I - B369 NONLINEAR ANALYSIS OF RC BRIDGE PIER

Okayama University Graduate student Shimabuku Jorge
Okayama University JSCE member, Professor Takemiya Hirokazu

1. INTRODUCTION

The Hyogo-Ken Nanbu Earthquake caused devasting damage to the Hanshin Expressway, especially to the Pilz-type RC bridge, destroying piers, leading to the total collapse of the a continuos 21 spans over 500m, length. In this study is investigated the nonlinear behavior of the superstructure with two types of supports (fixed and equivalent linear springs) and its relation with the shear degradation effect.

2. MODEL OF ANALYSIS

Fig.1 shows two analytical models of a typical column (B-505 type). Each model is represented by elastic column between inelastic hinges (one component model[1]) . The effect of foundation was idealized as fixed support (model A) and as a set of equivalent linear springs (model B). In model B, the analysis of pile-soil interaction was realized by the impedance fuctions[2]

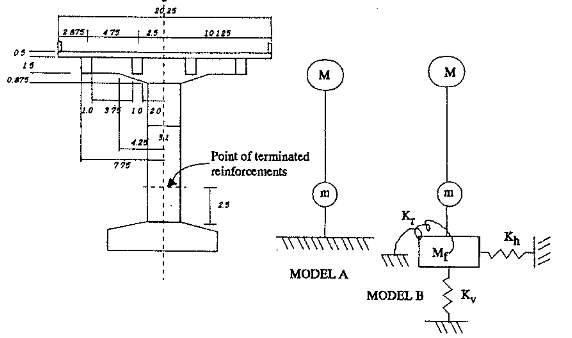


FIG 1 ANALYTICAL MODELS OF BRIDGE PIER

3. MODEL OF RC NONLINEAR BEHAVIOR

The primary moment curvature relationship of the element section is idealized by bilinear curve. The yield state was taken to coincide with the yielding of twelve reinforcement longitudinal bars.The nonlinear hysteresis of the pier including the following restoring characteristics: the stiffness degrading (by Q-hysteris model[3]), the strength degradation (function of degradation parameter β [4]), the P-delta effect (by geometric matrix), and the shear degradation effect by lowering the target maximun or minimun point to the level of cracking force until the crack-closing point is reached after which the target is the previous maximun or minimun point

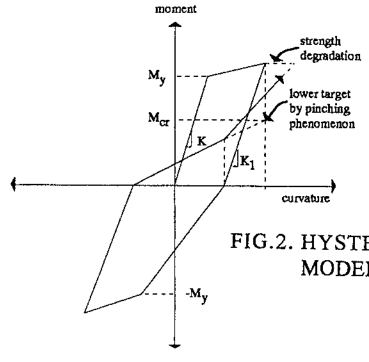


FIG.2. HYSTERESIS MODEL

4. DISCUSSION

The structure was excited by the Hyogo Ken Nanbu earthquake at JMA-NS component (fig. 3). Fig.4 depicts the shear degradation effect, it adequetly reveals the failure mechanisn observed in the Hanshin Expressway. That is: the initial cracks was dued to only flexural effects (3 peaks displacements before 8 seconds) and the posterior amplification of displacements due to apparition of shear cracks as we can see at the next peaks until the collapse of the pier. Fig. 5 shows the column responses in both models. If the shear degradation effect is not considering, the response of both models is practically equivalent and we can think that the soil structure interaction was not important point of the collapse of this structure (fig 5A). However when the shear degradation effect is considering (fig 5B, 5C and 5D); before approximate 8 seconds, the structure has a similar behavior for both models with the greatest peak around 7.8 seconds, but the effect of the equivalent linear spring appears from approximate 8 seconds as can appreciate at the peaks around 8.6, 9.5, 10.2 and 11 seconds. It is seen the effect of the soil-structure interaction collaborates with the shear cracks and the P-delta effect in the final collapse of the piers of the Hanshin Expressway, but not in the initial moments of the collapse.

KEY WORDS: shear degradation, support effect
〒700 岡山市津島中2-1-1岡山大学環境理工学部環境デザイン工学科 TEL(FAX) 086-251-814

REFERENCES:

1) Giberson, M. F., "Two Nonlinear Beams with definitions of Ductility", ASCE, Vol 95, ST2, 1969.
2) Takemiya, H., and Katayama, Y., "Seismic Design Procedure of Pile Foundation", Proc. 4th East Asia-Pacific Conf. on Structural Eng. and Construction, Seoul, Korea, 1993.
3) Saidi, M., "Hysteresis Models for Reinforced Concrete", ASCE, Vol 108, ST5, 1982.
4) Park, J. -Y., Ang, A. H. -S., "Mechanistic Seismic Damage Model for Reinforced Concrete", ASCE, Vol 111, ST4,1985.

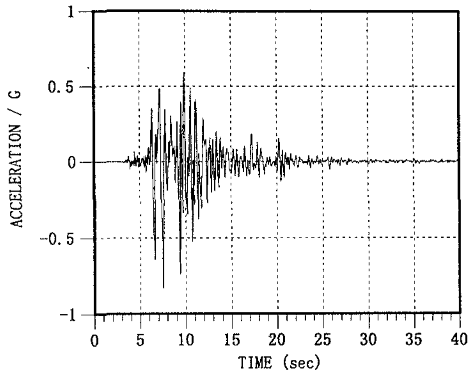


FIG.3. GROUND ACCELERATION JMA-NS

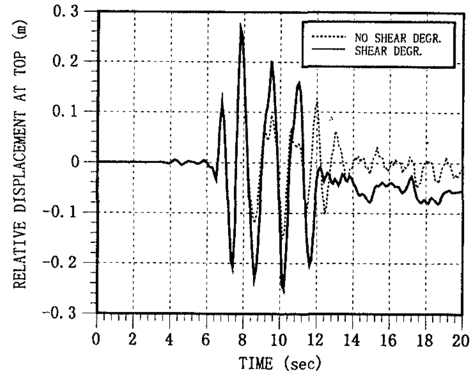
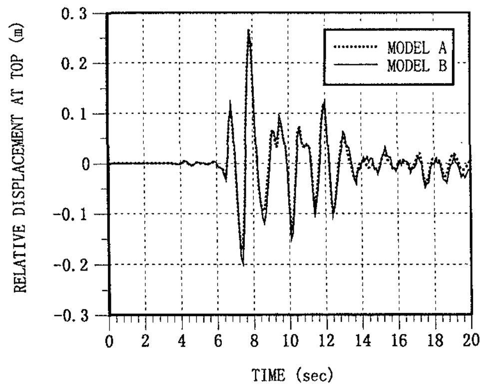
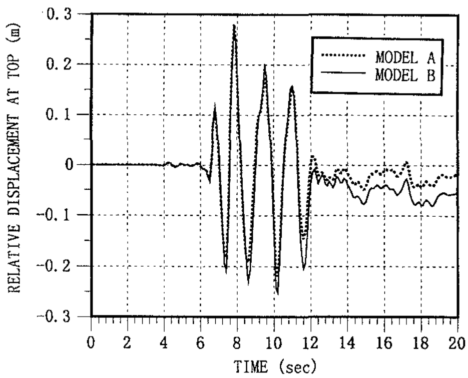


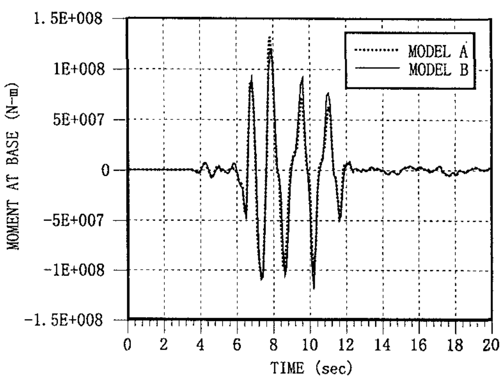
FIG.4. EFFECT OF SHEAR DEGRADATION IN MODEL B



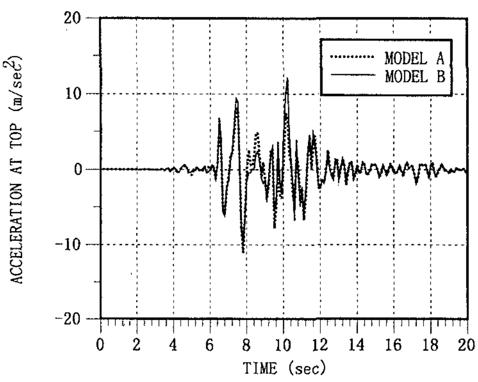
A) COMPARATION BETWEEN BOTH MODELS WITHOUT SHEAR DEGRADATION.



B) COMPARATION BETWEEN BOTH MODELS WITH SHEAR DEGRADATION.



C) COMPARATION BETWEEN BOTH MODELS WITH SHEAR DEGRADATION



D) COMPARATION BETWEEN BOTH MODELS WITH SHEAR DEGRADATION.

FIG.5. RESPONSE OF PIER B505 SUBJECT TO JMA-NS