

Performance Evaluation of Grout Materials for Connecting Precast Concrete Bridge Deck Panels
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The use of precast concrete panels to replace deteriorated concrete bridge decks allows fast and all-weather constructions, thus minimizing the traffic delay. Typically, the panels are prefabricated with the high quality concrete in a well-controlled environment. They would perform well under both traffic and environmental loadings. However, when the panel joints are not connected well, a poor composite action of the deck can be anticipated. Typically, cementitious grouts or epoxy mortars are used to fill the joints. While cementitious grouts are easier to mix and more compatible with the precast concrete panels; they are more susceptible to shrinkage. Also, voids or gaps may form as a result of poor flowability, entrapped air pockets, or excessive bleeding. This would lead to the deficient bonding and reduced protection to the steel reinforcement particularly when the longitudinal post-tensioning is not provided. In contrast, epoxy mortars have extremely low permeability and dry shrinkage as well as good adhesion to the concrete panels; but they are very sensitive to moisture variations and thermally incompatible to the substrate concrete. In addition, very limited information is available regarding how various grout materials would perform under abnormal weather conditions. As a result, evaluation of various commercial grout products is essential to establish a database that allows the bridge engineers to choose a more suitable grout material for a specific application. It is the intention of this project to evaluate the performance of different grouting materials and to provide TDOT professionals with realistic guidelines as to what materials allow for easy and fast construction while delivering a desirable overall system performance. Another objective of this project is to modify the existing products or to develop materials and proportions using local materials with the goal of achieving alternative materials that are more practical, durable, and cost-effective in light of local environmental effects.

Overall, 25 prepackaged grout products from 16 different manufacturers nationwide have been collected in this project, in which 22 materials were cementitious grouts and 3 were epoxy-based mortars. The project started with the evaluation of basic properties of these materials at the room temperature (approximately 73°F) with various substrate moisture conditions (dry, SSD, or wet). Later, materials that performed well at the room temperature were chosen for medium (85°F) and high temperature (95°F) testing. It was observed that out of 22 cementitious products when mixed, placed, and cured at the room temperature at the recommended water content, 14 of them showed medium to high flowability, 2 exhibited low flowability, and 6 were dry with almost no slump during mixing and placement. Most products showed adequate setting (only 4 have either quick or very slow setting), good compressive strength development (only 2 have low early-age strength), and medium to high flexural and/or slant shear bonding (only 3 showed very low flexural bonding capacity). Obviously, materials with low flowability, abnormal setting, low compressive strength, or very low bonding capacity were not preferred in this project.

The moisture condition of substrate was noted to have a mixed effect on the bonding capacity of grout materials. Under the flexural loading, 55% of materials demonstrated better bonding to the SSD substrate; while 35% of materials showed the highest bonding capacity when the substrate was dry and only 10% of materials displayed an improved bond to the wet substrate. For the slant shear test, approximately 42.8% of grout materials exhibited a higher bonding strength when the substrate was wet; whereas 28.6% of materials had better bonding to the dry substrate, and nearly 28.6% of materials displayed an enhanced bond to a SSD substrate. As a contrast, 3 epoxy products were typically hard to mix and place. Although they demonstrated high compressive strength development; the relatively low bonding capacity (both the flexural and the slant shear) observed in this study indicated that they were less desirable for the application of connecting the precast bridge deck panels.

It was found that overall, 15 cementitious grout products performed relatively well at the room temperature. They were then selected for medium (85°F) and high (95°F) temperature testing. Most products became less flowable, set faster, and gained the compressive strength more rapidly when mixed and cured at the medium or high temperature. However, both the flexural and the slant shear bond capacities were found to reduce substantially. This may be attributed to the decrease in flowability as well as the rapid setting when the temperature increased, which may lead to incomplete grout filling at the joint or the poor contact with the substrate.

The majority of 15 grout products showed high to very high dry shrinkage, but most of them had low to moderate rapid chloride ion permeability and excellent resistance to freezing and thawing with essentially no internal deterioration through 300 cycles although surface scaling sometimes severe scaling occurred. Only 1 product (CTS Rapid Set CEMENT ALL) performed rather poorly in freezing and thawing. Visual examination showed that severe longitudinal cracking took place at approximately 300 cycles. This poor performance may be associated with its high permeability and the lack of air-entrainment.

New grout materials (conventional mortar and high performance mortar) using type III cement or CTS special cement, local sand (coarse river sand and fine masonry sand), and different chemical admixtures (accelerator and superplasticizer) were developed in this study. In addition, ultra-high performance concrete (UHPC) using type III cement, silica fume, local sand (coarse river sand, sieved river sand, and fine masonry sand), quartz flour, accelerator and superplasticizer was investigated in this study. Also, conventional concrete mixtures were introduced in this study, which was used as a baseline for comparing how the normal concrete differed from the mortar mixes. It was found that most of these mixtures had good flowability, normal setting, rapid compressive strength development, good bonding capacity. However, the dry shrinkage of these mixtures was relatively high except the conventional concrete and CTS cement-based mortars, which exhibited low dry shrinkage. These mixtures also showed a wide variety of rapid chloride permeability and freeze and thaw durability. The normal mortars typically had excessive rapid chloride permeability; however, their freeze and thaw durability was high. Conversely, the high performance mortars showed low to moderate rapid chloride permeability, but their freeze and thaw durability was low. Surprisingly, the normal concrete demonstrated both low to moderate rapid chloride permeability and high freeze and thaw durability. The UHPC exhibited high rapid chloride permeability, but high freeze and thaw durability. The high rapid chloride permeability of UHPC may be due to the effect of steel fibers in the specimens. The CTS special cement-based mortars showed high rapid chloride permeability and low freeze and thaw durability.

The project is near completion and the draft final report will be submitted to TDOT for review by November 2016.

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