ABSTRACT

Montoya Rodríguez, Miguel A. M.S.C.E., Purdue University, December 2016. Quantifying Asphalt Emulsion-Based Chip Seal Curing Times Using Electrical Resistance Measurements. Major Professor: Prof. John Haddock.

Chip seals are among the most cost-effective surface treatments available for asphalt pavement preventive maintenance. Chip sealing typically consists of covering a pavement surface with asphalt emulsion into which aggregate chips are embedded. The asphalt emulsion cures through the evaporation of water, which helps to provide mechanical strength for the chip seal. Ultimately, the curing process enables the emulsion to adhere to the pavement while keeping the aggregate chips in place. The curing time for the chip seal depends on many factors, such as the asphalt emulsion and aggregate types, aggregate moisture content, emulsion and aggregate application rates, and environmental conditions (e.g., temperature, wind speed, relative humidity, and solar radiation).

Currently, no field technique is available that can quantify when sufficient mechanical strength has developed in the binder to allow traffic on a newly sealed roadway or to remove the surplus aggregate from a fresh chip seal. Such decisions are made by empirical factors that rely on the experience of field personnel. Consequently, frequent problems associated with the lack of early mechanical strength development of asphalt emulsion, which can result in premature surface treatment failure, have led to the need to improve the characterization of the chip seal curing process.

As such, this study investigated the use of an electrical resistance measurement to develop a sound construction methodology to prevent common failures that occur soon after construction. First, full frequency, two-point, uniaxial electrical impedance spectroscopy was used to characterize the electrical properties of asphalt emulsions and various asphalt emulsion-aggregate combinations. The laboratory test results suggest a relationship between the changes in the electrical resistance of an asphalt emulsion and the amount of curing that has occurred in a chip seal system.

In addition, standardized mechanical strength tests and full-scale field trials were conducted using a variety of materials. The electrical properties of the fresh seal coats were quantified by employing a handheld electrical device with a two-point probe to measure resistance. The findings suggest that chip seal systems gain significant mechanical strength when the initial electrical resistance measurement increases by a factor of 10. Finally, implementation of the methodology at five full-scale chip seal systems in Indiana indicates that curing times for the chip seal projects range within 3.5 and 4.0 hours.

Electrical resistance measurements can provide a rapid, nondestructive, low-cost indication of the amount of curing that has occurred in a chip seal. The application of this methodology will result in more accurate, robust, and timely decisions with regard to when a chip seal has gained sufficient mechanical strength to allow brooming or opening to unrestricted traffic without undue loss of cover aggregate. Furthermore, implementing this construction technique could positively impact chip seal construction quality as well as extend the service life of the chip seal. Lastly, the findings of this study can be extended to a variety of asphalt emulsion applications.