DGES, Inc.

ODOT - Interstate 5 Bridges over Columbia River

Seismic Retrofit of Truss Span Pier Foundations
Conceptual Design and Estimate

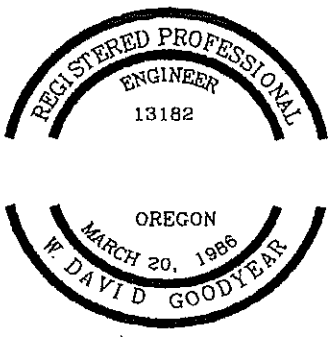
ODOT On-Call Design Contract 11814

Work Order No. 8

DGES Project No. 93-109.08

February 13, 1995

Draft



Description of Foundation Retrofit Concept

The design concept considered for estimating purposes consists of driving piles around the existing footings and constructing a surrounding pile cap which ties the new piles to the existing foundation units. The new piles are used to supplement (not replace) the capacity of the existing piles. The net effect of this concept is to create a single large foundation unit in place of the existing three separate foundation units at each pier.

Pier 2 was chosen as the basis of the conceptual design as it subjected to the largest seismic demand of those piers investigated in phase 1 (piers 1,2,3,4). Longitudinal loading governed at all piers investigated. As a result of the existing bearing arrangement, pier 2 must resist the full longitudinal load from both adjacent truss spans. All other truss piers (1-4, 6-13) resist the longitudinal force from a single adjacent span. Pier 4 carries the longitudinal load from the long span channel crossing (span 5). Although span 5 was not explicitly modeled for the phase 1 assessment, the mass of the span was estimated and was included in the overall seismic analysis. The demand on pier 4 is somewhat less than on pier 2. In conclusion, we expect pier 2 to be the most critical pier for the seismic design.

The elastic seismic demand is taken directly from the analytical results of phase 1. The three individual foundation reactions are combined for the design of the continuous retrofitted unit. The peak longitudinal overturning moments are summed together directly. The sum of the transverse overturning moments are reduced by the square root of 2 to acknowledge the likely phase differences between peak responses in this direction. The net vertical load on the pier is estimated by reducing the peak individual responses to account for the transverse frame action of the pier.

Assessment of the phase 1 analytical results indicates that the forces associated with plastic hinging of the pier columns exceeds the computed elastic demand. Therefore, elastic forces are used for the retrofit design of the foundation units.

The embedment length and the design capacities of the proposed piling for the retrofit design are estimated using the same approximate geotechnical idealizations and assumptions as were used in the analytical phase. The existing timber piles are assumed to have an ultimate bearing capacity of twice the plan specified working capacity of 40 tons. The existing piles are assumed to have no uplift capacity for the retrofit design. Pile uplift generally governs the retrofit design. New piles must be designed and detailed as anchor piles to resist the computed uplift.

The pile cap is connected to the existing footings by installing post-tensioning tendons in ducts drilled through the existing structure. The pile cap and tendons are sized to provide adequate nominal bending strength for transfer of the seismic overturning forces from the existing structure to the new piles.

Background of Estimate

In order to establish estimated costs for this construction scheme, contractors experienced in heavy marine work of this nature were consulted using preliminary versions of the design concept.

The cofferdam and seal are the most significant individual items from the standpoint of costs. The design of the cofferdam structure will be a major factor. The concept level design presented here does not investigate the details of the cofferdam structure. Sheet pile lengths were estimated using rule-of-thumb parameters. We have assumed that the cofferdam will be braced off to the existing structure. Cofferdam cost is estimated based on contractors' experience.

The concrete seal thickness is estimated by setting a vent elevation of +10' with the bottom of the seal set at the bottom of the existing footings. This elevation was chosen as a compromise to provide reasonably continuous access to the site while considering the limited headroom available under the existing bridge. We note that the 10-yr flood elevation at this location is +22.5' (as obtained from the ODOT Hydraulic Section via Steve Starkey of ODOT Bridge Section). River stages for more frequent recurrence intervals were not available at the time of inquiry. Considering the massive size of the seal and the cofferdam, the establishment of the design vent elevation could have a major impact upon final construction costs. This item warrants detailed consideration in the final design process.

Pile installation is affected by the limited headroom. Multiple splices will be required for each pile. The optimum pile type and size will depend to a large extent upon the experience and preferences of the contractor and upon available specialized equipment. For final design, we recommend that a full range of options be investigated and that the plans and specifications be designed to permit the contractors sufficient flexibility in this area.

The estimate was developed in some detail for pier 2. Costs for the other truss piers are estimated by subjectively assessing the differences with pier 2 and by using the pier 2 estimate as a baseline. A summary of this assessment follows.

- The retrofit of piers 3, 4, 6-10 will require a similar level of effort as for pier 2. The reduced longitudinal loading on these piers may permit the elimination of some piles, but there will be little or no reduction in the cofferdam and seal requirements. For the estimate, we assumed these piers will cost approximately 95% of the estimated cost of pier 2.

- Piers 11 and 12 are founded at a higher elevation than pier 2 and therefore it is expected that the cofferdam and seal requirements will be reduced at these locations. However, the reductions may be offset somewhat by the difficulties associated with further reduced headroom under the bridge near these piers and by the necessity of working these piers from the land side as opposed to the water-based operations anticipated at piers 2-4, 6-10. For the estimate, we assumed the overall costs for piers 11 and 12 will be approximately 90% of the estimated cost of pier 2.

- Pier 1 supports the north approach spans together with spans 1 of the truss configuration. Pier 1 was included in the phase 1 analysis. The approach spans were not explicitly modeled, but the mass was estimated and was included in the seismic analysis. The scope and configuration of pier 1 is significantly different from piers 2-4, 6-10. The overall size is smaller; the pile overload due to the computed elastic seismic demand is smaller. Headroom and water access is limited. Overall, we estimate the retrofit of pier 1 will cost about 25% of pier 2.

- Pier 13 supports the final truss spans at the south end of the crossing together with the south approach spans. The truss spans are supported on expansion bearings at pier 13. Loads on this pier are uncertain, but should be significantly less than the typical piers. However, the physical configuration is similar to those piers. Therefore, for the estimate, we assumed that retrofit of pier 13 will cost about 50% of pier 2.

Limitations and Recommendations

The estimate submitted here considers only the truss piers; approach piers and abutments are not included. The estimate also does not include any costs associated with the retrofit of the pier columns to provide additional strength and/or ductility to these elements.

We note that the retrofit of the foundation units will change the stiffness magnitude and configuration of the bridge. This will in turn effect the dynamic response and may change the level of seismic demand on the foundation units. Additional changes in response and demand could occur as the result of retrofit work on the bearings or on the columns. These changes can not be assessed without further analysis of the retrofitted system. Such analyses must be performed as a part of the final design work.

We also note that the phase 1 analysis which is used as the basis for this foundation retrofit estimate is based upon a limited set of geotechnical data and assumptions. Considering the costs of the anticipated work, we recommend a full geotechnical investigation and analysis as a part of the final design package. In addition to geotechnical stiffnesses and capacities, the issues of soil liquefaction and riverbed scour should be investigated. The design concept and estimate presented here does not consider these issues.

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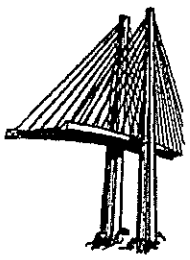

$ for col. confinement
& truss members
& brgs?

February 13, 1995

Mr. Phil Rabb
Oregon Department of Transportation
Rm. 329 Transportation Building
Salem, OR 97310

Re: Interstate 5 - Columbia River Crossing Seismic Survey
ODOT On-call Design Contract 11814, W.O. 8
DGES Project No. 93-109.08

Dear Mr. Rabb:

Enclosed for your initial review is a drawing illustrating one concept for reinforcing the truss pier foundations against the design seismic event. Also enclosed is our estimate of costs associated with this concept. An overview of the conceptual design and of the critical aspects of the cost estimate is provided in the enclosed summary.

Please offer any comments on the foundation scheme shown. We are available for discussion at your convenience. In the meantime, we are proceeding to develop concepts and estimates for truss bearing retrofits. We expect to submit bearing information in about 2 weeks (2/24).

We appreciate the opportunity to assist the Department with this interesting project.

Very truly,
DGES, Inc.

Glen Scroggins, PE

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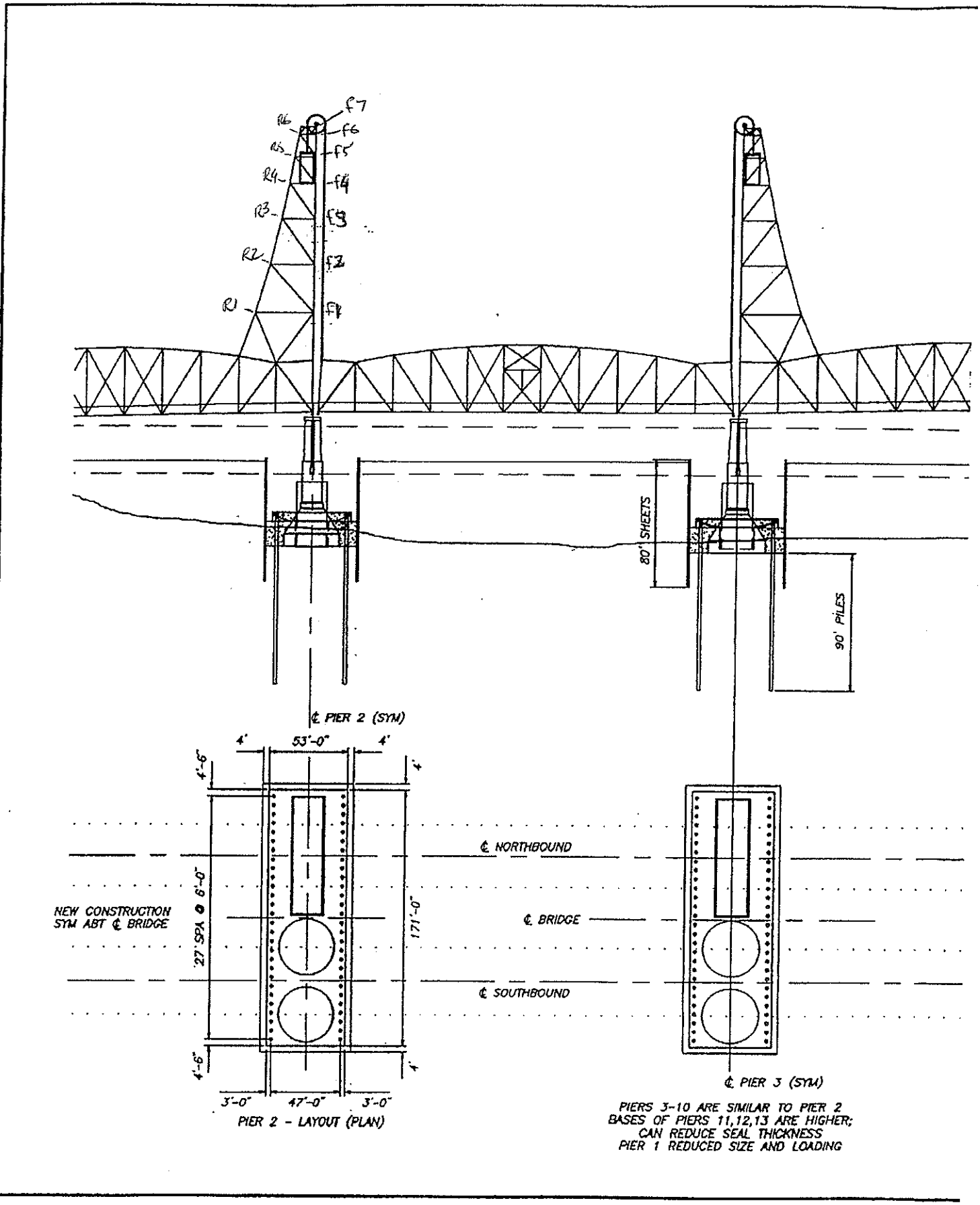
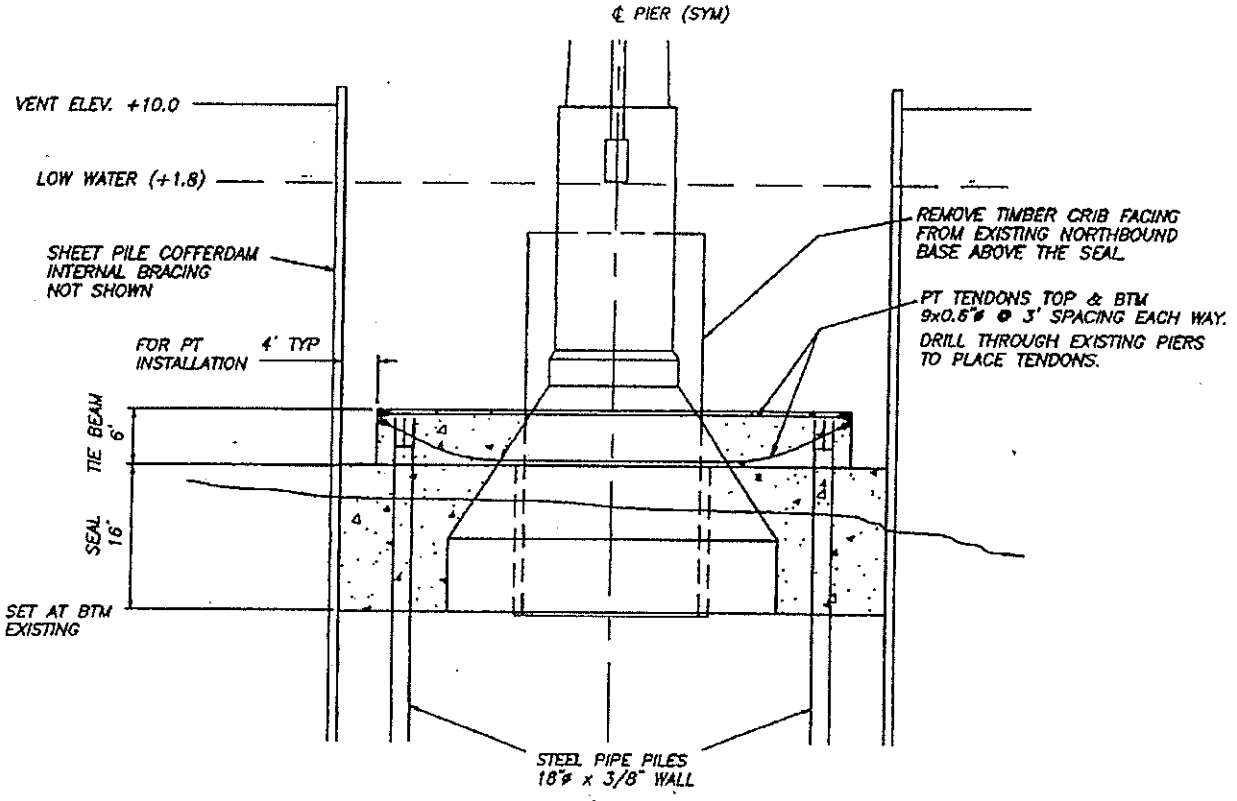
To PHIL RABB	From GLEN SCROGGINS
Co. ODOT	Co. DGES
Dept. BRIDGE	Phone # 360-754-0544
Fax #	Fax # 360-754-1714

RECEIVED
FEB 15 1995
BRIDGE DIVISION


R6
R5
R4
R3
R2
R1
F7
F6
F5
F4
F3
F2
F1
80' SHEETS
90' PILES
℄ PIER 2 (SYM)
4'
53'-0"
4'
4'-6"
4'
℄ NORTHBOUND
NEW CONSTRUCTION
SYM ABT ℄ BRIDGE
27' SPA @ 6'-0"
℄ BRIDGE
171'-0"
℄ SOUTHBOUND
4'-6"
4'
3'-0"
47'-0"
3'-0"
PIER 2 - LAYOUT (PLAN)
℄ PIER 3 (SYM)
PIERS 3-10 ARE SIMILAR TO PIER 2
BASES OF PIERS 11,12,13 ARE HIGHER;
CAN REDUCE SEAL THICKNESS
PIER 1 REDUCED SIZE AND LOADING



PRELIMINARY - NOT FOR CONSTRUCTION

DGES
CONSULTING ENGINEERS
OLYMPIA, WASHINGTON

TITLE

I-5 COLUMBIA RIVER BRIDGE
SEISMIC RETROFIT STUDY
FNDN REINFORCING CONCEPT

NO.	REVISION	DATE

DESIGNED		
DRAWN	G.S.	2/9/95
CHECKED		

DRAWING	REVISION
15R-1	0

I5AEST.XLS

DGES - FILENAME: I5AEST.XLS
LAST UPDATE: 2/10/95
ODOT - I5 COLUMBIA RIVER CROSSING
SEISMIC ASSESSMENT
ESTIMATE OF TRUSS FOUNDATION RETROFIT COSTS
BASED ON CONCEPT LEVEL DESIGN FOR PIER 2

ITEM	QUAN	UNIT	PRICE	TOTALS	COMMENTS
PIER 2					
PILES	6048	LF	$25	$151,200	
PILE INSTALLATION	56	EA (1000)	$2,000	$112,000	
PILE SPLICES	336	EA	$750	$252,000	
SHEET PILES (COFFERDAM)	39000	SF	$30	$1,170,000	
SEAL CONCRETE	4230	CY (150)	$200	$846,000	
PILE CAP CONCRETE	1740	CY	$300	$522,000	
POST-TENSIONING	72300	LB (175)	$2.45	$176,800	
CORING FOR PT	3200	LF	$100	$320,000	
MOBILIZATION/DEMOBILIZATION	1	LS	$150,000	$150,000	
TOTAL FOR PIER 2				$3,700,000	(3,700,000)
EXTENSION TO OTHER PIERS					
PIER 1	1	% PIER 2	25%	$925,000	REDUCED SIZE, LOADS
PIERS 3,4,6,7,8,9,10	7	% PIER 2	95%	$24,605,000	SIMILAR TO PIER 2 SLIGHTLY SMALLER LOADS
PIERS 11,12	2	% PIER 2	90%	$6,660,000	SMALLER SEALS/COFFERDAMS
PIER 13	1	% PIER 2	50%	$1,850,000	REDUCED LOADS
TOTAL TRUSS PIER FOUNDATION				$37,740,000	(34,000,000)
ENGINEERING			15%	$5,661,000	FINAL DESIGN INCLUDING GEOTECHNICAL & ADMINISTRATION
CONTINGENCY			10%	$3,599,000	
ESTIMATED TRUSS PIER FOUNDATION RETROFIT COST				$47,000,000	(43,000,000)