SUBSTRUCTURED HYBRID TESTS FOR THE ENHANCEMENT OF SEISMIC SAFETY OF BRIDGE PIERS WITH SEISMIC ISOLATORS

Kyoto University	Member	Yoshikazu YAMADA
Kyoto University	Member	Hirokazu IEMURA
Kyoto University	Member	Kazuyuki IZUNO
Japan Bridge Co.	Member	O Gerardo BERUMEN

INTRODUCTION

The geometry of the pier structural system is shown in Fig. 1 Its structure is dynamically analyzed, employing analytical and hybrid experiment-substructured methods, to obtain earthquake response of both pin-connected and seismic isolated support systems. The isolated case was analized using on-line hybrid experimentsn and the isolator was modelled experimental substructure, while for the non-isolated case, the whole structure was analitically modelled, assuming a fixed pin as support of girder, and realized conventional dynamic analysis. For the non-isolated case, T was nearly 0.5 seconds and we provided flexible structure for the isolated case, i.e. T = 2 sec.

ANALYSIS AND EXPERIMENTS

The first three earthquakes correspond to the records stipulated in the Japanese Seismic Design of Highway Bridges regulations, and they correspond to soil types hard, medium hard and soft, respectively, and El Centro record, as the typical input ground motion. Three different levels of maximum input accelerations for each different earthquake, that is for each general case, the structural system was analized 12 times. An HDR isolator was chosen for the experiment, it is a four layer High Damping device. After, the program of experiments started, and using the Substructured On-line Hybrid Loading system, and the isolator was tested for each one of the case studies, mentioned above, executing in this manner the dynamic analysis of the structure taking the HDR isolator as a proportional part of the experimental substructure for the pier structural system, in this case, it represented, approximately 1/57 of the total rigidity needed at the isolation level, (Girder-Pier Connection). The non-isolated case was analyzed directly to perform a standard dynamic analysis where the superstructure and the pier top were lumped together in one big mass.

RESULTS

For the earthquake response of the two general cases, Figures 2, 3, and 4 show response characteristics of girder displacement and accelerations and base shear, for isolated and non-isolated, are only for the El Centro Record, max. 300 gal. Fig. 5, 6 and 7 show the peak acceleration, displacement, shear and moment response for El Centro Earthquake, so both cases can be compared.

CONCLUSIONS

Results show significant contributions of the isolated system. However, the three first earthquakes provided less efficient or favorable response behaviour, but, instead, the El Centro Earthquake was ideal for justifying the effectivity of the isolation system, and our proposed structure is suitable for the El Centro record.The influence of the hardening effect was observed for Earthquakes 1, 2 and El Centro Record, when their response acceleration ratios increase at higher input accelerations, see Table 1. The seismic design forces are reduced, therefore seismic safety can be achieved. Especial care must be given to limiting the girder displacements of the isolated structure, to acceptable levels. We can perceive the influence of the higher modes in the response of the isolated system. On-line Hybrid experiments have provided a very efficient earthquake response data set.

Yoshikazu YAMADA, Hirokazu IEMURA, Kazuyuki IZUNO and Gerardo BERUMEN

Table 1 Comparison of Isolated and Non-Isolated Response Peak Values

(am) PEAK INPUT ACCELERATION (gal)	GIRDER Maximum Acceleration (gal)					GIRDER Maximum Displacement (cm)				Pier Base Maximum Shear(tonf) / Moment(tonf-m)			
	(ia) ISOLATED	(na) NON-ISOL.	$\beta=\frac{i_a}{a_m}$	$DR_A=\frac{i_a}{n_a}$	NR	(id) ISOLATED	(nd) NON-ISOL.	$IR_D=\frac{i_d}{n_d}$	NR	(is) ISOLATED	(ns) NON-ISOL.	$DR_S=\frac{i_s}{n_s}$	NR
100	35	252	0.35	0.14	0.25	1.90	1.34	1.42	1.0	587 / 2.4e5	1571 / 1.3e6	0.37 / 0.18	0.51 / 0.32
200	68	503	0.34	0.14	0.25	5.53	2.70	2.05	1.44	1174 / 4.2e5	3143 / 2.5e6	0.37 / 0.17	0.51 / 0.31
300	131	755	0.44	0.17	0.30	9.80	4.02	2.44	1.72	1765 / 7.6e5	4714 / 3.8e6	0.37 / 0.20	0.51 / 0.36

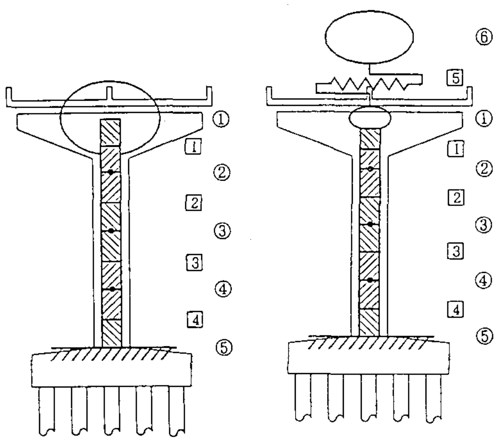

Fig. 1 Non-Isolated and Isolated Bridge Pier Model

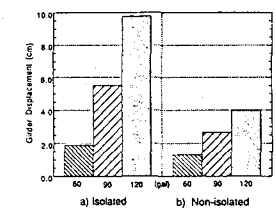

Fig. 5 Max. Girder Disp.

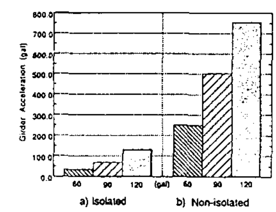

Fig. 6 Max. Girder Acc.

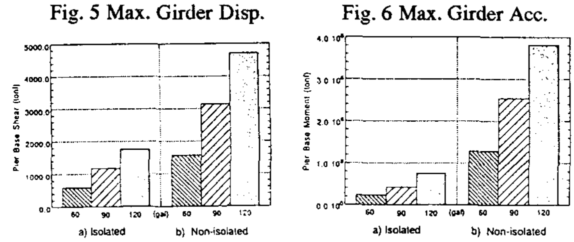

Fig. 7 Max. Pier Base Shear and Moment

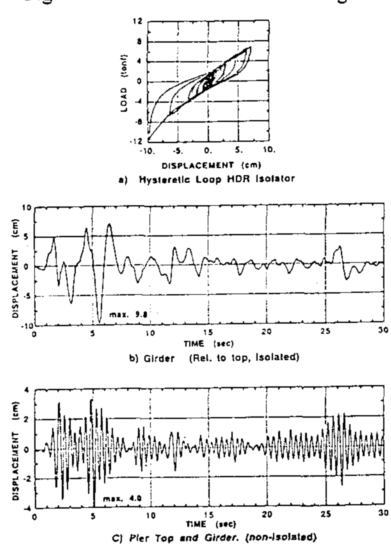

Fig. 2 Displacement Response

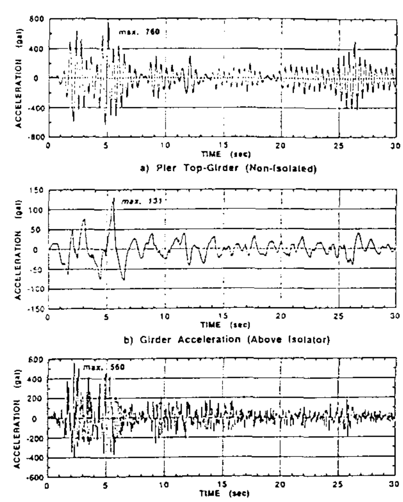

Fig. 3 Acceleration Response

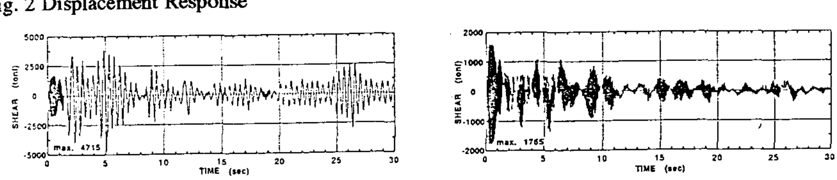

Fig. 4 Base Shear Response