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Comparative Study on Seismic Design of Bridge Foundations

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1. INTRODUCTION

It is desired that structural design codes are internationally harmonized in order to encourage the world trade. On the other hand, cost reduction is a very important factor domestically in our country. With these backgrounds, a comparative study on seismic design procedures was attempted with use of the Japan Road Association Specifications (JRA Specifications [1]) and the California Department of Transportation Bridge Design Specifications (Caltrans BDS [2]). In this study bridge superstructures, bearing supports, pier caps and soil conditions were kept identical. Pier types (wall- type or column- type), and sizes of piers and pile foundations were designed according of the both specifications. Results of the trial designs indicate that dimensions of piers, footings and piles are different between the two cases.

2. DESIGN CONDITIONS

Design conditions in this study are as follows:

1) Superstructure: 5-span continuous steel I-typed girders (span length: 5×40m, width: 12m);

2) Bearing supports: Elastic at all piers and abutments in the longitudinal direction, elastic at 4 piers in the transverse direction, and fixed at 2 abutments in the transverse direction;

3) Pier to be designed: Pier No.1 (See Fig.1);

4) Foundation type: Bored- type (or cast- in drilled hole) concrete piles;

5) Soil conditions: Alternative layer with SPT N- value 10-15, thickness of surface soil: 18m.

The above conditions are taken from one example of the JRA reference design examples [3].

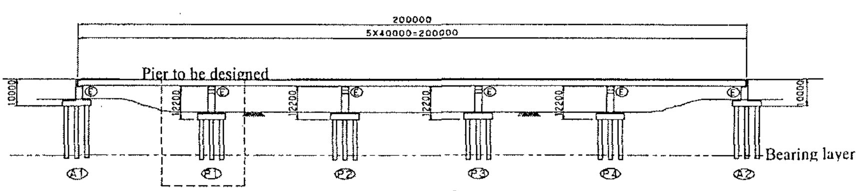

Fig.1 Side View of the Bridge Considered in this Study (After JRA Reference Examples [3])

E: elastic support

3. COMPARISON OF DESIGN CRITERIA AND DESIGN RESULTS

Design criteria/ conditions and the results of calculations based on the Caltrans BDS and the JRA Specifications are summarized in Table 1. BDS provides criteria only for so- called "ordinary bridges," which are most in California. Tow- level design (for moderate and severe events) is proposed as for future seismic design at Caltrans. It seems that Caltrans had introduced the one- level design (severe events) for the reason of economic consideration. On the other hand, the current JRA Specifications are based on the tow- level design. Fig.2 shows a comparison of elastic response

Bridge foundations, Caltrans BDS, Comparative study, JRA Specifications, Seismic design.

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spectra among BDS, JRA, and Eurocode 8 [4]. It is observed that there is some room for needs of discussions on design seismic actions. Maximum seismic actions were selected from respective response spectra, which have specific properties referring to their individual characters.

Results of the trial calculations are shown in Table 1. It is clear that the footing size and total pile volume in the Caltrans case are extremely smaller than the JRA case.

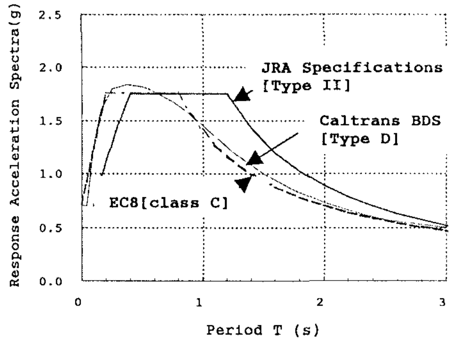

Fig. 2 Comparison of Response Acceleration Spectra among JRA, Caltrans and Eurocode 8

Table 1 Comparison of Design Criteria/ Conditions and Trial Results between Caltrans and JRA

Items	Caltrans BDS (1995)	JRA Specifications (1996)
Importance of bridge	Ordinary	Important
Seismic design	One- level design	Tow- level design
Design spectra (soil type)	Type D	Type II
Seismic actions for substructures	Case I: Trans. + 0.3 Long. Case II: Long. + 0.3 Trans.	Case I: Trans. Case II: Long.
Pier type	Column (Round φ2.1m)	Wall (Rectangular 2.2m × 5m)
Reduction of linear response	Z- factor (Z=5)	Equivalent Energy Assumption
Dimensions of footing	5.4m ×5.4m × 0.9m (depth)	8.5m × 8.5m × 2m (depth)
Dimensions of piles	φ400mm	φ1200mm
Numbers of piles	6 × 6 = 36	3 × 3 = 9

4. CONCLUDING REMARKS

In consideration of international code harmonization and construction cost reduction, a comparative study between the Caltrans BDS and the JRA Specifications was performed under the same conditions on superstructures and soils. The following can be concluded:

1) The Caltrans BDS has some provisions different from the JRA Specifications. The JRA Specifications seem more advanced, in terms of the application of deformation- based design.

2) Popular pier types and dimensions of footings/ piles are largely different between the two. Column piers are generally used in Caltrans in order to avoid nonlinear behavior of piles due to large seismic forces. On the other hand, wall- type piers are popular in JRA. It seems that this type distinction is a factor of making the difference in dimensions of footings and piles.

3) It is our understanding that Caltrans BDS, however, will be improved in near future by introducing the recommendations of the ATC- 32 [5]. New BDS may apply the deformation- based concept. The authors will continue to study on the bases of the differences between the two specifications and try to identify important factors for reducing construction cost of bridge foundations.

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[1] Japan Road Association: Specifications for Highway Bridges; Part V. Seismic design, 1996.

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