Multnomah County Willamette River Bridges Capital Improvement Plan

Seismic Vulnerabilities and Retrofit Report

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Multnomah County Willamette River Bridges Capital Improvement Plan

Seismic Vulnerabilities and Retrofit Report

1 INTRODUCTION

Multnomah County intends to develop a 20 year Capital Improvement Program which includes a programmatic evaluation and assessment of the seismic retrofit needs for the four major downtown Willamette River bridges owned by the County.

This report summarizes the vulnerabilities and proposed retrofits for the four moveable bridges: Broadway, Burnside, Morrison, and Hawthorne. The retrofits were developed based on the performance and earthquake levels outlined in Section 2 of this report.

The following guiding assumptions were used in developing this report.

- Identification of seismic vulnerabilities was based on existing reports, examination of existing bridge plans, simple hand calculations, and engineering judgment. No analyses or finite element models of the bridges were developed.
- Standard retrofit types was based on commonly used retrofit measures such as those noted in the Federal Highway Administration Seismic Retrofit Manual (FHWA), Oregon Department of Transportation (ODOT) Bridge Design and Drafting Manual, and the California Department of Transportation (Caltrans) Seismic Design Criteria.
- Detailed quantity breakdowns of the retrofit costs for each bridge were not developed.
- The geotechnical hazard vulnerabilities of liquefaction and lateral spreading were assessed based on existing geotechnical data.
- Retaining wall structures were not included in the seismic vulnerability assessment.
- Consistent retrofit strategies and costs were applied to similar components between the bridges.
- Retrofit strategies that address vulnerabilities in multiple components, such as base-isolation, were considered as system behavior modification retrofits.

The tables in Section 4 of the report briefly summarize the bridge component vulnerability and the retrofit course of action recommended for each earthquake level.

The vulnerabilities and retrofits for each bridge are provided in the appendices of this report. The appendices include comprehensive Seismic Vulnerability Forms for each bridge, representative figures showing the vulnerable components, and the background, notes and assumptions used to develop the construction cost estimates for each retrofit.

2 PERFORMANCE CRITERIA

In assessing the level of retrofit required, target performance levels and earthquake type are both required to determine the level of retrofit appropriate for each bridge. These, as well as the overall philosophy of the retrofit strategy, were developed for this project at a workshop session with Multnomah County and Consultant team staff.

2.1 Performance Levels

In determining the level of retrofit required, a desired performance level for each bridge was first determined. The Performance level definitions are provided in Table 1. These were developed using the FHWA Seismic Retrofit Manual as a guideline, but modified to provide definitions applicable to the Willamette River bridges.

Table 1. Performance Level Definitions

Performance Level	Abbr.	Definitions for Retrofit of Existing Structures
Do Nothing	DN	No retrofit measures undertaken.
No Collapse (Life Safety)	NC	No collapse with damage to foundations and some permanent deformation. May require significant repair and potential replacement of major structural components. Serviceability after the event is not assured.
Limited Operation	LO	Inelastic behavior allowing for emergency vehicles after inspection and removal of debris. Moveable components may not be able to operate without inspection, repairs, replacement and maintenance activities. Damage is repairable with or without impacts to traffic including limited permanent deformation. Foundations remain essentially elastic.
Full Operation (Serviceable)	FO	Essentially elastic for all main structural components, moveable components able to be operated after inspection, some repairs and maintenance activities. All traffic able to operate including river navigation.

2.2 Earthquake Levels

Three different Earthquake levels were selected for consideration. The probabilistic seismic hazard plots for each event are provided in Appendix D.

The 1000-yr event is the baseline major design event used by ODOT, FHWA, and the American Association for State Highway and Transportation Officials (AASHTO). This event in the Portland area has anticipated peak ground acceleration (PGA) of 0.28g.

The 500-yr event is used to capture a large event occurrence on the Cascadia Subduction Zone (CSZ) fault which has roughly 500 year return period and is a large contributor to the risk associated with a 500-yr CSZ event. According to ODOT, there is an estimated 37 percent chance of a large event (M8.0 – 9.0) on the Cascadia Subduction Zone Fault within the next 50 years. The anticipated PGA of the 500-yr CSZ event is 0.20g.

The 100-yr event is intended to capture a relatively minor seismic event and identify a minimal level of seismic upgrade that would provide some protection from collapse of the structures. The anticipated PGA of the 100-yr event is 0.07g.

The performance level targeted for each bridge and earthquake level is summarized in Table 2. In assigning importance categories to the bridges, the Burnside Bridge was considered essential and therefore was assigned higher performance levels for the given earthquakes than the other three bridges (which were considered standard).

Table 2. Bridge Earthquake Levels Summary

Earthquake Level (PGA)	Performance Level		Geotechnical Hazard (Liquefaction and Lateral Spreading)
	Broadway, Morrison, Hawthorne	Burnside	
100-year (0.07g)	NC	NC	Assume geotechnical hazards do not cause a collapse mechanism
500-year CSZ (0.20g)	NC	FO	Investigate / determine if geotechnical hazards cause a collapse mechanism
1000-year (0.28g)	NC	LO	Investigate / determine if geotechnical hazards cause a collapse mechanism

3 VULNERABILITIES AND RETROFITS

The current seismic design guideline for new bridges protects the foundation and superstructure by creating known fuses within the bridge. This is typically located in the columns, where seismic displacement and damage can be contained within a well detailed component. For existing bridges designed prior to the modern seismic codes, this type of fused system is often impractical; and so a variety of retrofit measures are used to develop a predictable and reliable seismic resistance system for the bridge structure. Additionally, ground improvement retrofits are often required to mitigate liquefaction and lateral spreading concerns.

Seismic retrofits are typically categorized according to what type of bridge behavior they are intended to protect. For typical girder type highway bridges, the conventional retrofit strategies are categorized as either a Phase 1 or Phase 2 type. For less common bridge types, such as trusses or arches, there are other general retrofits required to provide adequate seismic load path strengthening. In this report, we have designated these as "Load Path" retrofits. Lastly, for major bridges, there are retrofits that modify the dynamic behavior or interaction of the bridge structure as a means of protecting components. In this report, we have designated these as "System Behavior Modification" retrofits. Each of these retrofit types is discussed further below.

3.1 Phase 1 Retrofit

Phase 1 retrofits are intended to keep the superstructure from becoming disconnected from the substructure and collapsing. Phase 1 retrofits strengthen the first part of the primary load path, the connection of the superstructure to the substructure. These retrofits by themselves do not provide a complete seismic load path transfer mechanism but instead provide a relatively inexpensive solution to one common seismic failure mode.

As part of this study, the component retrofits that fit into a Phase 1 retrofit project are identified in the bridge summary tables shown in Section 4.

Typical Phase 1 retrofits recommended for the Willamette River bridges include:

- Replacement of failure prone bearings
- Extension of bearing seats
- Lateral and longitudinal restraint using cable restrainers or shear blocks
- Strengthening of girder bracing and diaphragms at the bearings
- Live load shoe or anchor strut modification to provide longitudinal restraint

3.2 Phase 2 Retrofits

Phase 2 retrofits are intended to provide a load path for anticipated seismic forces with adequate ductility from the superstructure to the ground. These retrofits typically include strengthening the substructure and typically involve significant costs; but together with Phase 1 retrofits provide a complete seismic retrofit solution for typical girder type bridges.

Typical Phase 2 retrofits recommended for the Willamette River bridges include:

- Encasement of columns using steel, concrete, or FRP to provide increased ductility and lateral strength
- Encasement and/or post-tensioning of bent caps and footings to provide adequate joint strength
- Footing enlargement and/or additional pile installation

3.3 Seismic Load Path Retrofits

The truss bridge and bascule components of the Willamette River bridges will require component retrofits that fall outside of the typical Phase 1 and Phase 2 retrofit types. These are typically component retrofits unique to the specific structure. They are designed to provide either a strengthened load path or to limit displacements of some bridge elements.

The types of retrofits in this category include:

- Strengthening of truss lateral bracing including counterweight braces
- Strengthening of trunnion supports
- Introduction of strengthening shear walls
- Broadway Rall wheel beam or Hawthorne tower strengthening

3.4 System Behavior Modification Retrofits

Each of the prior retrofit types targets a specific component of the bridge. The last type of retrofit employed in this study includes both base isolation and friction damped bracing systems that modify the bridge's dynamic behavior in a seismic event. This is accomplished by changing not only the capacity of a specific component, but the load and displacement demands that the bridge system undergoes in a seismic event.

A base isolation system works by providing a displacement isolation layer coupled with an energy absorbing damping device between components of the bridge. The intent of these measures is to limit the amount of seismic energy that is transferred from the ground into the structure. For the bridges in this study, this involves isolating the trusses and bascule spans from the piers. In most cases this, will serve to reduce the force demands in the superstructure and substructure, while increasing the relative displacements between the superstructure and substructure. A modified gap or joint will also be necessary to accommodate this increased movement.

A friction damped bracing systems acts as a seismic energy shock absorber and limits the overall system response. These are less common in the bridge industry but are more common in tall buildings and towers. Given the limited analysis scope of this study, it is assumed that they will be effective as part of the retrofit of the Hawthorne towers.

These retrofits require significant analysis to determine the right fit for the systems; however, it typically results in less strengthening requirements and less cost than strengthening the substructure to resist anticipated seismic force demands. In the bridge summary tables included in Section 4, the retrofits that will be affected by the inclusion of a system retrofit are identified.

As a consequence of base isolation, due to the higher displacement incurred, there are usually additional bridge components that require retrofit. These include deck joints and other movement limiting elements. This is a particular challenge for moveable bridges because large displacements, which are essential for absorbing energy within the base isolation systems, can negatively impact the operating machinery. As such, the system modification devices must be designed in a manner that does not compromise the bridge's operability following a seismic event. The additional cost of these modifications is usually significantly less, however, than the cost associated with traditional strengthening retrofits.

4 BRIDGE SUMMARIES

4.1 Broadway Bridge

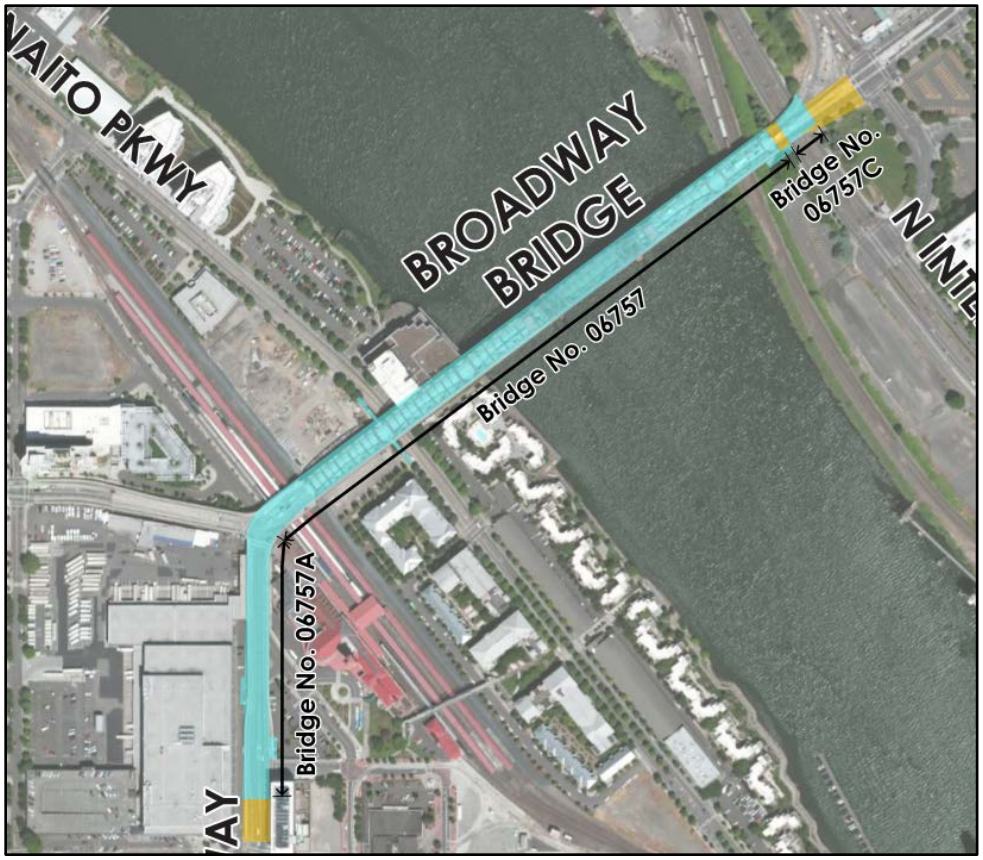
4.1.1 Bridge Background

The Broadway Bridge was originally constructed in 1912. Since then, numerous upgrades have been made to the mechanical systems and the bascule deck has been retrofitted with an FRP deck system. No seismic retrofits have been added to the bridge.

Union Station rail lines and SW Naito Parkway run under the west end of the bridge with an additional Union Pacific rail line under Span 7 on the east bank of the river. The Streetcar was reintroduced across the bridge in 2011 and the MAX lightrail line runs under the east approach structure.

For all earthquake levels on the Broadway Bridge, a performance level of No Collapse (NC) has been set.

Figure 1. Broadway Bridge Overview



4.1.2 West Approach Vulnerabilities

The West Approach of the bridge is made up of a steel floorbeam and stringer system supporting a concrete deck. The floorbeams are supported by steel built-up columns on spread footings.

Under the 500-yr CSZ and 1000-yr events, the primary vulnerabilities are the column and footing strength. Encasement of the columns and strengthening of the footings using an enlarged footing and micro-piles is the recommended retrofit.

Additionally the expansion bearing seats are insufficient and require retrofit for any of the seismic earthquake event levels. According to past studies in the area, there is potential for liquefaction or lateral spreading under the west approach. The mitigation required for this vulnerability is soil strengthening or densification.

4.1.3 Fixed River Spans Vulnerabilities

The Fixed River Spans of the Broadway Bridge are made up of five through truss spans with lengths from 184'-10¾" to 297'-2½" and a steel stringer and floorbeam span (Span 1) with a length of 125'-4¾". The trusses are supported on either concrete filled circular steel columns, or on concrete pier walls with stone cladding. Piers 1 through 3 are founded on concrete footings on concrete and timber piles. Piers 4 through 7 are founded on spread footings with deep caissons. The east abutment supporting span 7 is a retaining structure with fill behind it.

The vulnerabilities relevant to the piers supporting the moveable span (Piers 5 and 6) are described in the Moveable span section. The vulnerabilities of Span 1 and the L-B span, which is the transition between the west approach and the main river spans, are similar to those of the west approach.

The vulnerabilities in the fixed truss spans reside primarily with the columns and pier walls and the connection of the superstructure to the substructure. For the large events, a base isolation system under the truss spans is recommended to reduce the loads in the tall piers and to stabilize their connections to the superstructure. For the 100-yr event, improved connections between the superstructure and substructure are recommended.

According to a prior 1996 seismic analysis, the foundations were found to be stable with the exception of the liquefaction potential. If the recommended base isolation system is used for the truss spans, the loading to the deep foundations will be lessened and the risk will be reduced further.

4.1.4 Moveable Span Vulnerabilities

The Moveable Span of the Broadway Bridge is a 278'-long double leaf Rall wheel type bascule span. The counterweights are held above the bridge deck and the leaves are intended to be supported by the live load shoes and the anchor struts (although it appears that the Rall wheels support much of the weight as well). The bascule deck is a lightweight FRP deck system.

In addition to the vulnerabilities of the tall piers, which are similar to the vulnerabilities described for the fixed river span piers, the composition of the lift mechanism and counterweight present significant seismic vulnerabilities. In particular, the raised counterweight presents challenges for transferring the large inertial forces from the counterweight to the substructure. In its as-constructed state, the path is through the lateral support truss members, to the Rall wheel, and then to the truss components supporting the Rall wheel. Further, the anchor struts are critical members for the stability of the bascule leaves, but are not detailed to perform under seismic displacements.

The recommended retrofit for the moveable portion of Broadway Bridge is a combination of a base isolation system for the bascule spans, strengthening the lateral force transfer trusses, and adding lateral restraints to some components. The base isolation will serve to limit the forces and differential movements that the moveable components see because the superstructure system will move as a unit. It will also reduce forces in the substructure.

4.1.5 East Approach Vulnerabilities

The East Approach of the Broadway Bridge complex is a 2-span cast-in-place frame with fully integral superstructure to abutment and pier connections. In addition, there are concrete ties across the bottom providing a longitudinal link between the footings that result in a closed frame. The structure has good redundancy and the fill on either end of the bridge is anticipated to limit the overall structure movements and demands. For the 500-yr CSZ and 1000-yr events, the frame connections at top and bottom of the abutments and interior pier should be strengthened.

4.1.6 Retrofit Summary

Table 3 summarizes the results of the Seismic Vulnerabilities Assessment for the Broadway Bridge. The table identifies: (1) anticipated Phase 1 retrofit measures; (2) retrofit measures for each earthquake level; and (3) retrofit measures that are modified by the system retrofits. A description of each vulnerability and the recommended retrofit measures for each seismic level is included in Appendix A. Figures associated with each vulnerability can be found in Appendix B.

Table 3. Broadway Bridge Summary Table

Location	Number	Component	Phase 1 Retrofit	100-Yr	500-Yr CSZ	1000-Yr	Modified by System Retrofit
West Approach	1	Steel Columns			X	X	
West Approach	2	Exp. Bearing Seat Widths	X	X	X	X	
West Approach	3	Footings - Strength			X	X	
West Approach	4	Footings - Geotech Hazard			X	X	
Fixed Spans	1	Pier 2 Steel Columns		X	X	X	X
Fixed Spans	2	Pier 1, 3, 4, 7 Columns			X	X	X
Fixed Spans	3	Pier 2, 3, 4, 7, E. Abut Brngs	X	X	X	X	X
Fixed Spans	4	Pier 2, 3, 4, 7 Conc. Piers			X	X	X
Fixed Spans	5	Staircase Connection	X		X	X	X
Fixed Spans	6	Piers 1, 2, 3 Geotech Hazard				X	
Fixed Spans	7	Pier 4 Geotech Hazard				X	
Moveable Span	1	Piers 5, 6 Pier Walls			X	X	X
Moveable Span	2	Pier 5, 6 Bearings	X		X	X	X
Moveable Span	3	Pier 5, 6 Footings			X	X	X
Moveable Span	4	Anchor Struts	X	X	X	X	X
Moveable Span	5	Rall Wheel Track	X	X	X	X	X
Moveable Span	6	Truss Frame Counterweight		X	X	X	X
Moveable Span	7	Truss Frame at Rall Wheel		X	X	X	X
Moveable Span	8	Bascule Lateral Movement	X	X	X	X	X
Moveable Span	9	Live Load Shoes	X	X	X	X	X
East Approach	1	Conc. Frame Abutments			X	X	
East Approach	2	Interior Pier Wall			X	X	

4.2 Burnside Bridge

4.2.1 Bridge Background

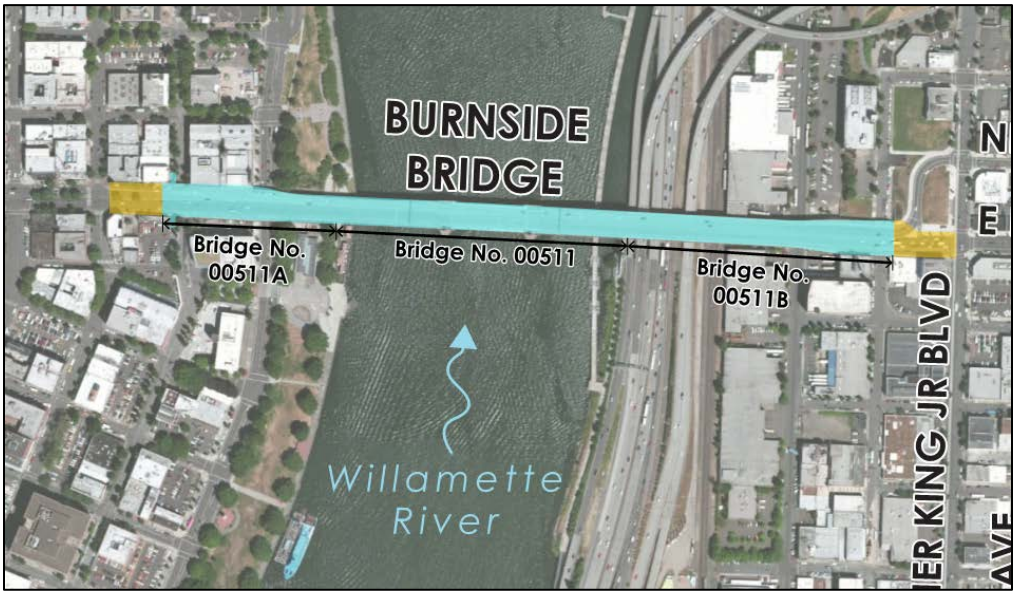
The Burnside Bridge was originally constructed in 1926. Since then, numerous rehabilitations have been made to the bridge's structural, mechanical, and electrical systems.. In 2001 a microsillica concrete deck overlay was added to the fixed and approach spans, and the deck for the main river spans was replaced in 2005. The following seismic retrofit improvements have been added to the bridge in either 2001 or 2005:

- Seismic restraints tying the superstructure to the substructure on the bridge approaches at Bents 1, 5, 8, 11, 14, 16-19, 22, 24, 26, 31, 33, 34
- Installation of seismic restraints and modification of bearings on Piers 1 and 4
- Installation of main trunnion support struts.

Tri-County Metropolitan Transportation District of Oregon (Trimet) light rail lines run under the West Approach (Span 3) of the bridge, and Union Pacific Railroad lines run under the East Approach (Span 23). The West Approach (Spans 5-13) and East Approach (Spans 28-32) are all in close proximity to adjacent buildings.

Metro, the elected regional government for the Portland metropolitan area, originally established Burnside Street as the seismic lifeline route across the Willamette River in the Portland area. This designation, which includes the Burnside Bridge, was made as part of its *Regional Emergency Transportation Routes* publication dated March, 1996. Because of this designation, the bridge's performance level for the 1000-year event was set as Limited Operation (LO), and the performance level for the 500-year CSZ event was set as Full Operation (FO). This means that the level of retrofit required to address a given vulnerability could be significantly greater than any of the other three bridges with an equivalent vulnerability. For example, a bearing retrofit under a No Collapse performance level would likely be a seat extender to catch the superstructure element. Under a Full Operation level, however, the bearing will need to be replaced and lateral restraints would need to be installed to control the anticipated movements. The impact of this higher performance level is captured within the higher retrofit costs associated with this bridge.

Figure 2. Burnside Bridge Overview



4.2.2 West Approach Vulnerabilities

The Burnside Bridge West Approach consists of: (1) sixteen spans of a reinforced concrete floor beam with multiple stringers and a concrete deck structure; and (2) three spans of reinforced concrete deck girders (RCDGs). For Spans 1-16, the floor beams are supported by concrete columns on spread footings. For Spans 17-19, the deck girders are supported by concrete columns on timber pile supported footings with enlarged bases and pile caps.

Under the 500-yr CSZ and 1000-yr events, the primary vulnerabilities are in the column lateral strength, superstructure to column connections, pier caps, and footing size. Encasement of the columns, superstructure to column connection and pier caps, and strengthening of the footings using an enlarged footing and micro-piles are the recommended retrofits.

Additionally, the expansion bearing seats are insufficient and require steel or concrete seat extension or catcher block retrofit for any of the earthquake event levels.

4.2.3 Fixed River Spans Vulnerabilities

The two Fixed River Spans are 268 feet long of constant depth steel deck trusses and a reinforced concrete deck. The spans are supported on lightly reinforced columns connected to timber piles footings with unreinforced pile caps on one end, and supported on the bascule piers on the other end.

Under the 500-yr CSZ and 1000-yr events, the timber piles are vulnerable to in uplift for applied loads in the bridge's longitudinal direction. This is due to the effects of the approach spans which are fixed at Piers 1 & 4. However, if the footing is retrofitted to allow it to rock, the uplift in the piles should not constitute a collapse-threatening situation. Additionally, the columns are poorly detailed for ductile behavior and in a high seismic event, would quickly deteriorate and lose vertical load carrying capacity. A steel shell retrofit of the piers is recommended for vertical capacity preservation and ductility. Last, the bearings and joints of the trusses are deficient and require retrofit measures.

According to past studies in the area, there is potential for liquefaction or lateral spreading around Piers 1 and 4. The mitigation required for this vulnerability is soil densification.

For the 100-year seismic hazard event, only the bearing and joint vulnerabilities identified above would be needed. Additionally, the overhead sign structure and light poles could collapse onto the bridge during seismic events and present serviceability challenges. It is also recommended that the truss diagonal and vertical member connections to the top and bottom chords be reviewed for potential overstress at the 500-yr CSZ and 1000-yr events.

4.2.4 Moveable Span Vulnerabilities

The Burnside Bridge's main river crossing span is a 252 feet long (trunnion-to-trunnion) double leaf steel deck truss bascule span. Reinforced concrete decks on the variable-depth bascule leafs are supported on concrete bascule piers which also house the counterweight and bascule machinery. Each bascule pier includes 35-44 foot unreinforced concrete walls from the pit floor to the top of the pile cap. The piers are connected with straight dowels to the unreinforced pile caps founded on timber piles.

In order to meet the designated performance levels for the bridge (including the moveable component's ability to operate after the 500-yr CSZ event), the retrofit is anticipated to be extensive and require a much higher level of effort than a similarly retrofitted component meeting the no collapse criteria.

A prior 1996 seismic analysis report stated that seismic isolation would not lead to a reduction in load demand on the foundations due to the very large and stiff foundations. Instead, alternative methods of foundation strengthening would be required. Based on our assessment, the timber piles would likely fail in both compression and uplift. The mitigation required for this vulnerability is the addition of steel piles around the perimeter of the footings. The pier walls under the truss seats have poor reinforcing details and would fail in a large seismic event - resulting in the loss of axial support capacity. An encasement retrofit of the pier walls is recommended to maintain vertical load capacity.

The bascule leaves and moveable components will require strengthening, and it is recommended that a base isolation system be installed in order to limit the seismic demand into the superstructure. The trunnion support posts are severely undersized and will likely require replacement concurrent with the base isolation system installation. The bracing of the bascule leaf appears significantly undersized to transfer seismic forces from the heavy deck and counterweights down into the substructure. Intermediate braces or replacement of existing braces is recommended.

Lateral and longitudinal restraint is lacking throughout the system. To accommodate this retrofit of this element, the following procedures are recommended:

- Construct a repairable structural fuse in the links in order to alleviate excessive force transfer into the light floor framing of the machinery room.

- Construct a steel strut to restrain the longitudinal movement and weak connection of the counterweight link to the machine room floor framing.

For the 100-year seismic hazard event, it is anticipated that the trunnion vertical posts, expansion joints, restrainers, and machinery room flooring vulnerabilities will need to be retrofitted.

4.2.5 East Approach Vulnerabilities

The Burnside Bridge East Approach consists of: (1) eight spans of 2-concrete encased steel plate girders with integral concrete encased floor beam superstructure; and (2) seven spans of multiple reinforced concrete deck girders superstructure. The steel structure spans are supported on two concrete encased steel columns on timber pile foundations with enlarged bases and pile caps. The concrete superstructure spans are supported on four concrete columns on spread footings.

Bents 21-27 have a low risk of foundation failure due to seismic hazards. This is due to the fill above the footings, the bracing between columns, and the large size of the footing compared to the columns. For Bents 28-34, the spread footings are buried in the ground and the columns are restrained by the roadway pavement at grade. This also results in a low risk of foundation failure.

In general, the vulnerabilities of the structures include the expansion joints between, loss of superstructure support due to unseating, inadequate superstructure to column connection, and large deck overhangs supported by a single floor beam.

For the 500-yr CSZ and 1000-yr events, the primary retrofit measures include columns encasement, in-fill walls, and connection strengthening. Strengthening of some footings and some additional Phase 1 retrofit measures are also required. Because of the higher performance levels required of the Burnside Bridge, these retrofits will be significantly more extensive in order to maintain a nearly elastic response of the structure.

4.2.6 Retrofit Summary

Table 4 summarizes the results of the Seismic Vulnerabilities Assessment for the Burnside Bridge. The table identifies: (1) anticipated Phase 1 retrofit measures; (2) retrofit measures for each earthquake level; and (3) retrofit measures that are modified by the system retrofits. A description of each vulnerability and the recommended retrofit measures for each seismic level is included in Appendix A. Figures associated with each vulnerability can be found in Appendix B.

Table 4. Burnside Bridge Summary Table

Location	Number	Component	Phase 1 Retrofit	100-Yr	500-Yr CSZ	1000-Yr	Modified by System Retrofit
West Approach	1	Bent Columns and super to sub conn.	X	X	X	X	
West Approach	2	Footings			X	X	
West Approach	3	Super. Seating on Expansion Bents	X	X	X	X	
West Approach	4	Pier Caps			X	X	
Fixed River Spans	1	Geotech - Liquefaction hazard			X	X	
Fixed River Spans	2	Geotech - Lateral Spread			X	X	
Fixed River Spans	3	Piers 1, 4 Foundation Timber Piles			X	X	
Fixed River Spans	4	Piers 1, 4, Columns			X	X	
Fixed River Spans	5	Fixed Bearing Conn. & Seat Width	X	X	X	X	
Fixed River Spans	6	Exp. Bearing. Conn. & Seat Width	X	X	X	X	
Fixed River Spans	7	Joints in Deck System Piers 1, 4	X	X	X	X	
Fixed River Spans	8	Piers 1, 4 Approach Fixed Conn.	X	X	X	X	
Fixed River Spans	9	Truss Conn. of Primary Members			X	X	
Fixed River Spans	10	Overhead Sign Structures			X	X	
Fixed River Spans	11	Lightings			X	X	
Moveable Span	1	Pier 2, 3 Foundation Timber Piles			X	X	
Moveable Span	2	Truss Seating on Piers 2, 3 Walls	X		X	X	X
Moveable Span	3	Conn.-Trunnion Support Vert. Post	X	X	X	X	X
Moveable Span	4	Conn.-Trunnion Anchorage	X		X	X	X
Moveable Span	5	Joints in Deck System Piers 2, 3	X	X	X	X	X
Moveable Span	6	Bascule Leaf Transverse Restraint	X	X	X	X	X
Moveable Span	7	Bascule Leaf Transverse Bracing	X		X	X	X
Moveable Span	8	Counterweight Restrainers	X	X	X	X	X
Moveable Span	9	Counterweight Link Fuse	X	X	X	X	X
Moveable Span	10	Mechanical Working Parts			X	X	X
Moveable Span	11	Pier Houses & Lightings			X	X	
East Approach	1	Connection - Pier to Foundation		X	X	X	
East Approach	2	Bent Columns		X	X	X	
East Approach	3	Rocker Bearings	X	X	X	X	
East Approach	4	Seat Width	X	X	X	X	
East Approach	5	RCDG Superstructure to Sub Conn.	X	X	X	X	
East Approach	6	Seating on Abutment	X		X	X	
East Approach	7	Large Overhang Floorbeam Support			X	X	

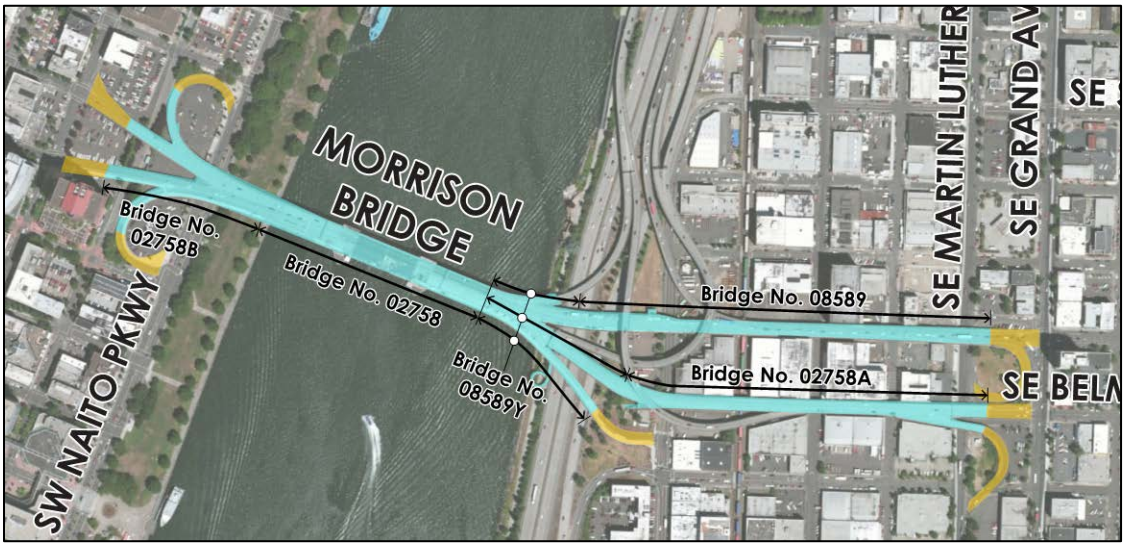
4.3 Morrison Bridge

4.3.1 Bridge Background

The Morrison Bridge was constructed in 1954, and the original design considered an equivalent seismic lateral force of 3% of the total dead load (0.03g). From the original construction some upgrades have been made to the mechanical systems and the bascule deck has been retrofitted with an FRP deck system. No seismic retrofits have been added to the bridge.

For all earthquake levels on the Morrison Bridge, a performance level of No Collapse (NC) was set.

Figure 3. Morrison Bridge Overview



4.3.2 West Approach Vulnerabilities

The bridge structure is comprised of a composite steel plate girder with concrete deck superstructure, reinforced concrete substructure (seat type bent cap with multi-column bent) and pile cap/spread type footing foundation.

The major vulnerabilities of the West Approach are a lack of proper seismic detailing in the columns joint connection to adjacent members such as the footing or bent cap, and a restraint to prevent unseating of the superstructure. Overall, 19 bents and 4 abutment locations require retrofit measures.

The current reinforcement of the Morrison footing-to-column and column-to-cap connection is vulnerable to joint shear failure (a mechanism commonly observed through research testing). This will present major challenges in a 1000-yr and 500-yr CSZ event. Joint replacement or strengthening of the pile cap and footing are also recommended. Additionally, the embedment of the piles in the pile cap is vulnerable to pull out or yielding if the moment transferred into the foundation exceeds the tension capacity of the footing. This is due to a thin concrete cover at the base of the pile cap and no observable anchorage of the pile head. The recommended retrofit measure is to provide an additional layer of concrete to increase the embedment depth.

Other vulnerabilities include a lack of transverse and longitudinal restraints at the bent caps to prevent the superstructure from unseating, strength concerns of the existing diaphragm members to distribute the seismic force to the substructure, and a lack of restraints at the in-span hinges. A traditional Phase I retrofit consisting of longitudinal cable restrainers, transverse reinforced concrete shear keys and diaphragm strengthening is recommended. In a 100-yr event, however, only longitudinal and transverse restraints are required.

4.3.3 Fixed River Spans Vulnerabilities

The East and West Fixed River Spans (referred to as Side Spans in the as-constructed drawings) cross over the Willamette River as steel trusses. They are comprised of a concrete deck supported by steel stringers and floorbeams. The end bearings of the truss rest a pier cap with four columns at the end adjacent to the river banks and the main large river piers on either end of the moveable span at the other end. The four columns at the river banks are supported by a pier wall type substructure and a pile cap foundation. The upper portion of the piles are protected by a seal course and cofferdam.

The deficiencies in the Fixed Spans are similar to the Approach Spans in that the footing, columns, and pier caps all lack proper rebar detailing. This includes insufficient embedment depth, confinement and joint protection. It is also anticipated that the existing fixed and expansion bearings are not adequate to transfer seismic loads or to accommodate large superstructure displacements.

The truss bearing connections utilize a rocker type bearing that often perform poorly under earthquake loads. The support it provides to the girder could be compromised if excessive movement is experienced and a replacement of these bearings is recommended. In addition, the lateral components of the truss superstructure (diaphragms, top and bottom struts) appear to be undersized and are at risk for buckling during cyclic loading. Under a 500-year CSZ or 1000-year event, it would require strengthening or replacement to transfer the seismic forces through the bearings.

Increased ductility is needed to address the substructure and foundation detailing deficiencies. Additional lateral capacity can be provided to the column with steel jacketing. The bent caps and footing will also need strengthening with additional doweled bars or prestressing. These items should also take priority during a 500-yr CSZ and 1000-yr seismic event.

The proposed retrofit measure for the fixed spans is to replace the bearings with base isolation devices. This will serve to minimize the forces in both the substructure and superstructure. Modifications to the joints and gaps on either side of the bascule span piers will also be necessary to enable the base isolation system to displace.

A portion of the Fixed Span extends into the pit area where the bascule counterweight space is located. This span likely has insufficient bearing width and inadequate deck support from the truss members. Seat extenders are commonly used to increase bearing width and replacement of the truss members is recommended.

4.3.4 Moveable Span Vulnerabilities

The Moveable Spans of the Morrison Bridge (referred to as the Bascule Spans in the as-constructed plans) consist of two twin steel truss superstructures, each resting on a mechanical trunnion with a counterweight fixed to the heel of the span. In Figure 3 above, the Movable Spans are includedas part of Bridge No. 02758. It has a concrete slab deck that is supported by a series of stringers and floorbeams. At a distance of approximately 37’-6” to the toe of the bascule, the top and bottom chords of the truss frame into plate girders.

Anticipated deficiencies include the capacity of the lateral supports of the trunnions, and the capacity of the bearings to transfer seismic loads to the substructure. These must be addressed for all earthquake levels. Strengthening of the truss lateral members, such as the top and bottom struts, counterweight bracing, and diaphragms is recommended. The trunnion would also need to be restrained transversely and longitudinally to prevent unseating.

A base isolation system is an option for the higher seismic levels (500-yr CSZ and 1000-yr). The existing trunnion would be replaced with a reduced height trunnion supported by a base isolation device to decrease the seismic loads transferred to the superstructure and the counterweight supports. Strengthening of the concrete trunnion support frame beams are included.

4.3.5 East Approach Vulnerabilities

The East Approach spans of Morrison Bridge end at the intersection two major streets: SE Morrison Street and SE Belmont Street. In Figure 3 above, it is listed as Bridge No. 08589 and No. 02578A. Similar to the West Approach, the East Approach consists of a composite steel plate girder and concrete deck superstructure with a reinforced concrete column substructure on spread footing foundations.

The major vulnerabilities of the East Approach can be summarized by a lack of proper detailing in the columns joint connection to adjacent members, and a lack of restraint to prevent unseating of the superstructure. Overall, 61 bents and 5 abutment locations require retrofit measures.

The retrofit solutions for the West Approach can also be applied to the East Approach due to the similarities in structure type. This includes column joint rehabilitation or replacement, column jacketing, superstructure collapse prevention with bearing restraints, and a strengthening of the spread footings. Only under the 500-yr CSZ and 1000-yr earthquake will substructure and foundation strengthening be required.

4.3.6 Retrofit Summary

Table 5 summarizes the results of the Seismic Vulnerabilities Assessment for the Morrison Bridge. The table identifies: (1) anticipated Phase 1 retrofit measures; (2) retrofit measures for each earthquake level; and (3) retrofit measures that are modified by the system retrofits. A description of each vulnerability and the recommended retrofit measures for each seismic level is included in Appendix A. Figures associated with each vulnerability can be found in Appendix B.

Table 5. Morrison Bridge Summary Table

Location	Number	Component	Phase 1 Retrofit	100-Yr	500-Yr CSZ	1000-Yr.	Modified by System Retrofit
West Approach	1	Footing - Rebar Detailing			X	X	
West Approach	2	Footing - Pile Embedment			X	X	
West Approach	3	Column - Rebar Detailing			X	X	
West Approach	4	Bent Cap - Trans/Long Restrainers	X	X	X	X	
West Approach	5	Bent Cap - Rebar Detailing			X	X	
West Approach	6	Superstructure Bearing Connections	X	X	X	X	
West Approach	7	Superstructure Diaphragms	X		X	X	
West Approach	8	Expansion Joint Restrainers	X	X	X	X	
Fixed Spans	1	Footing - Rebar Detailing			X	X	X
Fixed Spans	2	Column - Rebar Detailing			X	X	X
Fixed Spans	3	Bent Cap - Rebar Detailing			X	X	X
Fixed Spans	4	Trunnion Support Frame		X	X	X	X
Fixed Spans	5	Superstructure Bearing Connections	X	X	X	X	X
Fixed Spans	6	Superstructure Diaphragms	X		X	X	X
Fixed Spans	7	Truss Laterals			X	X	X

Location	Number	Component	Phase 1 Retrofit	100-Yr	500-Yr CSZ	1000-Yr.	Modified by System Retrofit
Fixed Spans	8	Pit Span Bearing Seats	X	X	X	X	
Fixed Spans	9	Deck Support Columns at Pit Span	X	X	X	X	X
Moveable Span	1	Trunnion Bearings/Live Load Shoes	X	X	X	X	X
Moveable Span	2	Superstructure Diaphragms	X		X	X	X
Moveable Span	3	Bascule Truss Lateral Brace	X		X	X	X
Moveable Span	4	Truss Bearing Anchor Bolts	X	X	X	X	X
Moveable Span	5	Counterweight Braces	X	X	X	X	X
Moveable Span	6	Trunnion Beam			X	X	X
Moveable Span	7	Piers 2 and 3 (including trunnion support frames)			X	X	X
East Approach	1	Footing - Rebar Detailing			X	X	
East Approach	2	Footing - Pile Embedment			X	X	
East Approach	3	Column - Rebar Detailing			X	X	
East Approach	4	Bent Cap - Trans/Long Restrainers	X	X	X	X	
East Approach	5	Bent Cap - Rebar Detailing			X	X	
East Approach	6	Superstructure Bearing Connections	X	X	X	X	
East Approach	7	Superstructure Diaphragms	X		X	X	
East Approach	8	Girders			X	X	
East Approach	9	In Span Hinge Restrainers	X		X	X	

4.4 Hawthorne Bridge

4.4.1 Bridge Background

The Hawthorne Bridge was originally constructed in 1910 and is now the oldest operating vertical lift bridge in the United States. Since its original construction, numerous upgrades have been made to the bridge including upgraded mechanical/electrical systems and widened sidewalks. In 1992, the transition spans on the East Approach, also known as the Water Avenue ramp, were replaced and some seismic details were included on that structure.

For all earthquake levels on the Hawthorne Bridge, a performance level of No Collapse (NC) was set.

Figure 4. Hawthorne Bridge Overview

4.4.2 West Approach Vulnerabilities

The West Approach spans are generally comprised of concrete columns and bent caps on concrete spread footings or pile caps. The superstructure consists of prestressed girders with a cast-in-place concrete deck.

Under the 500-yr CSZ and 1000-yr earthquake events, the primary vulnerabilities are insufficient flexural capacity in the columns and footings, and the potential for the superstructure to unseat at the bearings. Encasement of the columns and a strengthening of the footings using an enlarged footing and micro-piles is the recommended retrofit. The bent caps will also need to be strengthened to force hinging in the newly strengthened columns.

Seat extensions will be needed at the expansion joints to prevent the superstructure from falling off for all of the seismic earthquake levels.

4.4.3 Fixed River Spans Vulnerabilities

The Fixed River Spans of the Hawthorne Bridge are comprised of five through truss spans with lengths from 209'-3" to 244'-3½". The trusses are supported on large pile supported unreinforced concrete footings and pier walls. Span 5, the movable span, is supported by tall towers with counterweights in Spans 4 and 6.

At the 500-yr CSZ and 100-yr events, the vulnerabilities in the fixed truss spans are primarily with the footings, pier walls, and connections of the superstructure to the substructure. Sufficient detailing to transfer the seismic loads into the foundation is a concern. Base isolation is recommended at the top of Piers 1-4 and Pier 7 to reduce the load demands to the substructure. It is possible that the piers may yield at their base due to poor lateral strength. Steel confinement jackets are a common retrofit method used to enhance shear capacity for these situations.

For each seismic hazard level, catcher blocks and anchor bolt modifications are recommended at all of the truss bearings, and a Bottom chord lateral bracing strengthening is recommended in the three end panels of each span. Although not as critical as some of the other retrofit strategies, soil densification is also recommended at Piers 1 and 7 due to the potential for liquefaction.

4.4.4 Moveable Span Vulnerabilities

The Movable Span of the Hawthorne Bridge is a 244 foot vertical lift through truss. The primary vulnerabilities with this span are Piers 5 and 6 and the lift towers above them. When the bridge is in the closed position, the 440 ton counterweights are about 180 feet above the bridge deck. The existing towers and piers are severely undersized to carry such a large mass near its top during any seismic event. In particular, the raised counterweight presents challenges for transferring the large inertial forces from the counterweight to the substructure. This is due to the slender truss members that make up the tower.

For the 500-yr CSZ and 1000-yr events, as with the Fixed River Span piers, the tower piers will require isolation bearings to limit substructure demands and steel confinement jackets at their base to increase capacity. Even with the reduced loads in the superstructure from base isolation, the truss towers would see substantial benefits with replacement of the tower back legs, the diagonal bracing between the tower front legs, and the back span trusses where the tower back legs frame in. The three end panels of the span will also require the same strengthening of the bottom chord lateral bracing as described for the fixed spans.

Catcher blocks and anchor bolts modifications are recommended at the truss bearing locations similar to the Fixed River Spans. The notched anchor bolts will act as fuses to prevent excessive force from transmitting into the piers.

4.4.5 East Approach Vulnerabilities

The East Approach of the Hawthorne Bridge consists of 3 separate structures. Starting at Pier 1 near the river, the Water Avenue structure transitions from the main spans to three separate one-way ramp structures over a length of about 550 feet. This structure is comprised of Bulb I prestressed girders with a cast-in-place deck on concrete caps and columns with pile supported footings. The Hawthorne Boulevard viaduct structure is 1233 feet long and consists of simple steel I-girder spans on concrete caps and columns with concrete pile supported footings. The Madison Street viaduct is very similar to the Hawthorne Boulevard viaduct, measuring 1271 feet in length.

The vulnerabilities of the East Approach are mostly associated with the two viaduct structures. The concrete columns, bent caps, and footings are under-reinforced for seismic forces and plastic hinging. Jacketing of the columns is recommended. This will likely also require the footings to be strengthened to take the hinging force of the newly strengthened columns. Strengthening of the bent caps will likely be required.

The steel superstructure is vulnerable to bearing seat pull off. Thus, seat extensions or cable restraints are recommended at all expansion piers. At Pier 1 of the Water Avenue structure, there does not appear to be adequate transverse restraint of the superstructure, and the installation of shear lugs is recommended.

4.4.6 Retrofit Summary

Table 6 summarizes the results of the Seismic Vulnerabilities Assessment for the Hawthorne Bridge. The table identifies: (1) anticipated Phase 1 retrofit measures; (2) retrofit measures for each earthquake level; and (3) retrofit measures that are modified by the system retrofits. A description of each vulnerability and the recommended retrofit measures for each seismic level is included in Appendix A. Figures associated with each vulnerability can be found in Appendix B.

Table 6. Hawthorne Bridge Summary Table

Location	Number	Component	Phase 1 Retrofit	100-Yr	500-Yr CSZ	1000-Yr	Modified by System Retrofit
West Approach	1	Pile to Cap Connection			X	X	
West Approach	2	Spread Footings			X	X	
West Approach	3	Electrical Vault			X	X	
West Approach	4	Columns to Footings Connection			X	X	
West Approach	5	Abutments to Footings Connection			X	X	
West Approach	6	Columns			X	X	
West Approach	7	Seat Widths	X	X	X	X	

Location	Number	Component	Phase 1 Retrofit	100-Yr	500-Yr CSZ	1000-Yr	Modified by System Retrofit
West Approach	8	Bent Caps			X	X	
Fixed Spans	1	Piers 1-4, 7 Bearings	X	X	X	X	
Fixed Spans	2	Restraint at Piers 1-4,7			X	X	X
Fixed Spans	3	Geotech Liquefaction Hazard			X	X	
Fixed Spans	4	Bottom chord lateral bracing			X	X	X
Fixed Spans	5	Piers 1-4, 7			X	X	X
Moveable Span	1	Piers 5 - 6 Bearings	X	X	X	X	X
Moveable Span	2	Restraint at Piers 5 - 6			X	X	X
Moveable Span	3	Bottom chord lateral bracing			X	X	X
Moveable Span	4	Tower			X	X	X
Moveable Span	5	Piers 5 - 6			X	X	X
East Approach	1	Pier 1 Transition bearings	X	X	X	X	
East Approach	2	Girder seats	X	X	X	X	
East Approach	3	Abutments	X	X	X	X	
East Approach	4	Columns			X	X	
East Approach	5	Footings			X	X	
East Approach	6	Bent Caps			X	X	

5 CONSTRUCTION COST ESTIMATE APPROACH

As part of this assessment, programmatic-level construction cost estimates were prepared for each of the recommended retrofit measures assuming a 2014 construction year. These estimates are for planning purposes only and detailed estimates must be compiled based on project-specific analyses and designs.

In general, typical retrofit measures were identified and unit costs were developed. For each typical retrofit measure, the unit cost was based on the 1000-year earthquake level and a No Collapse criteria. The typical cost was then applied to equivalent retrofit measures across all four of the bridges. For example, the cost for column encasement was developed based on a typical approach structure column. This unit cost was then used for all approach columns regardless of column sizes or bridge specific details.

In order to capture some cost differences between the bridges and/or for the work required, modification factors were implemented for known complexities, as summarized in Table 7.

Table 7. Cost Estimate Modification Factors

Cost Modification Reason	Factor
500 yr CSZ event no collapse target design	0.95
100 yr event no collapse target design	0.75
Fully Operational/Limited Operation Performance Level design for Burnside	1.75

The following examples are provided to demonstrate how the modification factors were applied to different situations:

- Because the base costs assumed a 1000-yr event, we anticipate some modest reduction in the cost for designing to the 500 yr CSZ event. As such, a 0.95 factor was used.
- For the 100-yr event, many of the retrofit measures are based on Phase 1 needs. Because much of the cost is in access and placement of the components, a factor of 0.75 was used.
- Meeting the high performance levels for the Burnside Bridge will require significantly more involved and complicated retrofit measures than the 1000-yr No Collapse criteria. As such, a factor of 1.75 was used.

For each retrofit measure, a summary of the construction activities involved were identified. Using those activities, a unit cost was estimated. Cost data from ODOT and Caltrans, and other relevant projects were used as a basis for the unit costs developed herein. In addition, the costs developed as part of the prior 1996 Seismic Retrofit Reports relating to the main river spans were also considered. However, given the unique nature of most of the retrofit projects and the limited number of similar sample projects, the published cost data was not wholly relied on. Error in pricing is anticipated to be absorbed within the Contingency amount.

For many of the retrofits that are unique to a specific bridge, that cost was developed on its own. The details of the cost estimate development are included in Appendix C.

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Attachment A

Seismic Vulnerabilities Forms.

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Multnomah County Willamette River Bridges CIP

2014 UNBURDENED Retrofit Construction Cost Summary Table
(w/o Programmatic Costs, ROW, PE, and CEI)

	Compiled by:	**TCA**	Date:	5/30/2014
	Checked by:	**SMD**	Date:	11/7/2014

BROADWAY

Bridge Location	Phase 1	1000-yr	500-yr	100-yr
East Approach Spans	$ -	$ 300,000	$ 285,000	$ -
Moveable Spans	$ 5,750,000	$ 20,750,000	$ 21,612,000	$ 8,812,000
Fixed Spans	$ 10,000,000	$ 34,850,000	$ 33,107,000	$ 1,382,000
West Approach Spans	$ 225,000	$ 11,725,000	$ 11,143,000	$ 168,000
Total	$ 15,975,000	$ 67,625,000	$ 66,147,000	$ 10,362,000

BURNSIDE

Bridge Location	Phase 1	1000-yr	500-yr	100-yr
East Approach Spans	$ 1,560,000	$ 31,080,000	$ 29,598,000	$ 19,264,000
Moveable Spans	$ 17,020,000	$ 37,680,000	$ 35,802,000	$ 9,998,000
Fixed Spans	$ 880,000	$ 13,650,000	$ 12,974,000	$ 466,000
West Approach Spans	$ 1,980,000	$ 33,960,000	$ 32,298,000	$ 8,271,000
Total	$ 21,440,000	$ 116,370,000	$ 110,672,000	$ 37,999,000

HAWTHORNE

Bridge Location	Phase 1	1000-yr	500-yr	100-yr
East Approach Spans	$ 900,000	$ 27,525,000	$ 26,177,000	$ 730,000
Moveable Spans	$ 2,150,000	$ 26,150,000	$ 20,092,000	$ 564,000
Fixed Spans	$ 5,375,000	$ 46,875,000	$ 44,405,000	$ 1,030,000
West Approach Spans	$ 1,050,000	$ 9,175,000	$ 8,721,000	$ 784,000
Total	$ 9,475,000	$ 109,725,000	$ 99,395,000	$ 3,108,000

MORRISON

Bridge Location	Phase 1	1000-yr	500-yr	100-yr
East Approach Spans	$ 12,625,000	$ 60,250,000	$ 57,273,000	$ 14,669,000
Moveable Spans	$ 4,300,000	$ 34,300,000	$ 32,584,000	$ 3,974,000
Fixed Spans	$ 4,150,000	$ 35,050,000	$ 31,396,000	$ 3,448,000
West Approach Spans	$ 4,800,000	$ 20,925,000	$ 19,895,000	$ 5,631,000
Total	$ 25,875,000	$ 150,525,000	$ 141,148,000	$ 27,722,000

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**N Broadway St over N Interstate Ave [Broadway]**		*Checked by:*	**KPBU**	Date: 5/1/2014
Bridge Number	**06757C**				
Bridge Location	**West Approaches**	**(Includes 'Span 1' of main structure)**			
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1912-1995_Broadway_Br_and_App_Misc_Details.pdf**		
Vulnerable Component	**Steel Bent Columns**			*Drawing #*	**C4155/3**
Description of Vulnerability	***Steel columns have limited lateral load capability and slenderness concerns. Detailing for connections are prone to premature failure. Note: 2 columns have already been encased and will need additional encasing.***				
Proposed Retrofit	***Encase columns in reinforced concrete sections.***				
Number of Locations	**20**	**columns**		*PDF Page #*	**73**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**BW001**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1912-1995_Broadway_Br_and_App_Misc_Details.pdf**		
Vulnerable Component	**Expansion Bearing Seat Width**			*Drawing #*	**C4155/3**
Description of Vulnerability	***Expansion bearing seats are not sufficient to prevent superstructure from falling off.***				
Proposed Retrofit	***Add concrete beam seat on proposed column encasing.***				
Number of Locations	**3**	**piers**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**BW002**

Vulnerability Number	**3**	*As-Built Dwg. File*			
Vulnerable Component	**Footings**			*Drawing #*	
Description of Vulnerability	***Additional strength of columns will require additional strength to footings.***				
Proposed Retrofit	***Widen and deepen footing.***				
Number of Locations	**20**	**footings**		*PDF Page #*	
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	

Vulnerability Number	**4**	*As-Built Dwg. File*			
Vulnerable Component	**Footings**			*Drawing #*	
Description of Vulnerability	***Spread footings are on soil prone to liquifaction.***				
Proposed Retrofit	***Provide soil densification around footings.***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	
Unit Cost of Retrofit	**$7,000,000**	*each*		*Figure Ref. #*	

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**N Broadway St over N Interstate Ave [Broadway]**		*Checked by:*	**KPBU**	Date: 5/19/2014
Bridge Number	**06757C**				
Bridge Location	**West Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1912-1995_Broadway_Br_and_App_Misc_Details.pdf**		
Vulnerable Component	**Steel Bent Columns**			*Drawing #*	**C4155/3**
Description of Vulnerability	***Steel columns have limited lateral load capability and slenderness concerns. Detailing for connections are prone to premature failure. Note: 2 columns have already been encased and will need additional encasing.***				
Proposed Retrofit	***Encase columns in reinforced concrete sections.***				
Number of Locations	**20**	**columns**		*PDF Page #*	**73**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**BW001**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1912-1995_Broadway_Br_and_App_Misc_Details.pdf**		
Vulnerable Component	**Expansion Bearing Seat Width**			*Drawing #*	**C4155/3**
Description of Vulnerability	***Expansion bearing seats are not sufficient to prevent superstructure from falling off.***				
Proposed Retrofit	***Add concrete beam seat on proposed column encasing.***				
Number of Locations	**3**	**piers**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**BW002**

Vulnerability Number	**3**	*As-Built Dwg. File*			
Vulnerable Component	**Footings**			*Drawing #*	
Description of Vulnerability	***Additional strength of columns will require additional strength to footings.***				
Proposed Retrofit	***Widen and deepen footing.***				
Number of Locations	**20**	**footings**		*PDF Page #*	
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	

Vulnerability Number	**4**	*As-Built Dwg. File*			
Vulnerable Component	**Footings**			*Drawing #*	
Description of Vulnerability	***Spread footings are on soil prone to liquifaction.***				
Proposed Retrofit	***Provide soil densification around footings.***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	
Unit Cost of Retrofit	**$6,650,000**	*each*		*Figure Ref. #*	

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**N Broadway St over N Interstate Ave [Broadway]**		*Checked by:*	**KPBU**	Date: 5/19/2014
Bridge Number	**06757C**				
Bridge Location	**West Approaches**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1912-1995_Broadway_Br_and_App_Misc_Details.pdf**		
Vulnerable Component	**Steel Bent Columns**			*Drawing #*	**C4155/3**
Description of Vulnerability	***Steel columns have limited lateral load capability and slenderness concerns. Detailing for connections are prone to premature failure. Note: 2 columns have already been encased and will need additional encasing.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**20**	**columns**		*PDF Page #*	**73**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BW001**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1912-1995_Broadway_Br_and_App_Misc_Details.pdf**		
Vulnerable Component	**Expansion Bearing Seat Width**			*Drawing #*	**C4155/3**
Description of Vulnerability	***Expansion bearing seats are not sufficient to prevent superstructure from falling off.***				
Proposed Retrofit	***Add concrete beam seat on proposed column encasing.***				
Number of Locations	**3**	**piers**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**BW002**

Vulnerability Number	**3**	*As-Built Dwg. File*			
Vulnerable Component	**Footings**			*Drawing #*	
Description of Vulnerability	***Additional strength of columns will require additional strength to footings.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**20**	**footings**		*PDF Page #*	
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	

Vulnerability Number	**4**	*As-Built Dwg. File*			
Vulnerable Component	**Footings**			*Drawing #*	
Description of Vulnerability	***Spread footings are on soil prone to liquifaction.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**kpbu**	Date: 5/1/2014
Bridge Number	**06757**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 2 Columns**			*Drawing #*	**AH001-018**
Description of Vulnerability	***Steel columns have limited lateral capability. Additionally, connection details are prone to premature failure.***				
Proposed Retrofit	***Install reinforced concrete encasing around columns. Additionally, install additional steel cross bracing between columns. System Retrofit - Provide Base Isolation Bearings at piers 3, 4, and 7 to reduce overall load into columns.***				
Number of Locations	**2**	**columns**		*PDF Page #*	**52**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**BW003**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 1, 3, 4 & 7 Jacketed Column**			*Drawing #*	**AJ002-002**
Description of Vulnerability	***Concrete filled round steel columns have limited lateral displacement capacity and strength. Connection to below grade supporting elements is insufficient.***				
Proposed Retrofit	***Weld steel jackets seams and cross framing, add concrete infill walls, and struts to tie the pedestals together. System Retrofit - Provide Base Isolation Bearings at piers 3, 4, and 7 to reduce overall load into columns.***				
Number of Locations	**8**	**Columns**		*PDF Page #*	**189**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 2, 3, 4, & 7 and E. Abutment Bearings**			*Drawing #*	**AH001-037**
Description of Vulnerability	***Bearings are very tall and may become unstable under relatively small movements. Anchorage of bearings to Pier cap is likely insufficient. Insufficient seat width at top of piers.***				
Proposed Retrofit	***Install longitudinal restrainers and catcher blocks. System Retrofit - Provide Base Isolation Bearings***				
Number of Locations	**20**	**bearings**		*PDF Page #*	**71**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**BW004**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1927-1995_Broadway_Br_Repairs_Misc_Works.pdf**		
Vulnerable Component	**Pier 2, 3, 4, & 7 Concrete Piers**			*Drawing #*	**AG022-002**
Description of Vulnerability	***Concrete Piers are unreinforced and prone to brittle failure. Connections to Columns and Caisson are likely not sufficient.***				
Proposed Retrofit	***Install reinforced concrete shells to strength pier walls and footings. System Retrofit - Provide Base Isolation System to reduce loads to piers.***				
Number of Locations	**4**	**piers**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$2,500,000**	*each*		*Figure Ref. #*	**BW040**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**kpbu**	Date: 5/1/2014
Bridge Number	**06757**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**2002-09-01_Broadway_Rehab_Ph_4_7_Signed.pdf**		
Vulnerable Component	**Staircases to Naito Parkway**			*Drawing #*	**61442**
Description of Vulnerability	***Support of top of stairway to structure is vulnerable to failure due to movement of either the stairs or the main bridge.***				
Proposed Retrofit	***Install expansion device between stairs and main bridge to allow movement between structures.***				
Number of Locations	**2**	**bent**		*PDF Page #*	**80**
Unit Cost of Retrofit	**$100,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1996 Seismic Report - Geotech Appendix**		
Vulnerable Component	**Geotechnical Hazards - Piers,1, 2, and 3**			*Drawing #*	**NA**
Description of Vulnerability	***Concrete Pile supported footings on West side are prone to liquifaction. This will lead to uneven soil pressures on the foundation and potential settlement.***				
Proposed Retrofit	***Provide soil densification around piers***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**NA**
Unit Cost of Retrofit	**$7,000,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1996 Seismic Report - Geotech Appendix**		
Vulnerable Component	**Geotechnical Hazards - Pier 4**			*Drawing #*	**NA**
Description of Vulnerability	***Some of the soil around pier 4 is succeptible to liquifaction. Due to the sloped ground and potential for lateral spreading, large lateral forces on the Pier 4 substructure may occur.***				
Proposed Retrofit	***Provide soil densification around pier.***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**NA**
Unit Cost of Retrofit	**$7,000,000**	*each*		*Figure Ref. #*	**NA**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**kpbu**	Date: 5/19/2014
Bridge Number	**06757**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 2 Columns**			*Drawing #*	**AH001-018**
Description of Vulnerability	***Steel columns have limited lateral capability. Additionally, connection details are prone to premature failure.***				
Proposed Retrofit	***Install reinforced concrete encasing around columns. Additionally, install additional steel cross bracing between columns. System Retrofit - Provide Base Isolation Bearings at piers 3, 4, and 7 to reduce overall load into columns.***				
Number of Locations	**2**	**columns**		*PDF Page #*	**52**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**BW003**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 1, 3, 4 & 7 Jacketed Column**			*Drawing #*	**AJ002-002**
Description of Vulnerability	***Concrete filled round steel columns have limited lateral displacement capacity and strength. Connection to below grade supporting elements is insufficient.***				
Proposed Retrofit	***Weld steel jackets seams and cross framing, add concrete infill walls, and struts to tie the pedestals together. System Retrofit - Provide Base Isolation Bearings at piers 3, 4, and 7 to reduce overall load into columns.***				
Number of Locations	**8**	**Columns**		*PDF Page #*	**189**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 2, 3, 4, & 7 and E. Abutment Bearings**			*Drawing #*	**AH001-037**
Description of Vulnerability	***Bearings are very tall and may become unstable under relatively small movements. Anchorage of bearings to Pier cap is likely insufficient. Insufficient seat width at top of piers.***				
Proposed Retrofit	***Install longitudinal restrainers and catcher blocks. System Retrofit - Provide Base Isolation Bearings***				
Number of Locations	**20**	**bearings**		*PDF Page #*	**71**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**BW004**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1927-1995_Broadway_Br_Repairs_Misc_Works.pdf**		
Vulnerable Component	**Pier 2, 3, 4, & 7 Concrete Piers**			*Drawing #*	**AG022-002**
Description of Vulnerability	***Concrete Piers are unreinforced and prone to brittle failure. Connections to Columns and Caisson are likely not sufficient.***				
Proposed Retrofit	***Install reinforced concrete shells to strength pier walls and footings. System Retrofit - Provide Base Isolation System to reduce loads to piers.***				
Number of Locations	**4**	**piers**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$2,375,000**	*each*		*Figure Ref. #*	**BW040**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**kpbu**	Date: 5/19/2014
Bridge Number	**06757**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**2002-09-01_Broadway_Rehab_Ph_4_7_Signed.pdf**		
Vulnerable Component	**Staircases to Naito Parkway**			*Drawing #*	**61442**
Description of Vulnerability	***Support of top of stairway to structure is vulnerable to failure due to movement of either the stairs or the main bridge.***				
Proposed Retrofit	***Install expansion device between stairs and main bridge to allow movement between structures.***				
Number of Locations	**2**	**bent**		*PDF Page #*	**80**
Unit Cost of Retrofit	**$95,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1996 Seismic Report - Geotech Appendix**		
Vulnerable Component	**Geotechnical Hazards - Piers,1, 2, and 3**			*Drawing #*	**NA**
Description of Vulnerability	***Concrete Pile supported footings on West side are prone to liquifaction. This will lead to uneven soil pressures on the foundation and potential settlement.***				
Proposed Retrofit	***Provide soil densification around piers***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**NA**
Unit Cost of Retrofit	**$6,650,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1996 Seismic Report - Geotech Appendix**		
Vulnerable Component	**Geotechnical Hazards - Pier 4**			*Drawing #*	**NA**
Description of Vulnerability	***Some of the soil around pier 4 is succeptible to liquifaction. Due to the sloped ground and potential for lateral spreading, large lateral forces on the Pier 4 substructure may occur.***				
Proposed Retrofit	***Provide soil densification around piers***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**NA**
Unit Cost of Retrofit	**$6,650,000**	*each*		*Figure Ref. #*	**NA**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**KPBU**	Date: 5/19/2014
Bridge Number	**06757**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 2 Columns**			*Drawing #*	**AH001-018**
Description of Vulnerability	***Steel columns have limited lateral capability. Additionally, connection details are prone to premature failure.***				
Proposed Retrofit	***Install reinforced concrete encasing around columns. Additionally, install additional steel cross bracing between columns.***				
Number of Locations	**2**	**columns**		*PDF Page #*	**52**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**BW003**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 1, 3, 4 & 7 Jacketed Column**			*Drawing #*	**AJ002-002**
Description of Vulnerability	***Concrete filled round steel columns have limited lateral displacement capacity and strength. Connection to below grade supporting elements is insufficient.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**8**	**Columns**		*PDF Page #*	**189**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 2, 3, 4, & 7 and E. Abutment Bearings**			*Drawing #*	**AH001-037**
Description of Vulnerability	***Bearings are very tall and may become unstable under relatively small movements. Anchorage of bearings to Pier cap is likely insufficient. Insufficient seat width at top of piers.***				
Proposed Retrofit	***Install longitudinal restrainers and catcher blocks.***				
Number of Locations	**20**	**bearings**		*PDF Page #*	**71**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**BW004**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1927-1995_Broadway_Br_Repairs_Misc_Works.pdf**		
Vulnerable Component	**Pier 2, 3, 4, & 7 Concrete Piers**			*Drawing #*	**AG022-002**
Description of Vulnerability	***Concrete Piers are unreinforced and prone to brittle failure. Connections to Columns and Caisson are likely not sufficient.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**4**	**piers**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BW040**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**KPBU**	Date: 5/19/2014
Bridge Number	**06757**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**2002-09-01_Broadway_Rehab_Ph_4_7_Signed.pdf**		
Vulnerable Component	**Staircases to Naito Parkway**			*Drawing #*	**61442**
Description of Vulnerability	***Support of top of stairway to structure is vulnerable to failure due to movement of either the stairs or the main bridge.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**2**	**bent**		*PDF Page #*	**80**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1996 Seismic Report - Geotech Appendix**		
Vulnerable Component	**Geotechnical Hazards - Piers,1, 2, and 3**			*Drawing #*	**NA**
Description of Vulnerability	***Concrete Pile supported footings on West side are prone to liquifaction. This will lead to uneven soil pressures on the foundation and potential settlement.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**NA**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1996 Seismic Report - Geotech Appendix**		
Vulnerable Component	**Geotechnical Hazards - Pier 4**			*Drawing #*	**NA**
Description of Vulnerability	***Some of the soil around pier 4 is succeptible to liquifaction. Due to the sloped ground and potential for lateral spreading, large lateral forces on the Pier 4 substructure may occur.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**NA**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**NA**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**KPBU**	Date: 4/29/2014
Bridge Number	**06757**				
Bridge Location	**Moveable Span**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1927-1995_Broadway_Br_Repairs_Misc_Works.pdf**		
Vulnerable Component	**Pier 5 & 6 Pier Wall**			*Drawing #*	**AG022-003**
Description of Vulnerability	***Concrete pier walls have limited lateral load capability and slenderness concerns primarily in the longitudinal direction. Piers are 120' tall above the foundations and unreinforced. Exhibiting non-ductile or brittle responses.***				
Proposed Retrofit	***Strengthen Pier Walls with concrete jacket encasement. System Retrofit - Install isolation bearings at top of Piers to reduce loading in piers***				
Number of Locations	**2**	**Piers**		*PDF Page #*	**47**
Unit Cost of Retrofit	**$2,500,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 5 & 6 Bearings**			*Drawing #*	**AJ001-047**
Description of Vulnerability	***Bearings are tall and may become unstable under relatively small movements. Anchorage of bearings to Pier cap is likely insufficient. Insufficient seat width at top of piers.***				
Proposed Retrofit	***Replace Bearings and improve anchorage, provide stops for transverse and longitudinal movement. System Retrofit - Replace bearings with isolation bearing.***				
Number of Locations	**4**	**Bearings**		*PDF Page #*	**163**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**BW050**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 5 & 6 Footings**			*Drawing #*	**AH001-016**
Description of Vulnerability	***Pier Footings are approx. 80' tall and unreinforced. Lateral load and displacement capacity particularly in the longitudinal direction is insufficient. Will exhibit non-ductile behavior***				
Proposed Retrofit	***Strengthen Footings with drilled shaft additions around footing. System Retrofit - Base Isolation will reduce demands on footings and make footing strengthening unneeded or greatly reduced.***				
Number of Locations	**2**	**piers**		*PDF Page #*	**50**
Unit Cost of Retrofit	**$2,000,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1927-1995_Broadway_Br_Repairs_Misc_Works.pdf**		
Vulnerable Component	**Anchor Struts**			*Drawing #*	**AG008-001**
Description of Vulnerability	***The anchor struts may see very high forces in a seismic event and are key stability components of the bascule span.***				
Proposed Retrofit	***Strengthen or replace anchor struts and connections***				
Number of Locations	**4**			*PDF Page #*	**13**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**BW0051**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**KPBU**	Date: 4/29/2014
Bridge Number	**06757**				
Bridge Location	**Moveable Span**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Rall Wheel Track**			*Drawing #*	**AK001-023**
Description of Vulnerability	***The Rall wheel track lacks lateral supports or buffers to keep the wheel from working their way off in a prolonged seismic event.***				
Proposed Retrofit	***Provide Rall wheel stops***				
Number of Locations	**4**			*PDF Page #*	**217**
Unit Cost of Retrofit	**$200,000**	*each*		*Figure Ref. #*	**BW052**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Truss Frame at Counterweight**			*Drawing #*	**AK001-003**
Description of Vulnerability	***The truss frame that transfers lateral load from the counterweight to the Rall Wheels is insufficient***				
Proposed Retrofit	***Strength or replace transverse and longitudinal frame members to provide adequate strength. System Retrofit - Base Isolation system will reduce lateral load demands significantly.***				
Number of Locations	**2**			*PDF Page #*	**199**
Unit Cost of Retrofit	**$2,000,000**	*each*		*Figure Ref. #*	**BW053**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Truss Frame at Rall Wheel**			*Drawing #*	**AK001-003**
Description of Vulnerability	***The truss frame supports at the Rall wheel likely have insufficient lateral strength in a seismic event given the very large mass they support.***				
Proposed Retrofit	***Strength or replace transverse and longitudinal frame members to provide adequate strength. System Retrofit - Base Isolation system will reduce lateral load demands significantly.***				
Number of Locations	**2**			*PDF Page #*	**199**
Unit Cost of Retrofit	**$2,000,000**	*each*		*Figure Ref. #*	**BW053**

Vulnerability Number	**8**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Bascule Leaf Lateral Movement**			*Drawing #*	**AK001-003**
Description of Vulnerability	***The bascule leaves have little restraint from rotation about a vertical axis or lateral movement.***				
Proposed Retrofit	***Provide lateral stops at heel and toe of bascule leaves to engage in seismic event.***				
Number of Locations	**4**			*PDF Page #*	**199**
Unit Cost of Retrofit	**$200,000**	*each*		*Figure Ref. #*	

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**KPBU**	Date: 4/29/2014
Bridge Number	**06757**				
Bridge Location	**Moveable Span**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**9**	*As-Built Dwg. File*	**2009-08-01_Broadway_Portland_Streetcar_Loop**		
Vulnerable Component	**Live Load Shoes**			*Drawing #*	**S061**
Description of Vulnerability	***The live load shoes may see very high transverse forces as well as longitudinal forces in a forward direction that they are not detailed to contain.***				
Proposed Retrofit	***Provide lateral restraints around live load shoes to limit movement at that location***				
Number of Locations	**2**	**Bent**		*PDF Page #*	**96**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**kpbu**	Date: 5/14/2014
Bridge Number	**06757**				
Bridge Location	**Moveable Span**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1927-1995_Broadway_Br_Repairs_Misc_Works.pdf**		
Vulnerable Component	**Pier 5 & 6 Pier Wall**			*Drawing #*	**AG022-003**
Description of Vulnerability	***Concrete pier walls have limited lateral load capability and slenderness concerns primarily in the longitudinal direction. Piers are 120' tall above the foundations and unreinforced. Exhibiting non-ductile or brittle responses.***				
Proposed Retrofit	***Strengthen Pier Walls with concrete jacket encasement. System Retrofit - Install isolation bearings at top of Piers to reduce loading in piers***				
Number of Locations	**2**	**Piers**		*PDF Page #*	**47**
Unit Cost of Retrofit	**$2,375,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 5 & 6 Bearings**			*Drawing #*	**AJ001-047**
Description of Vulnerability	***Bearings are tall and may become unstable under relatively small movements. Anchorage of bearings to Pier cap is likely insufficient. Insufficient seat width at top of piers.***				
Proposed Retrofit	***Replace Bearings and improve anchorage, provide stops for transverse and longitudinal movement. System Retrofit - Replace bearings with isolation bearing.***				
Number of Locations	**4**	**Bearings**		*PDF Page #*	**163**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**BW050**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 5 & 6 Footings**			*Drawing #*	**AH001-016**
Description of Vulnerability	***Pier Footings are approx. 80' tall and unreinforced. Lateral load and displacement capacity particularly in the longitudinal direction is insufficient. Will exhibit non-ductile behavior***				
Proposed Retrofit	***Strengthen Footings with drilled shaft additions around footing. System Retrofit - Base Isolation will reduce demands on footings and make footing strengthening unneeded or greatly reduced.***				
Number of Locations	**2**	**piers**		*PDF Page #*	**50**
Unit Cost of Retrofit	**$1,900,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1927-1995_Broadway_Br_Repairs_Misc_Works.pdf**		
Vulnerable Component	**Anchor Struts**			*Drawing #*	**AG008-001**
Description of Vulnerability	***The anchor struts may see very high forces in a seismic event and are key stability components of the bascule span.***				
Proposed Retrofit	***Strengthen or replace anchor struts and connections***				
Number of Locations	**4**			*PDF Page #*	**13**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**BW0051**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**kpbu**	Date: 5/14/2014
Bridge Number	**06757**				
Bridge Location	**Moveable Span**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Rall Wheel Track**			*Drawing #*	**AK001-023**
Description of Vulnerability	***The Rall wheel track lacks lateral supports or buffers to keep the wheel from working their way off in a prolonged seismic event.***				
Proposed Retrofit	***Provide Rall wheel stops***				
Number of Locations	**4**			*PDF Page #*	**217**
Unit Cost of Retrofit	**$190,000**	*each*		*Figure Ref. #*	**BW052**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Truss Frame at Counterweight**			*Drawing #*	**AK001-003**
Description of Vulnerability	***The truss frame that transfers lateral load from the counterweight to the Rall Wheels is insufficient***				
Proposed Retrofit	***Strength or replace transverse and longitudinal frame members to provide adequate strength. System Retrofit - Base Isolation system will reduce lateral load demands significantly.***				
Number of Locations	**2**			*PDF Page #*	**199**
Unit Cost of Retrofit	**$1,900,000**	*each*		*Figure Ref. #*	**BW053**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Truss Frame at Rall Wheel**			*Drawing #*	**AK001-003**
Description of Vulnerability	***The truss frame supports at the Rall wheel likely have insufficient lateral strength in a seismic event given the very large mass they support.***				
Proposed Retrofit	***Strength or replace transverse and longitudinal frame members to provide adequate strength. System Retrofit - Base Isolation system will reduce lateral load demands significantly.***				
Number of Locations	**2**			*PDF Page #*	**199**
Unit Cost of Retrofit	**$1,900,000**	*each*		*Figure Ref. #*	**BW053**

Vulnerability Number	**8**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Bascule Leaf Lateral Movement**			*Drawing #*	**AK001-003**
Description of Vulnerability	***The bascule leaves have little restraint from rotation about a vertical axis or lateral movement.***				
Proposed Retrofit	***Provide lateral stops at heel and toe of bascule leaves to engage in seismic event.***				
Number of Locations	**4**			*PDF Page #*	**199**
Unit Cost of Retrofit	**$190,000**	*each*		*Figure Ref. #*	

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**kpbu**	Date: 5/14/2014
Bridge Number	**06757**				
Bridge Location	**Moveable Span**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**9**	*As-Built Dwg. File*	**2009-08-01_Broadway_Portland_Streetcar_Loop**		
Vulnerable Component	**Live Load Shoes**			*Drawing #*	**S061**
Description of Vulnerability	***The live load shoes may see very high transverse forces as well as longitudinal forces in a forward direction that they are not detailed to contain.***				
Proposed Retrofit	***Provide lateral restraints around live load shoes to limit movement at that location***				
Number of Locations	**2**	**Bent**		*PDF Page #*	**96**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**kpbu**	Date: 5/14/2014
Bridge Number	**06757**				
Bridge Location	**Moveable Span**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1927-1995_Broadway_Br_Repairs_Misc_Works.pdf**		
Vulnerable Component	**Pier 5 & 6 Pier Wall**			*Drawing #*	**AG022-003**
Description of Vulnerability	***Concrete pier walls have limited lateral load capability and slenderness concerns primarily in the longitudinal direction. Piers are 120' tall above the foundations and unreinforced. Exhibiting non-ductile or brittle responses.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**2**	**Piers**		*PDF Page #*	**47**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 5 & 6 Bearings**			*Drawing #*	**AJ001-047**
Description of Vulnerability	***Bearings are tall and may become unstable under relatively small movements. Anchorage of bearings to Pier cap is likely insufficient. Insufficient seat width at top of piers.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**4**	**Bearings**		*PDF Page #*	**163**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BW050**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Pier 5 & 6 Footings**			*Drawing #*	**AH001-016**
Description of Vulnerability	***Pier Footings are approx. 80' tall and unreinforced. Lateral load and displacement capacity particularly in the longitudinal direction is insufficient. Will exhibit non-ductile behavior***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**2**	**piers**		*PDF Page #*	**50**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1927-1995_Broadway_Br_Repairs_Misc_Works.pdf**		
Vulnerable Component	**Anchor Struts**			*Drawing #*	**AG008-001**
Description of Vulnerability	***The anchor struts may see very high forces in a seismic event and are key stability components of the bascule span.***				
Proposed Retrofit	***Strengthen or replace anchor struts and connections***				
Number of Locations	**4**			*PDF Page #*	**13**
Unit Cost of Retrofit	**$375,000**	*each*		*Figure Ref. #*	**BW0051**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**kpbu**	Date: 5/14/2014
Bridge Number	**06757**				
Bridge Location	**Moveable Span**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Rall Wheel Track**			*Drawing #*	**AK001-023**
Description of Vulnerability	***The Rall wheel track lacks lateral supports or buffers to keep the wheel from working their way off in a prolonged seismic event.***				
Proposed Retrofit	***Provide Rall wheel stops***				
Number of Locations	**4**			*PDF Page #*	**217**
Unit Cost of Retrofit	**$150,000**	*each*		*Figure Ref. #*	**BW052**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Truss Frame at Counterweight**			*Drawing #*	**AK001-003**
Description of Vulnerability	***The truss frame that transfers lateral load from the counterweight to the Rall Wheels is insufficient***				
Proposed Retrofit	***Strength or replace transverse and longitudinal frame members to provide adequate strength.***				
Number of Locations	**2**			*PDF Page #*	**199**
Unit Cost of Retrofit	**$1,500,000**	*each*		*Figure Ref. #*	**BW053**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Truss Frame at Rall Wheel**			*Drawing #*	**AK001-003**
Description of Vulnerability	***The truss frame supports at the Rall wheel likely have insufficient lateral strength in a seismic event given the very large mass they support.***				
Proposed Retrofit	***Strength or replace transverse and longitudinal frame members to provide adequate strength.***				
Number of Locations	**2**			*PDF Page #*	**199**
Unit Cost of Retrofit	**$1,500,000**	*each*		*Figure Ref. #*	**BW053**

Vulnerability Number	**8**	*As-Built Dwg. File*	**1911-12-12_Broadway_Main_Bridge.pdf**		
Vulnerable Component	**Bascule Leaf Lateral Movement**			*Drawing #*	**AK001-003**
Description of Vulnerability	***The bascule leaves have little restraint from rotation about a vertical axis or lateral movement.***				
Proposed Retrofit	***Provide lateral stops at heel and toe of bascule leaves to engage in seismic event.***				
Number of Locations	**4**			*PDF Page #*	**199**
Unit Cost of Retrofit	**$150,000**	*each*		*Figure Ref. #*	

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**CSK**	Date: **3/26/2014**
Bridge Name	**Willamette River, Broadway St [Broadway]**		*Checked by:*	**kpbu**	Date: 5/14/2014
Bridge Number	**06757**				
Bridge Location	**Moveable Span**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**9**	*As-Built Dwg. File*	**2009-08-01_Broadway_Portland_Streetcar_Loop**		
Vulnerable Component	**Live Load Shoes**			*Drawing #*	**S061**
Description of Vulnerability	***The live load shoes may see very high transverse forces as well as longitudinal forces in a forward direction that they are not detailed to contain.***				
Proposed Retrofit	***Provide lateral restraints around live load shoes to limit movement at that location***				
Number of Locations	**2**	**Bent**		*PDF Page #*	**96**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**KPBU**	Date:	**3/26/2014**
Bridge Name	**N Broadway St over N Interstate Ave [Broadway]**		*Checked by:*	**CSK**	Date:	5/13/2014
Bridge Number	**06757C**					
Bridge Location	**East Approaches**					
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**1**	*As-Built Dwg. File*	**1949_Interstate Ave Bridge Drawings_Broadway East Approach**		
Vulnerable Component	**Abutments**			*Drawing #*	**9139**
Description of Vulnerability	***Inadequate moment transfer mechanism at joints with superstructure and footing. Likely deterioration under cyclic loading.***				
Proposed Retrofit	***Provide built up concrete connections at joints to provide additional strength***				
Number of Locations	**2**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$100,000**	*each*		*Figure Ref. #*	**BW92**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1949_Interstate Ave Bridge Drawings_Broadway East Approach**		
Vulnerable Component	**Interior Pier Wall**			*Drawing #*	**9139**
Description of Vulnerability	***Inadequate moment transfer mechanism at joints with superstructure and footing. Likely deterioration under cyclic loading.***				
Proposed Retrofit	***Provide built up concrete connections at joints to provide additional strength***				
Number of Locations	**1**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$100,000**	*each*		*Figure Ref. #*	**BW93**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**KPBU**	Date:	3/26/2014
Bridge Name	**N Broadway St over N Interstate Ave [Broadway]**		*Checked by:*	**CSK**	Date:	5/13/2014
Bridge Number	**06757C**					
Bridge Location	**East Approaches**					
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**1**	*As-Built Dwg. File*	**1949_Interstate Ave Bridge Drawings_Broadway East Approach**		
Vulnerable Component	**Abutments**			*Drawing #*	**9139**
Description of Vulnerability	***Inadequate moment transfer mechanism at joints with superstructure and footing. Likely deterioration under cyclic loading.***				
Proposed Retrofit	***Provide built up concrete connections at joints to provide additional strength***				
Number of Locations	**2**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$95,000**	*each*		*Figure Ref. #*	**BW92**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1949_Interstate Ave Bridge Drawings_Broadway East Approach**		
Vulnerable Component	**Interior Pier Wall**			*Drawing #*	**9139**
Description of Vulnerability	***Inadequate moment transfer mechanism at joints with superstructure and footing. Likely deterioration under cyclic loading.***				
Proposed Retrofit	***Provide built up concrete connections at joints to provide additional strength***				
Number of Locations	**1**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$95,000**	*each*		*Figure Ref. #*	**BW93**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Broadway**		*Compiled by:*	**KPBU**	Date:	3/26/2014
Bridge Name	**N Broadway St over N Interstate Ave [Broadway]**		*Checked by:*	**CSK**	Date:	5/13/2014
Bridge Number	**06757C**					
Bridge Location	**East Approaches**					
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**1**	*As-Built Dwg. File*	**1949_Interstate Ave Bridge Drawings_Broadway East Approach**		
Vulnerable Component	**Abutments**			*Drawing #*	**9139**
Description of Vulnerability	***Inadequate moment transfer mechanism at joints with superstructure and footing. Likely deterioration under cyclic loading.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**2**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BW92**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1949_Interstate Ave Bridge Drawings_Broadway East Approach**		
Vulnerable Component	**Interior Pier Wall**			*Drawing #*	**9139**
Description of Vulnerability	***Inadequate moment transfer mechanism at joints with superstructure and footing. Likely deterioration under cyclic loading.***				
Proposed Retrofit	***No retrofit required for 100 year***				
Number of Locations	**1**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BW93**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AJCA/AXL**	Date: **4/11/2014**
Bridge Name	**Burnside St West Approach over Hwy 1 [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511A**				
Bridge Location	**West Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**Limited Operation (LO)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Columns**			*Drawing #*	**AB001-008**
Description of Vulnerability	***Bents 2-19 Columns are minimally reinforced and not detailed for hinging at top and bottom of columns.***				
Proposed Retrofit	***Concrete or steel jacketing to increase column flexural and shear capacity. For Bents 2-13, the bottom of columns have less concern due to the restraints of at grade slab/pavement/concrete.***				
Number of Locations	**72**			*PDF Page #*	**1**
Unit Cost of Retrofit	**$130,000**	*each*		*Figure Ref. #*	**BU301**

Vulnerability Number	**2**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Footings**			*Drawing #*	**AB001-008**
Description of Vulnerability	***Bents 2-19 footings assumed to be unreinforced (no reinforcing details). If columns are strengthened, footings will likely need strengthening as well.***				
Proposed Retrofit	***Footing enlargement and strengthening with possible addition of micropiles.***				
Number of Locations	**72**			*PDF Page #*	**1**
Unit Cost of Retrofit	**$880,000**	*each*		*Figure Ref. #*	**BU301**

Vulnerability Number	**3**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Superstructure Seating on Expansion Bent**			*Drawing #*	**AB001-0021, 25, 26, 27**
Description of Vulnerability	***Bents 1, 5, 8, 11, 14, 16, 17, 18, 19 have expansion joints where superstructure could pull off.***				
Proposed Retrofit	***Longitudinal restrainers or Steel/Concrete seat extension or catcher blocks.***				
Number of Locations	**9**			*PDF Page #*	**2**
Unit Cost of Retrofit	**$180,000**	*each*		*Figure Ref. #*	**BU302**

Vulnerability Number	**4**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Pier Caps/Floor Beams**			*Drawing #*	**AB001-0021, 22**
Description of Vulnerability	***Integral pier caps at Bents 2-16 may require strengthening to take seismic forces from girders or columns after columns are strengthened.***				
Proposed Retrofit	***Section enlargement.***				
Number of Locations	**15**			*PDF Page #*	**3**
Unit Cost of Retrofit	**$260,000**	*each*		*Figure Ref. #*	**BU303**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AJCA/AXL**	Date: **4/11/2014**
Bridge Name	**Burnside St West Approach over Hwy 1 [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511A**				
Bridge Location	**West Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**Full Operation (FO)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Columns**			*Drawing #*	**AB001-008**
Description of Vulnerability	***Bents 2-19 Columns are minimally reinforced and not detailed for hinging at top and bottom of columns.***				
Proposed Retrofit	***Concrete or steel jacketing to increase column flexural and shear capacity. For Bents 2-13, the bottom of columns have less concern due to the restraints of at grade slab/pavement/concrete.***				
Number of Locations	**72**			*PDF Page #*	**1**
Unit Cost of Retrofit	**$124,000**	*each*		*Figure Ref. #*	**BU301**

Vulnerability Number	**2**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Footings**			*Drawing #*	**AB001-008**
Description of Vulnerability	***Bents 2-19 footings assumed to be unreinforced (no reinforcing details). If columns are strengthened, footings will likely need strengthening as well.***				
Proposed Retrofit					
Number of Locations	**72**			*PDF Page #*	**1**
Unit Cost of Retrofit	**$836,000**	*each*		*Figure Ref. #*	**BU301**

Vulnerability Number	**3**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Superstructure Seating on Expansion Bent**			*Drawing #*	**AB001-0021, 25, 26, 27**
Description of Vulnerability	***Bents 1, 5, 8, 11, 14, 16, 17, 18, 19 have expansion joints where superstructure could pull off.***				
Proposed Retrofit	***Longitudinal restrainers or Steel/Concrete seat extension or catcher blocks.***				
Number of Locations	**9**			*PDF Page #*	**2**
Unit Cost of Retrofit	**$171,000**	*each*		*Figure Ref. #*	**BU302**

Vulnerability Number	**4**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Pier Caps/Floor Beams**			*Drawing #*	**AB001-0021, 22**
Description of Vulnerability	***Integral pier caps at Bents 2-16 may require strengthening to take seismic forces from girders or columns after columns are strengthened.***				
Proposed Retrofit	***Section enlargement.***				
Number of Locations	**15**			*PDF Page #*	**3**
Unit Cost of Retrofit	**$247,000**	*each*		*Figure Ref. #*	**BU303**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AJCA/AXL**	Date:	**4/11/2014**
Bridge Name	**Burnside St West Approach over Hwy 1 [Burnside]**		*Checked by:*	**kpbu**	Date:	5/20/2014
Bridge Number	**00511A**					
Bridge Location	**West Approaches**					
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**1**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Columns**			*Drawing #*	**AB001-008**
Description of Vulnerability	***Bents 2-19 Columns are minimally reinforced and not detailed for hinging at top and bottom of columns.***				
Proposed Retrofit	***Concrete or steel jacketing to ensure superstructure to substructure connection at column top.***				
Number of Locations	**72**			*PDF Page #*	**1**
Unit Cost of Retrofit	**$98,000**	*each*		*Figure Ref. #*	**BU301**

Vulnerability Number	**2**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Superstructure Seating on Expansion Bent**			*Drawing #*	**AB001-0021, 25, 26, 27**
Description of Vulnerability	***Bents 1, 5, 8, 11, 14, 16, 17, 18, 19 have exansion joints where superstructure could pull off.***				
Proposed Retrofit	***Longitudinal restrainers or Steel/Concrete seat extension or catcher blocks.***				
Number of Locations	**9**			*PDF Page #*	**2**
Unit Cost of Retrofit	**$135,000**	*each*		*Figure Ref. #*	**BU302**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**Limited Operation (LO)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1995-11-01_Burnside_Seismic_Evaluation_Report.pdf		
Vulnerable Component	**Liquefaction**			*Drawing #*	**Appendix D page 8**
Description of Vulnerability	***15ft of upper 15 to 30ft of soil will liquefy (occur in small, discontinuous zones) and resulting primarily in increased, unbalanced earth pressure on the upslope sides of the Piers 1 and 4 caps. For the downslope sides, no resistance in the upper 15ft.***				
Proposed Retrofit	***Provide soil densification around Piers 1 & 4.***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**1**
Unit Cost of Retrofit	**$12,250,000**	*each*		*Figure Ref. #*	**BU201**

Vulnerability Number	**2**	*As-Built Dwg. File*	1995-11-01_Burnside_Seismic_Evaluation_Report.pdf		
Vulnerable Component	**Slope Stability / Lateral Spreading**			*Drawing #*	**Appendix D page 8**
Description of Vulnerability	***2 or more feet of displacements of the river banks will apply pressure on the upslope side of the Piers 1 and 4 caps.***				
Proposed Retrofit	***Provide soil densification around Piers 1 & 4. Note: cost of vulernability 1 accounts for this.***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**1**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU201**

Vulnerability Number	**3**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Piers 1 & 4 Foundation Timber Piles**			*Drawing #*	**AB001-009 & 017**
Description of Vulnerability	***Timber piles could fail in uplift in the bridge longitudinal direction due to the effects of the approach spans which are fixed at Piers 1 & 4. However, if the footing is allowed to rock, the uplift in piles should not constitute a collapse-threatening situation.***				
Proposed Retrofit	***No proposed retrofit, allow footing to rock.***				
Number of Locations	**2**			*PDF Page #*	**2**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU202**

Vulnerability Number	**4**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Piers 1 & 4 Columns**			*Drawing #*	**AB001-009 & 017**
Description of Vulnerability	***Lightly reinforced (without proper seismic reinforcing details) columns could crack and loose of axial/vertical load carrying capacity.***				
Proposed Retrofit	***Steel shell retrofit for vertical capacity preservation.***				
Number of Locations	**4**	**columns**		*PDF Page #*	**3**
Unit Cost of Retrofit	**$130,000**	*each*		*Figure Ref. #*	**BU203**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**Limited Operation (LO)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Connections - super to sub., Fixed Bearings and Seat Width**			*Drawing #*	**AB001-012**
Description of Vulnerability	***Substructure to superstructure connections at Piers 2 & 3, fixed bearings anchor bolts and limited seat widths.***				
Proposed Retrofit	***Strengthen the bearing pedestals with dowels and concrete.***				
Number of Locations	**2**	**bents**		*PDF Page #*	**4**
Unit Cost of Retrofit	**$130,000**	*each*		*Figure Ref. #*	**BU204**

Vulnerability Number	**6**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Connections - super to sub., Expansion Bearings and Seat Width**			*Drawing #*	**AB001-040**
Description of Vulnerability	***Substructure to superstructure connections at Piers 1 & 4, expansion bearings and limited seat widths.***				
Proposed Retrofit	***Install longitudinal restrainers and catcher blocks. Note modification of bearings in 2001.***				
Number of Locations	**2**	**bents**		*PDF Page #*	**5**
Unit Cost of Retrofit	**$130,000**	*each*		*Figure Ref. #*	**BU205**

Vulnerability Number	**7**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Joint in the Deck System**			*Drawing #*	**AB001-070**
Description of Vulnerability	***Separating of the fixed spans to approach spans joint in the deck system.***				
Proposed Retrofit	***Strengthen the fixed span connection to the pier wall.***				
Number of Locations	**2**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$180,000**	*each*		*Figure Ref. #*	**BU206**

Vulnerability Number	**8**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Approach Deck Fixed Connection to Piers 1 & 4**			*Drawing #*	**AB001-010**
Description of Vulnerability	***Separating of the approach fixed span deck to Piers 1 and 4.***				
Proposed Retrofit	***None. Longitudinal restraints installed in 2001.***				
Number of Locations	**2**			*PDF Page #*	**7**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU207**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**Limited Operation (LO)**		

Vulnerability Number	**9**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Truss System - Connections of Primary Members**			*Drawing #*	**AB001-031**
Description of Vulnerability	***Moderate risk on weak link at connection points along top/bottom chord members.***				
Proposed Retrofit	***None, but will require analysis to confirm members are safe for limited operation and lifeline route.***				
Number of Locations	**72**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU208**

Vulnerability Number	**10**	*As-Built Dwg. File*	-		
Vulnerable Component	**Overhead Sign Structures**			*Drawing #*	**-**
Description of Vulnerability	***Collapse of overhead sign structures onto bridge, obstacle to use the bridge for limited operation.***				
Proposed Retrofit	***None, will require clean up if collapse onto bridge during seismic event.***				
Number of Locations	**2**			*PDF Page #*	**9**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU209**

Vulnerability Number	**11**	*As-Built Dwg. File*	-		
Vulnerable Component	**Lightings**			*Drawing #*	**-**
Description of Vulnerability	***Collapse of overhead sign structures onto bridge, obstacle to use the bridge for limited operation.***				
Proposed Retrofit	***None, will require clean up if collapse onto bridge during seismic event.***				
Number of Locations	**7**			*PDF Page #*	**9**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU209**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**Full Operation (FO)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1995-11-01_Burnside_Seismic_Evaluation_Report.pdf		
Vulnerable Component	**Liquefaction**			*Drawing #*	**Appendix D page 8**
Description of Vulnerability	***15ft of upper 15 to 30ft of soil will liquefy (occur in small, discontinuous zones) and resulting primarily in increased, unbalanced earth pressure on the upslope sides of the Piers 1 and 4 caps. For the downslope sides, no resistance in the upper 15ft.***				
Proposed Retrofit	***Provide soil densification around Piers 1 & 4.***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**1**
Unit Cost of Retrofit	**$11,640,000**	*each*		*Figure Ref. #*	**BU201**

Vulnerability Number	**2**	*As-Built Dwg. File*	1995-11-01_Burnside_Seismic_Evaluation_Report.pdf		
Vulnerable Component	**Slope Stability / Lateral Spreading**			*Drawing #*	**Appendix D page 8**
Description of Vulnerability	***2 or more feet of displacements of the river banks will apply pressure on the upslope side of the Piers 1 and 4 caps.***				
Proposed Retrofit	***Provide soil densification around Piers 1 & 4. Note: cost of vulernability 1 accounts for this.***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**1**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU201**

Vulnerability Number	**3**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Piers 1 & 4 Foundation Timber Piles**			*Drawing #*	**AB001-009 & 017**
Description of Vulnerability	***Timber piles could fail in uplift in the bridge longitudinal direction due to the effects of the approach spans which are fixed at Piers 1 & 4. However, if the footing is allowed to rock, the uplift in piles should not constitute a collapse-threathening situation.***				
Proposed Retrofit	***No proposed retrofit, allow footing to rock.***				
Number of Locations	**2**			*PDF Page #*	**2**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU202**

Vulnerability Number	**4**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Piers 1 & 4 Columns**			*Drawing #*	**AB001-009 & 017**
Description of Vulnerability	***Lightly reinforced (without proper seismic reinforcing details) columns could crack and loose of axial/vertical load carrying capacity.***				
Proposed Retrofit	***Steel shell retrofit for vertical capacity preservation.***				
Number of Locations	**4**	**columns**		*PDF Page #*	**3**
Unit Cost of Retrofit	**$124,000**	*each*		*Figure Ref. #*	**BU203**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**Full Operation (FO)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Connections - super to sub., Fixed Bearings and Seat Width**			*Drawing #*	**AB001-012**
Description of Vulnerability	***Substructure to superstructure connections at Piers 2 & 3, fixed bearings anchor bolts and limited seat widths.***				
Proposed Retrofit	***Strengthen the bearing pedestals with dowels and concrete.***				
Number of Locations	**2**	**bents**		*PDF Page #*	**4**
Unit Cost of Retrofit	**$124,000**	*each*		*Figure Ref. #*	**BU204**

Vulnerability Number	**6**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Connections - super to sub., Expansion Bearings and Seat Width**			*Drawing #*	**AB001-040**
Description of Vulnerability	***Substructure to superstructure connections at Piers 1 & 4, expansion bearings and limited seat widths.***				
Proposed Retrofit	***Install longitudinal restrainers and catcher blocks. Note modification of bearings in 2001.***				
Number of Locations	**2**	**bents**		*PDF Page #*	**5**
Unit Cost of Retrofit	**$124,000**	*each*		*Figure Ref. #*	**BU205**

Vulnerability Number	**7**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Joint in the Deck System**			*Drawing #*	**AB001-070**
Description of Vulnerability	***Separating of the fixed spans to approach spans joint in the deck system.***				
Proposed Retrofit	***Strengthen the fixed span connection to the pier wall.***				
Number of Locations	**2**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$171,000**	*each*		*Figure Ref. #*	**BU206**

Vulnerability Number	**8**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Approach Deck Fixed Connection to Piers 1 & 4**			*Drawing #*	**AB001-010**
Description of Vulnerability	***Separating of the approach fixed span deck to Piers 1 and 4.***				
Proposed Retrofit	***None. Longitudinal restraints installed in 2001.***				
Number of Locations	**2**			*PDF Page #*	**7**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU207**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**Full Operation (FO)**		

Vulnerability Number	**9**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Truss System - Connections of Primary Members**			*Drawing #*	**AB001-031**
Description of Vulnerability	***Moderate risk on weak link at connection points along top/bottom chord members.***				
Proposed Retrofit	***None, but will require analysis to confirm members are safe for limited operation and lifeline route.***				
Number of Locations	**72**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU208**

Vulnerability Number	**10**	*As-Built Dwg. File*	-		
Vulnerable Component	**Overhead Sign Structures**			*Drawing #*	**-**
Description of Vulnerability	***Collapse of overhead sign structures onto bridge, obstacle to use the bridge for full operation.***				
Proposed Retrofit	***None, will require clean up if collapse onto bridge during seismic event.***				
Number of Locations	**2**			*PDF Page #*	**9**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU209**

Vulnerability Number	**11**	*As-Built Dwg. File*	-		
Vulnerable Component	**Lightings**			*Drawing #*	**-**
Description of Vulnerability	***Collapse of overhead sign structures onto bridge, obstacle to use the bridge for full operation.***				
Proposed Retrofit	***None, will require clean up if collapse onto bridge during seismic event.***				
Number of Locations	**7**			*PDF Page #*	**9**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU209**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Connections - super to sub., Fixed Bearings and Seat Width**			*Drawing #*	**AB001-012**
Description of Vulnerability	***Substructure to superstructure connections at Piers 2 & 3, fixed bearings anchor bolts and limited seat widths.***				
Proposed Retrofit	***Strengthen the bearing pedestals with dowels and concrete.***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**4**
Unit Cost of Retrofit	**$98,000**	*each*		*Figure Ref. #*	**BU204**

Vulnerability Number	**2**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Connections - super to sub., Expansion Bearings and Seat Width**			*Drawing #*	**AB001-040**
Description of Vulnerability	***Substructure to superstructure connections at Piers 1 & 4, expansion bearings and limited seat widths.***				
Proposed Retrofit	***Provide soil densification around Piers 1 & 4. Note: cost of vulernability 1 accounts for this.***				
Number of Locations	**1**	**bridge site**		*PDF Page #*	**5**
Unit Cost of Retrofit	**$98,000**	*each*		*Figure Ref. #*	**BU205**

Vulnerability Number	**3**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Joint in the Deck System**			*Drawing #*	**AB001-070**
Description of Vulnerability	***Separating of the fixed spans to approach spans joint in the deck system.***				
Proposed Retrofit	***Strengthen the fixed span connection to the pier wall.***				
Number of Locations	**2**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$135,000**	*each*		*Figure Ref. #*	**BU206**

Vulnerability Number	**4**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Approach Deck Fixed Connection to Piers 1 & 4**			*Drawing #*	**AB001-010**
Description of Vulnerability	***Separating of the approach fixed span deck to Piers 1 and 4.***				
Proposed Retrofit	***None. Longitudinal restraints installed in 2001.***				
Number of Locations	**2**	**columns**		*PDF Page #*	**7**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU207**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Moveable Span**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**Limited Operation (LO)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Piers 2 & 3 Foundation Timber Piles**			*Drawing #*	**AB001-011**
Description of Vulnerability	***Timber piles could fail in both compression and uplift.***				
Proposed Retrofit	***Add steel piling to the pier footings.***				
Number of Locations	**2**	**piers**		*PDF Page #*	**1**
Unit Cost of Retrofit	**$3,500,000**	*each*		*Figure Ref. #*	**BU101**

Vulnerability Number	**2**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Piers 2 & 3 Bascule Pier Wall below Truss Seats**			*Drawing #*	**AB001-012**
Description of Vulnerability	***Pier wall under truss seats without proper seismic reinforcing details, potential lost of axial support capacity in seismic event.***				
Proposed Retrofit	***Steel shell retrofit for vertical capacity preservation.***				
Number of Locations	**2**	**piers**		*PDF Page #*	**2**
Unit Cost of Retrofit	**$4,380,000**	*each*		*Figure Ref. #*	**BU102**

Vulnerability Number	**3**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Connections - super to sub., Trunnion Support Vertical Post**			*Drawing #*	**AC001-002 & 005**
Description of Vulnerability	***The bottom 15ft of the trunnion support vertical post is unbraced and could be subject to high bending forces.***				
Proposed Retrofit	***Add transverse bracing at the trunnion support posts. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**4**			*PDF Page #*	**3**
Unit Cost of Retrofit	**$1,750,000**	*each*		*Figure Ref. #*	**BU103**

Vulnerability Number	**4**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Connections - super to sub., Anchorage of Trunnion to Bascule Piers**			*Drawing #*	**AC001-003 & 004**
Description of Vulnerability	***At the top of the trunnion support post, the bolts which connect the the trunnion bearing to the vertical support post and the frame diagonal are deficient.***				
Proposed Retrofit	***Install additional anchor bolts at the bearings of the trunnion frame diagonals. Strengthen the trunnion bearing bolts. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**4**			*PDF Page #*	**4**
Unit Cost of Retrofit	**$880,000**	*each*		*Figure Ref. #*	**BU104**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Moveable Span**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**Limited Operation (LO)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Joint in the Deck System at Piers 2 and 3**			*Drawing #*	**AC002-004**
Description of Vulnerability	***Separating of both the fixed and expansion joint system at Piers 2 and 3 pit deck.***				
Proposed Retrofit	***Strengthen the fixed span connection and install longitudinal restraints. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**4**			*PDF Page #*	**5**
Unit Cost of Retrofit	**$180,000**	*each*		*Figure Ref. #*	**BU105**

Vulnerability Number	**6**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Bascule Leaf Transverse Restraint**			*Drawing #*	**AC001-011**
Description of Vulnerability	***A transverse restraint is needed between bottom bracing of the leaf floorbeam at point 14 and the top of new bracing between the live load support pots.***				
Proposed Retrofit	***Add bascule leaf restraint in the Bridge's transverse direction consists of steel weldments. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**4**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$350,000**	*each*		*Figure Ref. #*	**BU106**

Vulnerability Number	**7**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Bascule Leaf Transverse Bracing**			*Drawing #*	**AC001-015**
Description of Vulnerability	***Lateral bracing of the bascule leaf will be inadequate to resist the higher force due to the retrofit above.***				
Proposed Retrofit	***Strengthen the bascule leaf bracing in the Bridge's transverse direction. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**2**			*PDF Page #*	**7**
Unit Cost of Retrofit	**$3,500,000**	*each*		*Figure Ref. #*	**BU107**

Vulnerability Number	**8**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Counterweight Restrainers**			*Drawing #*	**AC038-003**
Description of Vulnerability	***Add restrainers to the rear face of the counterweight to resist transverse movement, and transfer seismic forces into the pier.***				
Proposed Retrofit	***Mount two steel brackets low on the pit walls to restrain the transverse movement. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**2**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$350,000**	*each*		*Figure Ref. #*	**BU108**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Moveable Span**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**Limited Operation (LO)**		

Vulnerability Number	**9**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Counterweight Link Fuse**			*Drawing #*	**AC038-003**
Description of Vulnerability	***Develop a repairable structural fuse in the links to alleviate excessive force transfer into the light floor framing of the machinery room.***				
Proposed Retrofit	***Install a steel strut to restrain the longitudinal movement and weaken the connection of the counterweight link to the machine room floor framing. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**4**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$880,000**	*each*		*Figure Ref. #*	**BU108**

Vulnerability Number	**10**	*As-Built Dwg. File*	-		
Vulnerable Component	**Mechanical Equipment / Working Parts**			*Drawing #*	-
Description of Vulnerability	***Mechanical equipment to close the bascule spans for bridge operation will need to be functional during seismic event.***				
Proposed Retrofit	***System Retrofit - Provide Base Isolation System to protect mechanical components. Provide guideline to repair the mechanical work parts if there is damage.***				
Number of Locations	**2**			*PDF Page #*	-
Unit Cost of Retrofit	**$880,000**	*each*		*Figure Ref. #*	-

Vulnerability Number	**11**	*As-Built Dwg. File*	-		
Vulnerable Component	**Pier Houses**			*Drawing #*	-
Description of Vulnerability	***Collapse of pier houses onto bridge, obstacle to use the bridge for limited operation.***				
Proposed Retrofit	***None, will require clean up if collapse onto bridge during seismic event.***				
Number of Locations	**2**			*PDF Page #*	-
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	-

Vulnerability Number	**12**	*As-Built Dwg. File*	-		
Vulnerable Component	**Lightings**			*Drawing #*	-
Description of Vulnerability	***Collapse of lightings onto bridge, obstacle to use the bridge for limited operation.***				
Proposed Retrofit	***None, will require clean up if collapse onto bridge during seismic event.***				
Number of Locations	**3**			*PDF Page #*	-
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	-

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Moveable Span**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**Full Operation (FO)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Piers 2 & 3 Foundation Timber Piles**			*Drawing #*	**AB001-011**
Description of Vulnerability	***Timber piles could fail in both compression and uplift.***				
Proposed Retrofit	***Add steel piling to the pier footings.***				
Number of Locations	**2**	**piers**		*PDF Page #*	**1**
Unit Cost of Retrofit	**$3,325,000**	*each*		*Figure Ref. #*	**BU101**

Vulnerability Number	**2**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Piers 2 & 3 Bascule Pier Wall below Truss Seats**			*Drawing #*	**AB001-012**
Description of Vulnerability	***Pier wall under truss seats without proper seismic reinforcing details, potential lost of axial support capacity in seismic event.***				
Proposed Retrofit	***Steel shell retrofit for vertical capacity preservation.***				
Number of Locations	**2**	**piers**		*PDF Page #*	**2**
Unit Cost of Retrofit	**$4,161,000**	*each*		*Figure Ref. #*	**BU102**

Vulnerability Number	**3**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Connections - super to sub., Trunnion Support Vertical Post**			*Drawing #*	**AC001-002 & 005**
Description of Vulnerability	***The bottom 15ft of the trunnion supoprt vertical post is unbraced and could be subject to high bending forces.***				
Proposed Retrofit	***Add transverse bracing at the trunnion support posts. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**4**			*PDF Page #*	**3**
Unit Cost of Retrofit	**$1,663,000**	*each*		*Figure Ref. #*	**BU103**

Vulnerability Number	**4**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Connections - super to sub., Anchorage of Trunnion to Bascule Piers**			*Drawing #*	**AC001-003 & 004**
Description of Vulnerability	***At the top of the trunnion support post, the bolts which connect the the trunnion bearing to the vertical support post and the frame diagonal are deficient.***				
Proposed Retrofit	***Install additional anchor bolts at the bearings of the trunnion frame diagonals. Strengthen the trunnion bearing bolts. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**4**			*PDF Page #*	**4**
Unit Cost of Retrofit	**$836,000**	*each*		*Figure Ref. #*	**BU104**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Moveable Span**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**Full Operation (FO)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Joint in the Deck System at Piers 2 and 3**			*Drawing #*	**AC002-004**
Description of Vulnerability	***Separating of both the fixed and expansion joint system at Piers 2 and 3 pit deck.***				
Proposed Retrofit	***Strengthen the fixed span connection and install longitudinal restraints. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**4**			*PDF Page #*	**5**
Unit Cost of Retrofit	**$171,000**	*each*		*Figure Ref. #*	**BU105**

Vulnerability Number	**6**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Bascule Leaf Transverse Restraint**			*Drawing #*	**AC001-011**
Description of Vulnerability	***A transverse restraint is needed between bottom bracing of the leaf floorbeam at point 14 and the top of new bracing between the live load support pots.***				
Proposed Retrofit	***Add bascule leaf restraint in the Bridge's transverse direction consists of steel weldments. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**4**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$333,000**	*each*		*Figure Ref. #*	**BU106**

Vulnerability Number	**7**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Bascule Leaf Transverse Bracing**			*Drawing #*	**AC001-015**
Description of Vulnerability	***Lateral bracing of the bascule leaf will be inadequate to resist the higher force due to the retrofit above.***				
Proposed Retrofit	***Strengthen the bascule leaf bracing in the Bridge's transverse direction. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**2**			*PDF Page #*	**7**
Unit Cost of Retrofit	**$3,325,000**	*each*		*Figure Ref. #*	**BU107**

Vulnerability Number	**8**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Counterweight Restrainers**			*Drawing #*	**AC038-003**
Description of Vulnerability	***Add restrainers to the rear face of the counterweight to resist transverse movement, and transfer seismic forces into the pier.***				
Proposed Retrofit	***Mount two steel brackets low on the pit walls to restrain the transverse movement. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**2**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$333,000**	*each*		*Figure Ref. #*	**BU108**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Moveable Span**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**Full Operation (FO)**		

Vulnerability Number	**9**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Counterweight Link Fuse**			*Drawing #*	**AC038-003**
Description of Vulnerability	***Develop a repairable structural fuse in the links to alleviate excessive force transfer into the light floor framing of the machinery room.***				
Proposed Retrofit	***Install a steel strut to restrain the longitudinal movement and weaken the connection of the counterweight link to the machine room floor framing. System Retrofit - base Isolation will affect this retrofit***				
Number of Locations	**4**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$836,000**	*each*		*Figure Ref. #*	**BU108**

Vulnerability Number	**10**	*As-Built Dwg. File*	-		
Vulnerable Component	**Mechanical Equipment / Working Parts**			*Drawing #*	-
Description of Vulnerability	***Mechanical equipment to close the bascule spans for bridge operation will need to be functional during seismic event.***				
Proposed Retrofit	***System Retrofit - Provide Base Isolation System to protect mechanical components. Provide guideline to repair the mechanical work parts if there is damage.***				
Number of Locations	**2**			*PDF Page #*	-
Unit Cost of Retrofit	**$836,000**	*each*		*Figure Ref. #*	-

Vulnerability Number	**11**	*As-Built Dwg. File*	-		
Vulnerable Component	**Pier Houses**			*Drawing #*	-
Description of Vulnerability	***Collapse of pier houses onto bridge, obstacle to use the bridge for full operation.***				
Proposed Retrofit	***None, will require clean up if collapse onto bridge during seismic event.***				
Number of Locations	**2**			*PDF Page #*	-
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	-

Vulnerability Number	**12**	*As-Built Dwg. File*	-		
Vulnerable Component	**Lightings**			*Drawing #*	-
Description of Vulnerability	***Collapse of lightings onto bridge, obstacle to use the bridge for full operation.***				
Proposed Retrofit	***None, will require clean up if collapse onto bridge during seismic event.***				
Number of Locations	**3**			*PDF Page #*	-
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	-

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Moveable Span**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Connections - super to sub., Trunnion Support Vertical Post**			*Drawing #*	**AC001-002 & 005**
Description of Vulnerability	***The bottom 15ft of the trunnion supoprt vertical post is unbraced and could be subject to high bending forces.***				
Proposed Retrofit	***Add transverse bracing at the trunnion support posts.***				
Number of Locations	**4**	**piers**		*PDF Page #*	**3**
Unit Cost of Retrofit	**$1,310,000**	*each*		*Figure Ref. #*	**BU103**

Vulnerability Number	**2**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Joint in the Deck System at Piers 2 and 3**			*Drawing #*	**AC002-004**
Description of Vulnerability	***Separating of both the fixed and expansion joint system at Piers 2 and 3 pit deck.***				
Proposed Retrofit	***Strengthen the fixed span connection and install longitudinal restraints.***				
Number of Locations	**4**	**piers**		*PDF Page #*	**5**
Unit Cost of Retrofit	**$135,000**	*each*		*Figure Ref. #*	**BU105**

Vulnerability Number	**3**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Bascule Leaf Transverse Restraint**			*Drawing #*	**AC001-011**
Description of Vulnerability	***A transverse restraint is needed between bottom bracing of the leaf floorbeam at point 14 and the top of new bracing between the live load support pots.***				
Proposed Retrofit	***Add bascule leaf restraint in the Bridge's transverse direction consists of steel weldments.***				
Number of Locations	**4**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$263,000**	*each*		*Figure Ref. #*	**BU106**

Vulnerability Number	**4**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Counterweight Restrainers**			*Drawing #*	**AC038-003**
Description of Vulnerability	***Add restrainers to the rear face of the counterweight to resist transverse movement, and transfer seismic forces into the pier.***				
Proposed Retrofit	***Mount two steel brackets low on the pit walls to restrain the transverse movement.***				
Number of Locations	**2**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$263,000**	*each*		*Figure Ref. #*	**BU108**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **4/11/2014**
Bridge Name	**Willamette River, Burnside St (Burnside) [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511**				
Bridge Location	**Moveable Span**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	1924-1994_Burnside_Bascule_Span_and_MiscRepairs.pdf		
Vulnerable Component	**Counterweight Link Fuse**			*Drawing #*	**AC038-003**
Description of Vulnerability	***Develop a repairable structural fuse in the links to alleviate excessive force transfer into the light floor framing of the machinery room.***				
Proposed Retrofit	***Install a steel strut to restrain the longitudinal movement and weaken the connection of the counterweight link to the machine room floor framing.***				
Number of Locations	**4**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$660,000**	*each*		*Figure Ref. #*	**BU108**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **3/26/2014**
Bridge Name	**Burnside St (East Approach) over Hwy 1 & Conns [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511B**				
Bridge Location	**East Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**Limited Operation (LO)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Pile Caps**			*Drawing #*	**AB001-019**
Description of Vulnerability	***Bents 21-27, Low risk as footing is large compared to column, column will not able to rock the footing; Bents 24 to 27 are 20ft below ground.***				
Proposed Retrofit	***Minimal footing overlay with reinforcing dowels if strengthening from other members require additional capacities.***				
Number of Locations	**15**			*PDF Page #*	**1**
Unit Cost of Retrofit	**$130,000**	*each*		*Figure Ref. #*	**BU401**

Vulnerability Number	**2**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Spread footing**			*Drawing #*	**AB001-049**
Description of Vulnerability	***Bent 28, low risk, wall (from skate park) between columns, spread footing buried in ground***				
Proposed Retrofit	***None, but confirm columns is structurally connect to wall.***				
Number of Locations	**3**			*PDF Page #*	**2, 3**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU402**

Vulnerability Number	**3**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Spread footing**			*Drawing #*	**AB001-008**
Description of Vulnerability	***Bents 29-34, low risk, footing buried in ground, pavement or 6-10ft embedment will "fix" column at ground level***				
Proposed Retrofit	***None.***				
Number of Locations	**24**			*PDF Page #*	**4**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU403**

Vulnerability Number	**4**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Superstructure seating on Abutment**			*Drawing #*	**AB001-083**
Description of Vulnerability	***East Approach Abument (Bent 35), unreinforced abutment, crack and movement will lead to lost of superstructure seat support (out to out width 110ft)***				
Proposed Retrofit	***Seat Extender. Steel wall plate with shear studs attached to abutment wall.***				
Number of Locations	**1**			*PDF Page #*	**5**
Unit Cost of Retrofit	**$130,000**	*each*		*Figure Ref. #*	**BU404**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **3/26/2014**
Bridge Name	**Burnside St (East Approach) over Hwy 1 & Conns [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511B**				
Bridge Location	**East Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**Limited Operation (LO)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Connections - Bents to Below Ground Foundations**			*Drawing #*	**AB001-019, 047, 054**
Description of Vulnerability	***Shear/bending failure of anchor rod; not include Bent 28 columns, as column has 56-1in dia. bars connect to base, and possibly wall between columns (from skate park)***				
Proposed Retrofit	***Concrete confinement and dowels around column and support base.***				
Number of Locations	**15**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$130,000**	*each*		*Figure Ref. #*	**BU405**

Vulnerability Number	**6**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Bent Column (concrete encased steel column pairs with bracing)**			*Drawing #*	**AB001-047, 054, 059**
Description of Vulnerability	***Steel columns have limited lateral load capability and slenderness concerns.***				
Proposed Retrofit	***Concrete jacketing to increase column shear capacity.***				
Number of Locations	**15**			*PDF Page #*	**7**
Unit Cost of Retrofit	**$130,000**	*each*		*Figure Ref. #*	**BU406**

Vulnerability Number	**7**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Bent Column (concrete column)**			*Drawing #*	**AB001-008**
Description of Vulnerability	***Shear/bending failure at ground due to fixity from pavement or concrete floor; not include Bent 28 columns, as column has 56-1in dia. bars, possibly wall between columns (from skate park) and short span on one side***				
Proposed Retrofit	***In-fill wall above ground to prevent flexure failure and increase shear capacity.***				
Number of Locations	**24**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$130,000**	*each*		*Figure Ref. #*	**BU407**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **3/26/2014**
Bridge Name	**Burnside St (East Approach) over Hwy 1 & Conns [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511B**				
Bridge Location	**East Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**Full Operation (FO)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Pile Caps**			*Drawing #*	**AB001-019**
Description of Vulnerability	***Bents 21-27, Low risk as footing is large compared to column, column will not able to rock the footing; Bents 24 to 27 are 20ft below ground.***				
Proposed Retrofit	***Minimal footing overlay with reinforcing dowels if strengthening from other members require additional capacities.***				
Number of Locations	**15**			*PDF Page #*	**1**
Unit Cost of Retrofit	**$124,000**	*each*		*Figure Ref. #*	**BU401**

Vulnerability Number	**2**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Spread footing**			*Drawing #*	**AB001-049**
Description of Vulnerability	***Bent 28, low risk, wall (from skate park) between columns, spread footing buried in ground***				
Proposed Retrofit	***None, but confirm columns is structurally connect to wall.***				
Number of Locations	**3**			*PDF Page #*	**2, 3**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU402**

Vulnerability Number	**3**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Spread footing**			*Drawing #*	**AB001-008**
Description of Vulnerability	***Bents 29-34, low risk, footing buried in ground, pavement or 6-10ft embedment will "fix" column at ground level***				
Proposed Retrofit	***None.***				
Number of Locations	**24**			*PDF Page #*	**4**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**BU403**

Vulnerability Number	**4**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Superstructure seating on Abutment**			*Drawing #*	**AB001-083**
Description of Vulnerability	***East Approach Abument (Bent 35), unreinforced abutment, crack and movement will lead to lost of superstructure seat support (out to out width 110ft)***				
Proposed Retrofit	***Steel wall plate with shear studs attached to abutment wall.***				
Number of Locations	**1**			*PDF Page #*	**5**
Unit Cost of Retrofit	**$124,000**	*each*		*Figure Ref. #*	**BU404**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date: **3/26/2014**
Bridge Name	**Burnside St (East Approach) over Hwy 1 & Conns [Burnside]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511B**				
Bridge Location	**East Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**Full Operation (FO)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Connections - Bents to Below Ground Foundations**			*Drawing #*	**AB001-019, 047, 054**
Description of Vulnerability	***Shear/bending failure of anchor rod; not include Bent 28 columns, as column has 56-1in dia. bars connect to base, and possibly wall between columns (from skate park)***				
Proposed Retrofit	***Concrete confinement and dowels around column and support base.***				
Number of Locations	**15**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$124,000**	*each*		*Figure Ref. #*	**BU405**

Vulnerability Number	**6**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Bent Column (concrete encased steel column pairs with bracing)**			*Drawing #*	**AB001-047, 054, 059**
Description of Vulnerability	***Steel columns have limited lateral load capability and slenderness concerns.***				
Proposed Retrofit	***Concrete jacketing to increase column shear capacity***				
Number of Locations	**15**			*PDF Page #*	**7**
Unit Cost of Retrofit	**$124,000**	*each*		*Figure Ref. #*	**BU406**

Vulnerability Number	**7**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Bent Column (concrete column)**			*Drawing #*	**AB001-008**
Description of Vulnerability	***Shear/bending failure at ground due to fixity from pavement or concrete floor; not include Bent 28 columns, as column has 56-1in dia. bars, possibly wall between columns (from skate park) and short span on one side***				
Proposed Retrofit	***In-fill wall above ground to prevent flexure failure and increase shear capacity.***				
Number of Locations	**24**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$124,000**	*each*		*Figure Ref. #*	**BU407**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**			*Compiled by:*	**AXLI**	Date: **3/26/2014**
Bridge Name	**Burnside St (East Approach) over Hwy 1 & Conns [Burnside]**			*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**00511B**					
Bridge Location	**East Approaches**					
Seismic Event	**100 Yr**	*Desired Performance Level*		**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Connections - Bents to Below Ground Foundations**			*Drawing #*	**AB001-019, 047, 054**
Description of Vulnerability	***Shear/bending failure of anchor rod; not include Bent 28 columns, as column has 56-1in dia. bars connect to base, and possibly wall between columns (from skate park)***				
Proposed Retrofit	***Concrete confinement and dowels around column and support base.***				
Number of Locations	**15**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$98,000**	*each*		*Figure Ref. #*	**BU405**

Vulnerability Number	**2**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Bent Column (concrete column)**			*Drawing #*	**AB001-008**
Description of Vulnerability	***Shear/bending failure at ground due to fixity from pavement or concrete floor; not include Bent 28 columns, as column has 56-1in dia. bars, possibly wall between columns (from skate park) and short span on one side***				
Proposed Retrofit	***In-fill wall above ground to prevent flexure failure and increase shear capacity.***				
Number of Locations	**24**			*PDF Page #*	**8**
Unit Cost of Retrofit	**$98,000**	*each*		*Figure Ref. #*	**BU407**

Vulnerability Number	**3**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Rocker bearing**			*Drawing #*	**AB001-048, 049, 050, 054**
Description of Vulnerability	***Rocker bearing & anchor rod to column***				
Proposed Retrofit	***1. Provide restrainers to bearing to prevent collapse*** ***2. Replace bearings***				
Number of Locations	**11**			*PDF Page #*	
Unit Cost of Retrofit	**$98,000**	*each*		*Figure Ref. #*	

Vulnerability Number	**4**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Seat Width (Expansion)**			*Drawing #*	**AB001-053, 055**
Description of Vulnerability	***Inadequate seat width at Bents 31, 33 and 34***				
Proposed Retrofit	***Steel or Concrete seat extension or catcher blocks.***				
Number of Locations	**54**			*PDF Page #*	**10**
Unit Cost of Retrofit	**$98,000**	*each*		*Figure Ref. #*	**BU409**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Burnside**		*Compiled by:*	**AXLI**	Date:	**3/26/2014**
Bridge Name	**Burnside St (East Approach) over Hwy 1 & Conns [Burnside]**		*Checked by:*	**kpbu**	Date:	5/20/2014
Bridge Number	**00511B**					
Bridge Location	**East Approaches**					
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**5**	*As-Built Dwg. File*	1924-02-21_Burnside_As-Builts.pdf		
Vulnerable Component	**Connection - Substructure to Superstructure**			*Drawing #*	**AB001-008**
Description of Vulnerability	***RCDG to column connection with dowels only***				
Proposed Retrofit	***Concrete jacketing at connection.***				
Number of Locations	**24**			*PDF Page #*	**11**
Unit Cost of Retrofit	**$98,000**	*each*		*Figure Ref. #*	**BU410**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**West Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Footing**			*Drawing #*	**D9**
Description of Vulnerability	***Footing shear and flexural rebar detailing look insufficient. There are no flexural bars at the top of the footing and no stirrups to transfer the shear loads into the foundation. Column to footing joint is also poorly detailed, and the joint is a common failure mechanism during seismic loads. Vulnerability is footing fails prematurely before column hinges.***				
Proposed Retrofit	***Increase existing footing plan and elevation dimensions, drill and bond new dowels and stirrups in existing footing, drive new piles, complete joint replacement.***				
Number of Locations	**51**	**Footings**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**MR008**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Footing**			*Drawing #*	**D9**
Description of Vulnerability	***Pile head embedment depth into pile cap may not be sufficient enough for the pile head to act as a true "fixed" head. Vulnerability is pile head anchorage pull out or yielding when moment is transferred into footing.***				
Proposed Retrofit	***Add additional layer of concrete to increase pile head embedment depth to a minimum 24".***				
Number of Locations	**9**	**Footings**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR008**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Column**			*Drawing #*	**D9**
Description of Vulnerability	***Column flexural and shear strength insufficient for seismic demands. Stirrups are spaced too far apart to provide proper confinement for concrete core. Column to bent cap joint detailing is also poor, and the joint is a common failure mechanism where shear forces tend to concentrate. Vulnerability is low displacement capacity and non-ductile performance.***				
Proposed Retrofit	***Steel jacketing to provide confinement.***				
Number of Locations	**51**	**Columns**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR009**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Bent cap**			*Drawing #*	**D9**
Description of Vulnerability	***Bent Cap flexural strength insufficient for to transfer superstructure forces into the substructure during lateral loading. Vulnerability is the cap can fail prematurely before column hinges.***				
Proposed Retrofit	***Add concrete bolsters and doweling new rebar for the entire cap to increase stiffness.***				
Number of Locations	**19**	**Bents**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$150,000**	*each*		*Figure Ref. #*	**MR009**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**West Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Girder Restraint**			*Drawing #*	**D9**
Description of Vulnerability	***No transverse or longitudinal restraints at the superstructure to substructure connection. Vulnerability is superstructure unseating at the bearings.***				
Proposed Retrofit	***Reinforced concrete shear keys and longitudinal cable restraints.***				
Number of Locations	**24**	**Bents**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$100,000**	*each*		*Figure Ref. #*	**MR009**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Superstructure bearings at bent caps**			*Drawing #*	**D9**
Description of Vulnerability	***Stringer shoe rehabilitation. Vulnerability is this bearing type may perform poorly in seismic conditions to transfer loads from superstructure into substructure. Currently, the stringers are connected by anchor bolts to the shoes.***				
Proposed Retrofit	***Full bearing replacement with elastomeric pads.***				
Number of Locations	**24**	**Bents**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR010**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Superstructure diaphragms**			*Drawing #*	**D19**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is shear failure at the girder flange to deck connection during lateral movement.***				
Proposed Retrofit	***Replace diaphragms members to increase transverse stiffness.***				
Number of Locations	**24**	**Diaphragm Lines**		*PDF Page #*	**20**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR011**

Vulnerability Number	**8**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Expansion joints**			*Drawing #*	**D23**
Description of Vulnerability	***Vulnerability is movement during a seismic event may move beyond the capacity of the hinge***				
Proposed Retrofit	***Longitudinal cable restrainers. - Cost Included in vulnerability 5***				
Number of Locations	**21**	**Joints**		*PDF Page #*	**24**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR012**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**West Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Footing**			*Drawing #*	**D9**
Description of Vulnerability	***Footing shear and flexural rebar detailing look insufficient. There are no flexural bars at the top of the footing and no stirrups to transfer the shear loads into the foundation. Column to footing joint is also poorly detailed, and the joint is a common failure mechanism during seismic loads. Vulnerability is footing fails prematurely before column hinges.***				
Proposed Retrofit	***Increase existing footing plan and elevation dimensions, drill and bond new dowels and stirrups in existing footing, drive new piles, complete joint replacement.***				
Number of Locations	**51**	**Footings**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**MR008**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Footing**			*Drawing #*	**D9**
Description of Vulnerability	***Pile head embedment depth into pile cap may not be sufficient enough for the pile head to act as a true "fixed" head. Vulnerability is pile head anchorage pull out or yielding when moment is transferred into footing.***				
Proposed Retrofit	***Add additional layer of concrete to increase pile head embedment depth to a minimum 24".***				
Number of Locations	**9**	**Footings**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR008**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Column**			*Drawing #*	**D9**
Description of Vulnerability	***Column flexural and shear strength insufficient for seismic demands. Stirrups are spaced too far apart to provide proper confinement for concrete core. Column to bent cap joint detailing is also poor, and the joint is a common failure mechanism where shear forces tend to concentrate. Vulnerability is low displacement capacity and non-ductile performance.***				
Proposed Retrofit	***Steel jacketing to provide confinement.***				
Number of Locations	**51**	**Columns**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**MR009**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Bent cap**			*Drawing #*	**D9**
Description of Vulnerability	***Bent Cap flexural strength insufficient for to transfer superstructure forces into the substructure during lateral loading. Vulnerability is the cap can fail prematurely before column hinges.***				
Proposed Retrofit	***Add concrete bolsters and doweling new rebar for the entire cap to increase stiffness.***				
Number of Locations	**19**	**Bents**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$143,000**	*each*		*Figure Ref. #*	**MR009**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**West Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Girder Restraint**			*Drawing #*	**D9**
Description of Vulnerability	***No transverse or longitudinal restraints at the superstructure to substructure connection. Vulnerability is superstructure unseating at the bearings.***				
Proposed Retrofit	***Reinforced concrete shear keys and longitudinal cable restraints.***				
Number of Locations	**24**	**Bents**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$95,000**	*each*		*Figure Ref. #*	**MR009**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Superstructure bearings at bent caps**			*Drawing #*	**D9**
Description of Vulnerability	***Stringer shoe rehabilitation. Vulnerability is this bearing type may perform poorly in seismic conditions to transfer loads from superstructure into substructure. Currently, the stringers are connected by anchor bolts to the shoes.***				
Proposed Retrofit	***Full bearing replacement with elastomeric pads.***				
Number of Locations	**24**	**Bents**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**MR010**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Superstructure diaphragms**			*Drawing #*	**D19**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is shear failure at the girder flange to deck connection during lateral movement.***				
Proposed Retrofit	***Replace diaphragms members to increase transverse stiffness.***				
Number of Locations	**24**	**Diaphragm Lines**		*PDF Page #*	**20**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**MR011**

Vulnerability Number	**8**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Expansion joints**			*Drawing #*	**D23**
Description of Vulnerability	***Vulnerability is movement during a seismic event may move beyond the capacity of the hinge***				
Proposed Retrofit	***Longitudinal cable restrainers. - Cost Included in vulnerability 5***				
Number of Locations	**21**	**Joints**		*PDF Page #*	**24**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR012**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**West Approaches**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Bent cap restrainers**			*Drawing #*	**D9**
Description of Vulnerability	***No transverse or longitudinal retraints at the superstructure to substructure connection. Vulnerability is superstructure unseating at the bearings due to seismic event.***				
Proposed Retrofit	***Options include: 1. Reinforced concrete shear keys 2. Steel plate bumpers 3. Longitudinal cable restraints***				
Number of Locations	**24**	**Bents**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR009**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Superstructure bearings at bent caps**			*Drawing #*	**D9**
Description of Vulnerability	***Stringer shoe rehabilitation. Vulnerability is this bearing type may perform poorly in seismic conditions to transfer loads from superstructure into substructure. Currently, the stringers are connected by anchor bolts to the shoes.***				
Proposed Retrofit	***Full bearing replacement with elastomeric pads.***				
Number of Locations	**24**	**Bents**		*PDF Page #*	**10**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**MR010**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Superstructure diaphragms**			*Drawing #*	**D19**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is shear failure at the girder flange to deck connection during lateral movement.***				
Proposed Retrofit	***No retrofit needed for 100 yr event***				
Number of Locations	**55**	**Diaphragm Lines**		*PDF Page #*	**20**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR011**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-1990_Morrison_W_Approach_Intch_Eastbank_Yramp.pdf**		
Vulnerable Component	**Expansion joints**			*Drawing #*	**D23**
Description of Vulnerability	***Vulnerability is movement during a seismic event may move beyond the capacity of the hinge***				
Proposed Retrofit	***Longitudinal cable restrainers***				
Number of Locations	**21**	**Joints**		*PDF Page #*	**24**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR012**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Footing**			*Drawing #*	**A5 of 26**
Description of Vulnerability	***Footing shear and flexural rebar detailing look insufficient. There are no flexural bars at the top of the footing and no stirrups to transfer the shear loads into the foundation. Column to footing joint is also poorly detailed, and the joint is a common failure mechanism during seismic loads. Vulnerability is footing fails prematurely before column hinges.***				
Proposed Retrofit	***Increase existing footing plan and elevation dimensions, drill and bond new dowels and stirrups in existing footing, drive new piles, complete joint replacement. System Retrofit - Base isolating the structure would reduce the demands going into the foundation, making the footing retrofit less of a priority and potentially unnecessary.***				
Number of Locations	**4**	**Footings**		*PDF Page #*	**4**
Unit Cost of Retrofit	**$2,000,000**	*each*		*Figure Ref. #*	**MR014**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Column**			*Drawing #*	**A6 of 26**
Description of Vulnerability	***Column flexural and shear strength insufficient for seismic demands. Stirrups are spaced too far apart to provide proper confinement for concrete core. Column to bent cap joint detailing is also poor, and the joint is a common failure mechanism where shear forces tend to concentrate. Vulnerability is low displacement capacity and non-ductile performance.***				
Proposed Retrofit	***Steel jacketing to provide confinement. System Retrofit - Base isolating the structure would reduce the demands going into the substructure, making the column jacketing less of a priority and potentially unnecessary.***				
Number of Locations	**8**	**Columns**		*PDF Page #*	**5**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR015**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Bent cap**			*Drawing #*	**A6 of 26**
Description of Vulnerability	***Bent Cap at Piers 1 and 4 flexural strength insufficient for to transfer superstructure forces into the substructure during lateral loading. Vulnerability is the cap can fail prematurely before column hinges.***				
Proposed Retrofit	***Add concrete bolsters and doweling new rebar for the entire cap to increase stiffness. System Retrofit - Base isolating the structure would reduce the demands going into the substructure, making the bent cap strengthening less of a priority and potentially unnecessary.***				
Number of Locations	**2**	**Bents**		*PDF Page #*	**5**
Unit Cost of Retrofit	**$150,000**	*each*		*Figure Ref. #*	**MR015**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Trunnion Support Frame**			*Drawing #*	**A12 of 26**
Description of Vulnerability	***Embedment of vertical bars at Section E-E insufficient. Vulnerability is flexural reinforcement may not develop full strength and pulls out. Trunnion beam may see high torsion and out of plane forces.***				
Proposed Retrofit	***Add additional vertical bars. And build up overall frame***				
Number of Locations	**2**	**leaf**		*PDF Page #*	**11**
Unit Cost of Retrofit	**$1,500,000**	*each*		*Figure Ref. #*	**MR016**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Superstructure bearings at bent caps**			*Drawing #*	**C9 of 72**
Description of Vulnerability	***"Fixed" and "Exp" bearing shoe insufficient in transferring seismic forces through the anchor bolts to substructure.***				
Proposed Retrofit	***Full bearing replacement. System Retrofit - Replace existing bearings with isolalation bearings.***				
Number of Locations	**8**	**Bearings**		*PDF Page #*	**27**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**MR017**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Superstructure diaphragms**			*Drawing #*	**C5 of 72**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is buckling or yielding during lateral movement.***				
Proposed Retrofit	***Replace diaphragms members to increase transverse stiffness and strength. System Retrofit - Base isolating the structure would reduce the demands going into the superstructure, making the diaphragm strengthening less of a priority and potentially unnecessary.***				
Number of Locations	**18**	**Diaphragm Lines**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**MR018**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Truss laterals**			*Drawing #*	**C5 of 72**
Description of Vulnerability	***Top and bottom laterals may need strengthening to transfer transverse seismic forces from superstructure to substructure. Vulnerability is swaying of the truss frames.***				
Proposed Retrofit	***Replace brace members to increase truss stiffness and strength. System Retrofit - Base isolating the structure would reduce the demands going into the superstructure, making the top and bottom lateral replacement less of a priority and potentially unnecessary.***				
Number of Locations	**16**	**Bays**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**MR019**

Vulnerability Number	**8**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Pit span bearing seats**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***The fixed span over the bascule piers does not have sufficient bearing width.***				
Proposed Retrofit	***Concrete seat extenders with bars doweled into trunnion support beam or complete support frame retrofit with increased section width.***				
Number of Locations	**2**	**Pier Lines**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR30**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**9**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Deck Support Columns at Pit Span**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***The short steel columns supporting the deck span and resting on the trunnion beam are likely deficient in longitudinal seismic force transfer mechanism, primarily connection to floorbeam***				
Proposed Retrofit	***Full column replacement or retrofitted floor beam to column connection to allow rotation at the top.***				
Number of Locations	**2**	**Pier Lines**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$2,000,000**	*each*		*Figure Ref. #*	**MR31**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Footing**			*Drawing #*	**A5 of 26**
Description of Vulnerability	***Footing shear and flexural rebar detailing look insufficient. There are no flexural bars at the top of the footing and no stirrups to transfer the shear loads into the foundation. Column to footing joint is also poorly detailed, and the joint is a common failure mechanism during seismic loads. Vulnerability is footing fails prematurely before column hinges.***				
Proposed Retrofit	***Increase existing footing plan and elevation dimensions, drill and bond new dowels and stirrups in existing footing, drive new piles, complete joint replacement. System Retrofit - Base isolating the structure would reduce the demands going into the foundation, making the footing retrofit less of a priority and potentially unnecessary.***				
Number of Locations	**4**	**Footings**		*PDF Page #*	**4**
Unit Cost of Retrofit	**$1,900,000**	*each*		*Figure Ref. #*	**MR014**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Column**			*Drawing #*	**A6 of 26**
Description of Vulnerability	***Column flexural and shear strength insufficient for seismic demands. Stirrups are spaced too far apart to provide proper confinement for concrete core. Column to bent cap joint detailing is also poor, and the joint is a common failure mechanism where shear forces tend to concentrate. Vulnerability is low displacement capacity and non-ductile performance.***				
Proposed Retrofit	***Steel jacketing to provide confinement. System Retrofit - Base isolating the structure would reduce the demands going into the substructure, making the column jacketing less of a priority and potentially unnecessary.***				
Number of Locations	**8**	**Columns**		*PDF Page #*	**5**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**MR015**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Bent cap**			*Drawing #*	**A6 of 26**
Description of Vulnerability	***Bent Cap flexural strength insufficient for to transfer superstructure forces into the substructure during lateral loading. Vulnerability is the cap can fail prematurely before column hinges.***				
Proposed Retrofit	***Add concrete bolsters and doweling new rebar for the entire cap to increase stiffness. System Retrofit - Base isolating the structure would reduce the demands going into the substructure, making the bent cap strengthening less of a priority and potentially unnecessary.***				
Number of Locations	**2**	**Bents**		*PDF Page #*	**5**
Unit Cost of Retrofit	**$143,000**	*each*		*Figure Ref. #*	**MR015**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Trunnion Support Frame**			*Drawing #*	**A12 of 26**
Description of Vulnerability	***Embedment of vertical bars at Section E-E insufficient. Vulnerability is flexural reinforcement may not develop full strength and pulls out. Trunnion beam may see high torsion and out of plane forces.***				
Proposed Retrofit	***Add additional vertical bars.***				
Number of Locations	**2**	**leaf**		*PDF Page #*	**11**
Unit Cost of Retrofit	**$1,425,000**	*each*		*Figure Ref. #*	**MR016**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Superstructure bearings at bent caps**			*Drawing #*	**C9 of 72**
Description of Vulnerability	***"Fixed" and "Exp" bearing shoe insufficient in transferring seismic forces through the anchor bolts to substructure.***				
Proposed Retrofit	***Full bearing replacement. System Retrofit - Replace existing bearings with isolalation bearings.***				
Number of Locations	**8**	**Bearings**		*PDF Page #*	**27**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**MR017**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Superstructure diaphragms**			*Drawing #*	**C5 of 72**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is buckling or yielding during lateral movement.***				
Proposed Retrofit	***Replace diaphragms members to increase transverse stiffness. System Retrofit - Base isolating the structure would reduce the demands going into the superstructure, making the diaphragm strengthening less of a priority and potentially unnecessary.***				
Number of Locations	**18**	**Diaphragm Lines**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**MR018**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Truss laterals**			*Drawing #*	**C5 of 72**
Description of Vulnerability	***Top and bottom laterals may need strengthening to transfer transverse seismic forces from superstructure to substructure. Vulnerability is swaying of the truss frames.***				
Proposed Retrofit	***Replace brace members to increase truss stiffness. System Retrofit - Base isolating the structure would reduce the demands going into the superstructure, making the top and bottom lateral replacement less of a priority and potentially unnecessary.***				
Number of Locations	**16**	**Bays**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**MR019**

Vulnerability Number	**8**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Pit span bearing seats**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***The fixed span over the bascule piers does not have sufficient bearing width.***				
Proposed Retrofit	***Concrete seat extenders with bars doweled into trunnion support beam or complete support frame retrofit with increased section width.***				
Number of Locations	**2**	**Pier Lines**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**MR30**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**9**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Deck Support Columns at Pit Span**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***The short steel columns supporting the deck span and resting on the trunnion beam are likely deficient in longitudinal seismic force transfer mechanism, primarily connection to floorbeam.***				
Proposed Retrofit	***Full column replacement or retrofitted floor beam to column connection to allow rotation at the top.***				
Number of Locations	**2**	**Pier Lines**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$1,900,000**	*each*		*Figure Ref. #*	**MR31**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Trunnion Support Frame**			*Drawing #*	**A12 of 26**
Description of Vulnerability	***Embedment of vertical bars at Section E-E insufficient. Vulnerability is flexural reinforcement may not develop full strength and pulls out. Trunnion beam may see high torsion and out of plane forces.***				
Proposed Retrofit	***Add additional vertical bars***				
Number of Locations	**2**	**Frames**		*PDF Page #*	**11**
Unit Cost of Retrofit	**$1,125,000**	*each*		*Figure Ref. #*	**MR016**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Superstructure bearings at bent caps**			*Drawing #*	**C9 of 72**
Description of Vulnerability	***"Fixed" and "Exp" bearing shoe insufficient in transferring seismic forces through the anchor bolts to substructure.***				
Proposed Retrofit	***Full bearing replacement.***				
Number of Locations	**8**	**Bearings**		*PDF Page #*	**27**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR017**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Superstructure diaphragms**			*Drawing #*	**C5 of 72**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is buckling or yielding during lateral movement.***				
Proposed Retrofit	***No retrofit Needed for 100 yr event***				
Number of Locations	**18**	**Diaphragm Lines**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR018**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Truss laterals**			*Drawing #*	**C5 of 72**
Description of Vulnerability	***Top and bottom laterals may need strengthening to transfer transverse seismic forces from superstructure to substructure. Vulnerability is swaying of the truss frames.***				
Proposed Retrofit	***No Retrofit needed for 100 yr event***				
Number of Locations	**16**	**leaf**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR019**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Pit span bearing seats**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***The fixed span over the bascule piers does not have sufficient bearing width.***				
Proposed Retrofit	***Concrete seat extenders with bars doweled into trunnion support beam or complete support frame retrofit with increased section width.***				
Number of Locations	**2**	**Pier Lines**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**MR30**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Deck Support Columns at Pit Span**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***The short steel columns supporting the deck span and resting on the trunnion beam are likely deficient in longitudinal seismic force transfer mechanism, primarily connection to floorbeam.***				
Proposed Retrofit	***Full column replacement or retrofitted floor beam to column connection to allow rotation at the top.***				
Number of Locations	**8**	**Pier Lines**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**MR31**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Moveable Span**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Superstructure bearings**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***Trunion and live load shoe strength look insufficient to transfer seismic forces. Vulnerability is the bearing can perform poorly under seismic loading.***				
Proposed Retrofit	***Replace bearings, provide sufficient gap to allow for increased movement, but overall force demands will reduce. System Retrofit - Replace trunnion with isolation bearing, but still able to accommodate lifting of the bascule span.***				
Number of Locations	**8**	**Bearings**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**MR020**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Truss diaphragms**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is failure of the vertical members supporting the floor beams during lateral movement.***				
Proposed Retrofit	***Replace truss members, primarily the diagonal members to increase transverse stifness. System Retrofit - Base isolated trunnion will reduce demands going into the superstructure, making truss diaphragm strengthening less of a priority and potentially unncessary.***				
Number of Locations	**8**	**Diaphragm lines**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$2,000,000**	*each*		*Figure Ref. #*	**MR020**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Bascule Truss Lateral Braces**			*Drawing #*	**C15 of 72**
Description of Vulnerability	***Bottom laterals may need strengthening to transfer transverse seismic forces from superstructure to substructure. Vulnerability is swaying of the truss frames.***				
Proposed Retrofit	***Replace brace members to increase truss stiffness. System Retrofit - Base isolated trunnion will reduce demands going into the superstructure, making truss top and bottom lateral brace strengthening less of a priority and potentially unncessary.***				
Number of Locations	**8**	**Diaphragm lines**		*PDF Page #*	**33**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**MR021**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Trunnion Bearing Anchor Bolts**			*Drawing #*	**A12 of 26**
Description of Vulnerability	***Trunnion bearing anchor bolts are likely insufficient to transfer seismic loads into the trunnion frame***				
Proposed Retrofit	***Replace with high strength bolts or drill and bond additional anchor bolts around the existing bearing base plate.***				
Number of Locations	**4**	**Bearings**		*PDF Page #*	**11**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR022**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Moveable Span**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Counterweight Braces**			*Drawing #*	**C21 of 72**
Description of Vulnerability	***Bottom lateral braces are likely insufficient to transfer lateral inertial forces from the counterweight to the trunnion***				
Proposed Retrofit	***Add intemediate lateral support members between truss bays, replace supports with stiffer sections. System Retrofit - Base isolated trunnion will reduce demands going into the superstructure, making counterweight brace strengthening less of a priority and potentially unncessary.***				
Number of Locations	**2**			*PDF Page #*	**39**
Unit Cost of Retrofit	**$2,000,000**	*each*		*Figure Ref. #*	**MR24**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Truss Lateral support**			*Drawing #*	**C10 of 72**
Description of Vulnerability	***The truss overall lacks lateral support and will see high displacements in a seismic events.***				
Proposed Retrofit	***Add intemediate lateral support members between truss bays, replace supports with stiffer sections. System Retrofit - Base isolated trunnion will reduce demands going into the superstructure, making truss lateral support strengthening less of a priority and potentially unncessary.***				
Number of Locations	**2**			*PDF Page #*	**28**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**none**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Piers 2 and 3**			*Drawing #*	**A8**
Description of Vulnerability	***Piers 2 and 3 are vulnerable to longitudinal seismic shaking and deterioration***				
Proposed Retrofit	***Encase Piers to add strength, particularly at connection to Pile cap portion. System Retrofit - Base Isolation of bascule and river spans will reduce strength demands on piers.***				
Number of Locations	**2**			*PDF Page #*	**7**
Unit Cost of Retrofit	**$2,500,000**	*each*		*Figure Ref. #*	**NA**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Moveable Span**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Superstructure bearings**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***Trunion and live load shoe strength look insufficient to transfer seismic forces. Vulnerability is the bearing can perform poorly under seismic loading.***				
Proposed Retrofit	***Replace bearings, provide sufficient gap to allow for increased movement, but overall force demands will reduce. System Retrofit - Replace trunnion with isolation bearing, but still able to accommodate lifting of the bascule span.***				
Number of Locations	**8**	**Bearings**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**MR020**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Truss diaphragms**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is failure of the vertical members supporting the floor beams during lateral movement.***				
Proposed Retrofit	***Replace truss members, primarily the diagonal members to increase transverse stifness. System Retrofit - Base isolated trunnion will reduce demands going into the superstructure, making truss diaphragm strengthening less of a priority and potentially unncessary.***				
Number of Locations	**8**	**Diaphragm lines**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$1,900,000**	*each*		*Figure Ref. #*	**MR020**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Bascule Truss Lateral Braces**			*Drawing #*	**C15 of 72**
Description of Vulnerability	***Bottom laterals may need strengthening to transfer transverse seismic forces from superstructure to substructure. Vulnerability is swaying of the truss frames.***				
Proposed Retrofit	***Replace brace members to increase truss stiffness. System Retrofit - Base isolated trunnion will reduce demands going into the superstructure, making truss top and bottom lateral brace strengthening less of a priority and potentially unncessary.***				
Number of Locations	**8**	**Diaphragm lines**		*PDF Page #*	**33**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**MR021**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Trunnion Bearing Anchor Bolts**			*Drawing #*	**A12 of 26**
Description of Vulnerability	***Trunnion bearing anchor bolts are likely insufficient to transfer seismic loads into the trunnion frame***				
Proposed Retrofit	***Replace with high strength bolts or drill and bond additional anchor bolts around the existing bearing base plate.***				
Number of Locations	**4**	**Bearings**		*PDF Page #*	**11**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**MR022**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Moveable Span**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Counterweight Braces**			*Drawing #*	**C21 of 72**
Description of Vulnerability	***Bottom lateral braces are likely insufficient to transfer lateral inertial forces from the counterweight to the trunnion***				
Proposed Retrofit	***Add intemediate lateral support members between truss bays, replace supports with stiffer sections.*** ***System Retrofit*** ***- Base isolated trunnion will reduce demands going into the superstructure, making counterweight brace strengthening less of a priority and potentially unncessary.***				
Number of Locations	**2**			*PDF Page #*	**39**
Unit Cost of Retrofit	**$1,900,000**	*each*		*Figure Ref. #*	**MR24**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Truss Lateral support**			*Drawing #*	**C10 of 72**
Description of Vulnerability	***The truss overall lacks lateral support and will see high displacements in a seismic events.***				
Proposed Retrofit	***Add intemediate lateral support members between truss bays, replace supports with stiffer sections.*** ***System Retrofit*** ***- Base isolated trunnion will reduce demands going into the superstructure, making truss lateral support strengthening less of a priority and potentially unncessary.***				
Number of Locations	**2**			*PDF Page #*	**28**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**none**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Moveable Span**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Superstructure bearings**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***Trunion and live load shoe strength look insufficient to transfer seismic forces. Vulnerability is the bearing can perform poorly under seismic loading.***				
Proposed Retrofit	***Replace bearings, provide sufficient gap to allow for increased movement, but overall force demands will reduce.***				
Number of Locations	**8**	**Bearings**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$375,000**	*each*		*Figure Ref. #*	**MR020**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Truss diaphragms**			*Drawing #*	**C28 of 72**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is failure of the vertical members supporting the floor beams during lateral movement.***				
Proposed Retrofit	***No Retrofit needed for 100 yr event***				
Number of Locations	**8**	**Diaphragm lines**		*PDF Page #*	**46**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR020**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Bascule Truss Lateral Braces**			*Drawing #*	**C15 of 72**
Description of Vulnerability	***Bottom laterals may need strengthening to transfer transverse seismic forces from superstructure to substructure. Vulnerability is swaying of the truss frames.***				
Proposed Retrofit	***No Retrofit needed for 100 yr event***				
Number of Locations	**8**	**Diaphragm lines**		*PDF Page #*	**33**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR021**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Counterweight Braces**			*Drawing #*	**C21 of 72**
Description of Vulnerability	***Bottom lateral braces are likely insufficient to transfer lateral inertial forces from the counterweight to the trunnion***				
Proposed Retrofit	***Add intemediate lateral support members between truss bays, replace supports with stiffer sections.***				
Number of Locations	**2**			*PDF Page #*	**39**
Unit Cost of Retrofit	**$375,000**	*each*		*Figure Ref. #*	**MR24**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**W Morrison Br Conn over Hwy 1W (Front Ave) & Park [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758B**				
Bridge Location	**Moveable Span**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-03-30_Morrison_Bridge_AsBuilts.pdf**		
Vulnerable Component	**Trunnion Bearing Anchor Bolts**			*Drawing #*	**A12 of 26**
Description of Vulnerability	***Trunnion bearing anchor bolts are likely insufficient to transfer seismic loads into the trunnion frame***				
Proposed Retrofit	***Replace with high strength bolts or drill and bond additional anchor bolts around the existing bearing base plate.***				
Number of Locations	**4**	**Bearings**		*PDF Page #*	**11**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**MR022**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**SE Belmont St over Hwy 1 & Conns (Morrison Intchg) [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758A**				
Bridge Location	**East Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Footing**			*Drawing #*	**B11 of 68**
Description of Vulnerability	***Footing shear and flexural rebar detailing look insufficient. There are no flexural bars at the top of the footing and no stirrups to transfer the shear loads into the foundation. Column to footing joint is also poorly detailed, and the joint is a common failure mechanism during seismic loads. Vulnerability is footing fails prematurely before column hinges.***				
Proposed Retrofit	***Increase existing footing plan and elevation dimensions, drill and bond new dowels and stirrups in existing footing, drive new piles, complete joint replacement.***				
Number of Locations	**114**	**Footings**		*PDF Page #*	**18**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**MR001**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Footing**			*Drawing #*	**B11 of 68**
Description of Vulnerability	***Pile head embedment depth into pile cap may not be sufficient enough for the pile head to act as a true "fixed" head. Vulnerability is pile head anchorage pull out or yielding when moment is transferred into footing.***				
Proposed Retrofit	***Add additional layer of concrete to increase pile head embedment depth to a minimum 24". - Cost included with Vulnerability 1***				
Number of Locations	**114**	**Footings**		*PDF Page #*	**18**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR001**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Column**			*Drawing #*	**B16 of 68**
Description of Vulnerability	***Column flexural and shear strength insufficient for seismic demands. Stirrups are spaced too far apart to provide proper confinement for concrete core. Column to bent cap joint detailing is also poor, and the joint is a common failure mechanism where shear forces tend to concentrate. Vulnerability is low displacement capacity and non-ductile performance.***				
Proposed Retrofit	***Steel jacketing to provide confinement.***				
Number of Locations	**124**	**Columns**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR002**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Bent cap**			*Drawing #*	**B16 of 68**
Description of Vulnerability	***Bent Cap flexural strength insufficient for to transfer superstructure forces into the substructure during lateral loading. Vulnerability is the cap can fail prematurely before column hinges.***				
Proposed Retrofit	***Add concrete bolsters and doweling new rebar for the entire cap to increase stiffness.***				
Number of Locations	**55**	**Bents**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$100,000**	*each*		*Figure Ref. #*	**MR003**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**SE Belmont St over Hwy 1 & Conns (Morrison Intchg) [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758A**				
Bridge Location	**East Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Bent cap - Restrainers**			*Drawing #*	**B16 of 68**
Description of Vulnerability	***No transverse or longitudinal restraints at the superstructure to substructure connection. Vulnerability is superstructure unseating at the bearings.***				
Proposed Retrofit	***Reinforced concrete shear keys and longitudinal cable restraints.***				
Number of Locations	**69**	**Bents**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$100,000**	*each*		*Figure Ref. #*	**MR003**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Superstructure bearings at bent caps**			*Drawing #*	**B17 of 68**
Description of Vulnerability	***Stringer shoe rehabilitation. Vulnerability is this bearing type may perform poorly in seismic conditions to transfer loads from superstructure into substructure. Currently, the stringers are connected by anchor bolts to the shoes.***				
Proposed Retrofit	***Full bearing replacement with elastomeric pads.***				
Number of Locations	**69**	**Bents**		*PDF Page #*	**24**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR004**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Superstructure diaphragms**			*Drawing #*	**B43 of 68**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is shear failure at the girder flange to deck connection during lateral movement.***				
Proposed Retrofit	***Replace bearing diaphragms members to increase transverse stiffness.***				
Number of Locations	**104**	**Diaphragm Lines**		*PDF Page #*	**50**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR005**

Vulnerability Number	**8**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Superstructure girders**			*Drawing #*	**B43 of 68**
Description of Vulnerability	***Girder webs at end bearing and in span hinge may be succeptable to local buckling during transverse loading.***				
Proposed Retrofit	***Add additional shear stiffener plates or doubler plates to the web.***				
Number of Locations	**104**	**Pier/Bent Lines**		*PDF Page #*	**50**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR006**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**SE Belmont St over Hwy 1 & Conns (Morrison Intchg) [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758A**				
Bridge Location	**East Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**9**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**In span hinge restraints**			*Drawing #*	**B43 of 68**
Description of Vulnerability	***No transverse and longitudinal restraints at in span hinges. Vulnerability is relatively large gaps and unseating during shaking.***				
Proposed Retrofit	***Longitudinal cable restrainers and transverse stopper plate (similar to wind tongues) to limit movement.***				
Number of Locations	**32**	**Hinge Lines**		*PDF Page #*	**50**
Unit Cost of Retrofit	**$100,000**	*each*		*Figure Ref. #*	**MR007**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**SE Belmont St over Hwy 1 & Conns (Morrison Intchg) [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758A**				
Bridge Location	**East Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Footing**			*Drawing #*	**B11 of 68**
Description of Vulnerability	***Footing shear and flexural rebar detailing look insufficient. There are no flexural bars at the top of the footing and no stirrups to transfer the shear loads into the foundation. Column to footing joint is also poorly detailed, and the joint is a common failure mechanism during seismic loads. Vulnerability is footing fails prematurely before column hinges.***				
Proposed Retrofit	***Increase existing footing plan and elevation dimensions, drill and bond new dowels and stirrups in existing footing, drive new piles, complete joint replacement.***				
Number of Locations	**114**	**Footings**		*PDF Page #*	**18**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**MR001**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Footing**			*Drawing #*	**B11 of 68**
Description of Vulnerability	***Pile head embedment depth into pile cap may not be sufficient enough for the pile head to act as a true "fixed" head. Vulnerability is pile head anchorage pull out or yielding when moment is transferred into footing.***				
Proposed Retrofit	***Add additional layer of concrete to increase pile head embedment depth to a minimum 24". - Cost included with Vulnerability 1***				
Number of Locations	**114**	**Footings**		*PDF Page #*	**18**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR001**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Column**			*Drawing #*	**B16 of 68**
Description of Vulnerability	***Column flexural and shear strength insufficient for seismic demands. Stirrups are spaced too far apart to provide proper confinement for concrete core. Column to bent cap joint detailing is also poor, and the joint is a common failure mechanism where shear forces tend to concentrate. Vulnerability is low displacement capacity and non-ductile performance.***				
Proposed Retrofit	***Steel jacketing to provide confinement.***				
Number of Locations	**124**	**Columns**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**MR002**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Bent cap**			*Drawing #*	**B16 of 68**
Description of Vulnerability	***Bent Cap flexural strength insufficient for to transfer superstructure forces into the substructure during lateral loading. Vulnerability is the cap can fail prematurely before column hinges.***				
Proposed Retrofit	***Add concrete bolsters and doweling new rebar for the entire cap to increase stiffness.***				
Number of Locations	**55**	**Bents**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$95,000**	*each*		*Figure Ref. #*	**MR003**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**SE Belmont St over Hwy 1 & Conns (Morrison Intchg) [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758A**				
Bridge Location	**East Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Bent cap - Restrainers**			*Drawing #*	**B16 of 68**
Description of Vulnerability	***No transverse or longitudinal restraints at the superstructure to substructure connection. Vulnerability is superstructure unseating at the bearings.***				
Proposed Retrofit	***Reinforced concrete shear keys and longitudinal cable restraints.***				
Number of Locations	**69**	**Bents**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$95,000**	*each*		*Figure Ref. #*	**MR003**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Superstructure bearings at bent caps**			*Drawing #*	**B17 of 68**
Description of Vulnerability	***Stringer shoe rehabilitation. Vulnerability is this bearing type may perform poorly in seismic conditions to transfer loads from superstructure into substructure. Currently, the stringers are connected by anchor bolts to the shoes.***				
Proposed Retrofit	***Full bearing replacement with elastomeric pads.***				
Number of Locations	**69**	**Bents**		*PDF Page #*	**24**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**MR004**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Superstructure diaphragms**			*Drawing #*	**B43 of 68**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is shear failure at the girder flange to deck connection during lateral movement.***				
Proposed Retrofit	***Replace bearing diaphragms members to increase transverse stiffness.***				
Number of Locations	**104**	**Diaphragm Lines**		*PDF Page #*	**50**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**MR005**

Vulnerability Number	**8**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Superstructure girders**			*Drawing #*	**B43 of 68**
Description of Vulnerability	***Girder webs at end bearing and in span hinge may be succeptable to local buckling during transverse loading.***				
Proposed Retrofit	***Add additional shear stiffener plates or doubler plates to the web.***				
Number of Locations	**104**	**Pier/Bent Lines**		*PDF Page #*	**50**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**MR006**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**SE Belmont St over Hwy 1 & Conns (Morrison Intchg) [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758A**				
Bridge Location	**East Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**9**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**In span hinge restraints**			*Drawing #*	**B43 of 68**
Description of Vulnerability	***No transverse and longitudinal restraints at in span hinges. Vulnerability is relatively large gaps and unseating during shaking.***				
Proposed Retrofit	***Longitudinal cable restrainers and transverse stopper plate (similar to wind tongues) to limit movement.***				
Number of Locations	**32**	**Hinge Lines**		*PDF Page #*	**50**
Unit Cost of Retrofit	**$95,000**	*each*		*Figure Ref. #*	**MR007**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Morrison**		*Compiled by:*	**TCA**	Date: **4/2/2014**
Bridge Name	**SE Belmont St over Hwy 1 & Conns (Morrison Intchg) [Morrison]**		*Checked by:*	**KPBU**	Date: 5/14/2014
Bridge Number	**02758A**				
Bridge Location	**East Approaches**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Bent cap**			*Drawing #*	**B16 of 68**
Description of Vulnerability	***No transverse or longitudinal restraints at the superstructure to substructure connection. Vulnerability is superstructure unseating at the bearings.***				
Proposed Retrofit	***Reinforced concrete shear keys and longitudinal cable restraints.***				
Number of Locations	**69**	**Bents**		*PDF Page #*	**23**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR003**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Superstructure bearings at bent caps**			*Drawing #*	**B17 of 68**
Description of Vulnerability	***Stringer shoe rehabilitation. Vulnerability is this bearing type may perform poorly in seismic conditions to transfer loads from superstructure into substructure. Currently, the stringers are connected by anchor bolts to the shoes.***				
Proposed Retrofit	***Full bearing replacement with elastomeric pads.***				
Number of Locations	**69**	**Bents**		*PDF Page #*	**24**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**MR004**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**Superstructure diaphragms**			*Drawing #*	**B43 of 68**
Description of Vulnerability	***Superstructure cross brace diaphragms insufficient in transferring shear forces to substructure. Brace members are undersized and the vulnerability is shear failure at the girder flange to deck connection during lateral movement.***				
Proposed Retrofit	***No Retrofit needed at 100 yr event***				
Number of Locations	**252**	**Diaphragm Lines**		*PDF Page #*	**50**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**MR005**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-02-16_Morrison_East_Approach.pdf**		
Vulnerable Component	**In span hinge restraints**			*Drawing #*	**B43 of 68**
Description of Vulnerability	***No transverse and longitudinal restraints at in span hinges. Vulnerability is relatively large gaps and unseating during shaking.***				
Proposed Retrofit	***Longitudinal cable restrainers and transverse stopper plate (similar to wind tongues) to limit movement.***				
Number of Locations	**32**	**Hinge Lines**		*PDF Page #*	**50**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**MR007**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AXLI**	Date: **3/26/2014**
Bridge Name	**Willamette River, SW Hawthorne Blvd (Hawthorne Br) [Hawthorne]**		*Checked by:*	**KPBU**	Date: 5/20/2014
Bridge Number	**02757D**				
Bridge Location	**West Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Pile to cap connection**			*Drawing #*	**F0001-011**
Description of Vulnerability	***Bent 1: Only 1ft pile embedment in triangular shaped cap without anchor reinforcing; pile will pullout under seismic loading.***				
Proposed Retrofit	***Install additional micropile around existing footing, and tie to existing footing.***				
Number of Locations	**3**			*PDF Page #*	**1**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**HA301**

Vulnerability Number	**2**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Spread footing**			*Drawing #*	**F0001-012 to 015, 017**
Description of Vulnerability	***Bents 2, 3, 4, 7, 8, 9, 10, and 11 spread footing, no top layer of reinforcing in footings.***				
Proposed Retrofit	***Footing overlay on top of footing.***				
Number of Locations	**24**			*PDF Page #*	**2**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**HA302**

Vulnerability Number	**3**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Abutment 3 Electrical Vault**			*Drawing #*	**F0001-008**
Description of Vulnerability	***Thin wall with single dowel connected to footings, vault room could collapse under seismic loadings and afffect the electrical supply to Hawthorne Bridge.***				
Proposed Retrofit	***Add additional dowels.***				
Number of Locations	**1**			*PDF Page #*	**3**
Unit Cost of Retrofit	**$100,000**	*each*		*Figure Ref. #*	**HA303**

Vulnerability Number	**4**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Connections - Bents columns to spread footings**			*Drawing #*	**F0001-012 to 015, 017**
Description of Vulnerability	***Bents 2, 3, 4, 7, 8, 9, 10, and 11 columns to spread footings connections, inadequate reinforcing embedment length.***				
Proposed Retrofit	***Column Jacketing, add rebar doweled into footing. - Cost included with Vulnerability 6***				
Number of Locations	**24**			*PDF Page #*	**4**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**HA304**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AXLI**	Date: **3/26/2014**
Bridge Name	**Willamette River, SW Hawthorne Blvd (Hawthorne Br) [Hawthorne]**		*Checked by:*	**KPBU**	Date: 5/20/2014
Bridge Number	**02757D**				
Bridge Location	**West Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Connections - Abutments to spread footings**			*Drawing #*	**F0001-006-008**
Description of Vulnerability	***Abutments 1, 2, and 3 to spread footing connections, inadequate reinforcing embedment length. Total abutment length for all three abutments are 201ft.***				
Proposed Retrofit	***Add additional dowels at bottom of wall.***				
Number of Locations	**3**			*PDF Page #*	**5**
Unit Cost of Retrofit	**$100,000**	*each*		*Figure Ref. #*	**HA305**

Vulnerability Number	**6**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Bents columns**			*Drawing #*	**F0001-011-017**
Description of Vulnerability	***Inadequate shear capacity for Bents 1 (2ft dia.), 2 (3ft sq.) and 5 (2ft dia.) columns; inadequate flexural capacity for Bents 3, 4, 7, 8, 9, 10 and 11 (3ft sq.).***				
Proposed Retrofit	***Encase Columns or add shear walls.***				
Number of Locations	**35**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**HA306**

Vulnerability Number	**7**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Seat Widths**			*Drawing #*	**F0001-019**
Description of Vulnerability	***Marginal seat widths, Pier 7, Bents 1 to 5, Bents 7 to 9, Bents 10 to 11, Abutments 1 to 3, total 830ft.***				
Proposed Retrofit	***Concrete seat extension or steel seat extension.***				
Number of Locations	**14**			*PDF Page #*	**7**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**HA307**

Vulnerability Number	**8**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Cap Beams**			*Drawing #*	**F0001-013, 014, 015, 017**
Description of Vulnerability	***Bents 3, 4, 7, 8, 9, 10 and 11 cap beams, cap beams are capacity protected members if columns fail in flexure. Total 271ft (total of cap beam length shown here).***				
Proposed Retrofit	***Enlarge cap beam to increase capacity.***				
Number of Locations	**7**			*PDF Page #*	**9**
Unit Cost of Retrofit	**$150,000**	*each*		*Figure Ref. #*	**HA309**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AXLI**	Date: **3/26/2014**
Bridge Name	**Willamette River, SW Hawthorne Blvd (Hawthorne Br) [Hawthorne]**		*Checked by:*	**KPBU**	Date: 5/20/2014
Bridge Number	**02757D**				
Bridge Location	**West Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Pile to cap connection**			*Drawing #*	**F0001-011**
Description of Vulnerability	***Bent 1: Only 1ft pile embedment in triangular shaped cap without anchor reinforcing; pile will pullout under seismic loading.***				
Proposed Retrofit	***Install additional micropile around existing footing, and tie to existing footing.***				
Number of Locations	**3**			*PDF Page #*	**1**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**HA301**

Vulnerability Number	**2**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Spread footing**			*Drawing #*	**F0001-012 to 015, 017**
Description of Vulnerability	***Bents 2, 3, 4, 7, 8, 9, 10, and 11 spread footing, no top layer of reinforcing in footings.***				
Proposed Retrofit	***Footing overlay on top of footing.***				
Number of Locations	**24**			*PDF Page #*	**2**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**HA302**

Vulnerability Number	**3**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Abutment 3 Electrical Vault**			*Drawing #*	**F0001-008**
Description of Vulnerability	***Thin wall with single dowel connected to footings, vault room could collapse under seismic loadings and afffect the electrical supply to Hawthorne Bridge.***				
Proposed Retrofit	***Add additional dowels.***				
Number of Locations	**1**			*PDF Page #*	**3**
Unit Cost of Retrofit	**$95,000**	*each*		*Figure Ref. #*	**HA303**

Vulnerability Number	**4**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Connections - Bents columns to spread footings**			*Drawing #*	**F0001-012 to 015, 017**
Description of Vulnerability	***Bents 2, 3, 4, 7, 8, 9, 10, and 11 columns to spread footings connections, inadequate reinforcing embedment length.***				
Proposed Retrofit	***Column Jacketing, add rebar doweled into footing. - Cost included with Vulnerability 6***				
Number of Locations	**24**			*PDF Page #*	**4**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**HA304**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AXLI**	Date: **3/26/2014**
Bridge Name	**Willamette River, SW Hawthorne Blvd (Hawthorne Br) [Hawthorne]**		*Checked by:*	**KPBU**	Date: 5/20/2014
Bridge Number	**02757D**				
Bridge Location	**West Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Connections - Abutments to spread footings**			*Drawing #*	**F0001-006-008**
Description of Vulnerability	***Abutments 1, 2, and 3 to spread footing connections, inadequate reinforcing embedment length. Total abutment length for all three abutments are 201ft.***				
Proposed Retrofit	***Add additional dowels at bottom of wall.***				
Number of Locations	**3**			*PDF Page #*	**5**
Unit Cost of Retrofit	**$95,000**	*each*		*Figure Ref. #*	**HA305**

Vulnerability Number	**6**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Bents columns**			*Drawing #*	**F0001-011-017**
Description of Vulnerability	***Inadequate shear capacity for Bents 1 (2ft dia.), 2 (3ft sq.) and 5 (2ft dia.) columns; inadequate flexural capacity for Bents 3, 4, 7, 8, 9, 10 and 11 (3ft sq.).***				
Proposed Retrofit	***Encase Columns or add shear walls.***				
Number of Locations	**35**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**HA306**

Vulnerability Number	**7**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Seat Widths**			*Drawing #*	**F0001-019**
Description of Vulnerability	***Marginal seat widths, Pier 7, Bents 1 to 5, Bents 7 to 9, Bents 10 to 11, Abutments 1 to 3, total 830ft.***				
Proposed Retrofit	***Concrete seat extension or steel seat extension.***				
Number of Locations	**14**			*PDF Page #*	**7**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**HA307**

Vulnerability Number	**8**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Cap Beams**			*Drawing #*	**F0001-013, 014, 015, 017**
Description of Vulnerability	***Bents 3, 4, 7, 8, 9, 10 and 11 cap beams, cap beams are capacity protected members if columns fail in flexure. Total 271ft (total of cap beam length shown here).***				
Proposed Retrofit	***Enlarge cap beam to increase capacity.***				
Number of Locations	**7**			*PDF Page #*	**9**
Unit Cost of Retrofit	**$143,000**	*each*		*Figure Ref. #*	**HA309**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AXLI**	Date: **3/26/2014**
Bridge Name	**Willamette River, SW Hawthorne Blvd (Hawthorne Br) [Hawthorne]**		*Checked by:*	**KPBU**	Date: 5/20/2014
Bridge Number	**02757D**				
Bridge Location	**West Approaches**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Pile to cap connection**			*Drawing #*	**F0001-011**
Description of Vulnerability	***Bent 1: Only 1ft pile embedment in triangular shaped cap without anchor reinforcing; pile will pullout under seismic loading.***				
Proposed Retrofit	***No retrofit needed at 100 yr event***				
Number of Locations	**6**			*PDF Page #*	**1**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**HA301**

Vulnerability Number	**2**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Spread footing**			*Drawing #*	**F0001-012 to 015, 017**
Description of Vulnerability	***Bents 2, 3, 4, 7, 8, 9, 10, and 11 spread footing, no top layer of reinforcing in footings. Footing could crack under seismic loading, but should not fail.***				
Proposed Retrofit	***No retrofit needed at 100 yr event***				
Number of Locations	**24**			*PDF Page #*	**2**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**HA302**

Vulnerability Number	**3**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Bents columns**			*Drawing #*	**F0001-011-017**
Description of Vulnerability	***Inadequate shear capacity for Bents 1 (2ft dia.), 2 (3ft sq.) and 5 (2ft dia.) columns; inadequate flexural capacity for Bents 3, 4, 7, 8, 9, 10 and 11 (3ft sq.).***				
Proposed Retrofit	***No retrofit needed at 100 yr event***				
Number of Locations	**35**			*PDF Page #*	**6**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**HA306**

Vulnerability Number	**4**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Cap Beams**			*Drawing #*	**F0001-013, 014, 015, 017**
Description of Vulnerability	***Bents 3, 4, 7, 8, 9, 10 and 11 cap beams, cap beams are capacity protected members if columns fail in flexure. Total 271ft (total of cap beam length shown here).***				
Proposed Retrofit	***No retrofit needed at 100 yr event***				
Number of Locations	**7**			*PDF Page #*	**9**
Unit Cost of Retrofit	**$0**	*each*		*Figure Ref. #*	**HA309**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AXLI**	Date:	**3/26/2014**
Bridge Name	**Willamette River, SW Hawthorne Blvd (Hawthorne Br) [Hawthorne]**		*Checked by:*	**KPBU**	Date:	5/20/2014
Bridge Number	**02757D**					
Bridge Location	**West Approaches**					
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**5**	*As-Built Dwg. File*	1957-11-29_Hawthorne_West_Approaches.pdf		
Vulnerable Component	**Seat Widths**		*Drawing #*	**F0001-019**	
Description of Vulnerability	***Marginal seat widths, Pier 7, Bents 1 to 5, Bents 7 to 9, Bents 10 to 11, Abutments 1 to 3, total 830ft.***				
Proposed Retrofit	***Concrete seat extension or steel seat extension.***				
Number of Locations	**14**		*PDF Page #*	**7**	
Unit Cost of Retrofit	**$56,000**	*each*	*Figure Ref. #*	**HA307**	

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date: **3/26/2014**
Bridge Name	**Willamette River, Hawthorne Ave [Hawthorne]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**02757**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Bearings for Piers 1-4, 7**			*Drawing #*	**C0002-010**
Description of Vulnerability	***Existing bearings are vulnerable to topple off their piers during an earthquake.***				
Proposed Retrofit	***System Retrofit - Install Base Isolation Bearings***				
Number of Locations	**10**			*PDF Page #*	**10 of 43**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**HA101**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Superstructure pulling off Piers 1-4, 7**			*Drawing #*	**C0002-010**
Description of Vulnerability	***No transverse restraints at any of the existing piers.***				
Proposed Retrofit	***Insall shear lugs on top of pier walls***				
Number of Locations	**5**			*PDF Page #*	**10 of 43**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**HA101**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Piles at Piers 1 & 7**			*Drawing #*	**C0002-002**
Description of Vulnerability	***Liquifiable soils at bents 1 & 7***				
Proposed Retrofit	***Soil Densificaton***				
Number of Locations	**2**	**bridge site**		*PDF Page #*	**2 of 43**
Unit Cost of Retrofit	**$7,000,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Bottom Chord lateral bracing spans 1-4, 6**			*Drawing #*	**C0002-006**
Description of Vulnerability	***Lateral bracing overstressed during earthquake. (3 end panels of each span)***				
Proposed Retrofit	***Strengthening of bottom chord bracing including connections. System Retrofit - Base Isolation will reduce forces in lift span members***				
Number of Locations	**30**			*PDF Page #*	**6 of 43**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**HA102**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date: **3/26/2014**
Bridge Name	**Willamette River, Hawthorne Ave [Hawthorne]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**02757**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Existing Piers**			*Drawing #*	**C0002-002**
Description of Vulnerability	***Piers 1, 2, 3, 4 & 7 are unreinforced and not adequate for carrying forces from superstructure into piles.***				
Proposed Retrofit	***Strengthen Piers steel confinement jackets at base of piers*** ***System Retrofit*** ***- Base Isolation will lessen the forces into the substructure***				
Number of Locations	**5**			*PDF Page #*	**2 of 43**
Unit Cost of Retrofit	**$2,500,000**	*each*		*Figure Ref. #*	**HA104**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date: **3/26/2014**
Bridge Name	**Willamette River, Hawthorne Ave [Hawthorne]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**02757**				
Bridge Location	**Fixed River Spans**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Bearings for Piers 1-4, 7**			*Drawing #*	**C0002-010**
Description of Vulnerability	***Existing bearings are vulnerable to topple off their piers during an earthquake.***				
Proposed Retrofit	***System Retrofit - Install Base Isolation Bearings***				
Number of Locations	**10**			*PDF Page #*	**10 of 43**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**HA101**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Superstructure pulling off Piers 1-4, 7**			*Drawing #*	**C0002-010**
Description of Vulnerability	***No transverse restraints at any of the existing piers.***				
Proposed Retrofit	***Insall shear lugs on top of pier walls***				
Number of Locations	**5**			*PDF Page #*	**10 of 43**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**HA101**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Piles at Piers 1 & 7**			*Drawing #*	**C0002-002**
Description of Vulnerability	***Liquifiable soils at bents 1 & 7***				
Proposed Retrofit	***Soil Densificaton***				
Number of Locations	**2**	**bridge site**		*PDF Page #*	**2 of 43**
Unit Cost of Retrofit	**$6,650,000**	*each*		*Figure Ref. #*	**NA**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Bottom Chord lateral bracing spans 1-4, 6**			*Drawing #*	**C0002-006**
Description of Vulnerability	***Lateral bracing overstressed during earthquake. (3 end panels of each span)***				
Proposed Retrofit	***Strengthening of bottom chord bracing including connections. System Retrofit - Base Isolation will reduce forces in lift span members***				
Number of Locations	**30**			*PDF Page #*	**6 of 43**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**HA102**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**	*Compiled by:*	**AJCA**	Date:	**3/26/2014**
Bridge Name	**Willamette River, Hawthorne Ave [Hawthorne]**	*Checked by:*	**kpbu**	Date:	5/20/2014
Bridge Number	**02757**				
Bridge Location	**Fixed River Spans**				

Vulnerability Number	**5**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Existing Piers**			*Drawing #*	**C0002-002**
Description of Vulnerability	***Piers 1, 2, 3, 4 & 7 are unreinforced and not adequate for carrying forces from superstructure into piles.***				
Proposed Retrofit	***Strengthen Piers steel confinement jackets at base of piers System Retrofit - Base Isolation will lessen the forces into the substructure***				
Number of Locations	**5**			*PDF Page #*	**2 of 43**
Unit Cost of Retrofit	**$2,350,000**	*each*		*Figure Ref. #*	**HA104**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date:	**3/26/2014**
Bridge Name	**Willamette River, Hawthorne Ave [Hawthorne]**		*Checked by:*	**kpbu**	Date:	5/20/2014
Bridge Number	**02757**					
Bridge Location	**Fixed River Spans**					
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**1**	*As-Built Dwg. File*		
Vulnerable Component	**Bearings for Piers 1-4, 7**		*Drawing #*	
Description of Vulnerability	***Existing bearings are vulnerable to topple off their piers during an earthquake.***			
Proposed Retrofit	***Install catcher blocks and restrainers***			
Number of Locations	**10**		*PDF Page #*	
Unit Cost of Retrofit	**$75,000**	*each*	*Figure Ref. #*	**HA101**

Vulnerability Number	**2**	*As-Built Dwg. File*		
Vulnerable Component	**Superstructure pulling off Piers 1-4, 7**		*Drawing #*	
Description of Vulnerability	***No transverse restraints at any of the existing piers.***			
Proposed Retrofit	***Insall shear lugs on top of pier walls***			
Number of Locations	**5**		*PDF Page #*	
Unit Cost of Retrofit	**$56,000**	*each*	*Figure Ref. #*	**HA101**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date: **3/26/2014**
Bridge Name	**Willamette River, Hawthorne Ave [Hawthorne]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**02757**				
Bridge Location	**Moveable Span**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Bearings for Piers 5-6**			*Drawing #*	
Description of Vulnerability	***Existing bearings are vulnerable to topple off their piers during an earthquake.***				
Proposed Retrofit	***Install Isolation Bearings***				
Number of Locations	**4**			*PDF Page #*	
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**HA101**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Superstructure pulling off Piers 5-6**			*Drawing #*	
Description of Vulnerability	***No transverse restraints at any of the existing piers.***				
Proposed Retrofit	***Insall shear lugs on top of pier walls***				
Number of Locations	**2**			*PDF Page #*	
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**HA101**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Bottom Chord lateral bracing Span 5**			*Drawing #*	**C0002-004**
Description of Vulnerability	***Lateral bracing overstressed during earthquake. (3 end panels of each span)***				
Proposed Retrofit	***Strengthening of bottom chord bracing including connections. System Retrofit - Base Isolation will reduce forces in lift span members***				
Number of Locations	**6**			*PDF Page #*	**4 of 43**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**HA102**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Towers at Bents 5 & 6**			*Drawing #*	**C0002-004**
Description of Vulnerability	***Towers are not adequate to carry lateral forces from counterweights. Both front and back legs and transverse braces will require strengthening.***				
Proposed Retrofit	***Replace or strengthen existing members. System Retrofit - install isolation bearings to reduce forces in tower.***				
Number of Locations	**2**			*PDF Page #*	**4 of 43**
Unit Cost of Retrofit	**$8,000,000**	*each*		*Figure Ref. #*	**HA103**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date:	**3/26/2014**
Bridge Name	**Willamette River, Hawthorne Ave [Hawthorne]**		*Checked by:*	**kpbu**	Date:	5/20/2014
Bridge Number	**02757**					
Bridge Location	**Moveable Span**					
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**5**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Existing Piers**			*Drawing #*	**C0002-003**
Description of Vulnerability	***Piers 5 and 6 are unreinforced and not adequate for carrying forces from superstructure into piles.***				
Proposed Retrofit	***Strengthen Piers steel confinement jackets at base of piers*** ***System Retrofit*** ***- Base Isolation will lessen the forces into the substructure***				
Number of Locations	**2**			*PDF Page #*	**3 of 43**
Unit Cost of Retrofit	**$2,500,000**	*each*		*Figure Ref. #*	**HA104**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date: **3/26/2014**
Bridge Name	**Willamette River, Hawthorne Ave [Hawthorne]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**02757**				
Bridge Location	**Moveable Span**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Bearings for Piers 5-6**			*Drawing #*	
Description of Vulnerability	***Existing bearings are vulnerable to topple off their piers during an earthquake.***				
Proposed Retrofit	***Install Isolation Bearings***				
Number of Locations	**4**			*PDF Page #*	
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**HA101**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Superstructure pulling off Piers 5-6**			*Drawing #*	
Description of Vulnerability	***No transverse restraints at any of the existing piers.***				
Proposed Retrofit	***Insall shear lugs on top of pier walls***				
Number of Locations	**2**			*PDF Page #*	
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**HA101**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Bottom Chord lateral bracing Span 5**			*Drawing #*	**C0002-004**
Description of Vulnerability	***Lateral bracing overstressed during earthquake. (3 end panels of each span)***				
Proposed Retrofit	***Strengthening of bottom chord bracing including connections. System Retrofit - Base Isolation will reduce forces in lift span members***				
Number of Locations	**6**			*PDF Page #*	**4 of 43**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**HA102**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Towers at Bents 5 & 6**			*Drawing #*	**C0002-004**
Description of Vulnerability	***Towers are not adequate to carry lateral forces from counterweights. Both front and back legs and transverse braces will require strengthening.***				
Proposed Retrofit	***Replace or strengthen existing members. System Retrofit - install isolation bearings to reduce forces in tower.***				
Number of Locations	**2**			*PDF Page #*	**4 of 43**
Unit Cost of Retrofit	**$7,600,000**	*each*		*Figure Ref. #*	**HA103**

Vulnerability Number	**5**	*As-Built Dwg. File*	**1909_XX_XX_Hawthorne_Br_Main_Span.pdf**		
Vulnerable Component	**Existing Piers**			*Drawing #*	**C0002-003**
Description of Vulnerability	***Piers 5 and 6 are unreinforced and not adequate for carrying forces from superstructure into piles.***				
Proposed Retrofit	***Strengthen Piers steel confinement jackets at base of piers System Retrofit - Base Isolation will lessen the forces into***				
Number of Locations	**2**			*PDF Page #*	**3 of 43**
Unit Cost of Retrofit	**$2,375,000**	*each*		*Figure Ref. #*	**HA104**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date:	**3/26/2014**
Bridge Name	**Willamette River, Hawthorne Ave [Hawthorne]**		*Checked by:*	**kpbu**	Date:	5/20/2014
Bridge Number	**02757**					
Bridge Location	**Moveable Span**					
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**1**	*As-Built Dwg. File*		
Vulnerable Component	**Bearings for Piers 5-6**		*Drawing #*	
Description of Vulnerability	***Existing bearings are vulnerable to topple off their piers during an earthquake.***			
Proposed Retrofit	***Install catcher blocks and restrainers***			
Number of Locations	**4**		*PDF Page #*	
Unit Cost of Retrofit	**$113,000**	*each*	*Figure Ref. #*	**HA101**

Vulnerability Number	**2**	*As-Built Dwg. File*		
Vulnerable Component	**Superstructure pulling off Piers 5-6**		*Drawing #*	
Description of Vulnerability	***No transverse restraints at any of the existing piers.***			
Proposed Retrofit	***Insall shear lugs on top of pier walls***			
Number of Locations	**2**		*PDF Page #*	
Unit Cost of Retrofit	**$56,000**	*each*	*Figure Ref. #*	**HA101**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date: **3/26/2014**
Bridge Name	**SE Madison St Ramp over Hwy 1E SB (SE MLK Blvd) [Hawthorne]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**02757B**				
Bridge Location	**East Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Columns**			*Drawing #*	**47776**
Description of Vulnerability	***Bents 1 through 7M, 5W, 7H. Base of Columns frame into pile cap. Detailing not sufficient for hinging. Fairly short columns throughout. Tops frame into bent caps.***				
Proposed Retrofit	***Existing detail may require strengthening***				
Number of Locations	**32**			*PDF Page #*	**109**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**HA401**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Pile Cap Footings**			*Drawing #*	**47776**
Description of Vulnerability	***Footings may need to be strengthened to force hinging in the new retrofitted columns***				
Proposed Retrofit	***Footing overlay on top of footing, some additional micropiles may be necessary***				
Number of Locations	**32**			*PDF Page #*	**109**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**HA401**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating on Pier 1**			*Drawing #*	**47774**
Description of Vulnerability	***Pier 1. Longitudinal restraint not provided.***				
Proposed Retrofit	***Install seat extenders***				
Number of Locations	**1**			*PDF Page #*	**107**
Unit Cost of Retrofit	**$100,000**	*each*		*Figure Ref. #*	**HA402**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Connection at Pier 1**			*Drawing #*	**47774**
Description of Vulnerability	***Pier 1. No transverse restraint provided. No shear lugs present.***				
Proposed Retrofit	***Install restrainers and lateral shear lugs***				
Number of Locations	**1**			*PDF Page #*	**107**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**HA403**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date: **3/26/2014**
Bridge Name	**SE Madison St Ramp over Hwy 1E SB (SE MLK Blvd) [Hawthorne]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**02757B**				
Bridge Location	**East Approaches**				
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating on Expansion Bent**			*Drawing #*	**47784, 47790, 47796**
Description of Vulnerability	***Bent 4M, 4W, 4H have a low risk of pull off, as seismic restrainers are installed, adequacy is not certain.***				
Proposed Retrofit	***Rehabilitate restrainers as needed.***				
Number of Locations	**3**			*PDF Page #*	**117**
Unit Cost of Retrofit	**$100,000**	*each*		*Figure Ref. #*	**HA404**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating on Bent 7M, 6W, 7H**			*Drawing #*	**47801**
Description of Vulnerability	***Abutments are vulnerable to pull off if seat width or dowels are not adequate.***				
Proposed Retrofit	***Install seat extenders and lateral shear lugs***				
Number of Locations	**3**			*PDF Page #*	**133**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**HA405**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Columns**			*Drawing #*	
Description of Vulnerability	***Bents H1 through H21 and M1 through M20. Base of Columns frame into pile cap. Detailing not sufficient for hinging. Top of Columns frame into Bent Cap.***				
Proposed Retrofit	***Column jacketing is necessary to provide ductility, shear resistance, and lateral force resistance***				
Number of Locations	**86**			*PDF Page #*	**22**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**HA406**

Vulnerability Number	**8**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Pile Cap Footings**			*Drawing #*	
Description of Vulnerability	***Footings may need to be strengthened to force hinging in the new retrofitted columns.***				
Proposed Retrofit	***Footing overlay on top of footing, some additional micropiles may be necessary***				
Number of Locations	**86**			*PDF Page #*	**11**
Unit Cost of Retrofit	**$500,000**	*each*		*Figure Ref. #*	**HA407**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date:	**3/26/2014**
Bridge Name	**SE Madison St Ramp over Hwy 1E SB (SE MLK Blvd) [Hawthorne]**		*Checked by:*	**kpbu**	Date:	5/20/2014
Bridge Number	**02757B**					
Bridge Location	**East Approaches**					
Seismic Event	**1000 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**9**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating Abutments A1, A2, A3**			*Drawing #*	
Description of Vulnerability	***Abutments are vulnerable to pull off if seat width or dowels are not adequate.***				
Proposed Retrofit	***Install seat extenders and lateral shear lugs***				
Number of Locations	**3**			*PDF Page #*	**11**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**HA408**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date: **3/26/2014**
Bridge Name	**SE Madison St Ramp over Hwy 1E SB (SE MLK Blvd) [Hawthorne]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**02757B**				
Bridge Location	**East Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Columns**			*Drawing #*	**47776**
Description of Vulnerability	***Bents 1 through 7M, 5W, 7H. Base of Columns frame into pile cap. Detailing not sufficient for hinging. Fairly short columns throughout. Tops frame into bent caps.***				
Proposed Retrofit	***Existing detail may require strengthening***				
Number of Locations	**32**			*PDF Page #*	**109**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**HA401**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Pile Cap Footings**			*Drawing #*	**47776**
Description of Vulnerability	***Footings may need to be strengthened to force hinging in the new retrofitted columns***				
Proposed Retrofit	***Footing overlay on top of footing, some additional micropiles may be necessary***				
Number of Locations	**32**			*PDF Page #*	**109**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**HA401**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating on Pier 1**			*Drawing #*	**47774**
Description of Vulnerability	***Pier 1. Longitudinal restraint not provided.***				
Proposed Retrofit	***Install seat extenders***				
Number of Locations	**1**			*PDF Page #*	**107**
Unit Cost of Retrofit	**$95,000**	*each*		*Figure Ref. #*	**HA402**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Connection at Pier 1**			*Drawing #*	**47774**
Description of Vulnerability	***Pier 1. No transverse restraint provided. No shear lugs present.***				
Proposed Retrofit	***Install restrainers and lateral shear lugs***				
Number of Locations	**1**			*PDF Page #*	**107**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**HA403**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date: **3/26/2014**
Bridge Name	**SE Madison St Ramp over Hwy 1E SB (SE MLK Blvd) [Hawthorne]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**02757B**				
Bridge Location	**East Approaches**				
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating on Expansion Bent**			*Drawing #*	**47784, 47790, 47796**
Description of Vulnerability	***Bent 4M, 4W, 4H have a low risk of pull off, as seismic restrainers are installed, adequacy is not certain.***				
Proposed Retrofit	***Rehabilitate restrainers as needed.***				
Number of Locations	**3**			*PDF Page #*	**117**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**HA404**

Vulnerability Number	**6**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating on Bent 7M, 6W, 7H**			*Drawing #*	**47801**
Description of Vulnerability	***Abutments are vulnerable to pull off if seat width or dowels are not adequate.***				
Proposed Retrofit	***Install seat extenders and lateral shear lugs***				
Number of Locations	**3**			*PDF Page #*	**133**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**HA405**

Vulnerability Number	**7**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Columns**			*Drawing #*	
Description of Vulnerability	***Bents H1 through H21 and M1 through M20. Base of Columns frame into pile cap. Detailing not sufficient for hinging. Top of Columns frame into Bent Cap.***				
Proposed Retrofit	***Column jacketing is necessary to provide ductility, shear resistance, and lateral force resistance***				
Number of Locations	**86**			*PDF Page #*	**22**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**HA406**

Vulnerability Number	**8**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Pile Cap Footings**			*Drawing #*	
Description of Vulnerability	***Footings may need to be strengthened to force hinging in the new retrofitted columns.***				
Proposed Retrofit	***Footing overlay on top of footing, some additional micropiles may be necessary***				
Number of Locations	**86**			*PDF Page #*	**11**
Unit Cost of Retrofit	**$475,000**	*each*		*Figure Ref. #*	**HA407**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date:	**3/26/2014**
Bridge Name	**SE Madison St Ramp over Hwy 1E SB (SE MLK Blvd) [Hawthorne]**		*Checked by:*	**kpbu**	Date:	5/20/2014
Bridge Number	**02757B**					
Bridge Location	**East Approaches**					
Seismic Event	**500 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**9**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating Abutments A1, A2, A3**			*Drawing #*	
Description of Vulnerability	***Abutments are vulnerable to pull off if seat width or dowels are not adequate.***				
Proposed Retrofit	***Install seat extenders and lateral shear lugs***				
Number of Locations	**3**			*PDF Page #*	**11**
Unit Cost of Retrofit	**$71,000**	*each*		*Figure Ref. #*	**HA408**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date: **3/26/2014**
Bridge Name	**SE Madison St Ramp over Hwy 1E SB (SE MLK Blvd) [Hawthorne]**		*Checked by:*	**kpbu**	Date: 5/20/2014
Bridge Number	**02757B**				
Bridge Location	**East Approaches**				
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**		

Vulnerability Number	**1**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating on Pier 1**			*Drawing #*	**47774**
Description of Vulnerability	***Pier 1. Longitudinal restraint not provided.***				
Proposed Retrofit	***Install seat extenders***				
Number of Locations	**1**			*PDF Page #*	**107**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**HA402**

Vulnerability Number	**2**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Connection at Pier 1**			*Drawing #*	**47774**
Description of Vulnerability	***Pier 1. No transverse restraint provided. No shear lugs present.***				
Proposed Retrofit	***Install restrainers and lateral shear lugs***				
Number of Locations	**1**			*PDF Page #*	**107**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**HA403**

Vulnerability Number	**3**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating on Expansion Bent**			*Drawing #*	**47784, 47790, 47796**
Description of Vulnerability	***Bent 4M, 4W, 4H have a low risk of pull off, as seismic restrainers are installed, adequacy is not certain.***				
Proposed Retrofit	***Rehabilitate restrainers as needed.***				
Number of Locations	**3**			*PDF Page #*	**117**
Unit Cost of Retrofit	**$75,000**	*each*		*Figure Ref. #*	**HA404**

Vulnerability Number	**4**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating on Bent 7M, 6W, 7H**			*Drawing #*	**47801**
Description of Vulnerability	***Abutments are vulnerable to pull off if seat width or dowels are not adequate.***				
Proposed Retrofit	***Install seat extenders and lateral shear lugs***				
Number of Locations	**3**			*PDF Page #*	**133**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**HA405**

Multnomah County Willamette River Bridges CIP

Seismic Vulnerabilities and Retrofits worksheet

Bridge Complex	**Hawthorne**		*Compiled by:*	**AJCA**	Date:	**3/26/2014**
Bridge Name	**SE Madison St Ramp over Hwy 1E SB (SE MLK Blvd) [Hawthorne]**		*Checked by:*	**kpbu**	Date:	5/20/2014
Bridge Number	**02757B**					
Bridge Location	**East Approaches**					
Seismic Event	**100 Yr**	*Desired Performance Level*	**No Collapse (NC)**			

Vulnerability Number	**5**	*As-Built Dwg. File*	**1956-1991_Hawthorne_E_Approach_1991_E_Transition_Str.pdf**		
Vulnerable Component	**Superstructure Seating Abutments A1, A2, A3**			*Drawing #*	
Description of Vulnerability	***Abutments are vulnerable to pull off if seat width or dowels are not adequate.***				
Proposed Retrofit	***Install seat extenders and lateral shear lugs***				
Number of Locations	**3**			*PDF Page #*	**11**
Unit Cost of Retrofit	**$56,000**	*each*		*Figure Ref. #*	**HA408**

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Attachment B

Vulnerability Figures

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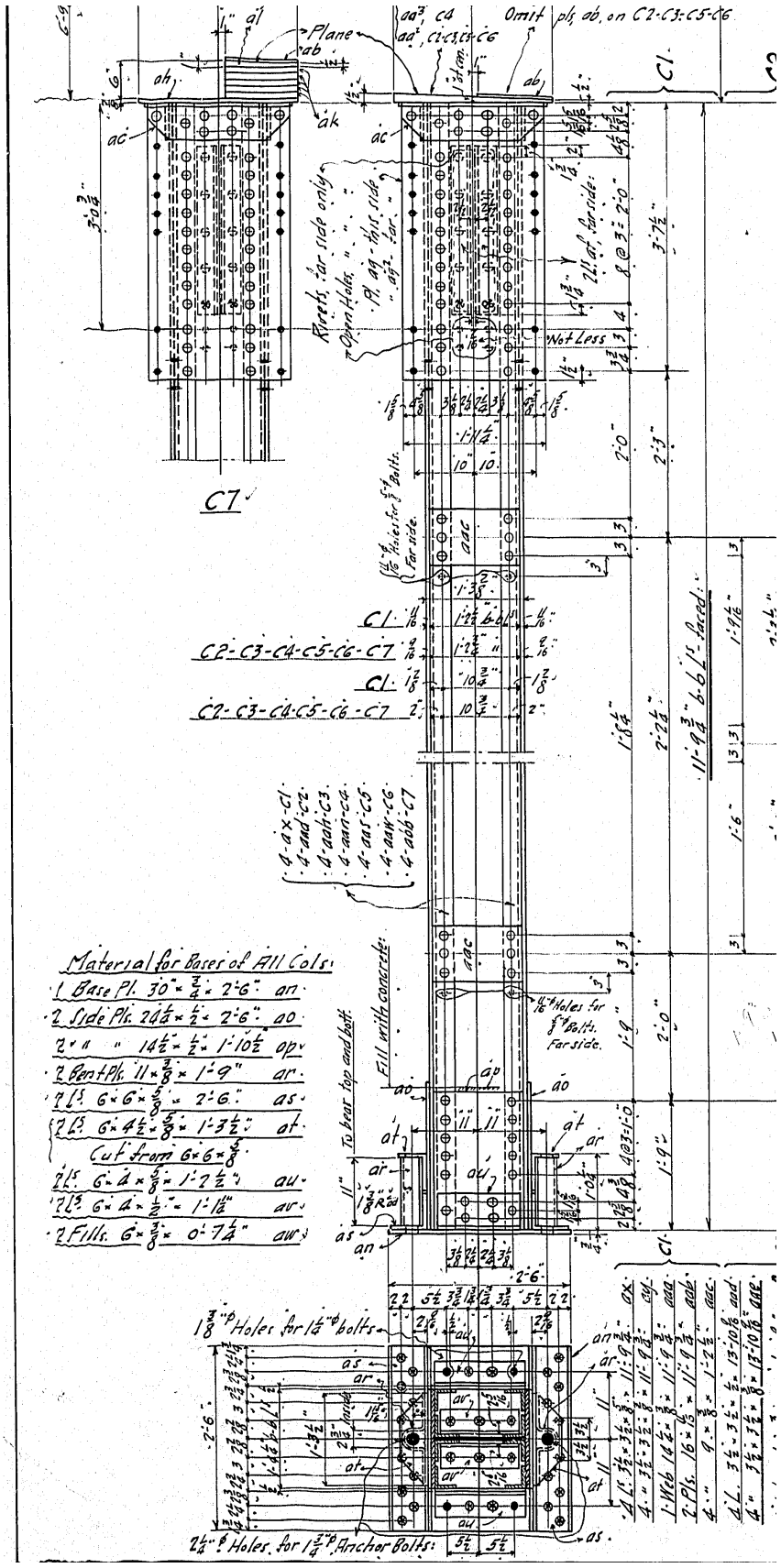


Figure BW001: Steel columns detail

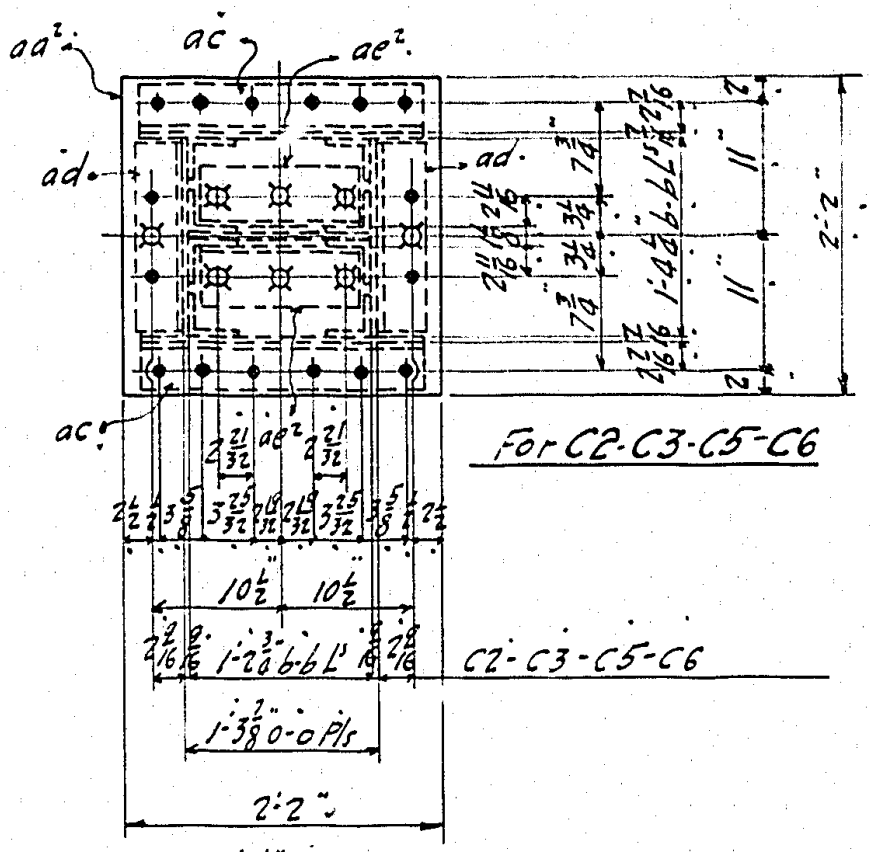
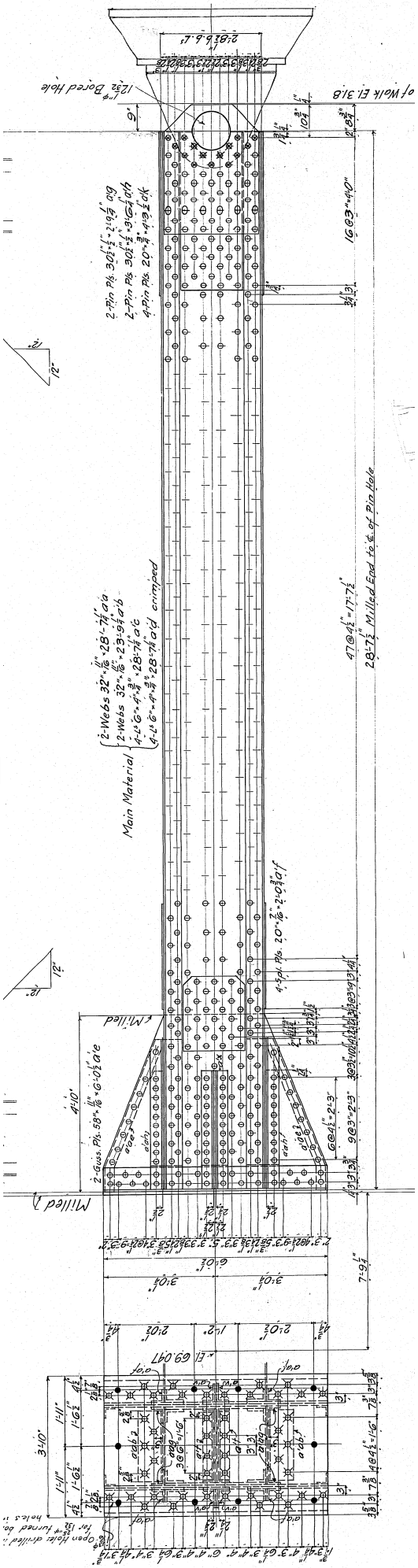


Figure BW002: Superstructure expansion bearing seats

Figure BW003:
Steel columns detail



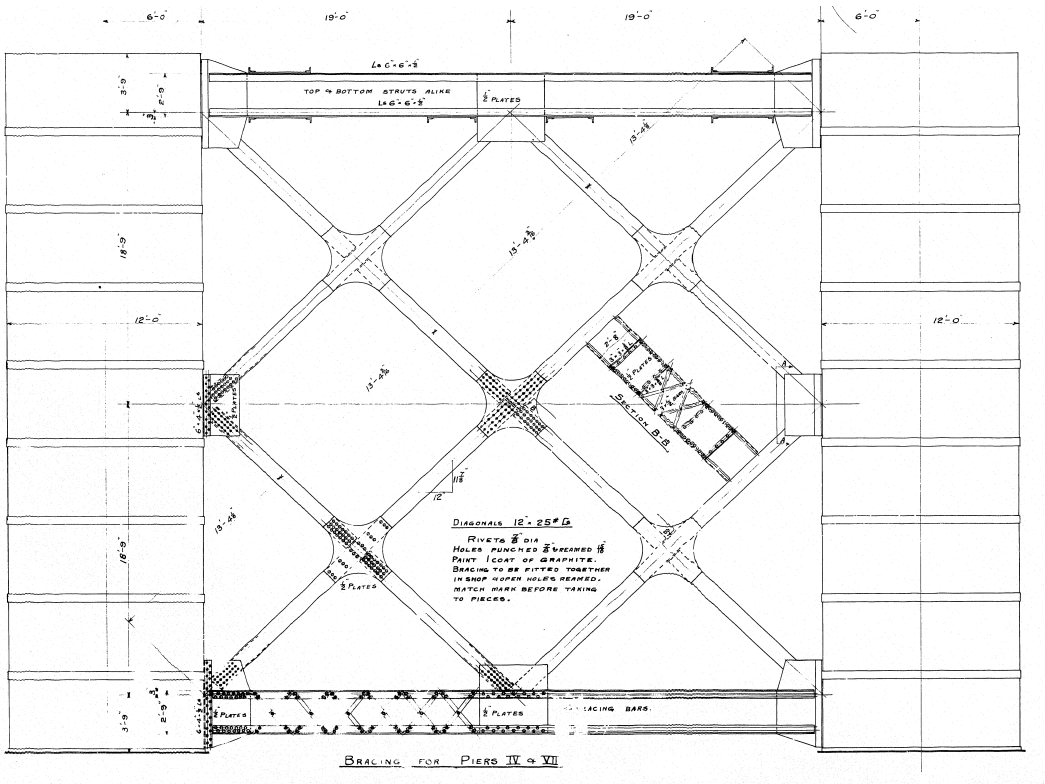


Figure BW004: Bearing detail

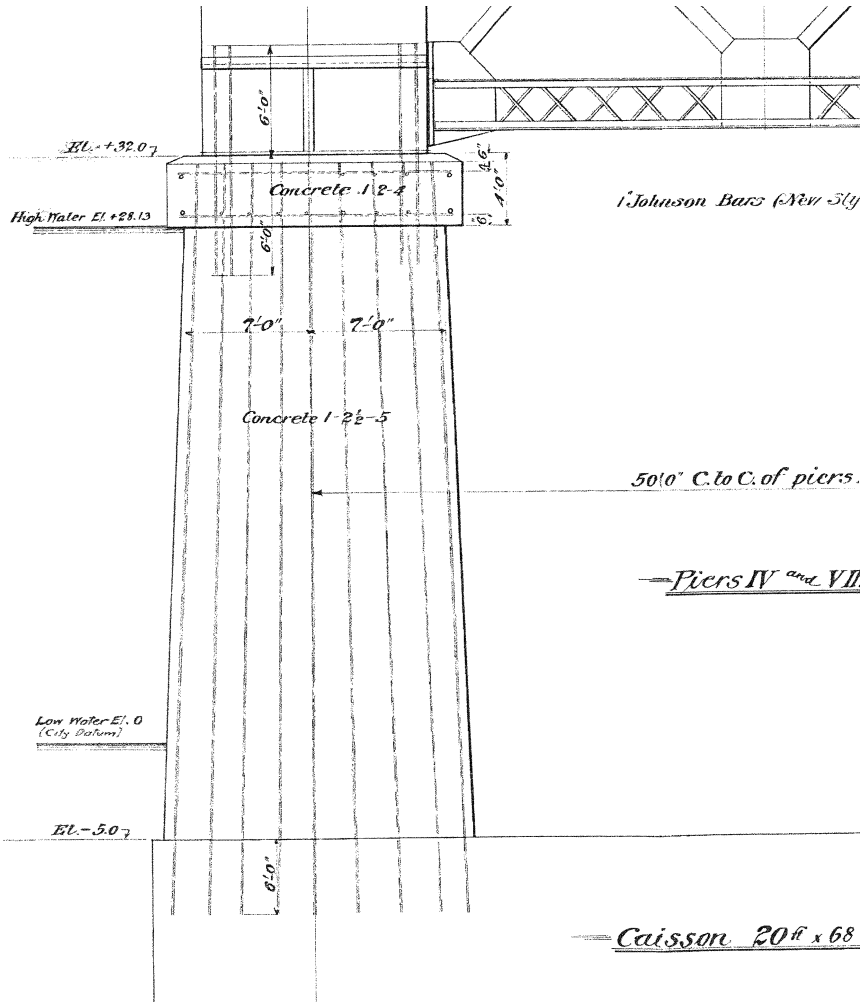


Figure BW040: Unreinforced concrete piers

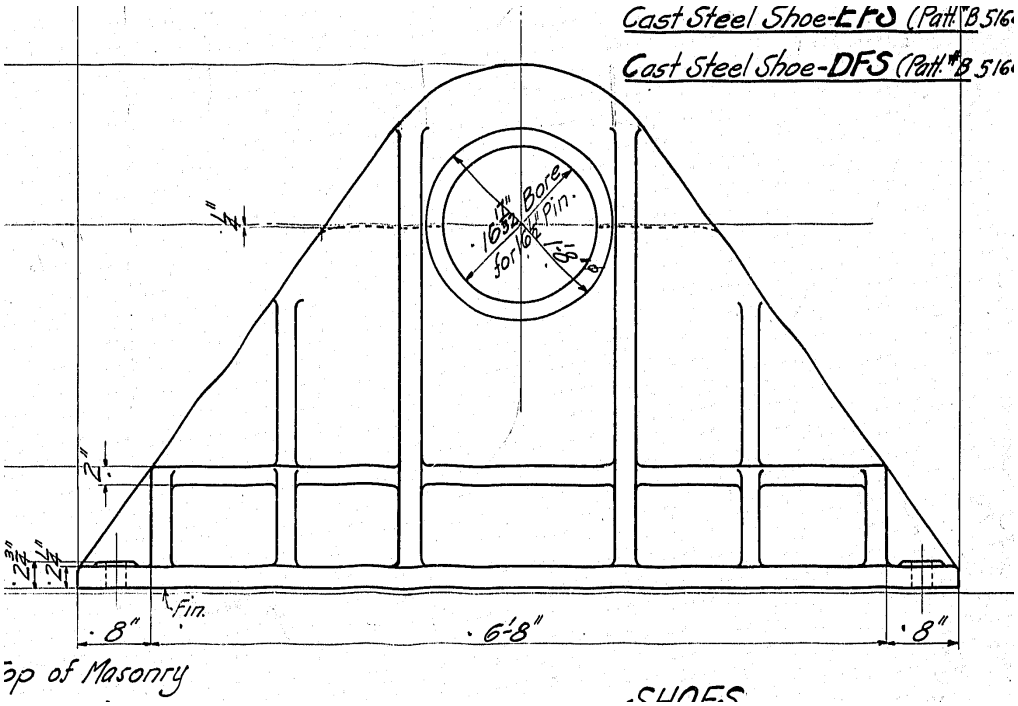


Figure BW050: Moveable span bearings

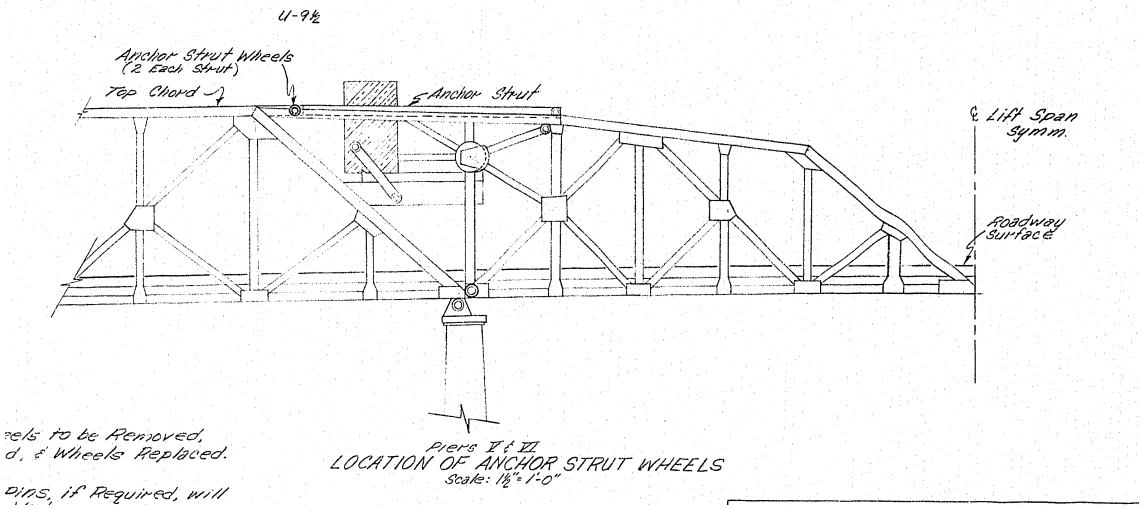


Figure BW051: Moveable span anchor strut

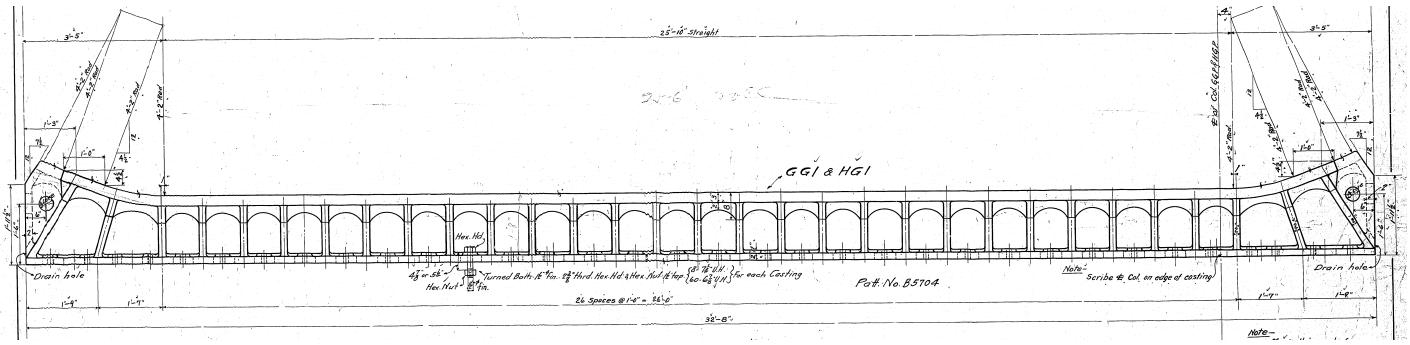


Figure BW052: Rall wheel track

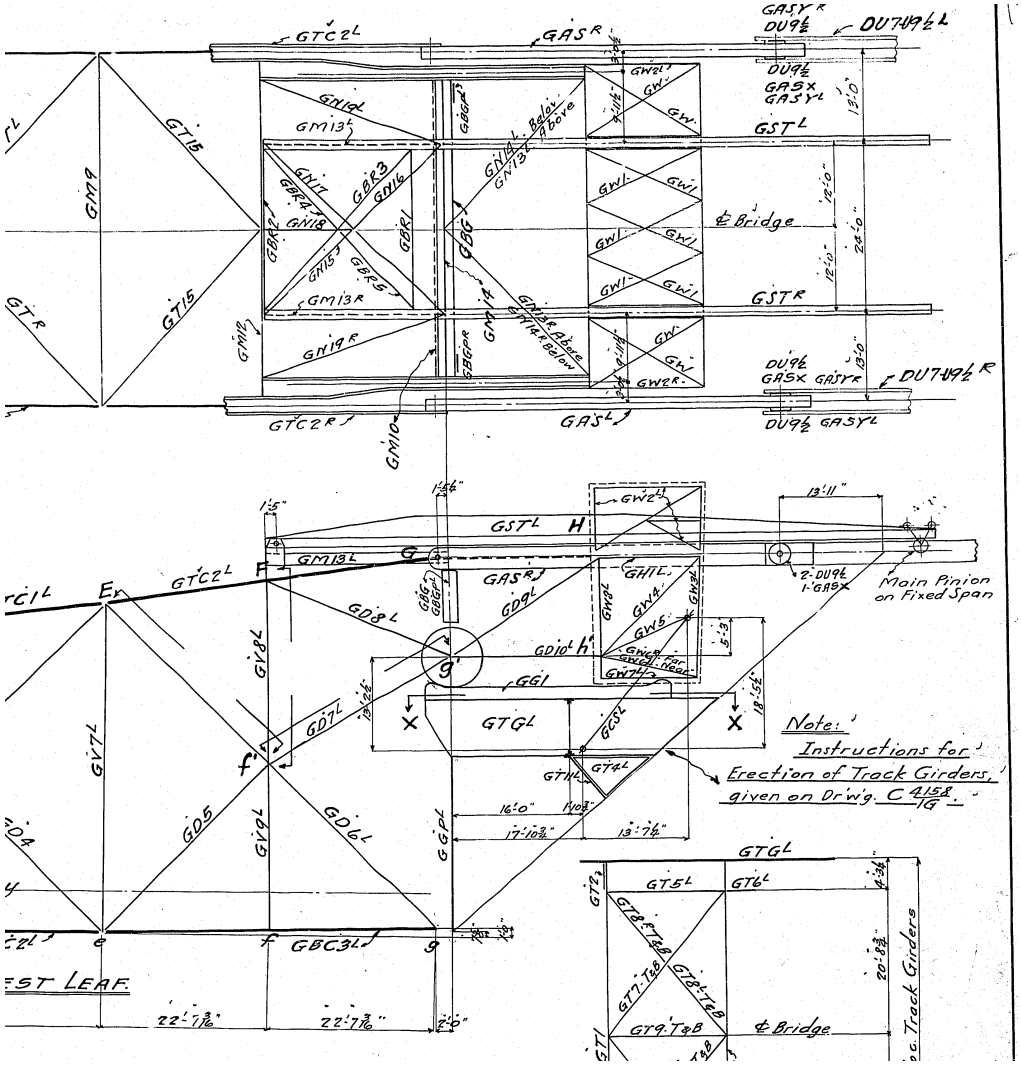


Figure BW053: Truss frame at rall wheels

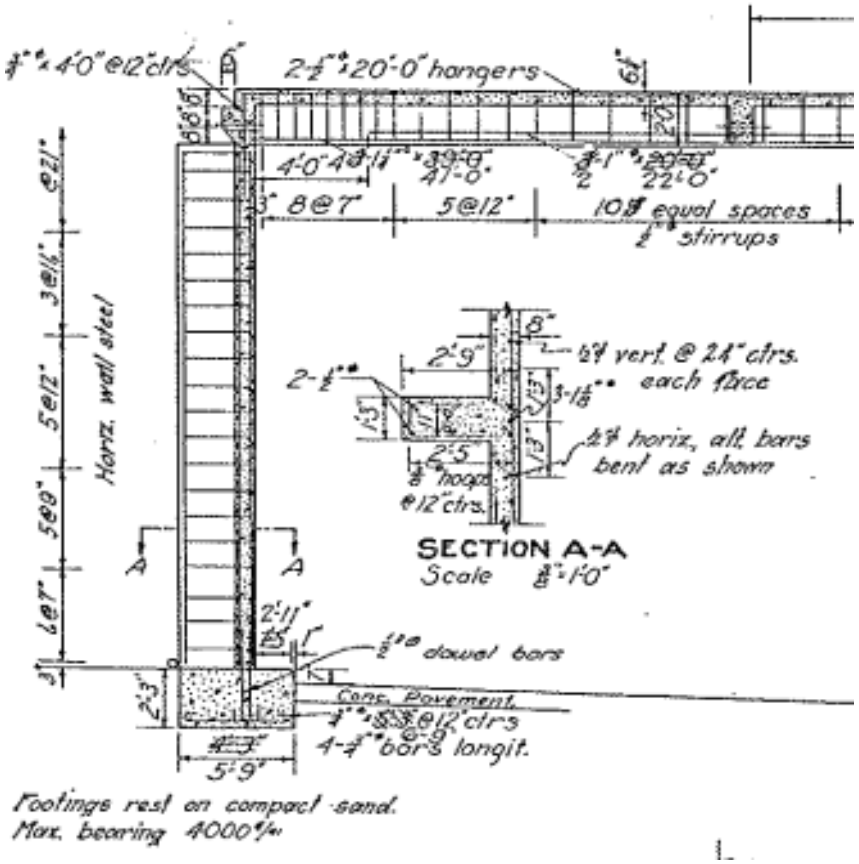


Figure BW92: Abutment joint

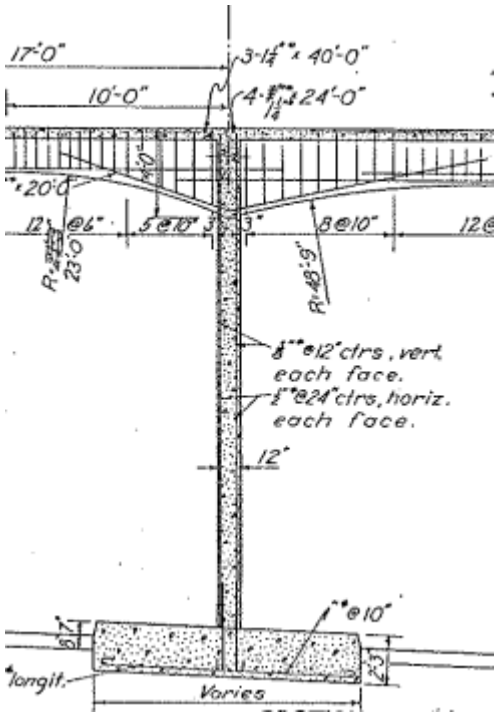


Figure BW93: Interior pier wall joint

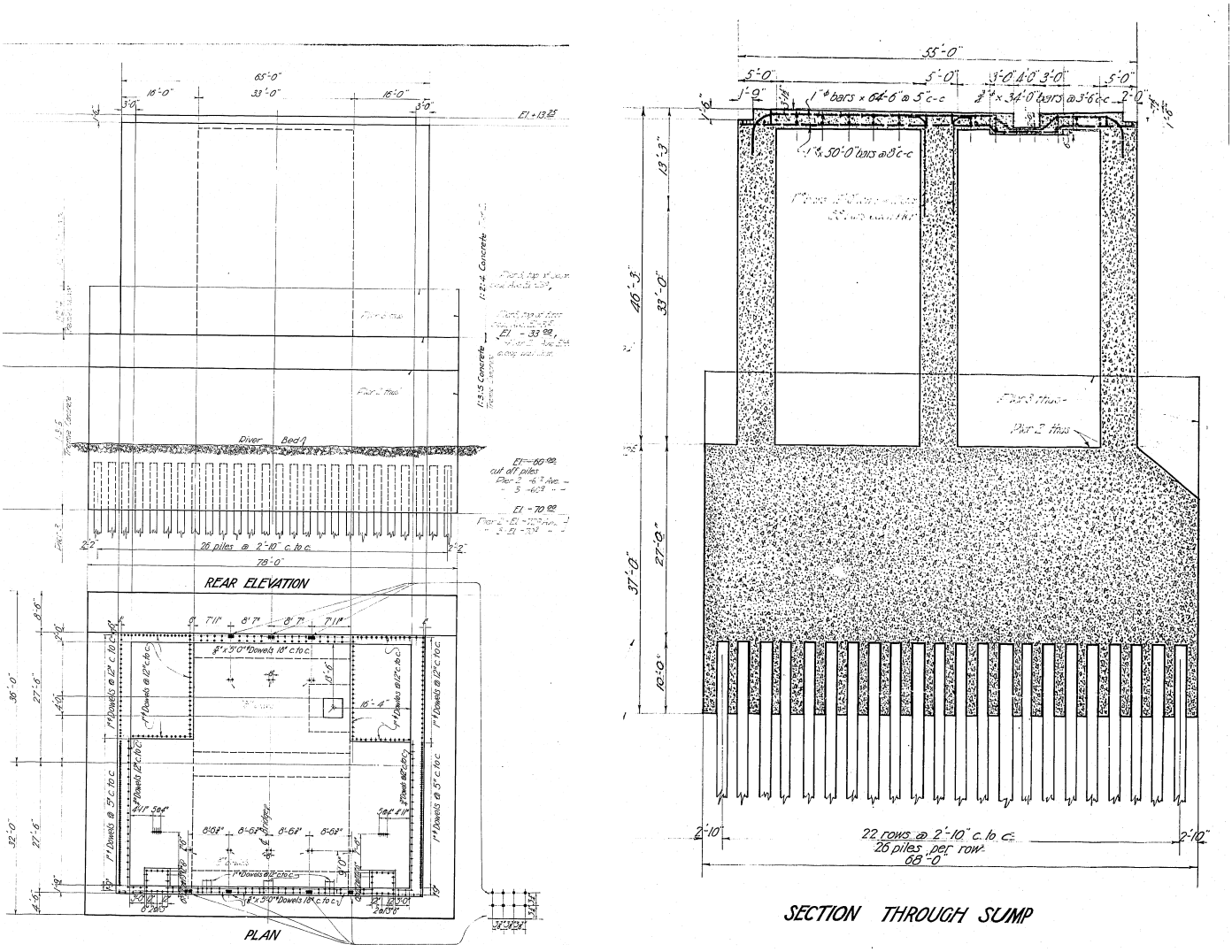


Figure BU101: Burnside Bridge Movable Spans Piers 2 & 3, foundation piles (outer piles) in both compression and uplift

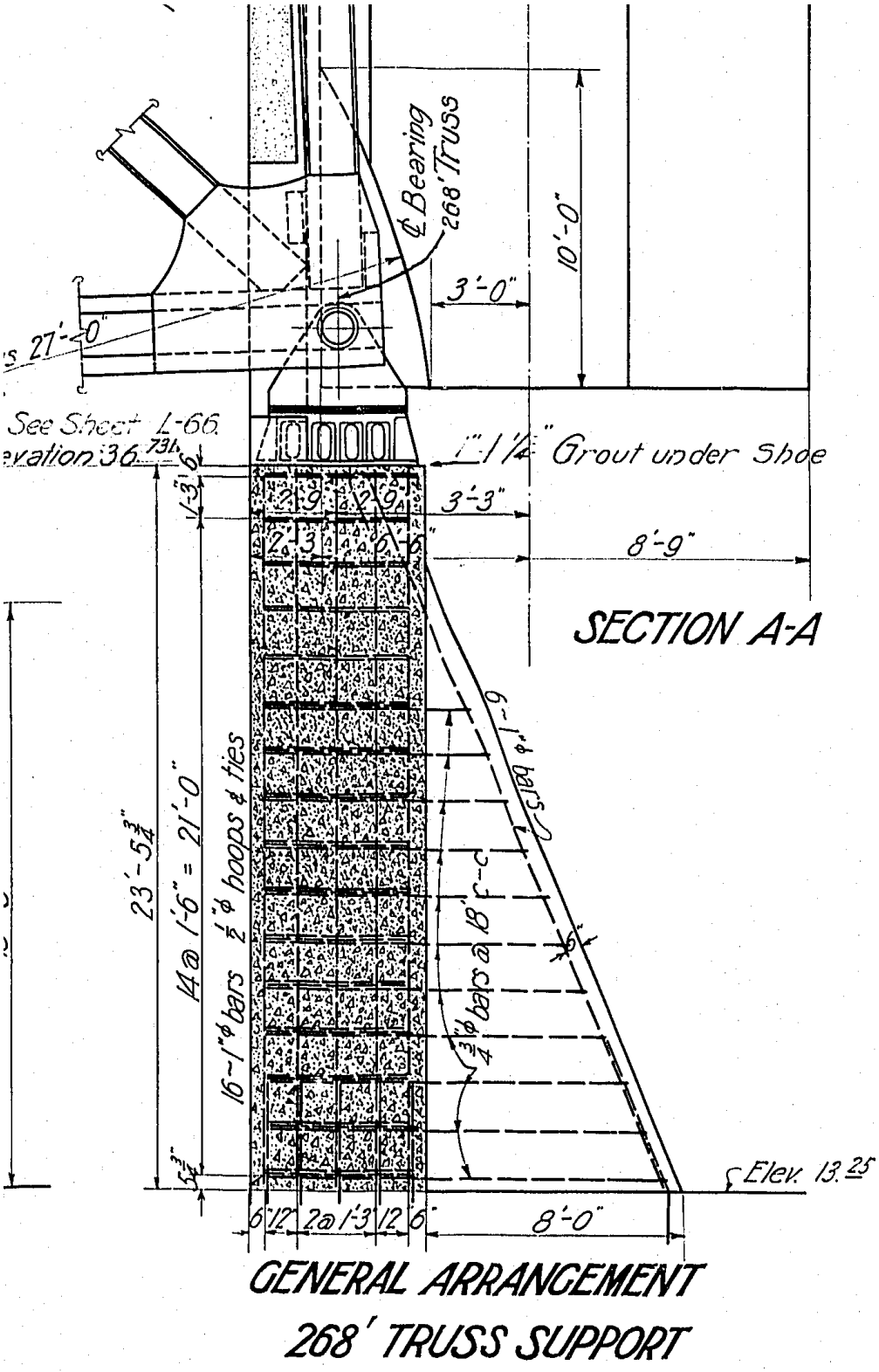


Figure BU102: Burnside Bridge Piers 2 & 3, Bascule Piers Wall without proper seismic reinforcing detailing, potential lost of axial support in seismic event

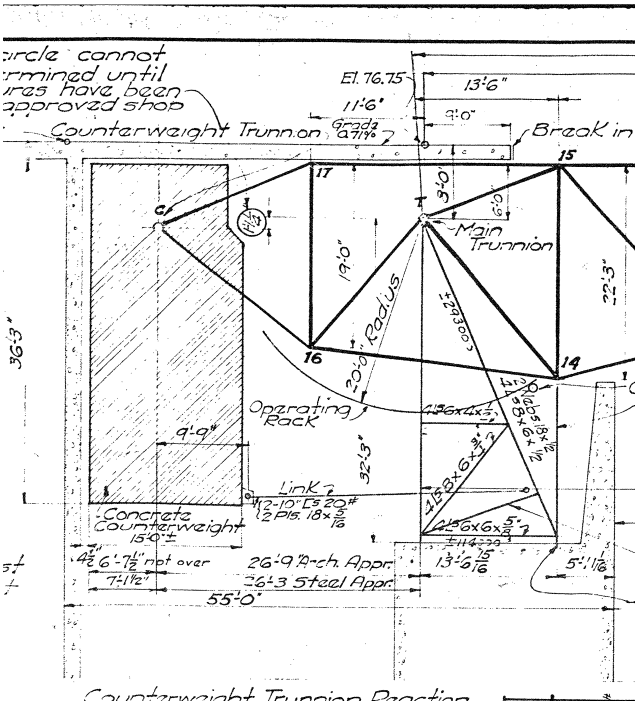


Figure BU103: Burnside Bridge Piers 2 & 3, Trunnion Support Vertical Post which could be subject to high Bending forces

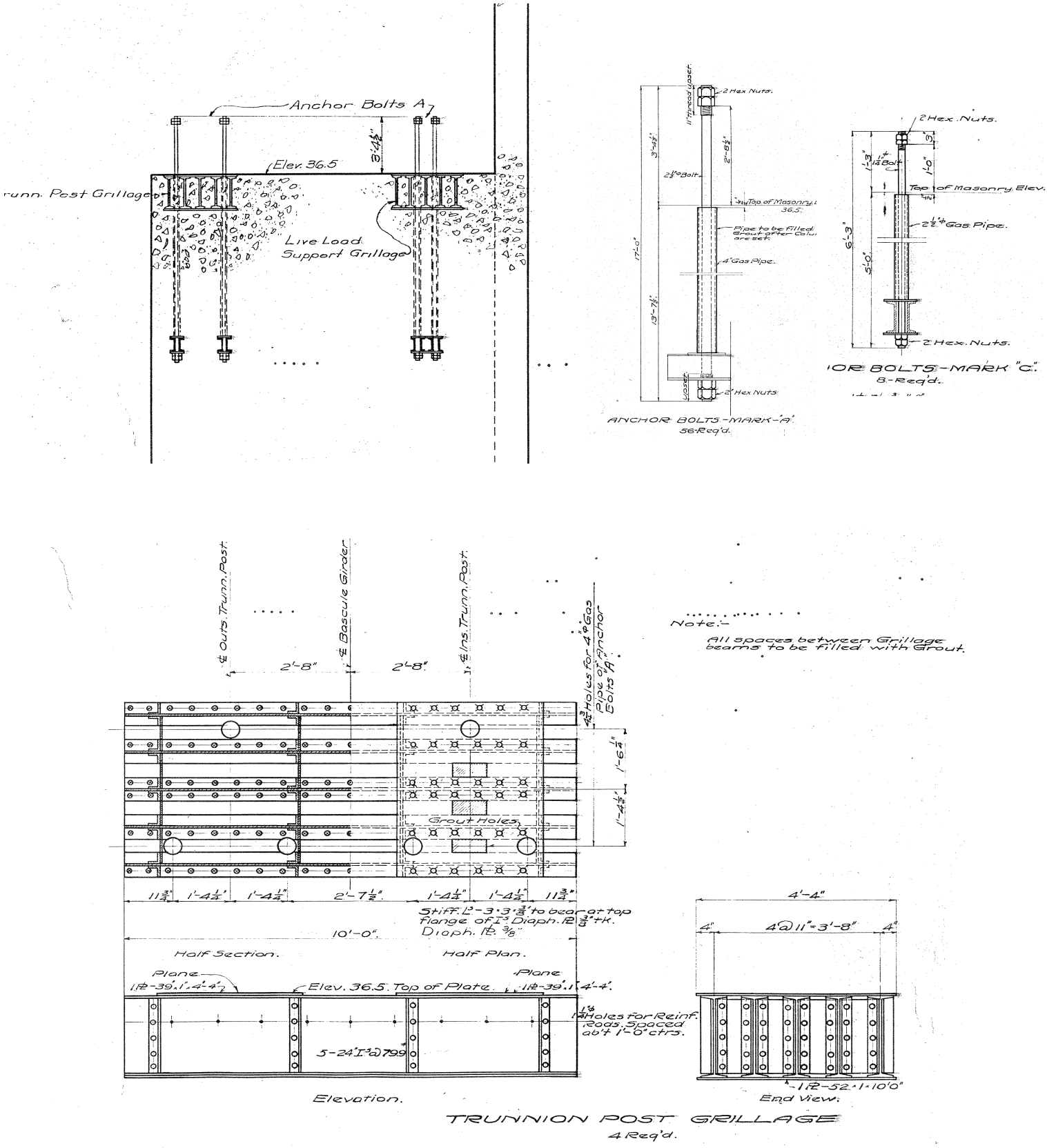
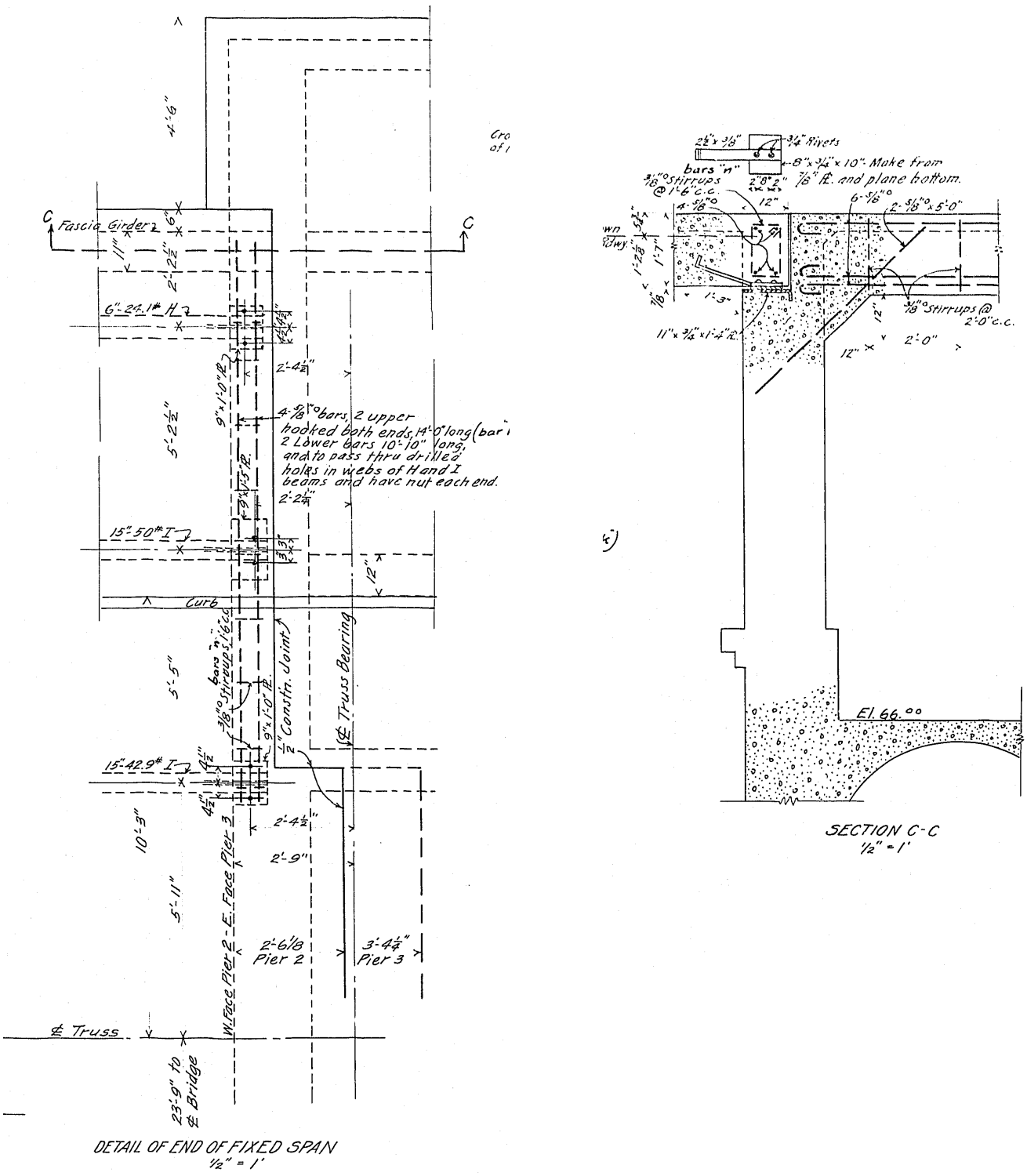


Figure BU104: Burnside Bridge Piers 2 & 3, Anchorage of the Trunnion Frame to the Bascule Piers



DETAIL OF END OF FIXED SPAN
½" = 1'

SECTION C-C
½" = 1'

Figure BU105: Joint in the Deck System at Piers 2 & 3, Fixed and Expansion Spans

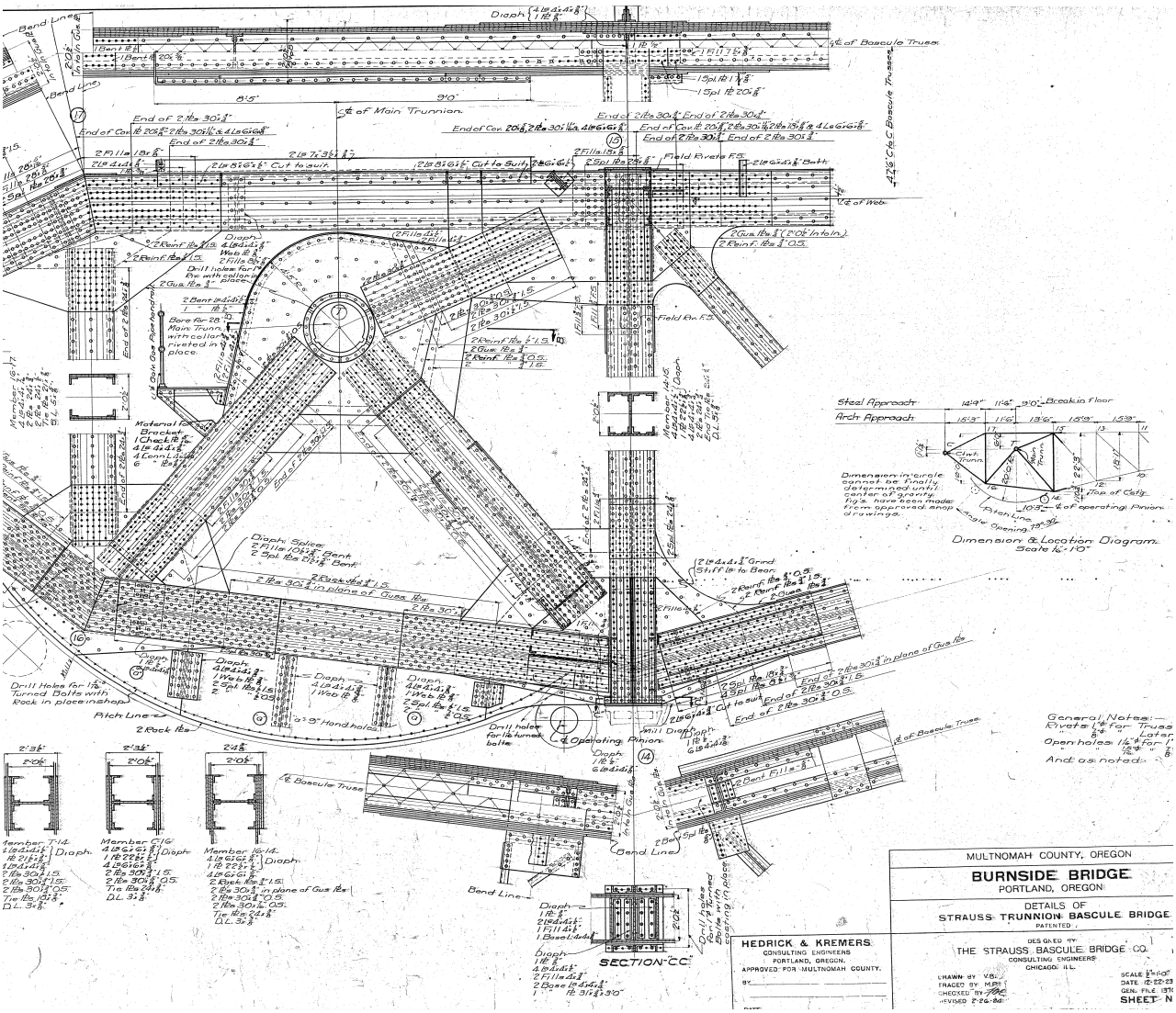


Figure BU106: Burnside Bridge Bascule Leaf Transverse Restraint at Point 14 to the Live Load Support Posts

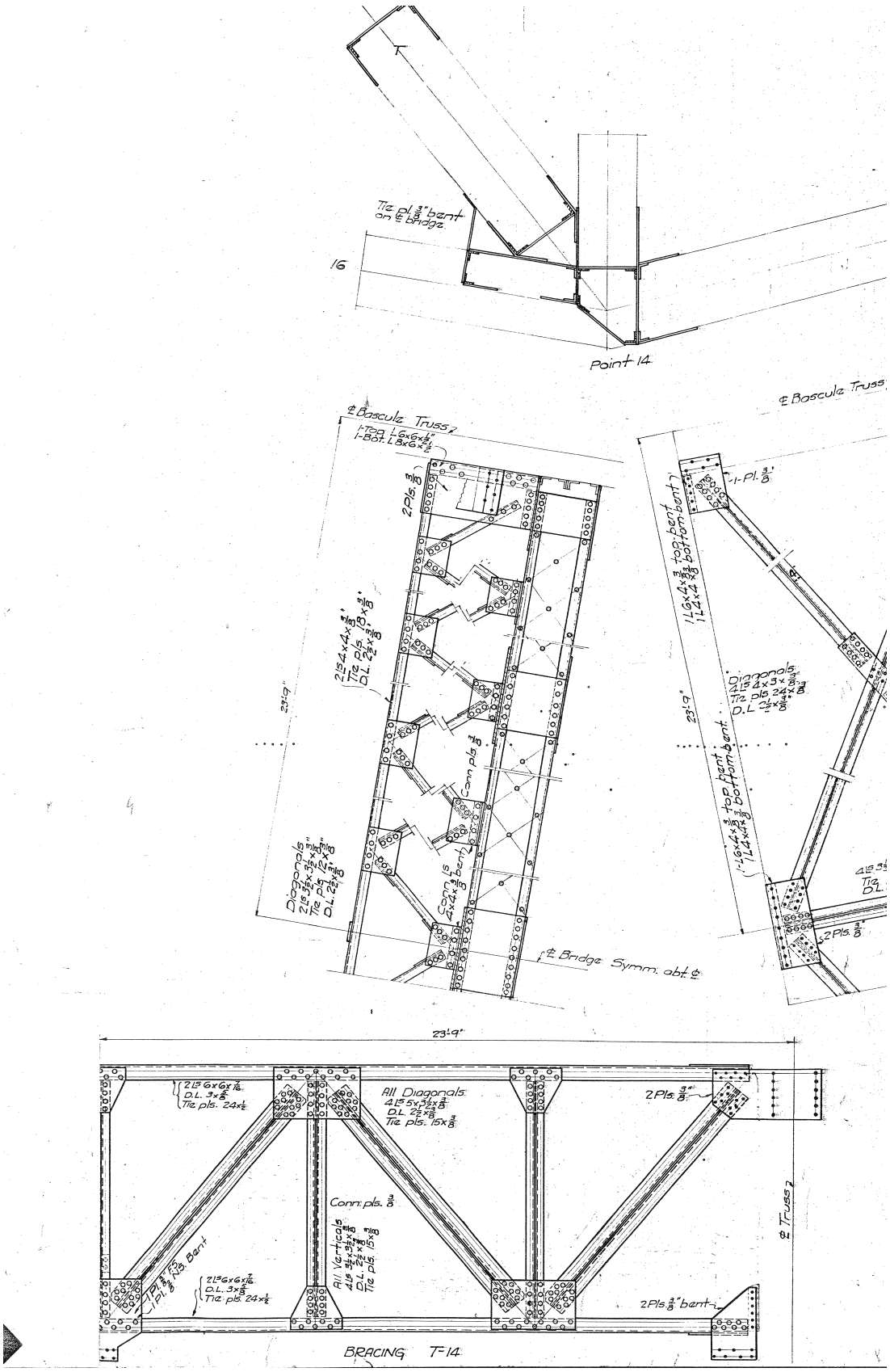
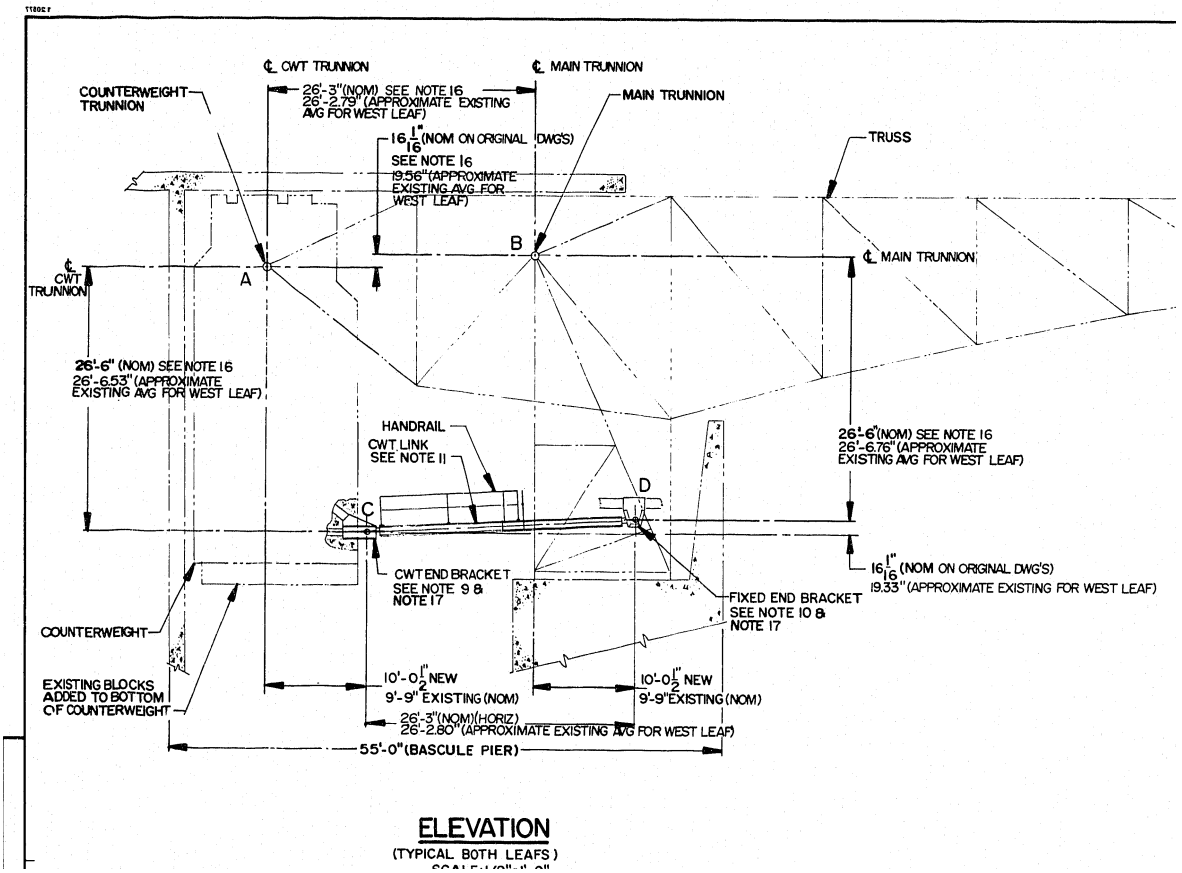
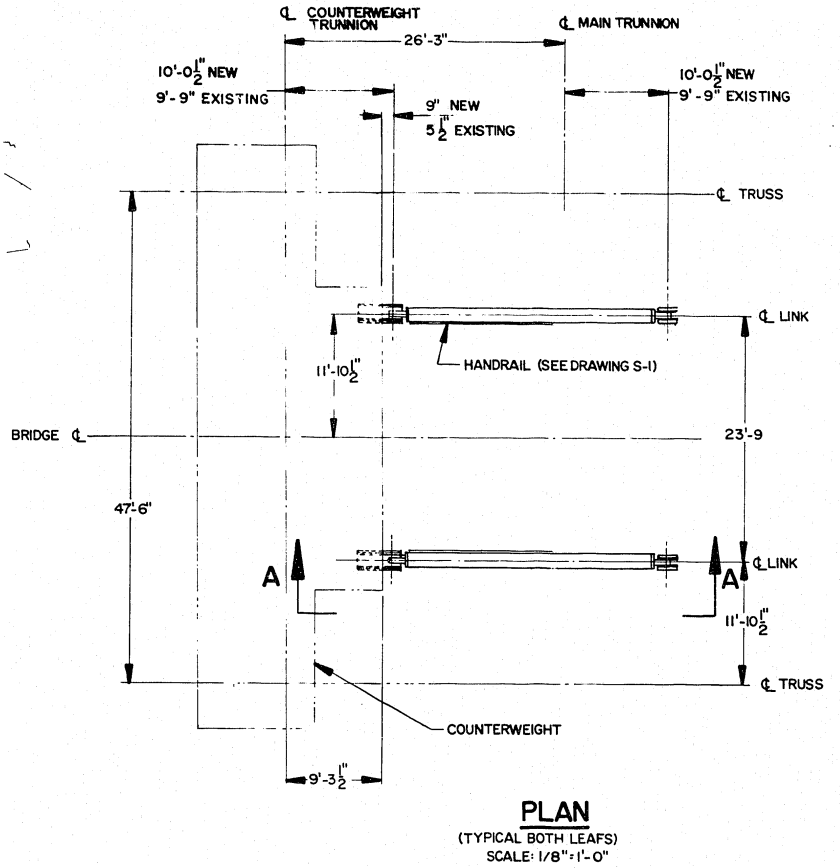


Figure BU107: Burnside Bridge Bascule Leaf Transverse Bracing will be weak if Transverse Restraint is added to Bascule Leaf at Point 14



ELEVATION
(TYPICAL BOTH LEAFS)



PLAN
(TYPICAL BOTH LEAFS)
SCALE: 1/8" = 1'-0"

Figure BU108: Counterweight Links - Restrainers and Link Fuse required for Seismic Loadings

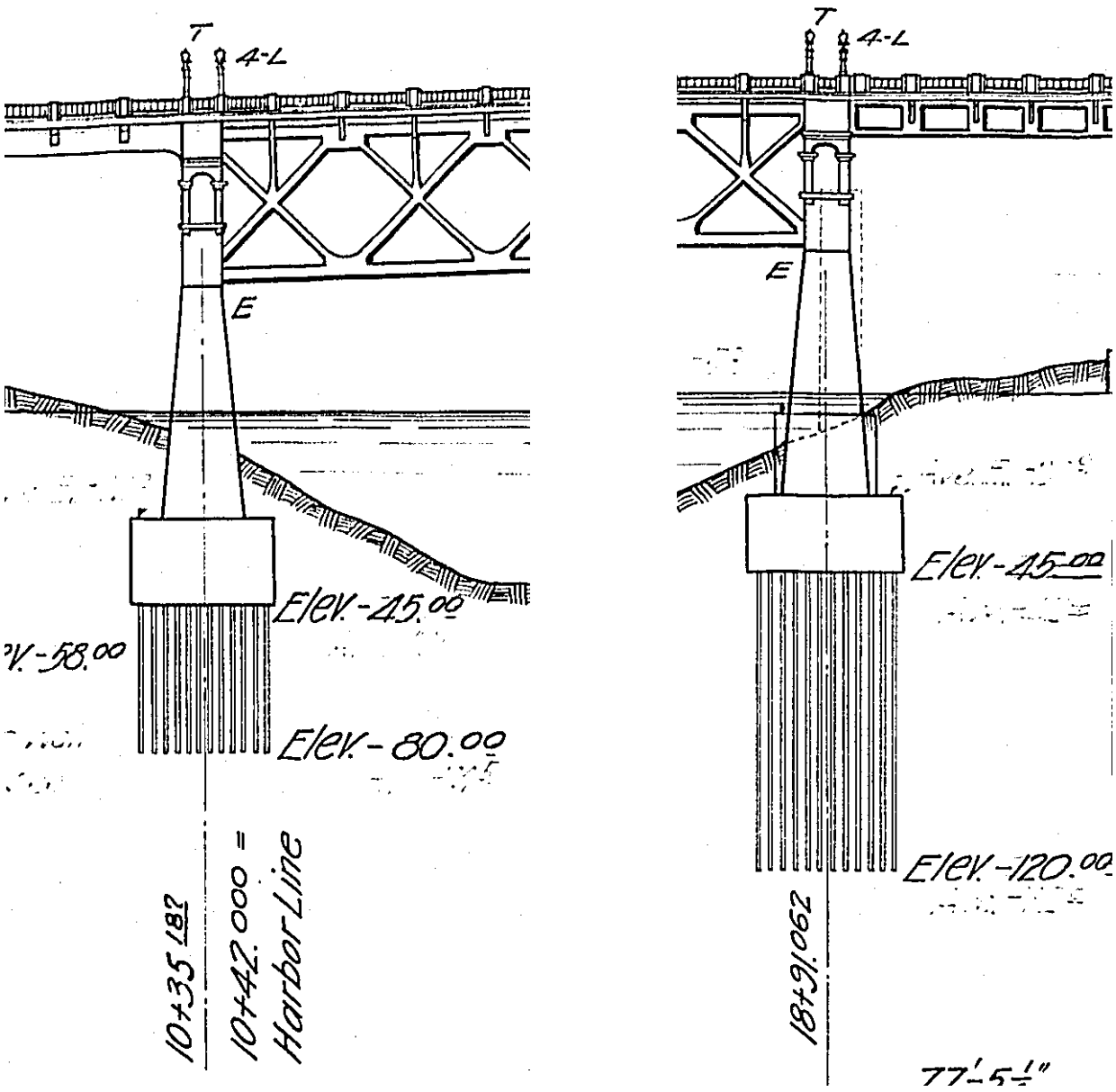


Figure BU201: Burnside Bridge Fixed Spans Piers 1 & 4 - showing sloping bank onto pile cap due to liquefaction

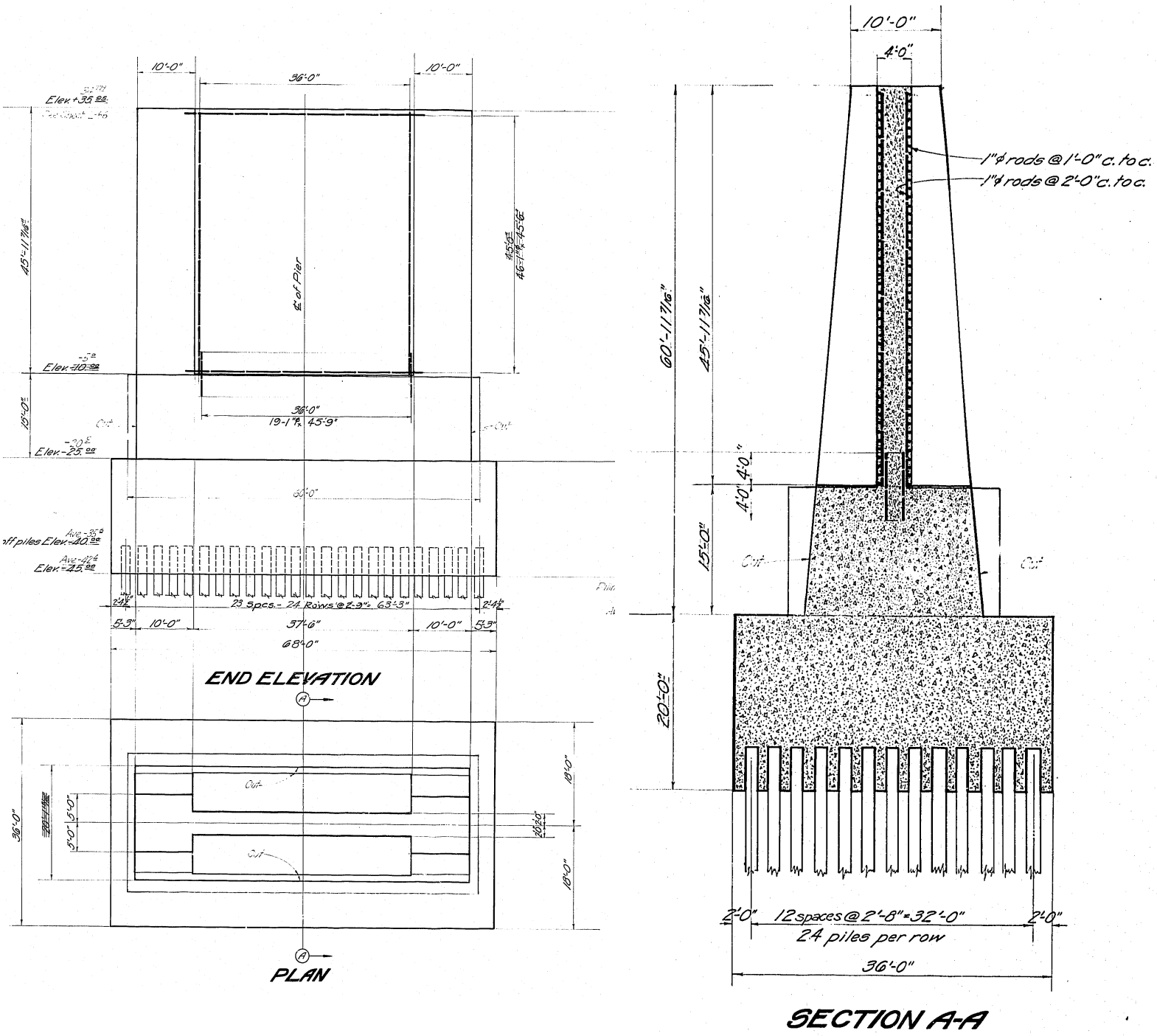


Figure BU202: Burnside Bridge Fixed Spans Piers 1 & 4, foundation piles (outer piles) in uplift, in bridge longitudinal direction

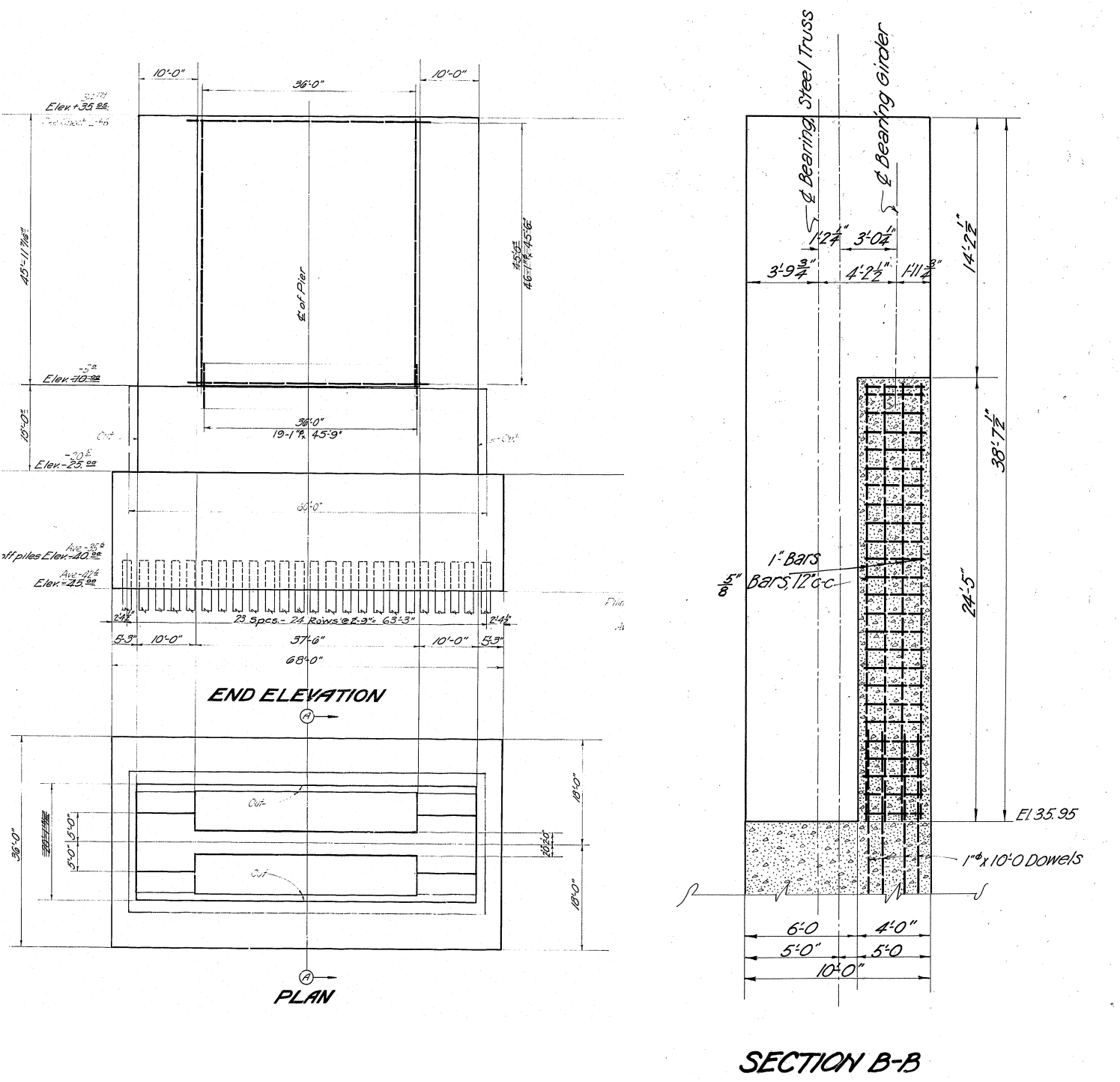


Figure BU203: Burnside Bridge Fixed Spans Piers 1 & 4 Columns, lightly reinforced and without proper seismic reinforcing detailing

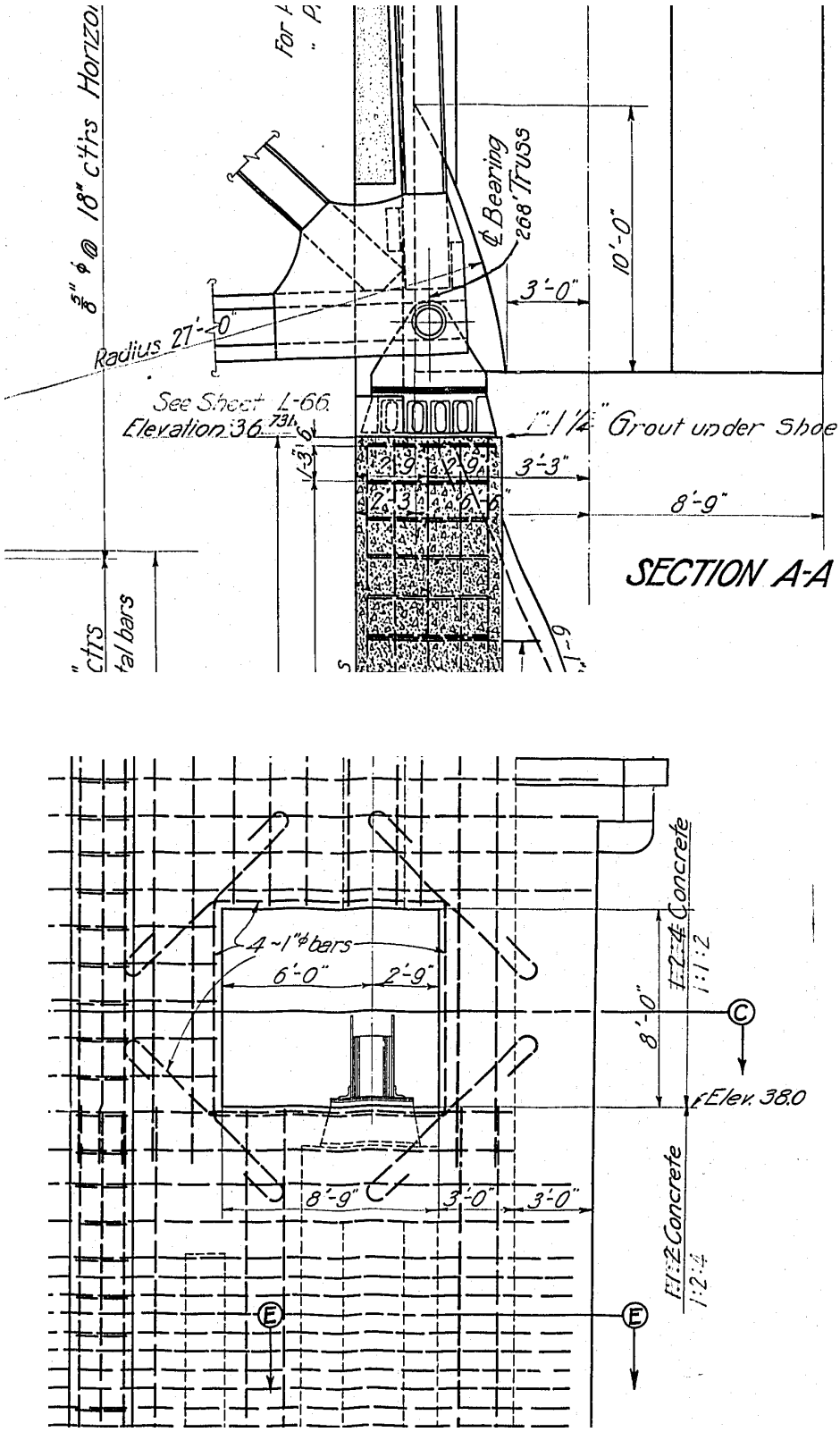


Figure BU204: Burnside Bridge Fixed Spans Truss Fixed Bearing and Bearing Seat Width (top, side view; bottom, front view) at Piers 2 & 3

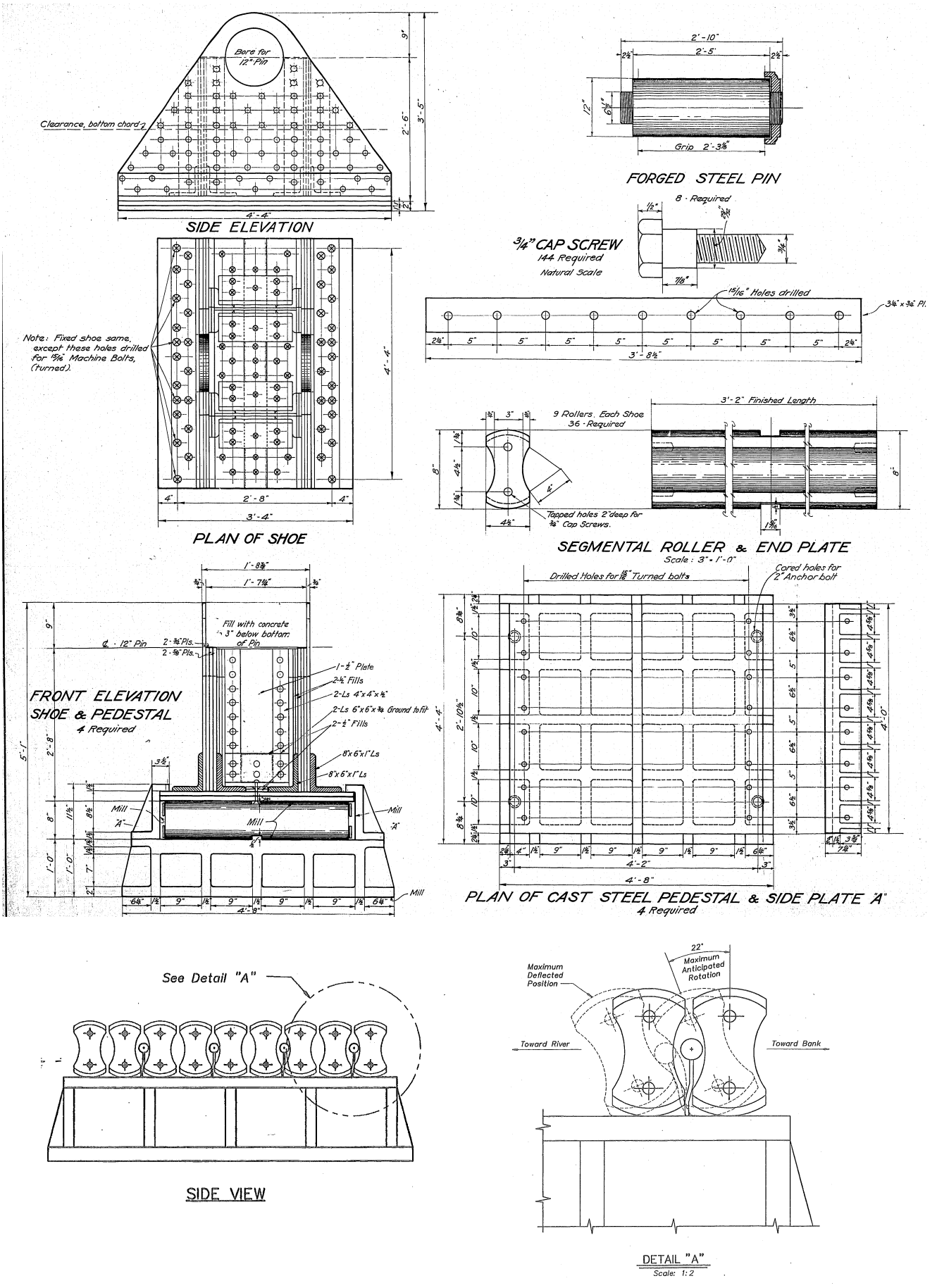
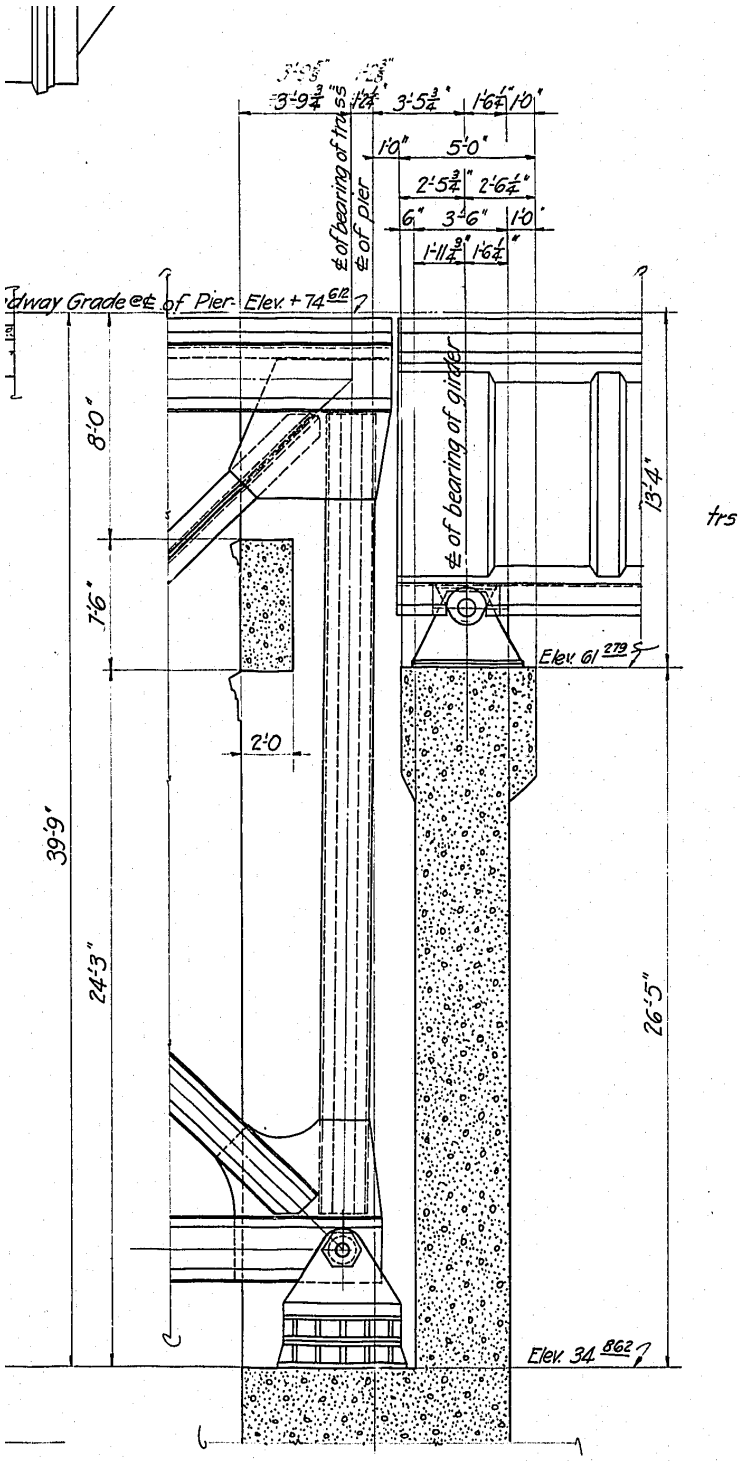
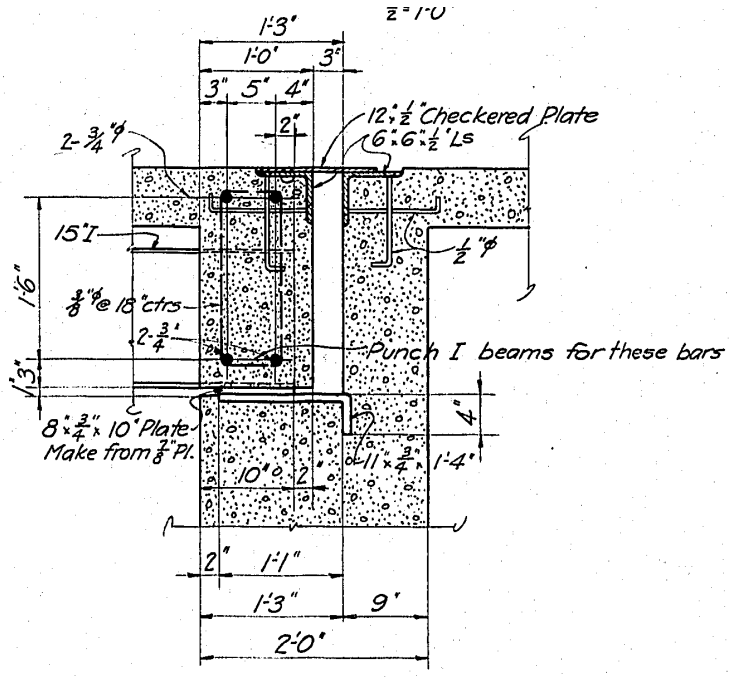


Figure BU205: Burnside Bridge Fixed Spans Truss Expansion Bearing and Bearing Seat Width at Piers 1 & 4, w/ modification in 2001



SECTION B-B



SECTION SHOWING TRUSS STRINGERS AT PIER 4

1"=1'-0"

Figure BU206: Burnside Bridge Fixed Spans to Approach Joint in the Deck System

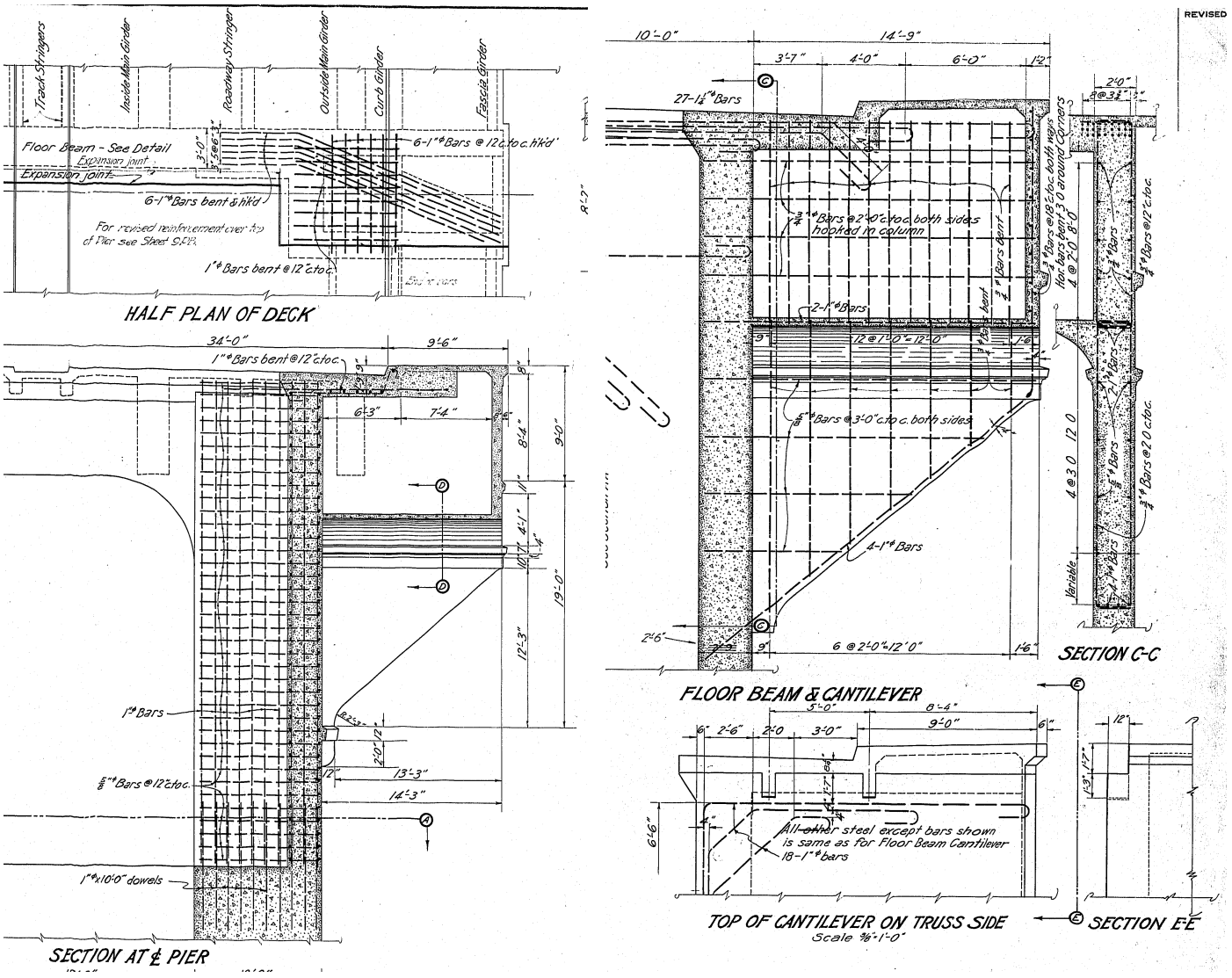


Figure BU207: Burnside Bridge Approach Span Deck Tie to Piers 1 & 4

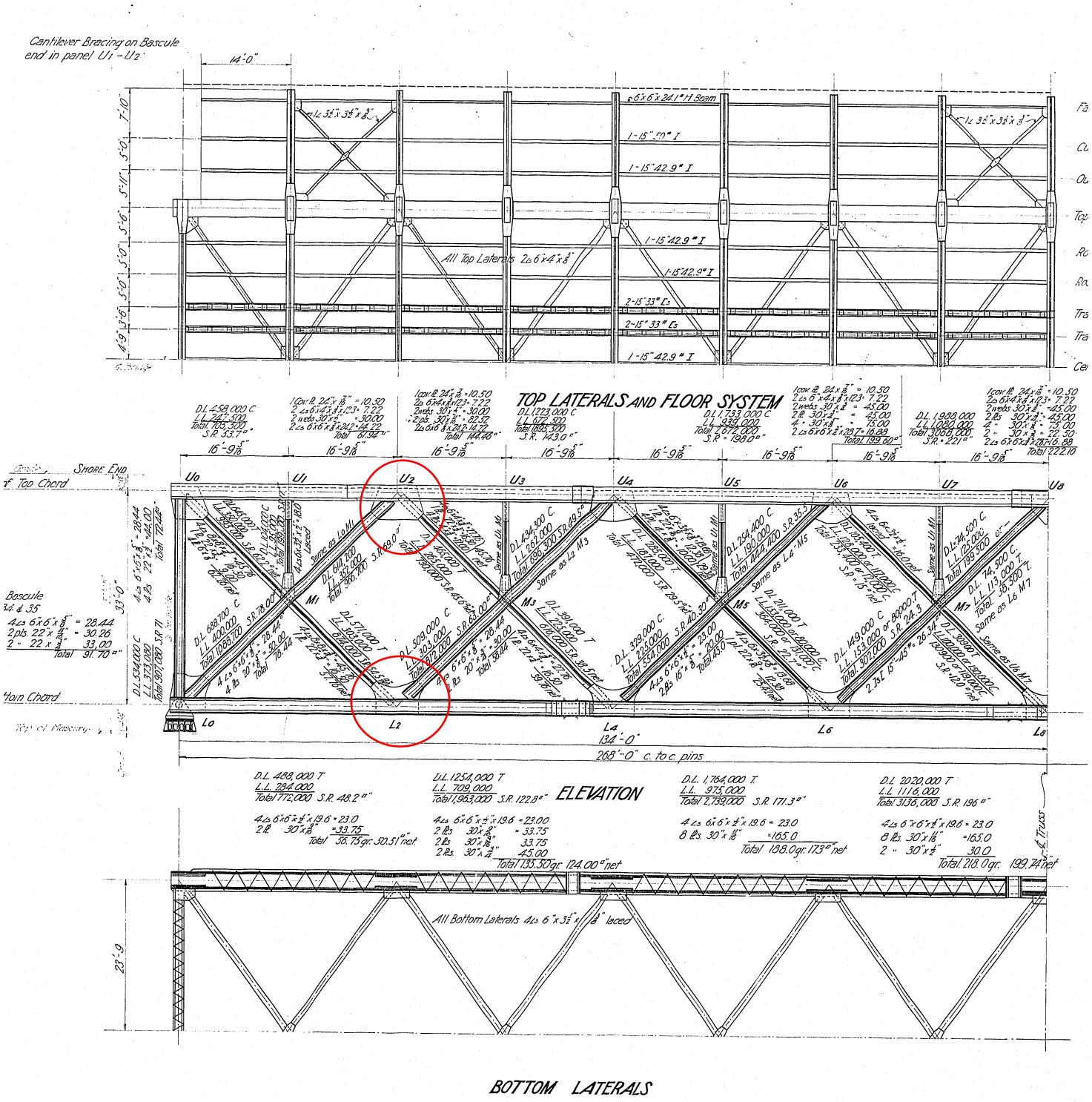


Figure BU208: Burnside Bridge Fixed Spans - Truss System Connections as Shown

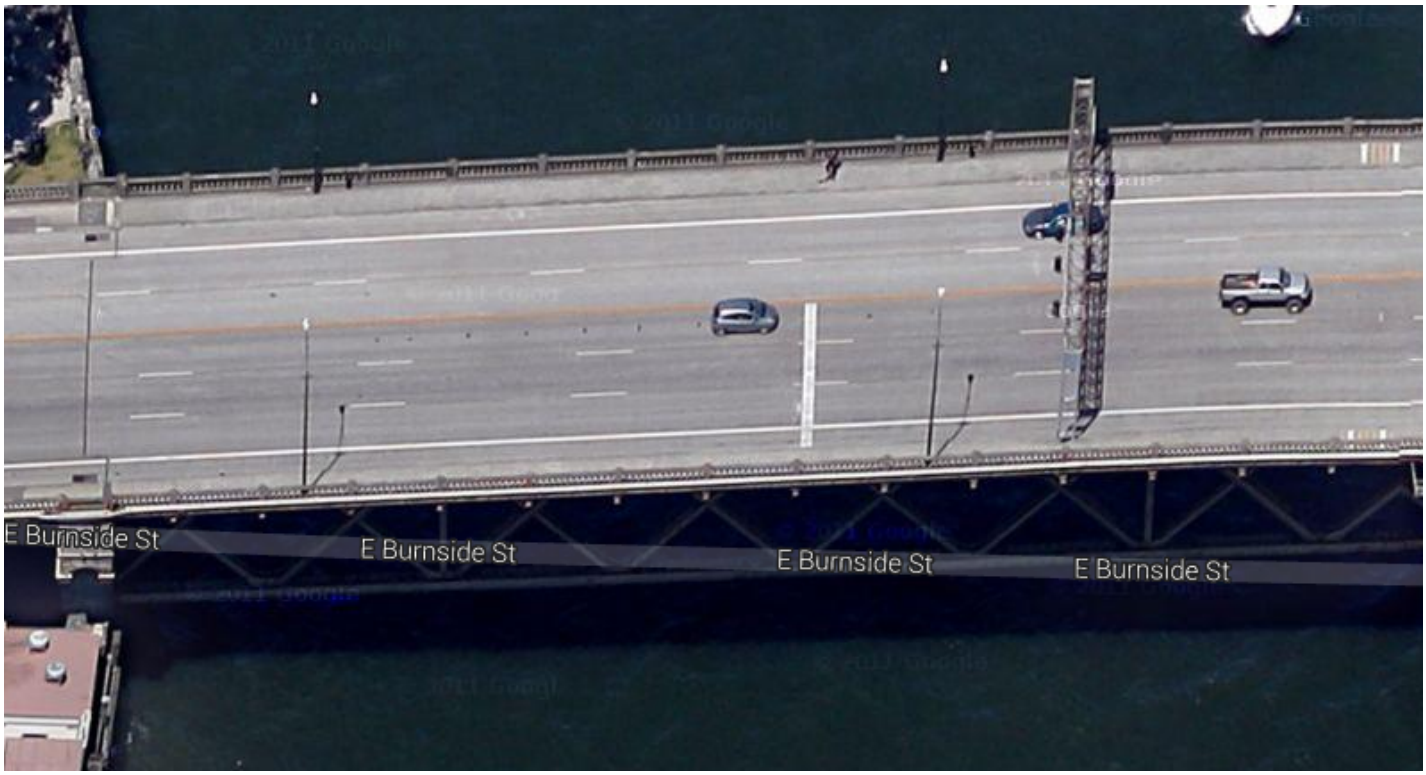
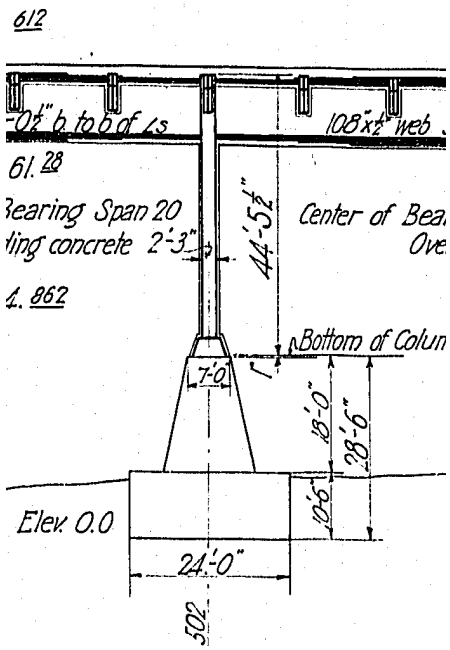
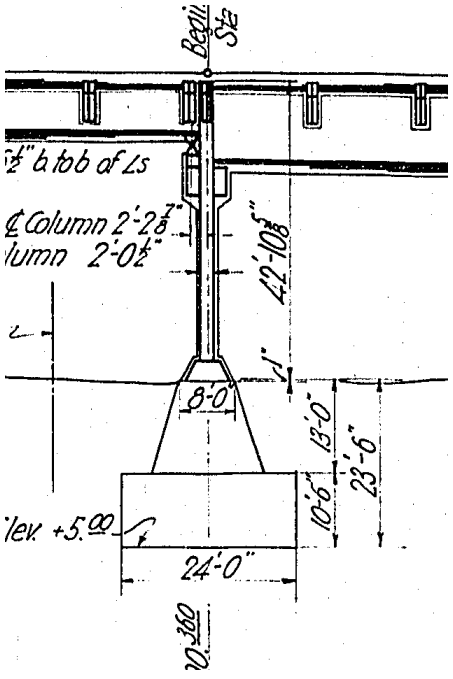


Figure BU209: Burnside Bridge Fixed Spans Aerial View - showing overhead structure and lightings on West Fixed Span (similar on East Fixed Span)



Bent 21 Elevation



Bent 24 Elevation

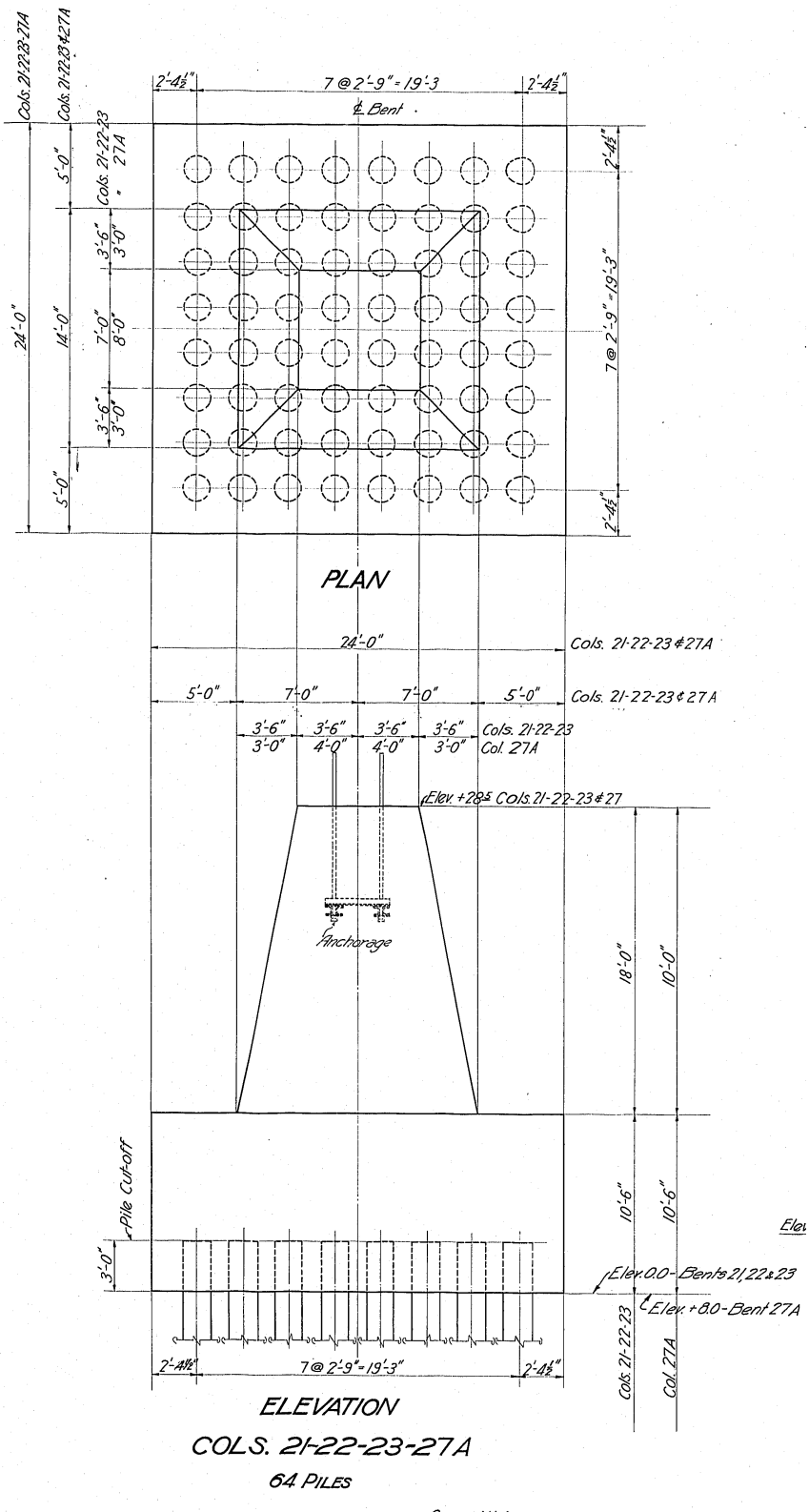
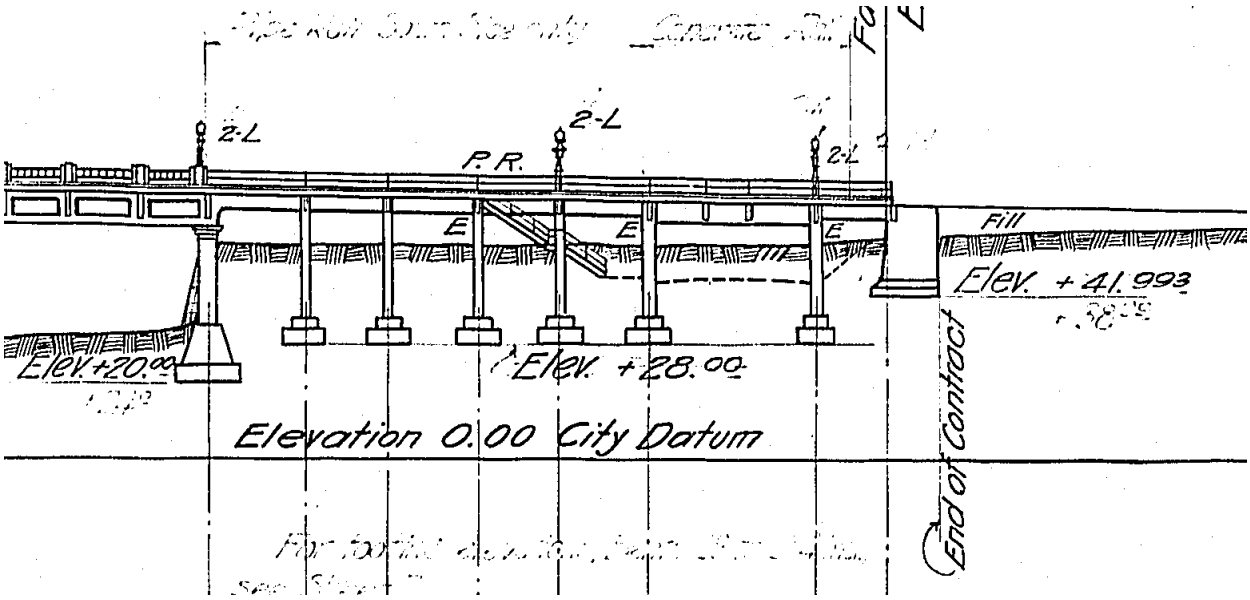


Figure BU401: Burnside Bridge East Approach Bents 21-27, Unreinforced pile cap with timber pile. Bents 21-23 not buried. Bents 24 to 27 buried 20ft in ground.



Bent 28-34 Elevations

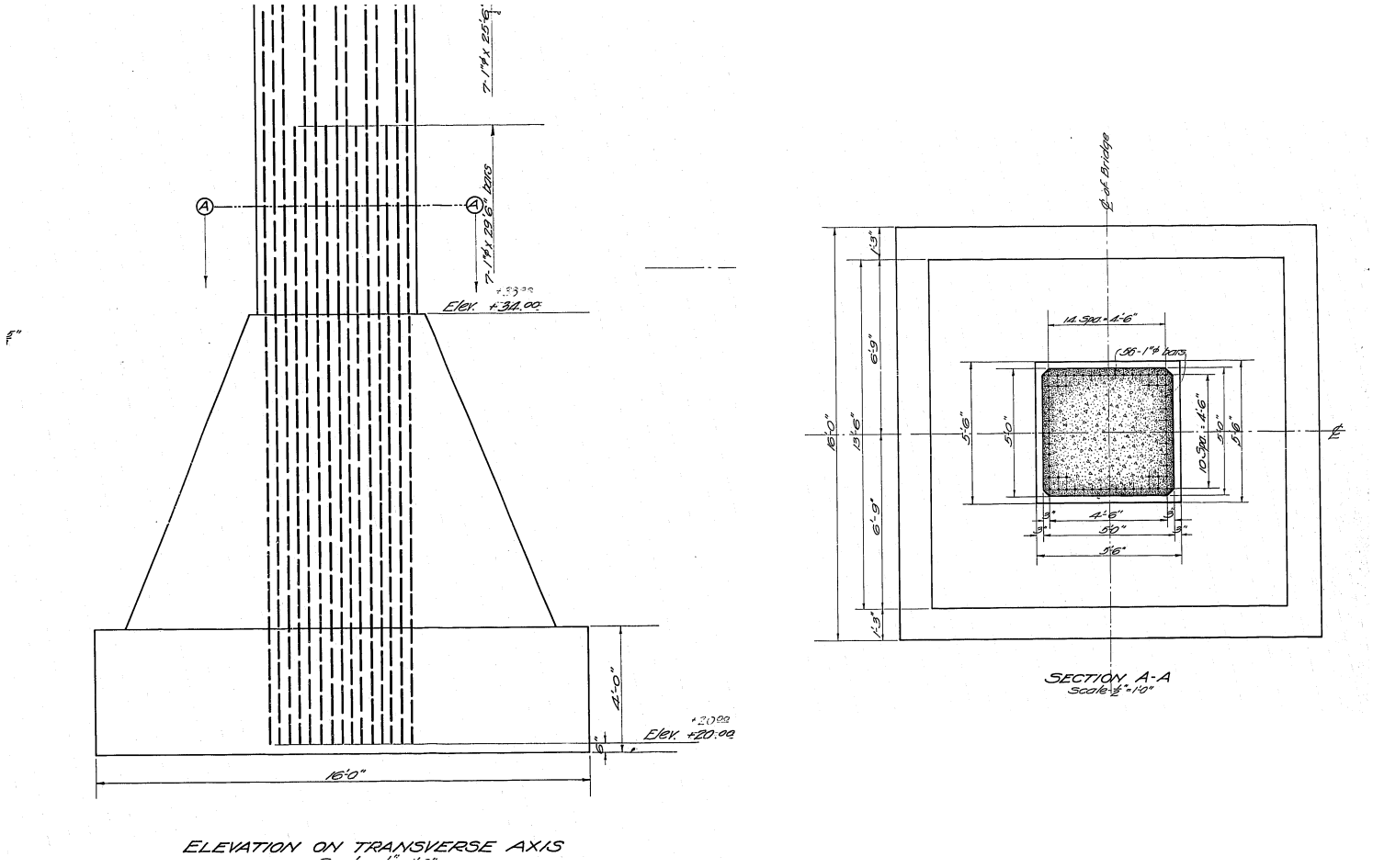
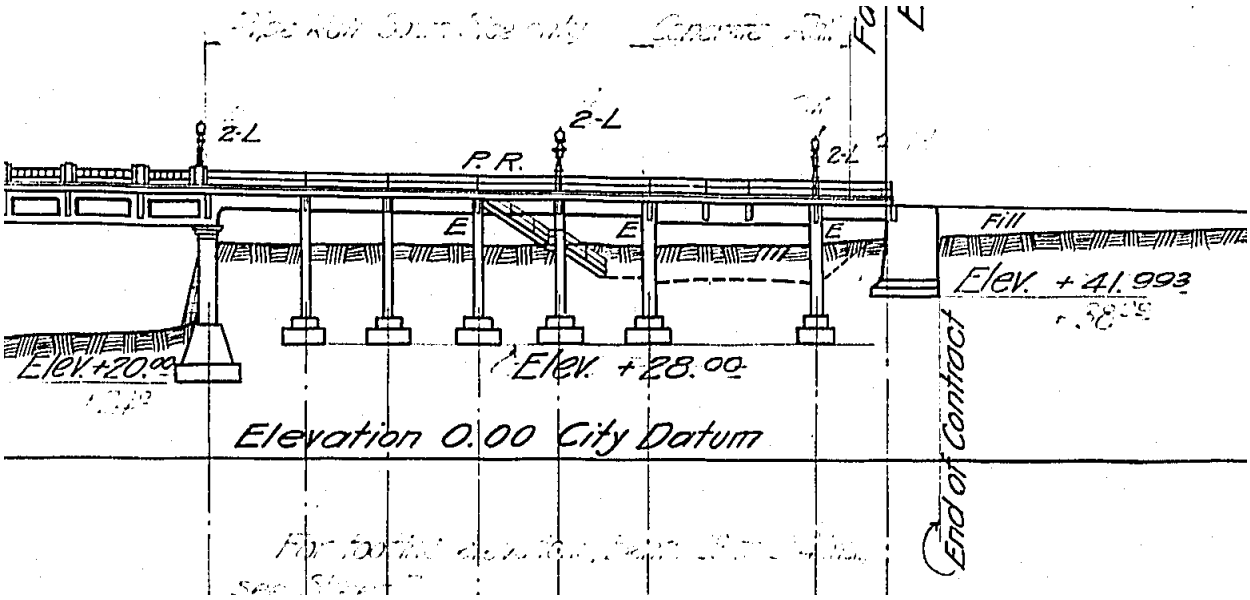
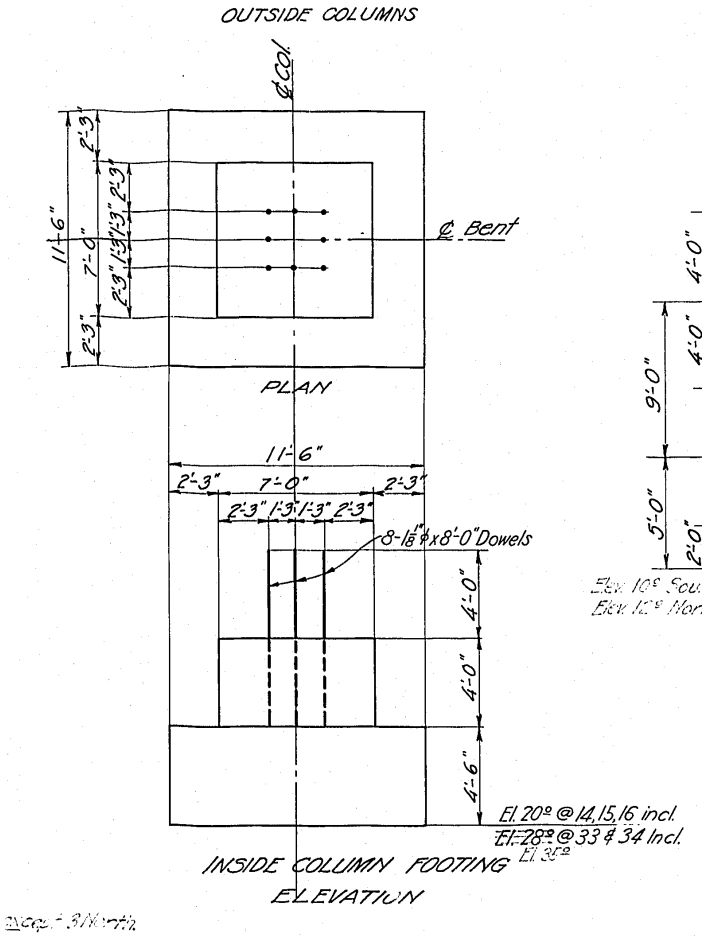


Figure BU402: Bent 28 Spread footing and column connection to base

BURNSIDE FIGURES



Bent 28-34 Elevations



BENTS 14, 15, 16, 33, 34

Figure BU403: Bents 29-34 Spread footing and column connection to base

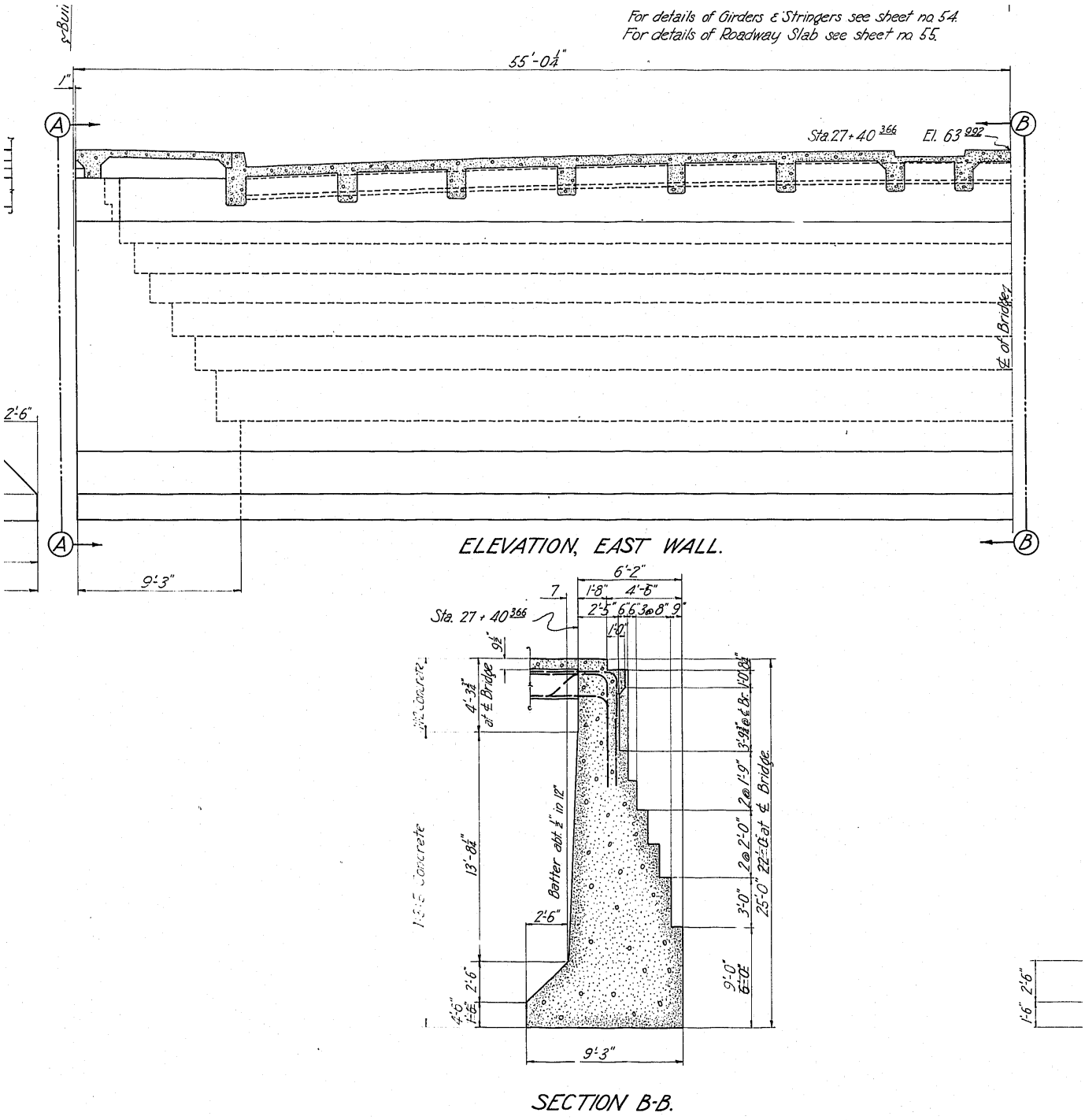


Figure BU404: Bent 35 East Approach Abutment

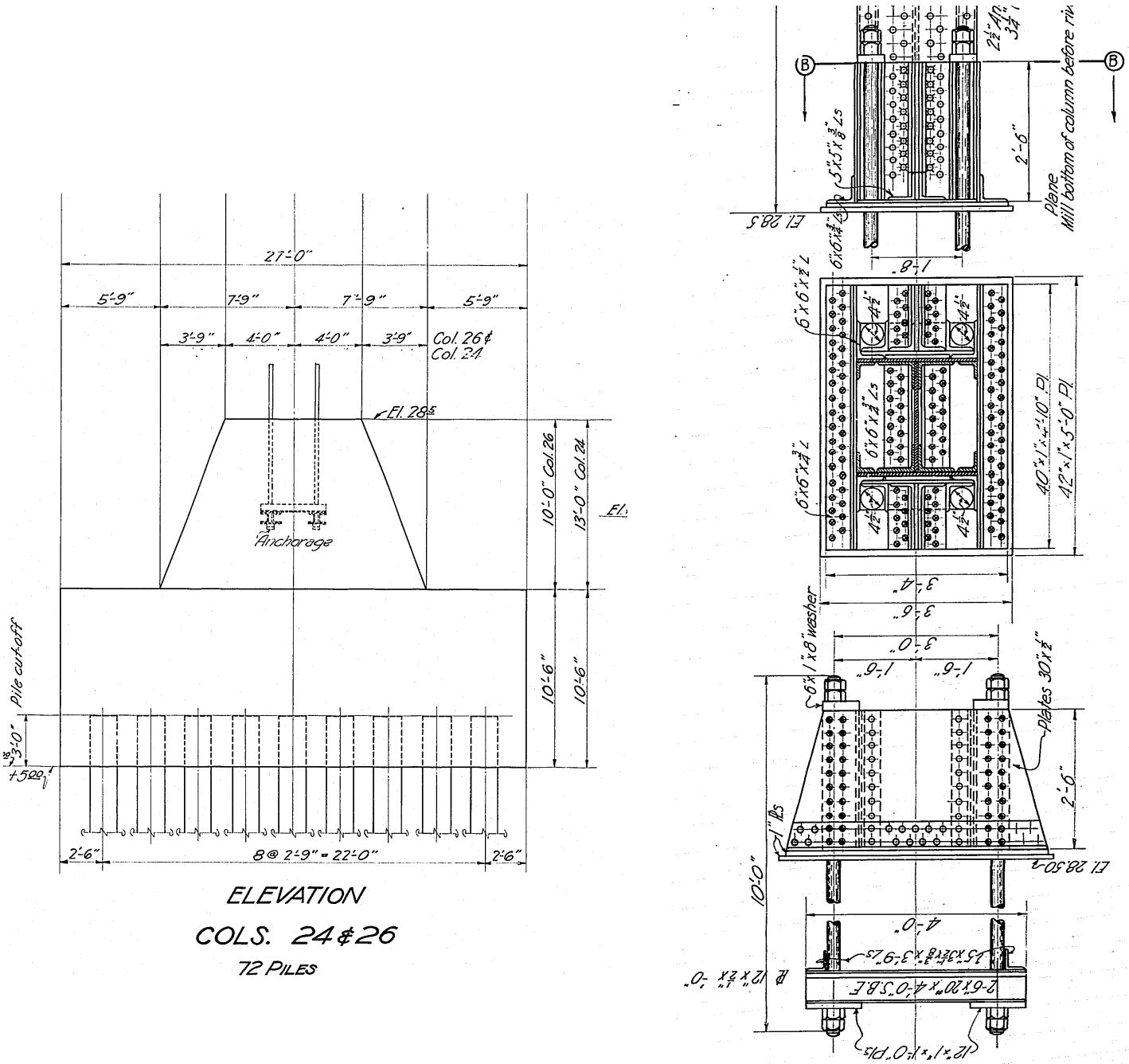


Figure BU405: Connections - Bents to Below Ground Foundations

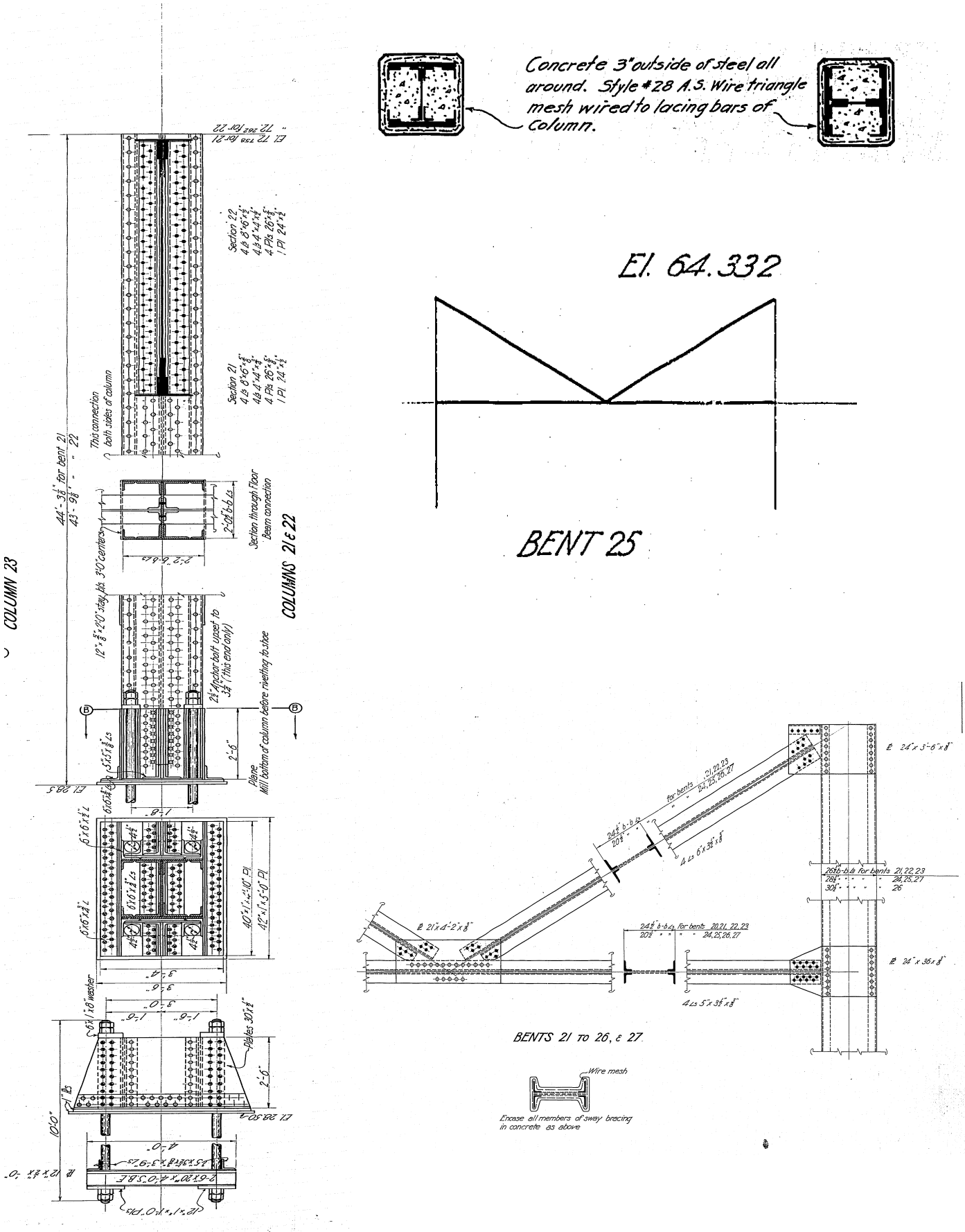
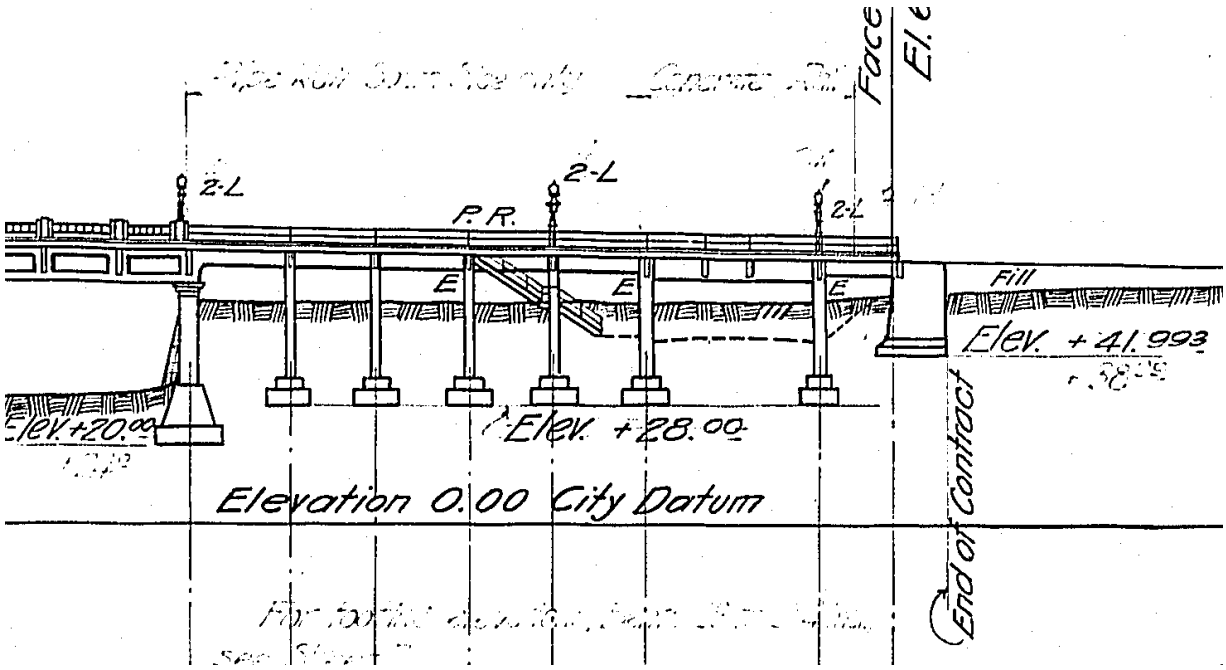
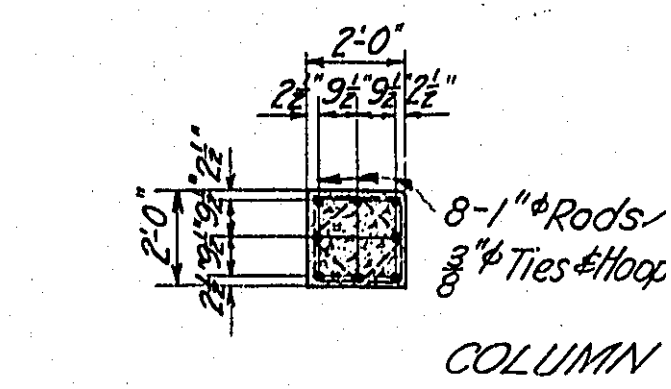


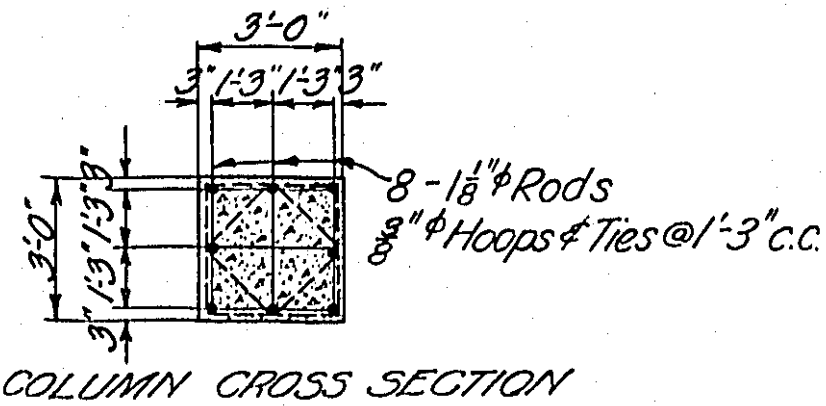
Figure BU406: Concrete encased steel column pairs with bracing





COLUMN

BENTS 2, 5 TO 13, & 29-32 INC



COLUMN CROSS SECTION

Figure BU407: Bents 29-34 Concrete columns

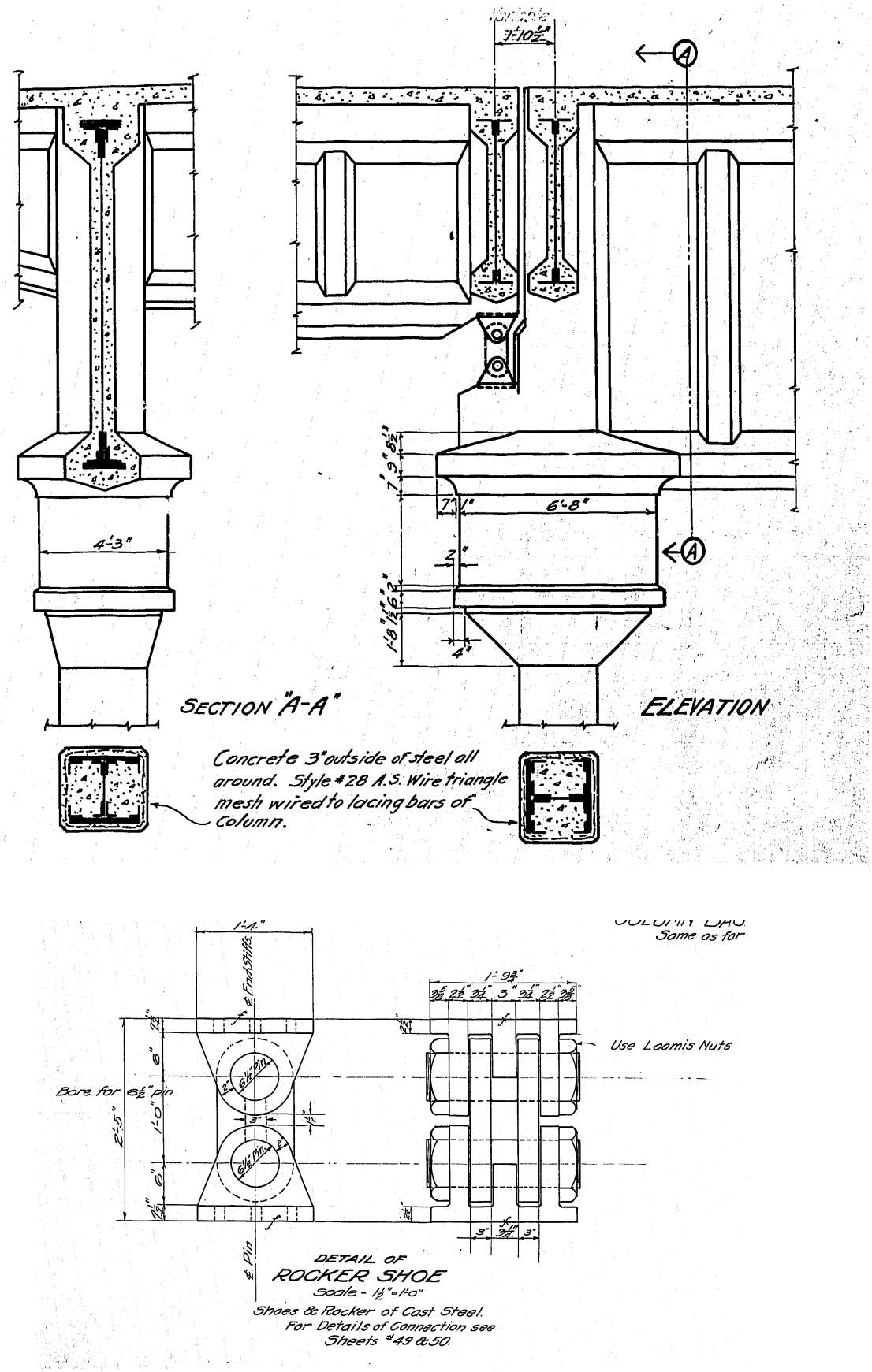


Figure BU408: Super to sub fixed condition and rocker bearing

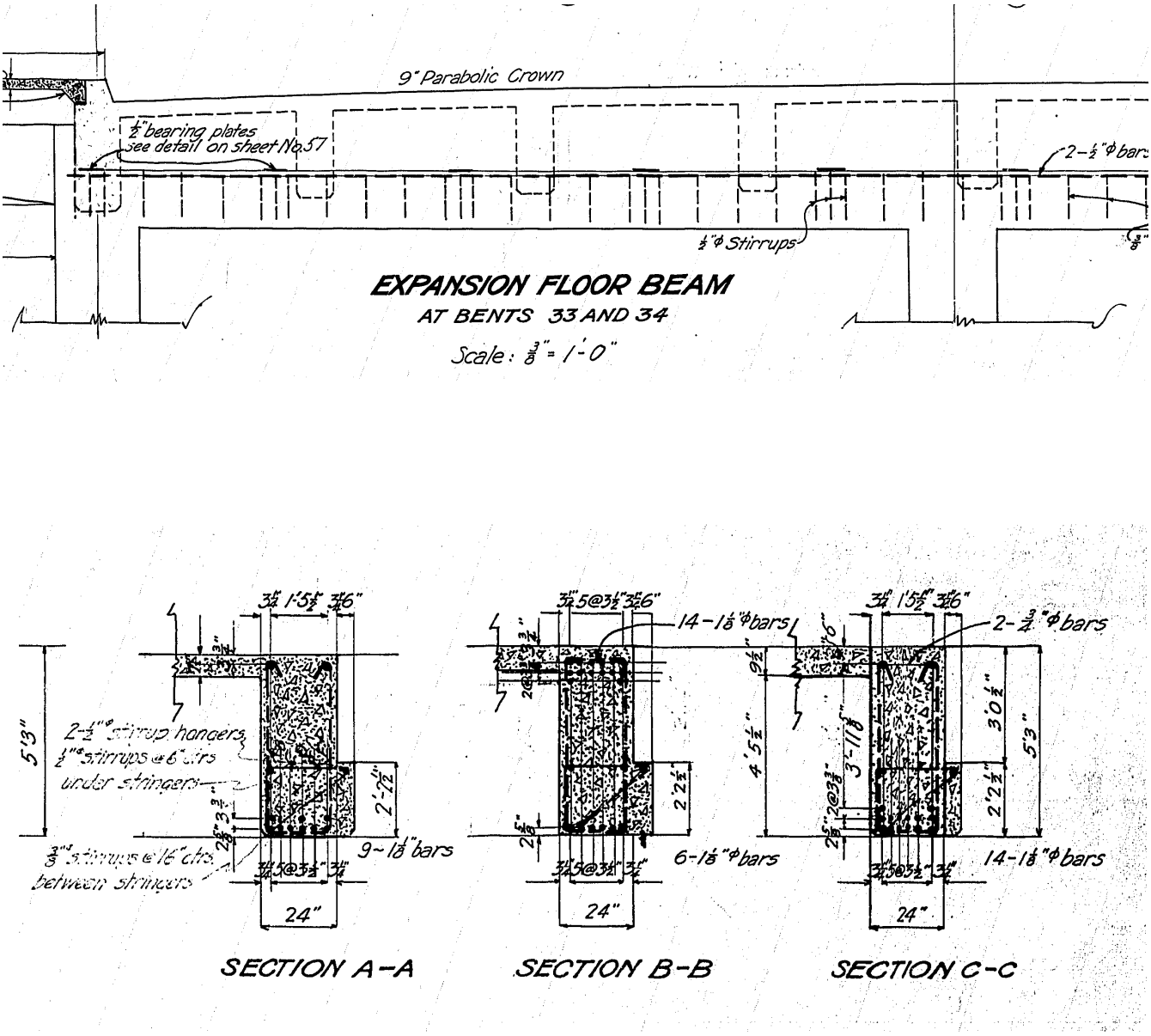


Figure BU409: Bents 31, 33, and 34 Expansion Seats

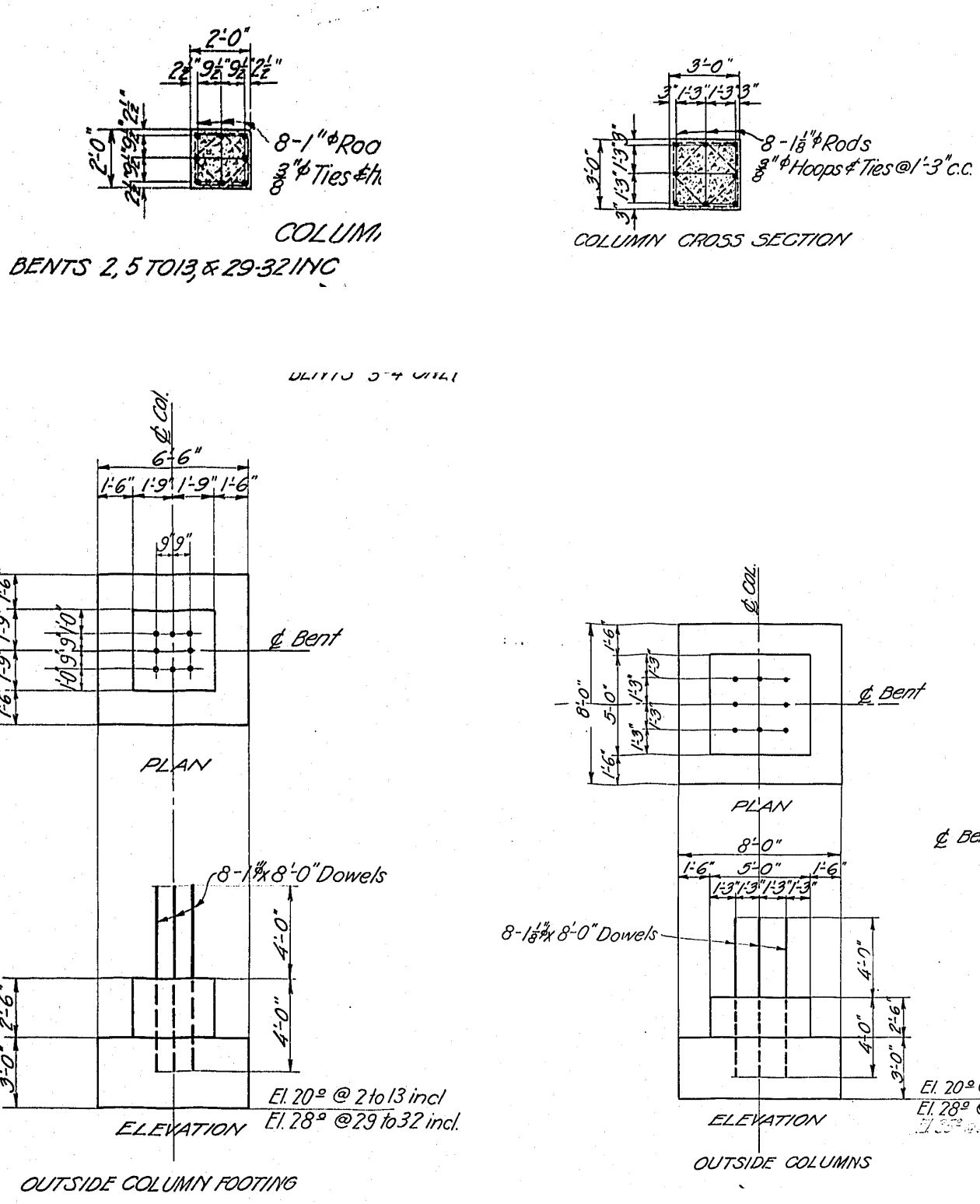
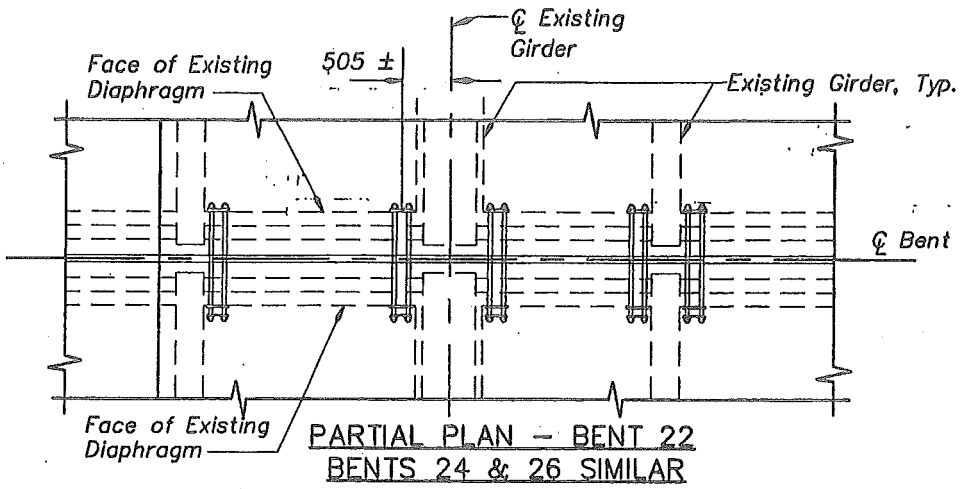


Figure BU410: RCDG to column connection with dowels



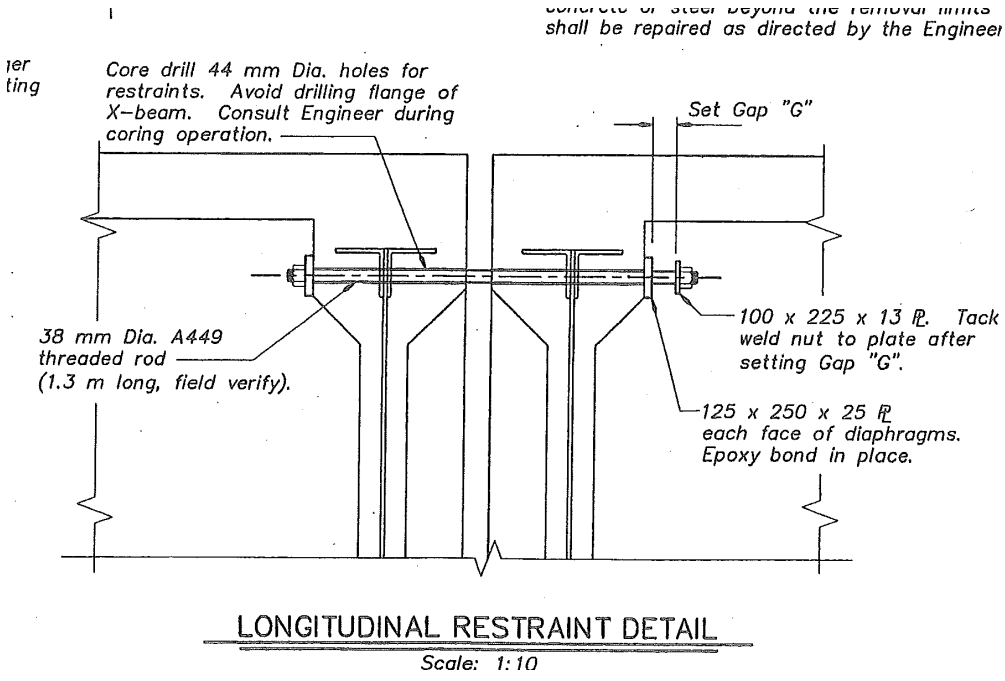
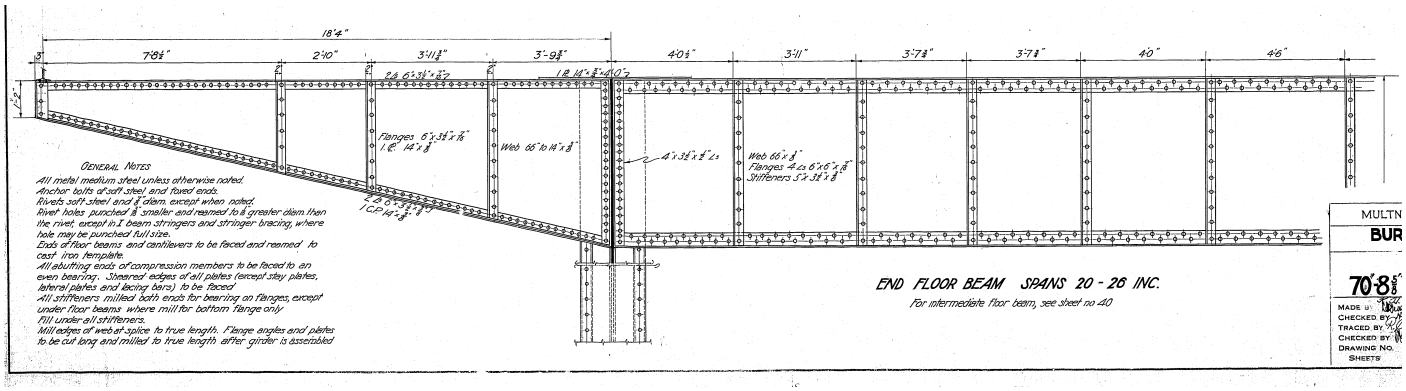
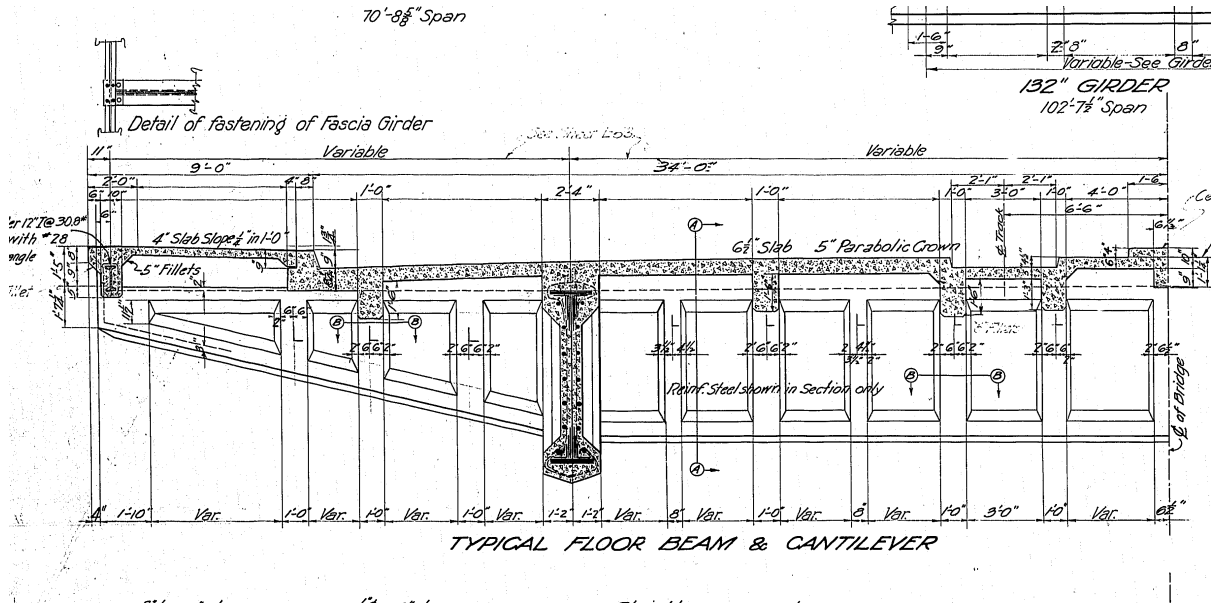


Figure BU411: Longitudinal Restraints at Exp. Joints





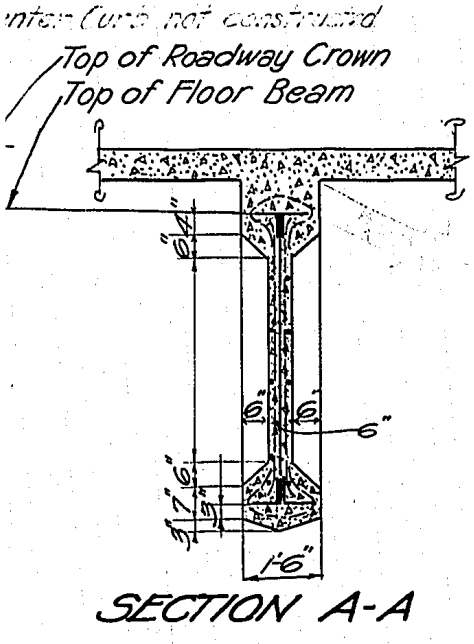


Figure BU412: Concrete encased steel floorbeam

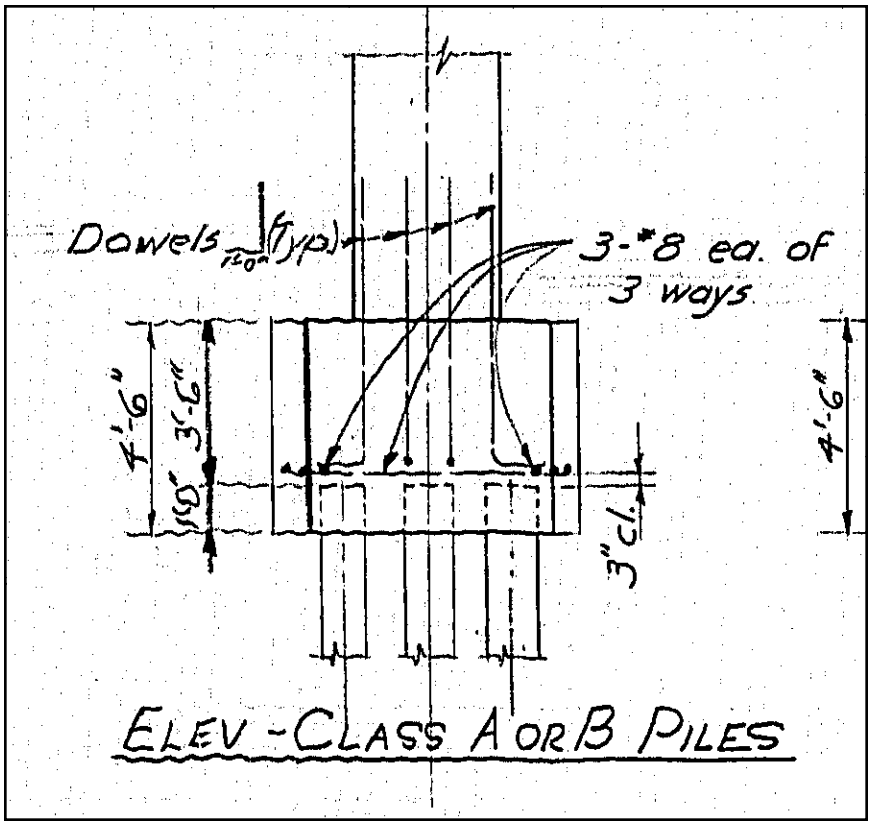


Figure MR001: Footing rebar detailing and pile head embedment

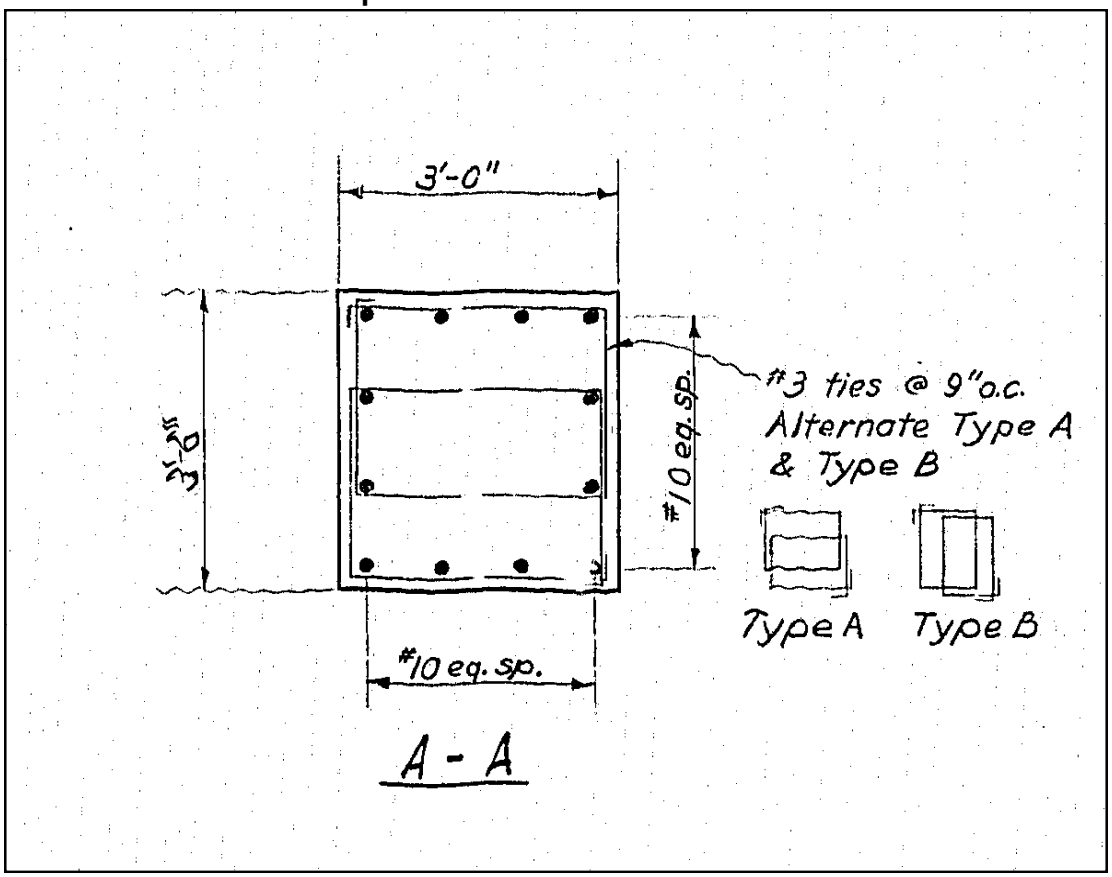


Figure MR002: Column flexural and shear reinforcement

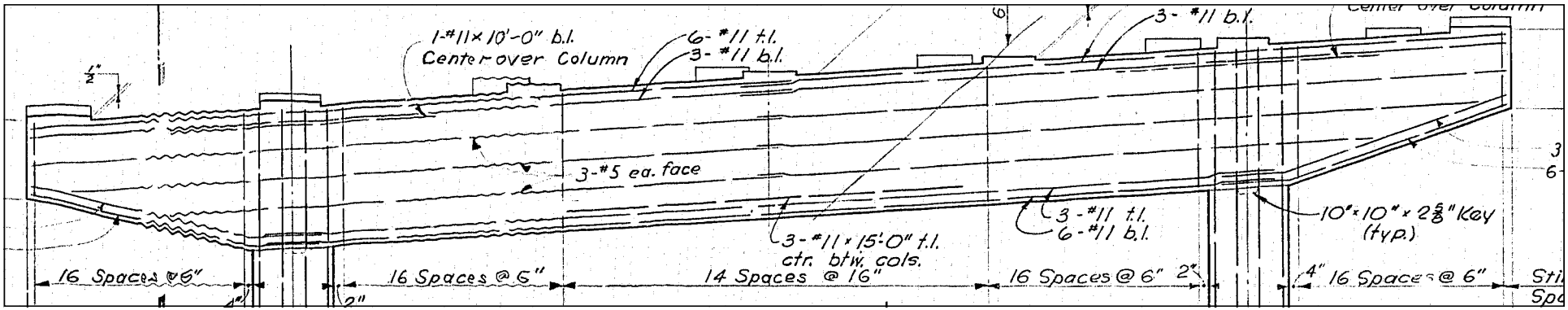


Figure MR003: Bent cap rebar and column joint detailing

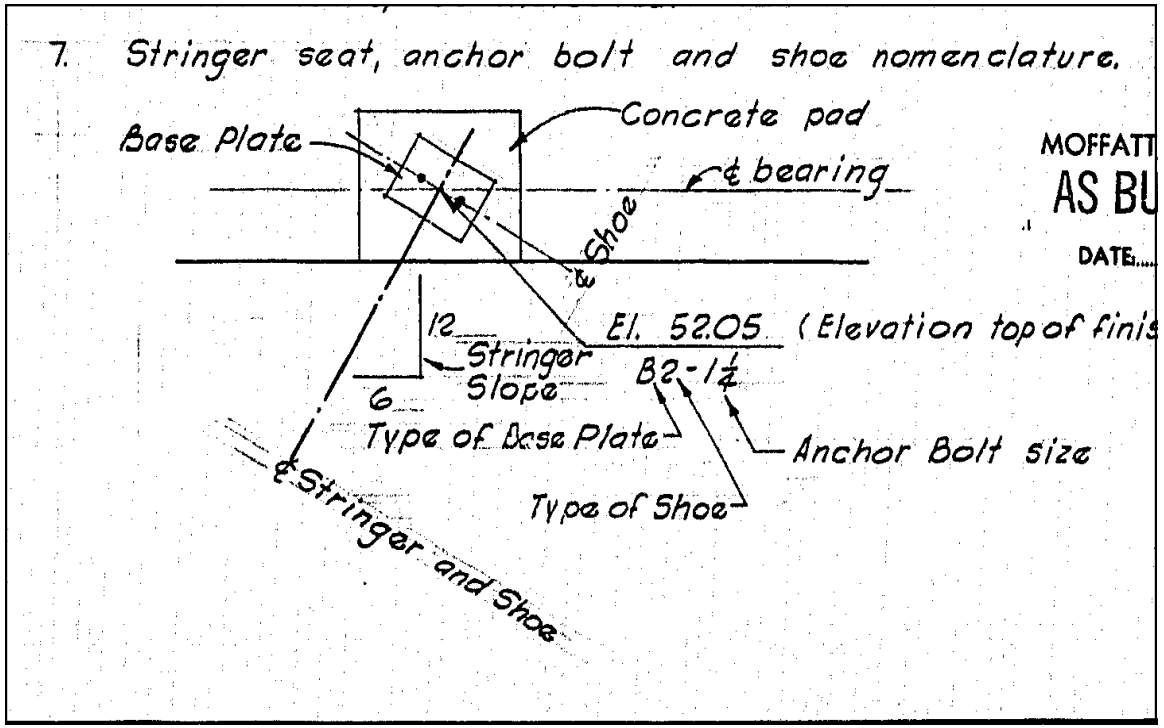


Figure MR004: Stringer shoe

MORRISON FIGURES

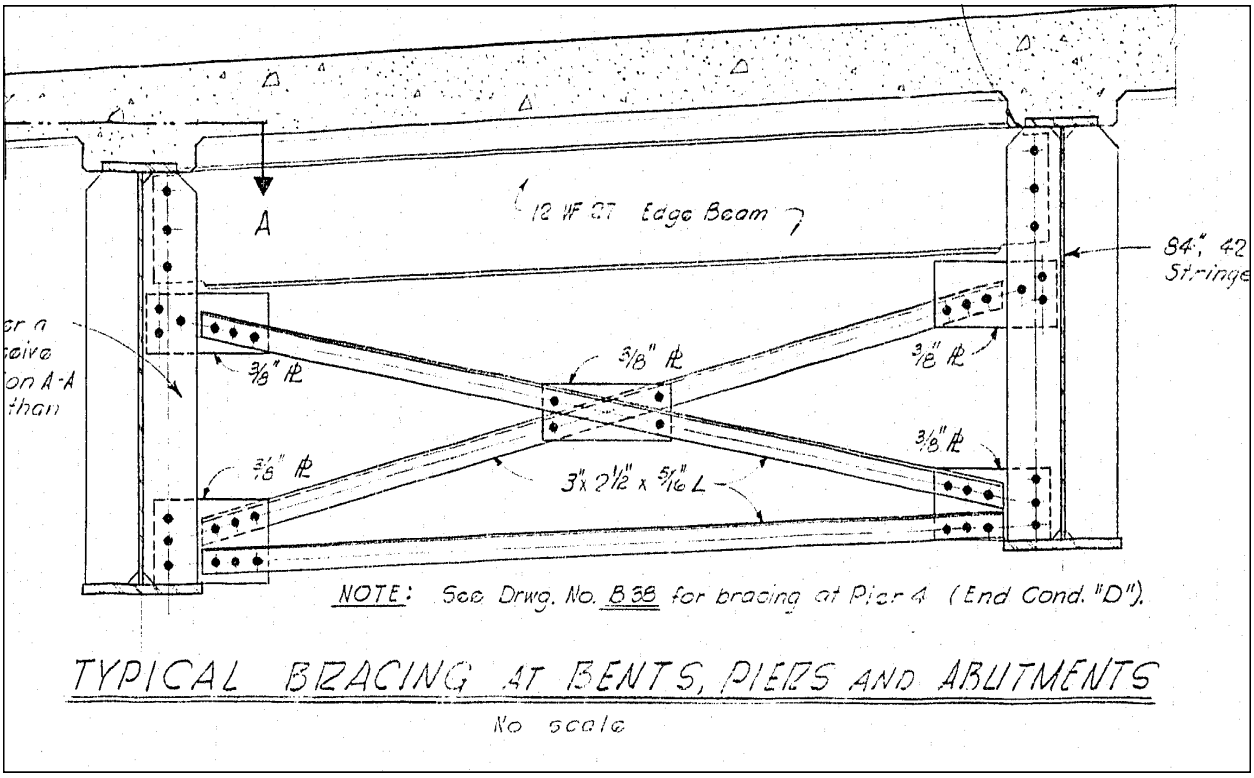


Figure MR005: Superstructure cross frame

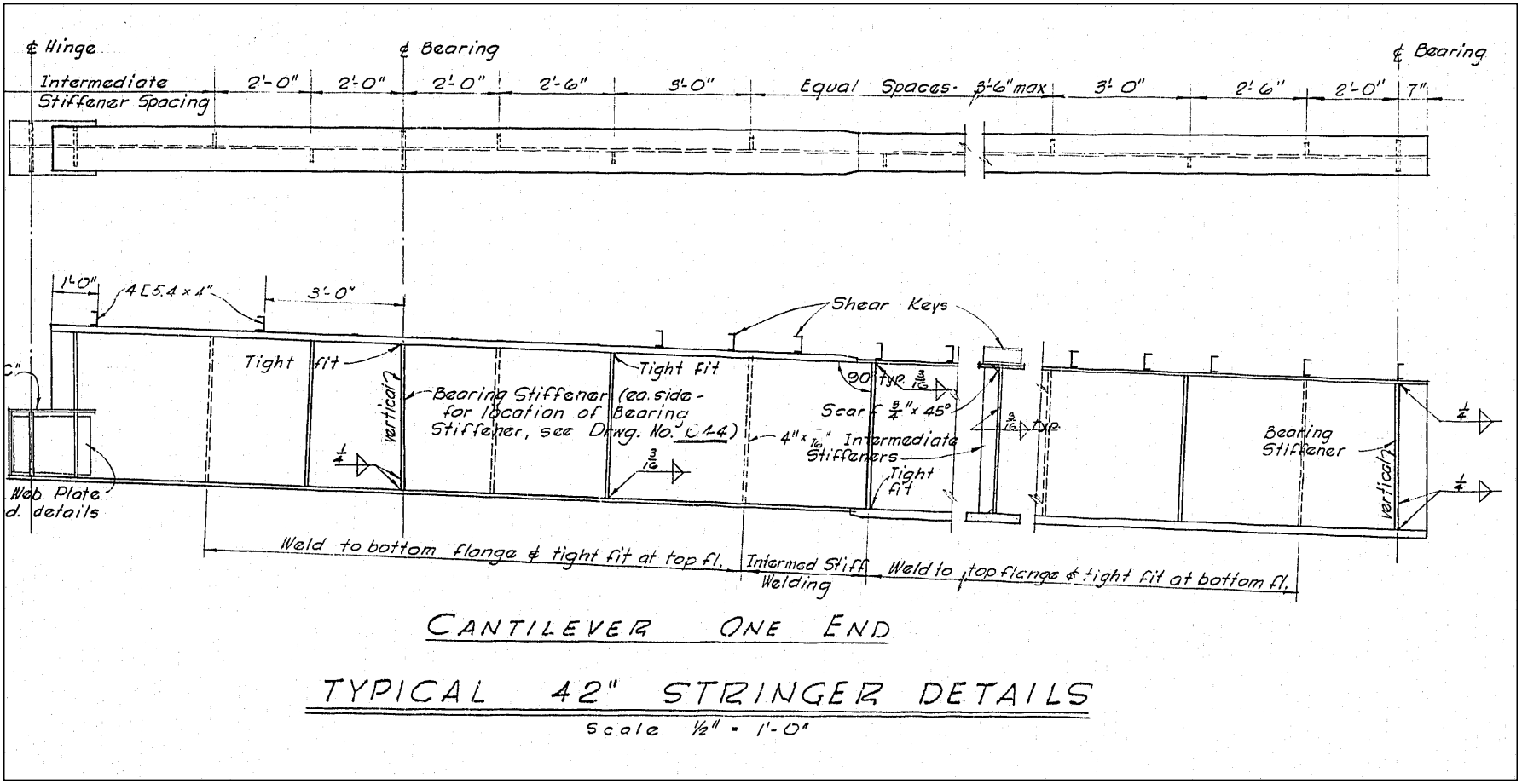


Figure MR006: Superstructure girder web stiffener

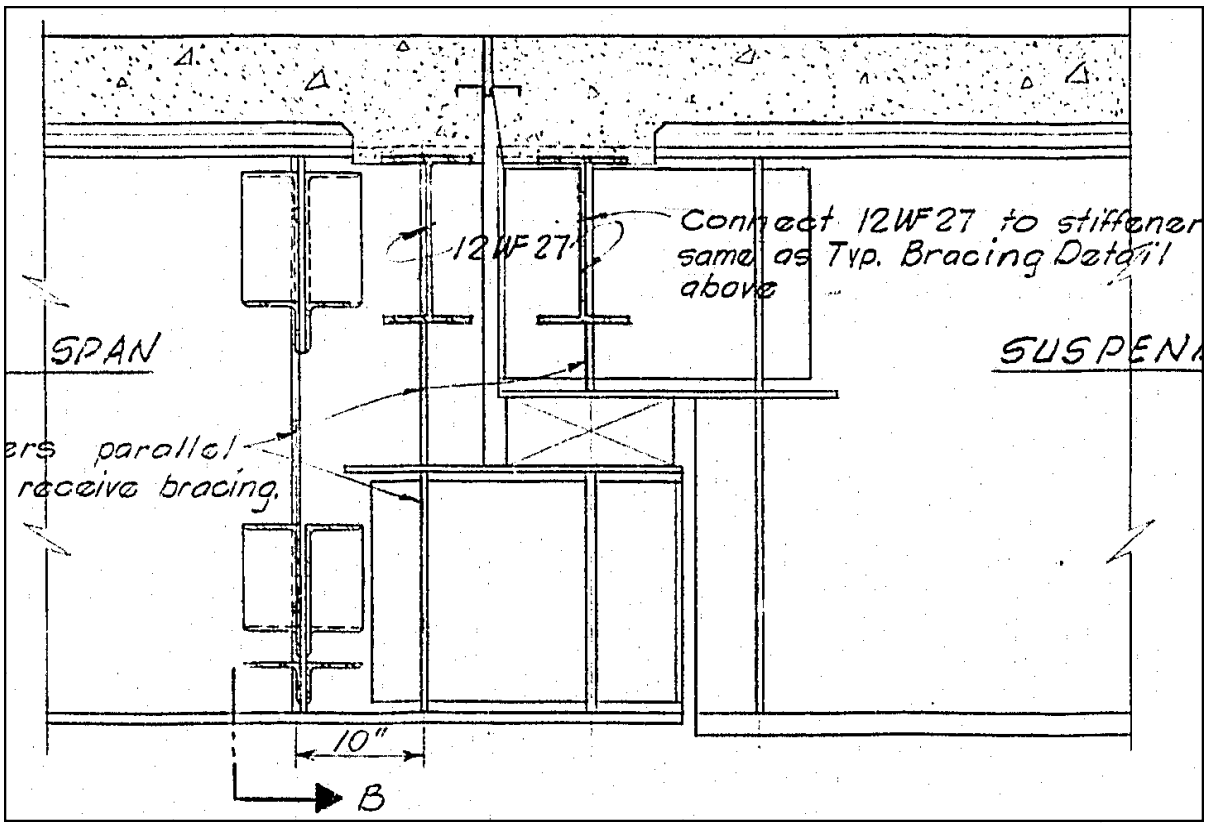


Figure MR007: In span hinge

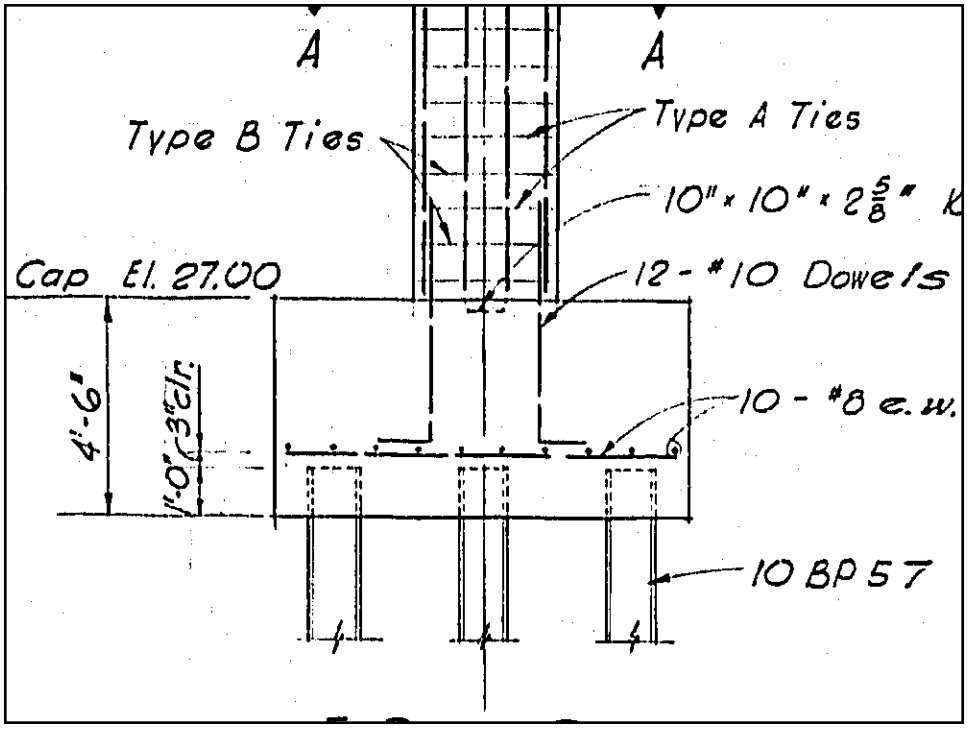


Figure MR008: Footing rebar detailing and pile head embedment

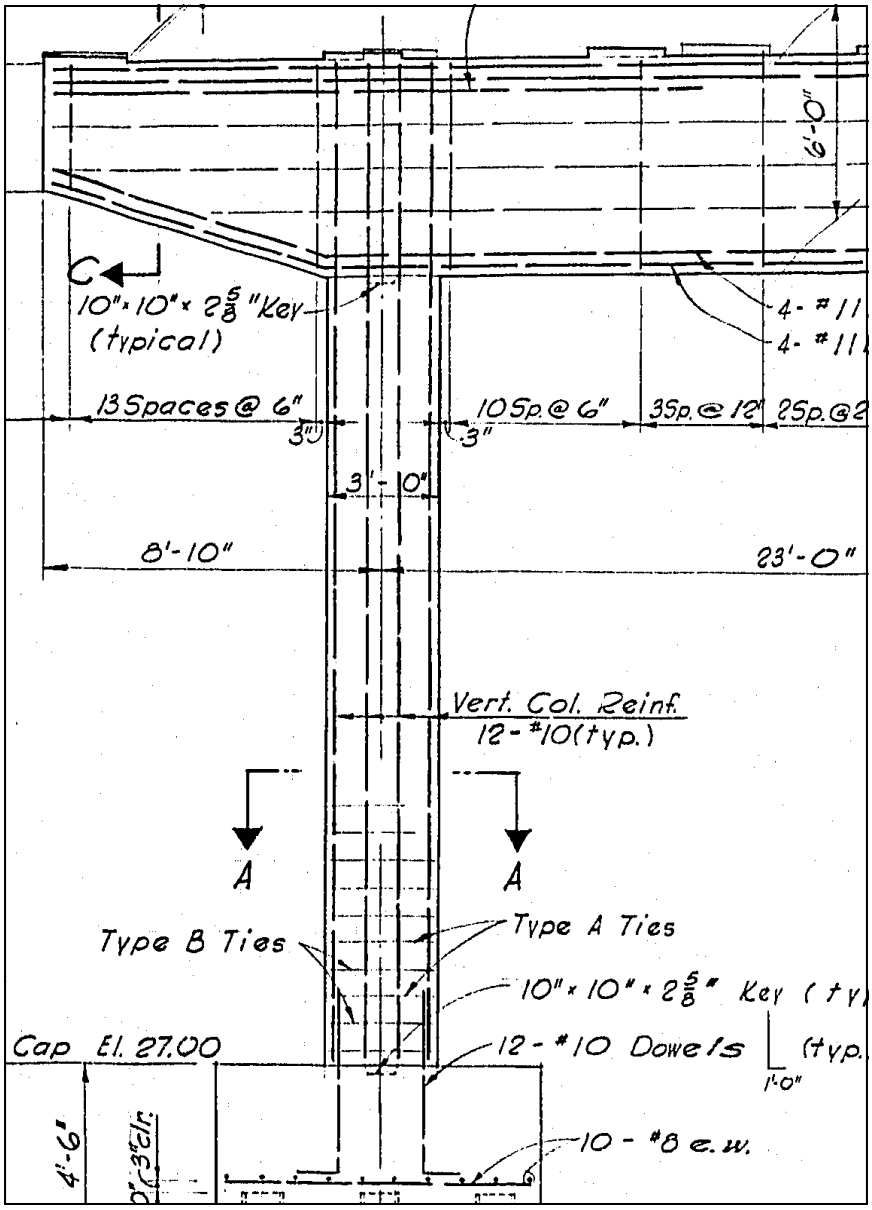


Figure MR009: Bent cap rebar and column joint detailing

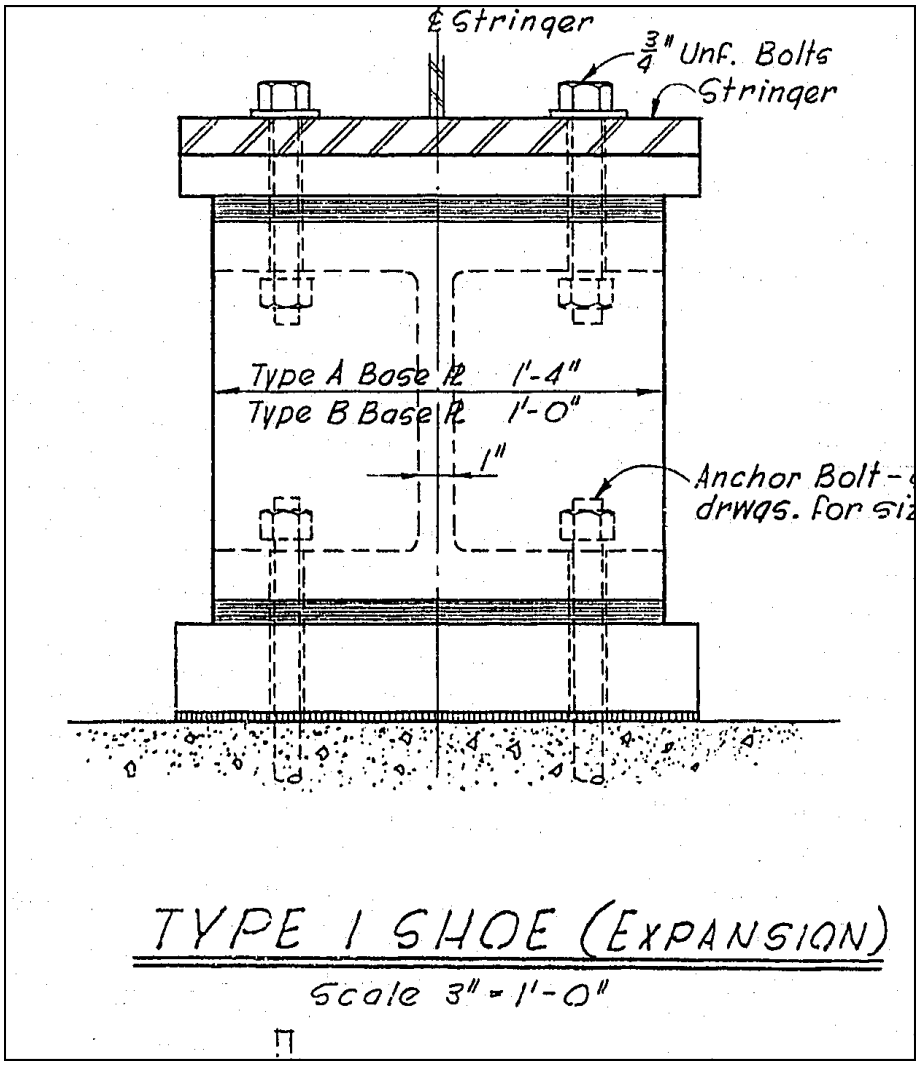


Figure MR010: Superstructure stringer shoe

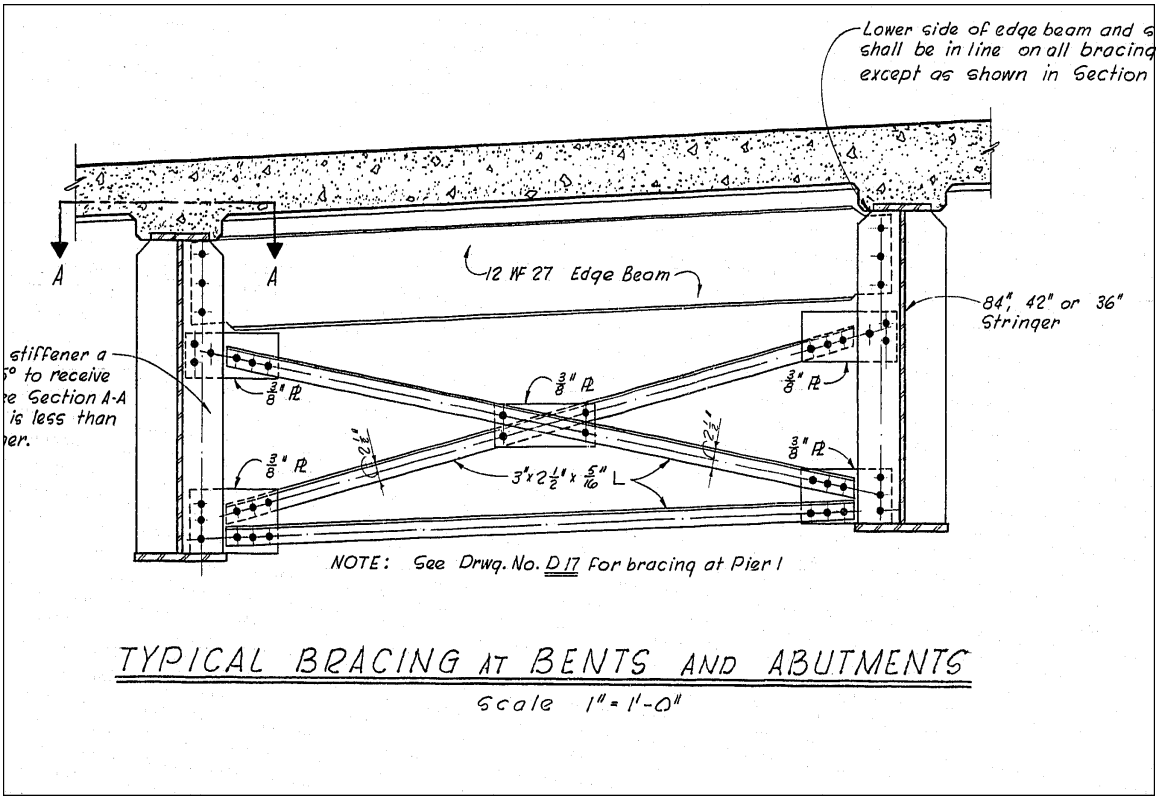


Figure MR011: Superstructure cross frame

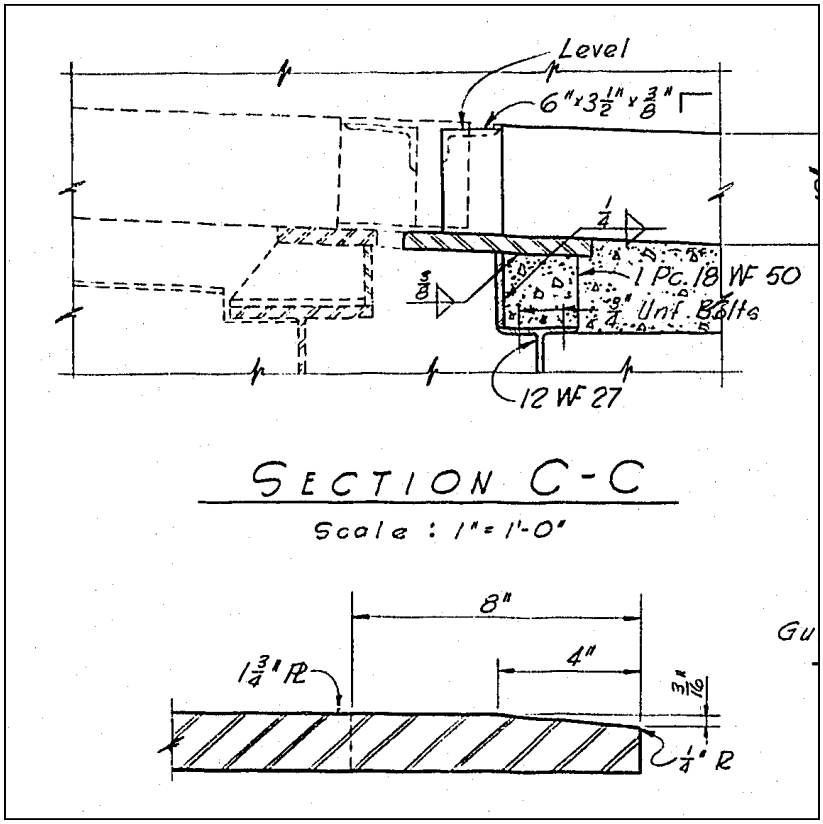


Figure MR012: Expansion joint

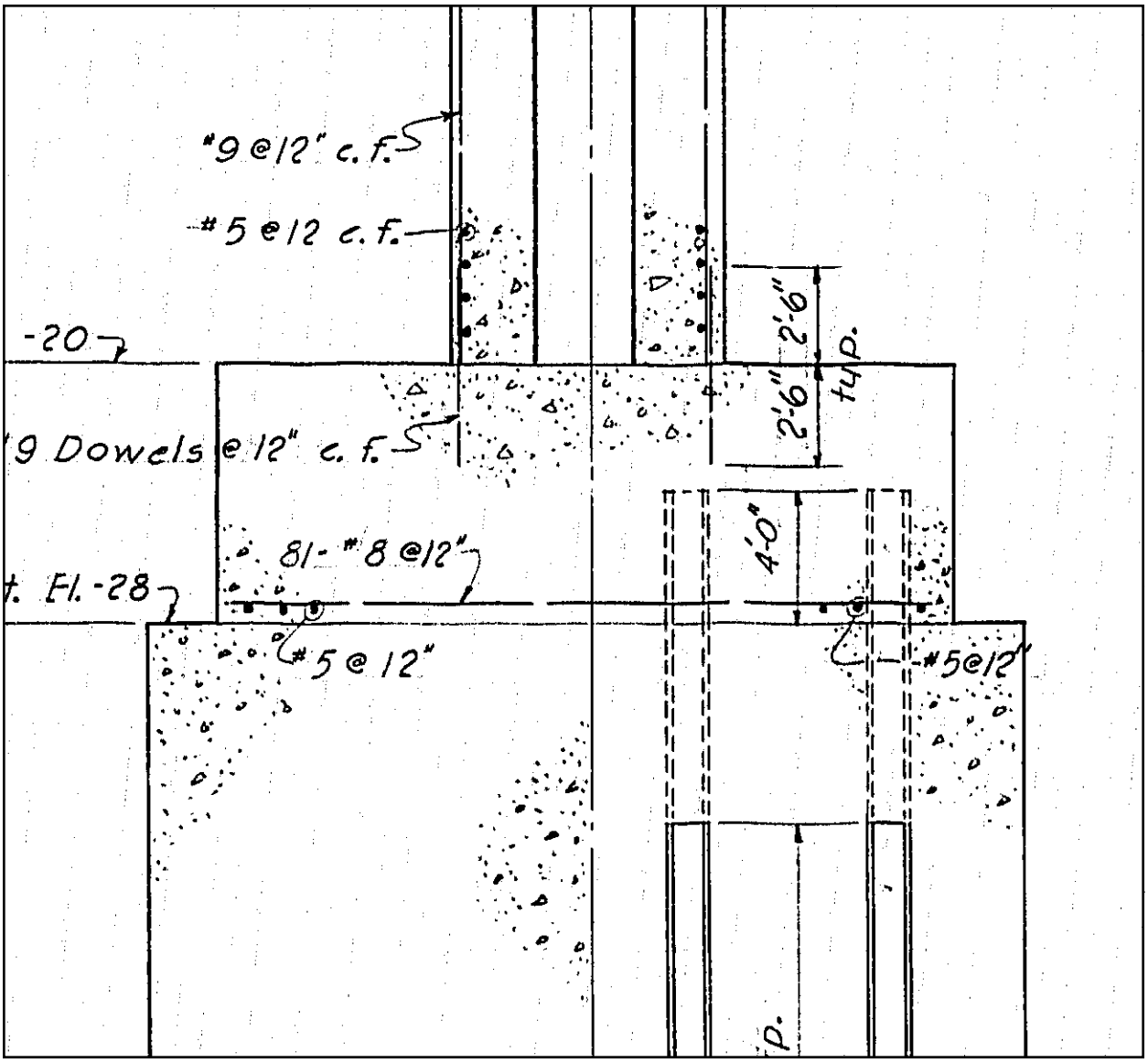


Figure MR014: Footing rebar detailing and pile head embedment

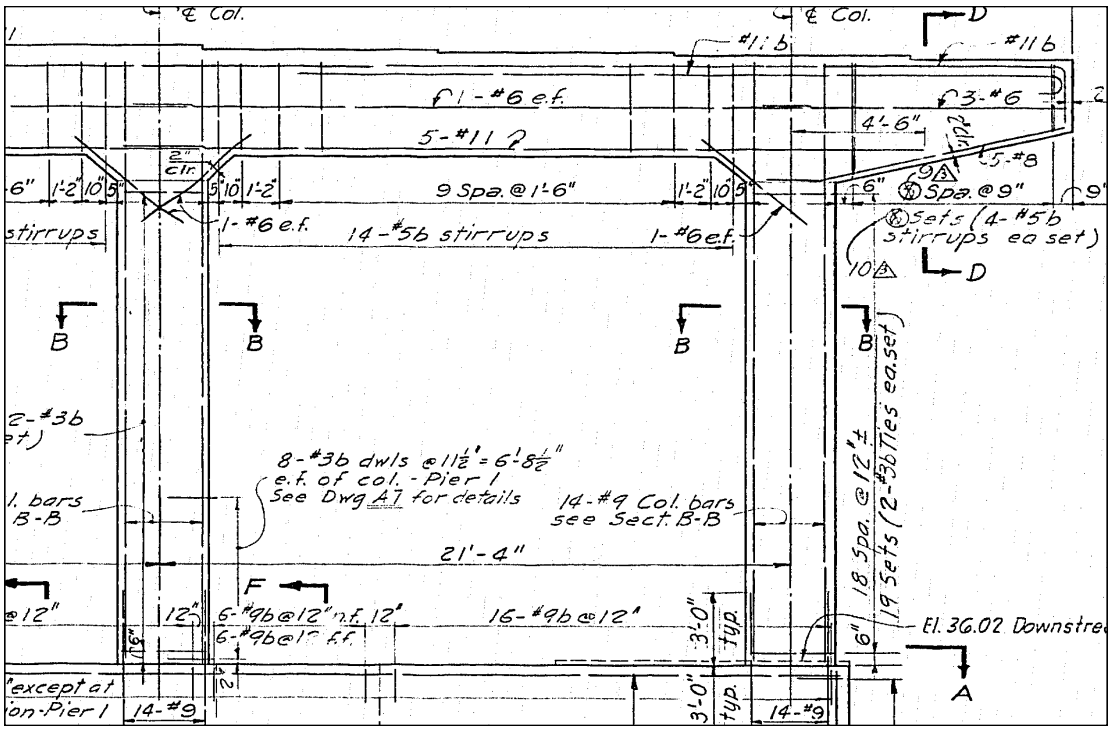


Figure MR015: Column and bent cap rebar detailing

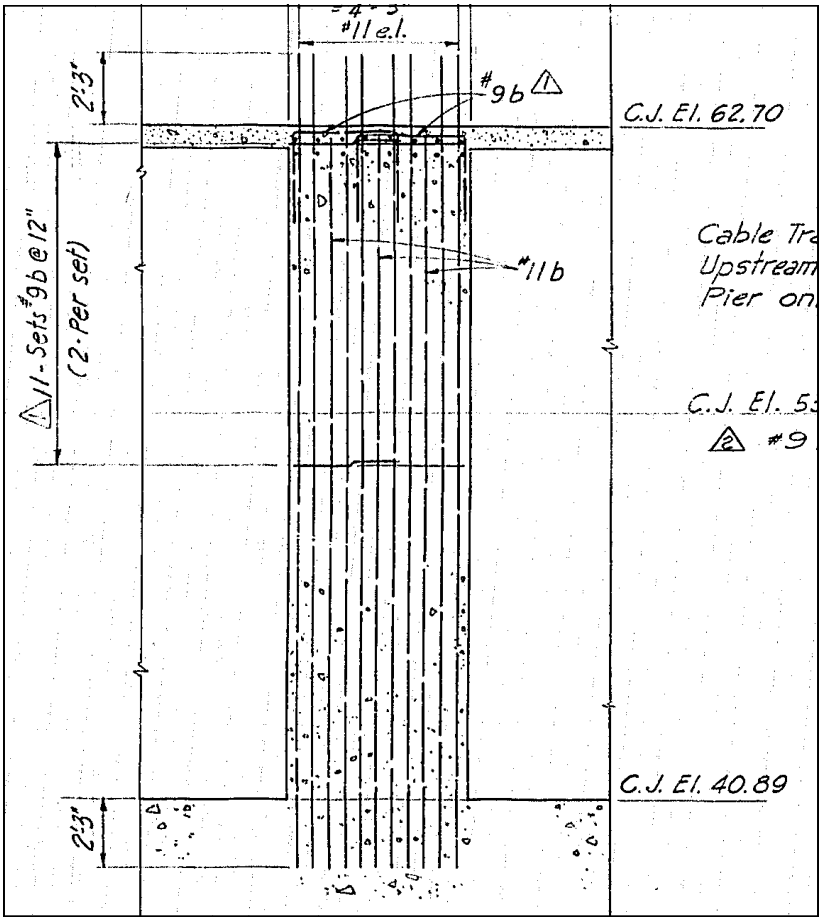


Figure MR016: Trunnion support frame rebar detailing

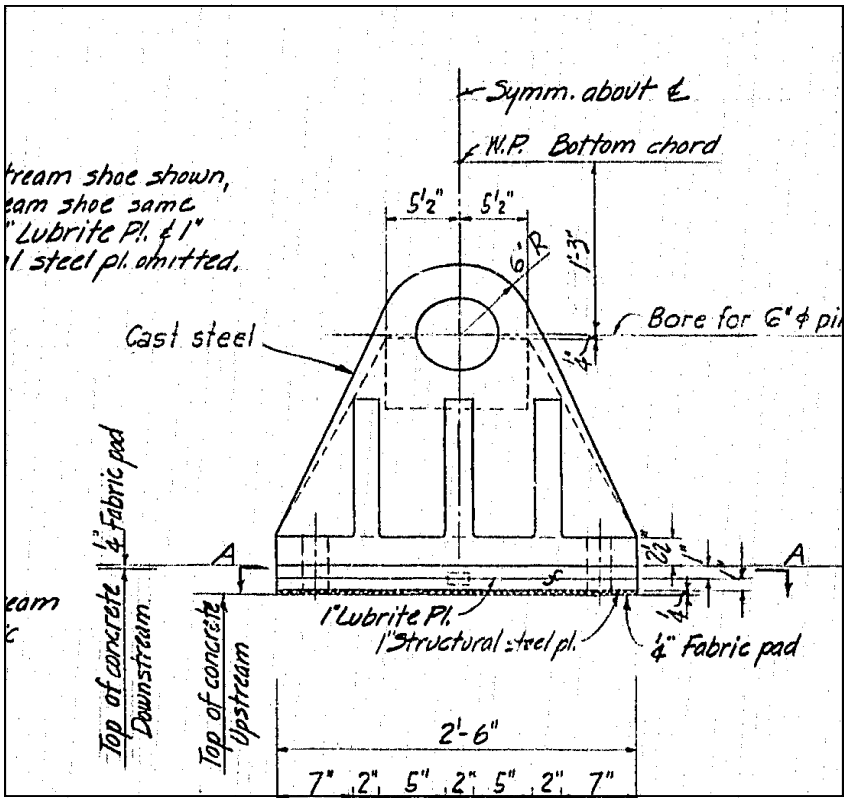


Figure MR017: Fixed span bearing

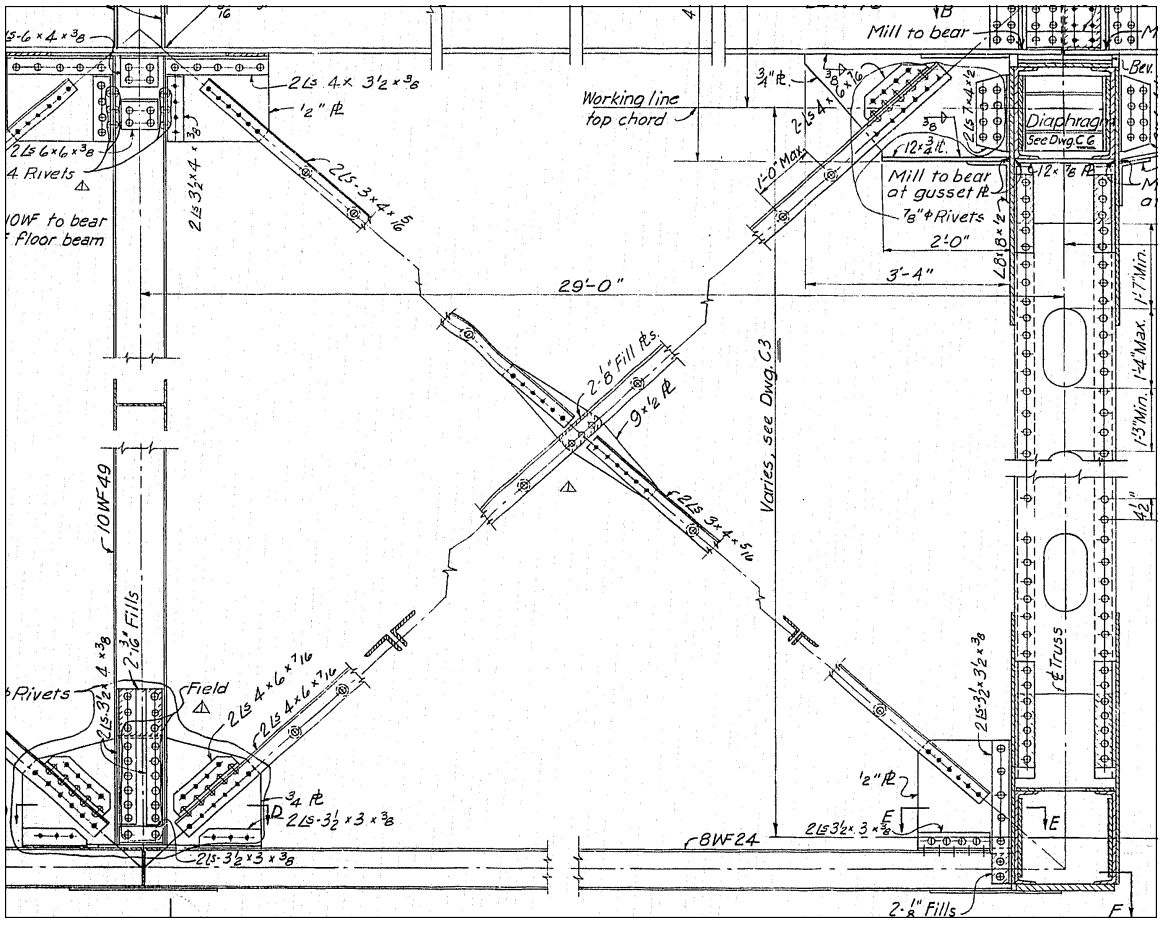


Figure MR018: Superstructure cross frame

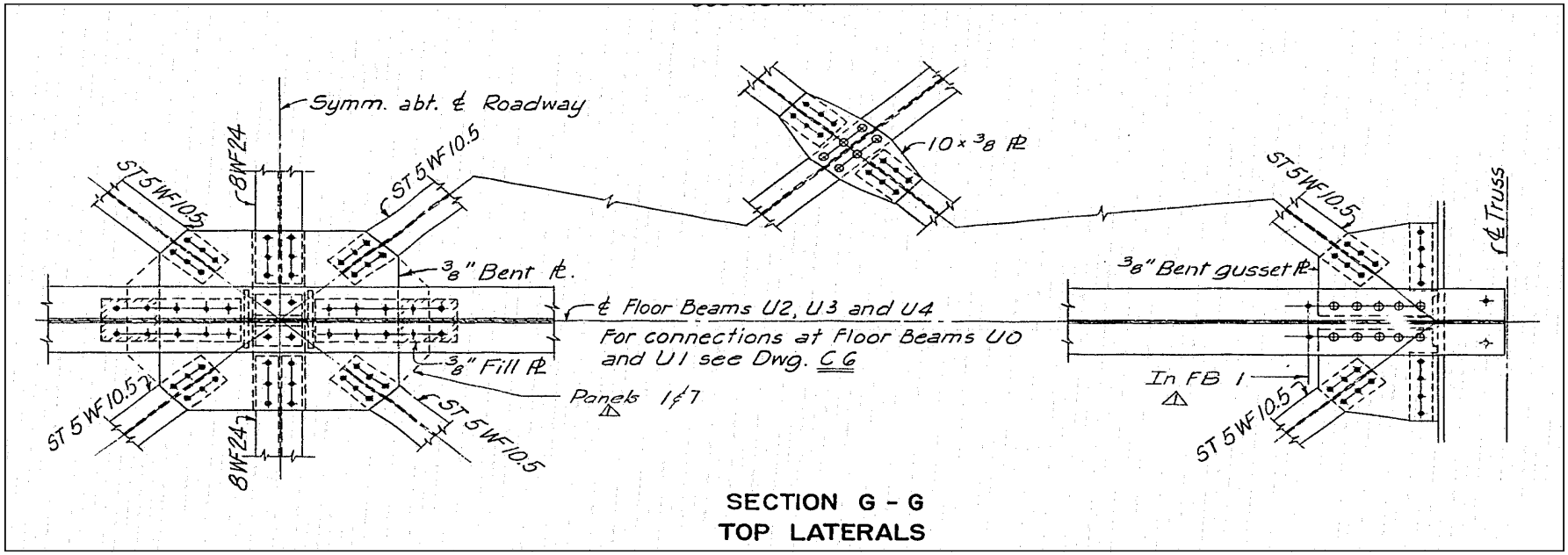


Figure MR019: Superstructure truss lateral brace

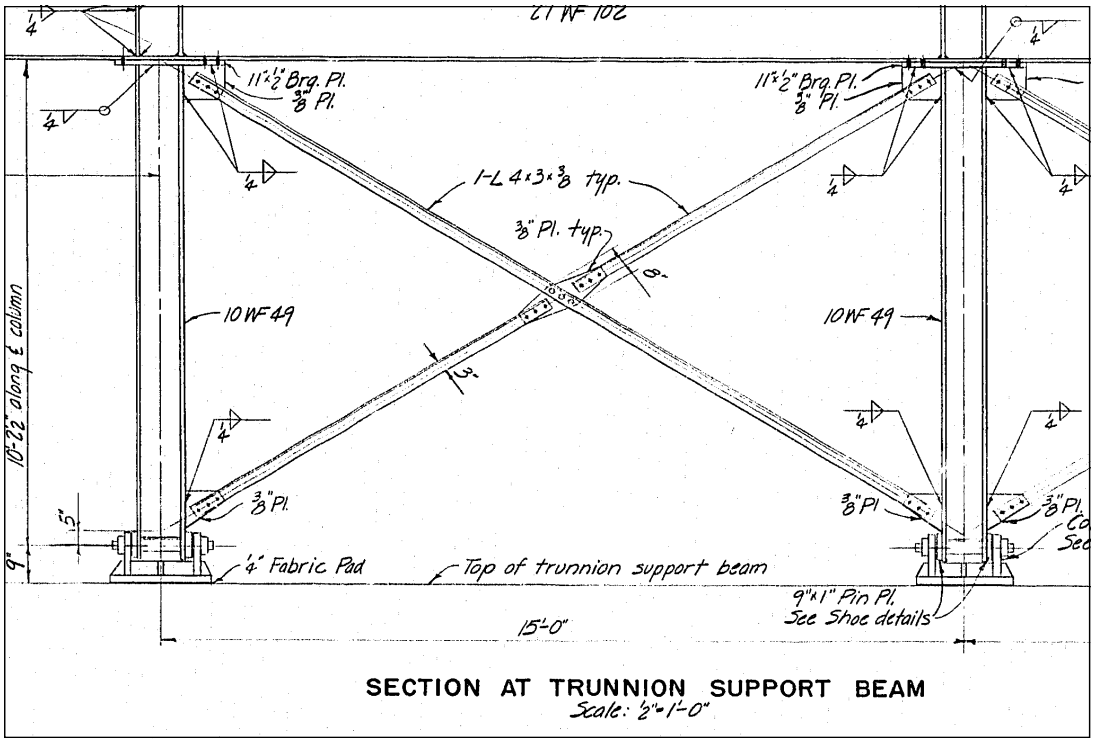


Figure MR020: Superstructure trunnion bearing and truss cross brace

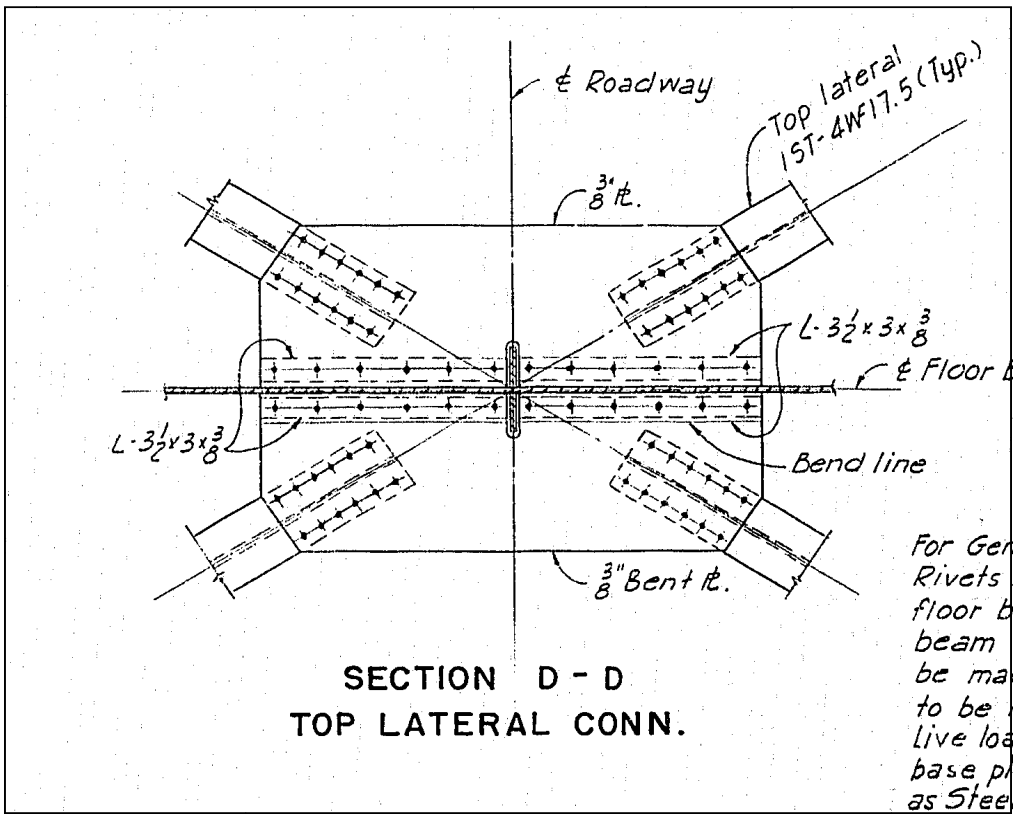


Figure MR021: Truss lateral brace

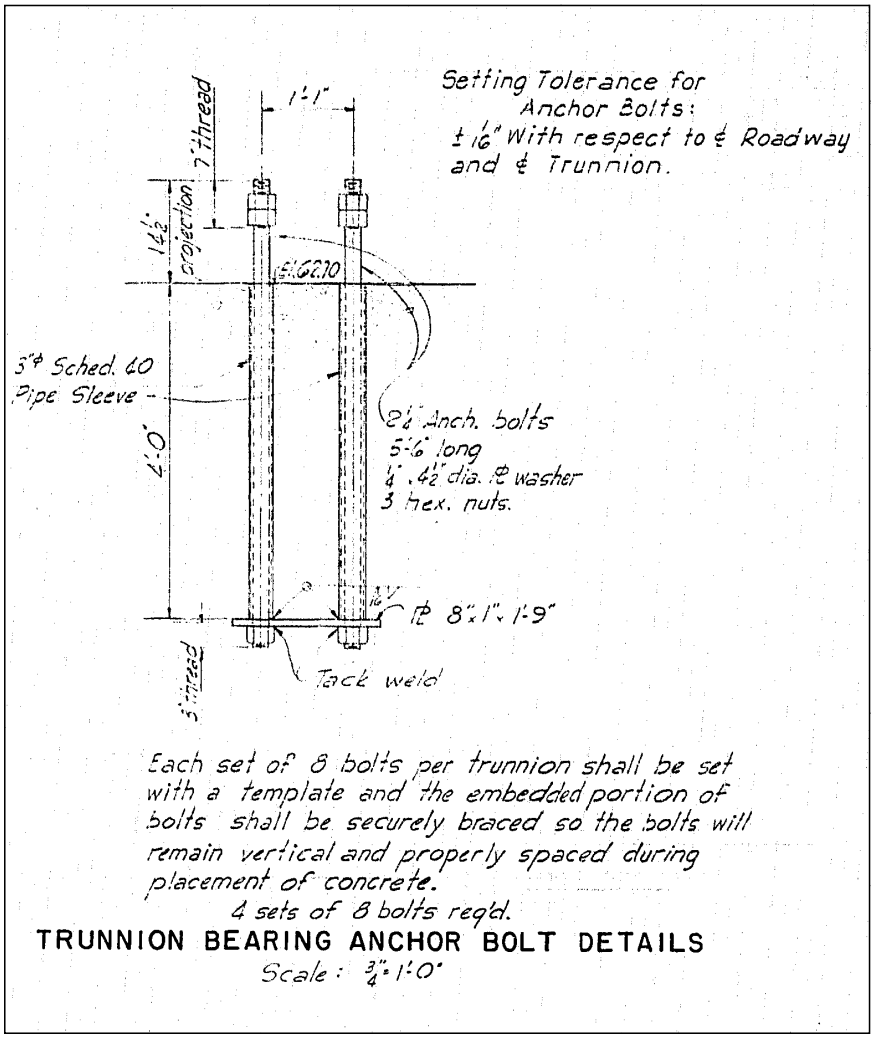


Figure MR022: Trunnion bearing anchor bolts

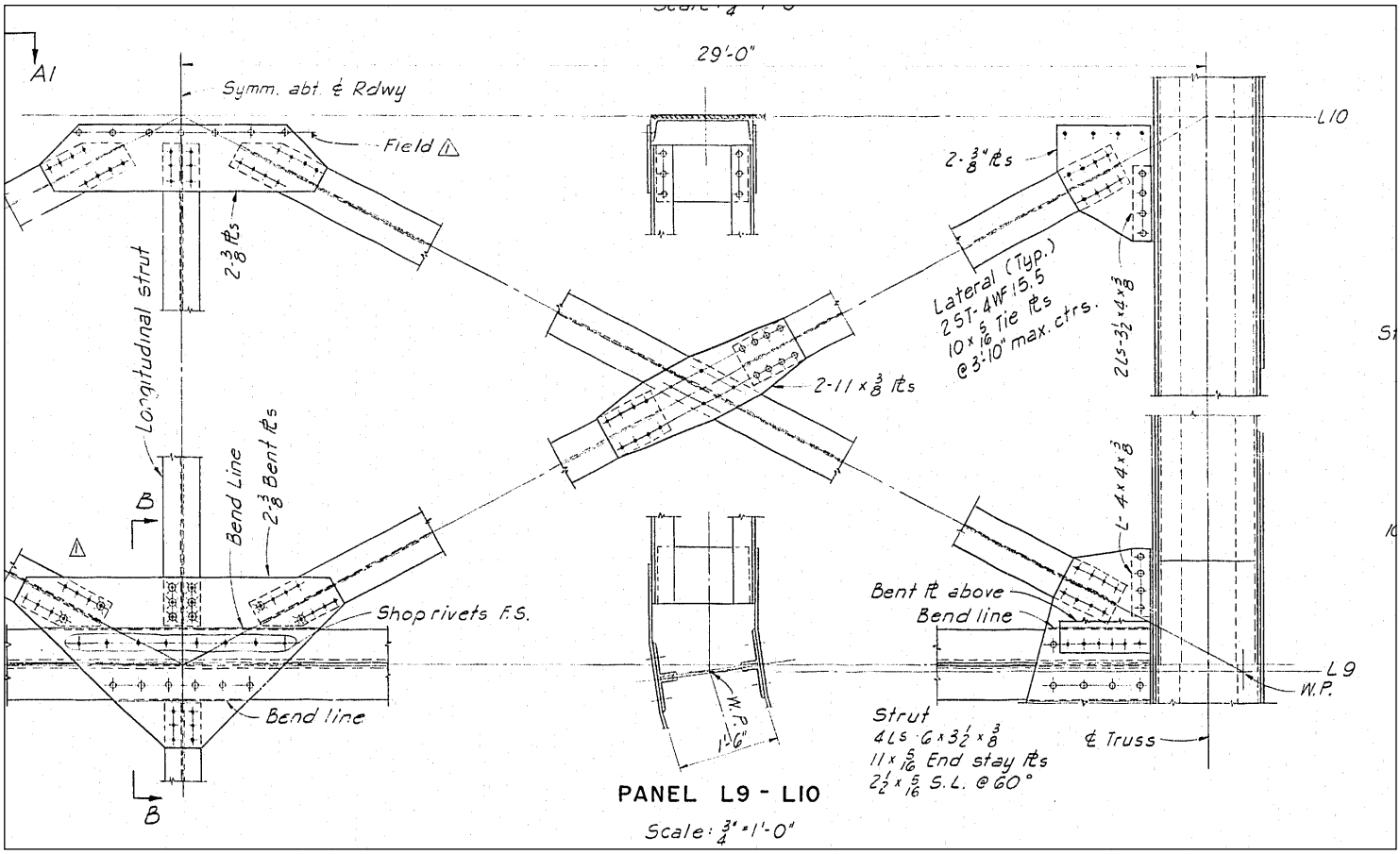


Figure MR024: Counterweight brace

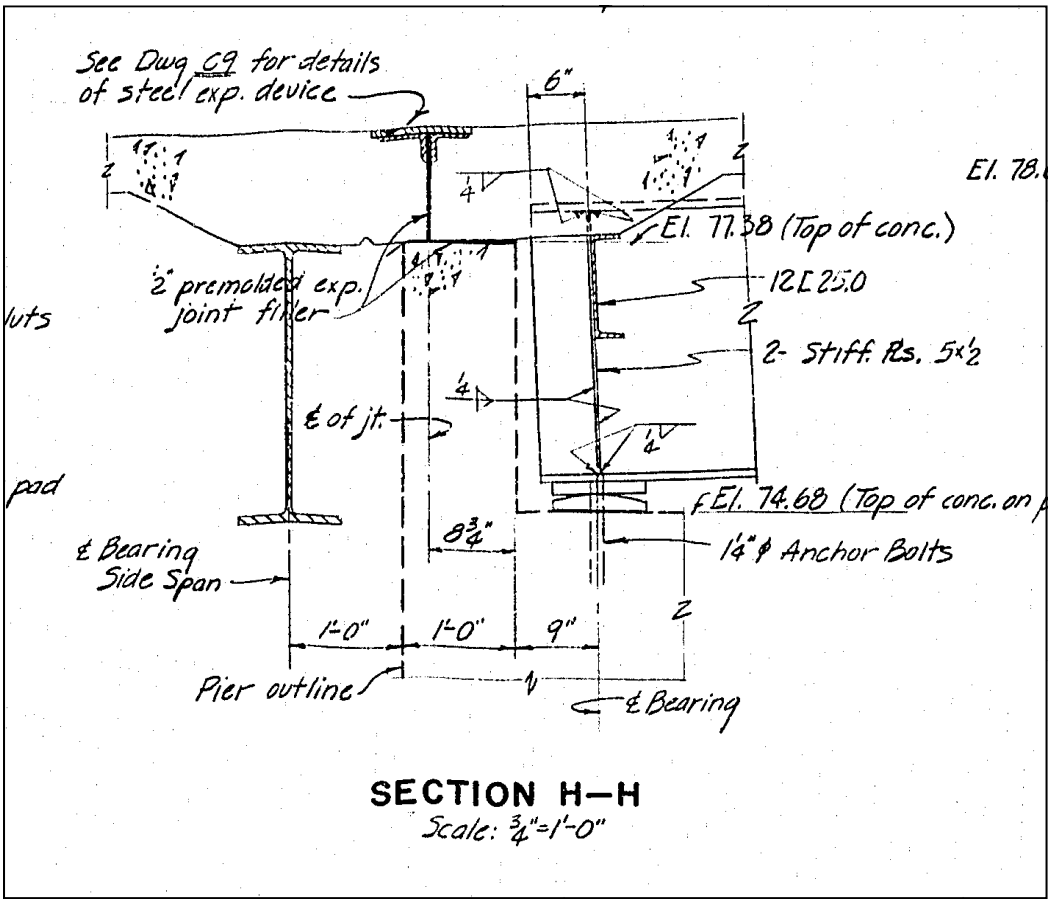


Figure MR030: Pit span bearing seat

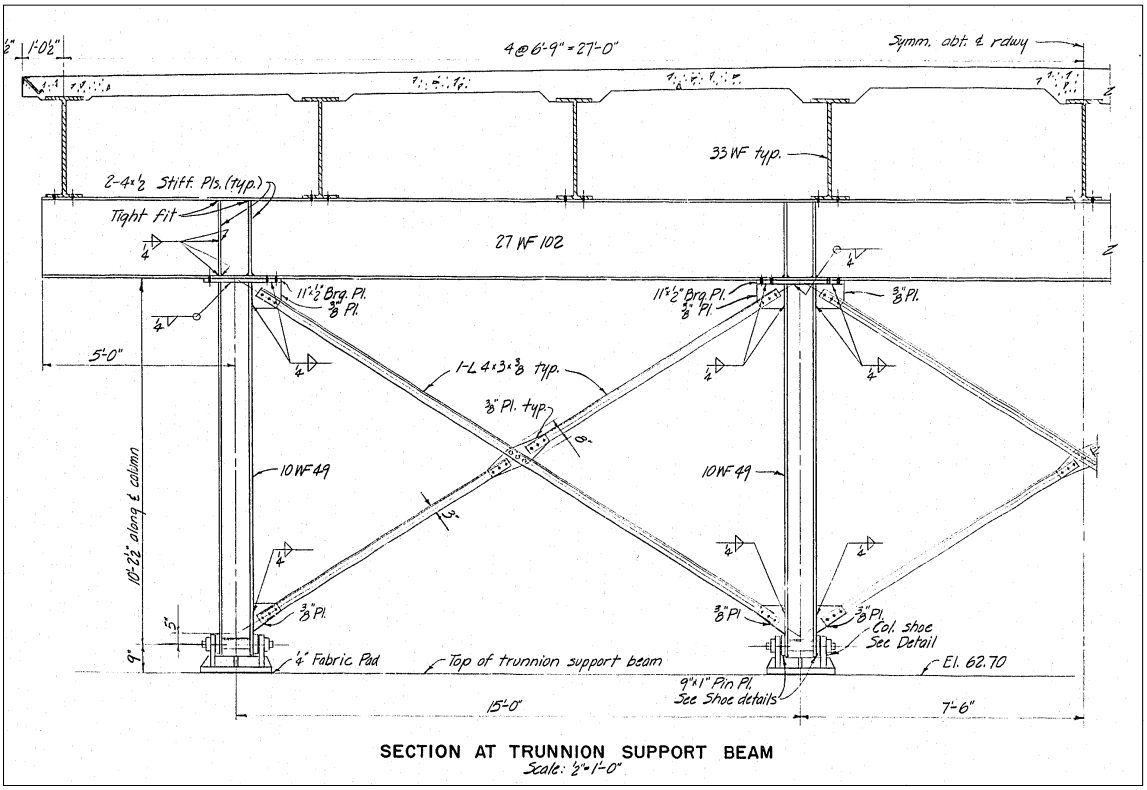


Figure MR031: Deck support columns at pit span

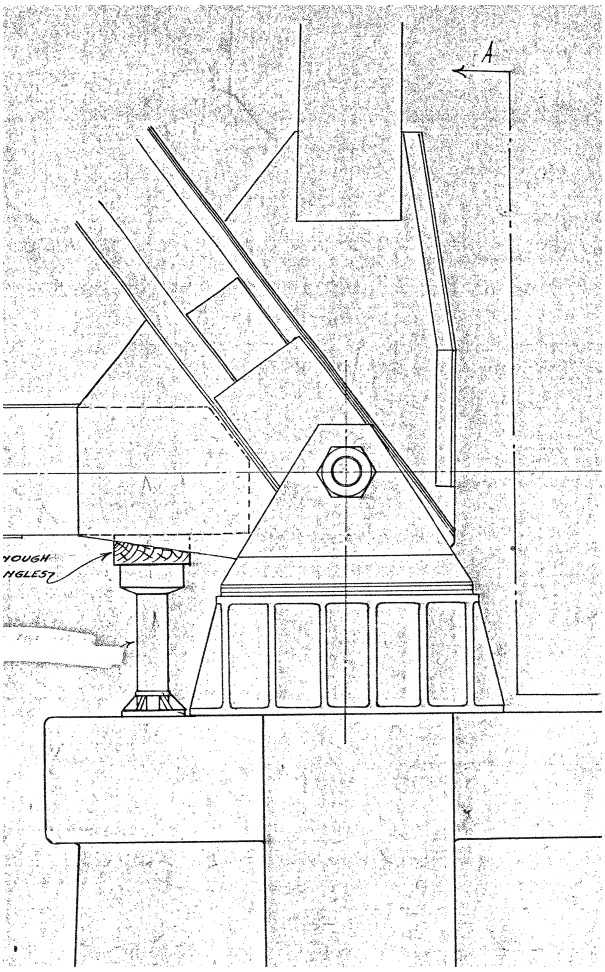
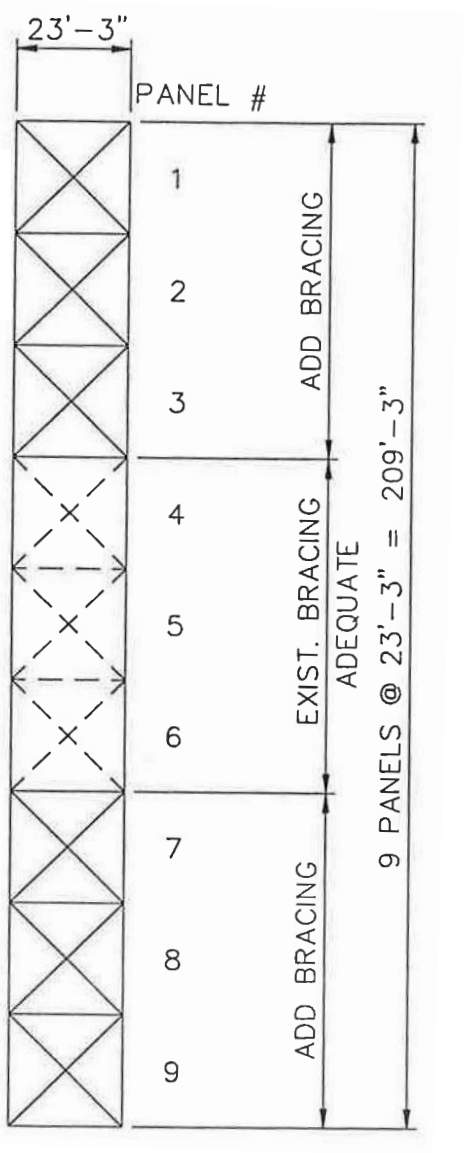
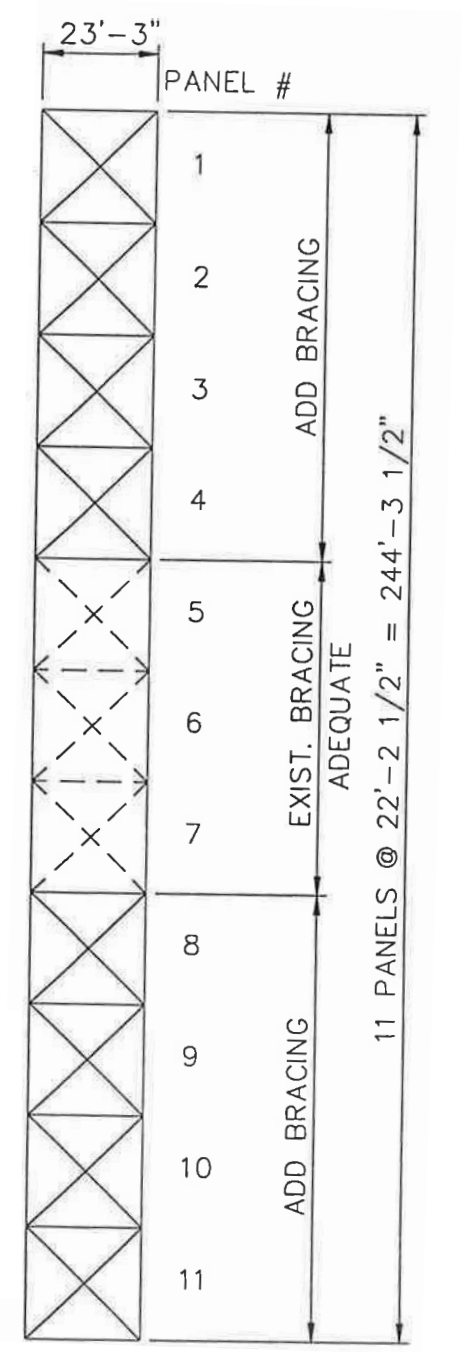


Figure HA101: Pier bearings



Spans 1-3



Spans 4-6

Figure HA102: Bottom chord lateral braces

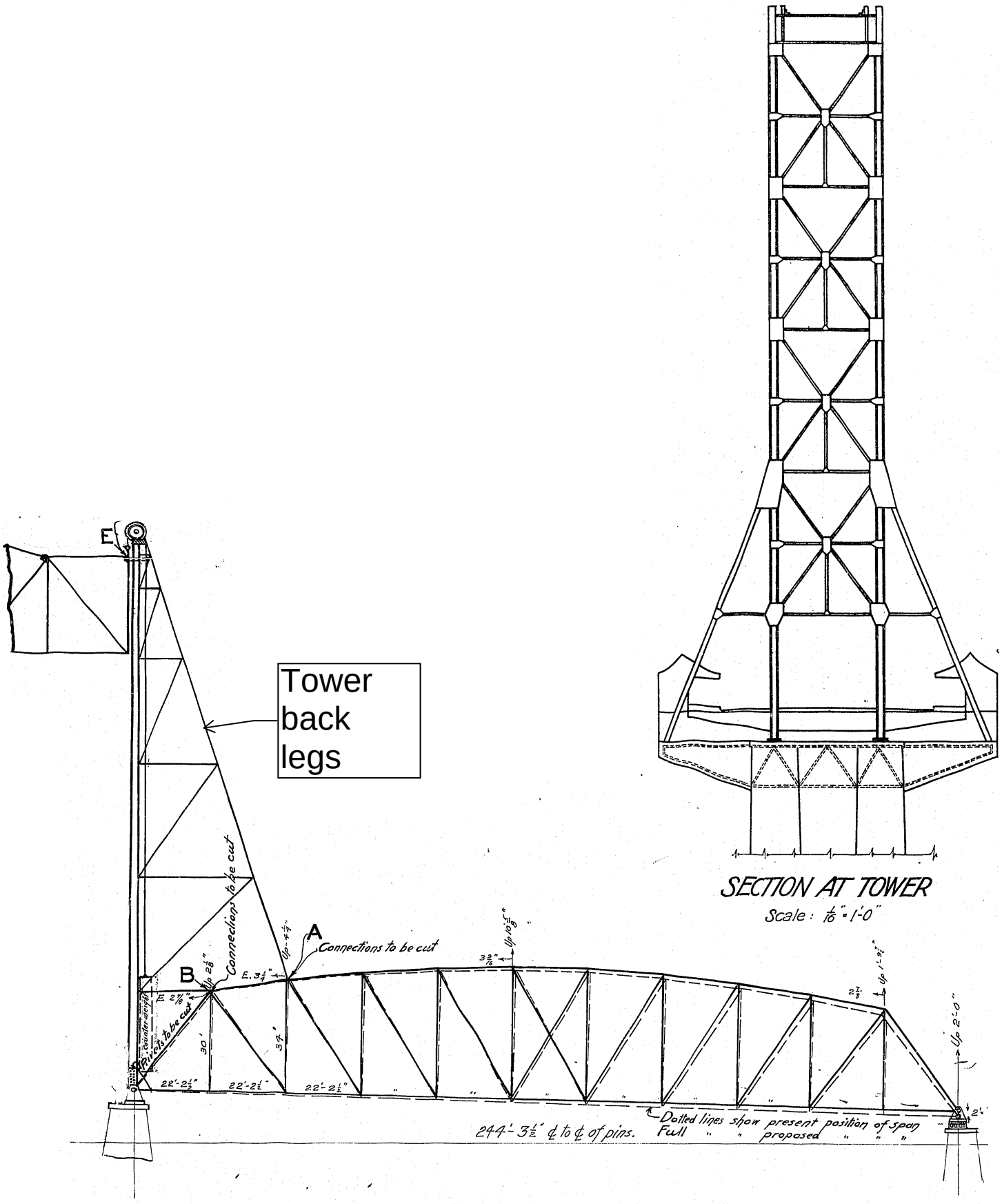


Figure HA103: Truss tower at moveable span

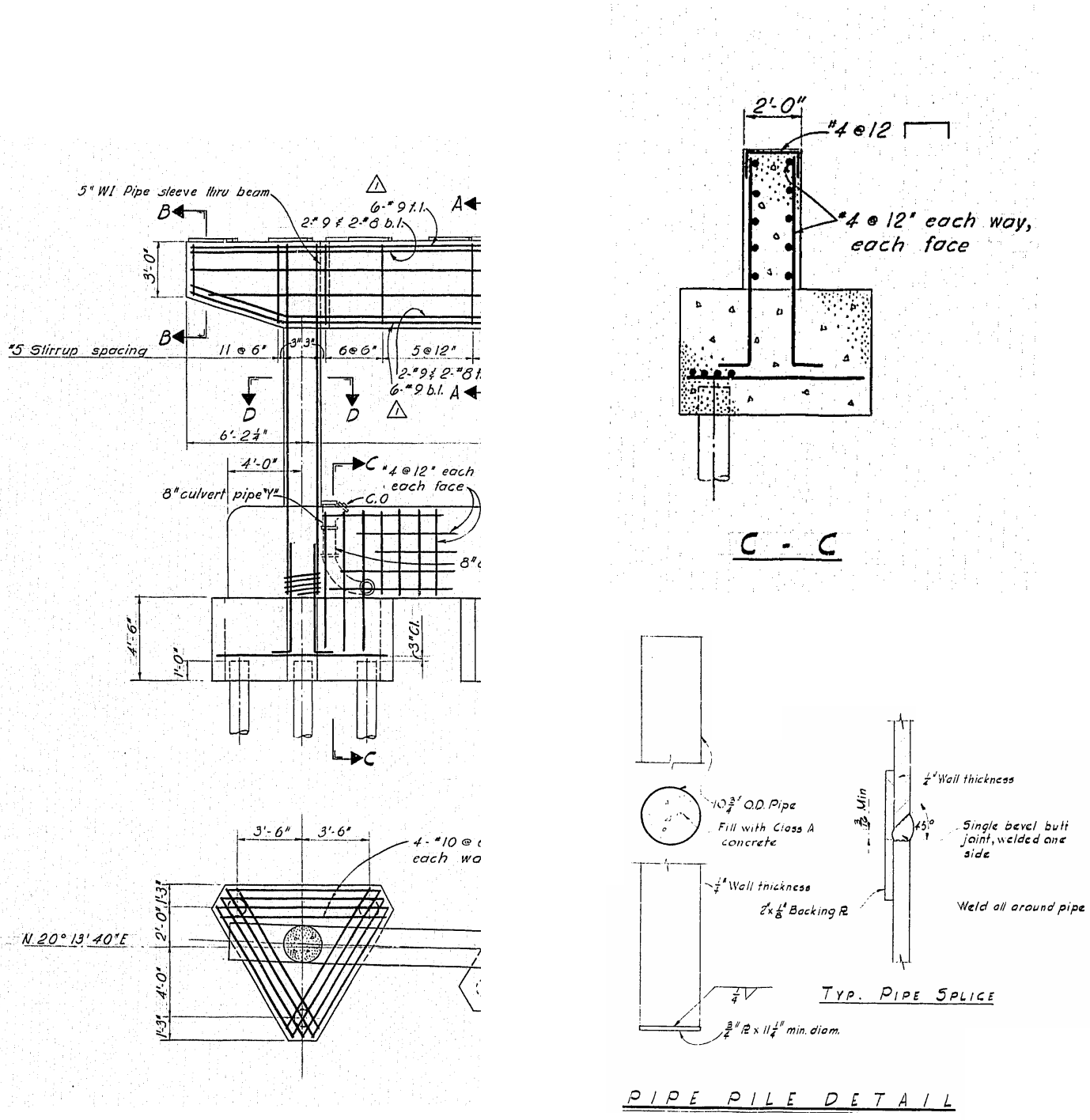


Figure HA301: Bent 1 pipe pile to cap connection

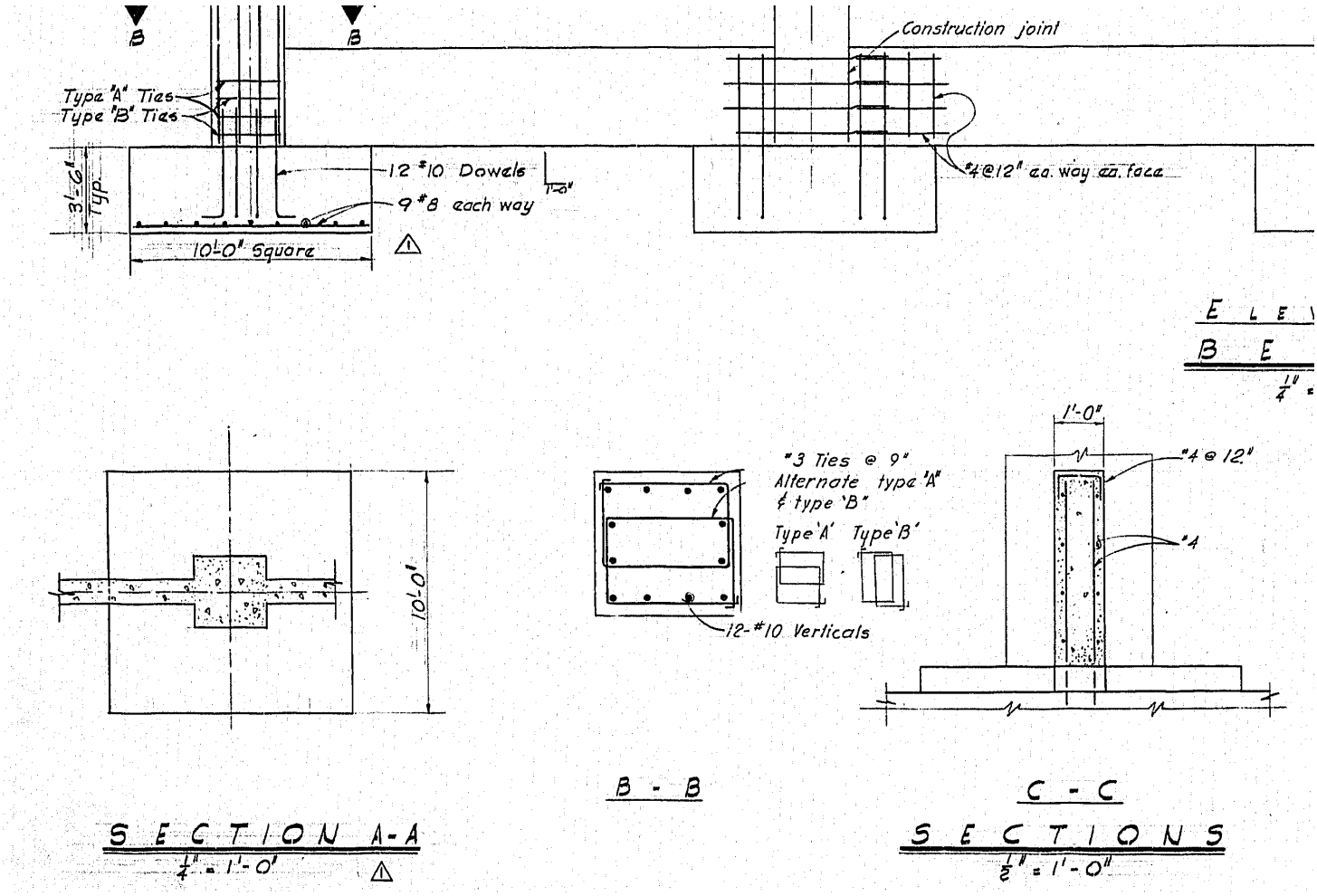


Figure HA302: Bents 2, 3, 4, 7, 8, 9, 10, and 11 spread footing with no top layer of reinforcing in footings. Only Bent 2 with short 1ft wall at bottom of column

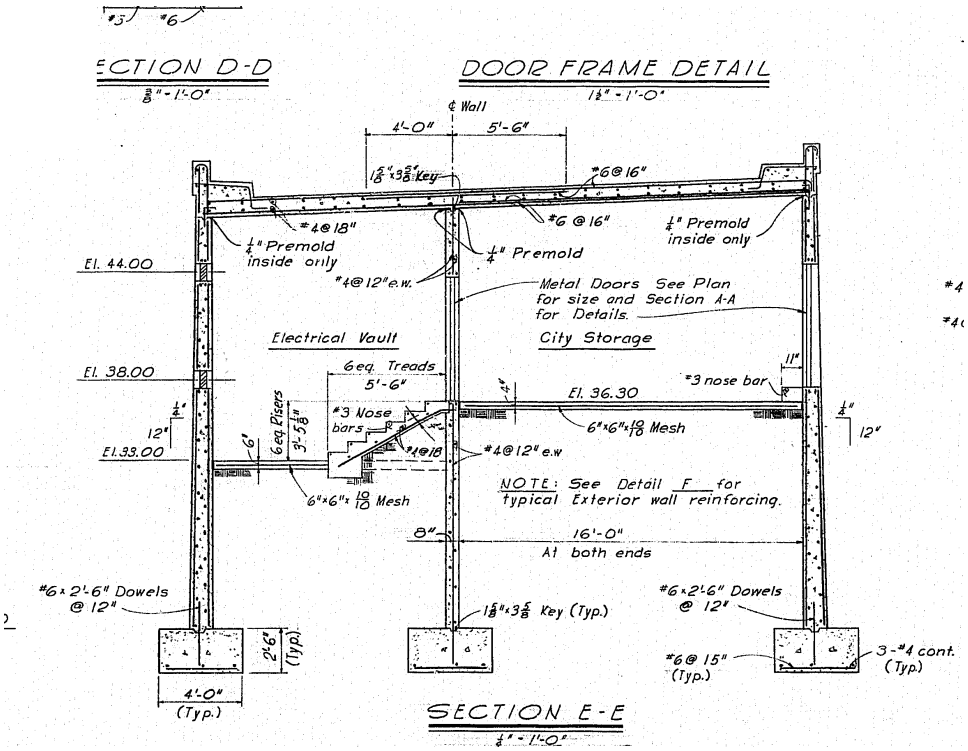


Figure HA303: Abutment 3 Electrical Vault, thin wall with dowels connected to footing. Vault room could collapse and affect the electrical supply for Hawthorne bridge

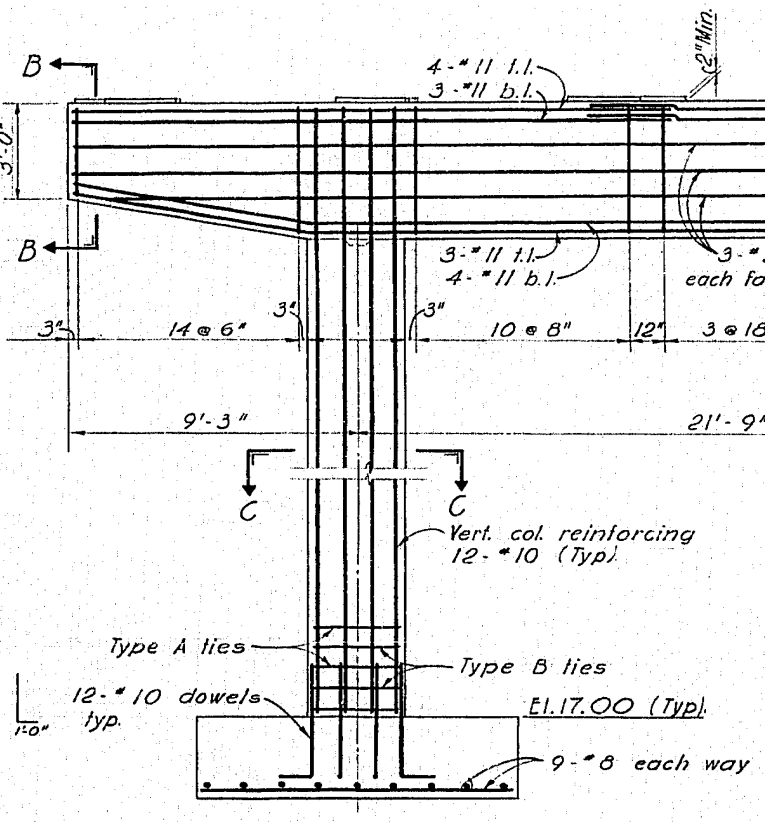


Figure HA304: Interior Bents Connections - Bents Columns to spread footing, inadequate reinforcing embedment

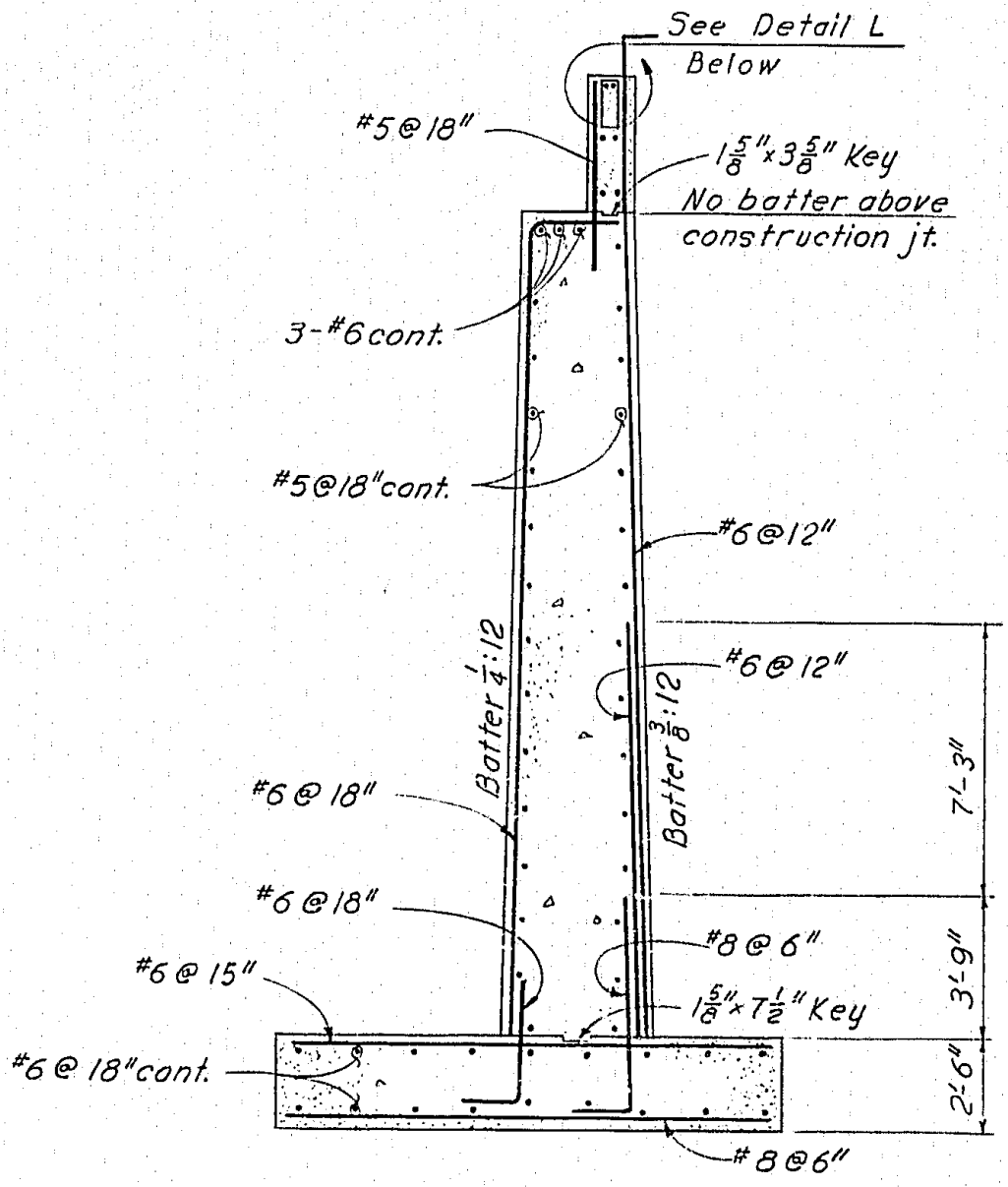


Figure HA305: Abutments 1, 2 and 3 to spread footings connection, inadequate reinforcing embedment length

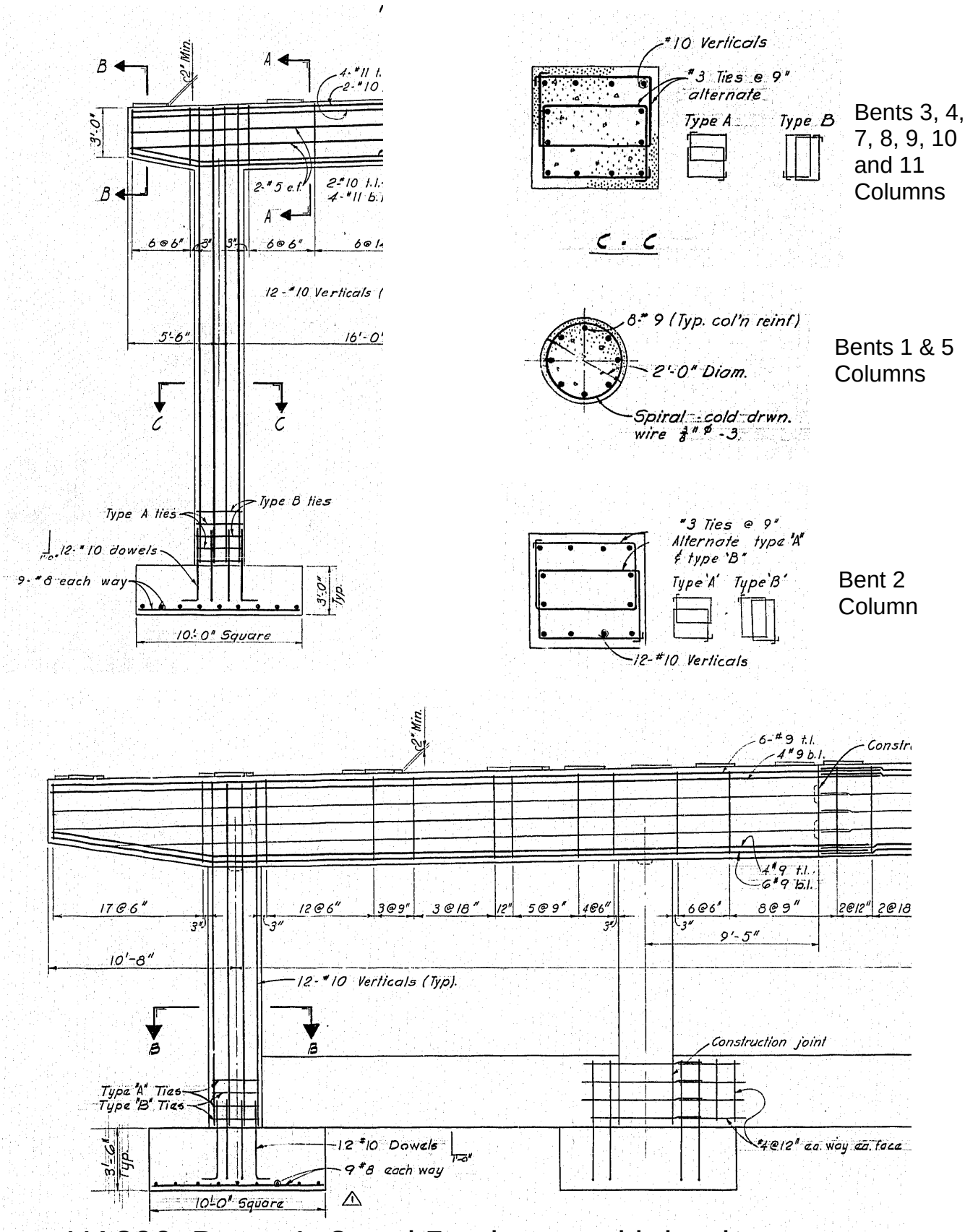


Figure HA306: Bents 1, 2 and 5 columns with inadequate shear capacity; Bents 3, 4, 7, 8, 9, 10 and 11 columns with inadequate flexural capacity

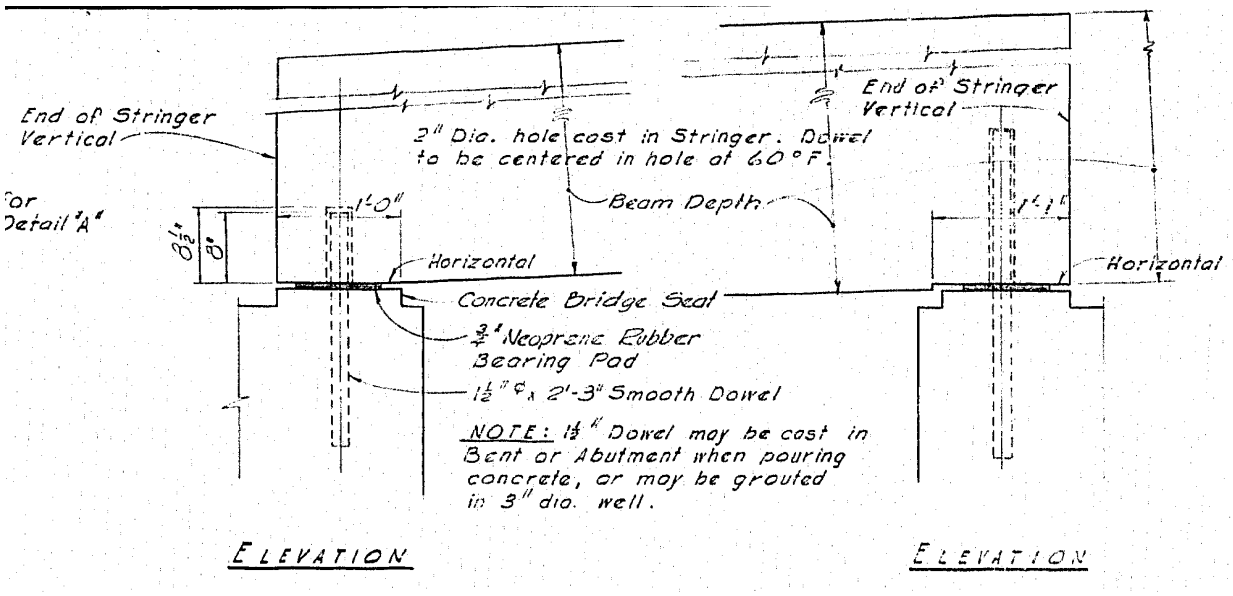


Figure HA307: Marginal longitudinal seat widths at bents

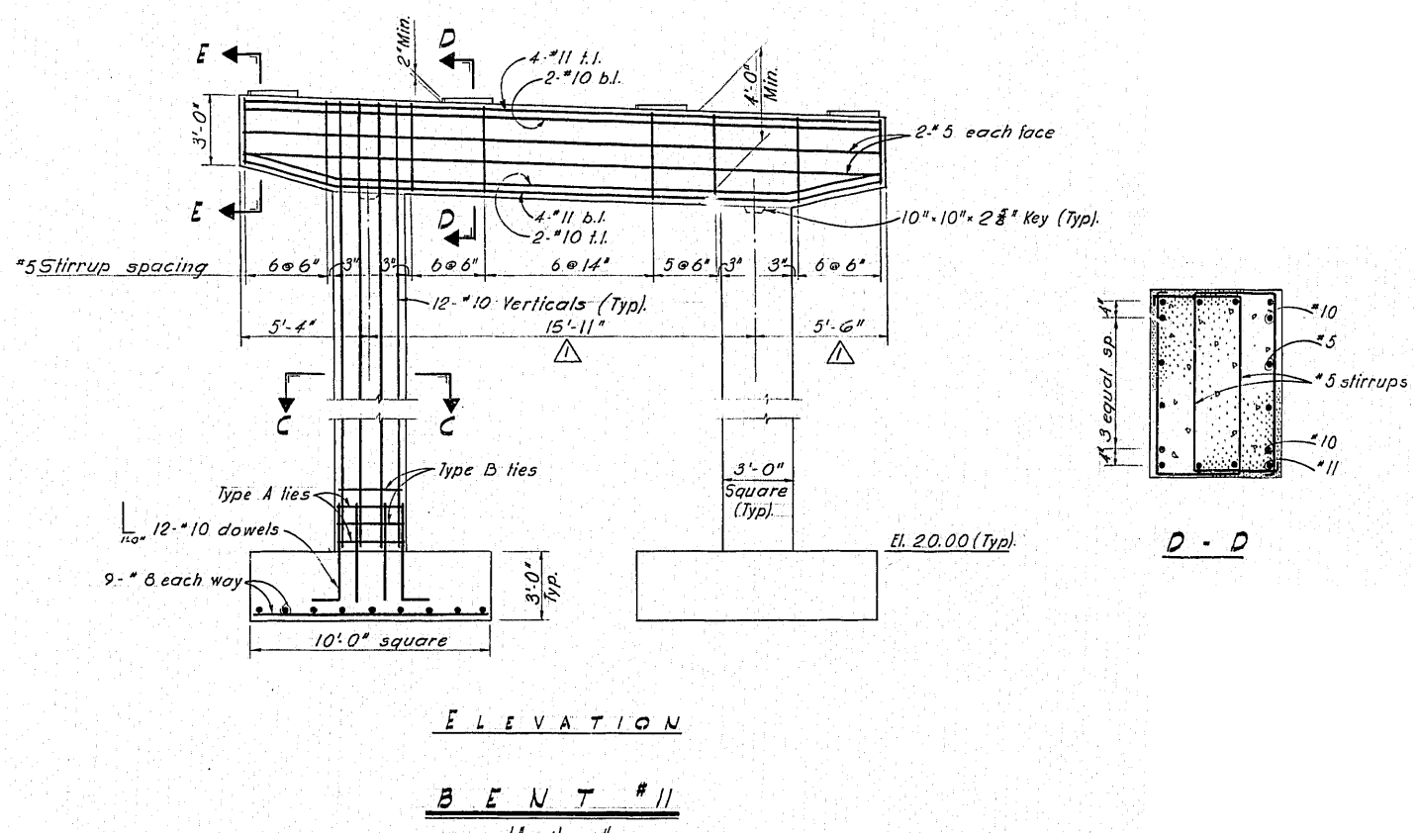


Figure HA309: Cap beam as capacity protected members but with inadequate flexural reinforcing

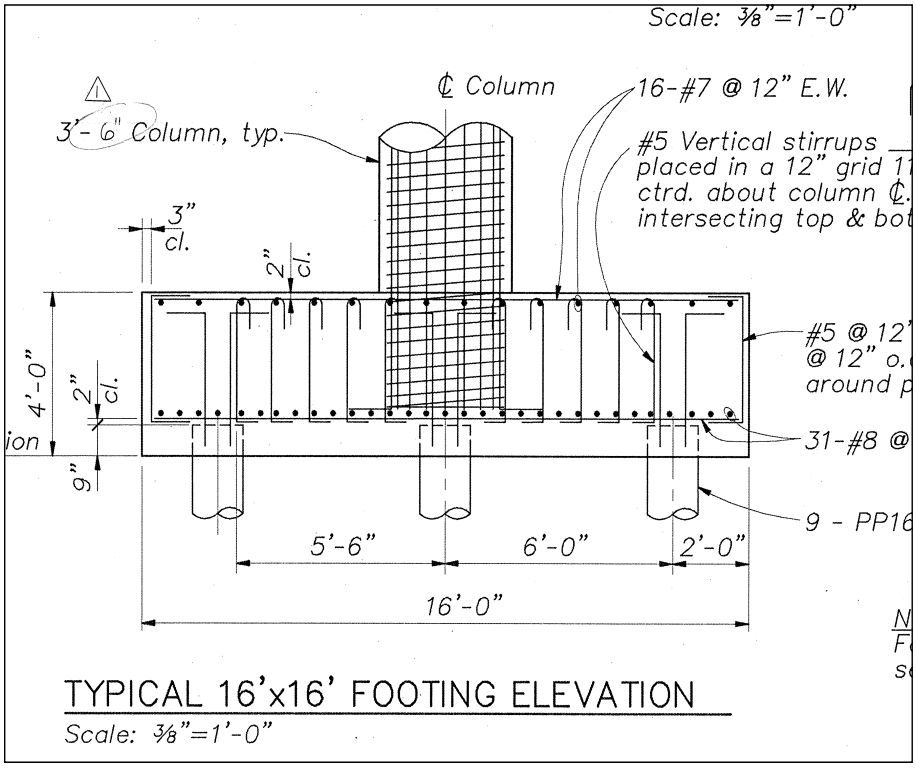


Figure HA401: Column to pile cap detail

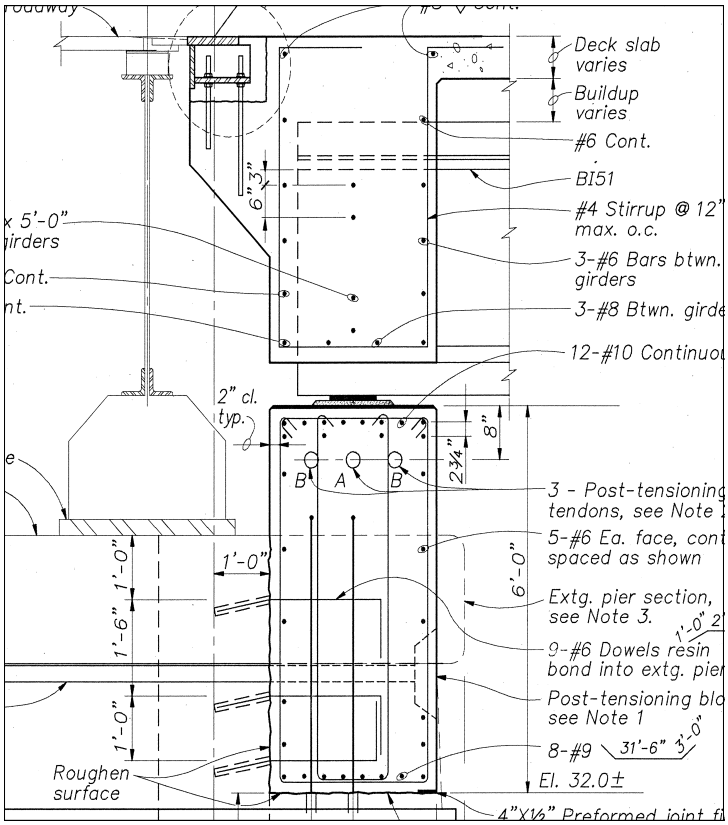


Figure HA402: Superstructure bearing seat

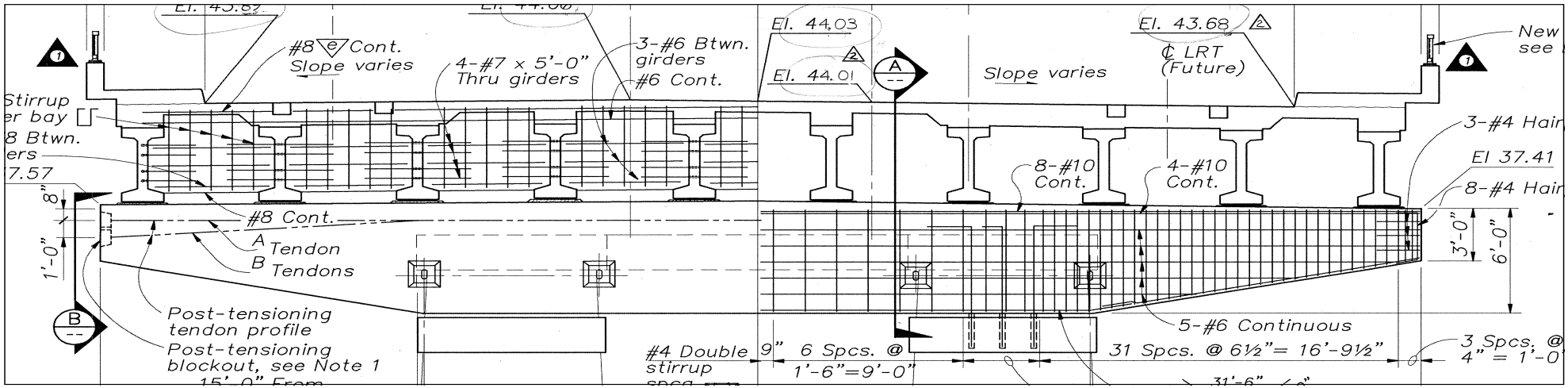


Figure HA403: Bent cap detail at Pier 1 (no transverse restraints observed)

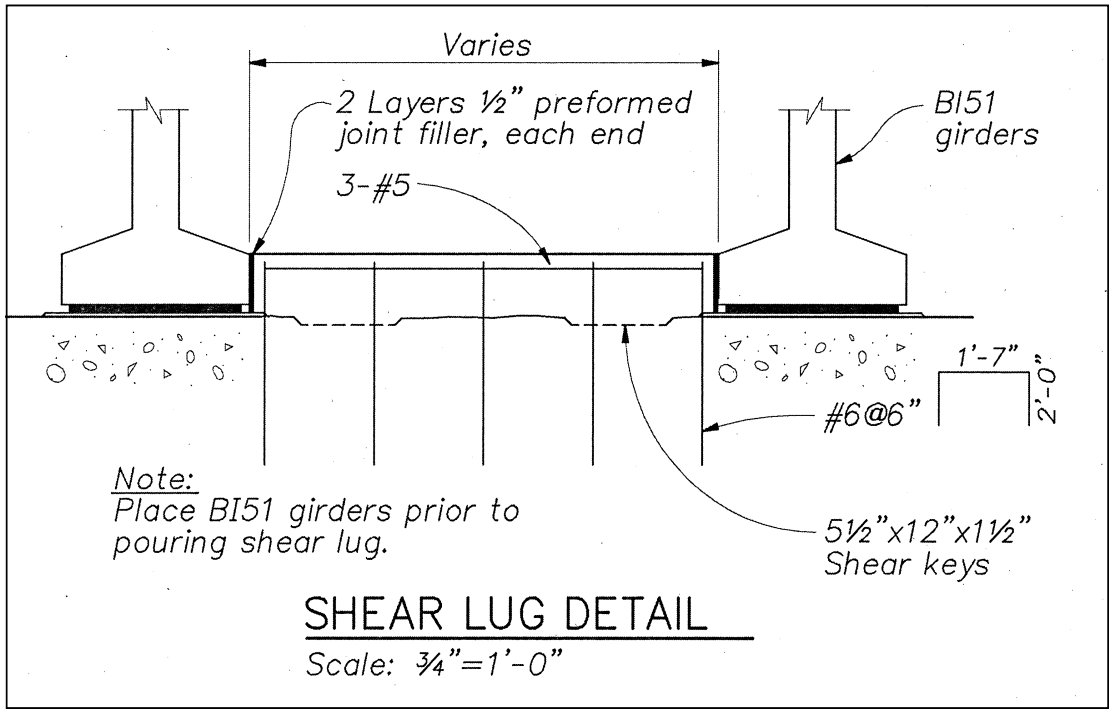


Figure HA404: Existing lateral restraint detail

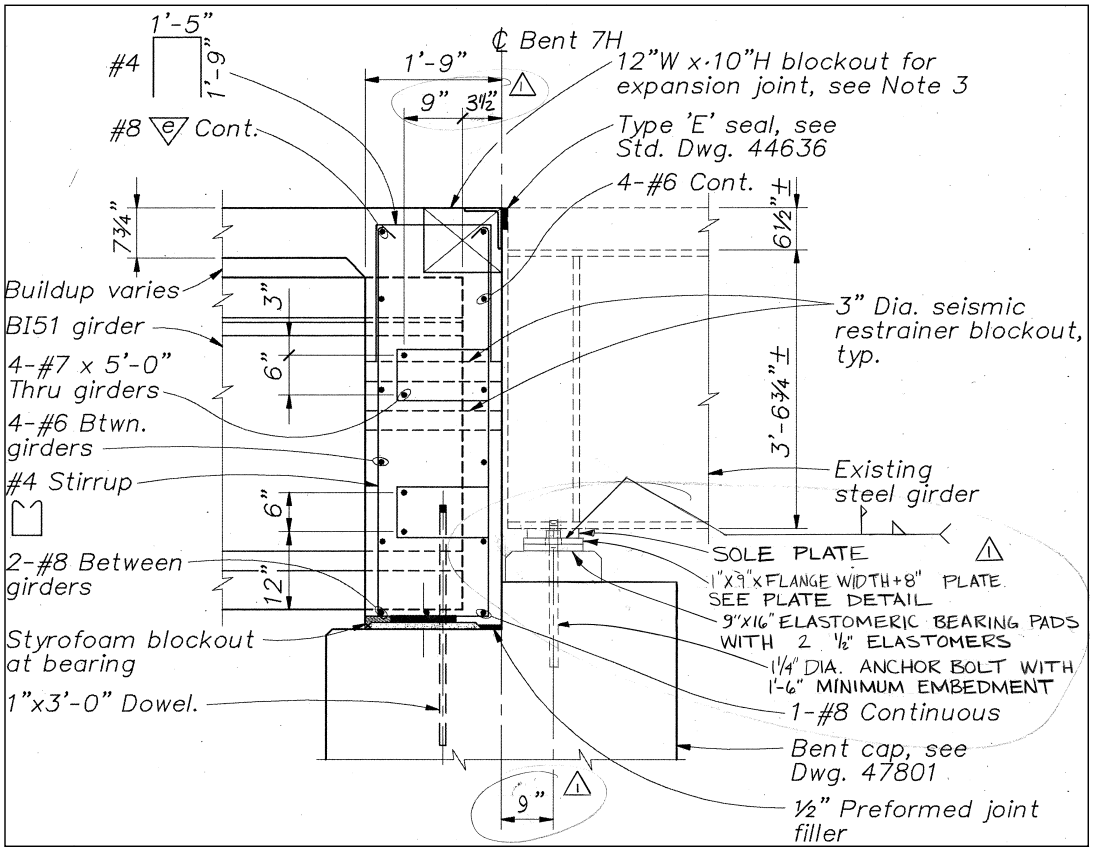


Figure HA405: Abutment seat detail

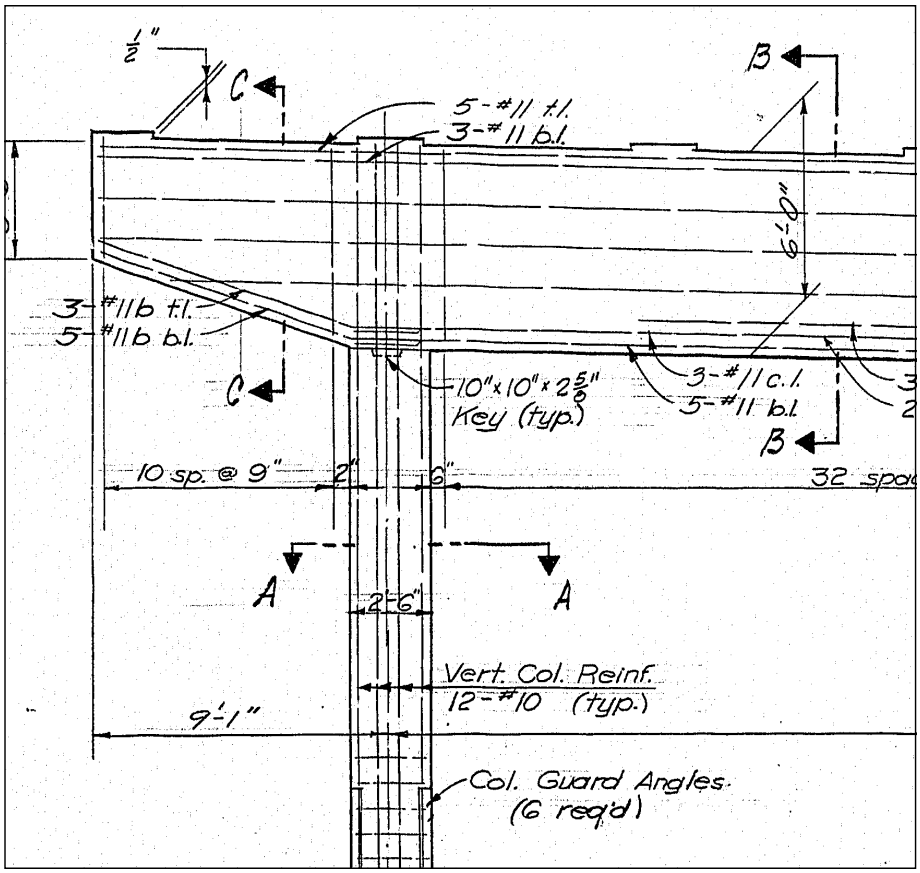


Figure HA406: Column to bent cap detail

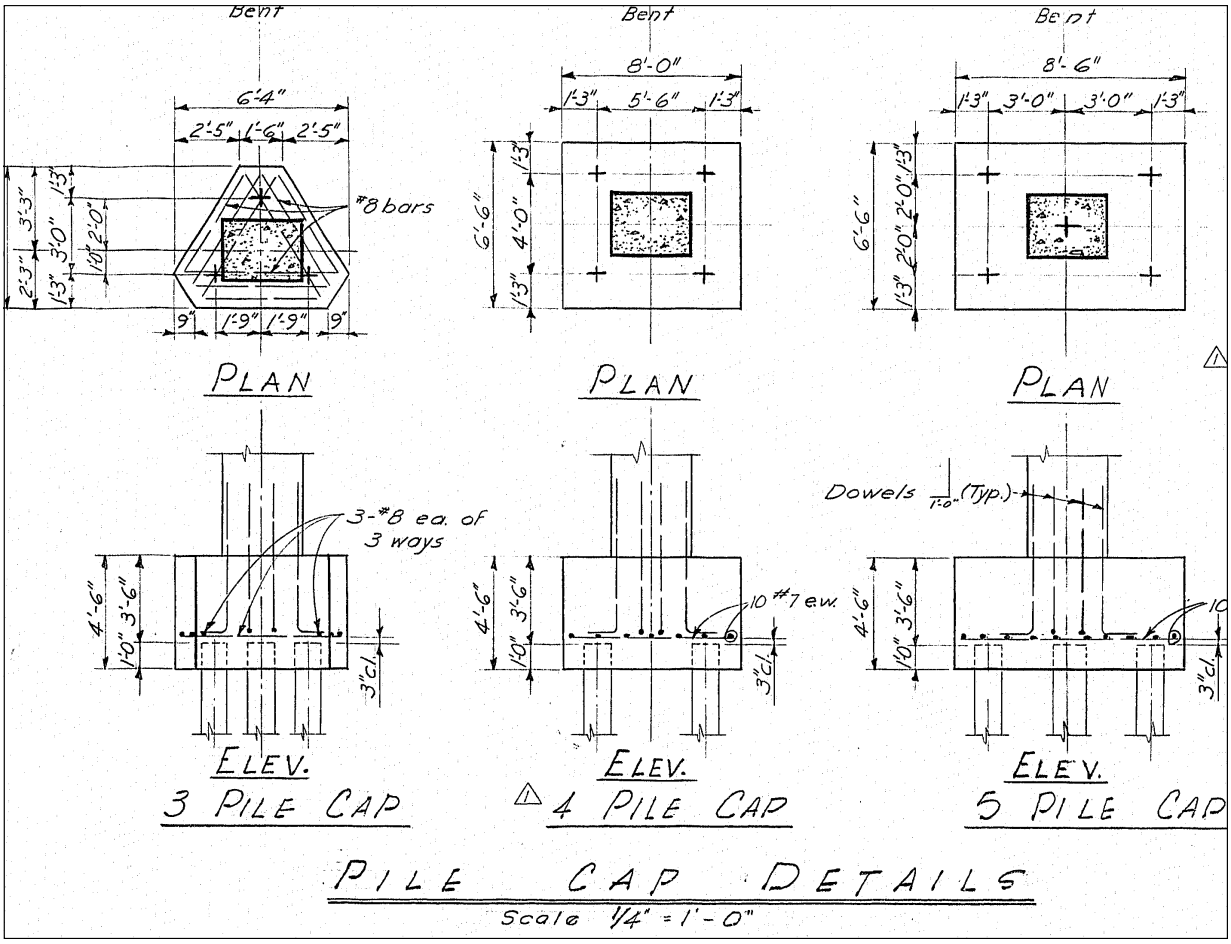


Figure HA407: Pile cap rebar detail

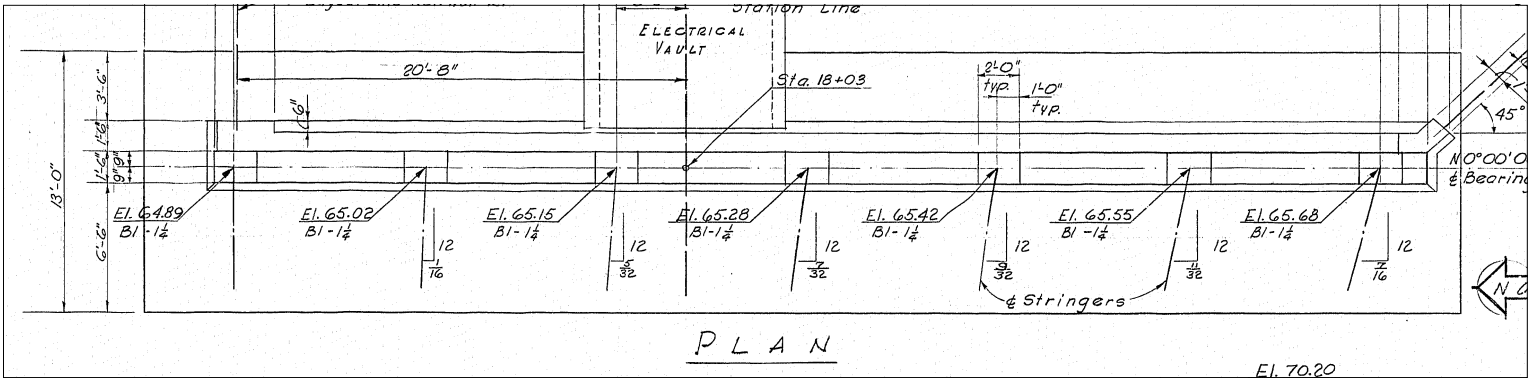


Figure HA408: Abutment seat detail

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Attachment C

Retrofit Cost Details

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Multnomah County CIP - Seismic

Vulnerability Form Descriptions matched to Standard Retrofit Types

By: TCA	**5/20/2014**
Checked: KPBU	5/21/2014

Bridge	Location	Vulnerability #	Count	Author's Description	Matched Standard description	cost for 1000 yr event		w/ 0.75 factor for 100 yr event	w/ 0.95 Factor for 500 yr event
Broadway	West Approach	1	1	Steel Bent Columns	Column strengthening	$ 75,000	/ Column	$ 56,000	$ 71,000
Broadway	West Approach	2	2	Expansion Bearing Seat Widths	Seat Extender	$ 75,000	/ Bent	$ 56,000	$ 71,000
Broadway	West Approach	3	3	Footings	Footing strengthening (Standard footing)	$ 500,000	/ Footing	$ 375,000	$ 475,000
Broadway	West Approach	4	4	Footings	Soil Densification	$ 7,000,000	/ Bridge Site (i.e West Side of Broadway Bridge)	$ 5,250,000	$ 6,650,000
Broadway	Fixed River Spans	1	5	Pier 2 Steel Columns	Column strengthening	$ 75,000	/ Column	$ 56,000	$ 71,000
Broadway	Fixed River Spans	2	6	Pier 1, 3, 4, 7 Jacketed Columns	**Unique** - Broadway Large Steel Column Retrofit	$ 500,000	/ Column	$ 375,000	$ 475,000
Broadway	Fixed River Spans	3	7	Pier 2, 3, 4, 7, E. Abut Bearings	Isolation bearings	$ 500,000	/ Bearing	$ 375,000	$ 475,000
Broadway	Fixed River Spans	4	8	Pier 2, 3, 4, 7 Conc. Piers	Pier strengthening	$ 2,500,000	/ Pier	$ 1,875,000	$ 2,375,000
Broadway	Fixed River Spans	5	9	Staircase to Naito Parkway	Longitudinal restrainers	$ 100,000	/ Bent	$ 75,000	$ 95,000
Broadway	Fixed River Spans	6	10	Geotechnical Hazards - Piers 1, 2 and 3	Soil Densification	$ 7,000,000	/ Bridge Site (i.e West Side of Broadway Bridge)	$ 5,250,000	$ 6,650,000
Broadway	Fixed River Spans	7	11	Geotech Hazard - Pier 4	Soil Densification	$ 7,000,000	/ Bridge Site (i.e West Side of Broadway Bridge)	$ 5,250,000	$ 6,650,000
Broadway	Moveable Spans	1	12	Piers 5, 6 Pier Walls	Pier strengthening	$ 2,500,000	/ Pier	$ 1,875,000	$ 2,375,000
Broadway	Moveable Spans	2	13	Pier 5, 6 Bearings	Isolation bearings	$ 500,000	/ Bearing	$ 375,000	$ 475,000
Broadway	Moveable Spans	3	14	Pier 5, 6 Footings	Footing strengthening (Major Footing)	$ 2,000,000	/ Pier	$ 1,500,000	$ 1,900,000
Broadway	Moveable Spans	4	15	Anchor Struts	**Unique** - Strengthen or replace anchor struts	$ 500,000	/ Anchor Strut	$ 375,000	$ 475,000
Broadway	Moveable Spans	5	16	Rall Wheel Track	Lateral Restrainers (Bascule)	$ 200,000	/ Location (counterweight, toe, etc.)	$ 150,000	$ 190,000
Broadway	Moveable Spans	6	17	Truss Frame at Counterweight	Truss frame strengthening (increase member size)	$ 2,000,000	/ Area identified	$ 1,500,000	$ 1,900,000
Broadway	Moveable Spans	7	18	Truss Frame at Rall Wheel	Truss frame strengthening (increase member size)	$ 2,000,000	/ Area identified	$ 1,500,000	$ 1,900,000
Broadway	Moveable Spans	8	19	Bascule Leaf Lateral Movement	Lateral Restrainers (Bascule)	$ 200,000	/ Location (counterweight, toe,	$ 150,000	$ 190,000
Broadway	Moveable Spans	9	20	Live Load Shoes	Transverse restraint (shear keys)	$ 75,000	/ Bent	$ 56,000	$ 71,000
Broadway	East Approach	1	21	Abutments	Abutment strengthening (provide concrete built up connection at joint)	$ 100,000	/ Abutment	$ 75,000	$ 95,000
Broadway	East Approach	2	22	Interior Pier Wall	Abutment strengthening (provide concrete built up connection at joint)	$ 100,000	/ Abutment	$ 75,000	$ 95,000

Multnomah County CIP - Seismic

Vulnerability Form Descriptions matched to Standard Retrofit Types

By: TCA	**5/20/2014**
Checked: KPBU	5/21/2014

Bridge	Location	Vulnerability #	Count	Author's Description	Matched Standard description	cost for 1000 yr event		w/ 0.75 factor for 100 yr event	w/ 0.95 Factor for 500 yr event
						includes 1.75 factor for Burnside higher performance level			
Burnside	West Approach	1	1	Columns	Column strengthening	$ 130,000	/ Column	$ 98,000	$ 124,000
Burnside	West Approach	2	2	Footings	Footing strengthening (Standard footing)	$ 880,000	/ Footing	$ 660,000	$ 836,000
Burnside	West Approach	3	3	Superstructure Seating on Expansion Bent	Longitudinal restrainers	$ 180,000	/ Bent	$ 135,000	$ 171,000
Burnside	West Approach	4	4	Pier Caps/Floor Beams	Bent cap strengthening	$ 260,000	/ Bent	$ 195,000	$ 247,000
Burnside	Fixed River Spans	1 & 2	5	Liquefaction/Slope Stability/Lateral Spreading	Soil Densification	$ 12,250,000	/ Bridge Site (i.e West Side of Broadway Bridge)	$ 9,188,000	$ 11,638,000
Burnside	Fixed River Spans	3	6	Piers 1, 4 Foundation Timber Piles	None	$ -		$ -	$ -
Burnside	Fixed River Spans	4	7	Piers 1, 4, Columns	Column strengthening	$ -	/ Column	$ -	$ -
Burnside	Fixed River Spans	5	8	Connections - super to sub., Fixed Bearings and Seat Width	Bearing replacement	$ 130,000	/ Bent	$ 98,000	$ 124,000
Burnside	Fixed River Spans	6	9	Connections - super to sub., Expansion Bearings and Seat Width	Bearing replacement	$ 130,000	/ Bent	$ 98,000	$ 124,000
Burnside	Fixed River Spans	7	10	Joint in Deck System	Abutment strengthening (provide concrete built up connection at joint)	$ 180,000	/ Abutment	$ 135,000	$ 171,000
Burnside	Fixed River Spans	8	11	Approach Deck Fixed Connection to Piers 1 & 4	None	$ -		$ -	$ -
Burnside	Fixed River Spans	9	12	Truss System - Connections of Primary Members	None	$ -		$ -	$ -
Burnside	Fixed River Spans	10 & 11	13	Overhead Sign Structures / Lightings	None	$ -		$ -	$ -
Burnside	Moveable Spans	1	14	Pier 2, 3 Foundation Timber Piles	Footing strengthening (Major Footing)	$ 3,500,000	/ Pier	$ 2,625,000	$ 3,325,000
Burnside	Moveable Spans	2	15	Piers 2 & 3 Bascule Pier Wall below Truss Seats	Pier strengthening	$ 4,380,000	/ Pier	$ 3,285,000	$ 4,161,000
Burnside	Moveable Spans	3	16	Connections - super to sub., Trunnion Support Vertical Post	**Unique** - Install transverse braces to trunnion support posts	$ 1,750,000	/ Location	$ 1,313,000	$ 1,663,000
Burnside	Moveable Spans	4	17	Connections - super to sub., Anchorage of Trunnion to Bascule Piers	Isolation bearings	$ 880,000	/ Bearing	$ 660,000	$ 836,000
Burnside	Moveable Spans	5	18	Joint in the Deck System at Piers 2 and 3	Longitudinal restrainers	$ 180,000	/ Bent	$ 135,000	$ 171,000
Burnside	Moveable Spans	6	19	Bascule Leaf Transverse Restraint	Lateral Restrainers (Bascule)	$ 350,000	/ Location (counterweight, toe, etc.)	$ 263,000	$ 333,000
Burnside	Moveable Spans	7	20	Bascule Leaf Transverse Bracing	Truss frame strengthening (increase member size)	$ 3,500,000	/ Area identified	$ 2,625,000	$ 3,325,000
Burnside	Moveable Spans	8	21	Counterweight Restrainers	Lateral Restrainers (Bascule)	$ 350,000	/ Location (counterweight, toe, etc.)	$ 263,000	$ 333,000
Burnside	Moveable Spans	9	22	Counterweight Link Fuse	**Unique** - Install steel strut to counterweight link	$ 880,000	/ Leaf	$ 660,000	$ 836,000
Burnside	Moveable Spans	10	23	Mechanical Equipment / Working Parts	Bearing replacement	$ 888,000	/ Leaf	$ 666,000	$ 844,000
Burnside	Moveable Spans	11	24	Pier Houses		$ -		$ -	$ -
Burnside	Moveable Spans	12	25	Lightings		$ -		$ -	$ -
Burnside	East Approach	1	26	Pile Caps	Column strengthening	$ 130,000	/ Column	$ 98,000	$ 124,000
Burnside	East Approach	2	27	Spread Footing	None	$ -		$ -	$ -
Burnside	East Approach	3	28	Spread Footing	None	$ -		$ -	$ -
Burnside	East Approach	4	29	Superstructure Seating on Abutment	Seat Extender	$ 130,000	/ Bent	$ 98,000	$ 124,000
Burnside	East Approach	5	30	Connections - Bents to Below Ground Foundations	Column strengthening	$ 130,000	/ Column	$ 98,000	$ 124,000
Burnside	East Approach	6	31	Bent Column (concrete encased steel column pairs with bracing)	Column strengthening	$ 130,000	/ Column	$ 98,000	$ 124,000
Burnside	East Approach	7	32	Bent Column (concrete column)	Column strengthening	$ 130,000	/ Bent	$ 98,000	$ 124,000
Burnside	East Approach	8	33	Rocker Bearing	Bearing replacement	$ 130,000	/ Bent	$ 98,000	$ 124,000
Burnside	East Approach	9	34	Seat Width (Expansion)	Seat Extender	$ 130,000	/ Bent	$ 98,000	$ 124,000
Burnside	East Approach	10	35	Connection - Substructure to Superstructure	Column strengthening	$ 130,000	/ Location	$ 98,000	$ 124,000
Burnside	East Approach	11	36	Expansion Joint	None	$ -		$ -	$ -
Burnside	East Approach	12	37	Concrete Encased Steel Floorbeam	**Unique** - Provide additional floorbeam bracing	$ 180,000	/ Location	$ 135,000	$ 171,000
Burnside	East Approach	13	38	Overhead Structure near end of East Approach	None	$ -		$ -	$ -

Multnomah County CIP - Seismic

Vulnerability Form Descriptions matched to Standard Retrofit Types

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Bridge	Location	Vulnerability #	Count	Author's Description	Matched Standard description	cost for 1000 yr event		w/ 0.75 factor for 100 yr event	w/ 0.95 Factor for 500 yr event
Morrison	West Approach	1	1	Footing	Footing strengthening (Standard footing)	$ 500,000	/ Footing	$ 375,000	$ 475,000
Morrison	West Approach	2	2	Footing	Footing strengthening (Standard footing)	$ -	/ Footing	$ -	$ -
Morrison	West Approach	3	3	Column	Column strengthening	$ 75,000	/ Column	$ 56,000	$ 71,000
Morrison	West Approach	4	4	Bent Cap	Bent cap strengthening	$ 150,000	/ Bent	$ 113,000	$ 143,000
Morrison	West Approach	5	5	Girder Restraint	Longitudinal restrainers	$ 100,000	/ Bent	$ 75,000	$ 95,000
Morrison	West Approach	6	6	Superstructure bearings at bent caps	Bearing replacement	$ 75,000	/ Bent	$ 56,000	$ 71,000
Morrison	West Approach	7	7	Superstructure Diaphragms	Girder Strengthening at Bearings	$ 75,000	/ Bent	$ 56,000	$ 71,000
Morrison	West Approach	8	8	Expansion Joints	Longitudinal restrainers	$ -	/ Bent	$ -	$ -
Morrison	Fixed River Spans	1	9	Footing	Footing strengthening (Major Footing)	$ 2,000,000	/ Pier	$ 1,500,000	$ 1,900,000
Morrison	Fixed River Spans	2	10	Column	Column strengthening	$ 75,000	/ Column	$ 56,000	$ 71,000
Morrison	Fixed River Spans	3	11	Bent Cap	Bent cap strengthening	$ 150,000	/ Bent	$ 113,000	$ 143,000
Morrison	Fixed River Spans	4	12	Trunnion Support Frame	**Unique** - Strengthen Trunnion Beam and supports	$ 1,500,000	/ Leaf	$ 1,125,000	$ 1,425,000
Morrison	Fixed River Spans	5	13	Superstructure Bearing at bent caps	Isolation bearings	$ 500,000	/ Bearing	$ 375,000	$ 475,000
Morrison	Fixed River Spans	6	14	Superstructure Diaphragms	Truss lateral brace strengthening	$ 500,000	/ Area identified	$ 375,000	$ 475,000
Morrison	Fixed River Spans	7	15	Truss Laterals	Truss lateral brace strengthening	$ 500,000	/ Area identified	$ 375,000	$ 475,000
Morrison	Fixed River Spans	8	16	Pit Span Bearing Seats	Seat Extender	$ 75,000	/ Bent	$ 56,000	$ 71,000
Morrison	Fixed River Spans	9	17	Deck Support Columns at Pit Span	Truss frame strengthening (increase member size)	$ 2,000,000	/ Area identified	$ 1,500,000	$ 1,900,000
Morrison	Moveable Spans	1	18	Superstructure bearings at bent caps	Isolation bearings	$ 500,000	/ Bearing	$ 375,000	$ 475,000
Morrison	Moveable Spans	2	19	Truss Diaphragms	Truss frame strengthening (increase member size)	$ 2,000,000	/ Area identified	$ 1,500,000	$ 1,900,000
Morrison	Moveable Spans	3	20	Bascule Truss Lateral Brace	Truss lateral brace strengthening	$ 500,000	/ Area identified	$ 375,000	$ 475,000
Morrison	Moveable Spans	4	21	Truss Bearing Anchor Bolts	Bearing replacement	$ 75,000	/ Bent	$ 56,000	$ 71,000
Morrison	Moveable Spans	5	22	Counterweight Braces	Truss frame strengthening (increase member size)	$ 2,000,000	/ Area identified	$ 1,500,000	$ 1,900,000
Morrison	Moveable Spans	6	23	Truss Lateral Support	Truss lateral brace strengthening	$ 500,000	/ Area identified	$ 375,000	$ 475,000
Morrison	Moveable Spans	7	24	Piers 2 and 3	Pier strengthening	$ 2,500,000	/ Pier	$ 1,875,000	$ 2,375,000
Morrison	East Approach	1	25	Footing	Footing strengthening (Standard footing)	$ 500,000	/ Footing	$ 375,000	$ 475,000
Morrison	East Approach	2	26	Footing	Footing strengthening (Standard footing)	$ -	/ Footing	$ -	$ -
Morrison	East Approach	3	27	Column	Column strengthening	$ 75,000	/ Column	$ 56,000	$ 71,000
Morrison	East Approach	4	28	Bent cap	Longitudinal restrainers	$ 100,000	/ Bent	$ 75,000	$ 95,000
Morrison	East Approach	5	29	Bent cap - Restrainers	Bent cap strengthening	$ 100,000	/ Bent	$ 75,000	$ 95,000
Morrison	East Approach	6	30	Superstructure Bearing at bent caps	Bearing replacement	$ 75,000	/ Bent	$ 56,000	$ 71,000
Morrison	East Approach	7	31	Superstructure Diaphragms	Girder Strengthening at Bearings	$ 75,000	/ Bent	$ 56,000	$ 71,000
Morrison	East Approach	8	32	Superstructure Girders	Girder Strengthening at Bearings	$ 75,000	/ Bent	$ 56,000	$ 71,000
Morrison	East Approach	9	33	In Span Hinge Restraints	Longitudinal restrainers	$ 100,000	/ Bent	$ 75,000	$ 95,000

Multnomah County CIP - Seismic

Vulnerability Form Descriptions matched to Standard Retrofit Types

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Bridge	Location	Vulnerability #	Count	Author's Description	Matched Standard description	cost for 1000 yr event		w/ 0.75 factor for 100 yr event	w/ 0.95 Factor for 500 yr event
Hawthorne	West Approach	1	1	Pile to cap connection	Footing strengthening (Standard footing)	$ 500,000	/ Footing	$ 375,000	$ 475,000
Hawthorne	West Approach	2	2	Spread footing	Footing strengthening (Standard footing)	$ 500,000	/ Footing	$ 375,000	$ 475,000
Hawthorne	West Approach	3	3	Abutment 3 Electrical Vault	Abutment strengthening (provide concrete built up connection at joint)	$ 100,000	/ Abutment	$ 75,000	$ 95,000
Hawthorne	West Approach	4	4	Connections - Bents columns to spread footings	Column strengthening	$ -	/ Column	$ -	$ -
Hawthorne	West Approach	5	5	Connections - Abutments to spread footings	Abutment strengthening (provide concrete built up connection at joint)	$ 100,000	/ Abutment	$ 75,000	$ 95,000
Hawthorne	West Approach	6	6	Bent columns	Column strengthening	$ 75,000	/ Column	$ 56,000	$ 71,000
Hawthorne	West Approach	7	7	Seat Widths	Seat Extender	$ 75,000	/ Bent	$ 56,000	$ 71,000
Hawthorne	West Approach	8	8	Cap Beams	Bent cap strengthening	$ 150,000	/ Bent	$ 113,000	$ 143,000
Hawthorne	Fixed River Spans	1	9	Bearings for Piers 1-4, 7	Isolation bearings	$ 500,000	/ Bearing	$ 375,000	$ 475,000
Hawthorne	Fixed River Spans	2	10	Superstructure pulling off Piers 1-4, 7	Transverse restraint (shear keys)	$ 75,000	/ Bent	$ 56,000	$ 71,000
Hawthorne	Fixed River Spans	3	11	Piles at Piers 1 & 7	Soil Densification	$ 7,000,000	/ Bridge Site (i.e West Side of Broadway Bridge)	$ 5,250,000	$ 6,650,000
Hawthorne	Fixed River Spans	4	12	Bottom Chord lateral bracing spans 1-4, 6	Truss lateral brace strengthening	$ 500,000	/ Area identified	$ 375,000	$ 475,000
Hawthorne	Fixed River Spans	5	13	Existing Piers	Pier strengthening	$ 2,500,000	/ Pier	$ 1,875,000	$ 2,375,000
Hawthorne	Moveable Spans	1	14	Bearings for Pies 5-6	Isolation bearings	$ 500,000	/ Bearing	$ 375,000	$ 475,000
Hawthorne	Moveable Spans	2	15	Superstructure pulling off Piers 5-6	Transverse restraint (shear keys)	$ 75,000	/ Bent	$ 56,000	$ 71,000
Hawthorne	Moveable Spans	3	16	Bottom Chord Lateral Bracing Span 5	Truss lateral brace strengthening	$ 500,000	/ Area identified	$ 375,000	$ 475,000
Hawthorne	Moveable Spans	4	17	Towers at Bents 5&6	**Unique -** Strengthen tower members	$ 8,000,000	/ Tower	$ 6,000,000	$ 7,600,000
Hawthorne	Moveable Spans	5	18	Existing Piers	Pier strengthening	$ 2,500,000	/ Pier	$ 1,875,000	$ 2,375,000
Hawthorne	East Approach	1	19	Columns	Column strengthening	$ 75,000	/ Column	$ 56,000	$ 71,000
Hawthorne	East Approach	2	20	Pile Cap Footings	Footing strengthening (Standard footing)	$ 500,000	/ Footing	$ 375,000	$ 475,000
Hawthorne	East Approach	3	21	Superstructure Seating on Pier 1	Longitudinal restrainers	$ 100,000	/ Bent	$ 75,000	$ 95,000
Hawthorne	East Approach	4	22	Superstructure Connection at Pier 1	Transverse restraint (shear keys)	$ 75,000	/ Bent	$ 56,000	$ 71,000
Hawthorne	East Approach	5	23	Superstructure Seating on Expansion Bent	Longitudinal restrainers	$ 75,000	/ Bent	$ 56,000	$ 71,000
Hawthorne	East Approach	6	24	Superstructure Seating on Bent 7M, 6W, 7H	Seat Extender	$ 75,000	/ Bent	$ 56,000	$ 71,000
Hawthorne	East Approach	7	25	Columns	Column strengthening	$ 75,000	/ Column	$ 56,000	$ 71,000
Hawthorne	East Approach	8	26	Pile cap footings	Footing strengthening (Standard footing)	$ 500,000	/ Footing	$ 375,000	$ 475,000
Hawthorne	East Approach	9	27	Superstructure Seating Abutments A1, A2, A3	Seat Extender	$ 75,000	/ Bent	$ 56,000	$ 71,000

Multnomah County CIP - Seismic

Standard and Unique Retrofit Descriptions and Unit Costs

By: TCA	**5/20/2014**
Checked: KPBU	5/21/2014

Retrofit Description	*Bridge*	*construction activities*	*Notes*	*Total*	*Unit*
Abutment strengthening (provide concrete built up connection at joint)		•Create access for work area		$ 100,000	/ Abutment
		•Dowel in new rebar at abutment to superstructure connection, form and pour concrete build up sections			
		•Allow concrete to cure before project clean up			
Bearing replacement		•Create access for work area		$ 75,000	/ Bent
		•Jack superstructure and provide temporary supports for dead load			
		•Remove and replace or strengthen existing bearing			
		•Lower superstructure and remove temporary supports			
Bent cap strengthening		•Create access for work area		$ 150,000	/ Bent
		•Remove existing concrete by hammer or drill, leaving existing rebar exposed			
		•Dowel or tie new flexural and shear reinforcement, form and pour concrete over rebar	Assumes cap build-up with post tensioning		
		•Allow concrete to cure before project clean up			
		•Provide post tensioning of bent cap			
Column strengthening		•Create access for work area including column tops		$ 75,000	/ Column
		•At connections, remove existing concrete from column by hammer or drill, leaving rebar exposed			
		•At connections, dowel or tie new flexural and shear reinforcement, form and pour concrete over rebar	Assumes connection detail modifications at top and bottom of column.		
		•Place steel jacket around the column and weld seam to seal enclosure	Assumes steel jacketing used as primary strengthening measure.		
		•Pour concrete filler between existing column surface and jacket to close void			
		•Allow concrete to cure before project clean up			
Footing strengthening (standard footing)		•Isolate work area from traffic or temporary road closure		$ 500,000	/ Footing
		•Excavate area around footing and provide shoring as needed			
		•Remove deteriorated existing concrete from footing by drill or hammer, leaving rebar exposed	Assumed to have tight work areas		
		•Dowel or tie in additional flexural and shear rebar, form and pour new footing	Assumed for footings on land.		
		•Place new deep foundation members (micro-piles, drilled shafts, piles)			
		•Place new reinforcing cage and concrete			
		•Allow concrete to cure before project clean up			

Multnomah County CIP - Seismic

Standard and Unique Retrofit Descriptions and Unit Costs

By: TCA	**5/20/2014**
Checked: KPBU	5/21/2014

Retrofit Description	*Bridge*	*construction activities*	*Notes*	*Total*	*Unit*
Footing strengthening (Major Footing)		•Create isolated work area around foundation with cofferdam and dewater		$ 2,000,000	/ Pier
		•Create access to the foundation location by work bridge, barge, or other measures			
		•Remove deteriorated existing concrete from footing by drill or hammer, leaving rebar exposed	Assumed for footings in river		
		•Excavate area around footing and provide shoring as needed			
		•Drill and dowell into existing foundation			
		•Place new deep foundation members (micro-piles, drilled shafts, piles)			
		•Place new reinforcing cage and concrete			
		•Allow concrete to cure before project clean up			
Girder Strengthening at Bearings		•Create access for work area		$ 75,000	/ Bent
		•Install additional diaphragms or stiffeners to girders			
Isolation bearings		•Create access for work area		$ 500,000	/ Bearing
		•Jack superstructure and provide temporary supports for dead load			
		•Remove and replace existing bearing with isolation bearing	These assume large bearings for truss supports.		
		•Lower superstructure and remove temporary supports			
Lateral Restrainers (Bascule)		•Create access for work area		$ 200,000	/ Location (counterweight , toe, etc.)
		•Install lateral restraining devices alongside bascule or lift portions of bridge	Assumed to include counterweight restraints, toe restraints, or heal restraints.		
Longitudinal restrainers		•Create access for work area		$ 125,000	/ Bent
		•Install transverse shear keys			
		•Install retrainer cable connections to girders and bent cap, install restrainer cable with recommended minimum sag	Assumed to also include transverse shear keys in most locations		
Pier strengthening		•Create access to the pier location by work bridge or barge.		$ 2,500,000	/ Pier
		•Isolate work area river using cofferdams			
		•Install additional anchor bolts where needed	Assumed to be pier in water		
		•drill and dowel additonal reinforcing into pier			
		•Place concrete encasement/strengthening around pier			
Soil Densification		•Create access to work area		$ 7,000,000	/ Bridge Site (i.e West Side of Broadway Bridge)
		•Provide soil densification via injection grouting, stone columns, or other method	Assumed area is large enough to provide support of bridge foundations under large lateral spreading movement or liquifaction		
Seat Extender		•Create access to work area		$ 75,000	/ Bent
		•Furnish and install new seat extender (concrete seat extenders require doweling of new rebar, steel extenders require new anchorage such as steel rods)			
Transverse restraint (Shear Keys)		•Create access for work area		$ 75,000	/ Bent
		•Install transverse shear keys	Assumed to be in areas where longitudinal restrainers are not needed.		

Multnomah County CIP - Seismic

Standard and Unique Retrofit Descriptions and Unit Costs

By: TCA	**5/20/2014**
Checked: KPBU	5/21/2014

Retrofit Description	*Bridge*	*construction activities*	*Notes*	*Total*	*Unit*
Truss frame strengthening (increase member size)		•Create access to the truss location		$ 2,000,000	/ Area identified
		•Support adjacent connecting members and superstructure temporarily			
		•Remove and replace or build up deficient truss member	Cost is per area identified (ie frame around counterweight, portal frames,etc)		
Truss lateral brace strengthening		•Create access to the truss location		$ 500,000	/ Area identified
		•Support adjacent connecting members and superstructure temporarily			
		•Remove and replace or build up deficient truss member			
Unique - Broadway Large Steel Column Retrofit	BW	•Create access for work area including column tops	Assumes connection detail modifications at top and bottom of column.	$ 500,000	/ Column
		•Place steel jacket around the column and weld seam to seal enclosure			
		•At connections, dowel or tie new flexural and shear reinforcement, form and pour concrete over rebar			
		•Install braces between columns			
Unique - Strengthen or replace anchor struts	BW	•Create access to the moveable span anchor strut location by scaffolding or other measures		$ 500,000	/ Anchor Strut
		•Remove and replace existing anchor strut with stronger, stiffer member			
Unique - Install transverse braces to trunnion support posts	BU	•Create access to the trunnion location by scaffolding or other measures		$ 1,000,000	/ Location
		•Install traverse braces to trunnions (steel bumpers, additional anchorages doweled into trunnion cap)			
Unique - Install steel strut to counterweight link	BU	•Create access to the counterweight and counterweight link location by scaffolding or other measures		$ 500,000	/ Leaf
		•Furnish and install steel strut to restrain longitudinal movement of the counterweight			
Unique - Provide additional floorbeam bracing	BU	•Create access to the floorbeam location by scaffolding or other measures		$ 100,000	/ Location
		•Isolate work area from traffic or temporary road closure			
		•Furnish and drill new brace connection plates, then install new braces			
Unique - Strengthen Trunnion Beam and Supports	MO	•Create access to the tower location by scaffolding or other measures		$ 1,500,000	/ Leaf
		•Support adjacent connecting members temporarily			
		•Place steel, concrete, and post tensioning to strengthen trunnion beam.			
		•Strengthen trunnion towers			
Unique - Strengthen tower members	HA	•Create access to the tower location by scaffolding or other measures		$ 8,000,000	/ Tower
		•Support adjacent connecting members temporarily			
		•Remove/replace and strengthen deficient tower members			
		•Install dampening devices			
		•Isolate work area from traffic or temporary road closure			

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Attachment D

Probabilistic Seismic Hazard Plots

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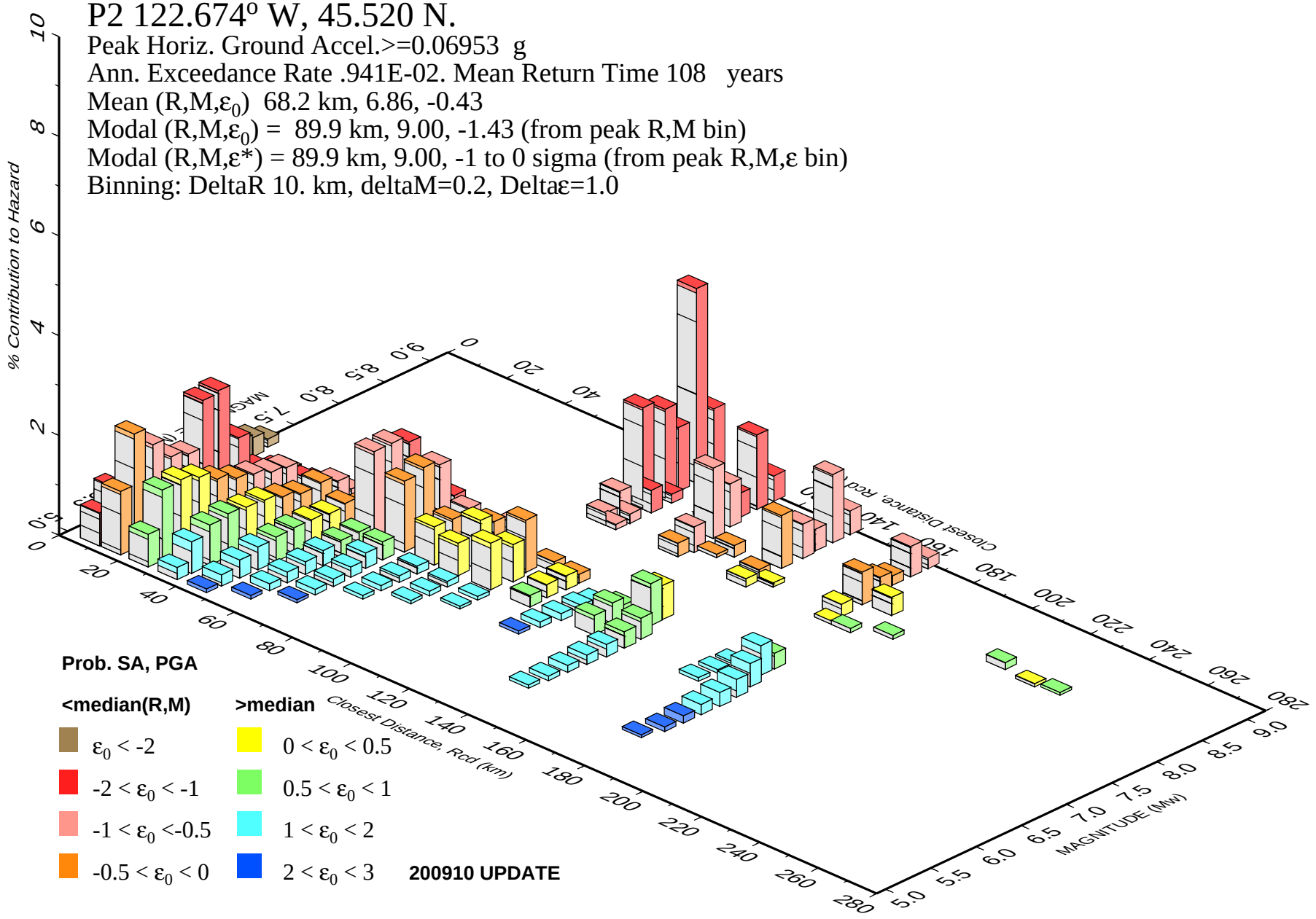
PSH Deaggregation on NEHRP BC rock

P2 122.674º W, 45.520 N.

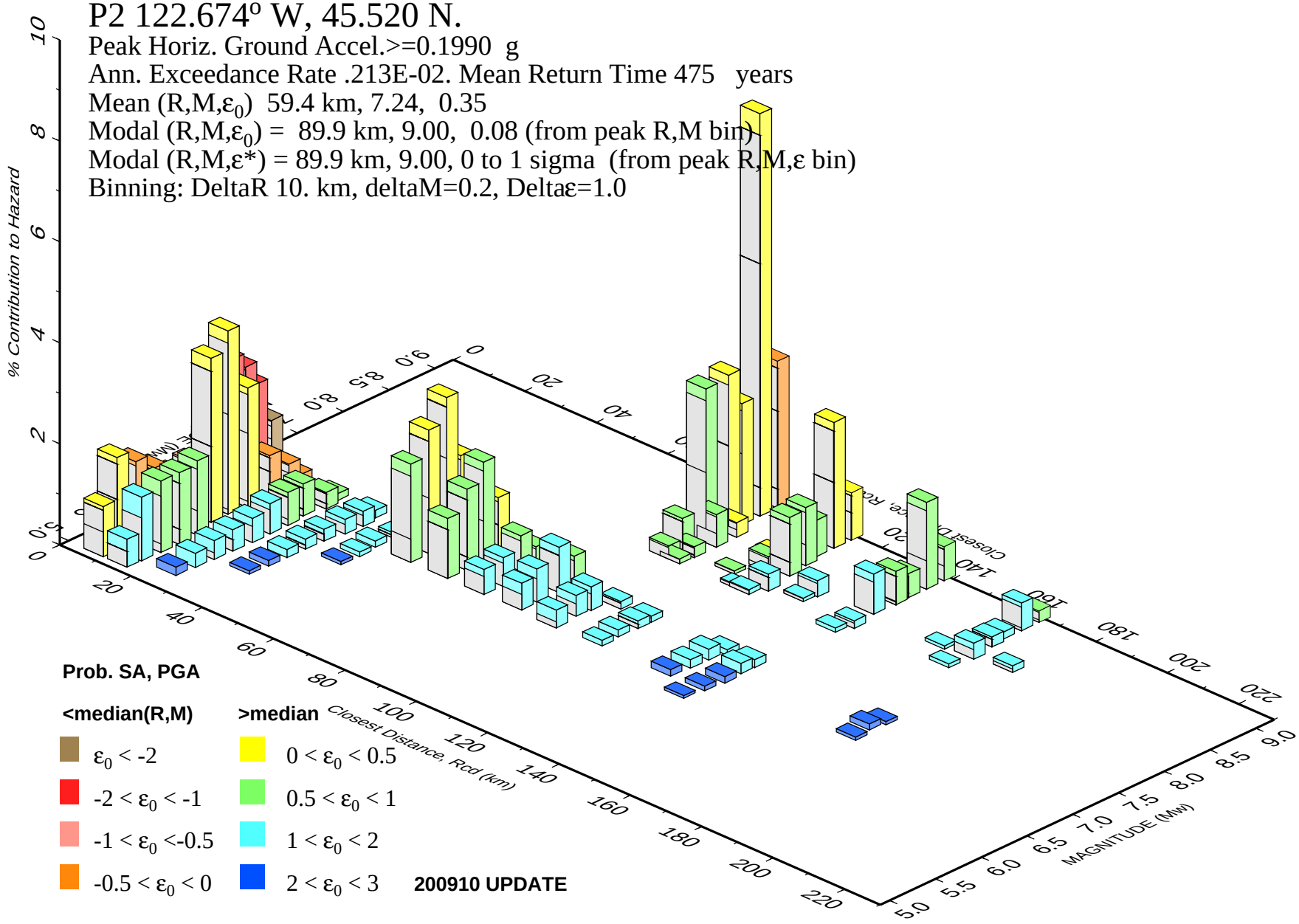
Peak Horiz. Ground Accel.>=0.06953 g
Ann. Exceedance Rate .941E-02. Mean Return Time 108 years
Mean (R,M,ε_0) 68.2 km, 6.86, -0.43
Modal (R,M,ε_0) = 89.9 km, 9.00, -1.43 (from peak R,M bin)
Modal (R,M,ε*) = 89.9 km, 9.00, -1 to 0 sigma (from peak R,M,ε bin)
Binning: DeltaR 10. km, deltaM=0.2, Deltaε=1.0



PSH Deaggregation on NEHRP BC rock

P2 122.674º W, 45.520 N.

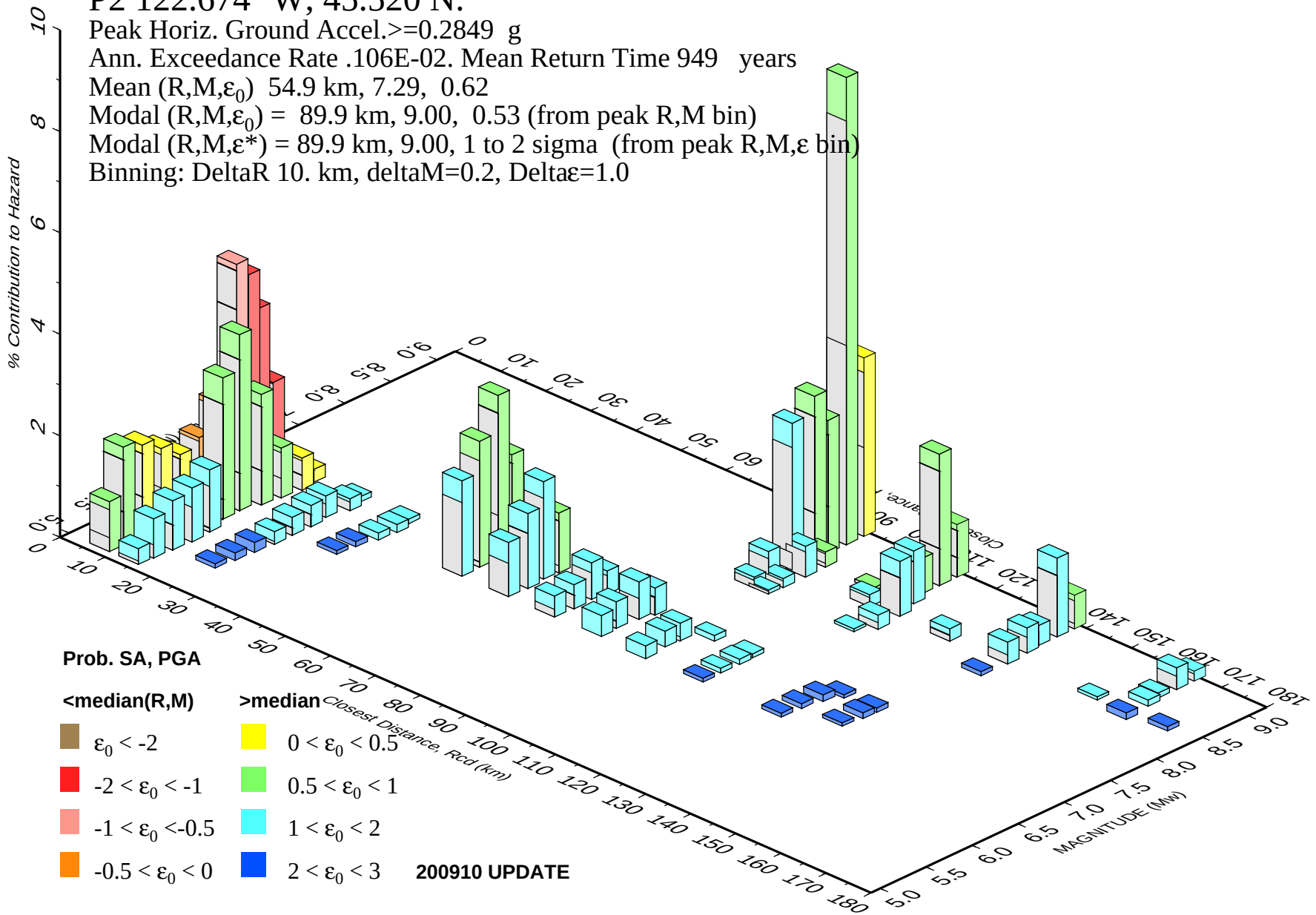
Peak Horiz. Ground Accel.>=0.1990 g
Ann. Exceedance Rate .213E-02. Mean Return Time 475 years
Mean (R,M,ε_0) 59.4 km, 7.24, 0.35
Modal (R,M,ε_0) = 89.9 km, 9.00, 0.08 (from peak R,M bin)
Modal (R,M,ε*) = 89.9 km, 9.00, 0 to 1 sigma (from peak R,M,ε bin)
Binning: DeltaR 10. km, deltaM=0.2, Deltaε=1.0



PSH Deaggregation on NEHRP BC rock

P2 122.674º W, 45.520 N.

Peak Horiz. Ground Accel.>=0.2849 g
Ann. Exceedance Rate .106E-02. Mean Return Time 949 years
Mean (R,M,ε_0) 54.9 km, 7.29, 0.62
Modal (R,M,ε_0) = 89.9 km, 9.00, 0.53 (from peak R,M bin)
Modal (R,M,ε*) = 89.9 km, 9.00, 1 to 2 sigma (from peak R,M,ε bin)
Binning: DeltaR 10. km, deltaM=0.2, Deltaε=1.0



Oregon Department of Transportation - **Bridge Section**

Project Name:	Multnomah County WRBs CIP	***Key Number:***	
Highway:	N/A	***Milepost:***	
Structure:	Multiple (Used coordinates from Morrison Bridge)	***Structure No.***	
County:	Multnomah		
Designer:	Drahota		

Sunday, November 09, 2014

Existing Bridge - Seismic Retrofit

EQ Return Period

M9.0 CSZE vs. 500-Year EQ

LATITUDE	LONGITUDE
45.5178	-122.6696
(42°00' to 46°15')	(-116°45' to -124°30')

USGS Seismic Design Tool 2002 Interactive Deag

HELP

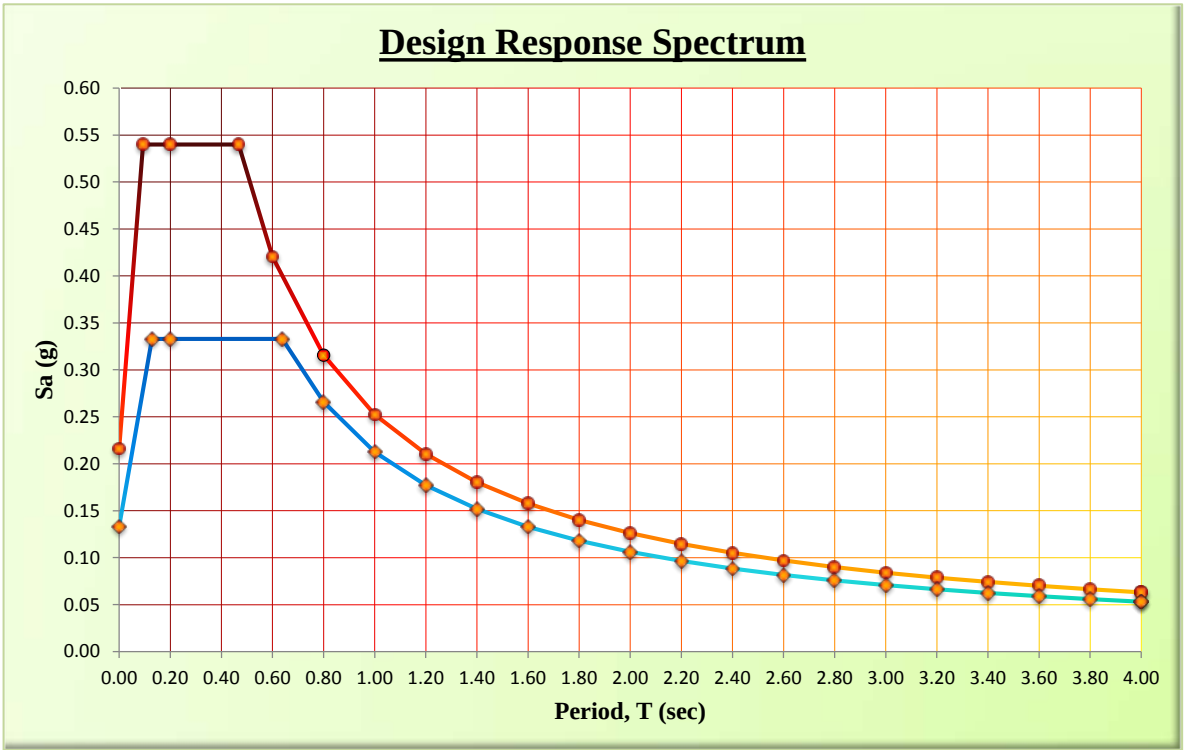
MAP YOUR BRIDGE!

2002 USGS Seismic Hazard Data

Site Class	PGA (g)	S_s (g)	S_1 (g)	F_{pga}	F_a	F_v	A_s (F_{pga}*PGA	S_{DS} (F_a*S_s)	S_{D1} (F_v*S_1)	SDC	$T_S=S_{D1}/S_{DS}$	$T_O=0.2*T_S$
C	0.1914	0.4500	0.1533	1.2000	1.2000	1.6467	0.2297	0.5401	0.2524	III	0.47	0.09
	0.1358	0.2775	0.1271	1.2000	1.2000	1.6729	0.1629	0.3330	0.2126		0.64	0.13

500-Year EQ

Period, T (sec)	S_a (g)
0.00	0.2160
0.09	0.5401
0.20	0.5401
0.47	0.5401
0.60	0.4207
0.80	0.3155
1.00	0.2524
1.20	0.2103
1.40	0.1803
1.60	0.1578
1.80	0.1402
2.00	0.1262
2.20	0.1147
2.40	0.1052
2.60	0.0971
2.80	0.0901
3.00	0.0841
3.20	0.0789
3.40	0.0742
3.60	0.0701
3.80	0.0664
4.00	0.0631
4.00	0.0631



M9.0 CSZE

T (sec)	Sa (g)
0.00	0.1332
0.13	0.3330
0.20	0.3330
0.64	0.3330
0.80	0.2658
1.00	0.2126
1.20	0.1772
1.40	0.1519
1.60	0.1329
1.80	0.1181
2.00	0.1063
2.20	0.0966
2.40	0.0886
2.60	0.0818
2.80	0.0759
3.00	0.0709
3.20	0.0664
3.40	0.0625
3.60	0.0591
3.80	0.0559
4.00	0.0532
4.00	0.0532
4.00	0.0532

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