CONCRETE MIXTURES THAT INCORPORATE INCLUSIONS TO REDUCE THE SOUND GENERATED IN PORTLAND CEMENT CONCRETE PAVEMENTS

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16. Abstract:

Tire-pavement interaction noise is one of the significant environmental problem in highly populated urban areas situated near busy highways. Traditionally, this problem was reduced through the use of sound barriers; but this method has limitations. The understanding that methodologies to reduce the sound at the source itself is necessary, has led to the development of modified cement concrete materials. This report outlines the systematic research effort conducted in order to develop and characterize two different cement based materials incorporating inclusions. Morphologically altered cellulose fibers were used in the first part of this study as inclusion materials in a plain cement mortar matrix. Flexible polypropylene fibers were used as inclusions in a porous concrete (gap-graded aggregate concrete) matrix in the second part.

The influence of morphologically altered cellulose fibers on the acoustic and mechanical properties of cellulose-cement composites is explained in the first part. Three fiber morphologies were considered (macro nodules, discrete fibers, and petite nodules). The main parameters studied include the normal incident acoustic absorption coefficient (α), specific damping capacity (χ), loss tangent ($\tan\delta$), storage modulus (E'), and loss modulus ($E'' = E' \tan\delta$). The acoustic absorption coefficient was found to increase with an increase in fiber volume for all three fiber types investigated, though "macro nodule" fibers were found to be the most effective. Stiffness-Loss relationships are reported for these composites and the behavior of cellulose-cement composites with soft cellulose fiber inclusions was found to be similar to a Voigt (series) composite model. Low volumes of fibers had a minimal effect on the loss tangent; however the stiffness was considerably reduced. Predictive equations for loss modulus as a function of fiber volume at different moisture conditions were developed. These relations compare well with the experimental values as well as the idealized Voigt composite behavior. This suggests that there is an optimum fiber volume, which maximizes the loss modulus for saturated composites while the loss modulus is practically independent of fiber volume for dry composites.

The influence of polypropylene fibers on the pore features and performance of Enhanced Porosity Concrete (EPC) is detailed in the second part of this report. It was found that the addition of fiber reinforcement does not significantly influence the porosity of the system, but the acoustic absorption is improved. The improvement in acoustic absorption due to the addition of fiber reinforcement is most prominent in mixtures with larger pore sizes. To identify mechanisms that are responsible for the improved behavior, electrical impedance measurements were used. The pore connectivity factor developed from impedance studies was found to be directly related to the acoustic absorption, and the addition of fibers significantly altered this factor. This serves as a helpful method to characterize the efficiency of fibers in acoustic absorption of porous concrete mixtures.

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