T·Y·LIN INTERNATIONAL

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Inspection and Evaluation of the I-91 Steel Deck Truss Bridges

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Discussion Topics

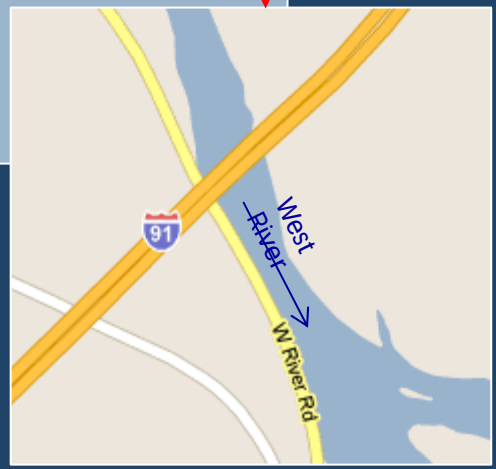
- Project Scope
- Bridge Type, Size, and Location
- Inspection Overview
- Coupon Extraction and Material Testing

Project Scope

- Bridge Inspection
- Material Testing
- Ultrasonic Testing of Fracture-Critical Members
- Load Rating (Truss Members, Gusset Plates, Links, Pins)
- Fatigue Analysis (Truss Members, Gusset Plates)
- Wind Analysis of Sway & Portal Bracing
- Conceptual Redundancy Study

Location

http://maps.google.com/

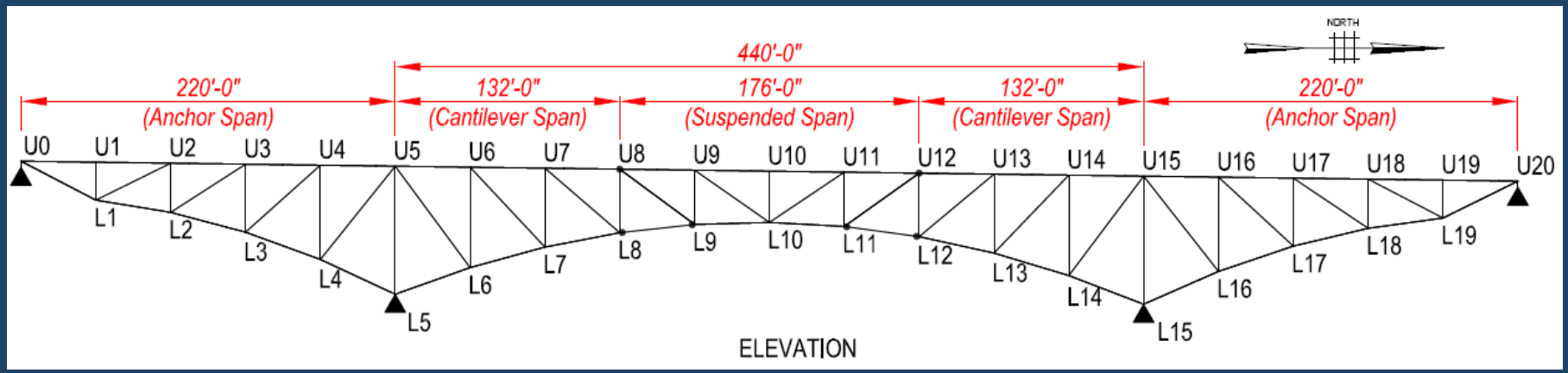


http://maps.google.com/

Type and Size

- Twin Deck Truss Bridges (Nos. 9N and 9S) carrying I-91 Northbound and Southbound over the West River.
- Constructed in 1958-1960 era.
- 30’-0” curb to curb.
- Total Truss Span = 880’-0”
  - 220’ Anchor Spans (each end)
  - 440’ Middle Span (132’ cantilever spans , 176’ suspended span)
- Material
  - Truss Components: ASTM A7-53T
  - Stringers & Floor Beams: ASTM A373-54T

Type and Size



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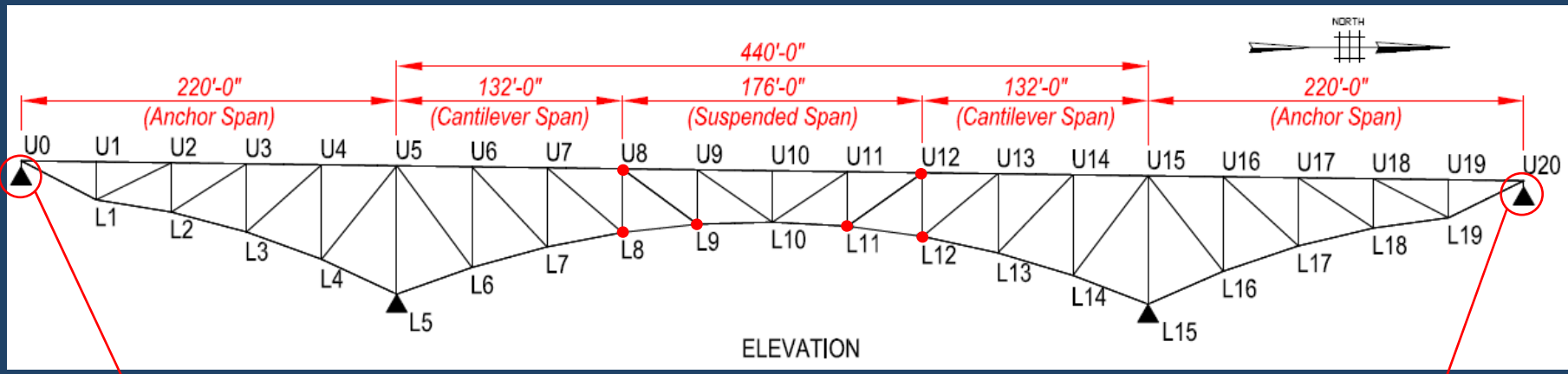
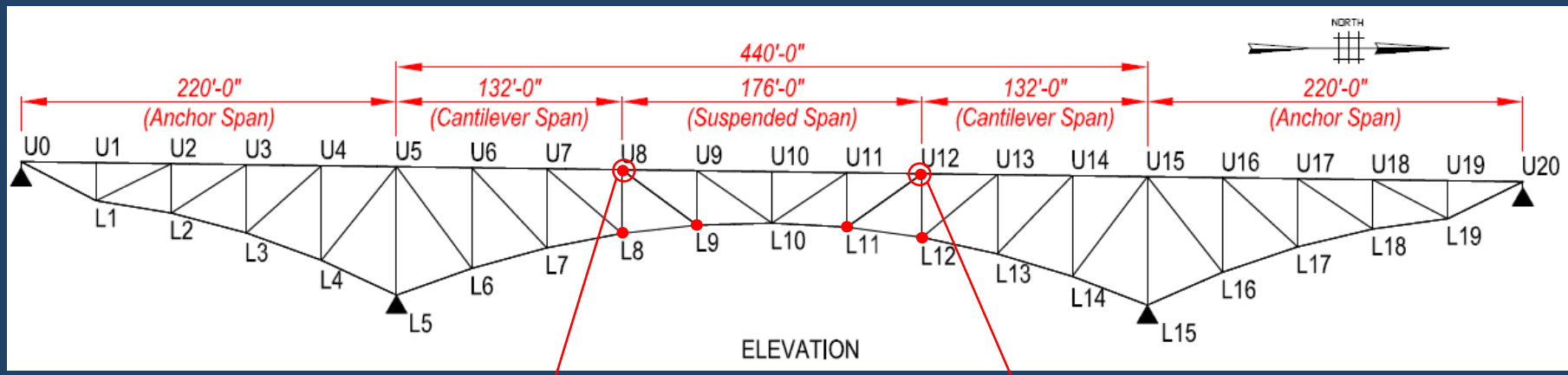


U0 Links

U20 Links

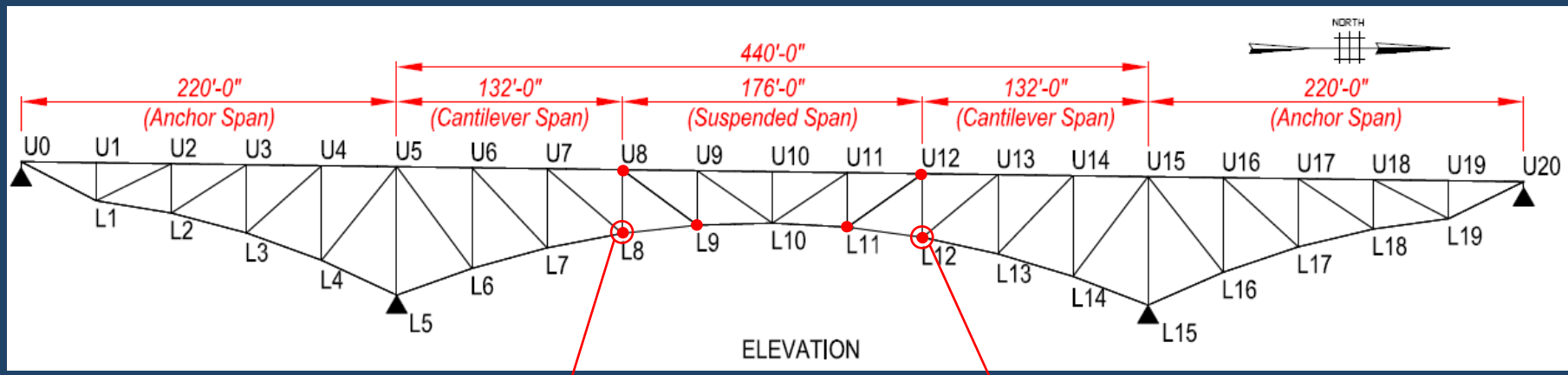
Type and Size



U8 Links

U12 Pin

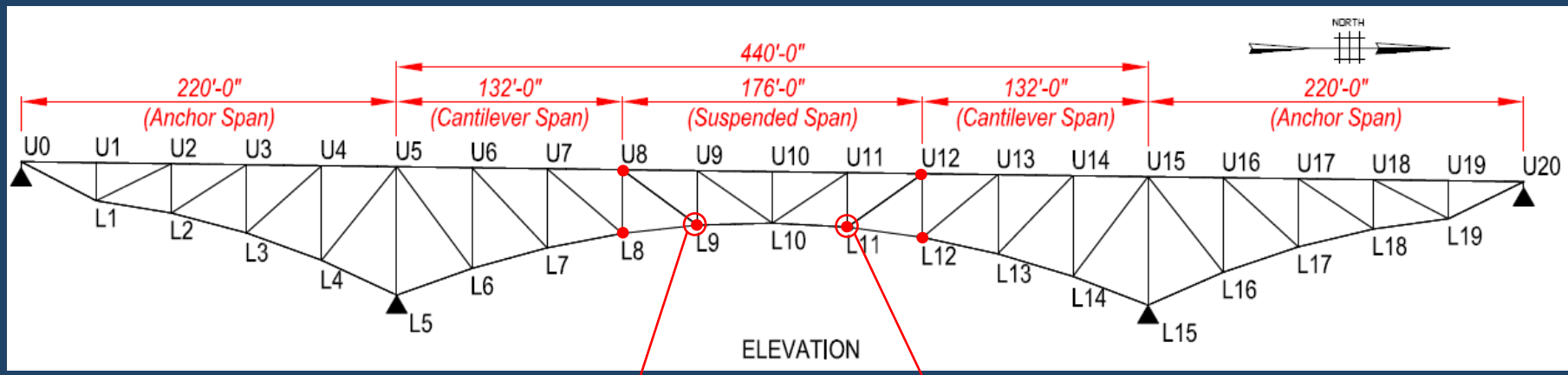
I-91 Deck Truss: Type and Size



L8 Slotted Hole

L12 Slotted Hole

I-91 Deck Truss: Type and Size



L9 Pin

L11 Pin

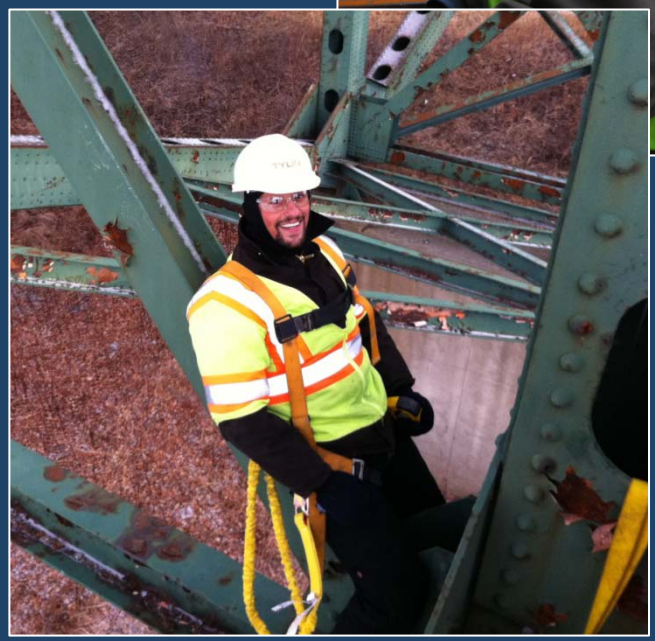
Inspection

- Objective:
  - Obtain detailed information that would assist with quantifying rehabilitation needs, and produce more accurate load ratings and life cycle analyses.
  - Note: Inspection does not replace regular NBIS inspection.
- General Details
  - Inspection Duration: November 29 – December 11, 2010.
  - Inspection Team = 4 Engineers/Inspectors + 1 UT Technician.
  - Used two under bridge inspection units to access all areas of the bridge.
    - Truck types: Aspen UB-50 and Aspen A-75.
  - Both inspection units contained in single lane closure each day.

Inspection Team

Joe Krajewski
Beaverton, OR

Justin Doornink
Beaverton, OR



Ken Rozansky
New York, NY

Shanta Keller
Falmouth, ME

Under Bridge Inspection Units

Inspection

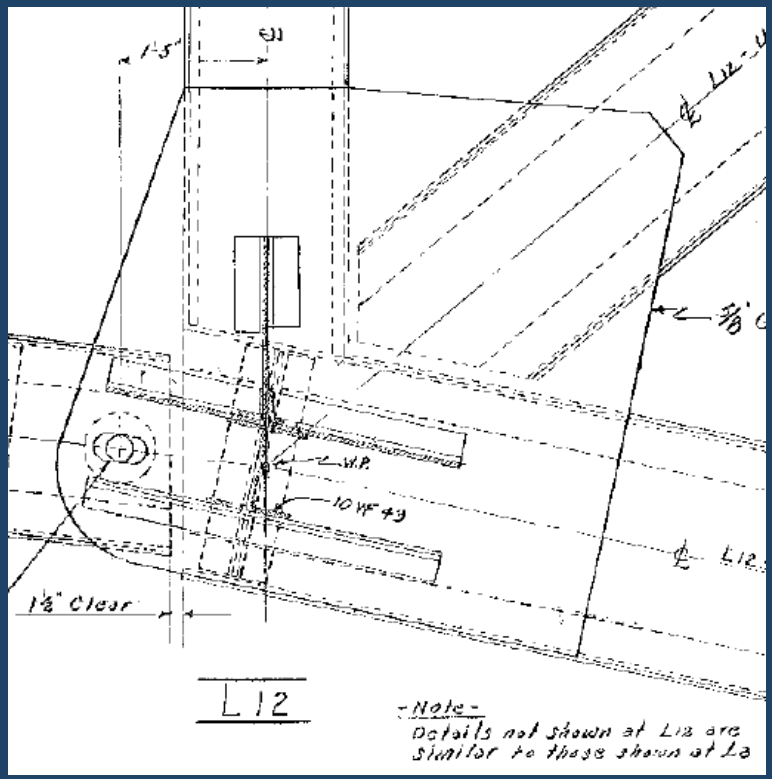
- Traditional Inspection Techniques:
  - Use of measuring tapes, calipers, carpenter's ruler, etc., to inspect, measure, and document As-Built geometries and existing conditions.
  - General condition assessment for all parts of bridge.
  - Quantify deterioration & section loss.
  - Verify and/or supplement shop drawing details (if available).
  - Special interest = gusset plate geometries.
  - Video recording & pictures for documentation.
- Advanced Inspection Techniques:
  - Shear wave ultrasonic testing
    - Links, link pins, and cover plate ends.
  - Phased array ultrasonic testing
    - Gusset plate pins.

Inspection

Typical Findings from Traditional Inspection Techniques

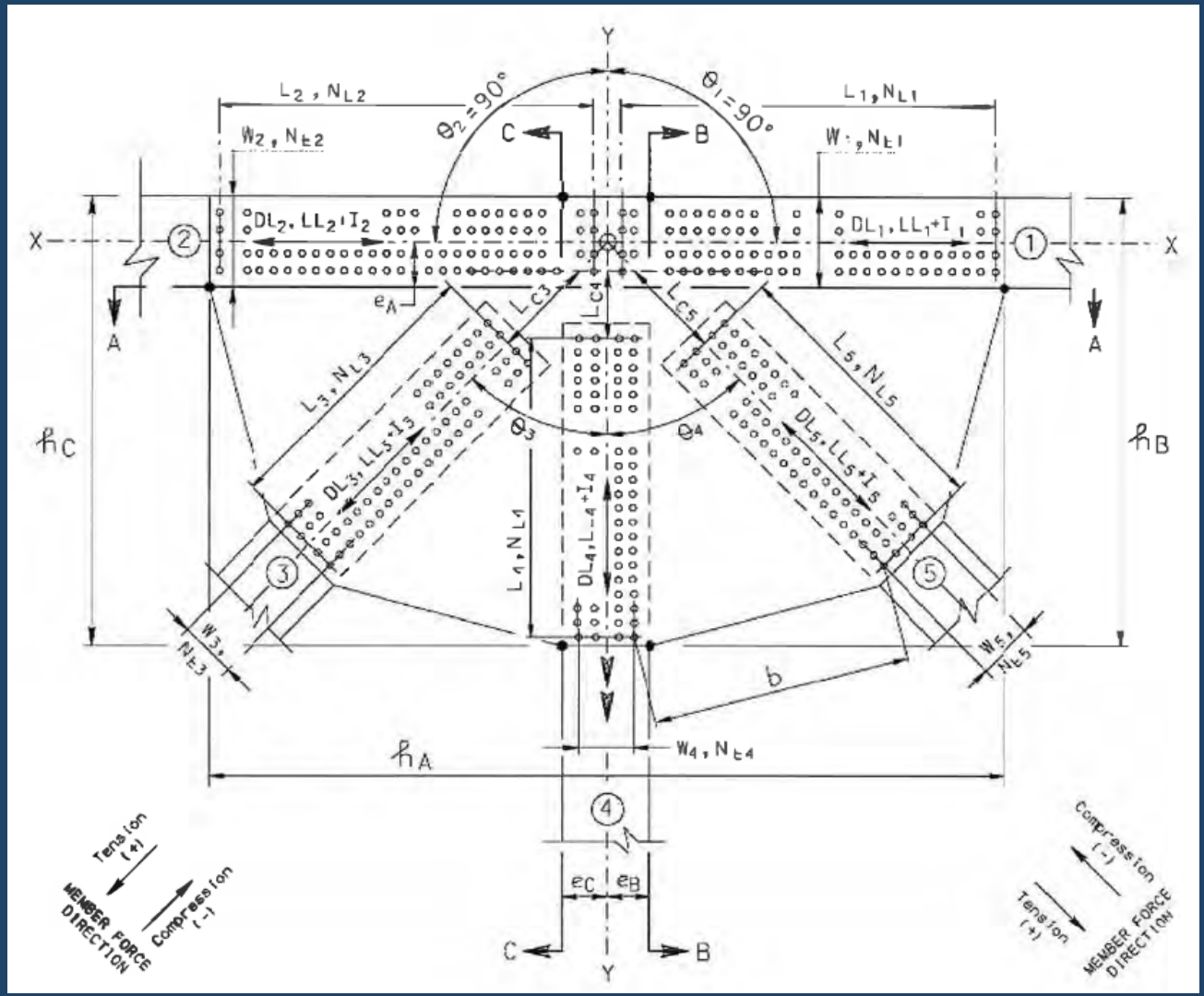
Inspection: Verify Shop Drawings

L12: Plan Set



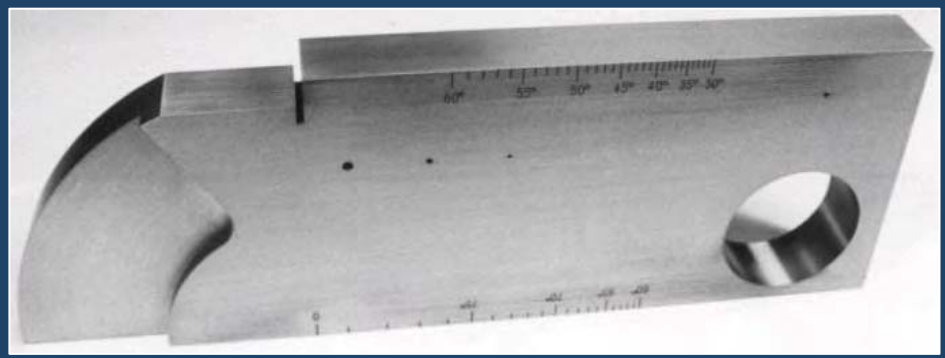
L12: Shop Drawings & As-Built

Inspection: Verify Gusset Plates

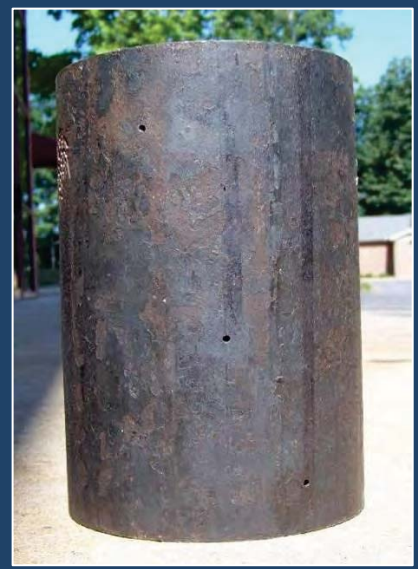


Ultrasonic Testing

- FHWA Bridge Inspector's Reference Manual
- FHWA Guidelines for Ultrasonic Inspection of Hanger Pins
- 2 Types of UT
  - Shear Wave – Traditional Method
  - Phased Array – Advanced Method
- Calibration Blocks



Type 2 Calibration Block



Bridge Pin Calibration Block

Shear Wave Ultrasonic Testing

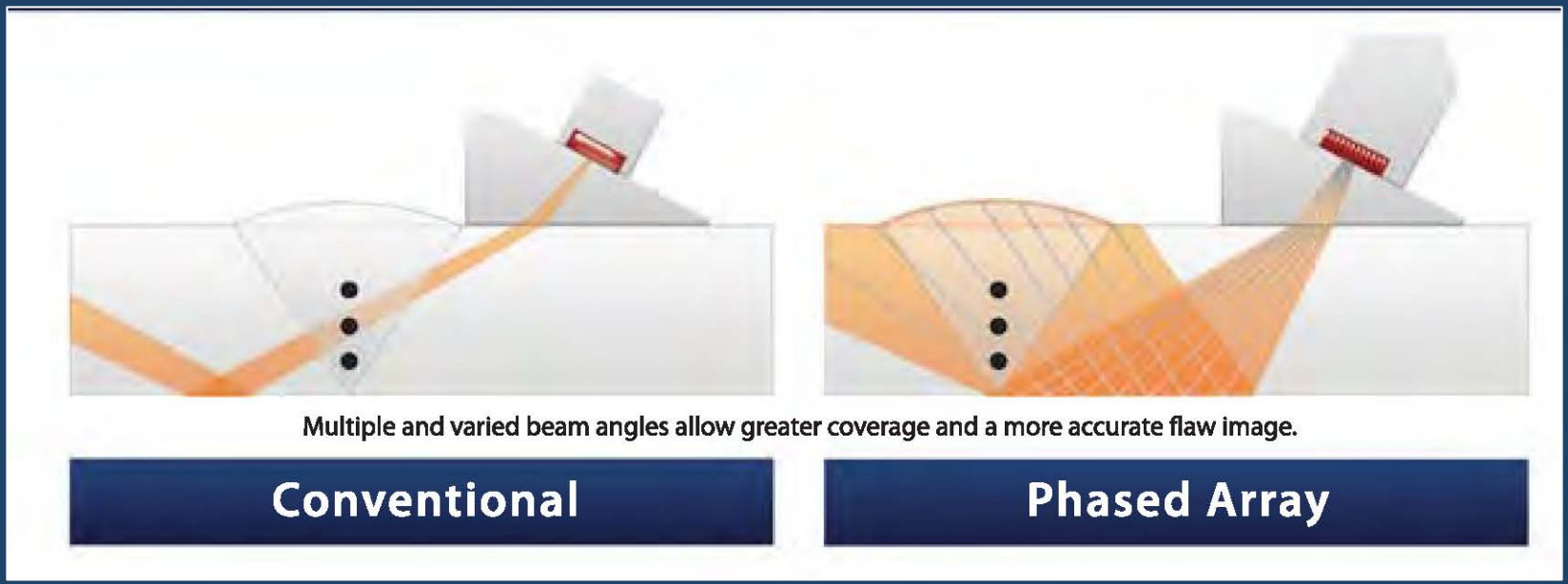
- Standard method of UT that has been used for many years.
- Used for gusset plates, links, link pins, stringer cover plate end welds.
- A variety of wedges were used to generate the appropriate shear wave angle of refraction for the specific parts being inspected.
- The bridge components inspected with Shear Wave UT were found to be reflector free (no indications).

Shear Wave Ultrasonic Testing

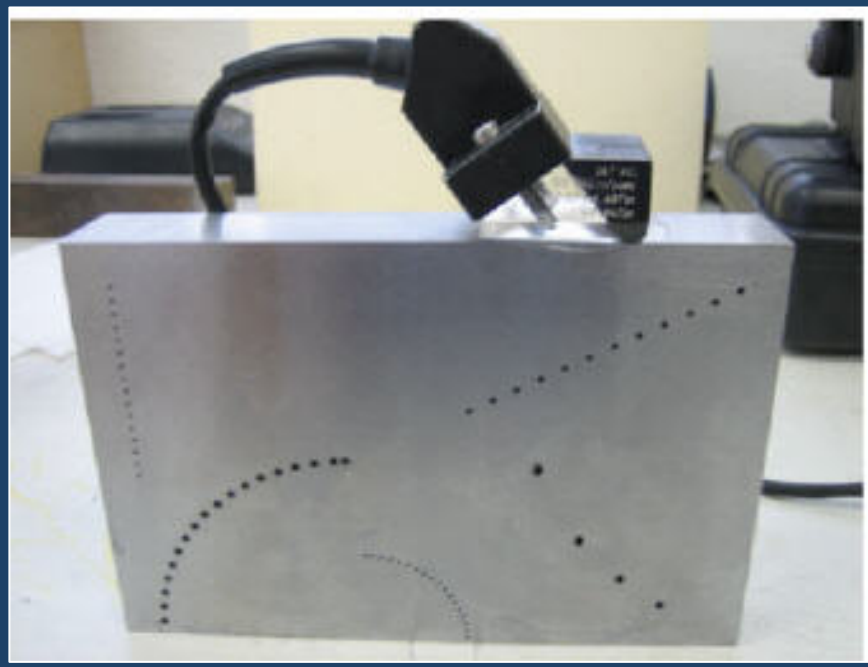
Phased Array Ultrasonic Testing

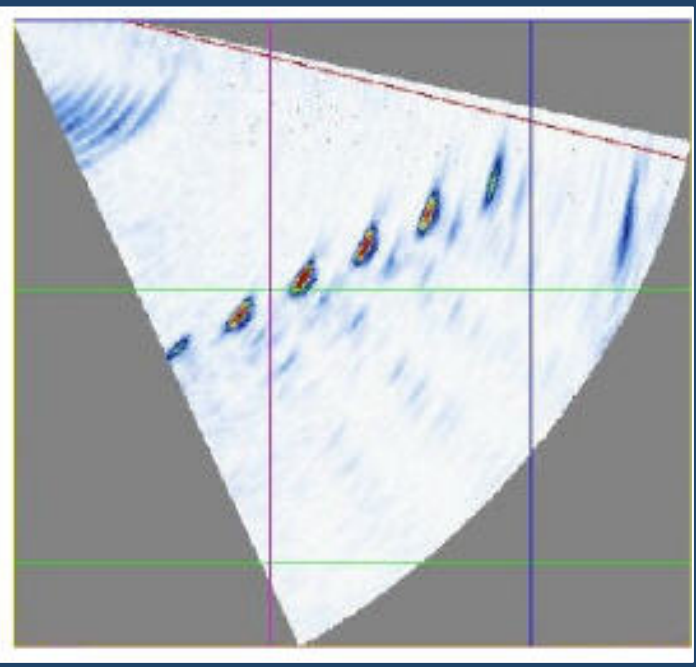
- Advanced method of UT that has been used for many years in medicine and in industrial NDT.
- Multiple probe elements that produce steerable, tightly focused and high-resolution beams.
- Phased Array can produce multiple slices through objects at various angles from a single point or with little movement.
- Phased Array displays images in real time.

Phased Array Ultrasonic Testing



Phased Array Ultrasonic Testing





Phased Array Ultrasonic Testing

- Gusset Plate Pin Inspection. U0, U8, U12, U20, L8, L9, L11 & L12.
- Test Results:
  - 9N – East Truss – L9, Acoustic Couplings.
  - 9N – East Truss – U12, Wear Grooves.
  - 9N – West Truss – L8, Wear Groove.
  - 9N – West Truss – U12, Wear Grooves & Acoustic Coupling.

Phased Array Ultrasonic Testing

Material Testing

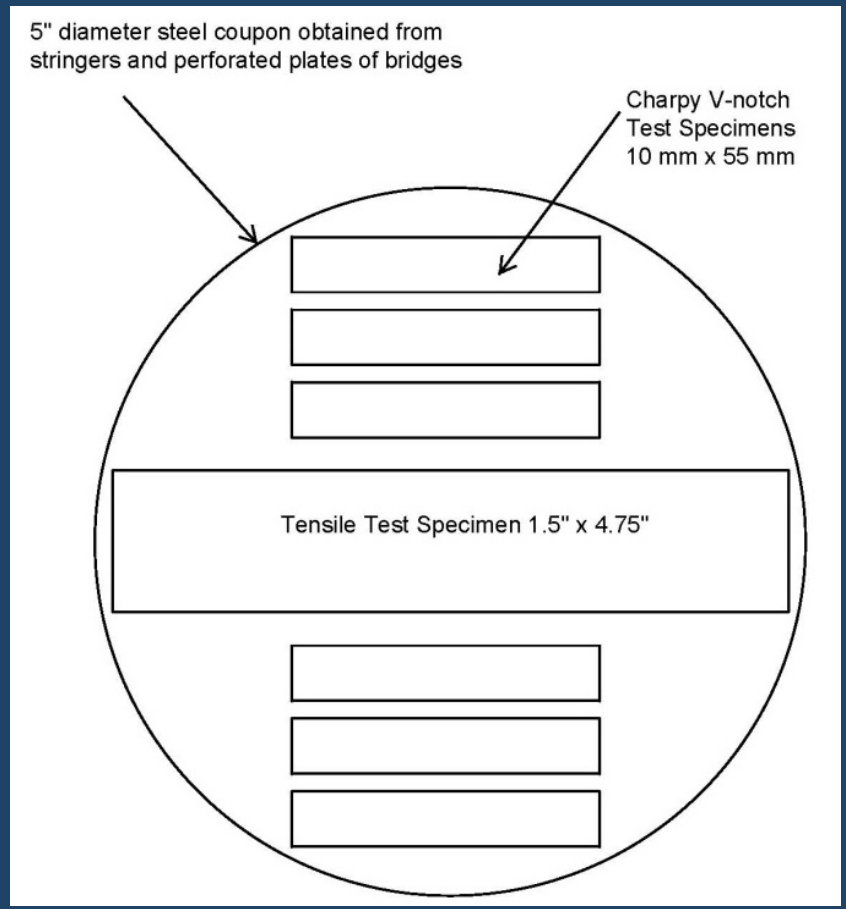
- 8 – 5 inch diameter steel coupons extracted from the south approach span stringers and truss perforated cover plates.
- Coupons were machined into test samples to verify grades and determine toughness.
- Trusses milled out of A7 Steel (not formulated for welding).
- Stringers milled out of A373 Steel (weldable version of A7).
- Testing consisted of tensile tests, Charpy V-Notch, Chemical Composition

Material Testing

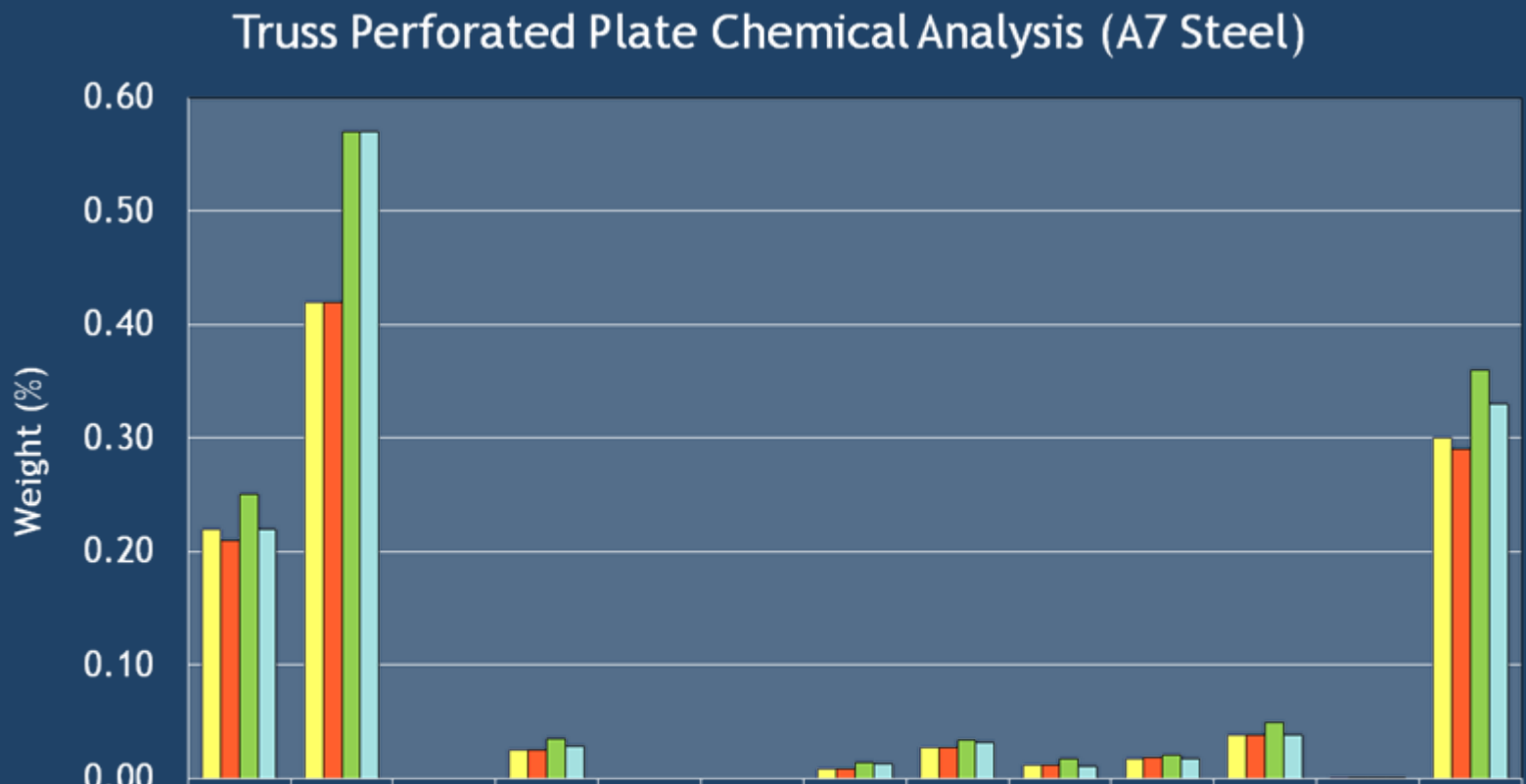
Coupon Extraction from Truss Cover Plate

Material Testing

- Tests per Coupon
  - 6-Charpy V-Notch
    - 30°, 40°, 50°, 60°, 70°, 80°F.
  - 1-Tensile Test.
  - 1-Chemical Analysis.
- 8 Coupons
  - 4 from Stringer Webs.
  - 4 from Perforated Plates.
- Orientation of Specimens
  - ½ Parallel to Rolling Direction.
  - ½ Perpendicular to Rolling Direction.

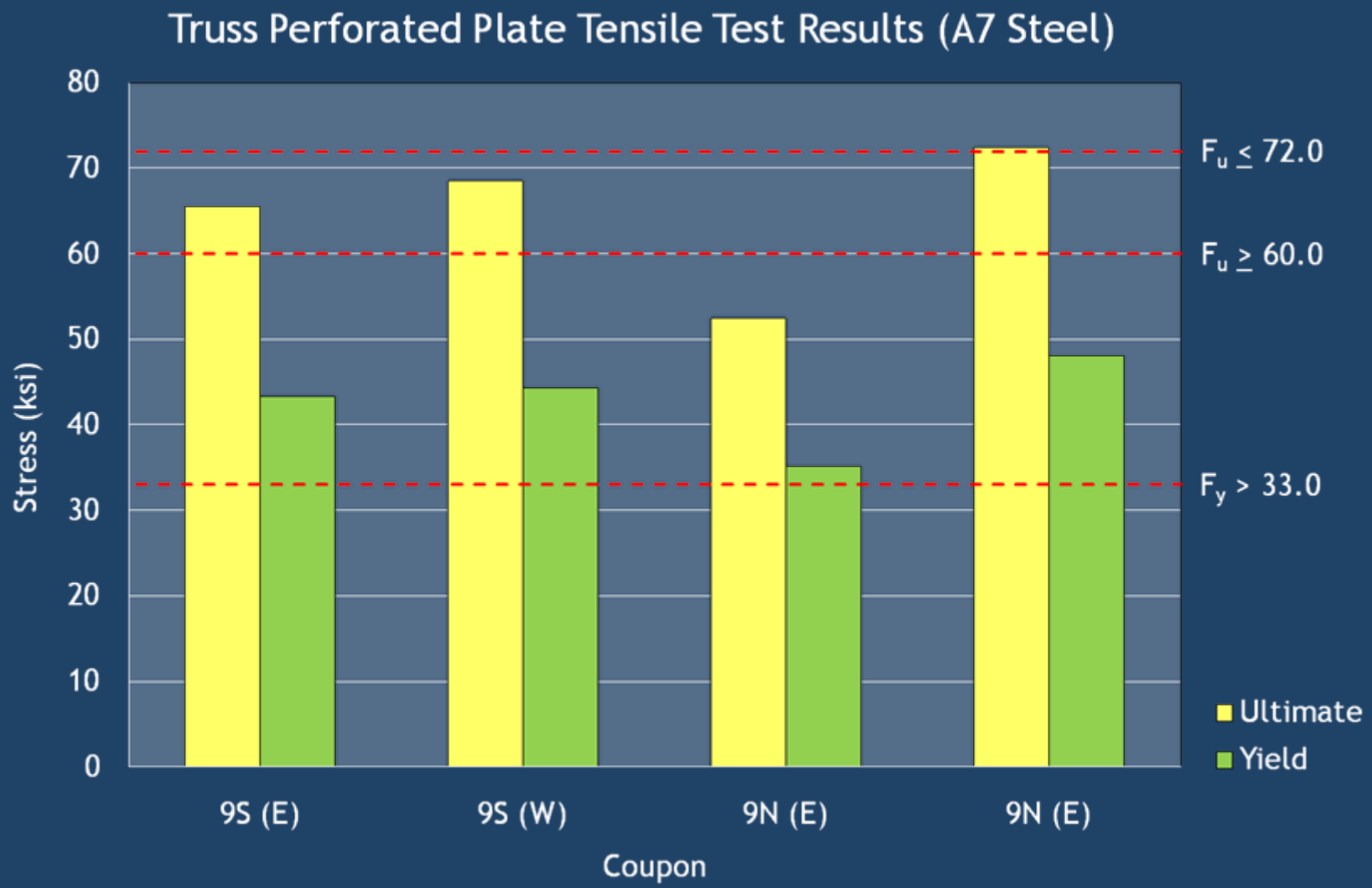


Material Testing



	C	Mn	Al	Cr	Cb	Cu	Mo	Ni	P	S	Si	V	C.E.
9S (E)	0.22	0.42	0.00	0.03	0.00	0.00	0.01	0.03	0.01	0.02	0.04	0.00	0.30
9S (W)	0.21	0.42	0.00	0.03	0.00	0.00	0.01	0.03	0.01	0.02	0.04	0.00	0.29
9N (E)	0.25	0.57	0.00	0.04	0.00	0.00	0.01	0.03	0.02	0.02	0.05	0.00	0.36
9N (E)	0.22	0.57	0.00	0.03	0.00	0.00	0.01	0.03	0.01	0.02	0.04	0.00	0.33

Material Testing



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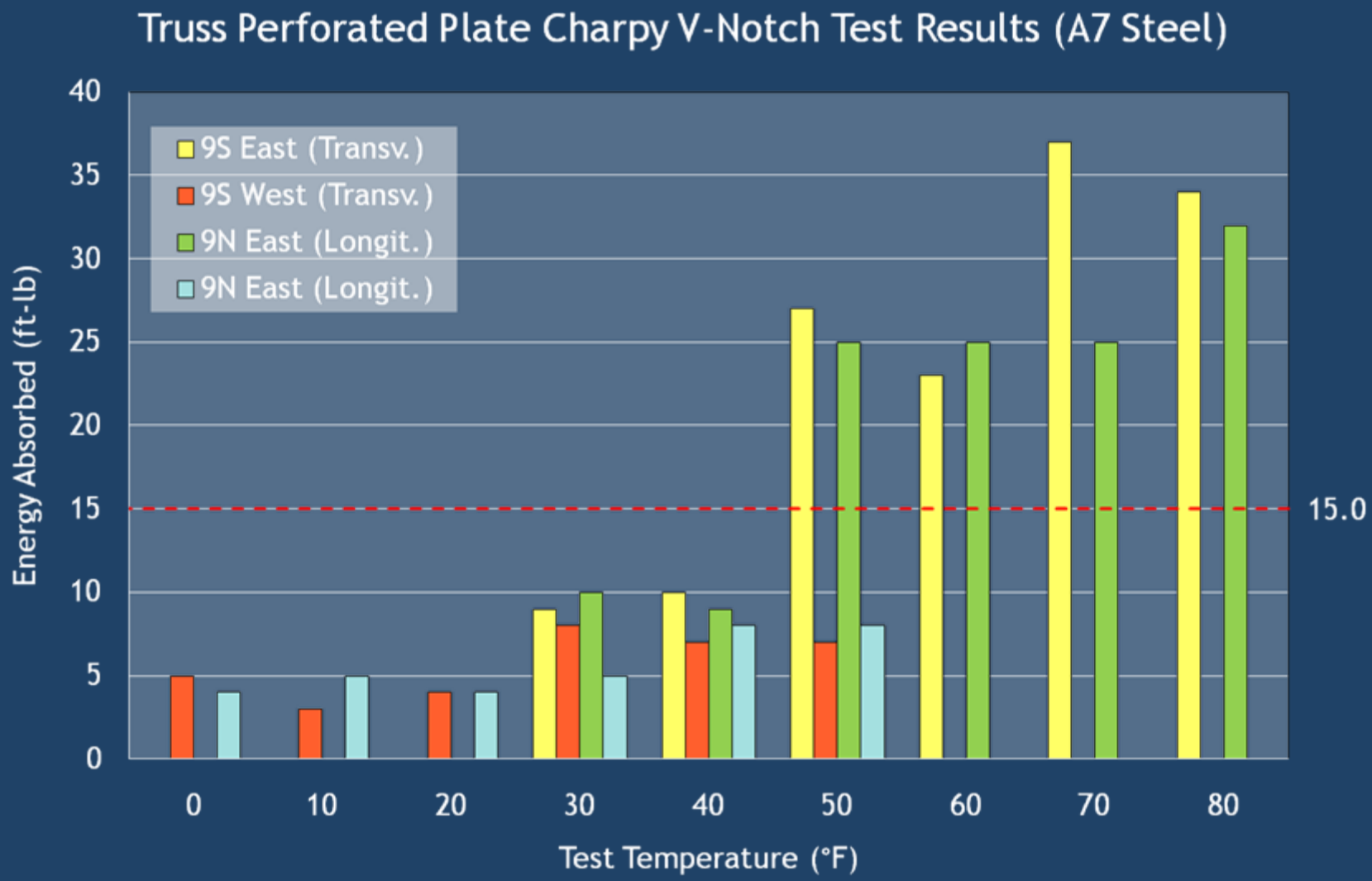

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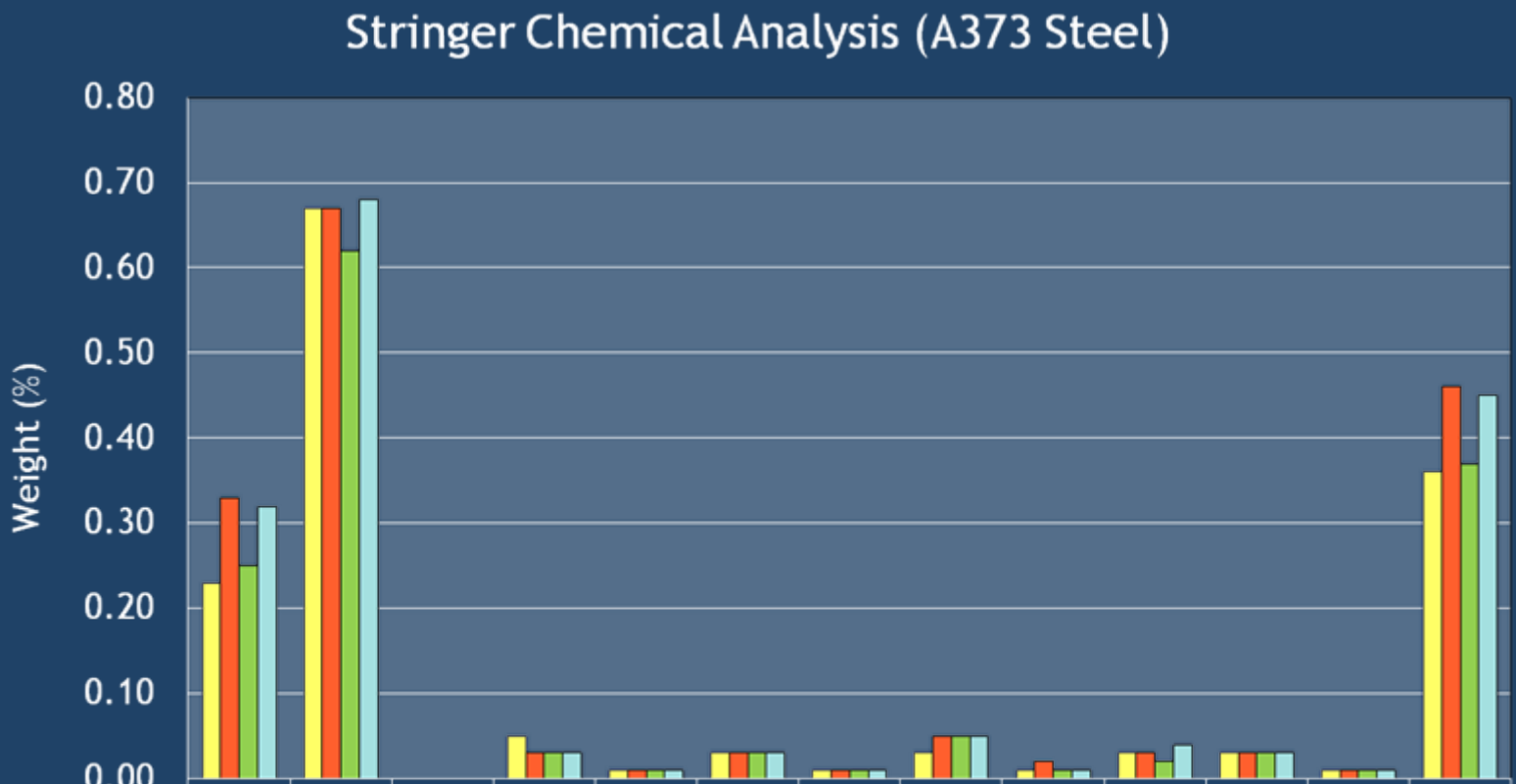
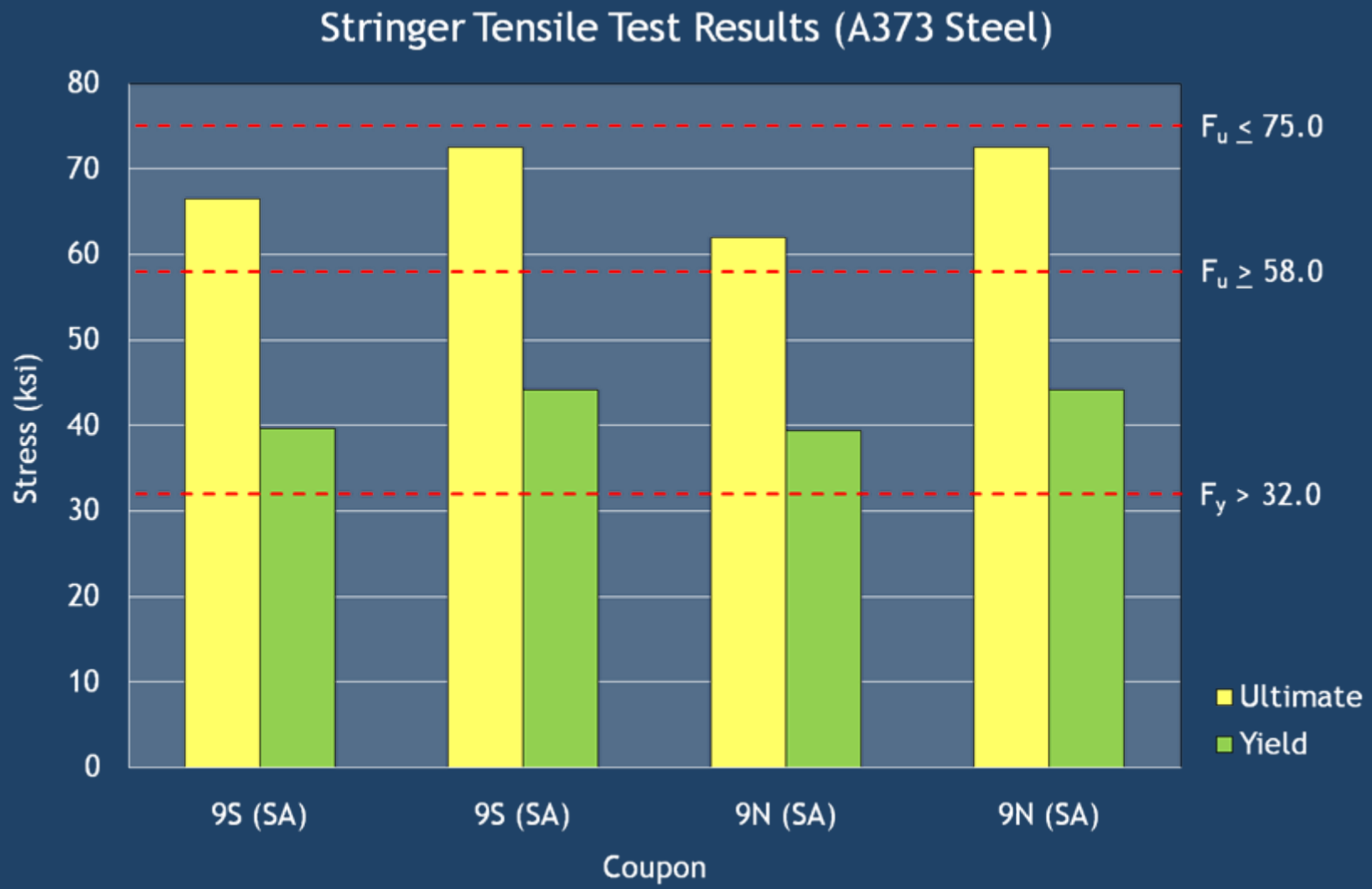
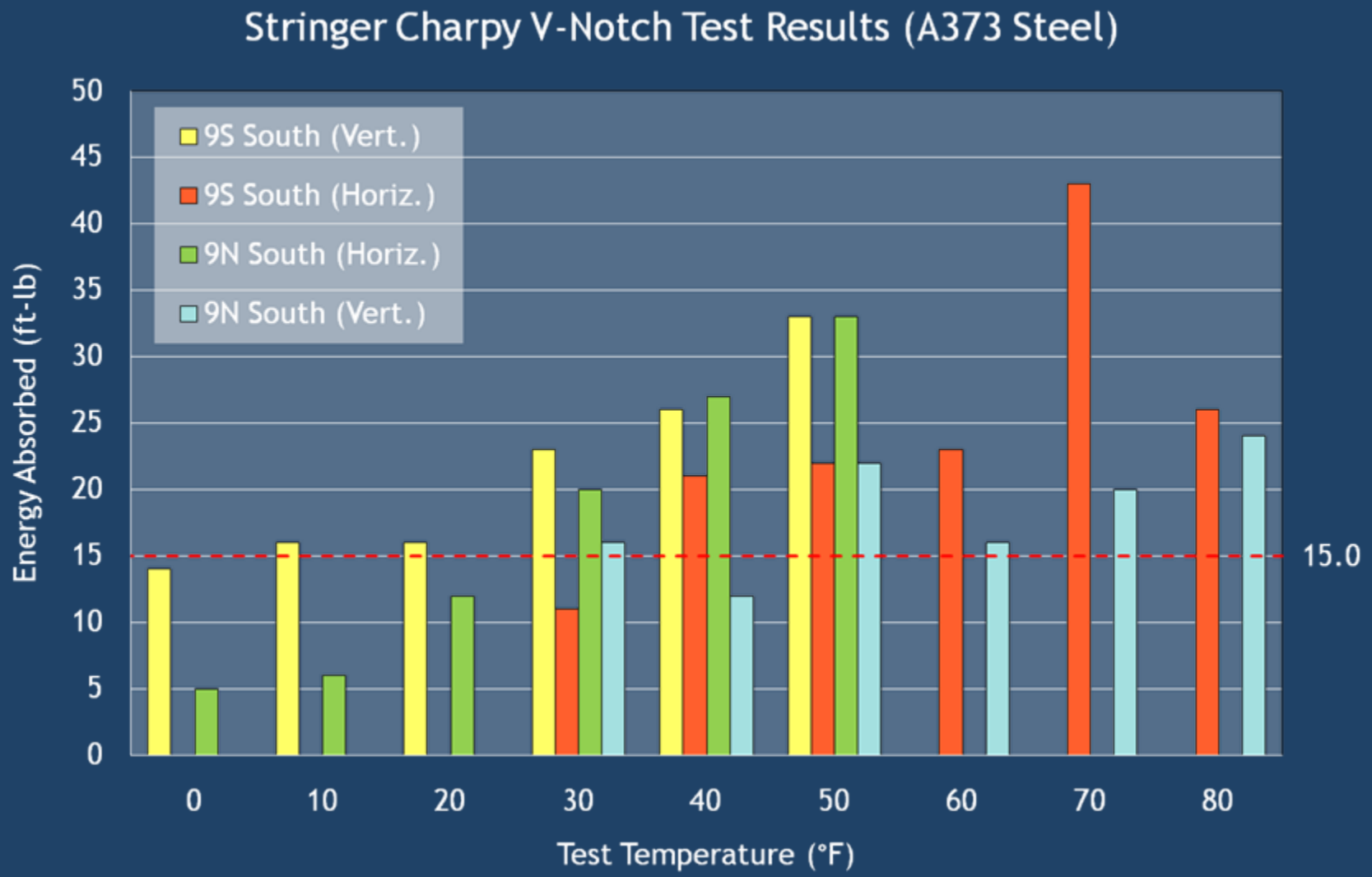


	C	Mn	Al	Cr	Cb	Cu	Mo	Ni	P	S	Si	V	C.E.
9S (SA)	0.23	0.67	0.00	0.05	0.01	0.03	0.01	0.03	0.01	0.03	0.03	0.01	0.36
9S (SA)	0.33	0.67	0.00	0.03	0.01	0.03	0.01	0.05	0.02	0.03	0.03	0.01	0.46
9N (SA)	0.25	0.62	0.00	0.03	0.01	0.03	0.01	0.05	0.01	0.02	0.03	0.01	0.37
9N (SA)	0.32	0.68	0.00	0.03	0.01	0.03	0.01	0.05	0.01	0.04	0.03	0.01	0.45

Material Testing



Material Testing



Questions?