

Keystone Wye Project

Owner – State of South Dakota - SDDOT

Project Manager – Todd Thompson, P.E.

Consultant – Stantec

Stantec Project Manager – Jan Hansen, P.E.

Sub Consultant – Wood Research and Development

WRD Project Manager – Dan Tingley, P.E.

Prime Contractor – Corr Construction Services

Project Manager – Jack Corr

Keystone Wye Bridges

Project Cost Guessing Game

1. In 1966, Summit Construction was the prime contractor for this project which included the two bridges, 3.2 miles of grading, 1.3 Million cu yds of Unclassified Excavation and Option Borrow. What was the dollar amount of the low bid for the entire project?
 - A. \$6,367,480
 - B. \$4,860,848
 - C. \$2,625,199
 - D. \$993,936

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Keystone Wye Bridges

Project Cost Guessing Game

2. George Moore was the bridge subcontractor. What was the dollar amount of the items that were only associated with the 2 bridges?
- A. \$2,282,006
 - B. \$1,374,748
 - C. \$784,868
 - D. \$398,111

Keystone Wye Bridges

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Keystone Wye Bridges

Project Cost Guessing Game

3. Corr Construction was the low bidder on the Keystone Wye Bridge Rehabilitation Project let in May of 2021. What was the bid cost for the project?
- A. \$7.2 Million
 - B. \$4.5 Million
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Keystone Wye Bridges

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Structure History

- Two former Chief Bridge Engineers, K.C. Wilson, PE and Clyde Jundt, PE designed these two structures
- These structures are the “Gateway” to the Black Hills and have gained international recognition



Project Need

- Decks needed repair or replacement; low clear cover in concrete decks, deck delamination's and spalls
- Timber – we thought was good but wanted expert opinion for any unknown or unidentified issues
 - SDDOT didn't have any expertise in glulam timber
- SDDOT wanted to keep this signature bridge in good condition for the long term. Bridge is currently 56 years old and was 50 when we started this project
- Wanted to keep the historical look and feel for any work we did

Project Solicitation

- Scope of work to:
 - Phase 1
 - Inspect both visually and with NDT
 - Make recommendations for work
 - Load rate structure based upon current condition
 - Phase 2
 - Design and produce bridge plans for the rehabilitation project
 - Shop plans review and approval
 - Construction questions

Project History

- SDDOT advertised nationally in the Fall of 2017 for proposals from firms to do this work
- SDDOT contracted with Stantec in January 2018
 - Stantec sub-contracted with Wood Research Development, an international firm that specializes in timber structures to provide timber technical guidance

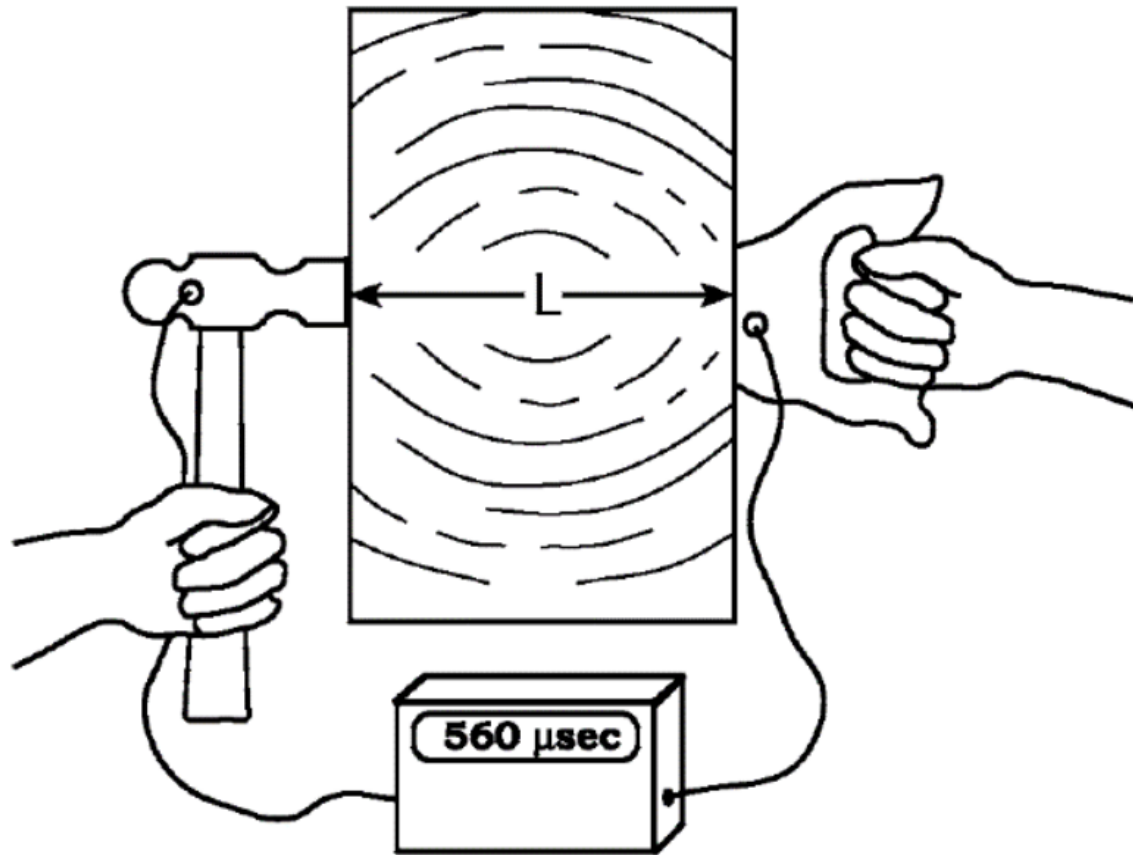
Project History – Phase 1 – Inspection and Recommendations

- Bridges were inspected in February and March 2018
- They also performed Non-Destructive Testing to evaluate the condition of the timber
- Consultant provided an Inspection and Evaluation report in November 2018 including recommendations on repair/rehabilitation strategies
- Consultant also provided bridge load ratings for both bridges based upon their inspection, evaluation and ND Testing results

Non-Destructive Testing

- Used Stress-Wave Timing Testing (SWT)
 - Measures the speed in which it travels through the timber
 - Faster – higher quality timber
 - Slower – more decay in the timber
- Took some cores to correlate and confirm the SWT results

Stress Wave Timing



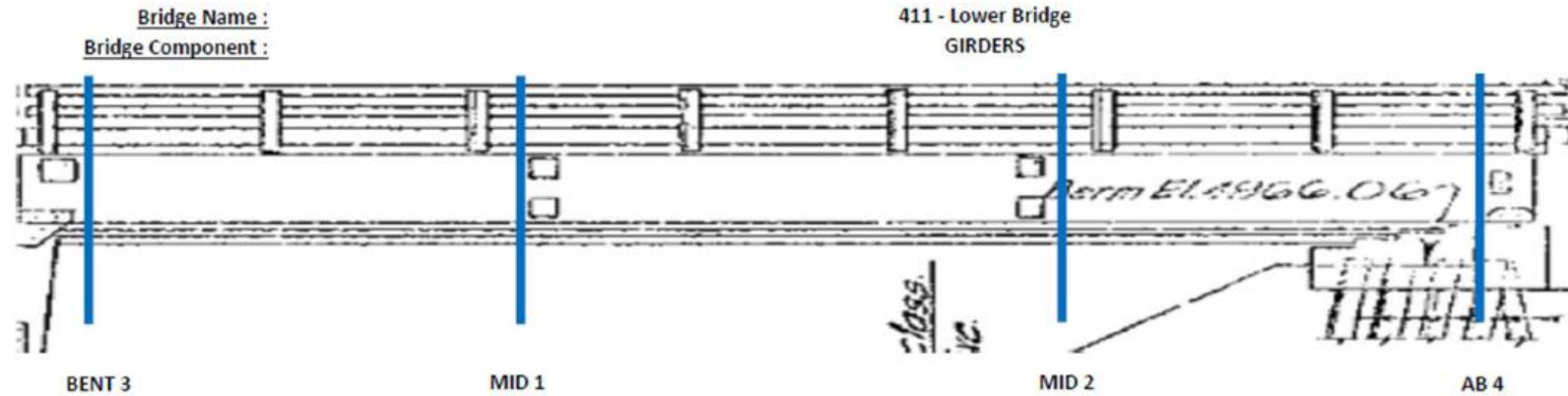
Source: U.S. Department of Agriculture, Forest Service.

Figure 3. Schematic. Illustration of the principle of stress wave timing tests.⁽¹⁾

Non-Destructive Testing

- Green – timber in good condition
- Yellow – timber starting to deteriorate
- Red – timber deteriorated and may impact load capacity
- Yellow/Red areas – moisture is normal driver for timber deterioration
- Results will establish a base line of the timber condition and identified areas that will need to be addressed

SWT Results



Location Per Plan :	Span 3	Girder 2	29 Laminations	55.49 FT Span Length
Location Per SD DOT Inspection :	Span 1	Girder 3	29 Laminations	55.49 FT Span Length

SWT Data								
Location :	Bent 3		MID 1		MID 2		AB 2	
Girder Height :	47 inches		47 inches		47 inches		47 inches	
Girder Width (Gauge Length) :	11 inches		11 inches		11 inches		11 inches	
Lamination Number	Raw SWT	Adjusted SWT	Raw SWT	Adjusted SWT	Raw SWT	Adjusted SWT	Raw SWT	Adjusted SWT
1	327	357	750	818	1241	1354	441	481
5	217	237	342	373	285	311	246	268
10	202	220	255	278	384	419	309	337
15	286	312	263	287	386	421	192	209
20	212	231	237	259	279	304	241	263
25	262	287	261	284	332	359	217	245



Recommendations

- Replace the concrete decks due to advanced deck deterioration along with very low clear cover
- Eliminate moisture getting to timber with revised details where possible (eliminate joints where possible)
- Control moisture in timber in locations where moisture can support deterioration – use of borate salts
- Various minor repairs to concrete and repair galvanized connections where necessary
- Initial Load ratings were good for in place condition of the bridges

Phase 2 – Design and Plans Production

- Take the recommendations and create a set of plans for construction



Deck Replacement

- Originally planned on replacing concrete deck with a concrete deck
 - But with stainless steel rebar
- During design we decided to have consultant look at timber deck vs concrete deck
 - Why? One of the biggest drivers of deterioration was leaking joints allowing moisture to get to the various timber members
 - Quicker construction time and weather in winter secondary drivers

Timber vs Concrete Deck

- Objectives of the study
 - Maintain the load carrying capacities
 - Control the flow of water to lessen future deterioration of the timber
 - Provide for speedy construction during tourist off-season
 - Durability, service life
 - Reasonable initial and maintenance costs

Timber vs Concrete Deck

- **Alternatives**

- 1. **Concrete** replaces the decks in kind.
 - a. Added benefits from stainless steel reinforcing
 - b. Expansion joints are replaced in kind with new assemblies
 - c. Load ratings remain the same or slightly better than today
- 2. **Timber** replaces the decks with prefabricated timber panels.
 - a. Expansion joints are eliminated
 - b. Load ratings are increased (initial thought due to lower DL weight)

Timber vs Concrete Deck

- Recommendation was to use Timber Decks
 - The timber decks with membrane and asphalt overlay eliminates the need for joints and should eliminate or minimize any water getting to the timber members
 - The lower bridge was composite before but the timber deck is now non-composite. This did produce a lower load rating. Which required us to strengthen the lower bridge with high strength fiber.
 - The timber decks are prefabricated off site and can be placed quickly which will help with the off-season construction. And can be done in lower temperatures as opposed to concrete deck
 - Office of Bridge Design agreed with that recommendation

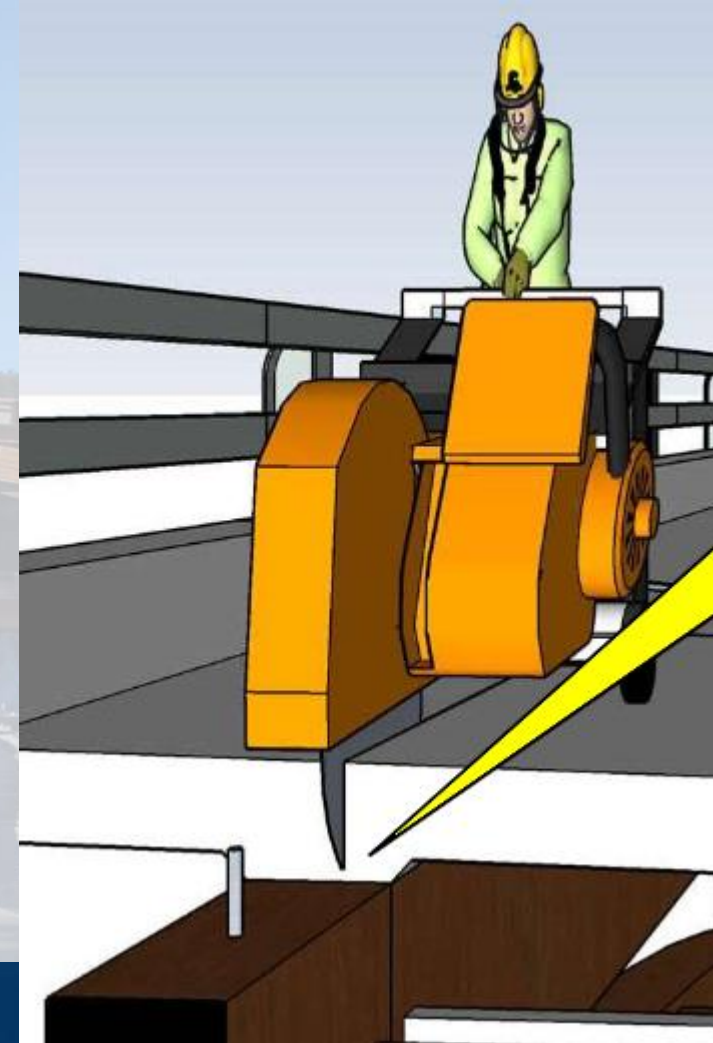
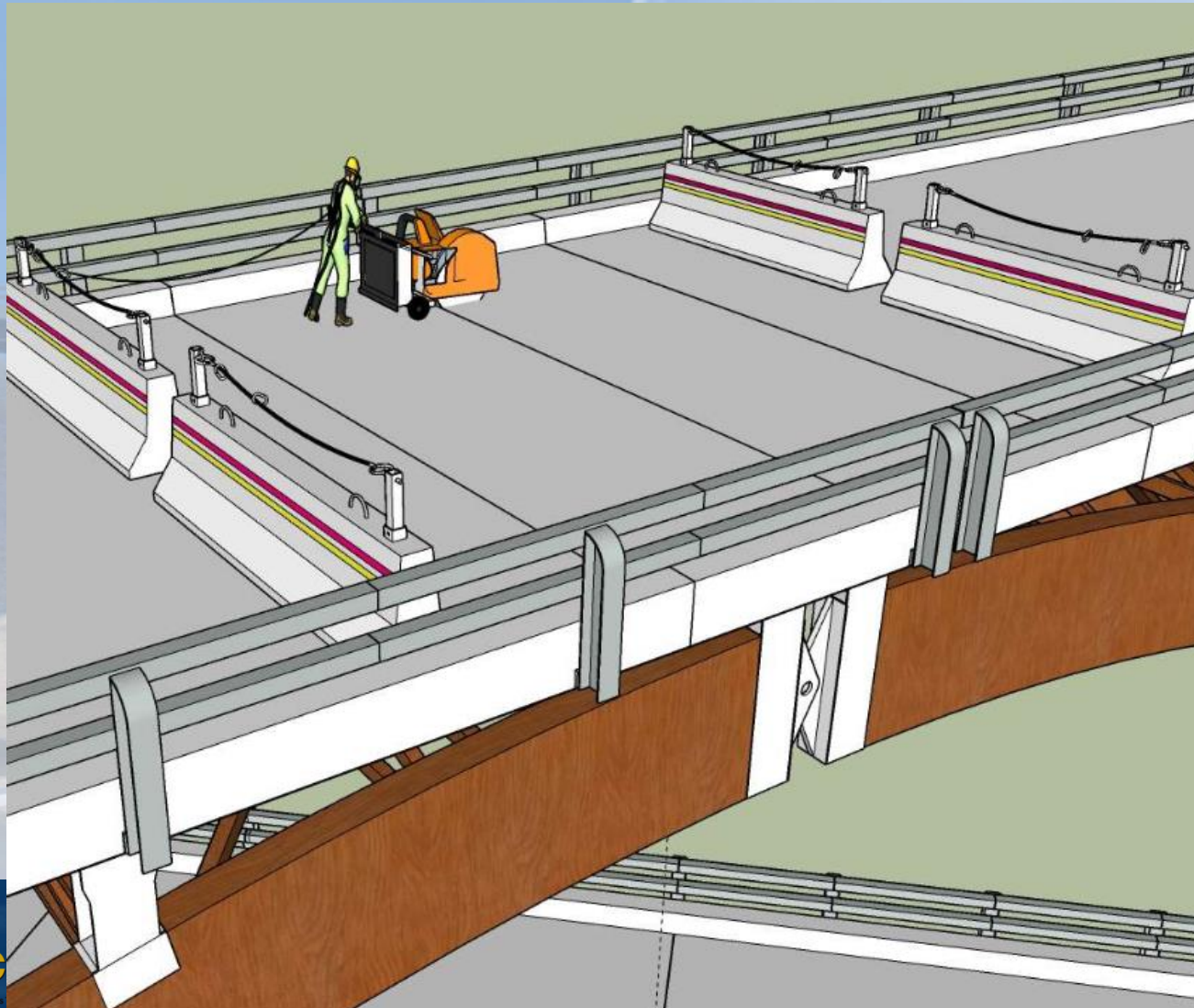
Bid Letting

- Bid Letting was 5/5/2021
- Intent to start construction Fall of 2021
 - After Labor Day and tourist season
- Complete construction Spring of 2022
 - Before Memorial Day and tourist season
- Tight construction time over the Winter with unpredictable weather
- Corr Construction was the low bidder
- But low bid was 39% over engineer's estimate
 - Coming off the pandemic
 - Remember the high timber prices? Yup – right when we advertised to bid

Construction (aka “The Fun Part”)

- Sequence:
 - Traffic Control
 - Remove Deck
 - Diffuse Timber
 - Timber Deck
 - Timber Rail
 - Tension Retrofit/Strengthening
 - Substructure Repair
 - Asphalt Pavement

Deck Removal

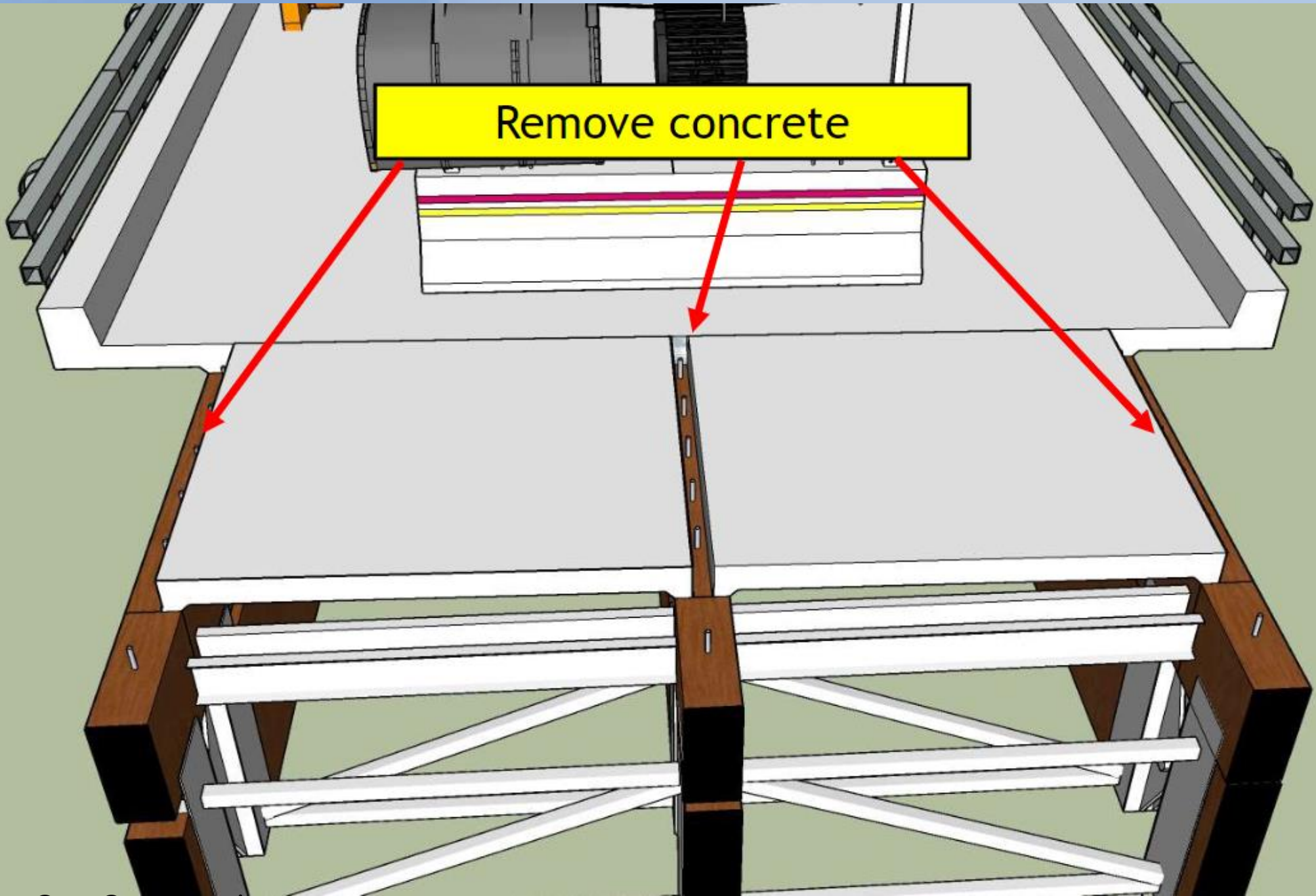


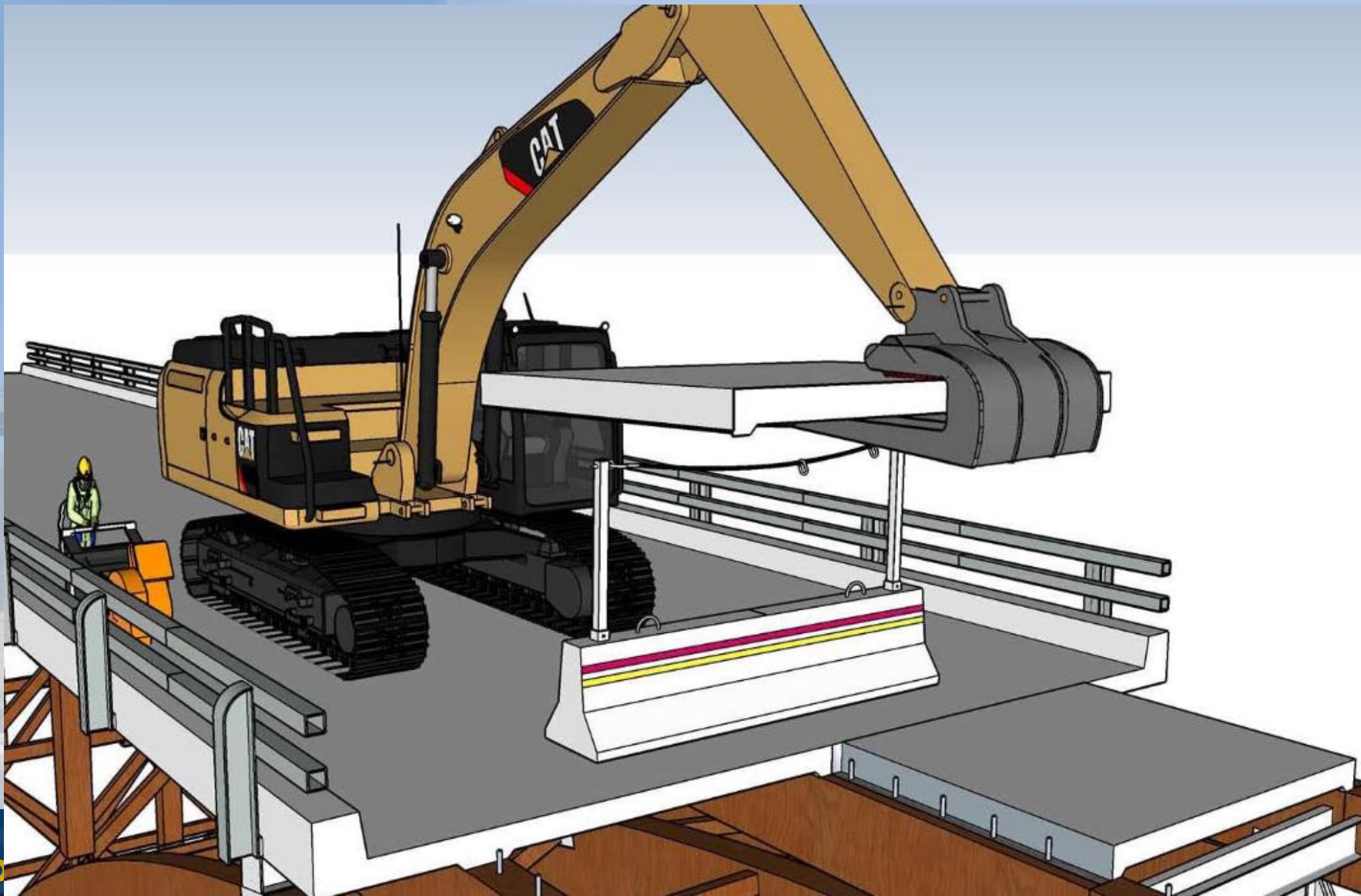
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Images from Corr Construction



Remove concrete









Innovation for Infrastructure Resiliency







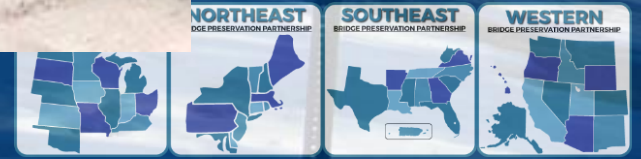








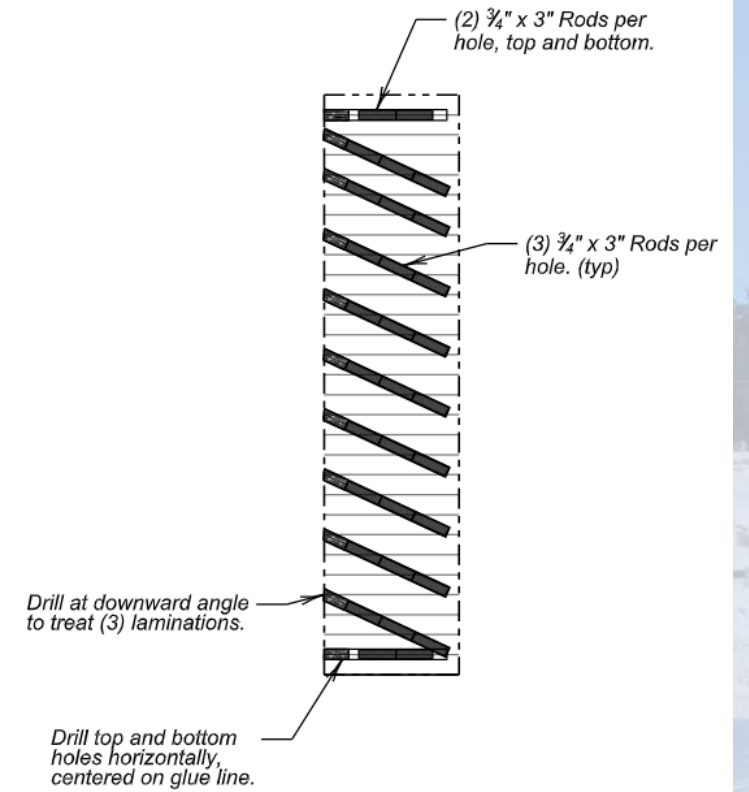
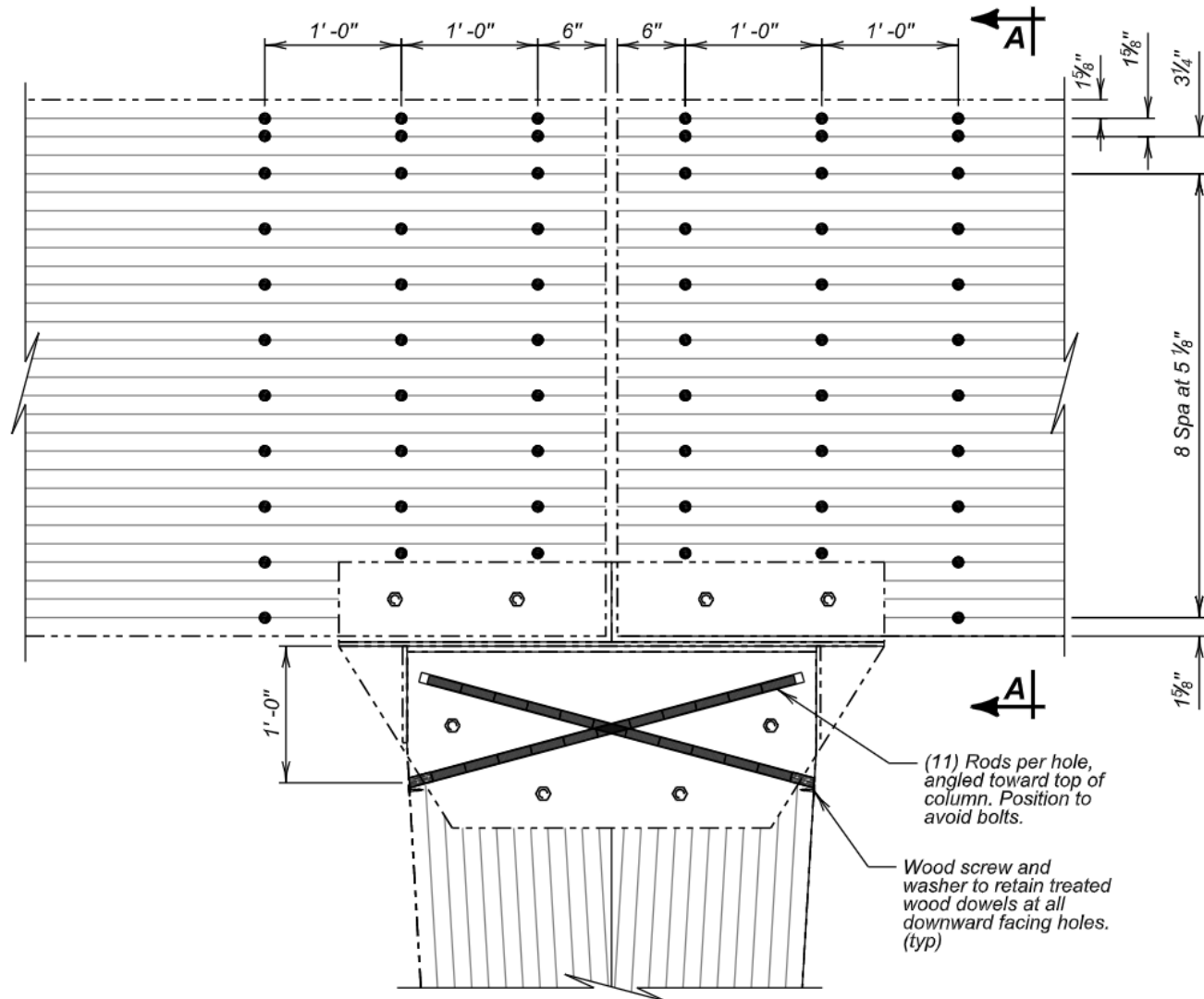
NATIONAL BRIDGE PRESERVATION CONFERENCE 2024
Innovation for Infrastructure Resiliency







Diffuse Timber



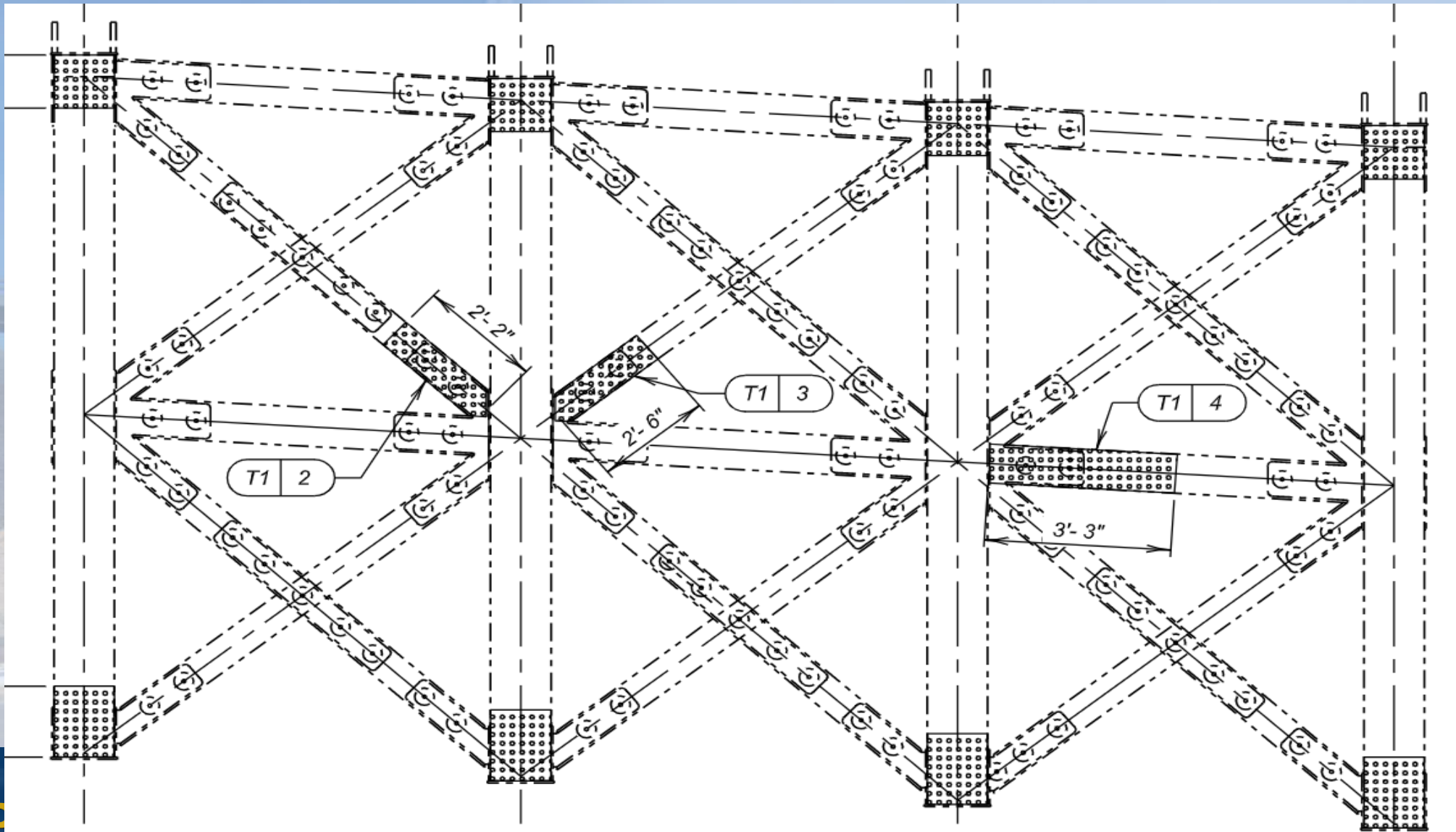








Repeat about 2000 times



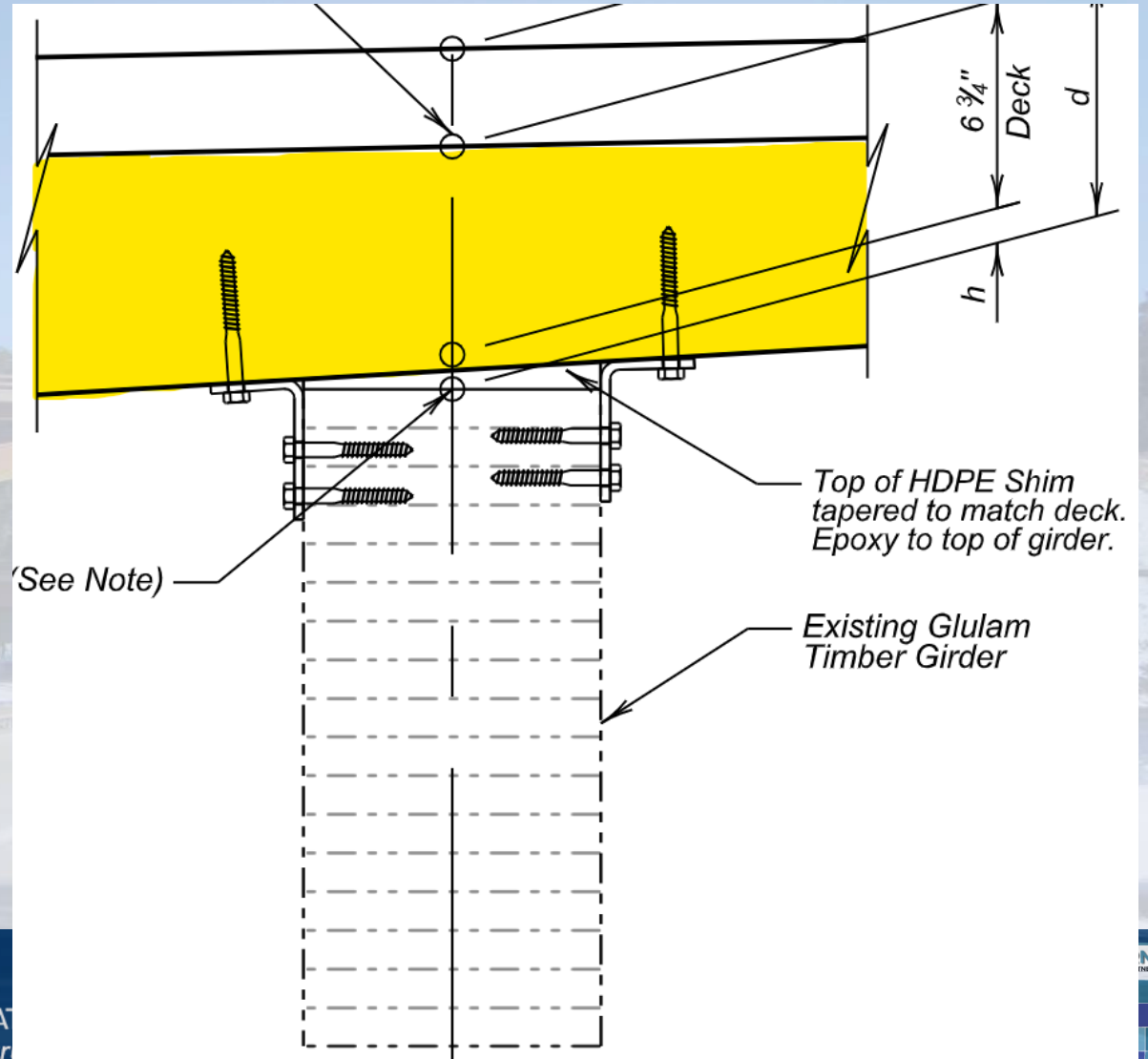
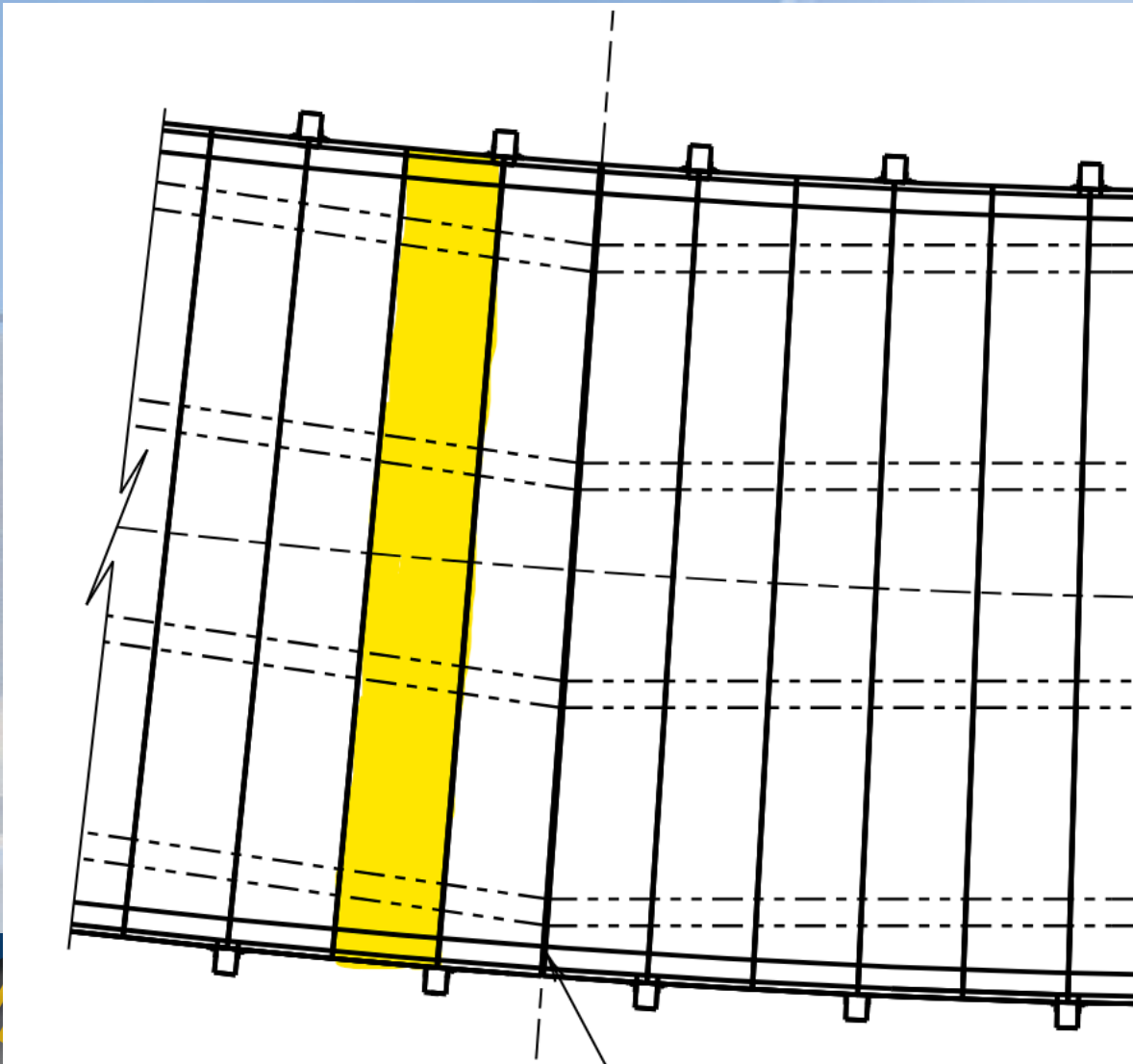
Construction (getting less fun now)

- Sequence:

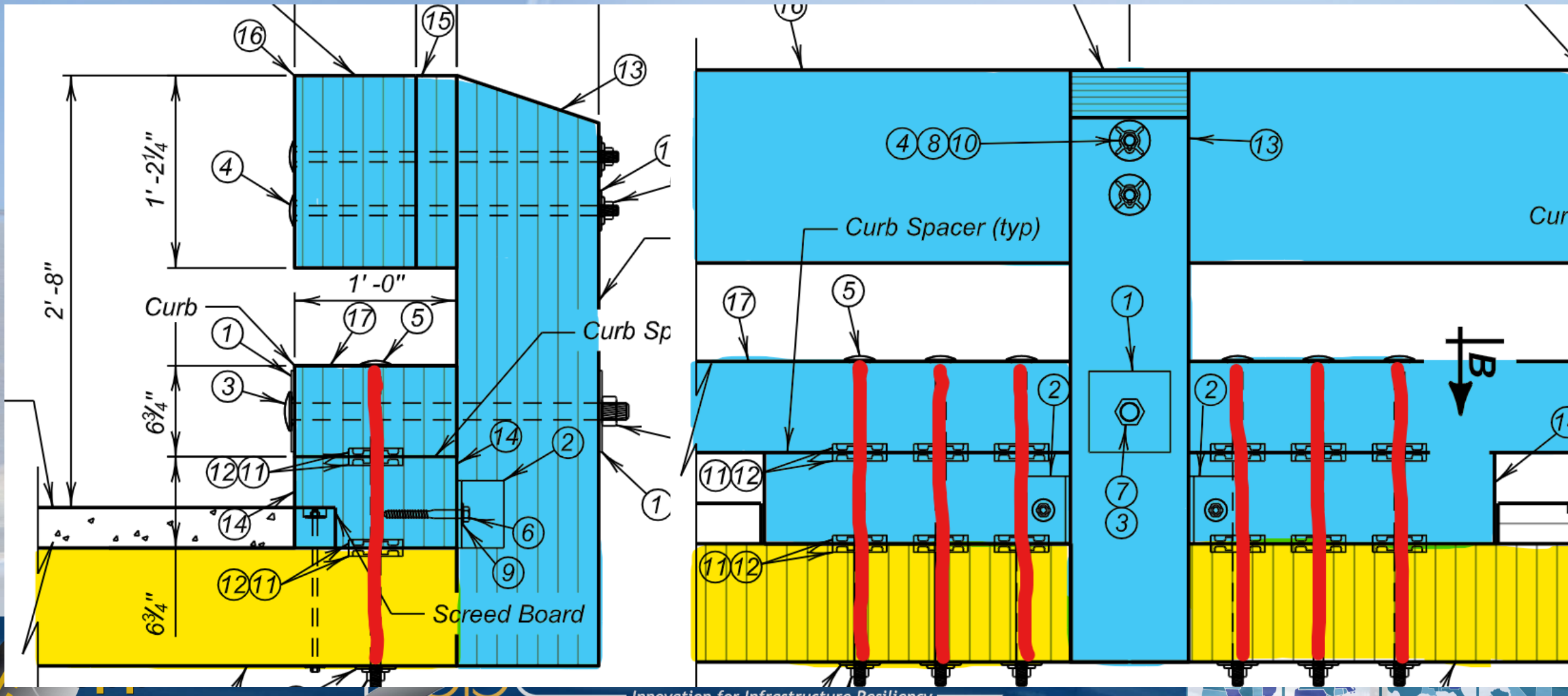
- ~~Traffic Control~~
- ~~Remove Deck~~
- ~~Diffuse Timber~~
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- Tension Retrofit
- Substructure Repair
- Asphalt Pavement

! Deadline May 20th

Timber Deck



Timber Rail

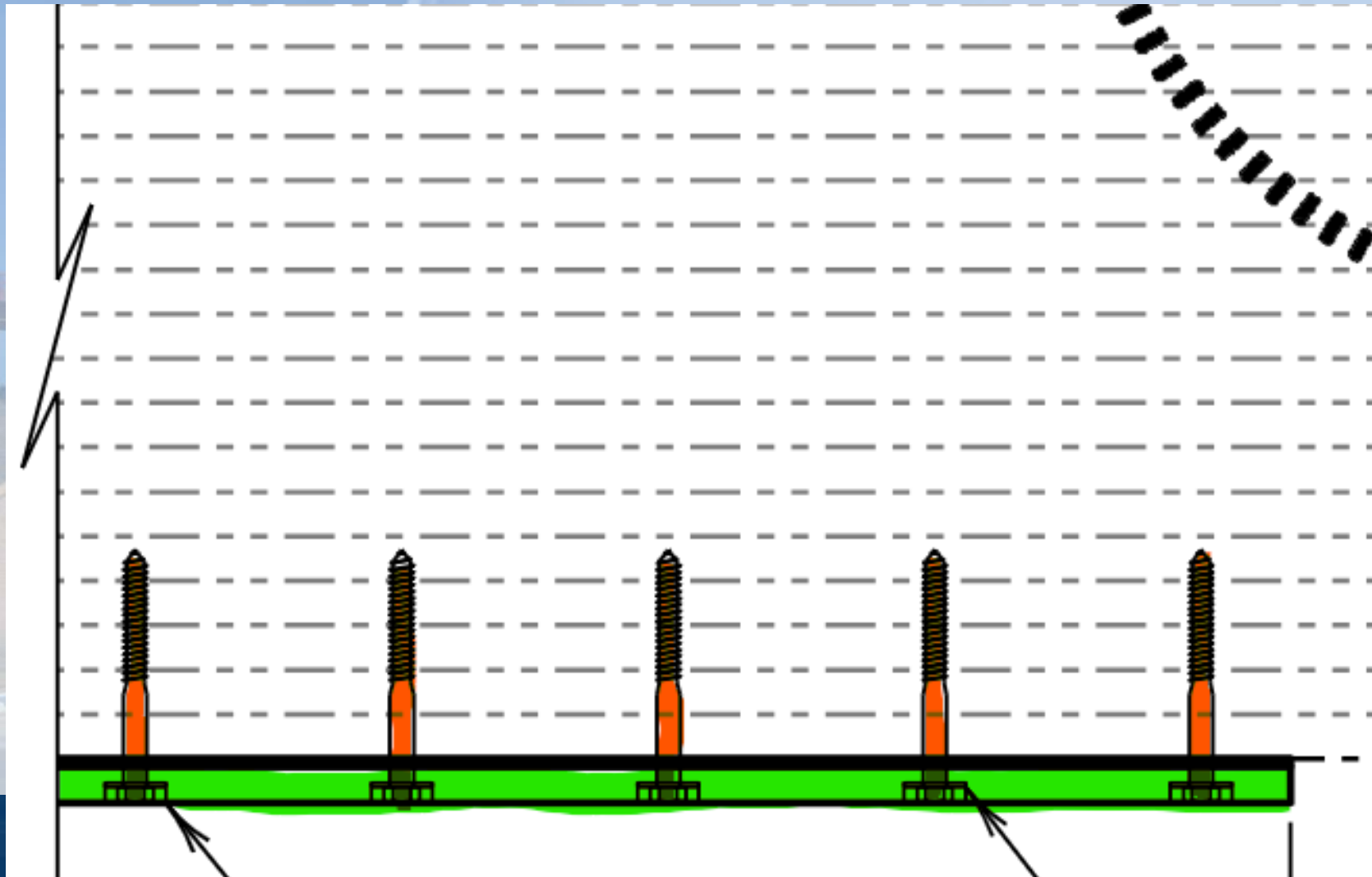


Shipping Issues





Tension Retrofit

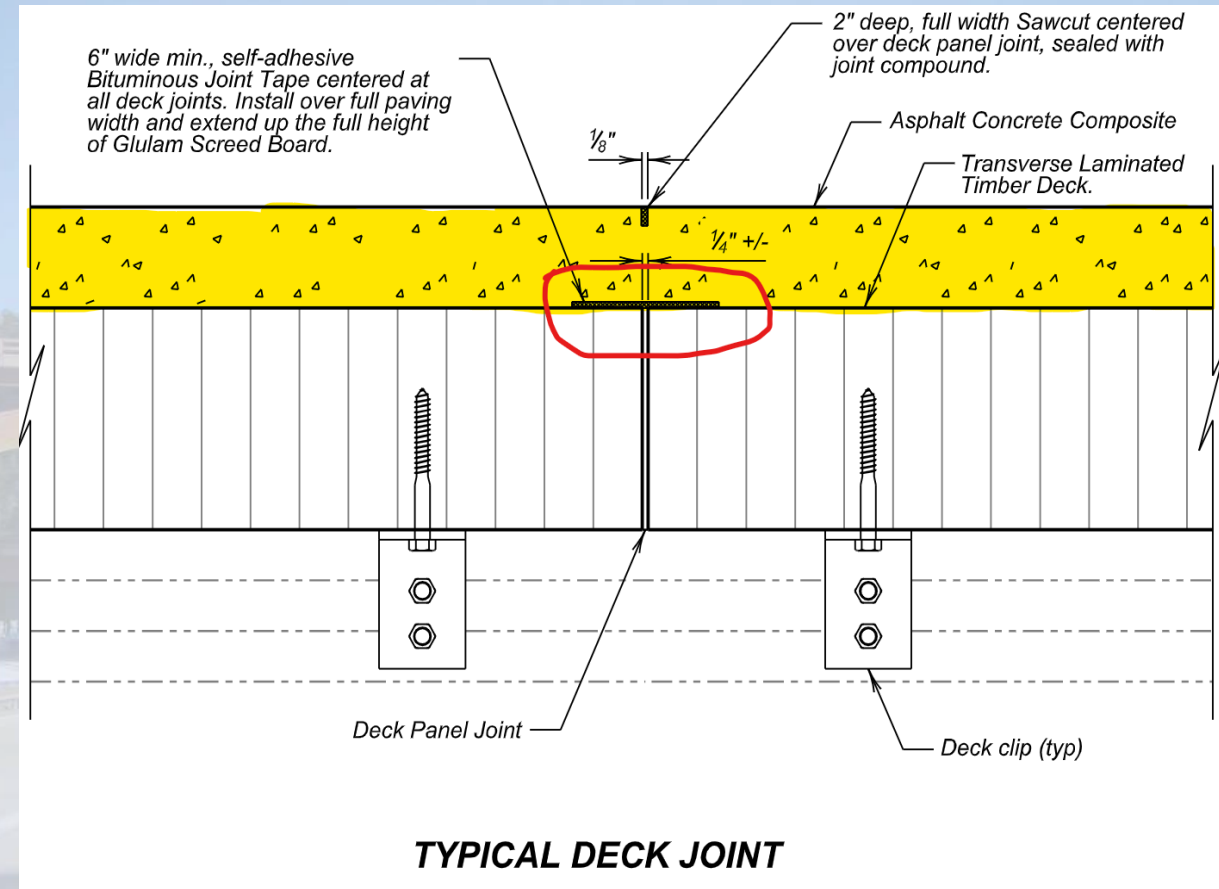
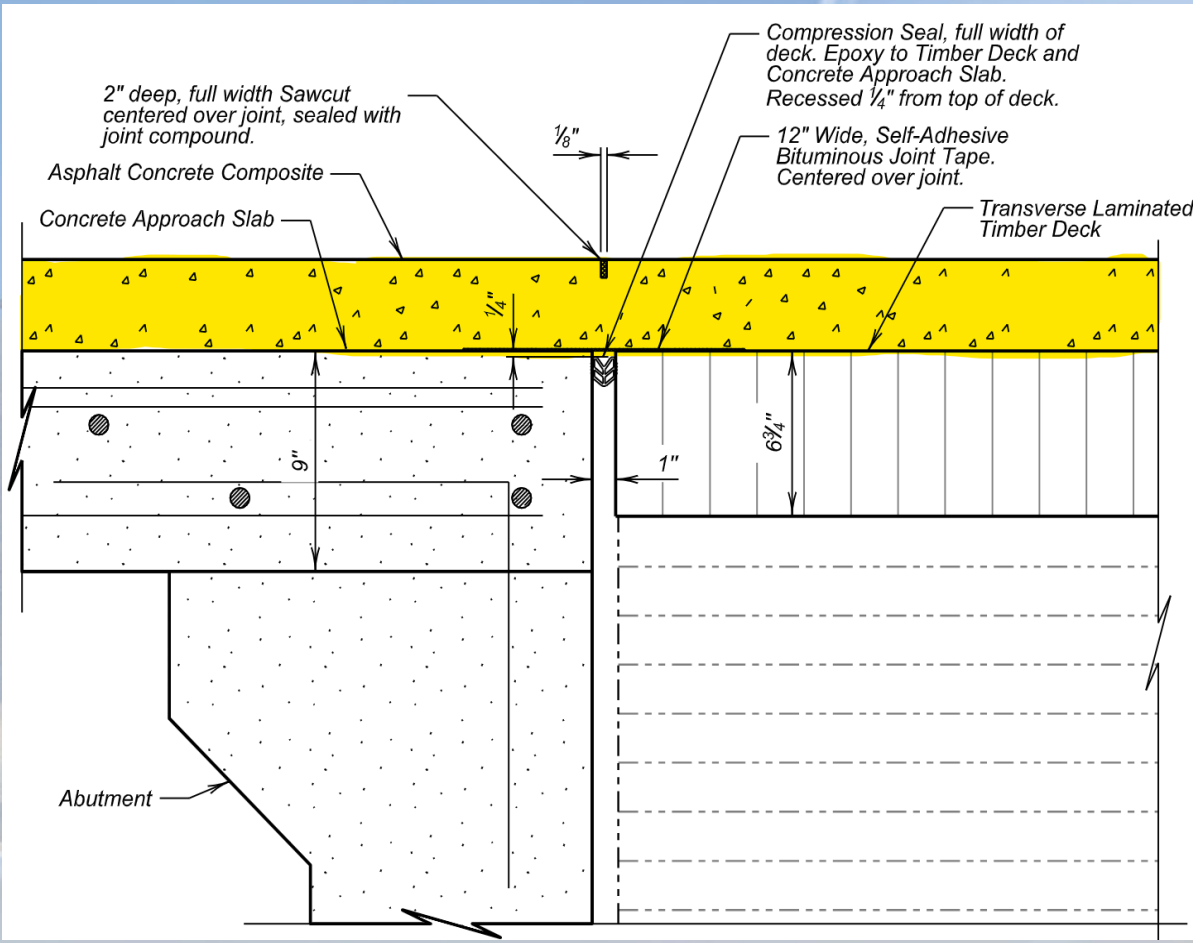


Substructure Repair





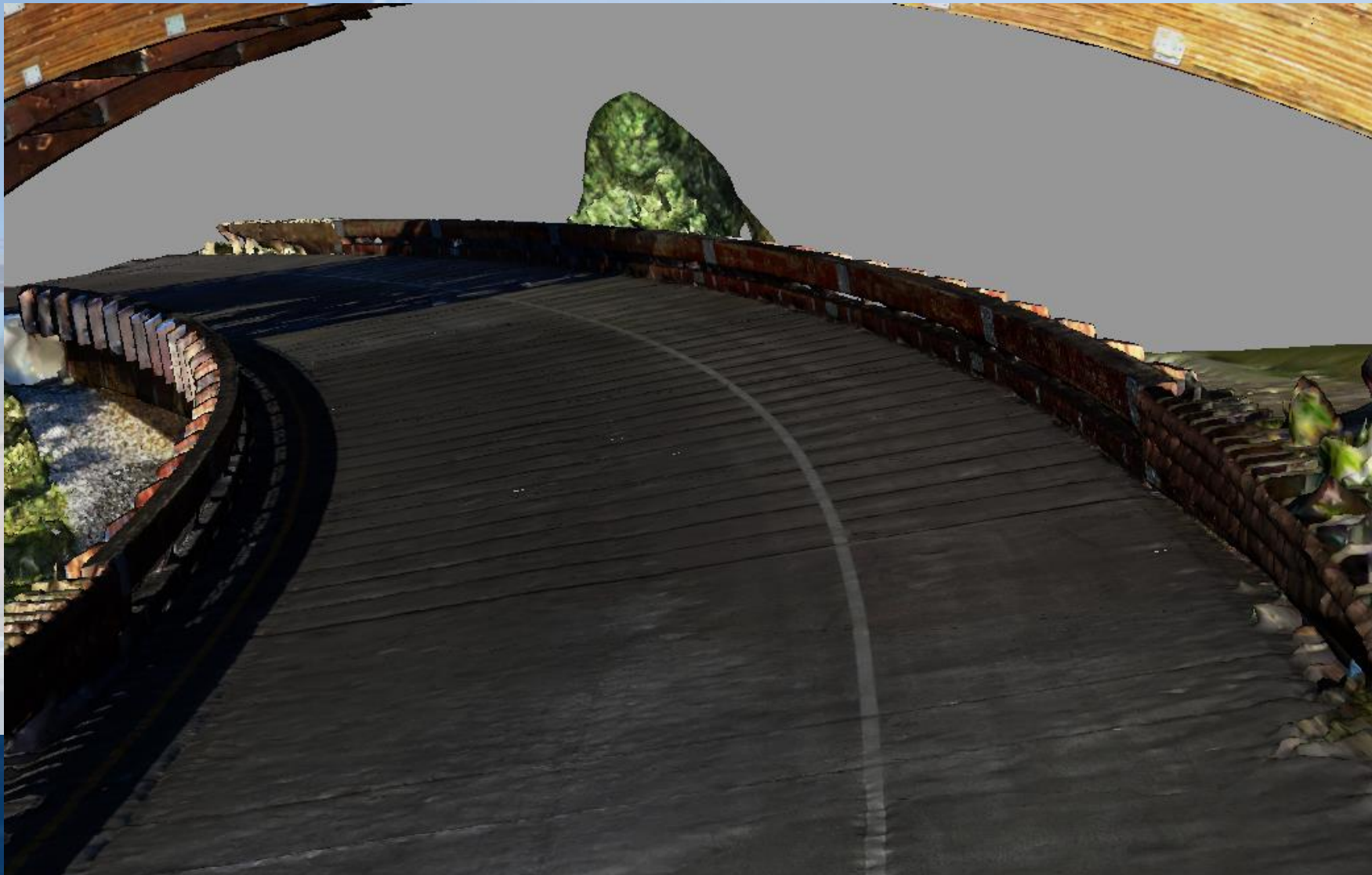
Asphalt Pavement



Digital Twin



Digital Twin



Digital Twin











An aerial photograph of a highway interchange. A main road runs diagonally from the bottom-left to the top-right. A road crosses it from the top to the bottom. Another road branches off to the right from the main road. A white car is visible on the road crossing from top to bottom. The surrounding area is grassy and hilly.

Thank You!

- Any Questions?

- Contact –

- Todd Thompson – todd.thompson@state.sd.us

Full Keystone Wye Video

- <https://sddigitalarchives.contentdm.oclc.org/digital/collection/government/id/215/>

