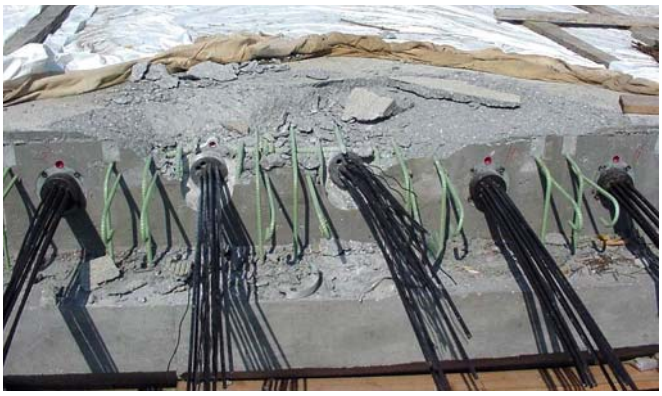
I. RESEARCH PROJECT TITLE

Alleviating Concrete Placement Issues due to Congestion of Reinforcement in Post-Tensioned Haunch Slab Bridges – Phase I

II. RESEARCH PROBLEM STATEMENT

The placement and consolidation of a consistently-good quality concrete in KDOT bridge decks has become increasingly difficult due to the congestion of reinforcement at pier and other locations. This issue has been exacerbated in recent years due to the employment of Post-Tensioned Haunch Slab (PTHS) Bridges, in which the reinforcement detailing required to resist bursting forces at post-tensioning anchorages has made placement and proper consolidation of concrete a nightmare for contractors. This has resulted in severe cases of honeycombing and other problems in the field (see figure below of failure in PTHS bridge due to poor concrete consolidation).



The development of Self-Consolidating Concrete (SCC) mixes in recent years has solved many of the concrete placement issues in the field, by enabling the concrete to flow through heavily-congested areas and consolidate without the need for external vibration. These mixes typically have slump-flows in the range of 24-28 inches, and are essentially self-leveling. However, these mixes cannot be use on bridge decks or other surfaces where "crowns" or sloping surfaces are required, because they are too fluid to hold these shapes.

Several precast concrete producers in the United States have recently developed "hybrid" concrete mixes which have slump-flows in the range of 17-20 inches. These mixes have the ability to pass through heavily congested areas with minimal vibration, yet still allow for mildly-sloping surfaces to be placed on the concrete. They also have the potential to help solve some critical issues of cast in place reinforced concrete in Kansas, especially in congested areas. As part of the PCI SCC Strand Bond Study, Dr. Peterman has had direct experience with the use of some of these hybrid concrete mixes.

One way to remedy the current problem with PTHS bridges is to develop a compatible hybrid mix to be used in the lower portions of the abutment and the anchorage area of the bridge deck, where congestion due to reinforcement is most prominent and prohibits good consolidation. Then, during the casting of the deck the mix can be transitioned, by adjustment of the admixture dosage, to a typical 4-5 inch slump near the top surface in order to hold the proper "crown" or slope. At the transition point, some vibration will be required in order to consolidate the lower slump concrete. Since the lower concrete will be a hybrid mix and not a true SCC, it will be able to accommodate this vibration without

segregation. While this approach holds promise to remedy congestion issues in PTHS bridges and other structures, it cannot be confidently employed without a systematic evaluation of the properties and methods necessary to ensure successful use in the field. Thus, the proposed work will include the following two phases.

Phase 1 – Development of compatible hybrid mixes (with 17-20 inch spreads) for use in KDOT bridge decks and other field-placed structural concrete elements.
Phase 2 – Instrumentation and monitoring of a PTHS Bridge utilizing a hybrid concrete mix. Monitor placement conditions, hydration temperatures, prestress forces/losses, and deflections.

III. RESEARCH PROGRAM

This proposal is for funds to cover Phase 1 – Development and verification of hybrid self-consolidating mixes for KDOT bridge applications. The following tasks are envisioned as part of this research program.

1. Develop hybrid concrete mixes using KDOT approved aggregate and cement sources.
2. Determine the amount of vibration required to properly consolidate these mixes without inducing segregation, and to blend these mixes with the 4-5" slump concrete.
3. Determine potential durability of these mixes, in terms of rapid chloride ion permeability, freeze thaw resistance, ASR resistance.
4. Determine the strength, modulus, and coefficient of thermal expansion of these mixes. Note, previous work with SCC has shown that there may be a considerable reduction in modulus when SCC is employed. In order for the proposed method to be successful, the modulus and thermal expansion of both the top and bottom layers needs to be essentially the same.
5. Determine the effect of time vs. slump/spread loss of these mixes.
6. Determine the ability of these mixes to adequately bond with mild reinforcing steel.

IV. AMOUNT OF FUNDING AND RESEARCH PERIOD

Phase 1 will be completed in 24 months with a budget of 78,000.

V. URGENCY AND PAYOFF POTENTIAL

Implementation of hybrid concrete mixes (spreads between 17 and 20 inches) along with conventional 4-5" slump concretes will ensure proper consolidation in critical bridge applications such as the anchorage points in PTHS bridges. This will eliminate the need for costly repairs and re-engineering of sections having improper consolidation and/or or honeycombs. The cost of this project will easily be recouped by the prevention of poor consolidation as demonstrated by the failure in Figure 1.

VI. IMPLEMENTATION STRATEGY

Following the successful field implementation of this approach in a test bridge that will be placed at the end of this study (and monitored in phase 2), this approach will be available for use in all PTHS bridges and other structures with heavily congested reinforcement. Special Provisions will be developed by KDOT in conjunction with KSU and the admixture suppliers.

VII. PROJECT PERSONNEL

The Principal Investigator from Kansas State University will be Dr. Robert Peterman, P.E. In addition, qualified graduate and undergraduate students will assist Dr. Peterman in the completion of this project.

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