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Experimental procedure for evaluation of coarse aggregate polishing resistance

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ABSTRACT

This paper presents the development of experimental methods for measuring aggregate textural retention, which is a very important property that influences pavement skid resistance. The 2nd version Aggregate Image Measurement System (AIMS-II) is used to measure coarse aggregate surface texture before and after different polishing time intervals in a modified Micro-Deval (MD) test procedure. The use of AIMS-II to compare aggregate surface texture and the evolution of aggregate polishing curves was verified and determined to be successful because AIMS-II texture measurement closely reflected historical data on aggregate frictional properties obtained by Illinois Department of Transportation (IDOT). Analytical functions, considering aggregate surface texture at different polishing times, were then used to describe the initial texture, rate of polishing, and terminal texture. Statistical analysis was used to determine that the required polishing time to achieve terminal texture in the modified MD is 210 min.

Introduction

Asphalt pavement performance is highly affected by its aggregate properties such as: strength, durability, and shape characteristics. Pavements skid resistance (Fwa et al., 2003; Masad et al., 2009; Kowalski et al., 2007; Rezaei et al., 2009), and permanent deformations (Schapery, 1978; Pan et al., 2006) are two of the most important performance parameters that are highly influenced by aggregate properties, and mix design. Skid resistance is a very important component of traffic safety (FHWA, 1980). There are two specific properties that determine the quality of asphalt pavement surface skid resistance: macrotexture and microtexture. Pavement macrotexture is primarily influenced by size, shape, and gradation of coarse aggregates; the nominal maximum aggregate size (NMAS); and construction techniques (Forster, 1981), while microtexture is primarily related to aggregate particle surface texture. Initial surface texture of aggregates and its ability to retain texture against polishing action of traffic and environmental factors are important parameters that influence the asphalt pavement skid resistance throughout its lifetime (Jayawickrama et al., 1996).

Several models have been developed to predict the change of skid resistance of asphalt pavement with time (Kowalski et al., 2007; Stephens and Goetz, 1960; Dahir et al., 1976; Henry and Liu, 1978). The main objective of such models is to define the proper time at which an asphalt pavement should be rehabilitated or even reconstructed to maintain minimum required skid resistance levels (Rezaei et al., 2011). Aggregate polishing characteristics are an essential input for those models. Several methods have been developed to simulate aggregate polishing; one of the most widely used is the British

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wheel/pendulum method (ASTM E303 ASTM E303-93, 1998 and ASTM D3319 (ASTM D33319-11, 1999). However, it was showed by Won and Fu (Won and Fu, 1996) that British pendulum results depend on many other factors besides aggregate texture. Crouch and Dunn (Crouch and Dunn, 2005) developed an indirect method to measure aggregate resistance to polishing called Micro-Deval voids at 9 h (MD9 h), in this method aggregates are polished for 9 h by using the Micro-Deval (MD) test. Then, the polished aggregates' uncompacted voids are measured, where fewer voids represent smoother aggregates.

Mahmoud and Masad (2007) used the MD test (Tex-461-A Tex-461-A, 2005) combined with the Aggregate Image Measurement System (AIMS-I Masad et al., 2005) to develop methods to evaluate aggregate resistance to polishing, abrasion, and breakage. Coarse aggregates from six different sources were tested, and analytical methods were presented to describe aggregate polishing at different polishing intervals in the MD. It was found that MD coupled with AIMS can be used to effectively characterize aggregate polishing, abrasion, and breakage. This conclusion was also obtained by Hossain et al. Hossain et al., 2007 arguing that MD can accurately distinguish between well and poor performing aggregates.

Xue et al. (2010) tested aggregates from ten different locations in Virginia using the MD test to assess their polishing characteristics. A digital camera and a Matlab code based on a unified Fourier method (Wang et al., 2005) were used to analyze the aggregate morphological characteristics. They concluded that the MD produces change in aggregate morphology but it is not significant for aggregates with strong granular structure, especially if surface texture is measured. Based on this result and other findings (Rezaei et al., 2009) indicating that not all aggregate can be polished in the MD, Lane et al. (2011) proposed modifying the MD test by adding an abrasive grit to induce more abrasion and polishing. The findings indicated that the modified MD procedure introduces changes in texture rather than angularity, except for those materials that are highly abrasion susceptible.

Table 1
Type of aggregate tested.

Sample	Type of aggregate	Geology
S1	Limestone	Pennsylvanian/Bond/Millersville
S2	Limestone	Mississippian/Salem
S3	Limestone	Ordovician/Galena
S4	Dolomite (reef formation)	Silurian/Racine
S5	Dolomite	Silurian/Racine/Joliet
S6	Crushed Gravel	Henry Formation, Wisconsin in Glacial Till
S7	Chert Gravel	Maramec River Gravel, 99% Chert
S8	Steel Slag	Steel Slag
S9	Air-Cooled Blast Furnace Steel Slag	Air-Cooled Blast Furnace Slag
S10	Quartzite	Lower Proterozoic Quartzite (Baraboo Formation)
S11	Diabase – Sandstone	Mississippian/Rosiclare Sandstone

Objective and research tasks

The main objective of this study is to develop an experimental procedure for measuring coarse aggregate polishing resistance characteristics utilizing a modified MD procedure and second version of Aggregate Image Measurement System (AIMS-II). The procedure developed in this study builds on and enhances a previously developed procedure (Mahmoud and Masad, 2007). To achieve this objective the following tasks were performed:

(1) Aggregate selection: eleven aggregate sources were selected in coordination with Illinois Department of Transportation (IDOT) personnel, as listed in Table 1.
(2) MD procedure modification: a 750 g single size (passing 1/2 in. sieve and retained on 3/8 in. sieve) aggregate MD procedure was adopted for this study. This represents a different aggregate gradation and sample weight from the original procedure.

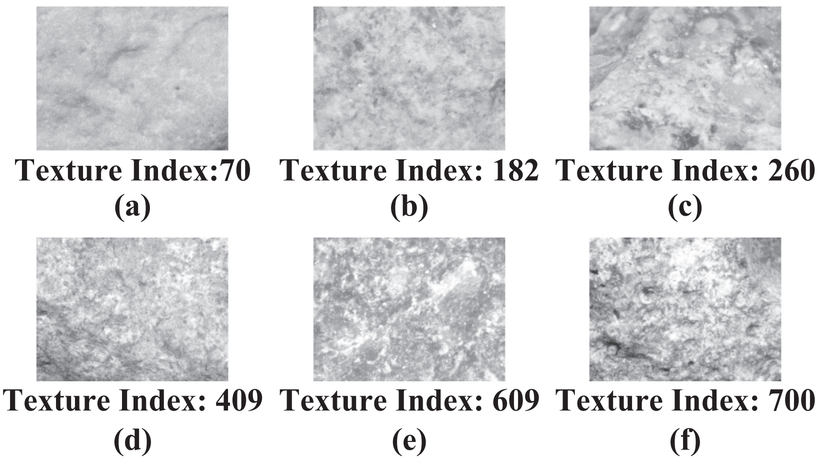

Fig. 1. AIMS-II aggregate surface texture gray-scale images: (a) Source 5, (b) Source 3, (c) Source 1, (d) Source 8, (e) Source 10, and (f) Source 9.