Impact of Seismic Design Requirements on Bridges in Alabama

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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

"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

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

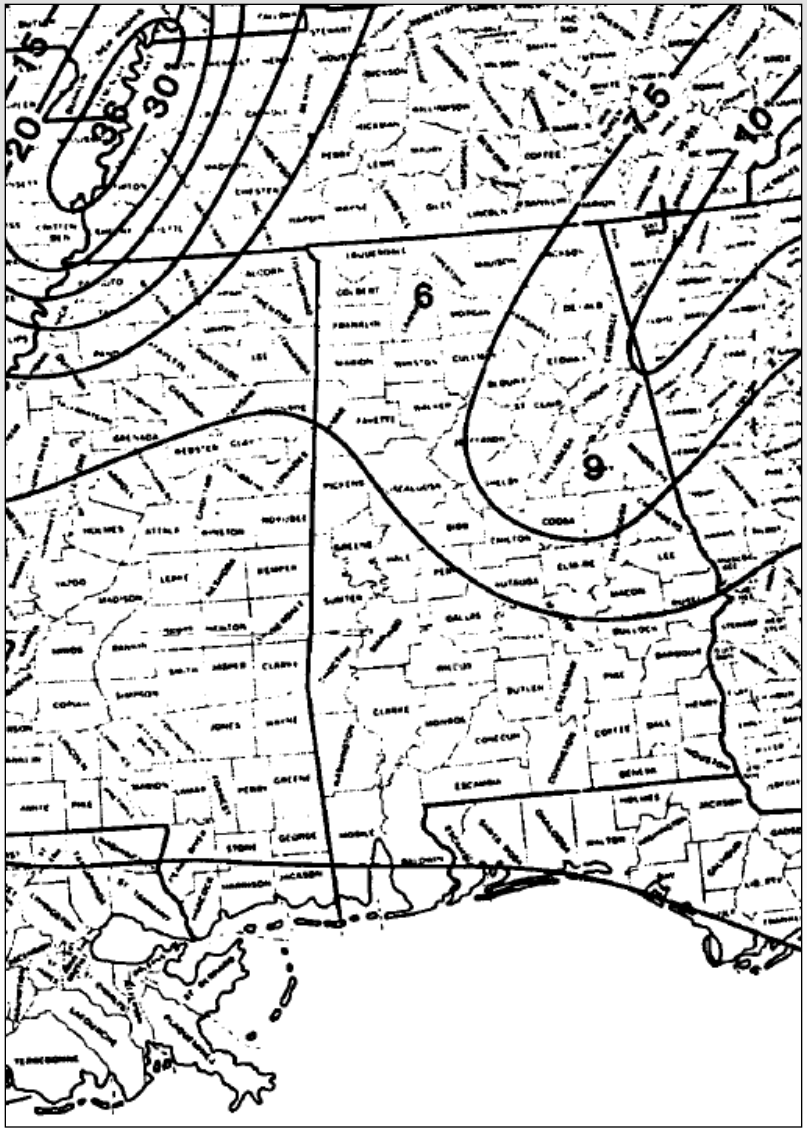
Seismic Design of Bridges

- 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

AASHTO Specifications

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

Seismic Maps – Standard



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

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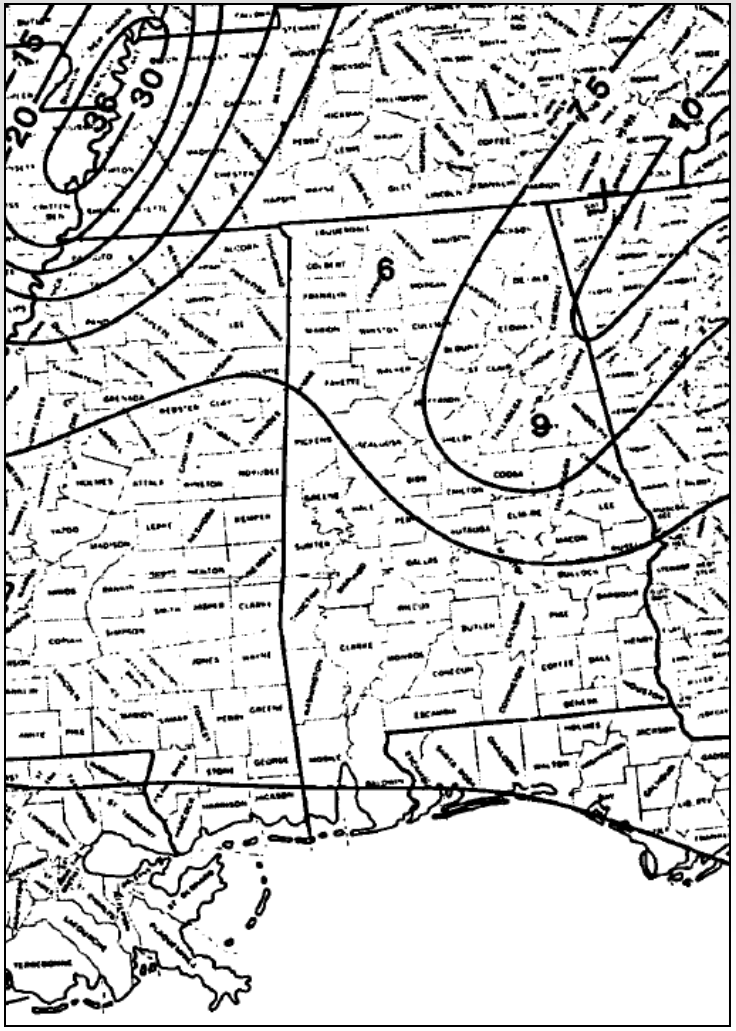
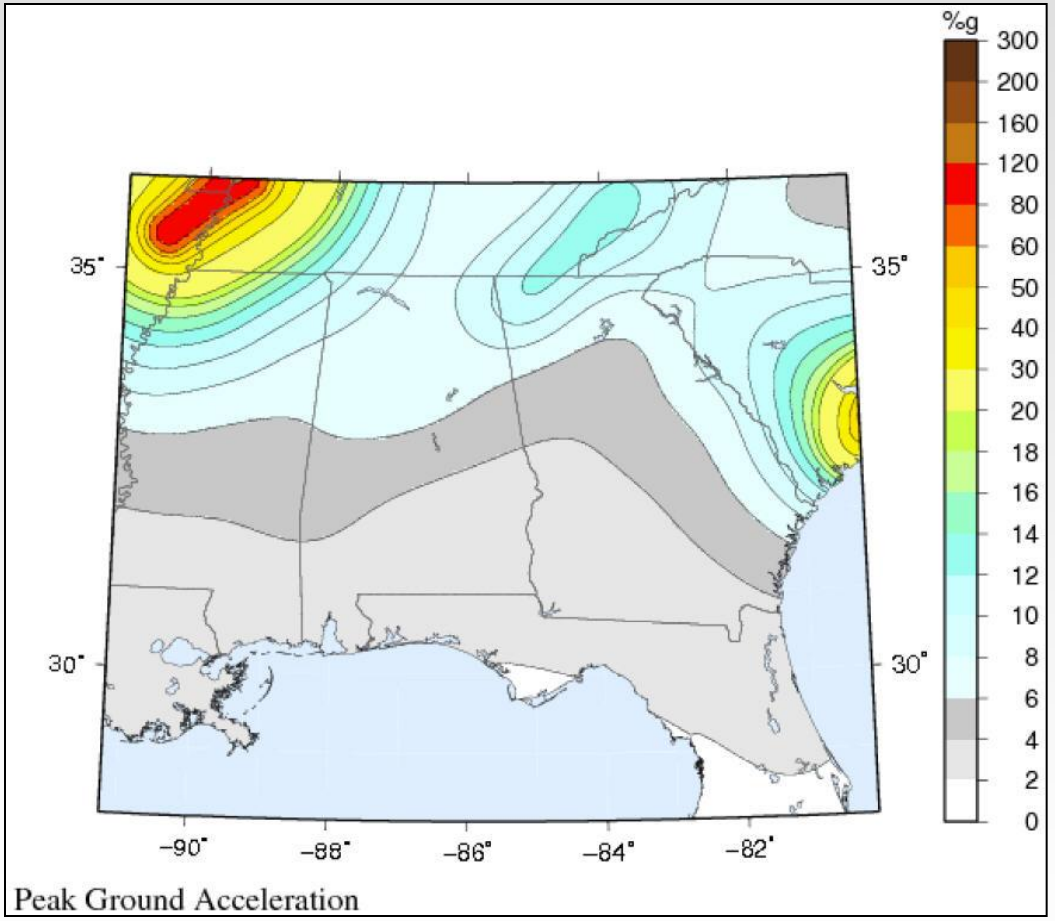
Standard Specification

- 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)

Hazard Maps – Comparison





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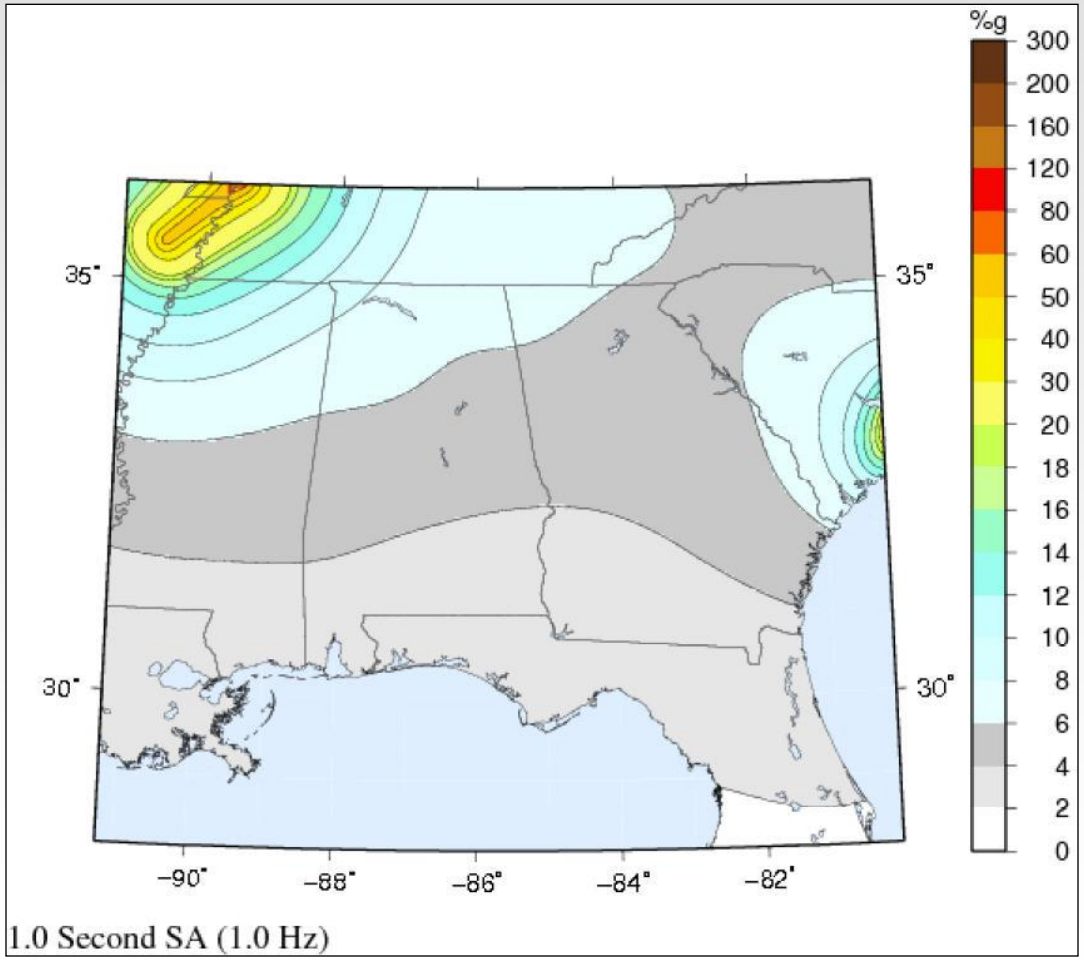
Hazard Maps – LRFD



1.0 Second SA (1.0 Hz)

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

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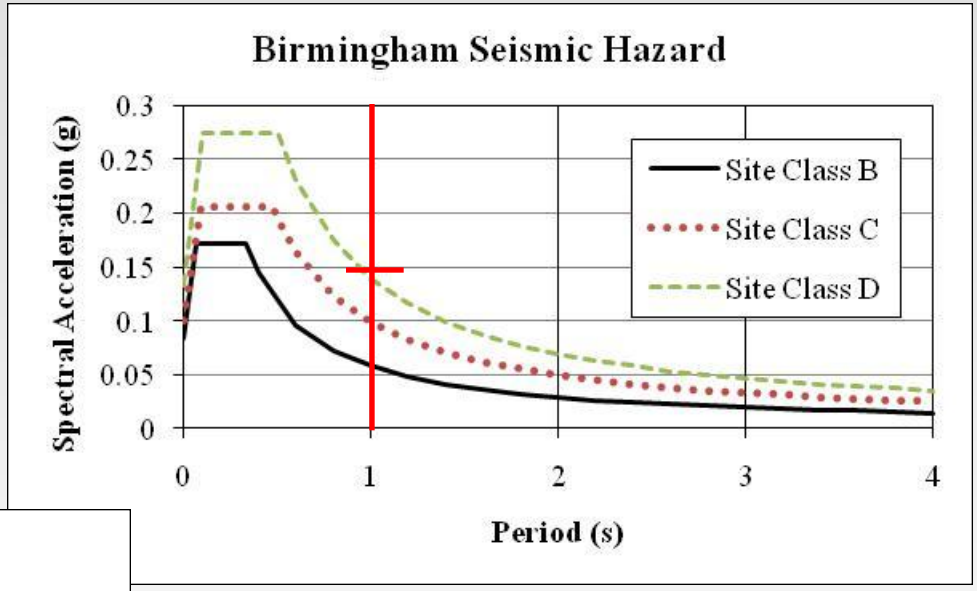
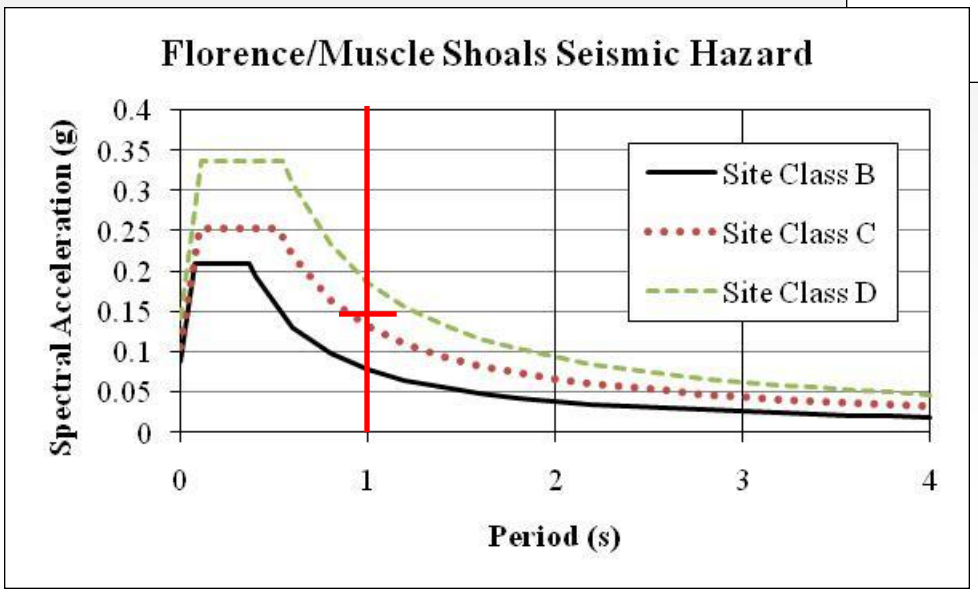
Design Spectrum for Alabama





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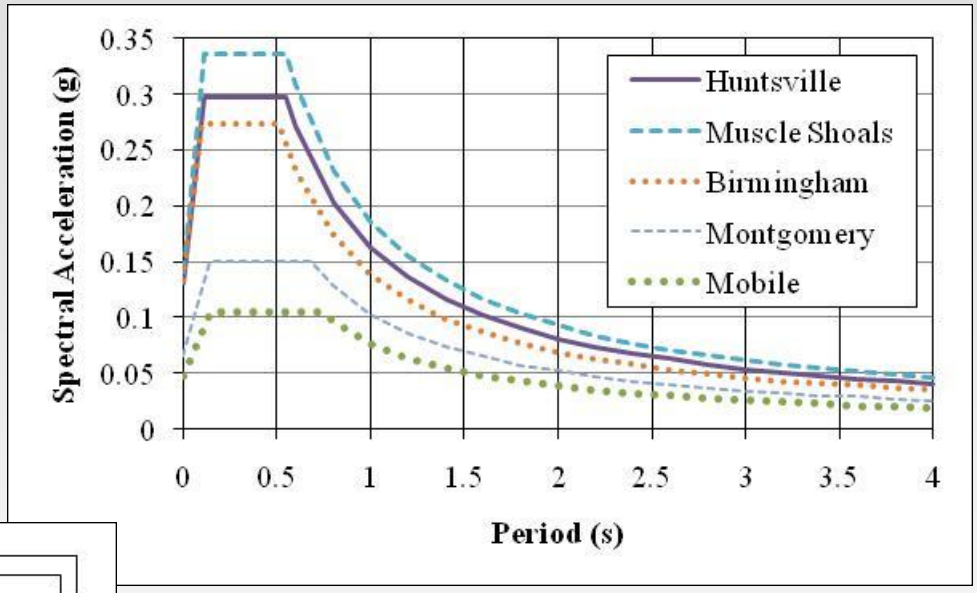
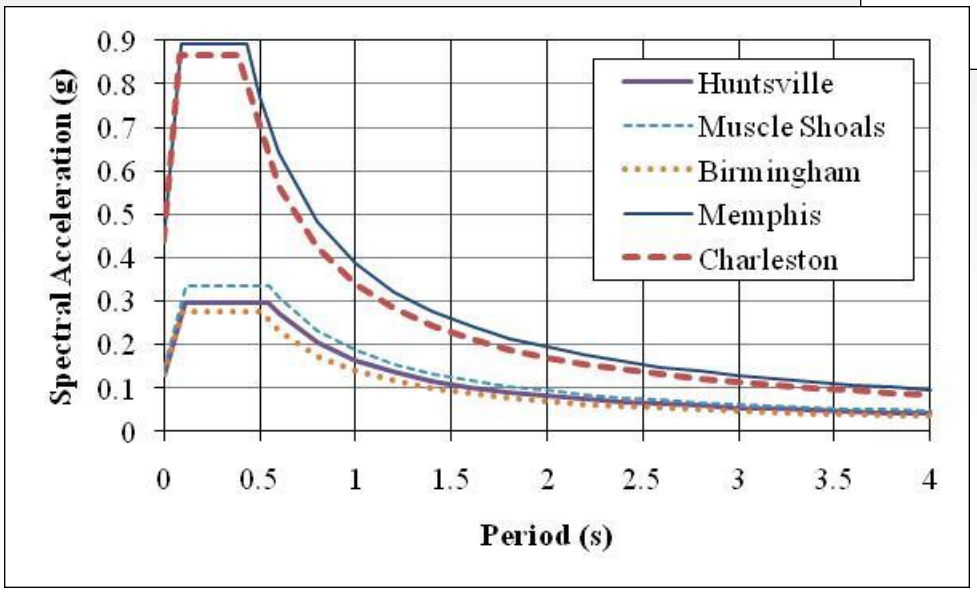
Design Spectrum Comparison





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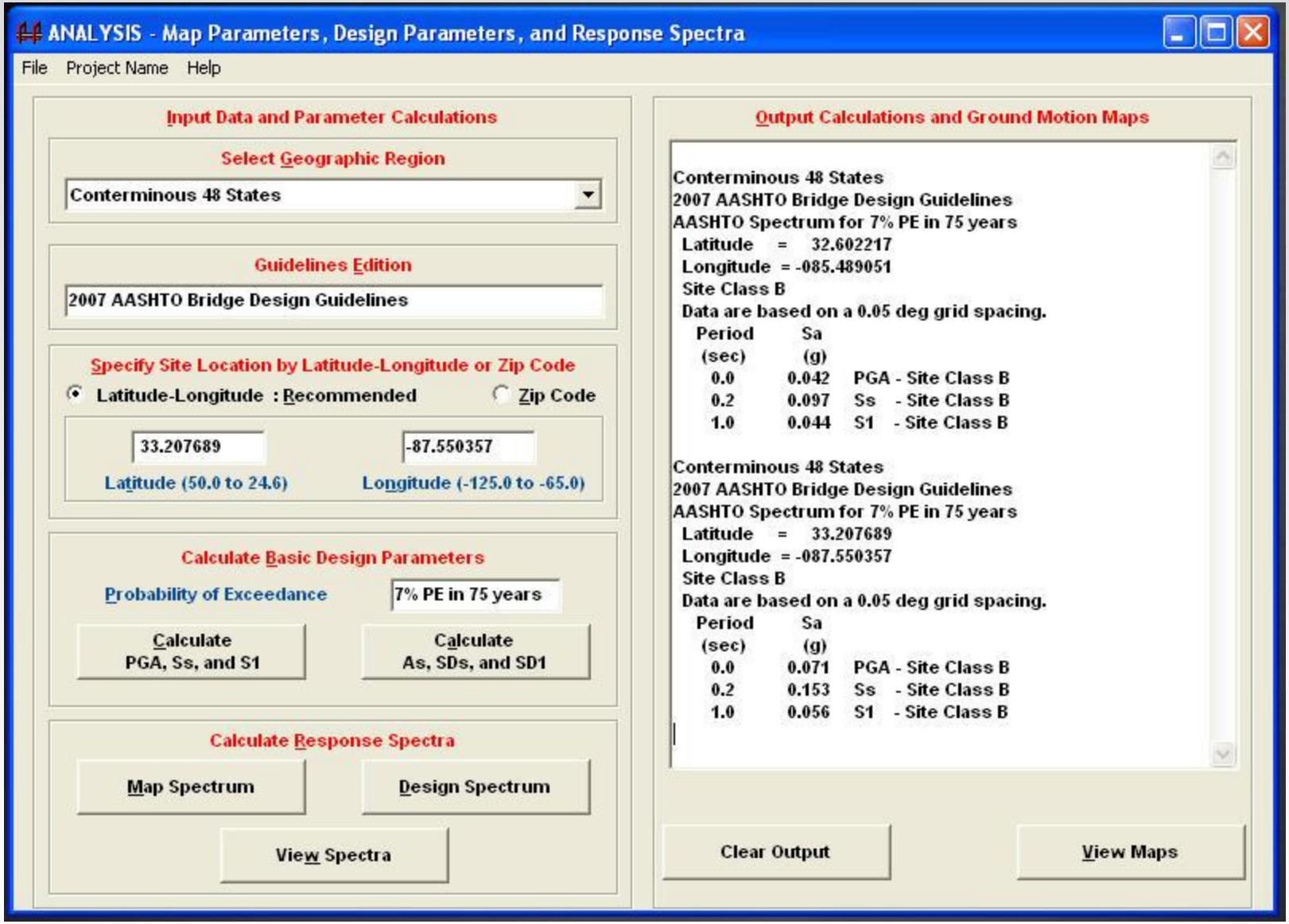

http://earthquake.usgs.gov/hazards/designmaps/aashtocd.php

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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

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

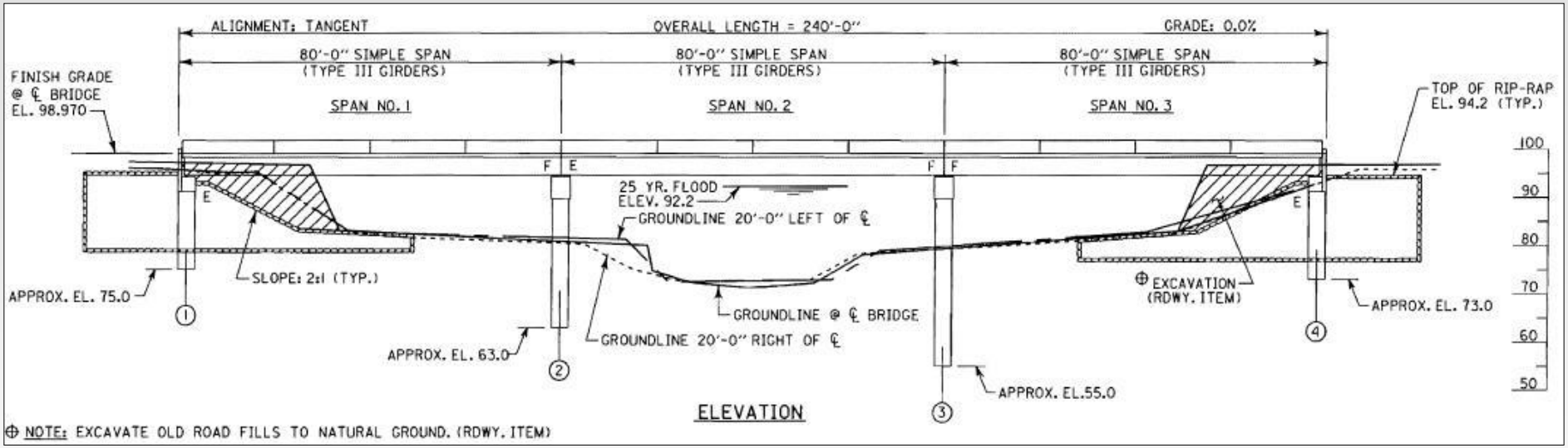
Current Research

- 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

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

Oseligee Creek



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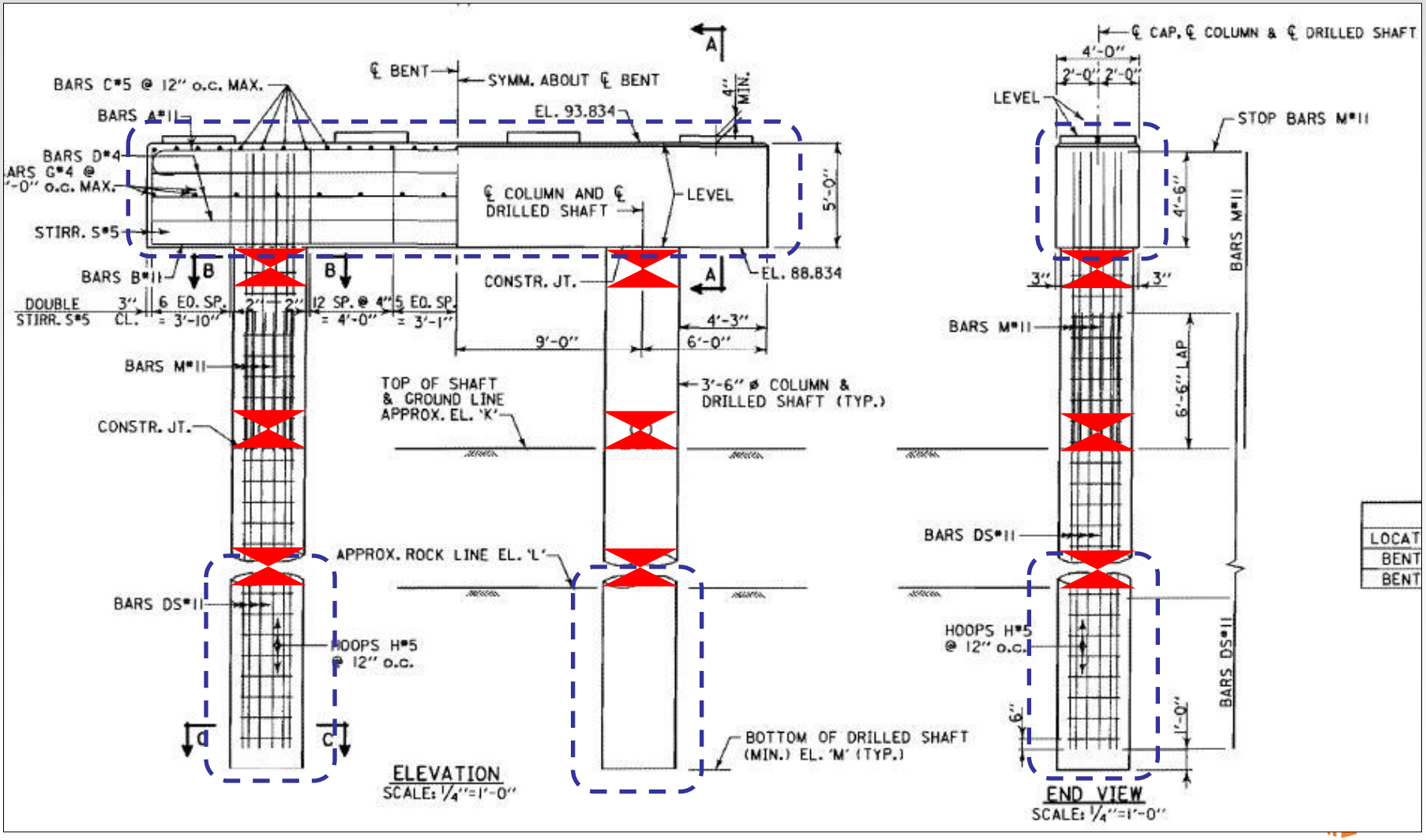
Oseligee Creek



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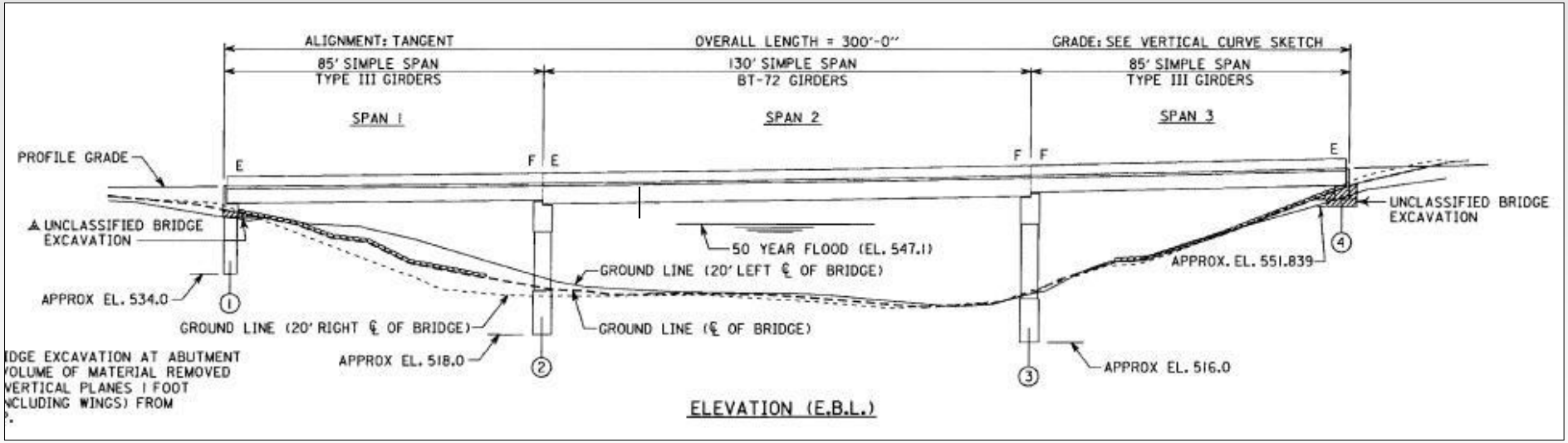
Little Bear Creek



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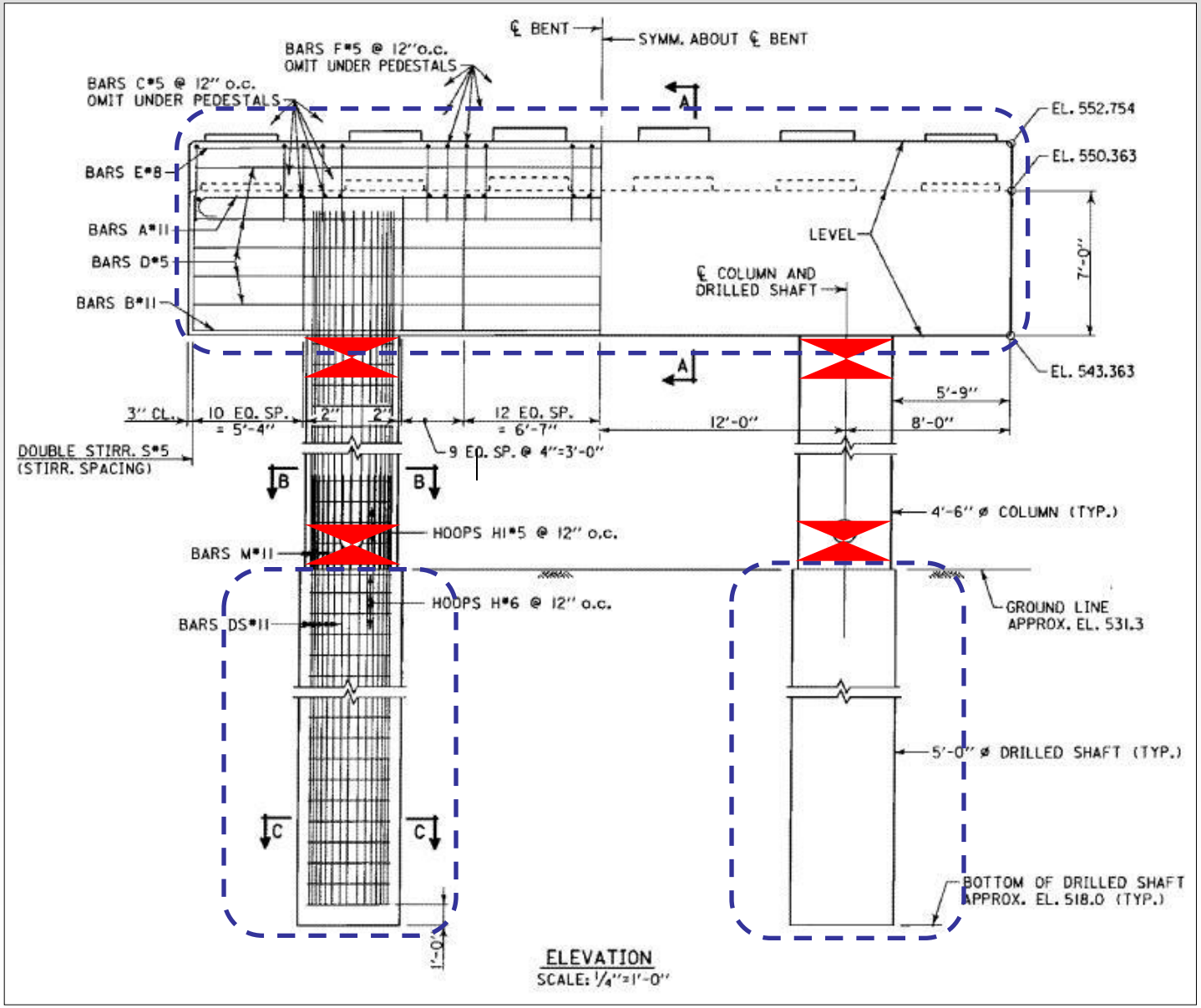
Little Bear Creek



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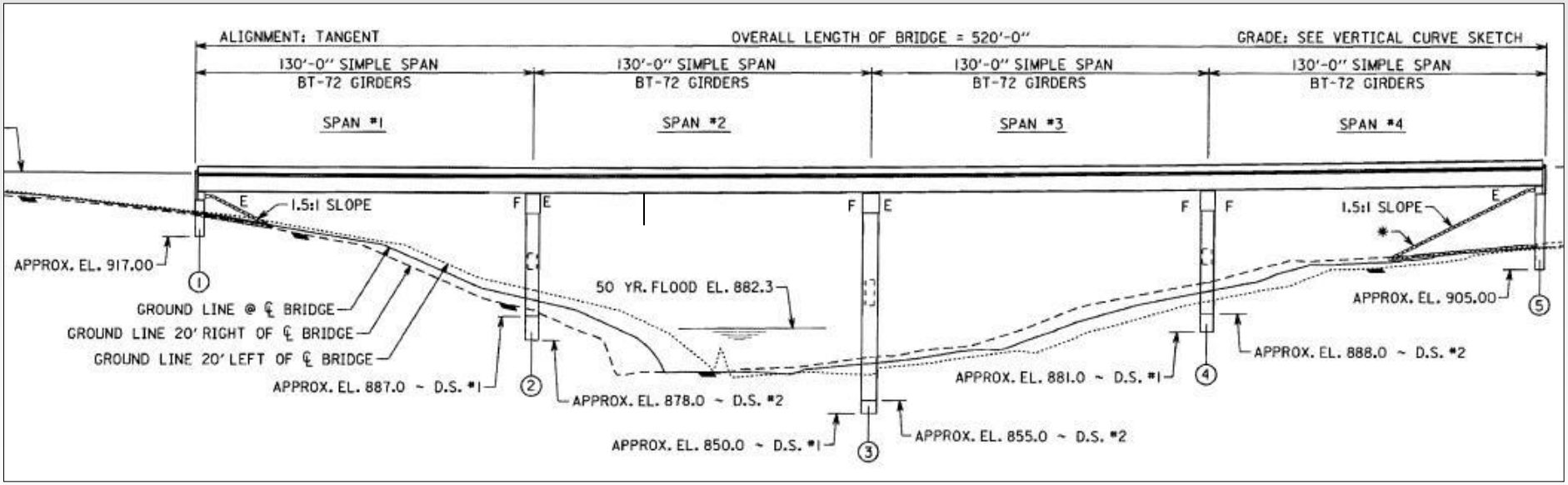
Scarham Creek



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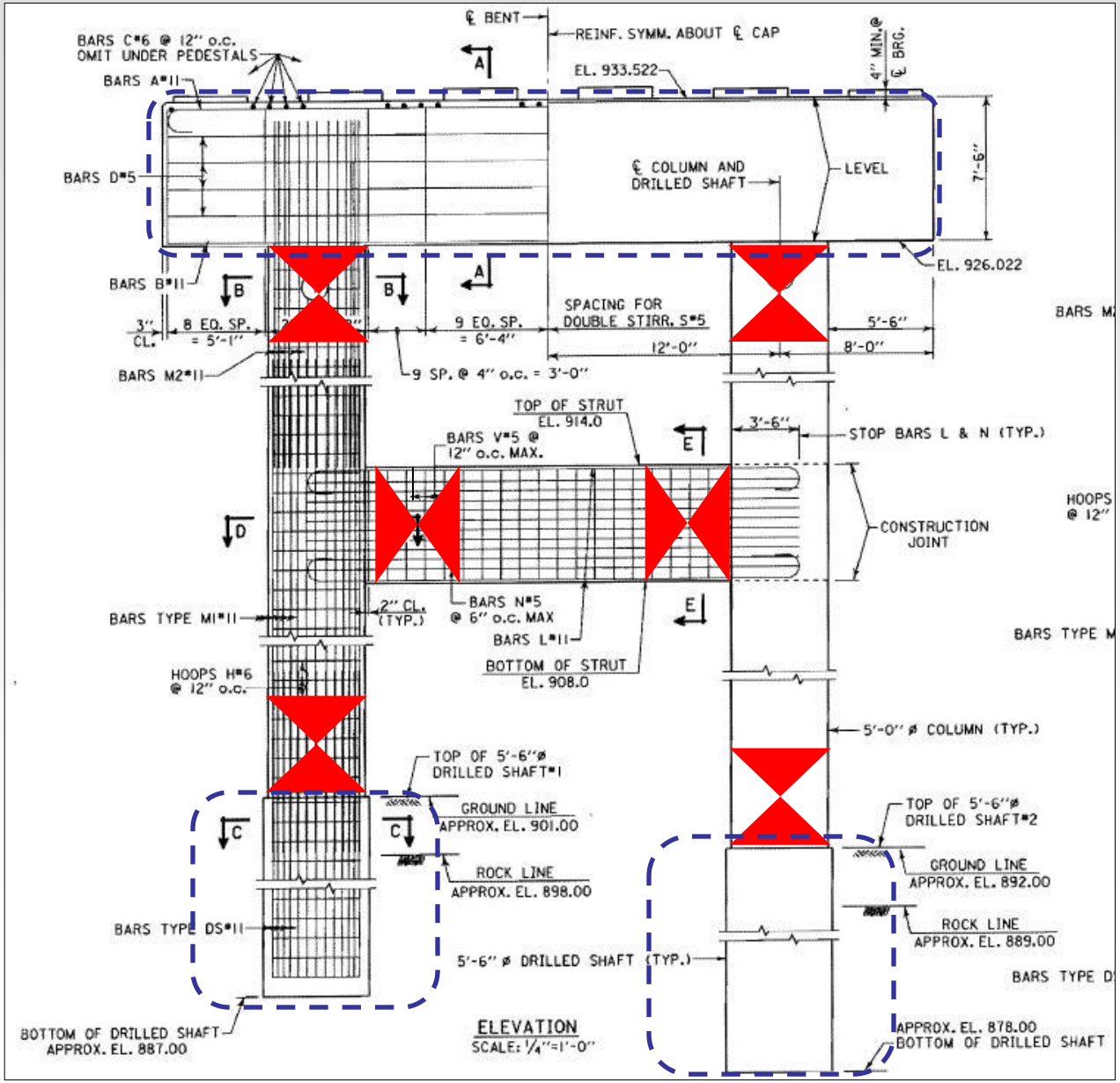
Scarham Creek



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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)

Bridge Damage from January 12, 2010 Haiti Earthquake

Questions?

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