

# Impact of Seismic Design Requirements on Bridges in Alabama



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Justin D. Marshall, Ph.D., P.E.

Assistant Professor

Civil Engineering Department

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# Overview

- Introduction
- Seismic Design Methodology
- AASHTO Standard Specification Provisions
- Guide Specification for Seismic Design (2009)
- Selected Bridges in Alabama
- Conclusion



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“The most desirable type of design code or criteria is one that puts the least restrictions on the initiative, imagination and innovation of the designer.”

-Newmark, N.M. and W.J. Hall, 1982, *Earthquake Spectra and Design*, EERI Monograph Series



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“Most literature in the structural field deals with strength and stability for the very good reason, not always obvious to the amateur, that if a structure is not sufficiently strong, it makes very little difference what other attributes it has. One might almost say that its strength is essential and otherwise unimportant.”

-Hardy Cross, 1952, *Engineers and Ivy Towers*, McGraw-Hill Book Company



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# Seismic Design

- Critical Elements for Seismic Design
  - Strength
    - Resist inertial forces imparted to structure without failure
  - Stiffness
    - Provides stability during and after shaking
  - Ductility
    - Dissipates the energy imparted to the structure by the ground motion



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# Seismic Design of Bridges

- Life-safety performance for design event
- Ductile elements dissipate energy through damage (typically hinging in reinforced concrete columns)
- Capacity design used for other substructure elements
- Elastic behavior for superstructure
- Complete load path is essential



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# AASHTO Specifications

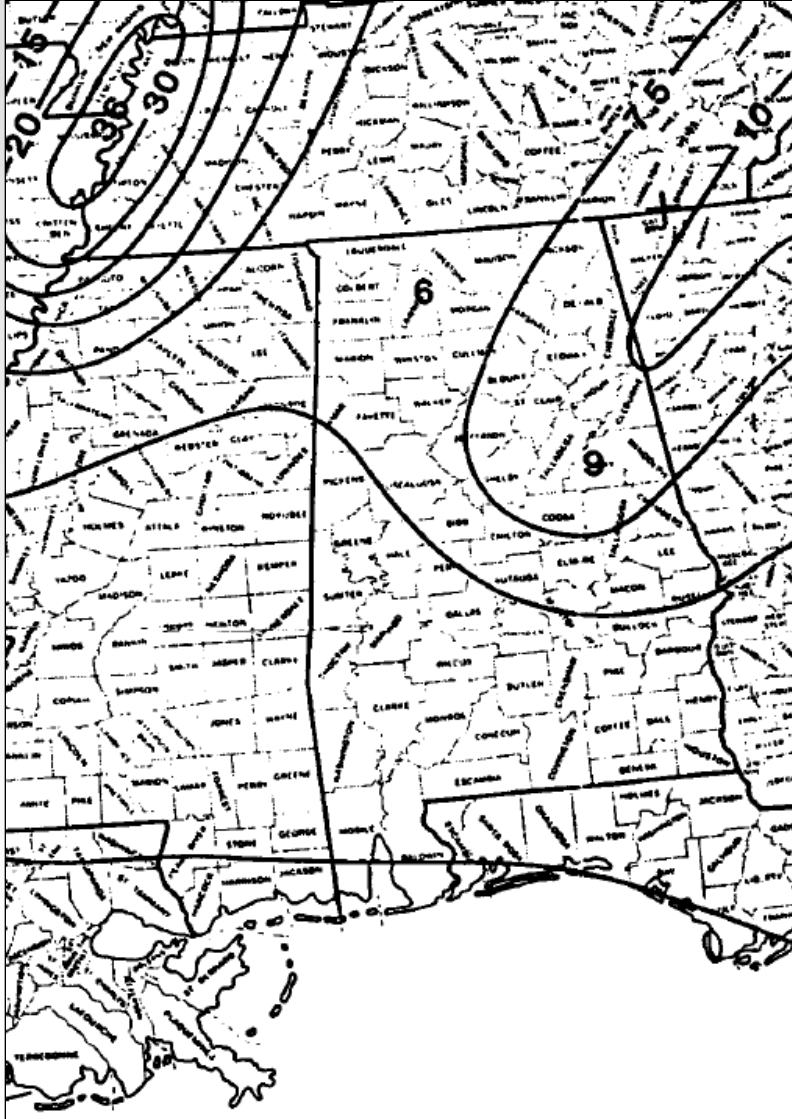
- AASHTO Standard Specification for Highway Bridges (17<sup>th</sup> Edition)
  - Force-based design methodology
- AASHTO Guide Specifications for LRFD Seismic Bridge Design (2009 – First Edition)
  - Displacement-based design methodology



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# Seismic Maps – Standard



Design Earthquake = 475  
Year Return Period (15%  
Probability of Exceedance  
in 75 Years)



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# Standard Specification

- Most Bridges in AL – SPC A ( $< 0.09g$ )
- Seismic Performance Category A:
  - Seismic Analysis Not Required
  - Restrained Connections Designed for 20% of Dead Load Reaction (Superstructure to Substructure)
  - Minimum Bearing Seat Length
  - No Consideration of Seismic Forces for Steel or Reinforced Concrete Component Design

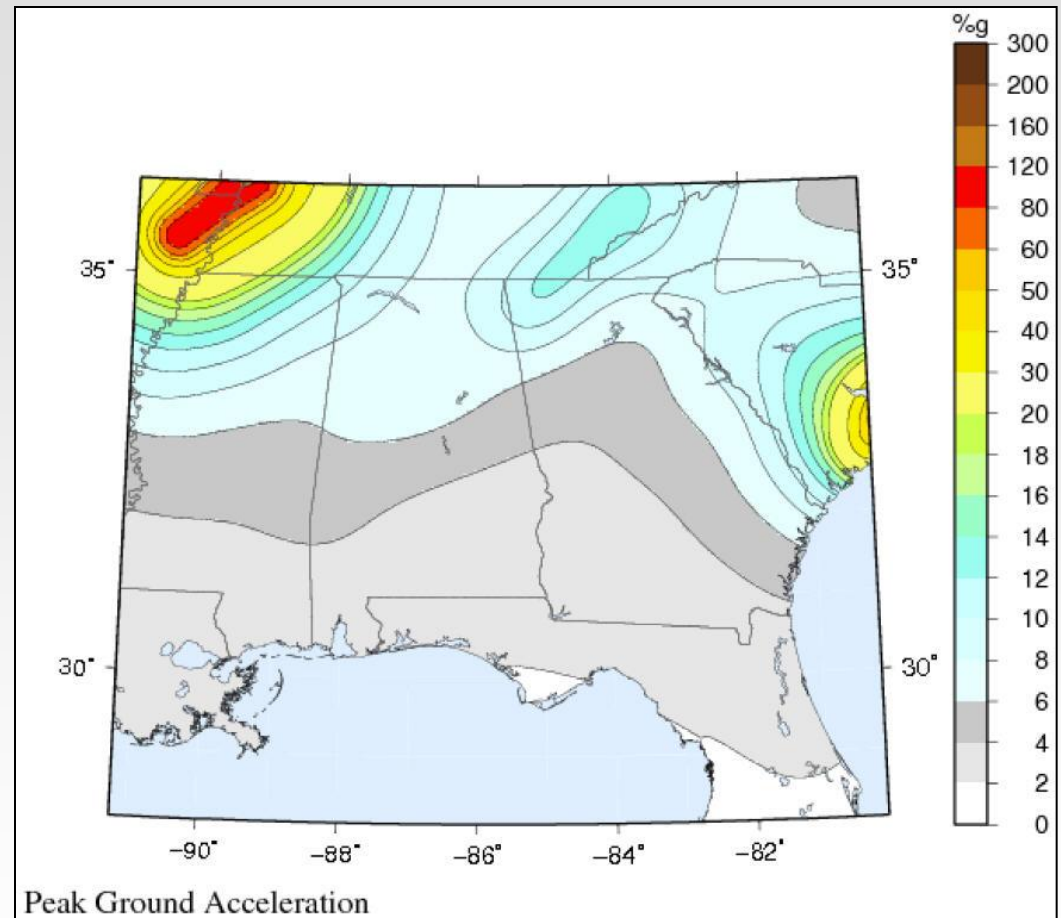
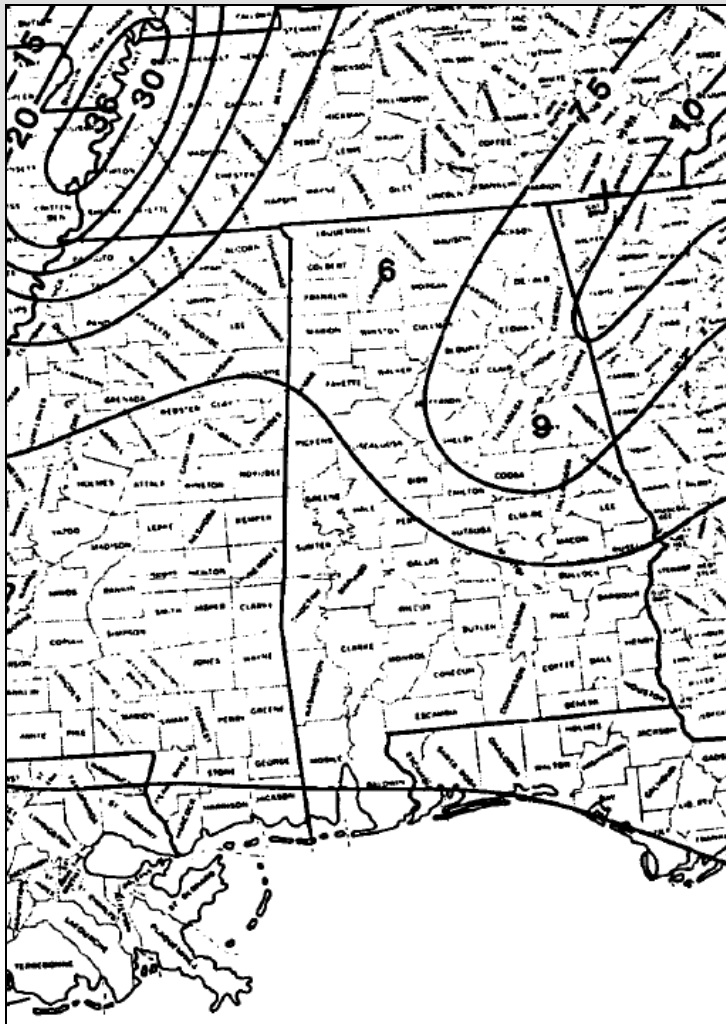
(Ref: Section 5. DIV I-A)



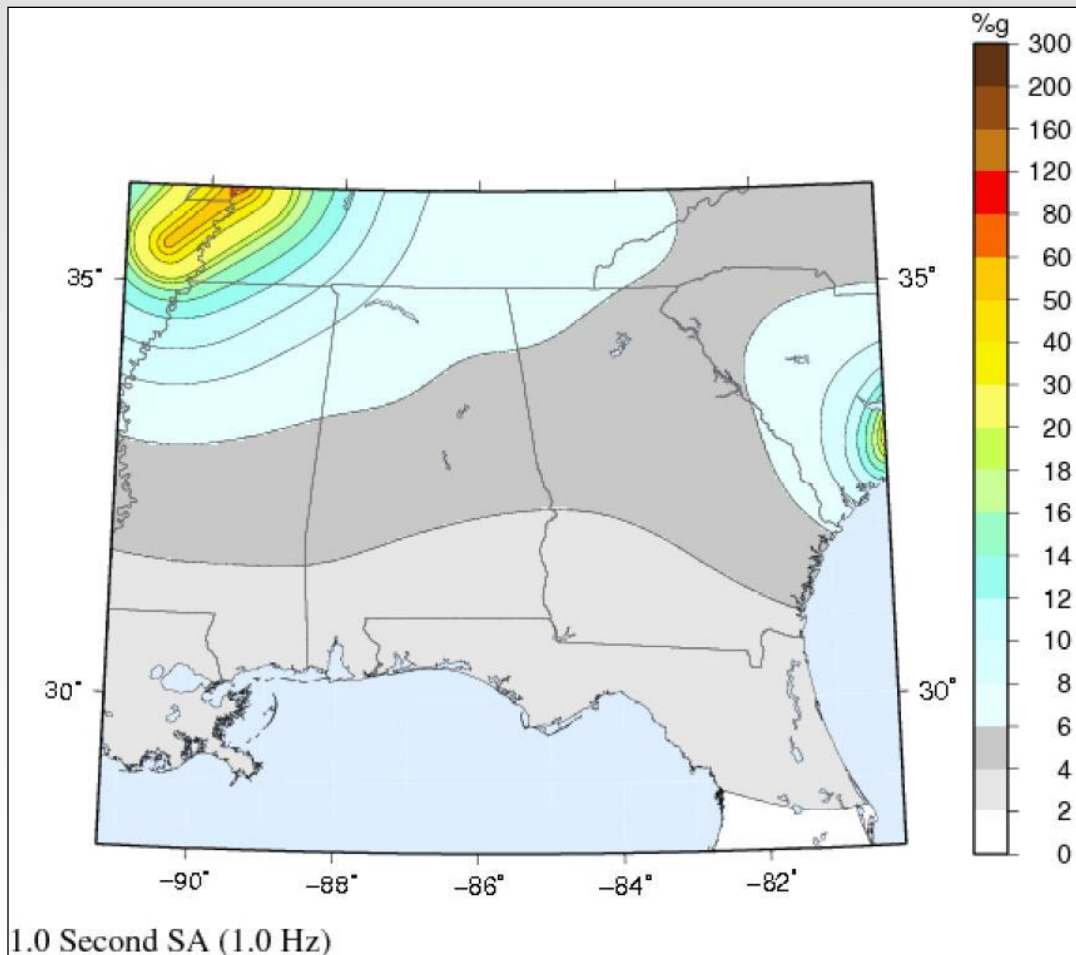
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# Hazard Maps – Comparison

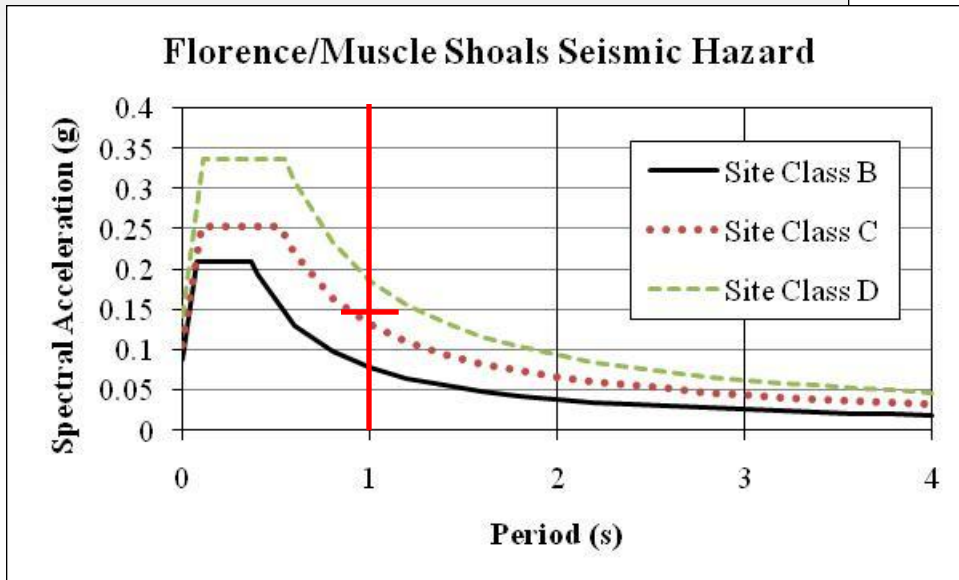
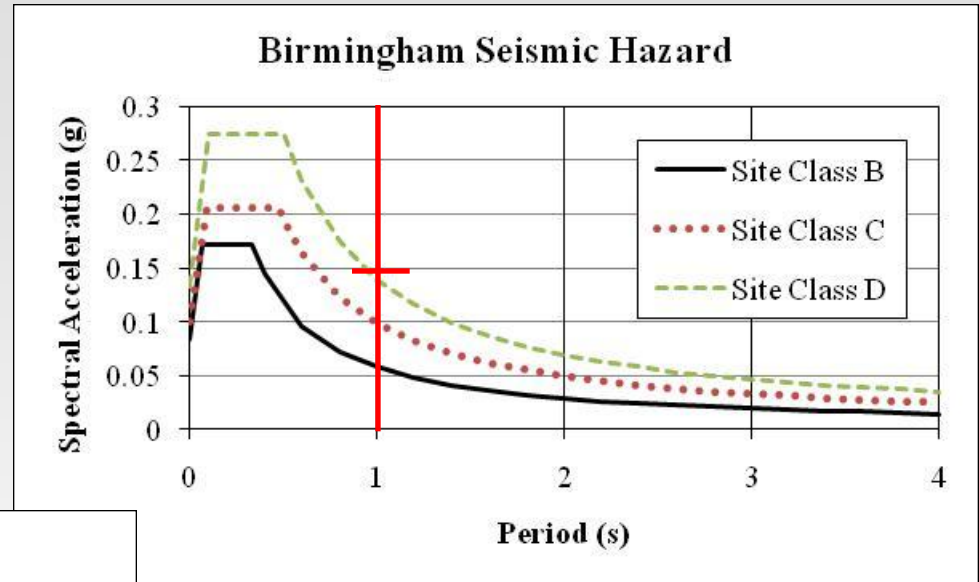


# Hazard Maps – LRFD

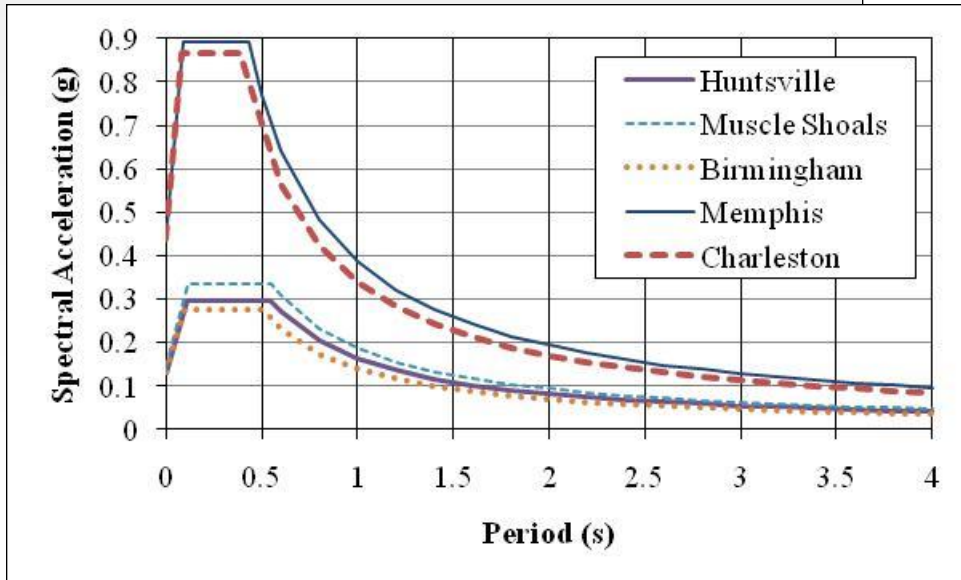
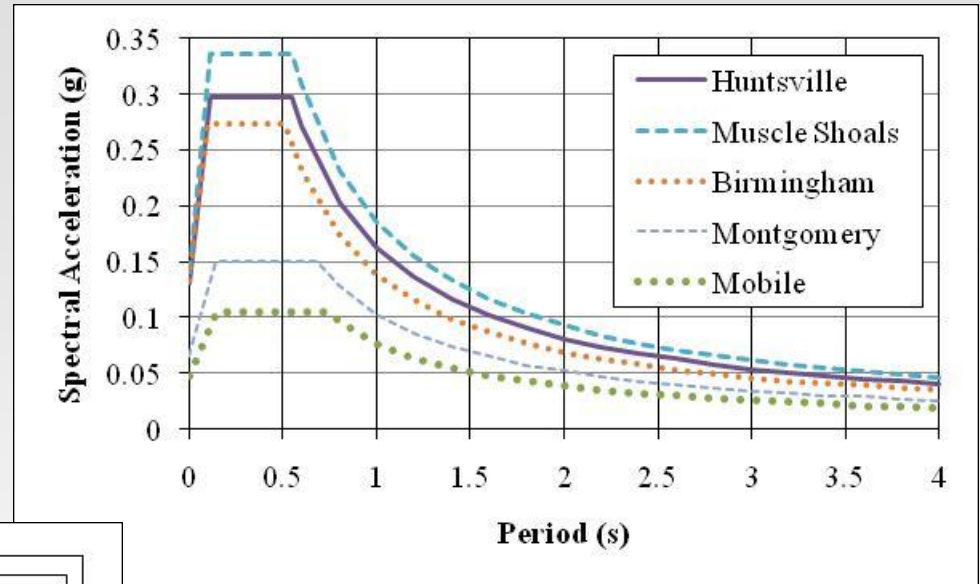


Design Earthquake = 975  
Year Return Period (7%  
Probability of Exceedance  
in 75 Years)

# Design Spectrum for Alabama



# Design Spectrum Comparison



**ANALYSIS - Map Parameters, Design Parameters, and Response Spectra**

File Project Name Help

**Input Data and Parameter Calculations**

Select Geographic Region

Conterminous 48 States

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Guidelines Edition

2007 AASHTO Bridge Design Guidelines

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Specify Site Location by Latitude-Longitude or Zip Code

Latitude-Longitude : Recommended  Zip Code

Latitude: 33.207689 Longitude: -87.550357

Latitude (50.0 to 24.6) Longitude (-125.0 to -65.0)

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Calculate Basic Design Parameters

Probability of Exceedance: 7% PE in 75 years

Calculate PGA, Ss, and S1      Calculate As, SDs, and SD1

---

Calculate Response Spectra

Map Spectrum      Design Spectrum

View Spectra

**Output Calculations and Ground Motion Maps**

Conterminous 48 States  
 2007 AASHTO Bridge Design Guidelines  
 AASHTO Spectrum for 7% PE in 75 years  
 Latitude = 32.602217  
 Longitude = -085.489051  
 Site Class B  
 Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.042	PGA - Site Class B
0.2	0.097	Ss - Site Class B
1.0	0.044	S1 - Site Class B

---

Conterminous 48 States  
 2007 AASHTO Bridge Design Guidelines  
 AASHTO Spectrum for 7% PE in 75 years  
 Latitude = 33.207689  
 Longitude = -087.550357  
 Site Class B  
 Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.071	PGA - Site Class B
0.2	0.153	Ss - Site Class B
1.0	0.056	S1 - Site Class B

Clear Output      View Maps

<http://earthquake.usgs.gov/hazards/designmaps/aashtocd.php>

# Guide Specifications

- Seismic Design Category A:
  - No Analysis Required
  - $A_s < 0.05$  – Horizontal Connection Design for  $0.15w$
  - $A_s > 0.05$  – Horizontal Connection Design for  $0.25w$
  - Minimum Bearing Seat Lengths
  - Shear Reinforcement Required if  $S_{D1} > 0.10$



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# Guide Specifications

- Seismic Design Category B
  - Limited Ductility Response Expected
  - EQ Resisting System Should Be Identified
  - Displacement Demand and Capacity Analysis Required
  - Specified Detailing Requirements
  - Liquefaction Check Considered for Certain Conditions



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# Current Research

- Determine the effect of seismic design requirements in LRFD Guide Specification for bridges in Alabama
- Develop simple, cost-effective and widely applicable construction details
- Analyze three existing concrete girder bridges and update to current provisions for worst case seismic hazard
- Develop local seismic design aids



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# Selected Bridges

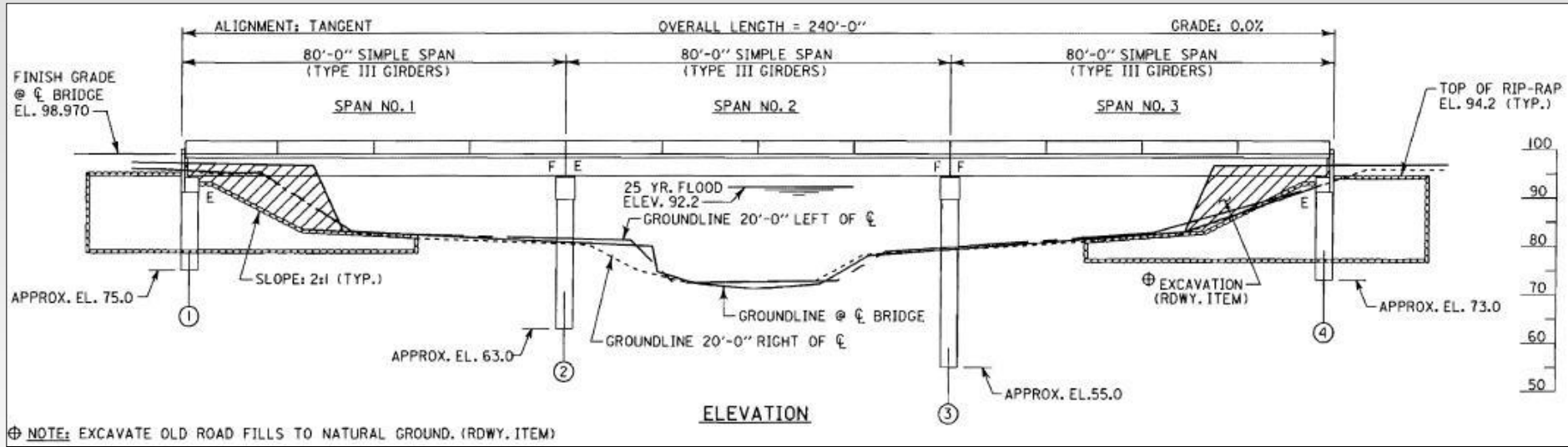
- Oseligee Creek on C.R. 1289 (Chambers County) – (3) 80' Simple Spans, 32'-9" Wide
- Little Bear Creek on EB S.R. 24 (Franklin County) – 130' Main Span, (2) 85' End Spans, 42'-9" Wide
- Scarham Creek on S.R. 75 (Marshall County) – (4) 130' Simple Spans 40' Wide



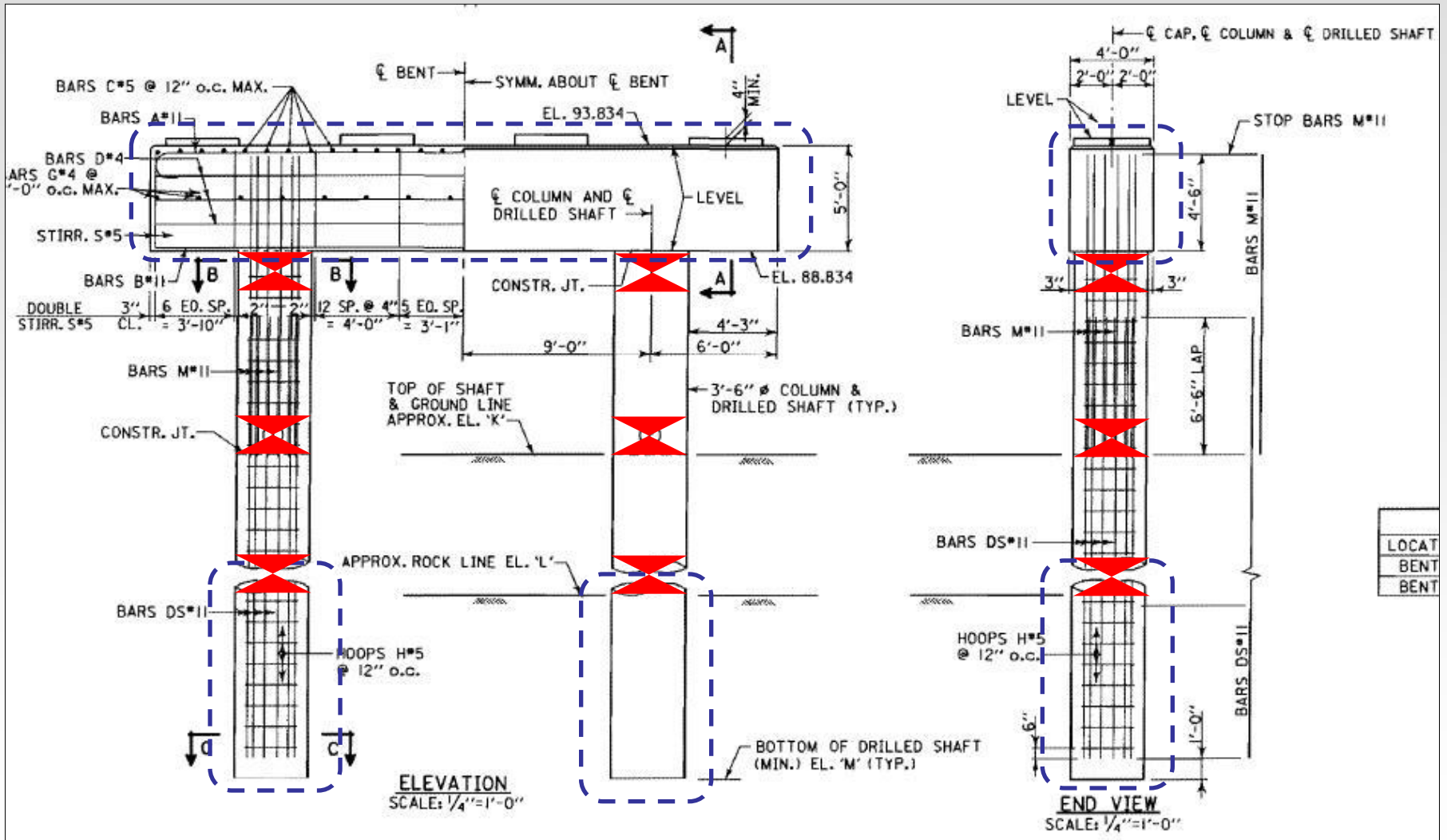
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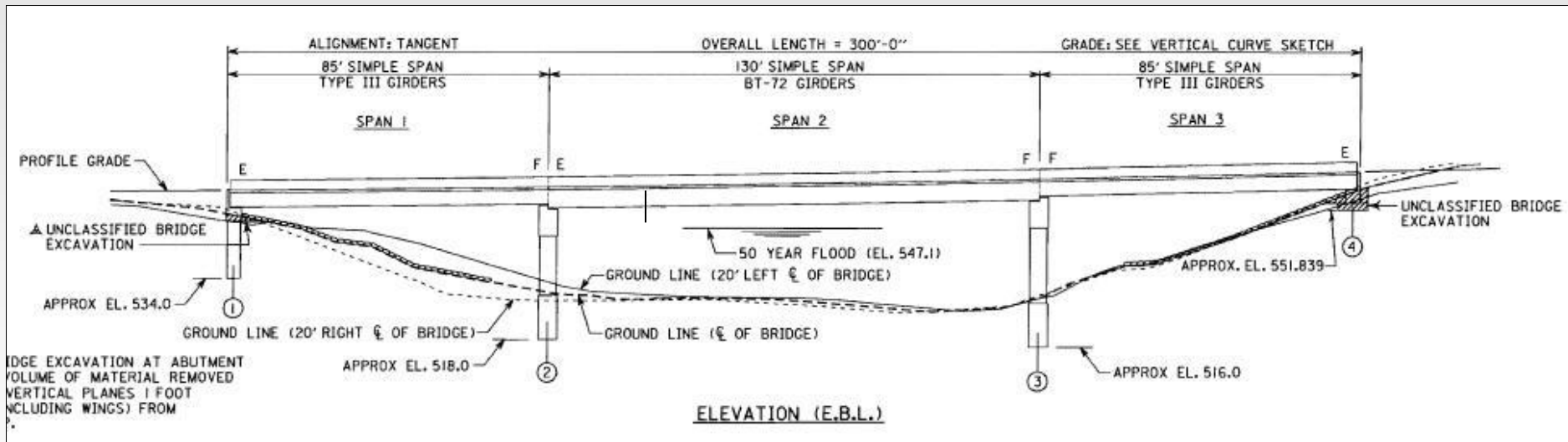
# Oselige Creek



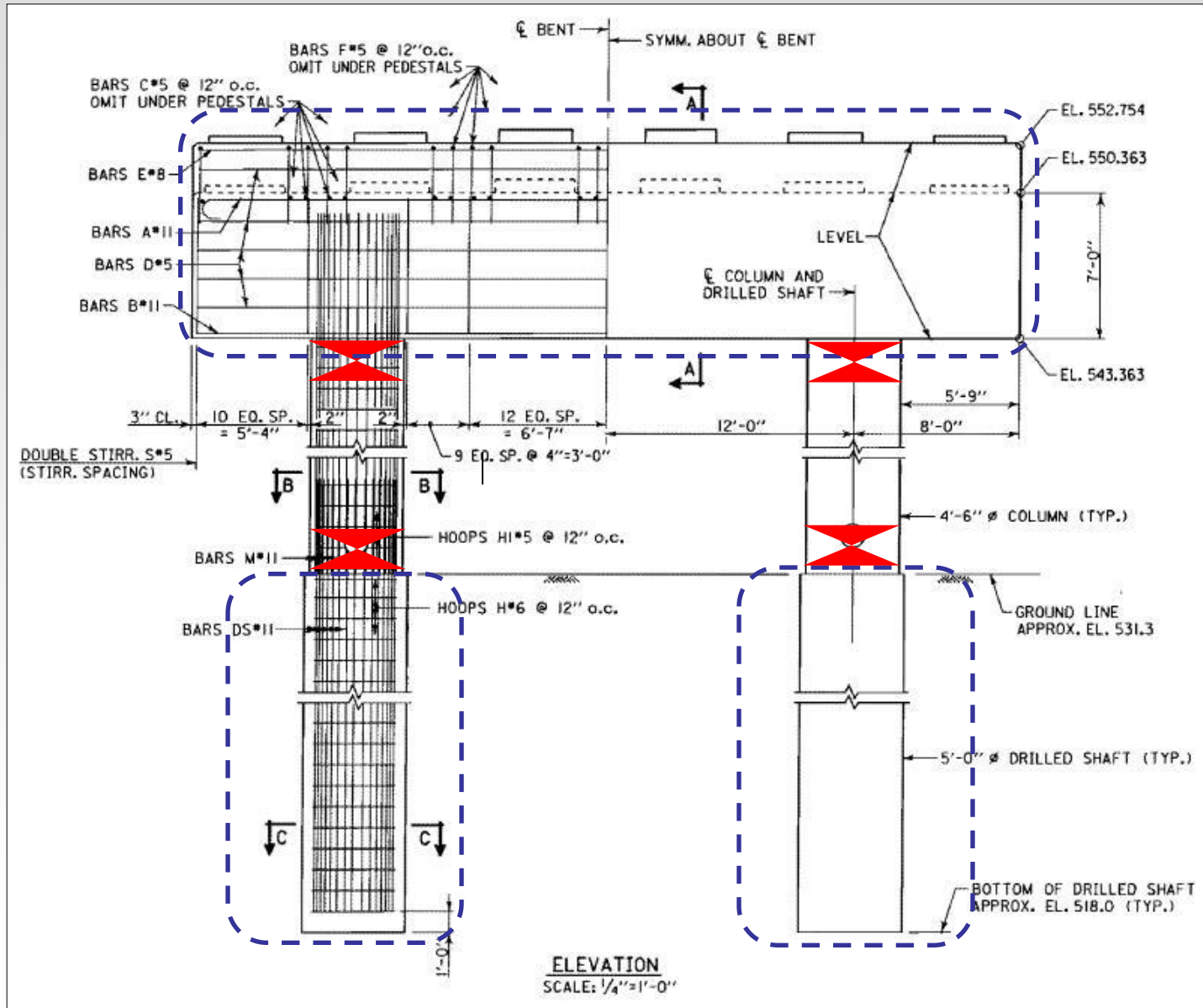
# Oseligee Creek



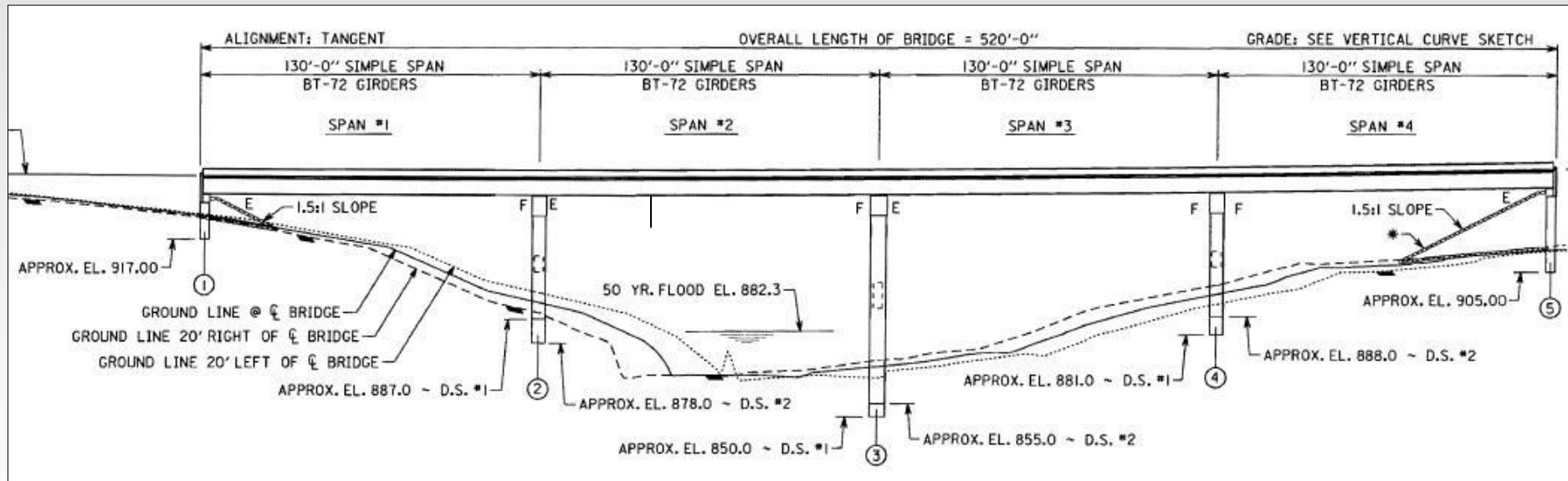
# Little Bear Creek



# Little Bear Creek



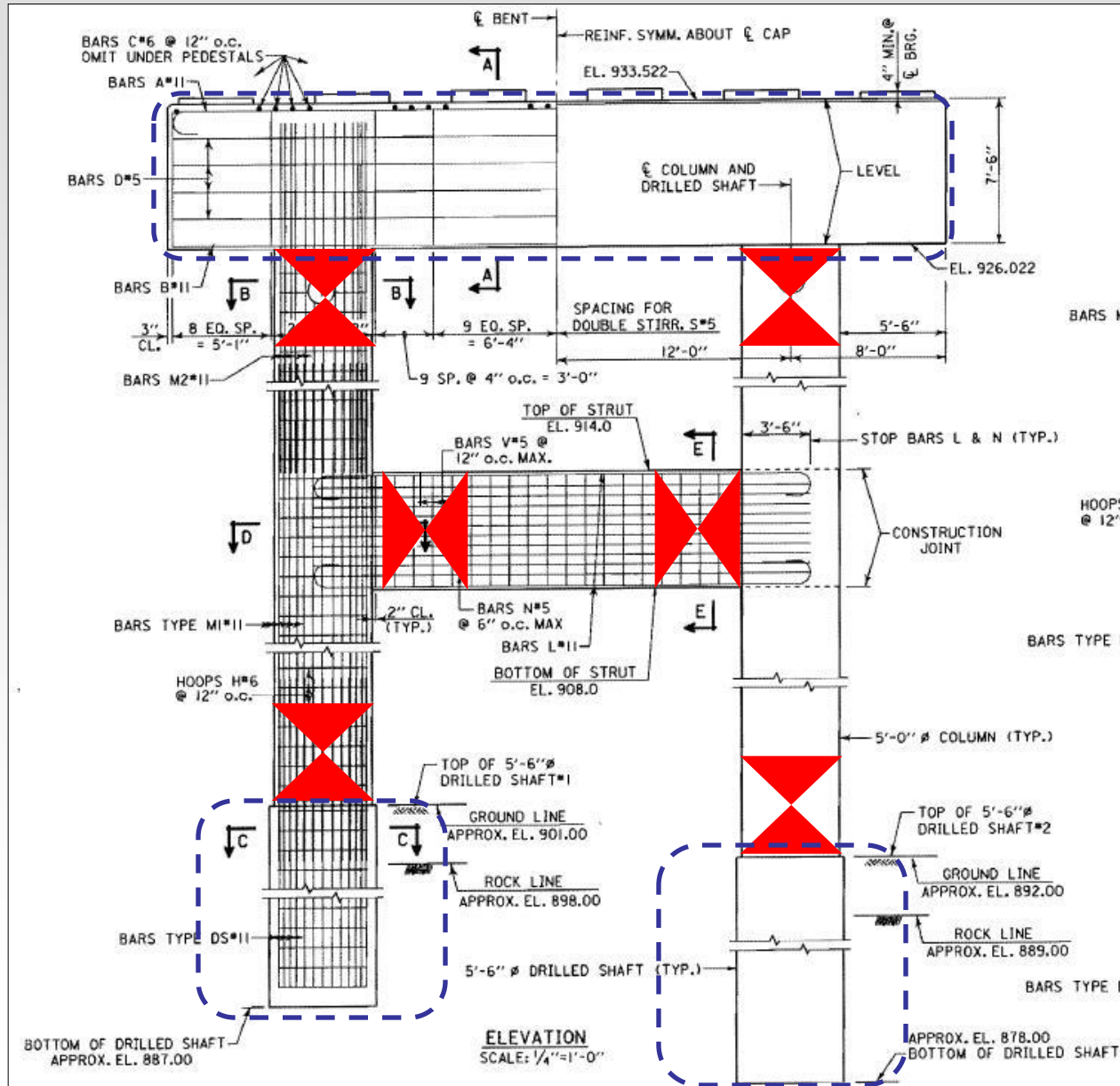
# Scarham Creek



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# Scarham Creek



# Bridge Modifications

- Additional shear reinforcing at hinge locations
- More robust horizontal connection details at girder bearing
- Additional analysis and design will be required for SDC B bridges (fundamental period, ductility capacity/demand, capacity design for elements)



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## Bridge Damage from January 12, 2010 Haiti Earthquake



# Questions?