不完全合成桁の挙動に関する研究

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BEHAVIOR OF COMPOSITE BEAMS WITH INCOMPLETE INTERACTION

by

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ABSTRACT

Steel-concrete composite beams are structural elements of practical importance in building and bridge structures. This thesis presents the theoretical and experimental studies on behavior of composite beams with incomplete interaction, partial composite beams and curved composite girders. The contents of this study consist of 6 main investigative themes as described below.

The elastic and elastic-plastic analysis of composite beams with incomplete interaction is proposed in Chapter 2. A composite beam element with an assembly of beam elements for concrete slab and steel beam and a spring element for shear connectors is used in the present analysis, which reduces the number of equations considerably. Cubic polynomials are herein used as the shape functions for not only bending but also axial deformations of the beams, since they represent results from complicated deformations in the composite beams. This composite element is applied to the analysis of continuous composite beams and the elastic-plastic analysis of composite beams with incomplete interaction. For the analysis of nonlinear problems, the stress-strain curves of concrete and steel and the load-slip curve of a shear connector are simply assumed by bilinear functions. The iterative initial strain method is employed in the nonlinear analysis. The numerical results are compared with the other test results and the computational values based on other numerical methods, and found to be in good agreement.

The effective width of composite beams with incomplete interaction is proposed in Chapter 3. The models of the composite beams proposed herein are as follows; (1) a composite T-section. (2) a composite section with a number of equally spaced steel section connected to the concrete slab. (3) a composite π -section under a symmetric loading. (4) a composite π -section under an antisymmetric loading. The constitutive equations which relate the effective width of composite beams with incomplete interaction are formulated by the Airy's stress function and solved by series solutions. Stresses evaluated by the proposed method are compared with those obtained from the finite prism and the finite strip method, where the finite prism and the finite strip are applied to the concrete slab and the steel beam, respectively, and the comparison shows good agreement. The effective width ratios of

composite beams with various shear connector modulus under a uniformly distributed load and a concentrated load at the mid-span is presented.

Chapter 4 aims to provide some informations on static and fatigue behavior of complete and partial composite beams under negative bending. Six composite beams were statically tested and seven were tested under repeated loading. The beams were tested as "upside down" to create the conditions of negative bending. Special emphasis is given to bending stiffness, efficiency of reinforcing bars, crack pattern, crack width and failure mode.

A simplified method for the calculation of stresses and deflections of partial composite beams under negative bending is proposed in Chapter 5. A moment diagram near intermediate supports of a continuous beam under a concentrated load and/or a uniformly distributed load is able to simulate to a simply supported beam under a concentrated load at the mid-span. In the present study, an idealized moment diagram of a cantilever beam is used for the negative moment region. The results evaluated from the simplified method are compared with the test results and those obtained from the finite element method.

Chapter 6 presents the formulations for the finite strip analysis of curved composite girders with incomplete interaction. The curved composite girders are modelled by curved strip elements for concrete slab and steel girder and spring elements for shear connectors. The shear connectors are assumed as a two-dimensional spring element along a nodal line.

The elastic behavior of curved composite box girders is discussed in Chapter 7. Three curved composite box girders were tested in order to provide additional informations related to the bending behavior of curved composite box girders. Test specimens were fabricated where different radii, cross sections and placements of shear connectors are considered. Test results are compared with computational values based on the finite strip method shown in Chapter 6, and they are in good agreement.

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