FY 07/08 Research Initial Scope of Work

I. Project Title: **S055**

High Performance Fiber Reinforced Concrete for Bridge Structures

II. Background:

High early strength cement based materials are currently used for patching and surface repair of deteriorating concrete elements. A typical method to provide immediate rehabilitation to a severely cracked concrete surface is to overlay it with a high strength material that will provide a smooth, crack free cover for the existing material below. For the case of concrete pavements and bridge decks and approach slabs, it is desired to obtain a crack resistant rapid curing high strength concrete. A high early strength material needs to provide: i) a solution to the compatibility problem associated with improperly bonded overlays, and ii) needs to exhibit crack resistance in order to improve the durability of the structure. High Performance Fiber Reinforced Concrete (HyFRC) is an excellent candidate as a structural material due to its early stage stability, high flexure strength at short curing times, and high crack resistance.

III. Project Problem Statement:

The problem statement addresses the need for controlling and minimizing crack formation in materials for bridge decks. The majority of California DOT applications have stringent requirements on allowable curing times for cement based materials that forces the use of early set and high early strength materials and mix designs. This is an acceptable solution for the short term; however, the high cement contents typically associated with early strength mix designs may result in elements that are susceptible to dimensional stability problems (i.e. increased shrinkage and resulting tensile strains with a reduced potential for stress relaxation) and hence cracking followed by durability problems in bridge decks. Hybrid fiber reinforced composites on the other hand are very crack resistant and have the potential to develop high early flexural strength at short curing times. Furthermore, their workability allows for cast-in-place applications. Therefore, can HyFRC be used for bridge rehabilitation to increase durability and crack resistance?

IV. Objective:

This research explores the implementation of an early strength cement based HyFRC for the durable repair of existing structures (i.e. replacement of bridge decks) or use in new structures. In this project Caltrans seeks to address workability and high early strength for possible employment of HyFRC as viable production/construction material. HyFRC as possible high performance repair and strengthening material will be tested for its high early strength characteristics (compressive and flexure tests), crack resistance and bond characteristics to existing concrete, and for its workability for large scale production of cast-in-place applications. Large scale tests of bridge deck slabs shall be conducted.

FY 07/08 Research Initial Scope of Work

V. Description of Work and Expected Deliverables:

Phase I: Development of HyFRC mix design for high early strength and high workability for cast in place applications.
Phase II: Laboratory scale testing (compressive, flexure and bond tests) of HyFRC.
Phase III: Full scale testing of HyFRC as a bridge deck slab.

Expected deliverables: HyFRC mix design

VI. Estimate of Duration:

24 months

VII. Related Research:

- Ezeldin, A. and Lowe, S., "Mechanical Properties of Steel Fiber Reinforced Rapid-Set Materials," **ACI Materials Journal**, v. 88, no. 4, 1991, pp. 384 – 389. Demonstrated that incorporation of a relatively low amount of steel fibers in to a rapid set material can significantly improve the flexural toughness at 24 hours.
- Ding, Y. and Kusterle, W., "Comparitive Study of Steel Fibre-Reinforced Concrete and Steel Mesh-Reinforced Concretes at Early Ages in Panel Tests," **Cement and Concrete Research**, v. 29, 1999, pp. 1827 – 1834. Demonstrated the improved performance of steel fiber reinforced concrete with respect to punching shear in test panels at early ages (curing time was less than 1 day).
- Naaman, A. and Hammoud, H., "Fatigue Characteristics of High Performance Fiber-Reinforced Concrete," **Cement and Concrete Composites**, v. 20, 1998, 353-363. Demonstrated that steel fiber reinforced high early strength concrete (f'_c = 5 ksi (35 MPa) @ 24 hours) can sustain cyclic fatigue stresses more than twice those of a comparable plain concrete specimen.
- Naaman et al, "Influence of Different Fibers on Plastic Shrinkage Cracking of Concrete," **ACI Materials Journal**, v. 102, no. 1, 2005, pp. 49-58. Demonstrated that the incorporation of a relatively low fiber volume fraction (V_f = 0.4%) of polyvinyl alcohol (PVA) micro-fibers, can virtually eliminate plastic shrinkage cracking.

VIII. Deployment Potential:

This study will provide guidelines for Maintenance to deploy the early strength, hybrid fiber reinforced composite mix design developed by this project.

IX. Date: July 18, 2007