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Investigating Resilient Modulus Interdependence to Moisture for Reclaimed Asphalt Pavement Aggregates

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Abstract

A variety of factors affect the overall performance of the material within pavement structure, with moisture content susceptibility being recognized as one of the most important factors that is known to directly affect the resilient modulus of granular base layer materials and consequently the overall performance of pavement structures. While the effect has been widely investigated for virgin aggregate, more limited research has been undertaken to quantify the effect of various moisture conditions on base layer materials containing reclaimed asphalt pavement (RAP) material. The present study aims to examine the effect of moisture on the resilient modulus of base layer materials containing RAP and a direct comparison to a virgin aggregate is presented, in order to identify potential variations in performance. Specifically more in depth information is provided regarding the sensitivity of RAP to variations in moisture conditions. Resilient modulus determination was performed, via laboratory triaxial testing on materials with varying RAP percentages and moisture contents and compared to the behavior of a course grained virgin aggregate material under similar conditions. For the current research the investigated RAP material exhibited modulus values that are equivalent or exceed those of a virgin aggregate utilized for base material at OMC and below. More details outlining the variations in modulus under various loading conditions are presented.

Keywords: RAP, resilient modulus, moisture content

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1 Background and Objectives

As virgin aggregate becomes increasingly difficult to source and more costly to implement, alternative base layer materials are becoming increasingly more attractive to investigate and implement as a base layer material for pavement structures. The suitability of these materials needs to be investigated before being accepted to be utilized as a replacement to virgin aggregates in the base layer of pavement structures. In order to be accepted the material needs to be investigated and their performance characterized. Reclaimed Asphalt Pavement (RAP) is the material that has been milled, removed, potentially reprocessed and consists of the remaining asphalt and aggregates from a pavement previously in service. RAP consists of high quality, well graded aggregates coated with asphalt, when properly screened and crushed (FHWA, 1997). Ageing road infrastructure in need to be repaired, rehabilitated or fully replaced means that RAP material is becoming increasingly more available., This fact in combination with existing virgin aggregate becoming more difficult to source and more costly to implement, alternative pavement layer materials are becoming increasingly more attractive to investigate. The use of RAP conserves energy, lowers transportation costs required to obtain quality virgin aggregate, and overall preserves valuable resources (Copeland, 2011). These factors lead to both economic and environmental benefits which are vital aspects in today's construction environment.

The material though widely accepted to be utilized in asphalt concrete layers of the pavement structure where according to Copeland (2011) it is most commonly used as an aggregate and virgin asphalt binder substitute in recycled asphalt paving. Though widely implemented in the asphalt concrete layer(s) according to Bennert et al (2000) despite the current recycling efforts, RAP stockpiles in areas continue to grow in size, and as a consequence, additional uses for the excess material need to be considered. One additionally usage is that RAP can also be potentially be more widely utilized in the granular base layer. The material is currently implemented by a limited number of road authorities, with wide discrepancies concerning it's potentially viability as a base layer s material equivalent to virgin aggregate material in regards to its mechanical characteristics.

In Bennert et al (2000) it was noted that 100% RAP specimens have higher stiffness, higher resilient modulus values, and lower shear strengths than dense-graded aggregate base course specimens. On the other hand McGarrah (2007) after preliminarily examining practices regarding RAP in unbound base applications concluded that 100% RAP does not produce a product of adequate base course quality and should not be allowed. Various other research studies have settled on mixing virgin aggregate with RAP as a compromise to reach desired mechanical properties (Attia and Abdelrahman, 2010; Kim et al., 2007; Guthrie et al., 2007; Kim et al., 2007b). Both the allowed percentage of RAP allowed in base layers, as well as more basic knowledge related to its suitability for usage in base layers are not currently well defined and researched. Research for example is limited and knowledge is still being developed regarding the strength behavior and characteristics of RAP materials in regards, to traditionally utilized virgin aggregates for the base course. Though various testing methods are available to test the strength characteristics of base course materials, including the traditional CBR method, the resilient modulus testing method is rapidly gaining acceptance, due to the increased information it can provide regarding the behavior (Uzan, 1985) of the material in a more representative set of conditions when compared to more traditional methods. The property is utilized for example in the Mechanistic-Empirical Pavement Design Guide (MEPDG) (NCHRP, 2004).

The resilient modulus (Mr) is multi-faceted property that can more fully define the structural capacity of unbound base layer materials for pavement design and analysis purposes. It is a commonly conducted laboratory procedure to characterize the stiffness and elasticity responses of the base layer material (Huang, 1993). Two of the factors affecting the Mr include the state of stress and the moisture content of the material. Current research data exists concerning these factors on more commonly utilized virgin aggregates, while a more limited set of research is available to understand the effect of