PROJECT DESCRIPTION FOR
PROPOSED REGIONAL POOLED FUND STUDY

I. Research Project Title: Minimizing Cracking in Bridge Decks Supported by Precast Prestressed Concrete Girders

II. Research Project Statement:

Studies of cracking in bridge decks have focused on steel girder bridges under the assumption that cracking in decks supported by steel girders will be worse than in decks supported by precast prestressed concrete girders. Over the past two years, a study for the Kansas Department of Transportation (KsDOT) of a small population of bridges with decks containing innovative concrete mixes (eight with prestressed concrete girders and four with steel girders) indicates that not only will decks supported on prestressed concrete girders crack less than those supported by steel girders, but that the use of precast prestressed concrete girders offers a substantial advantage in limiting cracking over the use of steel girders – with reductions on the order of 80 percent for a variety on concrete mixtures. These observations contrast with work on the ongoing Pooled-Fund Study on the Construction of Crack-Free Bridge Decks, which includes three decks (two designed as low-cracking and one serving as control) supported by precast prestressed concrete girders, that indicates that these decks have no advantage over decks on steel girder bridges and, in fact, may under some circumstances exhibit more cracking than decks on steel girder bridges. Interestingly, the crack patterns in the two studies differ, with the prestressed girder bridges in the innovative deck study exhibiting low amounts of well-distributed cracking in the decks and the prestressed girder bridges in the pooled-fund study exhibiting a majority of deck cracks in the positive moment regions and virtually no cracks over the piers. This suggests that there may be two factors involved – both related to prestressing. In one case, the prestressing force, combined with creep, leads to continued shortening of the girders and, in turn, the decks. This places the deck in compression, limiting the effects of shrinkage and thus limiting crack formation. In a way, this is a form of post-tensioning of the deck. In the other case, the combined effects of the age of the girders when placed, the magnitude and eccentricity of the prestress force, and the overall design resulted in camber of the girders, which can place the decks in tension as the camber of the girders continues to grow. This latter point is supported by the observation that after several years, cracking in positive-moment regions of decks in the pooled-fund bridges has begun to decrease. Because of the high potential to take advantage of the "post-tensioning" effect of the shortening girders to reduce cracking, it is economically beneficial to gain an improved understanding of cracking in bridge decks supported by precast prestressed concrete girders – an understanding that will be highly useful in improving the durability of bridge decks across the U.S.

III. Research Objectives:

The objectives of the proposed five-year study are to survey reinforced concrete decks on precast prestressed concrete girder bridges to obtain an accurate evaluation of deck performance, compare their performance with the performance observed for similar steel girder bridges, and use the results to develop design procedures to minimize cracking in bridge decks supported by precast prestressed concrete girders. The following tasks will be used to achieve the project objectives.

1. Sort structures in Kansas by age and type and obtain parallel recommendations from partner states with assistance from KsDOT and the Precast/Prestressed Concrete Institute.
2. Select 80 precast prestressed girder bridges and 40 steel bridges for evaluation – 40 in Kansas supported by precast prestressed girders to be matched with the existing inventory of over 150 surveyed steel girder bridges in Kansas and 80 in partner states, half supported by precast prestressed girders and half supported by steel girders to calibrate the results to account for differences in state design and construction specifications. Additional bridges will be added in partner states if funding above that required for the proposed scope is obtained.
3. Evaluate the status of the bridge decks using current bridge deck management data.
4. Use field books, construction diaries, and other construction data to determine actual placement procedures and conditions, including construction specifications and special provisions, placing schedule, any construction problems involved with the structure, and the details and sequence of prestressed girder casting, delivery, and installation.
5. Perform onsite field surveys of the 120 bridges to determine crack densities.
6. Evaluate the data to determine consistent relationships or patterns of occurrence to estimate the level of protection provided to reinforcing steel by the deck construction method.
7. Compare the performance observed for decks supported by precast prestressed girders with the performance of decks supported by steel girders.
8. Develop a best-practices approach to design and construction to minimize deck cracking on precast prestressed concrete girder bridges.
9. Present workshops on study findings in partner states and assist partner state DOTs in implementing the best-practices approach.

10. Develop a project report, including conclusions on the degree of performance, the effects of construction variables, with special emphasis on the sequence of prestressed girder casting, delivery, and installation, and the relative durability of decks cast on precast prestressed girder bridges compared to decks on steel girder bridges. The report will include the best-practices approach to design and construction to minimize deck cracking. The study will be closely coordinated with KsDOT and partner state DOT design and research engineers at all stages of planning, execution, and data evaluation and will be performed in concert with the on-going Pooled-Fund Study on the Construction of Crack-Free Bridge Decks (including bridge deck surveys).

The key products of the proposed study will be a direct comparison between the crack densities of bridge decks cast on precast prestressed concrete girders with those cast on steel girders, an improved understanding of the combined effects of prestressing and camber on the formation of cracks in decks, and a best-practices approach for design and construction. The results will allow state departments of transportation to implement design and construction practices to minimize cracking in decks on prestressed concrete girder bridges.

A technical committee, structured with one representative from each state providing funds, will oversee the project and meet on an annual basis.

IV. Benefits:

Bridge decks represent a significant investment and a major liability in terms of long-term maintenance requirements. Conflicting observations indicate that decks on girders supported by precast prestressed girders may have significant advantages over decks supported by steel girders but that those advantages may depend on details of design and construction to ensure that increasing camber after concrete placement will not cause cracking in the positive moment regions of the decks. The proposed study will leverage the work on the long-term Pooled-Fund Study on the Construction of Crack-Free Bridge Decks, which emphasizes steel girder bridges, to broaden the current level of understanding to increase the design life of decks for a greater range of bridges and produce design and construction procedures that will minimize cracking in bridge decks supported by precast prestressed concrete girders.

V. Budget and Schedule:

Estimated budget: $750,000 (includes travel costs for state representatives).

Estimated duration: 5 years (start 9/1/15, end 8/31/20).

VI. Project Personnel:

The project will be directed by David Darwin, Ph.D., P.E., Deane E. Ackers Distinguished Professor of Civil Engineering and Chair of the Department of Civil. Environmental & Architectural Engineering and Matthew O'Reilly, Ph.D., P.E., Assistant Professor of Civil Engineering at the University of Kansas. Darwin has extensive experience in concrete materials, the causes and control of cracking in concrete decks, and bridge deck evaluation. He has directed three bridge deck evaluation studies for KsDOT. He is an active researcher in both reinforced concrete and steel-concrete composite structures, and is past chairman of American Concrete Institute Committees 224, Cracking, and 408, Bond and Development of Reinforcement, and the American Society of Civil Engineers Committee on Composite Construction. He is a Life Member of the Precast/Prestressed Concrete Institute. O'Reilly is an expert on concrete materials and the durability of concrete structures.

Professors Darwin and O'Reilly will be assisted in this study by student researchers in the School of Engineering at the University of Kansas who have the appropriate training in reinforced concrete and composite structures.

Contact: David Darwin, Ph.D., P.E. (daved@ku.edu) or Matthew O'Reilly, Ph.D., P.E. (oreilly3@ku.edu) Univ. of Kansas, Dept. of Civil, Environ. & Arch. Engrg., 2150 Learned Hall, Lawrence, KS 66045-7609, 785/864-3827, fax: 785/864-5631