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EXTENDED ABSTRACT

Evaluation of Durability Properties of Cement Stabilized Base Mixtures Contains Different Amounts of RAP during Wet and Dry Cycles

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1. Introduction

Recently, the focus in the construction and improvement of pavements has been on using recycled materials to make them more sustainable. The use of recycled asphalt pavement (RAP) has gained interest among agencies and policy makers as a way to recycle waste materials and reuse valuable aggregate coating with bitumen. However, there are limited studies on the issue of durability and its impact on the mixing design and optimal amount of RAP. This study aims to investigate different durability criteria for cement-stabilized mixtures containing RAP and determine the optimal amount of RAP and cement to ensure durability.

2. Methodology

2.1. Experimental study

To investigate the durability of CTB mixture comparison strength 7, 28 days is considered. In addition, an indirect tensile strength in dry and wet conditions is performed. The TSR is calculated as the proportion of ITS wet by dry. Other durability criteria in wet and dry cycles test method such as percentage of weight loss of stabilized samples, percentage of volume changes of the sample in wet and dry conditions, and percentage of changes in compressive strength after 12 wet and drying cycles.

3. Results and discussion

The compressive strength of cement-stabilized base mixtures is an important characteristic, and as shown in Fig. 1, increasing the percentage of recycled asphalt pavement (RAP) in the mixture decreases the unconfined compressive strength, while increasing the percentage of cement increases it (Yuan D et.al., 2010, Ghanizadeh et. al., 2018, Suddeepong et. al., 2018). However, the minimum tensile strength ratio (TSR) of 70% for asphalt mixtures may not work for cement-stabilized mixtures containing RAPs, and large amounts of cement may be required to meet durability requirements. None of the mixtures containing RAPs meet the TSR criterion of 80, except for two mixing schemes (R0C5 and R0C7), which cannot be accepted based on the criterion of maximum compressive strength. To control cracking, other solutions such as using a stress-absorbing material interlayer

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(SAMI) or adding fibers to the mixture can be examined. If we accept a TSR durability index of 50%, all mixtures perform well, but this finding may not be completely accurate compared to previous studies.

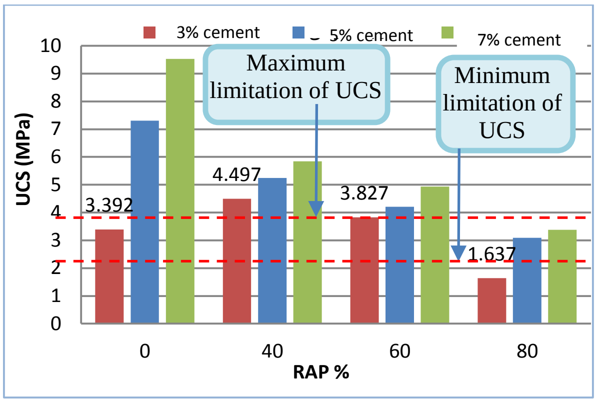

Fig. 1. Seven days UCS results-versus RAP%

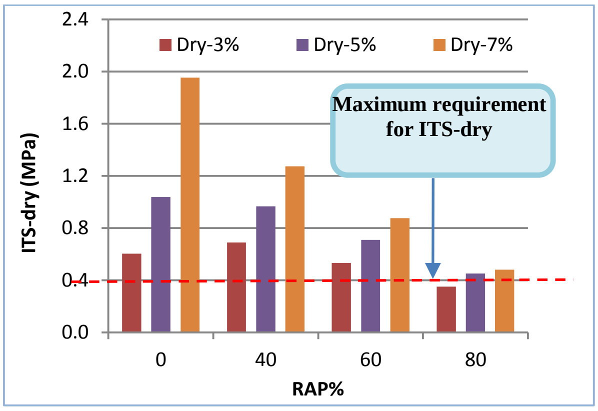

Fig. 2. Indirect tensile strength of stabilized mixtures versus RAP% to investigation of maximum ITS-dry=400 (2.8) PSI as a durability criterion

Previous studies have recommended limiting the ITS value of stabilized mixtures to 400 KPa (Xiao et. al., 2018). Fig. 2 shows that only the R80C3 mixture meets this condition, while the rest of the mixtures deviate from it. The presence of the bitumen phase in stabilized cement mixtures containing RAPs increases the mixture's tensile strength, which can lead to a shift from brittle to flexible behavior. Moreover, the rest of the mixtures have practically deviated from this value. Another important issue that can be mentioned in this section is the relationship between compressive strength and indirect tensile strength. The relationship between indirect tensile strength and compressive strength for ordinary concrete is defined as (T=0.55Fc ^ .5), (Newman et. al., 2003). According to Fig. 3, it can be seen that at a certain amount of compressive strength, in the stabilized sample containing RAPs, more tensile strength is observed than the sample without RAPs. This means that the presence of the bitumen phase in stabilized cement mixtures containing RAPs increases the tensile strength of the mixture. In other words, although the compressive strength of the mixture has been reduced its indirect tensile strength has been increased, it can be concluded that the behavior of the mixture has shifted from brittle to flexible. Also, if we consider the maximum allowable compressive strength of 3.5MPa, which is defined to prevent excessive brittleness of the cement-stabilized layer (Tang et. al., 2012). If the maximum allowable compressive strength is converted to ITS based on the relationship shown in Fig. 3, it is consistent with the values suggested by previous authorities. The addition of RAPs and increased adhesion of bitumen to cement in concrete media increases the tensile strength and reduces the cracking potential. As shown in Fig. 5, based on a modified ITS of 780 KPa for mixtures containing RAPs, some mixing schemes are accepted, including R80C3 to R80C7, R60C3 to R60C5, and R40C3.

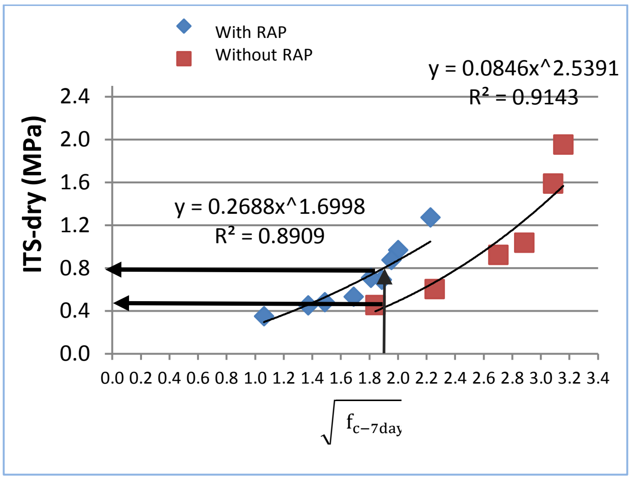

Fig. 3. The relation between compression strength ($f_{c-7day}^{0.5}$) and indirect tensile strength

As shown in Fig. 4, the cumulative weight loss of various cement-stabilized mixtures containing RAPs in 12 wet and dry cycles shows that with increasing RAPs and increasing cement, the weight loss decreases significantly. This experiment proves that increasing the RAPs to the cement-stabilized base mixture increases the adhesion of the materials to each other and reduces the wear potential of the particles to be brushed. perhaps the philosophy of this test method should be changed for mixtures containing RAPs, because brushing is done just after removing the sample from the oven at a temperature of 50 degree after 48 hours, which causes the aggregate bitumen soften and fill the cracks and the particles stick together (healing action), so brushing in these conditions may not seem logical and it is necessary to apply modifications in the standard process for such mixtures. However, by comparing the maximum weight loss with the allowable values of the regulations (12%), this criterion is not restrictive for the designs made in this research.

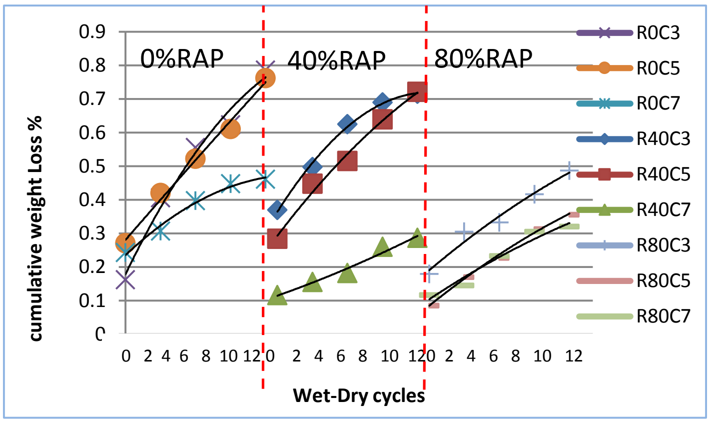

Fig. 4. Cumulative weight Loss versus wet-dry cycles

The following diagram, Fig. 5, is the volumetric changes of the sample in wet and drying experiments. It should be noted that the sample enters the water bath and saturation experienced increasing the volume, and on the other hand, the drying of the sample in the oven and the loss of water will reduce the sample volume, which was observed in each cycle. Fig. 5 shows the average positive volume change (expansion) and negative volume (contraction) in 12 consecutive cycles as a standard for each mixing design. This means that in the R80C30, the shrinkage of the sample after drying in the oven is greater than the amount of expansion of the sample in water, which ultimately shows the average volume changes in a wet cycle and drying of 9%.

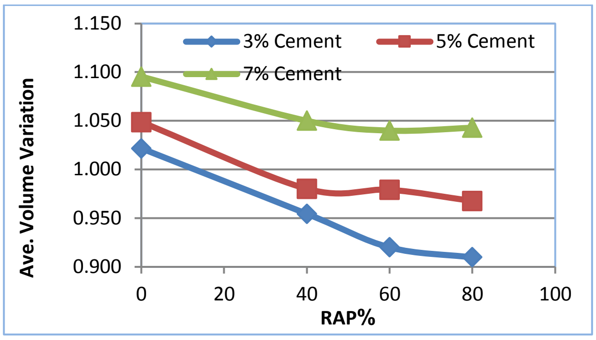

Fig. 5. Average of volume variation versus rap percent

Fig. 6 shows that samples subjected to 12 wet and dry cycles have lower compressive strength compared to samples processed under standard curing conditions for 28 days. This is likely due to the defects caused by successive wetting and drying and changing cyclic volumes in the stabilizing mixture. Samples without RAPs and with 80% RAPs have lower compressive strength compared to samples with 40% and 60% RAPs for mixing designs with 5% and 7% cement, which is different from samples with 3% cement and their different compressive strength.

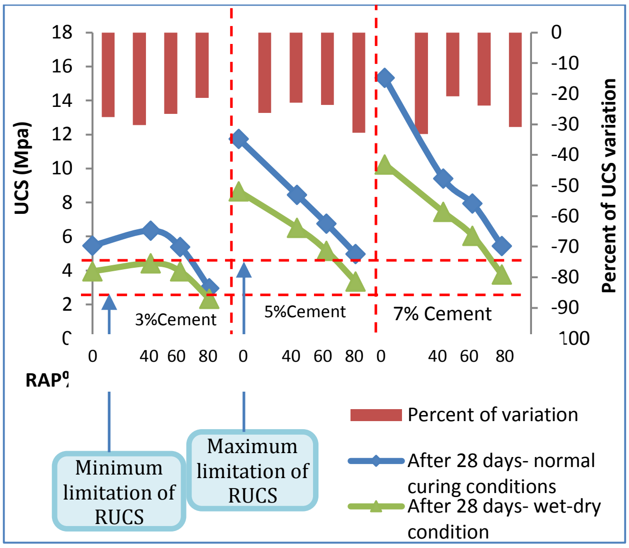

Fig. 6. Comparison of compressive strength in terms of percentage of RAPs- in normal 28- day samples curing and after 28- day under durability wet and drying condition

4. Conclusions

The purpose of this paper was to obtain the percentage of optimal RAP in cement-stabilized base mixtures according to durability criteria and to evaluate different durability tests and compare different criteria. Accordingly, the most important results of this research are as follows:

According to the results, it was found that the criterion of maximum compressive strength issue by various authorities as an indicator to control the occurrence of cracks in the cement-stabilized base layer and further reduce the potential for reflecting cracks in the asphalt surface layer, between 300 and 500PSI (2.1 to 3.5MPa) should be reviewed for base mixtures stabilized with cement containing RAPs.

The presence of RAPs in the cement- stabilized mixture changes the behavior of the mixture from brittle to flexible. In this regard, new limits can be defined between the maximum modified compressive strength of 5.75MPa and the minimum of 3.5MPa for cement-stabilized base mixtures containing RAPs.

It was observed that adding amounts of RAPs between 40 to 60% to the cement-stabilized base mixture can change the behavior of the mixture from brittle to flexible, and by increasing the adhesion resistance of bitumen in RAPs to the adhesion resistance of cement, The cracking potential of this type of mix is improved compared to the base mix stabilized with cement without RAPs.

It is suggested that a new criterion be selected in the selection of the minimum TSR for the examination of base mixtures stabilized with cement containing RAPs (between 50 and 70%) to estimate the durability of such mixtures. In this regard, the author is suggested more research.

According to the wet and dry test results, it seems that modifications should be made to the method of this test for stabilized mixtures containing RAPs. Further research is needed in this area.

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