コンクリート構造物の地盤・構造連成解析
（2）鋼板コンクリート構造物の非線形性における日米規格の比較

Soil-Structure Interaction Analysis for Concrete Structures
(2) Japanese and US Standards for Structural Nonlinearity of SC Structures

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During severe earthquakes the inelastic structure behavior should be considered in the seismic analysis of nuclear facilities. In this study, differences of structural nonlinearity of SC Structures between Japanese and US standards have been confirmed by SSI analyses applying iterative equivalent linear analysis procedure.

Keywords: Soil-Structure Interaction, Steel-Composite Concrete, Nonlinear Seismic Response Analysis

1. Introduction

To capture accurate and numerically efficient Soil-Structure Interaction (SSI) effects, dynamic substructuring approaches were developed in complex frequency. These SSI substructuring approaches have been widely used in practice over some decades, especially in the United States. Since the application of these substructuring approaches in complex frequency is limited to the elastic material behavior, an iterative hybrid frequency-time SSI approach was implemented, extending the application of the substructuring approaches to capture the nonlinear structure behavior [1]. In the previous study [2], SSI analyses for Steel-composite Concrete (SC) walls consisting of steel panels and infilled concrete have been performed considering the structural nonlinearity of the SC shear walls using the Japanese JEAC4618 standard [3]. In this study, the differences between the seismic SSI structure responses based on Japan and US standards for the SC walls were investigated for a typical embedded nuclear building.

2. Analysis Modeling and Condition

2-1. Nonlinearity of SC Shear Wall in Japanese Standard

By following JEAC4618-2009, trilinear skeleton curves were applied to the structural nonlinearity of SC shear walls for both shear force - shear strain and moment - curvature relationships.

2-2. Nonlinearity of SC Shear Wall in US Standard

Nonlinearity of SC shear wall modelling was conducted based on AISC N690-18 [4].

The effective out-of-plane flexural stiffness of SC walls was calculated by the following formula.

$$EI_{eff} = E_s I_s + c_2 E_c I_c \qquad \text{Eq.(1)}$$

where

E_i: Elastic modulus (*i*=*s*: steel, *i*=*c*: concrete)
I_i: Second moment of area (*i*=*s*: steel, *i*=*c*: concrete)
c_2: Neutral axis distance from the top plate

As for uncracked concrete condition, the effective shear stiffness of SC walls was calculated by the following formula.

$$GA_{eff} = G_s A_s + G_c A_c \qquad \text{Eq.(2)}$$

where

G_i: Shear elastic modulus (*i*=*s*: steel, *i*=*c*: concrete)
A_i: Gross area per unit (*i*=*s*: steel, *i*=*c*: concrete)

As for cracked concrete condition, the effective shear stiffness was reduced by the following formula.

$$GA_{eff} = 0.5\bar{\rho}^{-0.42} G_s A_s \qquad \text{Eq.(3)}$$

where $\bar{\rho}$ denotes strength-adjusted reinforcement ratio as defined in the AISC N690 standard.

3. Conclusion

In this study, iterative hybrid frequency-time SSI analyses were performed for the typical embedded nuclear building with SC walls based on the Japan and US standards. The SSI dynamic behaviors for the two standards were compared. Some significant differences between them were observed.

References

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