

RES2013-18

The research project which is the subject of this Final Report grew out of two, two-year projects which were directed toward evaluating the quality of concrete being placed on Tennessee bridge decks in terms of the ability of the concrete to resist the penetration of chloride ions. This resistance was measured by the conventional method known as the Rapid Chloride Ion Penetration Test (RCP Test) and the newer Surface Resistivity Test (SR Test). Near the end of that testing, the deck of the SR 56 Bridge over the Caney Fork River, the Hurricane Bridge, in Dekalb County was being replaced with lightweight concrete. Coincidentally, a lightweight concrete replacement deck for the I-40 Bridge over the French Broad River in East Tennessee was about to get started. Both of these decks were slated to be cast with a ternary blend concrete with cementitious material consisting of cement, ground granulated blast furnace slag, and fly ash. As a motivating factor to achieve a concrete with high resistance to the penetration of chloride ions, a target value of SR was set such that a measured SR of that value or greater would result in a bonus. The major focus of the research performed on the project described in this Final Report was directed toward learning more about the effective use of a ternary blend mix for lightweight concrete, including the identification of an SR value that could be reasonably chosen as a lower limit expectation for bridge deck concrete.

Very few things on this project went smoothly. Unforeseen and for a long time undetected problems with the moist room in the new Civil Engineering Building led at once to some confusion and disappointing results and to some potentially important information in terms of measurement and specification of SR values as a construction acceptance criterion. The details of the research are presented in this Final Report; the practical results of the research are briefly summarized in the following paragraphs.

(1) There is nothing inherent in the make-up of lightweight concrete to suggest that the use of it in either replacement decks or newly built decks is in any way inappropriate. Based on available literature, the choice of expanded slate as the lightweight coarse aggregate, rather than expanded shale or expanded clay is a sound one. However, as noted in the following paragraphs, there are some special considerations that affect the use of lightweight concrete and which have some influence on any chosen acceptance criteria for lightweight concrete (LWC).

(2) Based both on research reported in available literature and experience on this project, one can argue that proper aggregate saturation is the primary quality control concern for LWC. The positive effect of internal curing only occurs with properly saturated aggregate. Poorly saturated aggregate leads to difficulty in pumping; the pressure in the pumping process forces water into the partially open voids in the aggregate, thus reducing the amount of water available to enhance the lubricating effect of the cementitious paste.

(3) One motivating objective of this project was to identify a reasonable minimum SR value to specify for mix designs to achieve an adequate resistance to chloride ion penetration. Work to accomplish this objective evolved into a study of the effects a number of variables have on Surface

Resistivity, the results of which are reported herein. However, the surprising discovery of the large effect that cement brand had on the test results, coupled with the differences between lab and field mixes, made the specification of a lower bound SR value essentially impossible. A lower bound of 18 would not be unreasonable for Buzzi mixes; based on the tests performed on this project, that lower bound would be almost unreachable for Cemex mixes.

(4) Shrinkage of properly saturated lightweight concrete is not appreciably different from that of normal weight concrete. At 28-days the shrinkage of lightweight concrete may actually be a bit lower than that of comparable normal weight concrete; however, the final shrinkage would be expected to be somewhat larger than that of normal weight. The effects of some variables on shrinkage are shown in the report in the graphs of shrinkage vs. time.

(5) The inspection of five bridge decks indicated only minor cracking but raised potential concerns because of one difference between lightweight and normal weight aggregates. Lightweight aggregate tends to float closer to the top than normal weight, a phenomenon which is particularly exacerbated by improper aggregate saturation. Although contactors have reported that it is often cheaper to get a deck finished and later grind it smooth rather than meet profile requirements, the grinding exposes the lightweight aggregate near the surface which is then ground smooth. This aggregate exposure is a potential issue for porous aggregate as the pore connectivity potentially allows some chloride ion penetration into the deck. Whether or not this is a problem is unknown.