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Performances of hydrated cement treated crushed rock base for Western Australian roads

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Abstract: The resilient modulus (RM) of hydrated cement treated crushed rock base (HCTCRB) affected by amount of hydration periods, compaction and dryback processes was presented using repeated load triaxial tests. The related trends of RM corresponding to the different hydration periods still cannot be concluded. Instead, It is found that the moisture content plays more major influence on the RM performance. Higher additional water during compaction of HCTCRB, even at its optimum moisture content and induced higher dry density, led to the inferior RM performance compared to the sample without water addition. The RM of damper samples can be improved through dryback process and superior to that of the sample without water addition at the same moisture content. However, the samples without water addition during compaction deliver the comparable RM values even its dry density is lower than the other two types. These results indicate the significant influence of moisture content to the performances of HCTCRB with regardless of the dry density. Finally, the experimental results of HCTCRB and parent material are evaluated with the K-θ model and the model recommended by Austroads. These two models provide the excellent fit of the tested results with high degree of determination.

Key words: base course; hydrated cement treated crushed rock base; cement modified material; repeated load triaxial test; resilient modulus; pavement

1 Introduction

The flexible pavements in Western Australia (WA) have a surface of approximately 30 mm in thickness. Thus, traffic loads on the road surface result in high stress levels on underlying layer. Crushed rock base (CRB) was the traditional base course material used in WA. CRB is an unbound granular material that has the insufficient capability to resist the increasing traffic loads and volumes. Moreover, CRB is susceptible to moisture which accelerates pavement deterioration. High quality aggregates are therefore required for the base course layer. These requirements led to the improvement of base course material in WA.

Cement is usually used to improve the engineering properties of the unbound granular materials such as

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crushed rock, aggregates and soils. Cement treated base (CTB) is a mixture of the original base course material, cement and water used for pavement structure. Cement content for CTB varies from 3% to 8% by mass of the aggregate which depends on the required strength (Garber et al. 2011). CTB mixture can be placed and compacted in the field immediately after mixing and hauling to the site. The strength of the base course is greatly improved using CTB. For example, a typical modulus of crushed rock base can be developed from 500 MPa to 5000 MPa by blending it with 4%-5% cement to construct CTB (Austroads 2010).

The cement stabilisation technique has been employed in WA by blending small amounts of cement with standard CRB. However, it is believed that even 1% of cement can lead the base course material too stiff and prone to fatigue cracking. Thus, the approach to prevent the bound characteristics of the base course layer was investigated. The investigation outcome was unique base course material used in WA called hydrated cement treated crushed rock base (HCTCRB) (Butkus 2004; Harris and Lockwood 2009; Rehman 2012). HCTCRB is made by mixing 2% of general purpose Portland cement with standard CRB at the optimum amount of water obtained by main roads Western Australia (MRWA) test method (MRWA 2007). Unlike the common CTB, the mix is stored and cured to have the specific hydration period. And then it is retreated by putting the hydrated mix to the mixer to break bonds generated during the hydration reaction. Finally, HCTCRB is transported and constructed in the field. The retreated process makes HCTCRB different from the conventional CTB. HCTCRB is expected to provide higher strength and lower moisture sensitivity than CRB while prevent the base layer becoming too stiff.

Over the years, HCTCRB has been commonly used as a base course material in WA, with a relatively high modulus value, about 800-1000 MPa, in particular for heavy traffic pavements. HCTCRB was developed during the empirical design period and has not yet been characterised following the pavement mechanistic approach. Therefore, uncertainties during manufacturing and construction procedures are still taking place. This uncertainty has contributed to the early damage of some new highways and roads. Some of highways and roads in WA are exhibiting extensive surface damage as a result of increasing traffic volume. However, explanations for the damage occurring under present conditions are difficult to determine and assess. Accordingly, an understanding of the material characteristics, in accordance with the pavement mechanistic approach, is strongly advised to maximise its use.

This paper aims to present the resilient modulus (RM) of HCTCRB affected by amount of hydration periods, compaction processes and dryback using the repeated load triaxial tests. The study is designed to further standardise HCTCRB's manufacture and construction, and overcome doubts regarding its use.

Some basic properties of base course materials used in WA were previously explored by Jitsangiam et al. (2013). Particle size distributions of CRB and HCTCRB at different hydration periods were examined at before and after compaction. The particle size distributions of CRB at before and after compaction conformed to the MRWA specification (MRWA 2008). It was found that hydration periods insignificantly differentiate the HCTCRB gradation characteristics. The gradation of HCTCRB for all hydration periods which varied from 3 to 45 days failed to meet the specification either before or after compaction. The fine contents (smaller than 4.75 mm) of HCTCRB samples before compaction were below the lower limit of the specification. After compaction, HCTCRB grains were broken resulting in smaller grain size. The gradation curves shifted up, and the fine contents were closer to the lower limit while the coarse grain lines lay just above the upper limit. The shear strength parameters of CRB and HCTCRB were investigated using scanning electron microscopy and static triaxial test. Observation of the scanning electron microscope pictures of CRB and HCTCRB conformed well to the static triaxial tests which revealed that CRB showed higher internal friction angles but less cohesion than HCTCRB. From static triaxial tests, the cohesion and angle of internal friction parameters of CRB were 38 kPa and 59°, for HCTCRB these two parameters were 169 kPa and 46°, respectively.