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SR 519 Design Build Project

Atlantic Street Ramp Innovative Design

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Design Build - Project Partners

Washington State Department of Transportation

SDOT
Seattle Department of Transportation

Kiewit

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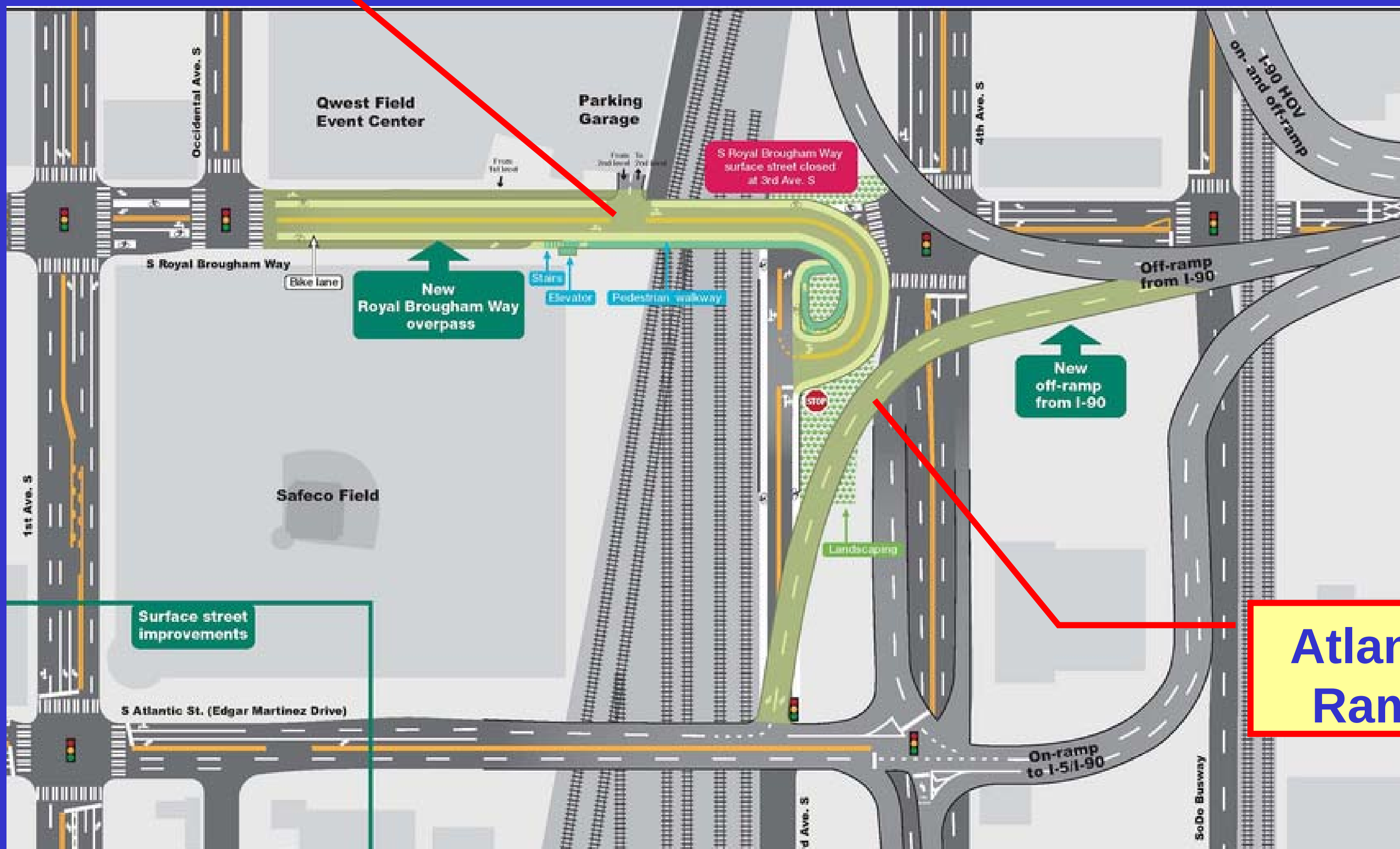
Project Delivery Method – Allowed for Innovations

Project Overview

RBW Bridge



Atlantic Ramp

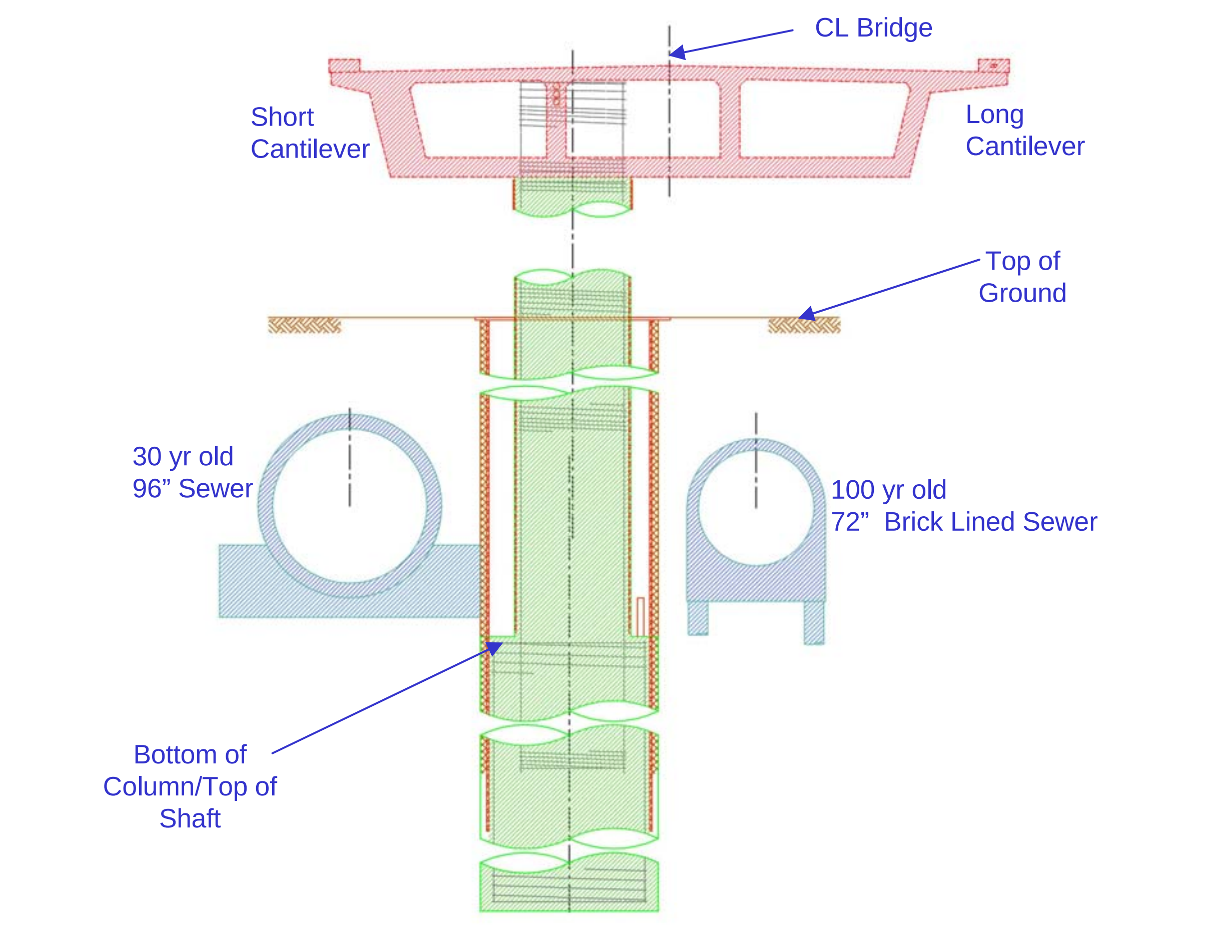
Project Schedule

- Bid Design – June/July 2008 (6 weeks)
- Begin Final Design – October 2008
- Complete All Major Design Elements – July 2009
- Open to Traffic – RBW Winter 2010, A. Ramp June 2010

RBW – Design Innovations

Preliminary Design	Innovative Approach	Benefit
Steel Superstructure	Concrete Superstructure	Less Maintenance/Lower Cost
Bridge for West Approach	Geofoam Fill	Less Maintenance/Lower Cost
Asymmetrical Piers	Asymmetrical Box/Thickened Web	Better Balanced Structure
6 foot columns with Crash Walls	Stretch Columns to 30 sf	No Crash Walls/Keep RBW Open to Traffic
Steel Superstructure over BNSF	Pre-cambered PS Girders over BNSF	No Future Painting over BNSF/Lower Cost
Ground Improvement and Fill at East Approach	Geofoam Fill	Less Risk/Lower Cost

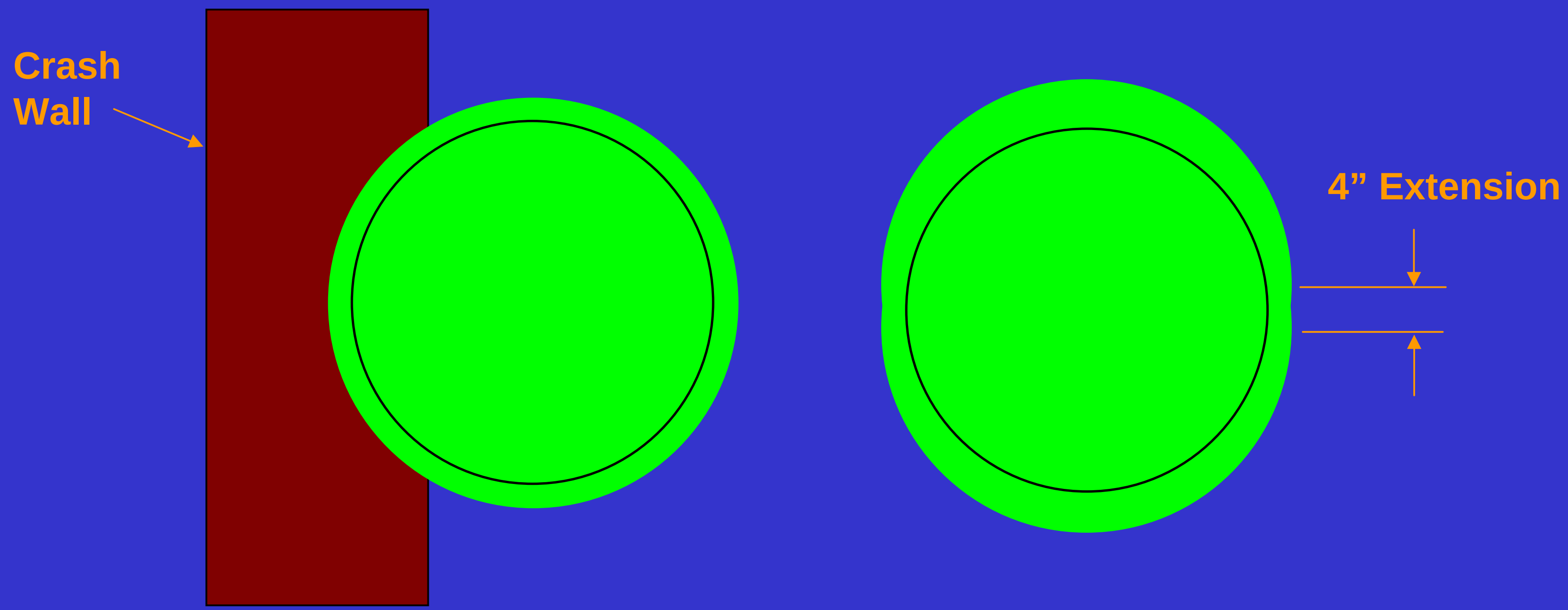
RBW – Asymmetrical Piers



RBW – Pre-Cambered WF Girders

- First Pre-cambered highway girders in Washington
- Limited Structural Depth – Girders must following roadway profile

RBW – Piers 3 & 4 Columns
15 feet from C.L. BNSF Tracks



6’ diameter shaft = 28 sf
Requires Crash Walls

6’ diameter shaft with
4” extension = 30 sf
No Crash Walls

Atlantic Ramp – Design Innovations

Preliminary Design	Innovative Approach	Benefit
Steel Superstructure	Concrete Superstructure	Less Maintenance/Lower Cost
12 foot Conventionally Drilled Shafts	10 foot Oscillated Shafts	Less Risk/Faster/Lower Cost
6 foot Standard Columns	7 foot Reduced Moment Section (RMS) Columns	Less EQ Load to Shafts/7 foot Columns/Less Shaft Cost
Standard Fixed Closure at Existing Bridge	Seismic Fuse at Existing Bridge	Less Risk to Existing Bridge/Concrete Superstructure

Bridge Layout

- ❖ Post-tensioned, CIP concrete box girder
- ❖ 5 Spans: 177’ – 221’ – 241’ – 276’ – 211’
- ❖ Total Structure length = 1155’
- ❖ Tie into WB I90 (north)
- ❖ Tie into EMW (south)

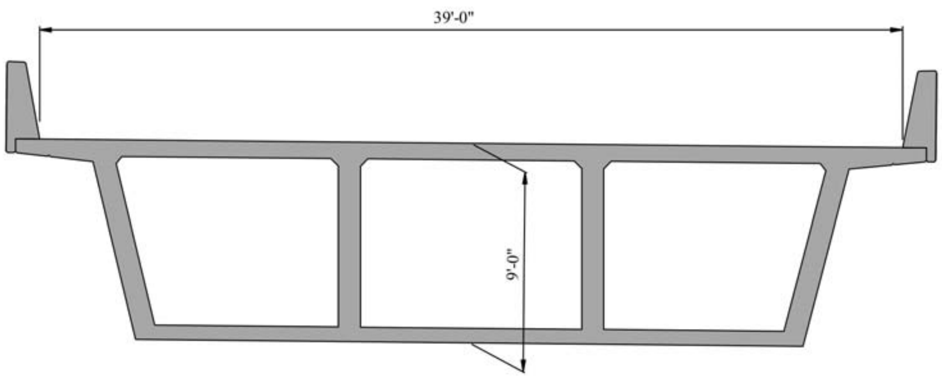
Cross Section

❖ 9’ deep box girder

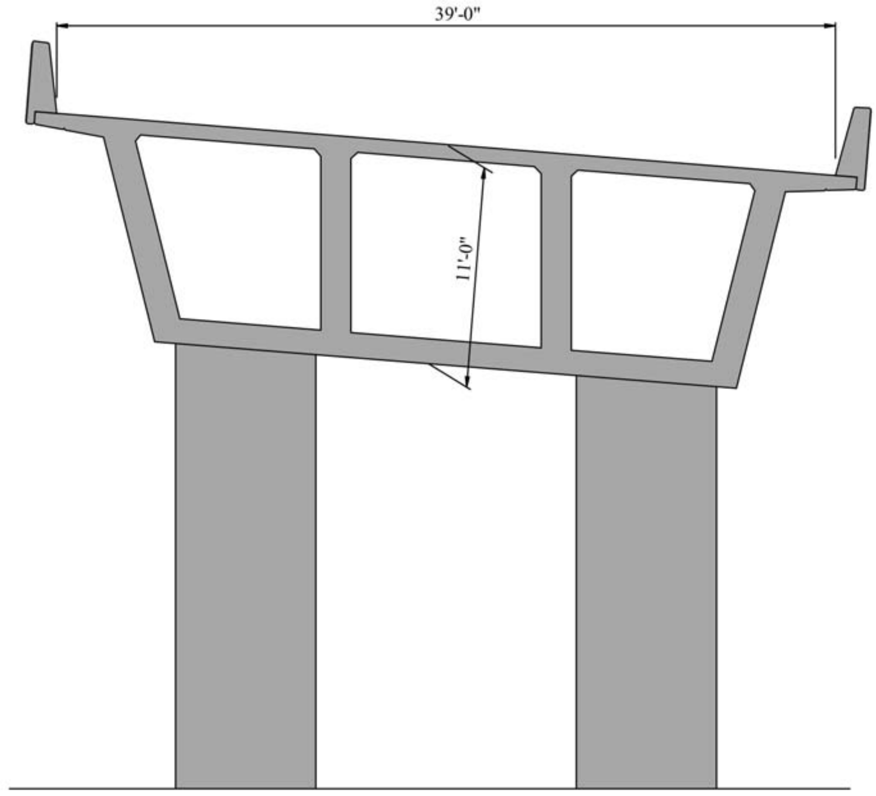
❖ 50’ length haunched girders to 11’ deep box girder at piers

❖ 7’ columns typical

❖ 6’ column at pier 6



TYPICAL SECTION



SECTION AT PIER

Drilled Shafts

- 10' drilled shafts (8' at Pier 6)
- Constructed using oscillator method

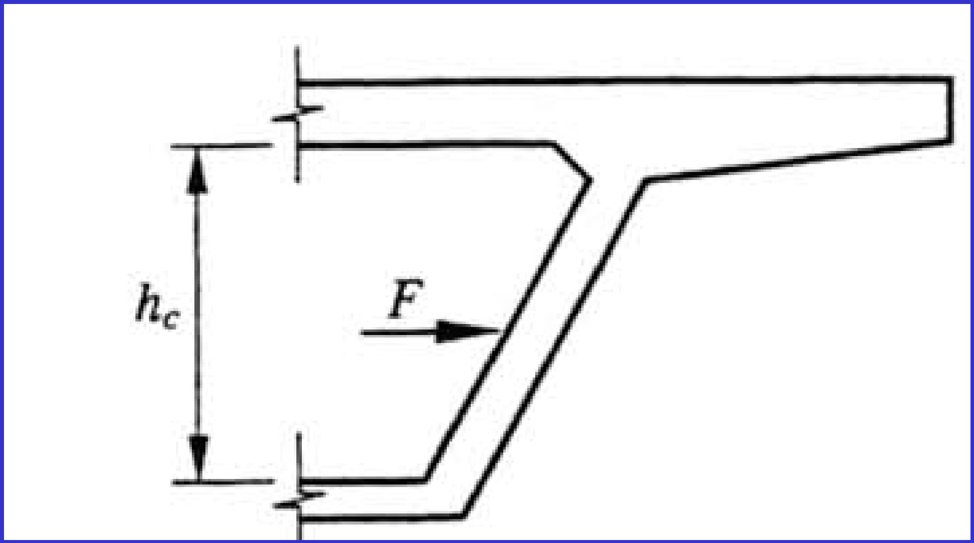
Drilled Shafts

❖ Pier 6 construction constraints

Web Design Due to Horizontal PT

❖ Caltrans' Practice

1. Check regional bending

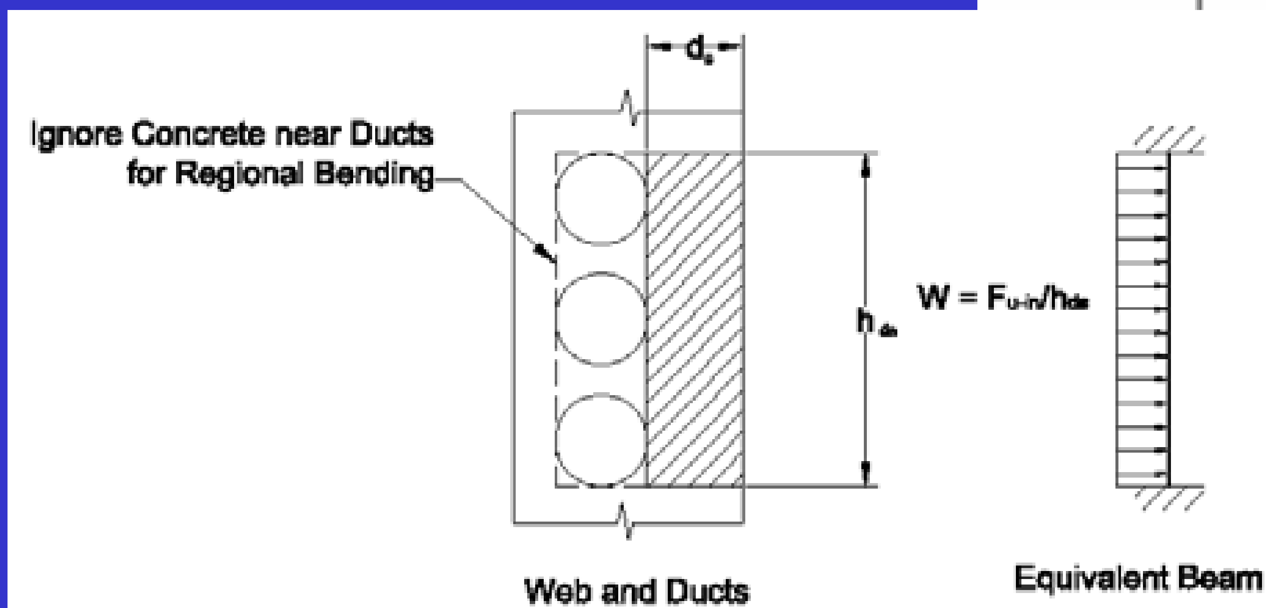


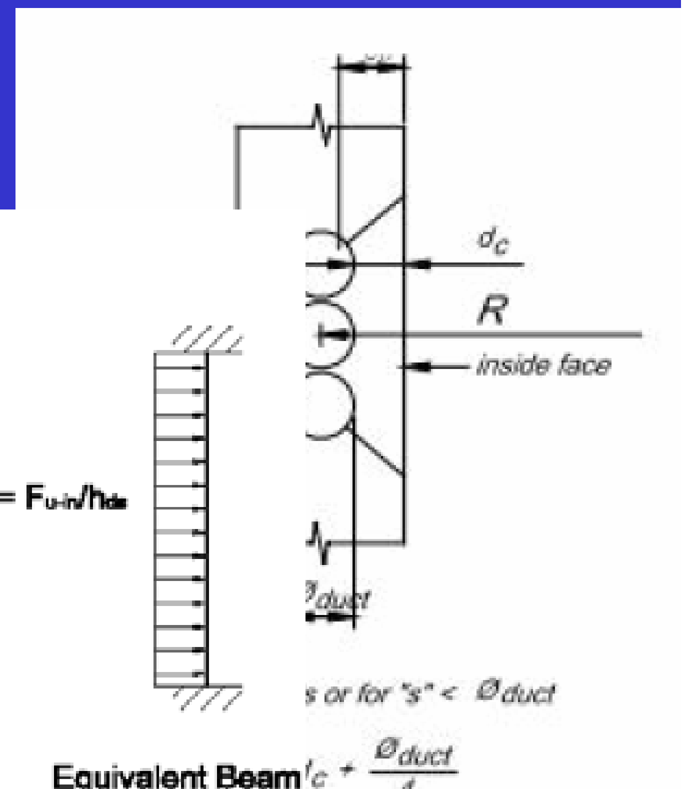
2. Stresses induced by shear and regional bending are not additive

Web Design Due to Horizontal PT

❖ NCHRP Report 620

1. Shear resistance to pullout
2. Cracking of concrete cover





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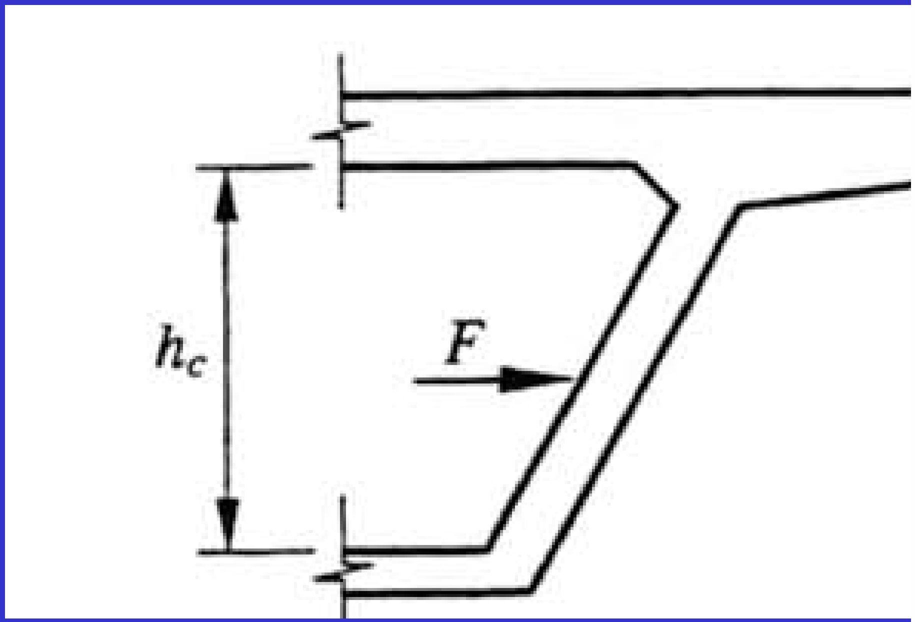
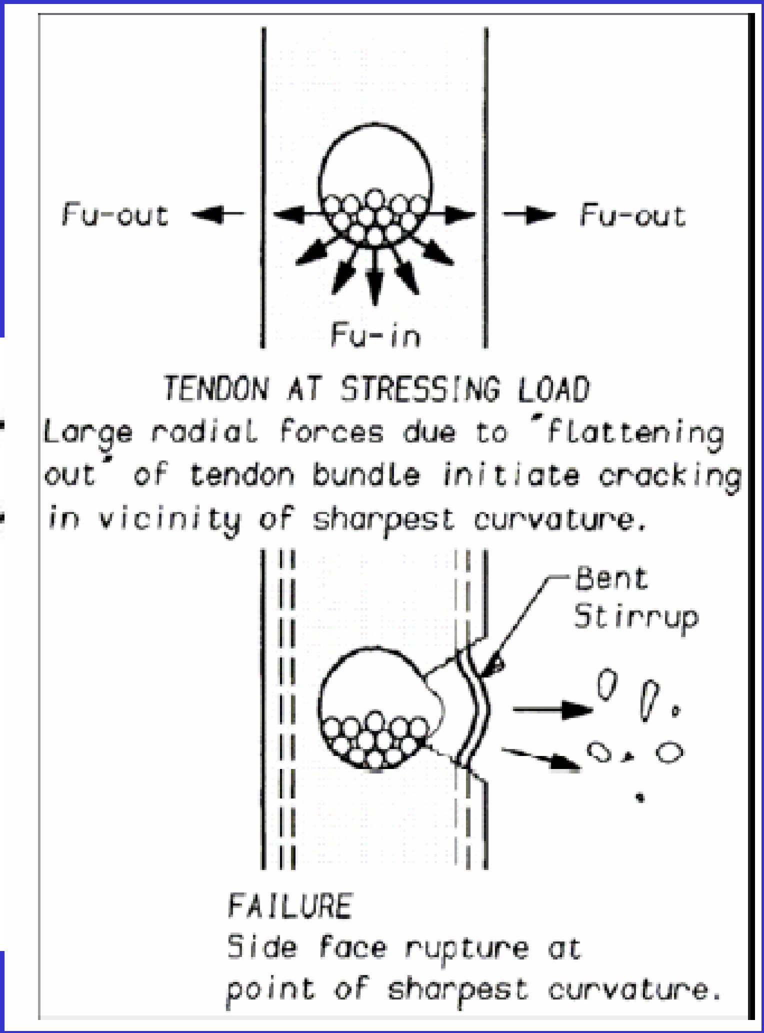
Web Design Due to Horizontal PT

- ❖ NCHRP Report 620
  3. Regional bending
  4. Out of plane force effect

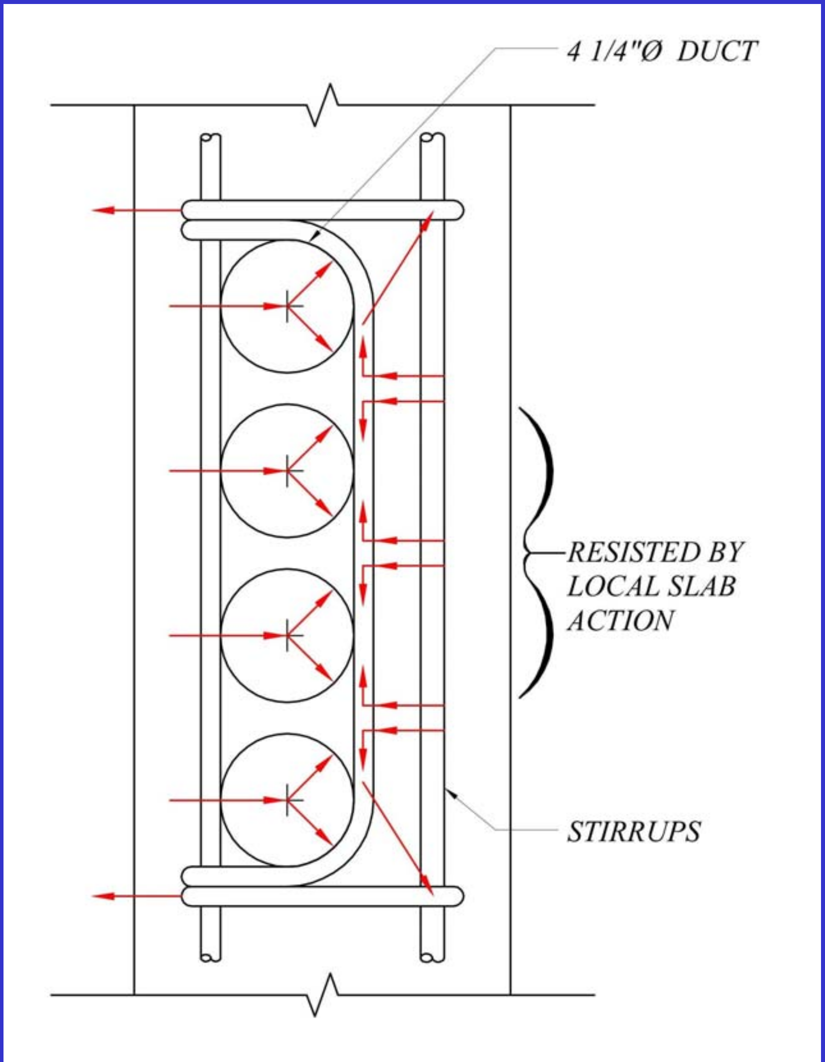




Web Confinement Reinf. Design

Strut-and-tie method

When sizing the web stirrups, the effect of regional bending should be added to the effect of global flexural and torsion shear



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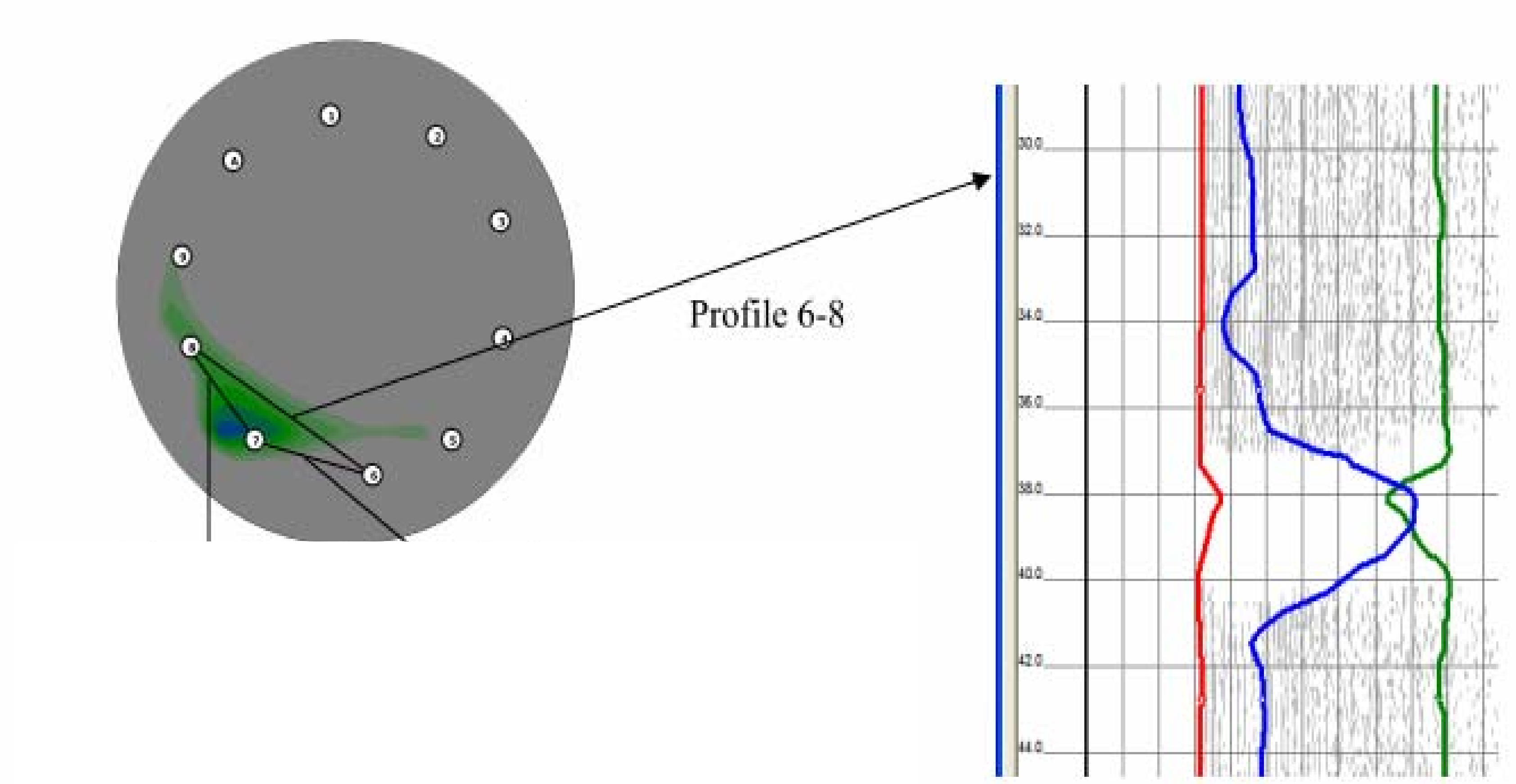
Construction Issues

- ❖ Shaft anomaly detected with CSL
- ❖ Repair procedure: 5” cored holes with rebar



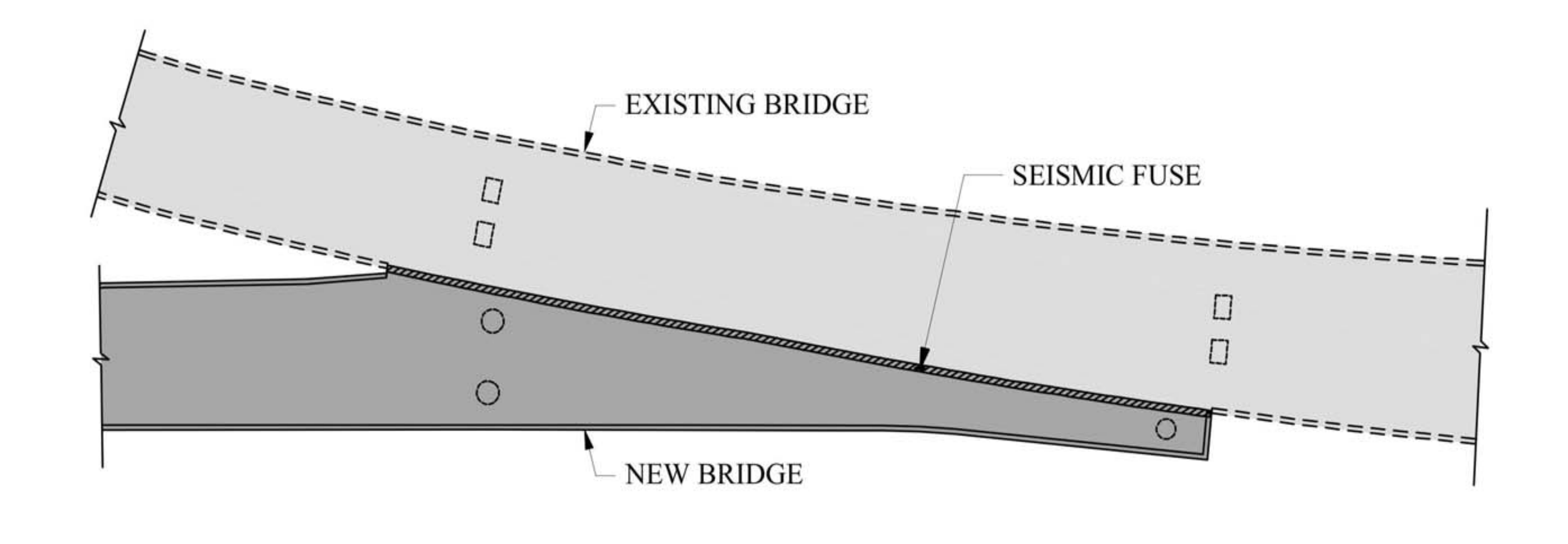
Construction Issues

❖ Pier 1 – relocated shaft

Construction Issues

❖ Span 5 constructed over Sound Transit LR power line

Seismic Fuse – *Introduction*

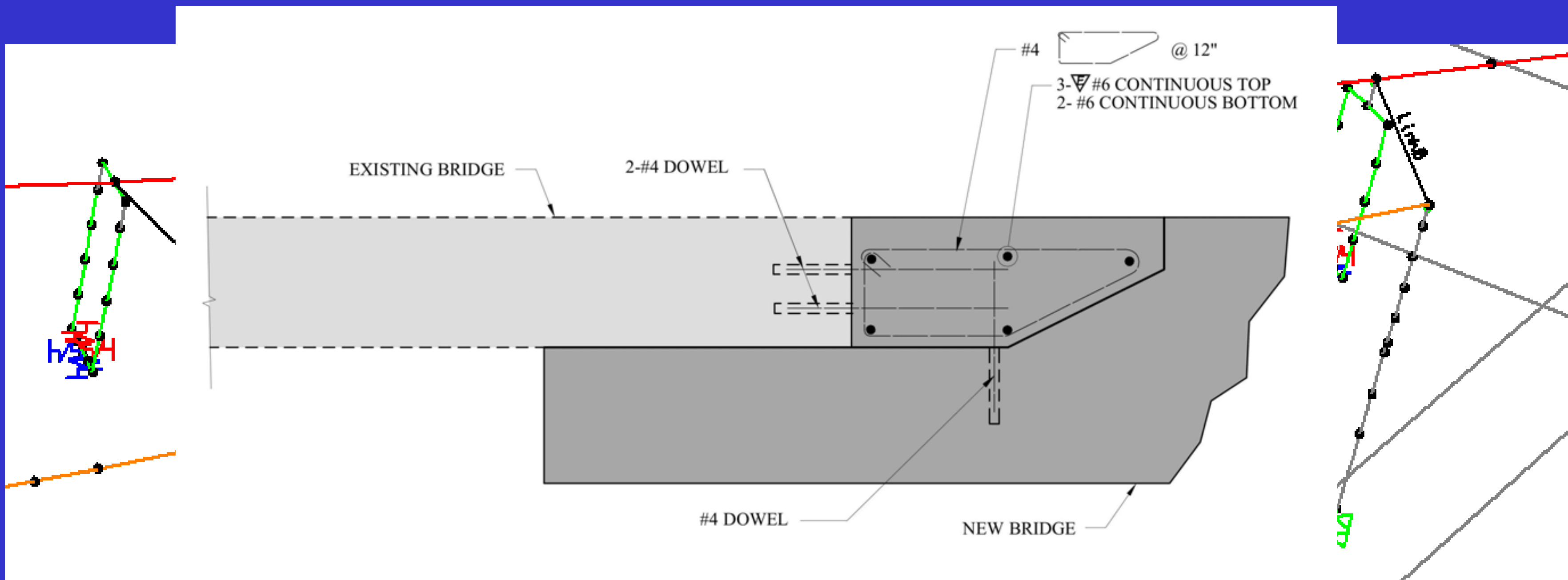


- 2ft wide and 250 ft long connecting existing I90 off ramp and proposed Atlantic ramp;
- different from conventional expansion joint to improve traffic safety, especially for motorcycles;

Seismic Fuse – *Design Philosophy*

1. Service condition – combined structures behave as a unit
2. Seismic condition – before more than 5% seismic demands transferred from new structure to existing structure, combined structure separate and behave independently

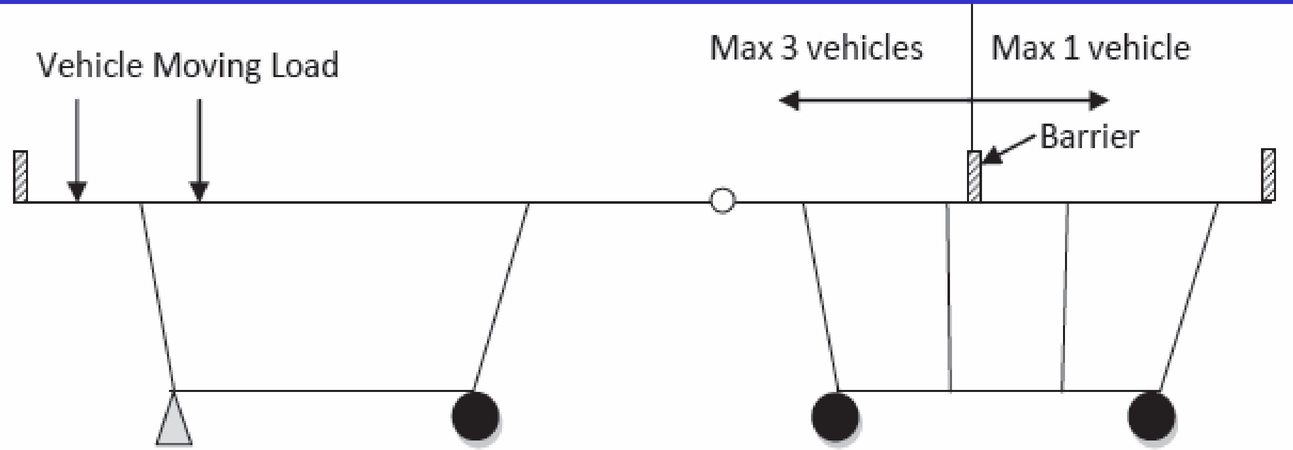
<u>Seismic Fuse – *Link Modeling*</u>



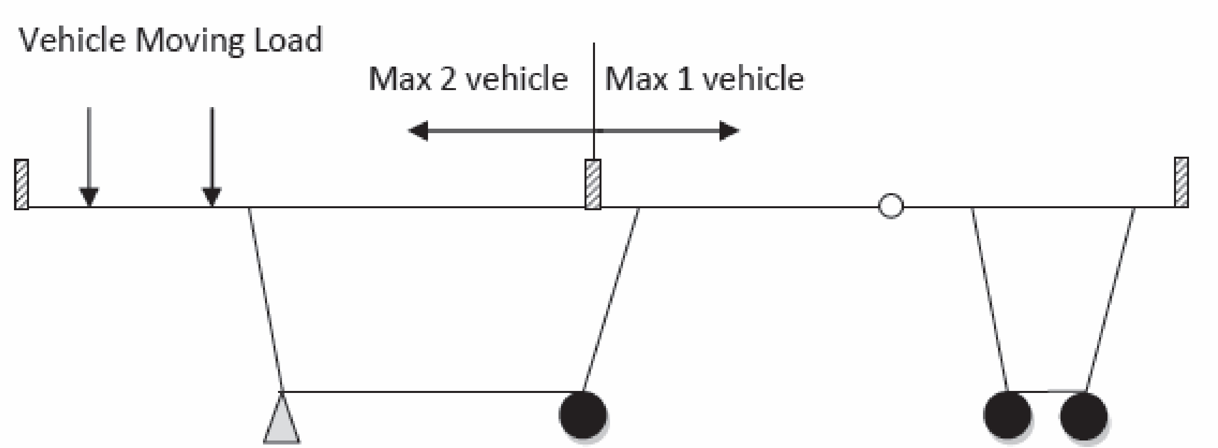
<u>Seismic Fuse Details</u>

- ❖ Linear elastic links at 20ft ± spacing to represent seismic fuse
- ❖ Stiffness determined in each directions

Moving Vehicle Loading – Local Analysis

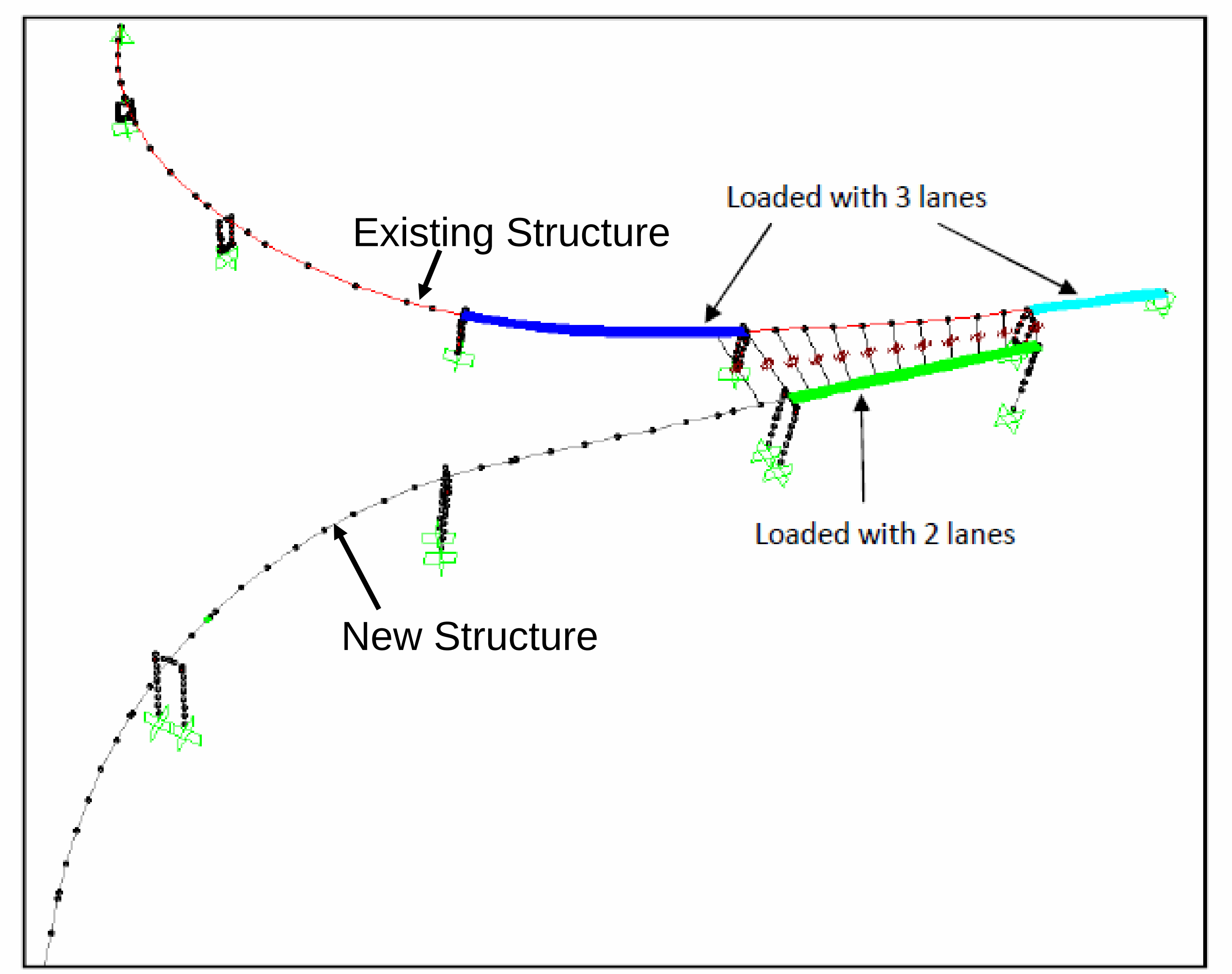


At Beginning Section



At End Section

Moving Vehicle Loading – Global Analysis



Seismic Fuse – *Seismic Analysis*

- linear elastic response spectrum analysis can capture the displacement resulting from inelastic response of a bridge;
- link forces are determined by the relative displacement between the two structures;
- Response spectrum input at every 15º due to highly curved geometry
- Foundation stiffness envelop both soft foundation case (liquefied soil + 0.85f'c) and stiff foundation (non-liquefied soil + 1.50f'c) case as per BDM requirements

Seismic Fuse –*Capacity*

- Similar to shear key concept at abutment, seismic fuse is a sacrificial element;
- Recent seismic events have shown that shear key capacity are underestimated if determined by current codes;
- Recent research by UCSD was adopted

$$V_o = \phi_o \bar{V}_n = \frac{\phi_o(\bar{\mu}_f \cos\bar{\alpha} + \sin\bar{\alpha})A_{vf}\left(\frac{\bar{f}_{su}}{\bar{f}_y}\right)\bar{f}_y}{1 - \bar{\mu}_f \tan\beta}$$

which is equivalent to 1.48 $A_{vf}\, f_{ye}$;

Seismic Fuse –*Conclusions*

- ❖ More dowels are needed at the end segments to meet the service requirements;
- ❖ Seismic fuse will break off at 75%± of the current earthquake design magnitude;
- ❖ With the seismic fuse's "protection", the additional displacement imposed to the existing I-90 off ramp from the proposed Atlantic Ramp can be controlled within 5%;

Reduced Moment Section –*Concepts*

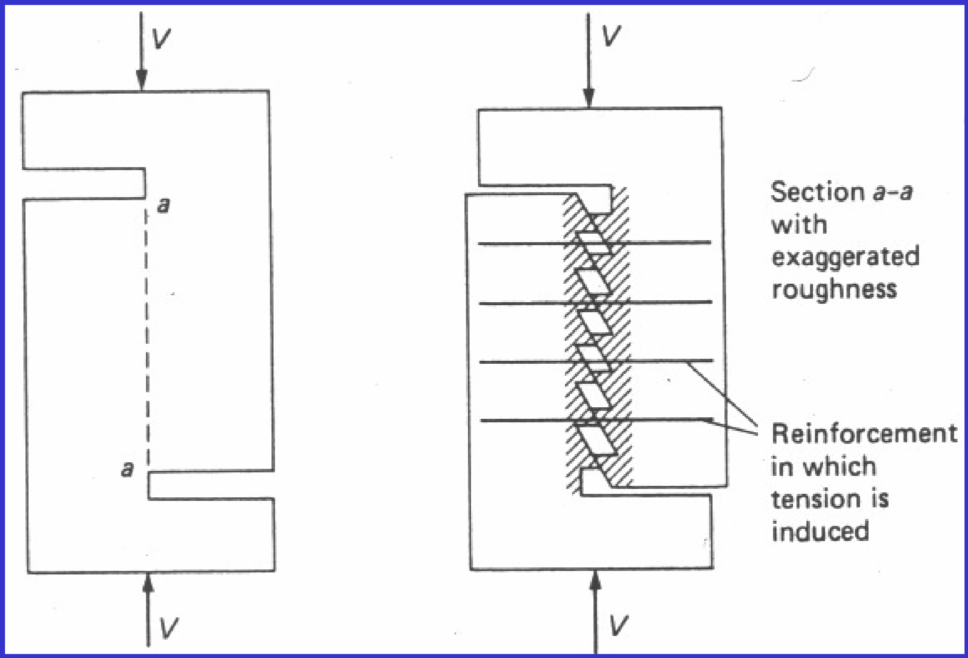
- Reduce demands to the capacity-protected member – drilled shaft under seismic condition

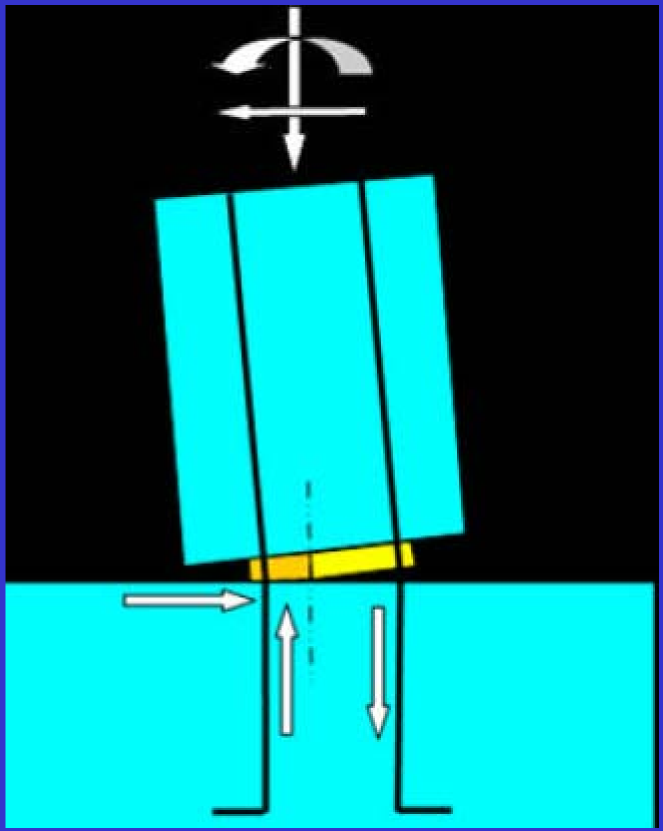
- Maintain continuity between column and drilled shaft under service condition

- Different from typical two-way hinges used in California

Reduced Moment Section –Shear *Design*

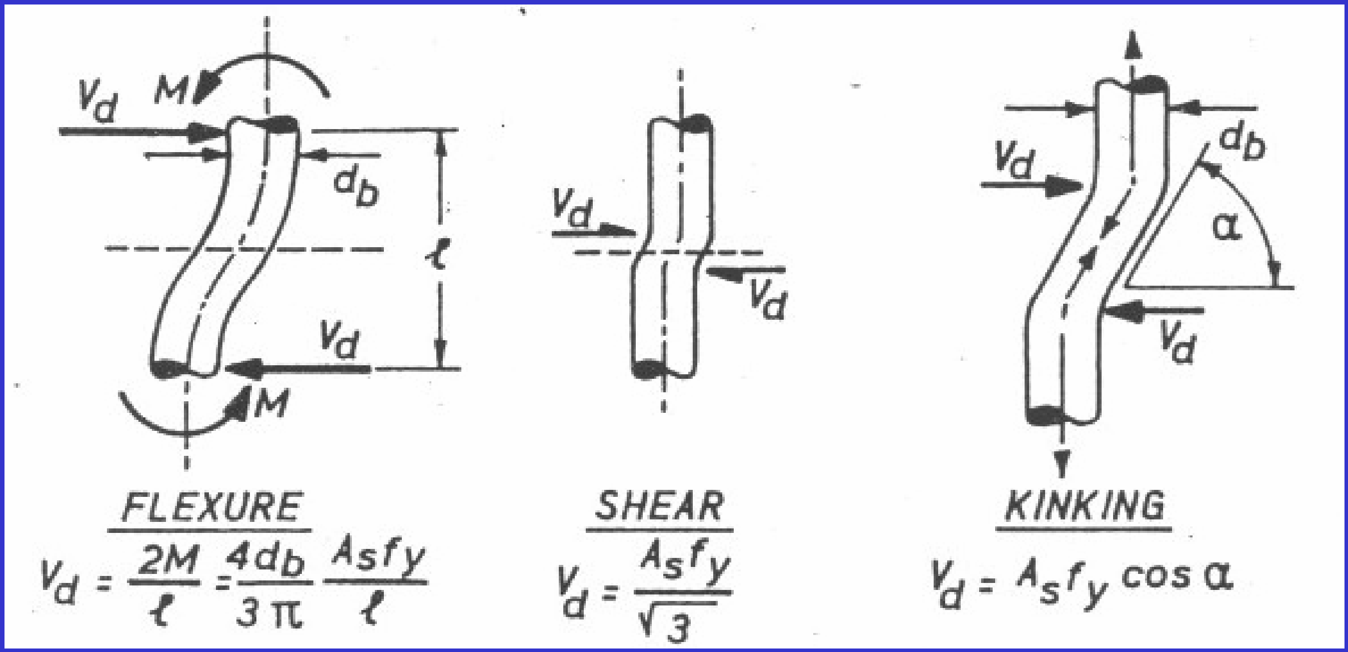
- Conventionally shear friction method may not valid due to extensive flexural cracks *(after UNR report)*





Reduced Moment Section –Shear *Design*

❖ Research done by UNR on two-way hinges



$V_n = \mu(P + T_s)$

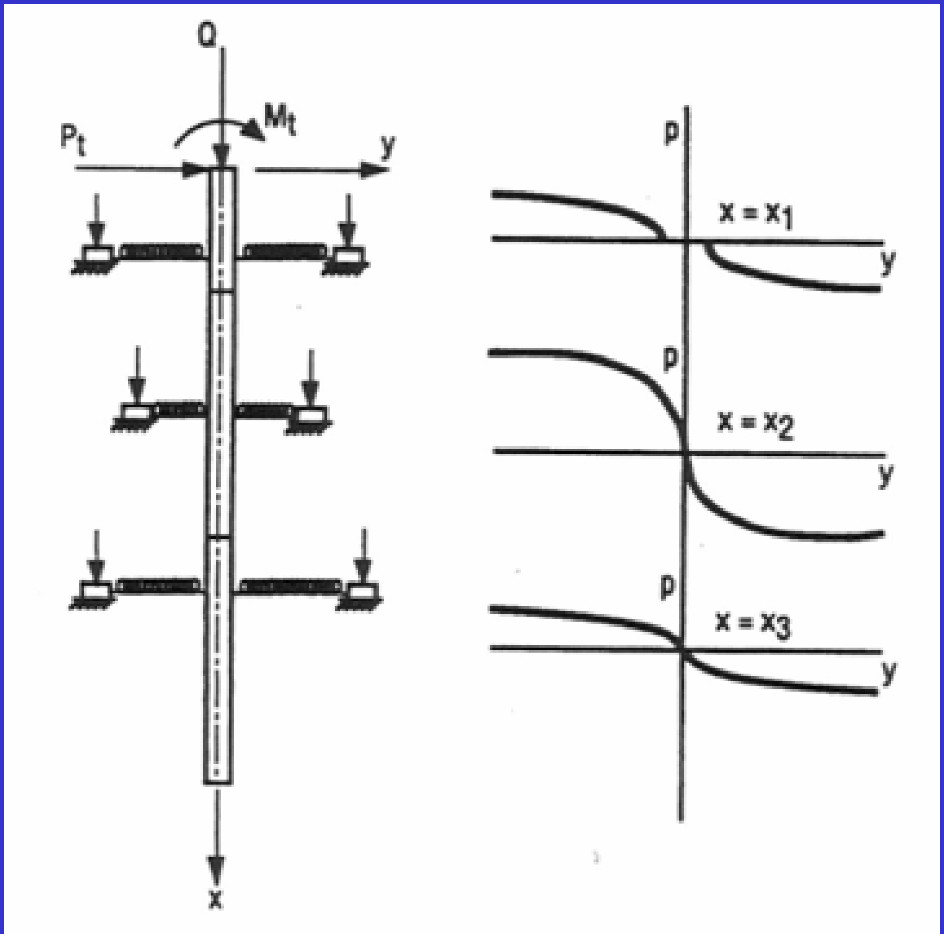
where μ = shear friction factor;

P = applied axial load;

Ts = tension force in rebars

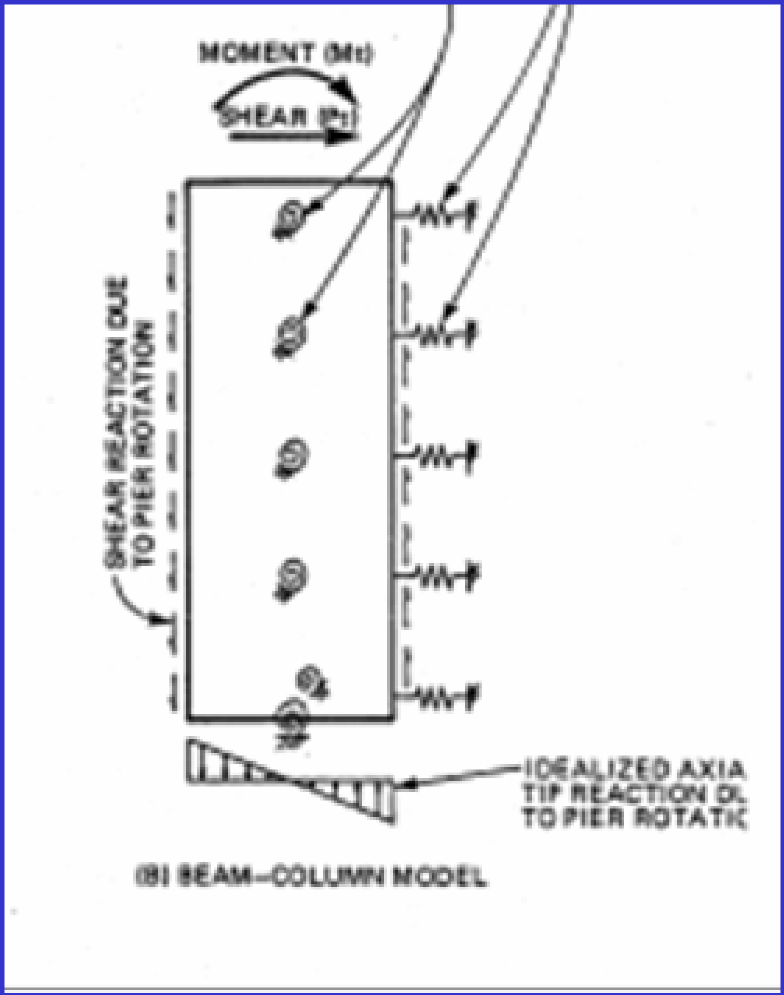
Diameter Effect on Drilled Shaft Design

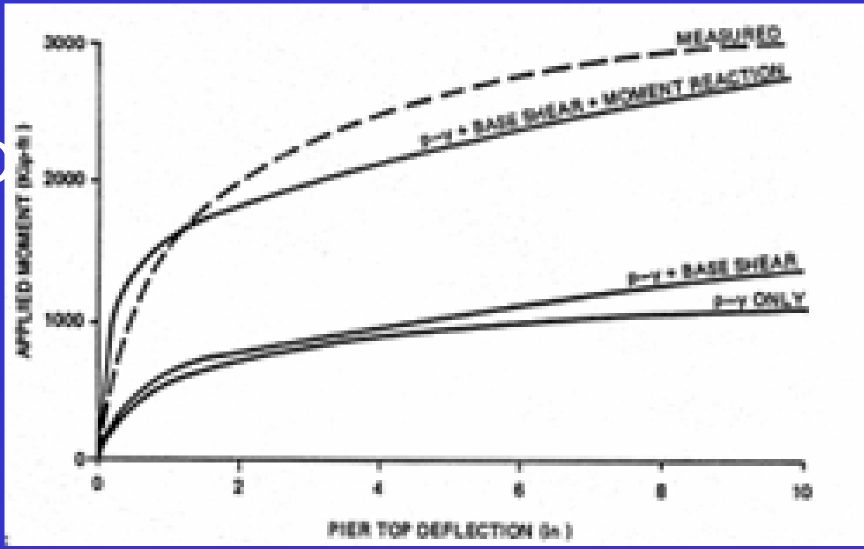
❖ Conventional Pile Lateral Analysis



Diameter Effect on Drilled Shaft Design

❖ Large Diameter Drilled Shaft *(after Lam I.P.)*





Diameter Effect on Drilled Shaft Design

- Recommendations from Lam I.P.

  Apply a scale factor of Diameter/2 to the P-Y curve to make up the modeling defects

Questions?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