Stability of cold mixes, cement and developed gradations has shown more significant effect to increase the stability of cold mixes.

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