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Nonlinear Dynamic Response of RC Shear Wall

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1. Introduction

Reinforced concrete (RC) shear wall has been widely adopted as a major structural member in the main building of the nuclear power plant. Since it is required for the RC shear wall to have enough energy dissipation capacity and to prevent potential brittle failure, it is necessary to understand the inelastic deformation and stiffness degradation phenomena accumulated with severe earthquakes. To evaluate the inelastic deformation and energy dissipation capacity adequately, a seismic response of an isolated shear wall specimen is obtained from nonlinear dynamic analysis using the developed numerical model and is compared with experimental data.

2. Numerical Modeling

2.1 Material Model

The material behavior of concrete is described by an orthotropic constitutive relation, focusing on the tension-compression region with tension-stiffening and compression softening effects based on the smeared crack concept in the principal strain directions.

Fig. 1 shows the hysteretic stress-strain relation of concrete assumed in this study. A smooth transition curve is used to define the crack opening and closing.

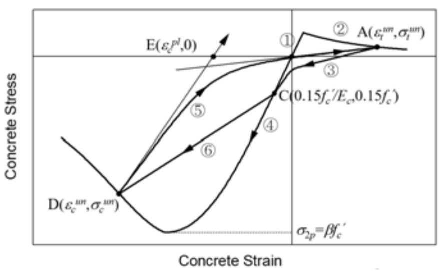

Fig. 1. Hysteretic stress-strain relation of concrete.

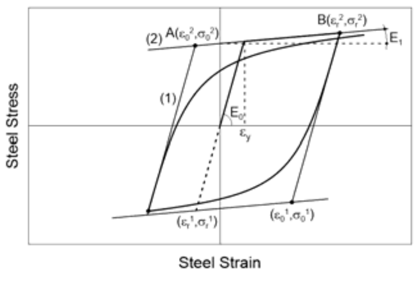

Fig. 2. Hysteretic stress-strain relation of reinforcing steel.

The behavior of a reinforced concrete element subjected to cyclic loading in the inelastic range is sensitive to the hysteretic characteristics of the reinforcing steel. One of the most widely used models proposed by Menegotto [1] is selected in this study (see Fig. 2).

2.2 Dynamic Analysis Procedure

For the nonlinear dynamic analysis, a combination of the modified Newton-Raphson method and Newmark's method with unconditionally stable condition are adopted. Fig. 3 shows a flow chart of nonlinear dynamic analysis procedure. More details of numerical evaluation procedures can be found elsewhere [2].

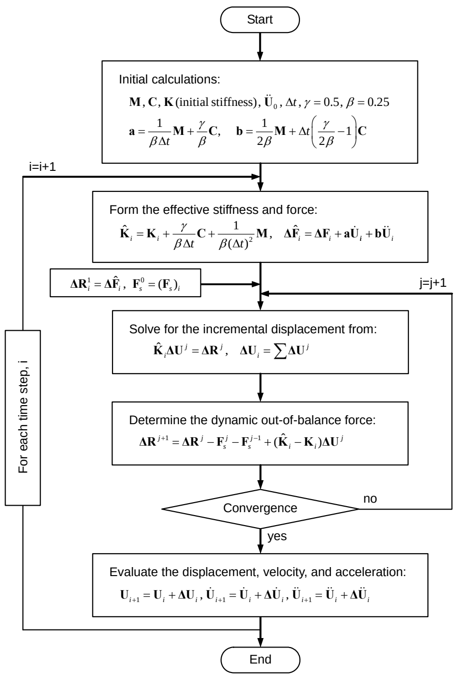

Fig. 3. Nonlinear dynamic analysis procedure.

3. Numerical Application

To simulate the nonlinear dynamic behavior of RC shear wall, an isolated wall specimen (see Fig. 4) which is subjected to earthquake motion tested by NUPEC [3] is analyzed. The web wall has a thickness of 75 mm, a flange wall center to center length of 3,000 mm, the clear height of 2,020 mm, as well as a shear span ratio of 0.8.

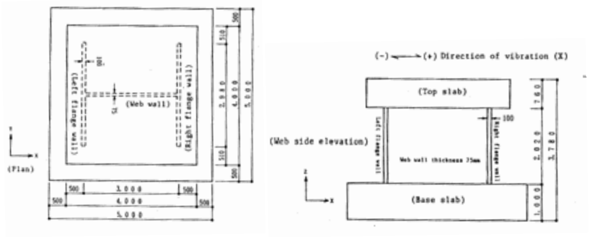

Fig. 4. Geometries and dimensions of shear wall specimen.

In order to produce nonlinearity in the material, an additional weight of 9.11×10^5 N is attached at upper and lower surfaces of the top slab. The material properties and the reinforcement ratios used in the modeling are listed in Table I.

Table I: Material properties of shear wall

Concrete			Reinforcement			
E_c (MPa)	f_c' (MPa)	f_t (MPa)	E_s (MPa)	f_y (MPa)	ρ(%) Vertical	ρ(%) Horizontal
22,945	28.6	2.24	184,365	383.4	1.2	1.2

The finite element discretization of the wall used in the analysis is shown in Fig. 5. The horizontal accelerations at upper surface of base slab is applied as a base motion (see Fig. 6) to the shear wall at a constant time interval, ΔT = 0.001 sec.

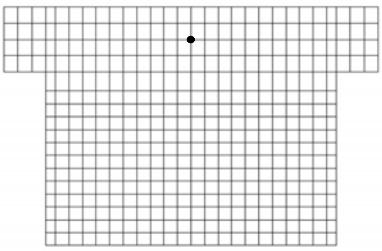

Fig. 5. FE mesh for shear wall.

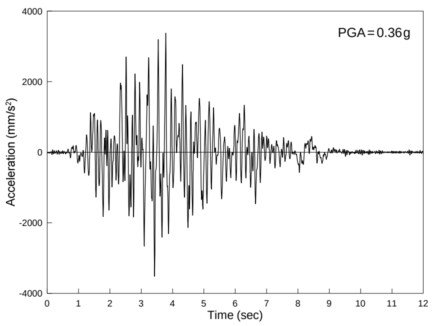

Fig. 6. Horizontal accelerations at upper surface of base slab.

The acceleration history at the center of top slab for 12 second earthquake motion are compared in Fig. 7. The overall analysis results including the peak acceleration value and response cycle have a comparable agreement with the experimental results.

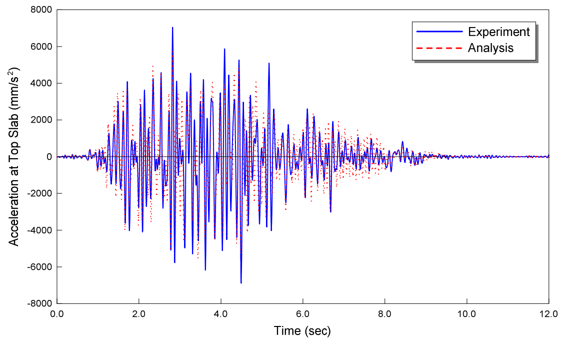

Fig. 7. Acceleration history at center of top slab.

Fig. 8 shows the acceleration response spectra (at center of top slab) comparison from the nonlinear dynamic analysis with 4% damping and linear dynamic analyses with 7% damping and reduced stiffness. Because the nonlinear analysis considers energy dissipation explicitly, the peak response is less than that of linear analysis even though the lesser damping value is used in the nonlinear analysis.

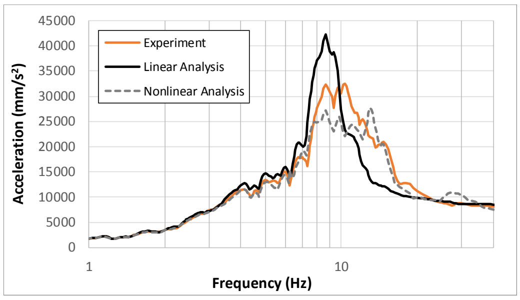

Fig. 8. Response spectra comparison.

4. Conclusions

In this study, the dynamic responses from the nonlinear dynamic analysis of RC shear wall are compared. From the response spectra comparison, the effect of nonlinear hysteresis behavior on damping is identified.

ACKNOWLEDGEMENTS

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