Environmental Factors Affecting Subgrade Heaving and its Prevention using Modified Fly Ash

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ABSTRACT

Natural expansive soils and chemically treated sulfate soils undergo large volume changes due to moisture fluctuations resulting in distress to the built pavement structures. Annual repair costs relating to pavement cracking in USA is considered to be millions of dollars. Thus, understanding the fundamental heaving phenomenon are two folds: 1) reducing expansive soil distress, and 2) enhancing recycled waste material applications. The objectives of the study are to: 1) understand the physical and chemical parameters affecting heaving, 2) study the influence of alkalinity and humic acid, a good Al chelator/binder in organic soils, on ettringite formation, and 3) apply modified fly ash to prevent heaving. To better understand the ettringite formation, laboratory syntheses were conducted using two Ca sources, e.g., $CaCl_2$ and CaO. Single-phased ettringite was formed in $CaCl_2$ system; however, in the case of CaO system this mineral was formed only in absence of CO_2. In the presence of humic acid, both ettringite and $CaCO_3$ was formed irrespective of the Ca source. The presence of alkalinity prevented ettringite formation and favored $CaCO_3$ formation. This study suggests that in addition to high sulfate and reactive alumina, pH, and alkalinity play a significant role in heaving. The term 'Reactive Al' refers to Al dissolved from poorly-crystalline and amorphous minerals, and humic acid. Thus, reactive Al, alkalinity and SO_4^{2-} which are quantifiable may help predict heaving. Lastly, the compaction of subgrade retards heaving phenomenon by blocking the pores access of ettringite forming candidate ions, e.g. calcium (Ca), aluminum (Al), sulfates (SO_4^{2-}), and H_2O.

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