8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

NONLINEAR ANALYSIS OF ISOLATED BRIDGES UNDER NEAR-FIELD GROUND MOTIONS

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Key Words: *Isolated Bridge, Unseating Prevention Device, Dynamic Analysis, Vector Form Intrinsic Finite Element.*

ABSTRACT

Isolated bridges have been extensively used to mitigate the induced seismic forces by a shift of natural period. However, the deck displacement becomes excessively large when subjected to a ground motion with large intensity or unexpected characteristics. Such a large displacement may result in unseating of the deck. Therefore, unseating prevention devices are important particularly for isolated bridges [1]. Lately, it is expected to modify the bridge seismic design codes based on the seismic performance of whole bridges and their elements. Understanding of the performance of the components of isolated bridges, such as bearings, unseating prevention devices, columns, under extreme condition is helpful to determine the goal of performance. In this paper, a nonlinear structural dynamic analysis method is studied to simulate the dynamic behaviour of the isolated bridges under extreme earthquakes.

The Vector Form Intrinsic Finite Element (VFIFE), a new computational method developed by Ting *et al*. [2], is adopted in this study because the VFIFE has the superior in managing the engineering problems with material nonlinearity, discontinuity, large deformation and arbitrary rigid body motions of deformable body. Since the VFIFE is in infant stage, there are still a number of undeveloped elements. Two kinds of new elements, bilinear elements and elements with a gap or a hook, are developed to analyzing isolated bridges with unseating prevention devices in this study. Additionally, the Rayleigh damping is first considered in VFIFE. Since it is not necessary to assemble the global stiffness matrix in the computational procedure of the VFIFE, structural damping was regarded as proportional to mass matrix only.

A three-span isolated bridge with a total length of 3@40 m = 120m, as shown in Fig. 1, is analyzed to verify the accuracy of the developed elements and Rayleigh damping analysis. The columns and isolators are assumed to be perfect elastoplastic and bilinear elastoplastic, respectively. The unseating prevention devices are installed at both end abutments. The devices are simulated as elements with a hook. The damping ratios of the system are assumed 5% for the first and second modes. In simulation, the isolated

bridge is subjected to near-field ground motions recorded at Sun-Moon Lake in the 1999 Chi-Chi, Taiwan earthquake.

To verify the accuracy of the VFIFE the analytical results are compared with those by the conventional Finite Element analysis. Fig. 2 shows the comparison of the displacement at the midpoint of the deck, the force of unseating prevention device at the A2 abutment. The hysteretic loops of the isolators at A1 abutment and P1 column and the bottom of P1 column are compared in Fig. 3. It is revealed that both results by the VFIFE and the Finite Element (SAP2000) agree to each other. The developed VFIFE elements and Rayleigh damping analysis are accurate and can be extended to take the fracture into account for simulating the ultimate situation.

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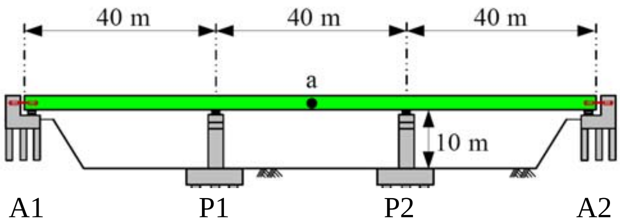

Fig. 1 Target Isolated bridge

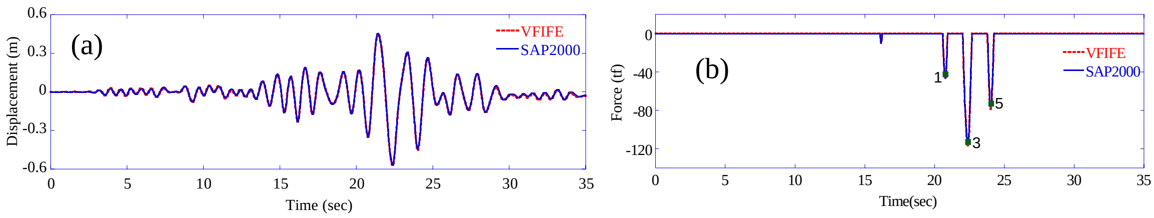

Fig. 2 (a) The Displacement at Midpont of Deck (b) the force of Unseating Prevention Device at Abutment A2

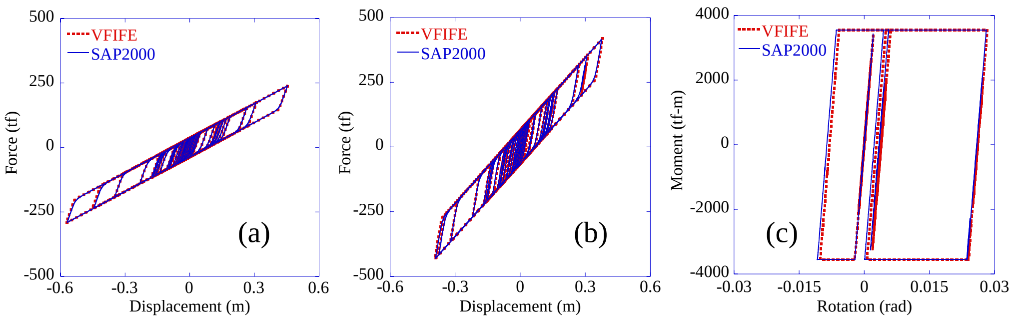

Fig. 3 The Hysteretic Loops of (a) Isolator at A1 (b) Isolator at P1 (c) the Bottom of Column P1