SEISMIC EVALUATION

OF

FOX ISLAND BRIDGE, NO. 26211-A

FOR

PIERCE COUNTY, WASHINGTON

JULY 15, 1994

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EXPIRES 7/31/96

HNTB

HNTB

FOX ISLAND BRIDGE #26211-A

SEISMIC EVALUATION

AUTHORIZATION

In compliance with the terms of *Supplemental Agreement Number 2 to Provide Structural Engineering Services for Fox Island Bridge #26211-A Analysis,* June 3, 1994, HNTB has completed a seismic evaluation. The methods, results, and conclusions of our evaluation are presented in this report.

DESCRIPTION

The Fox Island Bridge built in 1963 is a 1949-foot long structure that consists of four distinct bridge units described as follows: 1) three-span continuous haunched concrete T-beam with 65-foot spans supported on pile bents; 2) two-span continuous haunched concrete T-beam with 120-foot spans and 27-foot cantilevers at each end supported on frame bents; 3) 50-foot simple span concrete T-beam; and 4) 65-foot simple span rolled steel beam.

The integrity of the bridge with regard to withstanding region-probable seismic accelerations was evaluated by structural analyses. One of the three-span continuous units and one of the two-span continuous units were selected as representative of the whole bridge. The simple spans were evaluated for provision of minimum support lengths only, in accordance with the AASHTO Standard Specifications for Highway Bridges. Seismic forces and displacements were determined using computational software known as SEISAB operating on a VAX/VMS hardware platform. SEISAB generated seismic loadings using the multi-mode response spectrum technique adopted by AASHTO. Loads were applied to finite element models (FEM's) mathematically constructed from data extracted from engineering drawings provided by Pierce County. Data for the FEM's consist of geometry, mass, and stiffness properties calculated for selected points in the superstructures and substructures.

Parameters used in the analysis were as follows: 1) acceleration coefficient equal 0.29; 2) subsurface soils Type I; 3) yield strength of reinforcing steel, Fy = 40 ksi; 4) compressive strength of concrete, f'c = 3 ksi; 5) unit weight of concrete equal to 155 pcf; 6) spread footings fully restrained at bottom of seal; and 7) piles fully restrained at 4-feet above tip elevations.

Structural capacities for critical concrete bridge elements were determined in accordance with the current AASHTO *Standard Specifications for Highway Bridges* Load Factor Design Method. Ultimate pile capacities were taken as 3 times the minimum bearing value shown on the drawings; uplift assumed to be 50% of bearing capacity. Spread footings were investigated for stability against overturning only.

RESULTS

The results of the seismic analysis with regard to bridge element strengths is presented below in the form of direct numerical comparisons of demand and actual capacities for the critical elements of the bridge. The capacity ratio (CR) represents the amount of overload that would occur in an element, i.e. CR = 1.25 means that the element would experience a 25% overload.

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Element	Location	Demand Capacity	Actual Capacity	CR
Column of end frame bent	Two-span unit	M_u = 1770 ft-kips	$\varnothing M_n$ = 53 ft-kips	33.4
Base section of end frame bent	Two-span unit	M_u = 9590 ft-kips	$\varnothing M_n$ = 1620 ft-kips	5.92
Column of center frame bent	Two-span unit	M_u = 3200 ft-kips	$\varnothing M_n$ = 531 ft-kips	6.03
Base section of center frame bent	Two-span unit	M_u = 46,300 ft-kips	$\varnothing M_n$ = 7,570 ft-kips	6.12
20" battered pile	Three-span unit	P_u = 440 kips tension	$\varnothing P_n$ = 228 kips tension	1.93

The spread footings of the two-span unit were evaluated for stability with regard to overturning. The numerical results are presented below. The eccentricity ratio (ER) represents the tendency of the substructure to overturn in response to predicted seismic lateral loads. Specifically, it is the calculated eccentricity of the axial foundation force divided by one-third of the footing width, or ER = (Mot/P) divided by (B/3). An ER value greater than 1.00 indicates an instability problem, an ER value greater than 1.5 means the substructure will overturn.

Spread Footing Location	Force Eccentricity	1/3 Footing Width	ER
End pier of two-span unit	6.65ft.	3.33ft.	2.00
Center pier of two-span unit	22.4ft.	8.17ft.	2.74

A comparison of actual vs. "AASHTO Div. I-A" required end support lengths is presented below. Minimum end support length is required at expansion type bearings where no positive longitudinal linkage exists to prevent the superstructure from dropping off its end support due to seismic displacements. Any end support length that is less than the AASHTO required length constitutes an unstable configuration.

End Support Locations	Actual Support Length	AASHTO Required Support Length
Expansion end of steel beam units	10 1/4"	42"
Expansion end of three-span unit	14 1/4"	20 3/4"

CONCLUSIONS

The seismic analysis of the Fox Island Bridge indicates that the substructure is significantly undersized to withstand region-probable seismic accelerations. The mode of failure would likely be the collapse of the columns in the frame bents of a two-span unit near the main navigation channel. If all the columns of the frame bents were retrofitted to meet the demand capacity, the mode of failure would change to foundation instability and probable overturning of the frame bents.

A complete substructure retrofit of all bents is required to provide the demand capacity for seismic forces. A complete substructure retrofit would include full-height strengthening of the frame bents, enlarging and strengthening of the spread footings, and enlarging and strengthening the pile bents.

The results also indicate that the superstructure is inadequately constrained against falling off the end supports at expansion joints. End support lengths are less than the AASHTO requirements and no positive longitudinal linkage is provided. A complete superstructure retrofit would include installation of longitudinal, transverse and vertical restrainer devices at each expansion joint.