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EARTHQUAKE RESPONSE BEHAVIOR OF PRESTRESSED CONCRETE VIADUCT STRUCTURE BASED ON SUBSTRUCTURED PSEUDO-DYNAMIC TEST

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INTRODUCTION

In order to clarify inelastic behavior of elevated prestressed concrete bridges (hereafter PC), various loading tests have been carried out to study the inelastic behavior of RC bridge piers subjected to earthquake excitation. Since the girders of these bridges have generally shoe for bearing on the piers, only the piers are subjected to earthquake forces. On the other hand, because of the fixation between girders and piers in viaduct structures, not only the piers but also the girders may have some damage during earthquake. Yet not enough tests have been performed to study the inelastic behavior of PC girders due to severe earthquake excitation. The purpose of the present study is to study the inelastic response behavior of such PC girders by substructured pseudo-dynamic test.

OUTLINES OF TESTS

A structural model was selected so it can represent a small scale viaduct structure (Fig. 1). Substructured pseudo-dynamic test using modified Hyogo-Ken Nanbu (NS 1995) earthquake where the time scale was magnified as half the original one while the maximum ground acceleration was 818 gal (Fig. 2) was conducted. For simplicity and due to the difficulty of implementing members with varying inflection points, it was assumed that the viaduct girder is symmetric with respect to the centerline of each bay. A cantilever PC member from the model representing half of the PC girder was tested experimentally while the remaining members were treated analytically using one component model proposed by Giberson [1]. Takeda tri-linear hysteretic model [2] was used for the restoring force-displacement model of RC piers. Details of specimen are shown in Fig. 3. Specimen was tested using the setup shown in Fig. 4. Response analyses were carried out for the same viaduct model and a comparison between experimental and test results was conducted. After the completion of the substructured pseudo -dynamic test, cyclic loading test was carried out for the same specimen till failure. The plastic deformability expressed in terms of ductility factor was also examined.

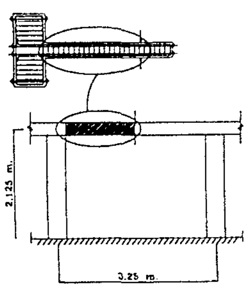

Fig. 1 Model used for the pseudo-dynamic test

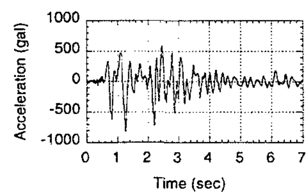

Fig. 2 Input ground acceleration for the viaduct model

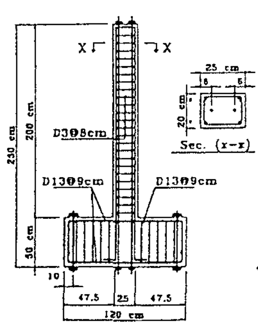

Fig. 3 Test specimens

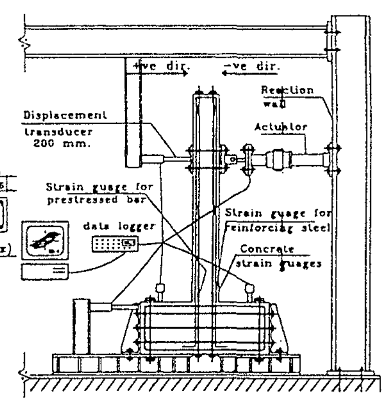

Fig. 4 Loading setup

TEST RESULTS

The hysteresis loops of the tested PC girder shown in Fig. 5 indicate stiffness degradation, bauschinger effect for both the unloading and reloading and also pinching of hysteretic moment rotation curve. The hysteresis loop of the RC pier is shown in Fig. 6. From both figures, It can be concluded that not only the RC piers but also

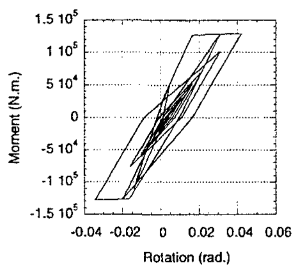

Fig. 6 moment-rotation curve for the bottom of the RC pier

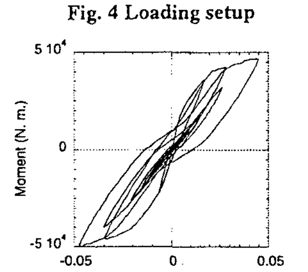

Fig. 5 Moment-rotation curve for the left end of the PC girder from pseudo-dynamic test

KEYWORDS: Inelastic response analysis; prestressed concrete.
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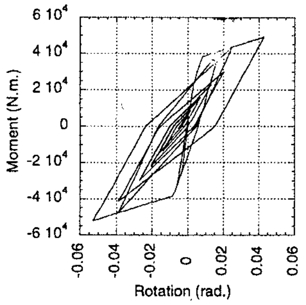

Fig. 7 Analytical moment-rotation curve for the left end of the PC girder

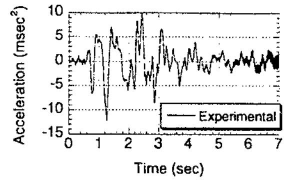

Fig. 8 Experimental acceleration time history of the viaduct model

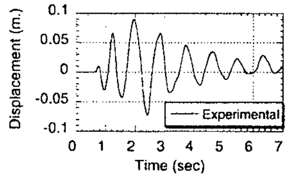

Fig. 9 Experimental displacement time history of the viaduct model

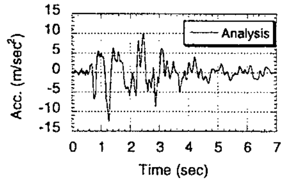

Fig. 10 Analytical acceleration time history of the viaduct model

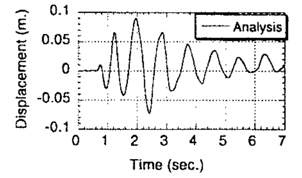

Fig. 11 Analytical displacement time history of the viaduct model

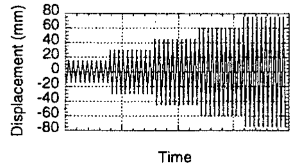

Fig. 12 Applied cyclic wave to the viaduct model

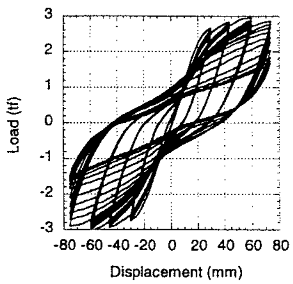

Fig. 13 Load displacement curve for cyclic loading test

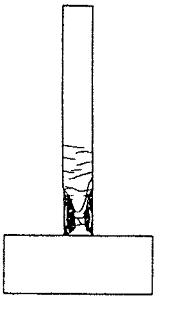

Fig. 14 Cracking pattern

the PC girder undergoes extensive damage during the earthquake excitation. Analytical hysteretic moment-rotation curve for the PC girder using the same program used in the substructured pseudo-dynamic test is shown in Fig. 7. The acceleration and displacement time histories of the response analysis in Fig. 8, 9 show that the time and direction of the maximum acceleration and displacement are consistent with those of the input ground acceleration. analytical acceleration and displacement time histories are shown in Fig. 10 and 11. A good agreement between both analytical and test result was obtained.

Cyclic loading test was conducted using the input cyclic excitation shown in Fig. 12 after the completion of the pseudo-dynamic test. The resulting load-displacement curve is shown in Fig. 13. The test was continued till the displacement reached about 5 times the yielding displacement of the prestressed tendon. Fig. 14 shows the cracking pattern and failure mode of the tested specimen.

CONCLUSIONS

Based on the above investigation, the following conclusions can be extracted:

1) Not only the RC piers but also the PC girders are subjected to inelastic deformation that may cause a considerable damage. As a consequence, adequate care should be given to the PC girder design to satisfy the requirements of a seismic resistant structure.

2) In general, since PC girder is designed mainly to resist dead and live loads, prestressed tendons and steel bars are arranged unsymmetrically in the cross section. Therefore, they can not resist the reversed loading resulted from earthquake excitation whereas one direction will suffer severe damage. Symmetrical specimen can obtain the same load carrying capacity in the two directions.

3) A good agreement between the analytical and experimental results for the viaduct model was obtained.

REFERENCES

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