Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 999 (1997)

Artikel: Stochastic long-term analysis of composite girders
Autor: Takami, Katsuhiko / Hamada, Sumio
DOI: https://doi.org/10.5169/seals-1087

Stochastic Long-Term Analysis of Composite Girders

Katsuhiko TAKAMI
Associate Professor
Yamaguchi University
Ube, Japan

Katsuhiko Takami, born 1955, received his Dr. Eng. from Kyusyu University, Japan in 1986.

Sumio HAMADA
Professor
Yamaguchi University
Ube, Japan

Sumio Hamada, born 1944, received his Ph.D from the University of Alberta in 1972.

Summary

The creep properties of concrete significantly influence the long-term behavior of steel-concrete incomplete composite girders. In this paper, a stochastic creep analysis based on the First-Order Second-Moment Method are carried out considering the uncertainties of creep properties. The results are compared with those obtained from the Monte Carlo simulation. The effect of variability of material properties on the long-term behavior of incomplete composite girders are exhibited.

1. Introduction

The creep properties of concrete significantly influence the long-term behavior of steel-concrete incomplete composite girders. In the design of those structures, the deterministic creep coefficient, such as the ACI-209 model, the CEB-FIP-90 model is utilized to estimate long-term effects. These creep properties are subjected to some amount of variability. Therefore, it is not so easy to correctly predict the long-term behavior of these girders. In this study, a stochastic creep FEM analysis based on the First-Order Second-Moment Method are carried out considering the uncertainties of creep properties. The results are compared with those obtained from the Monte Carlo simulation.

2. Stochastic FEM Analysis based on the F.O.S.M

The incomplete composite girder in this FEM analysis consists of a concrete beam element, a steel beam element and a continuous spring element which connects concrete and steel.
Using the age adjusted effective modulus method in constitutive low on the concrete, the creep stiffness equation of the incomplete composite girder is expressed as following.

$$[K]\{U\} = \{F\} + \{G\} \qquad (1)$$

where

$[K]$:creep stiffness matrix of composite beam, $\{U\}$:creep displacement vector

$\{F\}$:external force vector, $\{G\}$: creep force vector

The sensitivity displacement is derived from Eq.(1) as

$$[K]\frac{\partial\{U\}}{\partial X_i} = -\frac{\partial[K]}{\partial X_i}\{U\} + \frac{\partial\{G\}}{\partial X_i} \tag{2}$$

$$(i = 1 \sim m)$$

where Xi is probabilistic variables such as the relative humidity, affecting creep behavior of concrete. The value m is the number of the probabilistic variable. The variances of deflection and stress of the concrete slab and steel beam can be evaluated from Eq.(2).

3. Calculation and Results

The CEB-FIP-90 model has adopted as a creep coefficient, which mainly consists of 4 terms of the relative humidity, the mean compressive strength of concrete, the notational size of member and the age of concrete. Besides the creep coefficient the aging coefficient and the modulus elasticity of concrete at loading time also effect the age adjusted effective modulus in the analysis. In this study, the relative humidity, the compressive strength of concrete at the age of 28 days, the modulus of elasticity of concrete and the aging coefficient are regarded as probabilistic variable. The data of those values are the mean value and the coefficient of variation which represents the scatter. Other data are deterministic values.

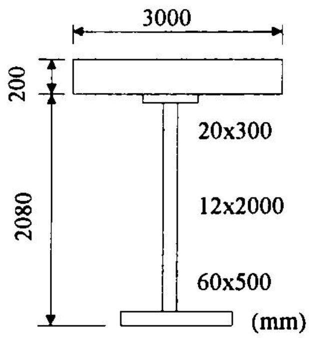

Fig.1 Cross Section

The numerical calculations are carried out for the simple composite beam shown in Fig.1. The following numerical values are adopted: span length L=40m; modulus elasticity of steel $E_s=2.1\times10^5$MPa; uniformly distributed sustained load p=54.145kN/m; rigidity of connector Qz=0.4kN/mm/mm; loading time and final time for creep analysis is 14days, 10000days, respectively; mean relative humidity RH=60%; mean compressive strength of concrete at the age of 28days f_{ck}=30MPa; mean aging coefficient χ=0.76; mean modulus elasticity of concrete $E_c=2.85\times10^5$MPa.

The comparisons of the variance of creep deflection and creep stress of concrete at the mid span are shown in Fig.2 and Fig.3 between this study and Monte Carlo simulations, where the number of sampling calculation is 1000, and every coefficient of the variation of relative humidity, compressive strength of concrete, aging coefficient, and modulus elasticity of concrete ranges from 10% to 40%. Results of this study show good agreements with those from Monte Carlo simulations.

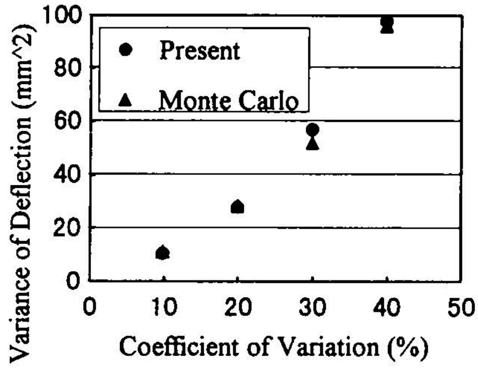

Fig.2 Comparison of Result(a)

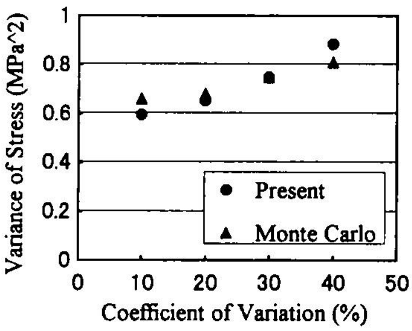

Fig.3 Comparison of Result(b)

4. Conclusion

The present paper expresses the incomplete composite analysis including the scatter of material properties of long-term behavior, which results in good agreement with the results evaluated from the Monte Carlo method.