ABSTRACT

Presented in this report are the results of an investigation of the use of lightweight concretes in prestressed and reinforced concrete structures. Both "sand-lightweight" and "all-lightweight" concretes are included in the study. The sand-lightweight concrete consists of 100% sand substitution for fines, along with Idealite coarse and medium lightweight aggregate and Type I cement. The all-lightweight concrete consists of Haydite coarse, medium, and fine aggregates along with Type I cement.

The study is divided into three parts: a materials study of the concretes themselves, a laboratory study of the behavior of both non-composite and composite beams that included prestressed (15 beams) and reinforced (3 beams) beams, and the field measurement of camber of prestressed girders (5 girders) used in the fabrication of a composite bridge in Iowa. The minimum test period for the laboratory beams is 6 months, although data is recorded for 1 year for 3 of the beams. The test period for the bridge girders is 560 days.

The laboratory prestressed concrete beams are designed in five groups (3 beams in each group) to investigate the loss of

prestress, initial and time-dependent camber, load-deflection behavior (under single and repeated load cycles) and the effect of different slab casting schedules. One group of 3 reinforced beams is used to investigate the initial and time-dependent deflection, load-deflection behavior after sustained loading, and the effect of different slab casting schedules.

The methods described for predicting material behavior and structural response are generalized to apply to prestressed and reinforced structures of normal weight, sand-lightweight, and all-lightweight concrete. Continuous time functions are provided for all needed parameters, so that the general equations readily lend themselves to computer solution. Approximate equations are also included.

Design procedures are presented for the following:

1. Calculation of strength and elastic properties, creep and shrinkage of the lightweight concretes of this project at any time, including ultimate values. An indication is also given of the calculation of these properties for other concretes in general.

2. Calculation of loss of prestress and camber at any time, including ultimate values, of non-composite and composite prestressed structures.

3. Calculation of deflections at any time, including ultimate values, of non-composite and composite reinforced structures.

4. Calculation of deflections of prestressed concrete members under single and repeated load cycles (with constant as well as increasing stress range). Calculation of deflections of reinforced concrete members under sustained loads in the non-linear range for short times (24 hours) is also included.

Results computed by these methods are shown to be in good agreement with the control specimen data, the laboratory beam data, and the bridge girder data.

Published experimental data concerning the time-dependent (prestress loss, camber, and deflection) effects and load deflection response of prestressed and reinforced beams are shown to be in reasonable agreement with the results computed by the design methods presented in this report. Ranges of variation are also shown. These data include normal weight, sand-lightweight and all-lightweight concrete, non-composite and composite members, and both laboratory specimens and actual structures.

This project is thought to be the first such comprehensive study of the initial plus time-dependent material behavior and related structural response of both non-composite and composite structures using different weight concretes. A new procedure is also developed for predicting the entire load-deflection curve of both reinforced and prestressed members under repeated load cycles into the cracking range.

Keywords: all-lightweight concrete; beams (structural); bridge girders; camber; composite construction (concrete to concrete); creep (materials); deflection; lightweight concrete; loss of prestress; modulus of elasticity; normal weight concrete; precast concrete; prestressed concrete, repeated cycle; sand-lightweight concrete; shrinkage; single cycle; steel relaxation; strain; stress; structural design; sustained; test beams; time-dependent.