Doctoral Thesis

FATIGUE BEHAVIOR OF HIGH-STRENGTH CONCRETE UNDER MARINE CONDITIONS

(submerged under reversible loading)

by

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November 1987

DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

Fatigue Behavior of High-Strength Concrete Under Marine Conditions

By

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DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF ENGINEERING

in the

GRADUATE DIVISION

OF THE

UNIVERSITY OF CALIFORNIA, BERKELEY

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ABSTRACT

In this study, 24 high-strength reinforced concrete beams were tested in fatigue under simulated marine conditions. Low-cycle, high-magnitude loading was imposed on beams, some of which were exposed to air, and others which were submerged in water. The beams were cycled at 1 Hz, to 80% of their 'yield' capacity in negative and positive flexure.

Four concrete mixes were compared. Half of the specimens were made with lightweight aggregate (LWA), and half were made with river gravel (NWA). Half of each group contained silica-fume as partial replacement of cement (13%). By manipulating the water/cement ratio, the 28 day compressive strength of all concretes was 9500±300 psi. The main findings are:

(a) High-strength LWA concrete's fatigue life is comparable to or better than NWA concrete of similar compressive strength.

(b) The incorporation of silica fume in LWA concrete nearly doubled its fatigue life compared to NWA concretes and to LWA concrete without silica fume.

(c) The increase in fatigue life was not related to compressive or splitting tensile strength, modulus of elasticity or modulus of rupture.

(d) The increased fatigue life appeared to be directly related to improved bond between concrete and reinforcement.

(e) No significant difference between fatigue life in air or in water was observed.

(f) All specimens cracked after a few thousand cycles, and finally failed by brittle fracture of the steel. The previously reported phenomenon of water pumping through the cracks was observed, but did not appear to be directly related to the subsequent failure.

Pull-out bond tests were performed for the above concretes. The main findings were:

(g) The incorporation of silica-fume in LWA concrete nearly doubled the bond strength with steel (at a slip of 0.01 inch), as compared to all NWA concretes or LWA concrete without silica fume.

(h) The excellent bond strength of LWA concrete with silica-fume is apparently the result of its internal structure. When silica fume is added to the concrete mix, the adhesion is greatly improved. LWA concrete utilizes this additional adhesion effectively. NWA concrete with silica-fume, on the other hand, is not able to utilize the increased adhesion due to microcracking.

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Acknowledgements

I wish to thank the distinguished members of my dissertation committee for their assistance and guidance, and especially the chairman, Prof. Ben C. Gerwick.

Prof. Gerwick's determination and his belief in me made this project possible. His experience and wisdom contributed to every step of the project, and his optimistic guidance carried us through difficult and frustrating times.

A team of engineering students participated in the laboratory work, carrying a large portion of the effort with dedication and enthusiasm. Thanks John, Peter, Brian, and James.

The Faculty and gradute students at the Materials Group were immensely helpfull in their support, insight, and productive criticism throughout the work. Special thanks to Kamal who listened, suggested, lended a hand, and shared room and Mac with me for the last two years.

My wife, Michàl's, contribution to this, and all other aspects of our life is immesurable. Thanks for being you and being here with me.

Sea Grant of California sponsored the project.

California Sea Grant College Program

Project R/OE-1; Ben Gerwick