Bridge Division & Gresham Smith Presentation on From Manual to Mastered: API-Powered QC Procedure at Scale for BrDR MCB Models

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2025 Rating and Design User Group Meeting

Boise, ID | August 12-13, 2025

Bridge Division and Gresham Smith

Introductions:

- **Rodney Roberts, P.E., MDOT**
- **Yun Lin, P.E., Ph.D., Gresham Smith**

Bridge Division and Gresham Smith

- Contract Scope
- 223 Box Girder Bridges
- This contract used a 247-item verification checklist to check the BrR model inputs
- Reviewed 20 Box Girders at a time

Verification Checklist for MDOT MCB

Verification Checklist Items

1. **Verify the number of spans for this box**
2. **Verify the number of cells for this box g**
3. **Verify the span length from bearing to b**
4. **Verify the average humidity 75%.**
5. **Verify the structure type as Not integra**
6. **Verify the structure is not post-tensione**
7. **Verify the structure is not analyzing wel**
8. **Verify the rating method (LFD, LRFR a should be LFD.)**
9. **Verify the analysis type as Line Girder.**
10. **Verify the Control options**
    - a. For LFD:
      - 1. Check box—Generate a tenth point
      - 2. Check box—Generate at support fa
      - 3. Check box—Generate at section ch
      - 4. Check box—Generate at user-defin
      - 5. Don't Check box—Ignore Shear
      - 6. Check box for Distribution factor ap
      - 7. Don't Check box—Ignore flexure
11. **Verify Structure Definition Impact/Dyr**
    - a. Check box for Standard AASHTO imp
    - b. Modified impact is 0. Use Standard Eq
    - c. Constant impact override is 0%
12. **Verify Load Case Description:**
    - a. DC1 DC acting on non-composite sec
    - b. DC2 DC acting on long-term composi
    - c. DW DW acting on long-term composit
    - d. SIP forms Weight due to stay-in-place
13. **Verify Hinge Locations—None for the**
14. **Verify Structure Cross Section**
    - a. Check Input method—should be simple
    - b. Check concrete strength for top slab a
    - c. Check Entry method—should be width
    - d. Check all Overall dimensions (D, CJ,
    - e. Check Cells dimensions (Top left web slab thickness, S1, S2, S3, S4 and etc.).
    - f. Check Fillets dimensions (Top Exterior Bottom Exterior and Interior web fillet Horizon
15. **Verify Cross Section Range Propertie**
    - a. Check left and right end projection dim
    - b. Check Start and End section for corre
    - c. Check Depth vary
    - d. Check Solid section
    - f. Check Support number
    - g. Check Start distance
    - h. Check Length
    - i. Check End distance
    - j. Check Effective supports
16. **Verify Structure Typical Section**
    - a. Check Superstructure definition referer
    - b. Check Deck dimensions (Distance fro start and end)
    - c. Check Parapet (not needed for these s
    - d. Check Median (not needed for these s
    - e. Check Railing (not needed for these st
    - f. Check Generic
      - 1. Check name
      - 2. Check load case
      - 3. Check Measure to
      - 4. Check Edge of deck distance meas
      - 5. Check Distance at start
      - 6. Check Distance at end
      - 7. Check Front face orientation
    - g. Check Sidewalk (if one existed for this model)
      - 1. Check width (in)
      - 2. Check thickness (in)
      - 3. Check concrete material (psi)
      - 4. Check load case (DC1, DC2, etc.)
      - 5. Check measure to (left or right)
      - 6. Check edge of deck distance measured from (left
      - 7. Check distance at start (ft)
      - 8. Check distance at end (ft)
      - 9. Check pedestrian load (ksf)
    - h. Check Lane Position
      - 1. Check Travelway number
      - 2. Check Distance from left edge of travelway to su
      - 3. Check Distance from right edge of travelway to s
      - 4. Check Distance from left edge of travelway to su
      - 5. Check Distance from right edge of travelway to s
    - i. Check Striped lanes
      - 1. Check Striped travelway number
      - 2. Check Distance from left edge of travelway to su
      - 3. Check Distance from right edge of travelway to s
      - 4. Check Distance from left edge of travelway to su
      - 5. Check Distance from right edge of travelway to s
    - j. Check wearing surface
      - 1. Check wearing surface material
      - 2 Check description
      - 3. Check wearing surface thickness (in)
      - 4. Check thickness field measured (DW = 1.25 if ch
      - 5. Check wearing surface density (pcf)
      - 6. Check load case (DC1, DC2, DW and SIP Forn
17. **Verify Framing Plan Detail**
    - a. Check Layout
      - 1. Check skew angle (degrees + or -) at each support
    - b. Check Interior diaphragms
      - 1. Check stagger perpendicular diaphragms
      - 2. Check span number
      - 3. Start distance (ft)
      - 4. Check diaphragm spacing (ft)
      - 5. Check number of spaces
      - 6. Check length (ft)
      - 7. Check end distance (ft)
      - 8. Check diaphragm thickness (in)
      - 9. Check diaphragm load (kips)
18. **Verify Superstructure Loads**
    - a. Check Uniform (Pedestrian load (lb/ft))
      - 1. Check load case (DC1, DC2, DW, SIP Forms)
      - 2. Check span
      - 3. Check uniform load (kip/ft)
      - 4. Check apply to full box only
    - b. Check Distributed (Pedestrian load (lb/ft))
      - 1. Check load case name (DC1, DC2, DW, SIP Forms)
      - 2. Check support number
      - 3. Check start distance (ft)
      - 4. Check length (ft)
      - 5. Check end distance (ft)
      - 6. Check load start (kip/ft)
      - 7. Check load end (kip/ft)
      - 8. Check apply to full box only
    - c. Check Concentrated (Pedestrian load (lb/ft)
      - 1. Check load case name (DC1, DC2, DW, SIP Forms)
      - 2. Check support name
      - 3. Check distance (ft)
      - 4. Check Px (kip)
      - 5. Check Py (kip)
      - 6. Check M (kip-ft)

Verification Checklist for MDOT MCB

7. Check apply to full box only
d. Check Settlement (Pedestrian load (lb/ft)
1. Check load case name
2. Check support number
3. Check horizontal (in)
4. Check vertical (in)
5. Check rotational (radians)
e. Check Uniform temperature (Pedestrian loa
1. Check load case name
2. Check temperature rise (F)
3. Check temperature fall (F)
f. Check Gradient temperature (Pedestrian loa
1. Check load case name
2. Check temperature value T1 (F)
3. Check temperature value T2 (F)
4. Check temperature value T3 (F)
g. Check Wind (Pedestrian load (lb/ft)
1. Check load case name
2. Check Wind load basis (Gust speed)
3. Check Gust speed wind load
1) Check Limit state - Strength (III
2) Check Limit state - Strength V (v
3) Check Limit state - Service I (wi
4) Check Limit state - Service IV (v
4. Check Fastest-mile speed wind load (w
5. Check Wind load path (use Truss action
19. Verify Supports
a. Check General
1. Check Support number
2. Check Support type (Pinned, Roller, Fix
3. Check Translation constraints (X, Y)
4. Check Rotation constraints (Z)

5. Check Wind load path (use Truss action)
19. Verify Supports
a. Check General
1. Check Support number
2. Check Support type (Pinned, Roller, Fixed
3. Check Translation constraints (X, Y)
4. Check Rotation constraints (Z)
b. Check Elastic
1. Check Support number
2. Check Translation spring constant (kip/ft)
3. Check Rotation spring constant (kip-in/rad)
4. Check Override computed Z rotation sprin
20. Verify Slab Reinforcement
a. Check type (always should be Multi Cell Box)
b. Check Transverse reference lines (not used in
1. Check Input method (distance or percentag
2. Check reference line
3. Check measured from support
4. Check distance along left edge deck (ft)
5. Check distance along right edge deck (ft)
c. Check Cells-top slab reinforcement
1. Check cell (1, 2, 3 etc., all cells, all exterior
2. Check material grade reinforcing steel (40
3. Check Reference point (Support number 1
4. Check direction (left or right)
5. Check start distance (ft)
6. Check length (ft)
7. Check end distance (ft)
8. Check number of bars
9. Check number bars for left web. Verifying
10. Check bar size
11. Check clear cover (in)
12 Check measured from (top of slab or botto
13. Check bar spacing
14. Check side cover (in)

15. Check start fully developed
16. Check end fully developed
d. Check Cells-bottom slab reinforcemen
1. Check cell (1, 2, 3 etc., all cells, all
2. Check material grade reinforcing st
3. Check Reference point (Support nu
4. Check direction (left or right)
5. Check start distance (ft)
6. Check length (ft)
7. Check end distance (ft)
8. Check number of bars
9. Check number bars for left web
10. Check bar size
11. Check clear cover (in)
12 Check measured from (top of slab
13. Check bar spacing
14. Check side cover (in)
15. Check start fully developed
16. Check end fully developed
e. Check Overhangs
1. Check overhang (right, left or both)
2. Check material grade reinforcing st
3. Check Reference point (Support nu
4. Check direction (left or right)
5. Check start distance (ft)
6. Check length (ft)
7. Check end distance (ft)
8. Check number of bars
9. Check bar size
10. Check clear cover (in)
11. Check measured from (top of slab
12. Check bar spacing
13. Check side cover (in)
14. Check start fully developed
15. Check end fully developed

14. Check start fully developed
15. Check end fully developed
21. Verify Live Load Distribution (leave blank let BrR program will compute these distribution factors)
22. Verify Points of Interest (leave blank)
23. Verify Vertical Shear Reinforcement Definition
a. Check name (S Bars or Z Bars)
b. Check material (Grade 40, Grade 50 or Grade 60 ksi Steel)
c. Check bar size
d. Check number of legs
e. Check inclination (alpha) (Degrees) (45) Z bar only
24. Verify Web Shear Reinforcement
a. Check Input reference type (usually use Centerline bearings)
b. Check linked with (other webs)
c. Check span ranges (span 1, 2, etc.)
d. Check name (S Bars or Z Bars)
e. Check start distance (ft)
f. Check number of spaces
g. Check spacing (in)
h. Check length (ft)
i. Check end distance (ft)
25. Verify Web Shear Reinforcement for each Web 1-through number of webs
a. Input reference type (use Centerline bearings)
b. Span ranges
c. Span
d. Name (S bars, Z bars)
e. Start distance (ft)
f. Number of spaces
g. Spacing (in)
h. Length (ft)
i. End distance (ft)

Main Challenges and Our Approach

Detailed MCB Models:
Multi-cell structures are highly input-intensive compared to other bridge types.

Labor intensive task with limited budget:
The scope included 223 MCBs and a 247-item verification checklist—under a constrained *budget*.

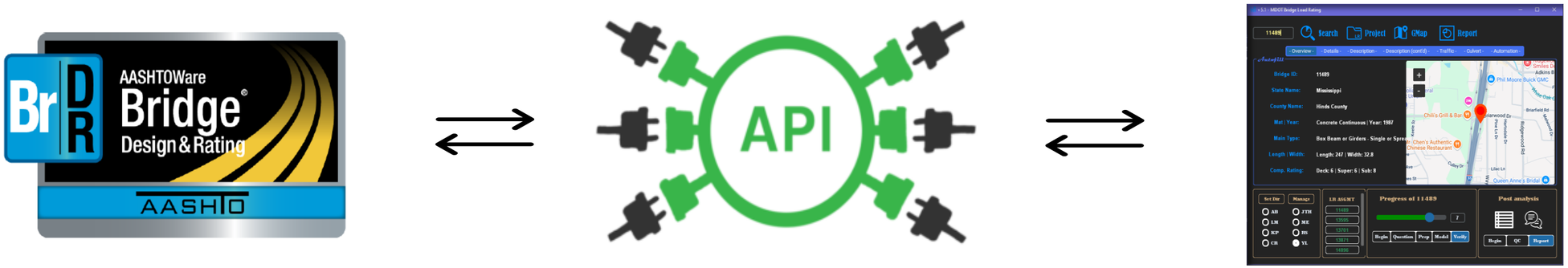
Multiple Modelers, Varying Styles:
Models were created by different engineers with varying habits and approaches, making consistency and review more challenging.

Importance of Accuracy:
MDOT's ExpressPass Program demands high accuracy for its automated permit approval process.

Our Approach:
Leverage the BrDR API (Application Programming Interface) to extract model data and present it in a more reviewer-friendly format.

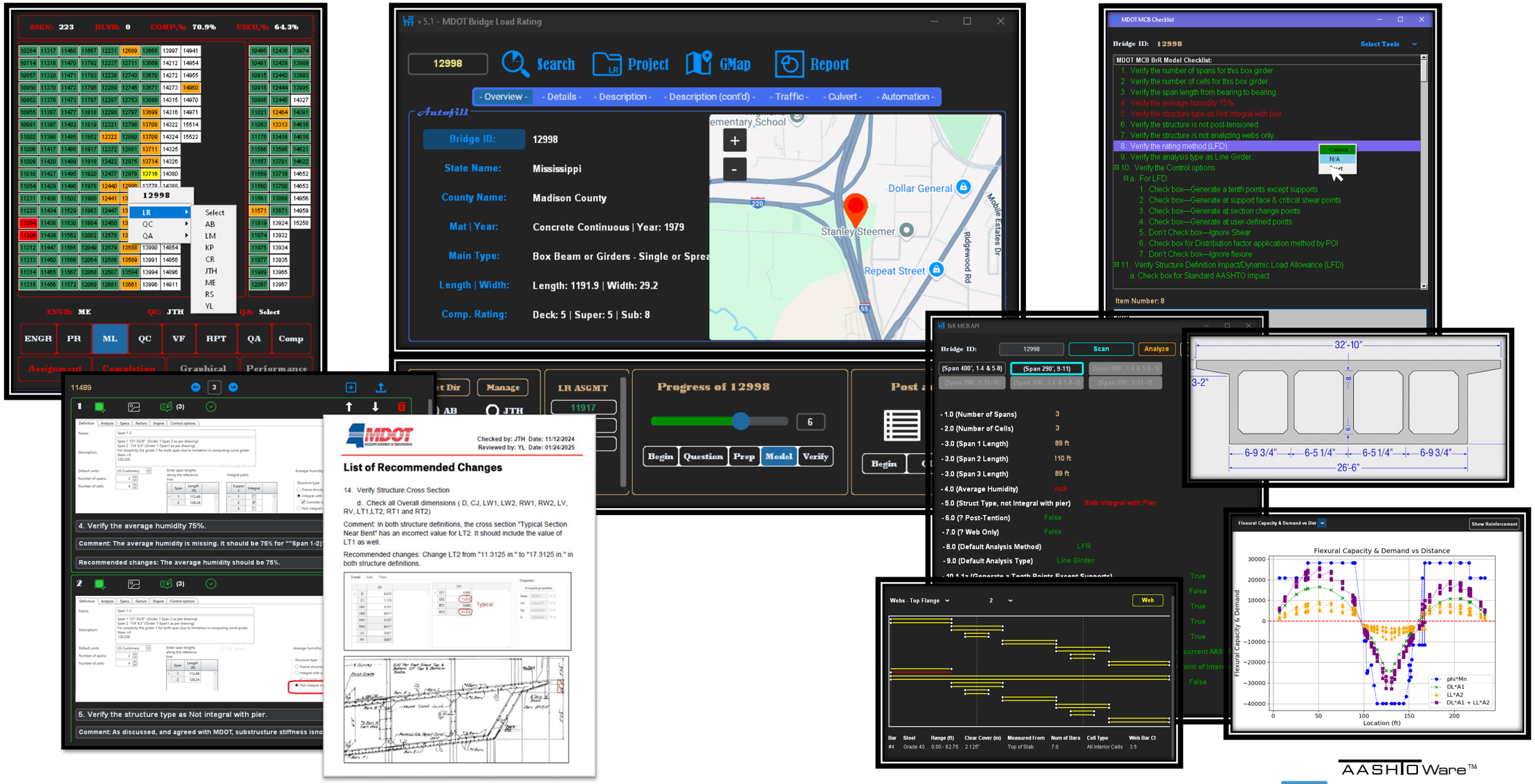
Bridging Programs with API

(Application Programming Interface)



AASHTOWare™ BRIDGE DESIGN AND RATING

QC Workflow with LRM (Load Rating Management)



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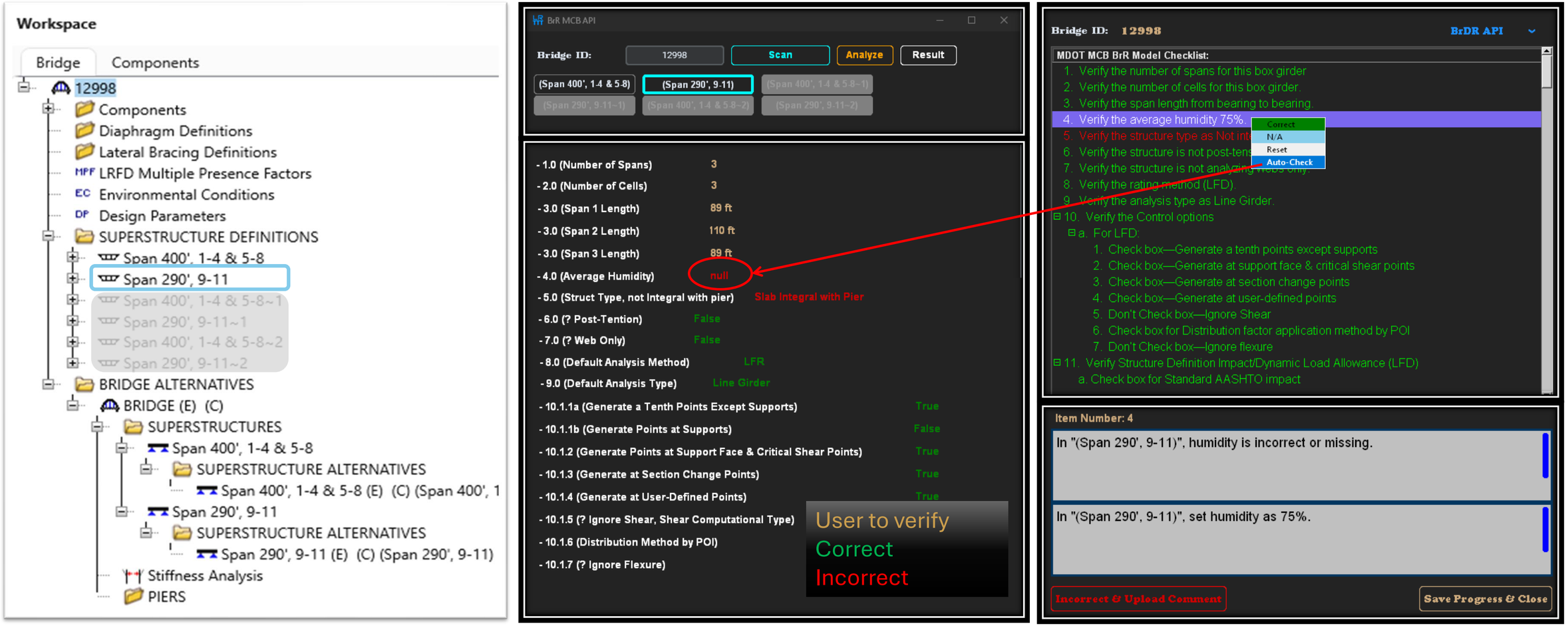
LRM – BrDR Interactions via API



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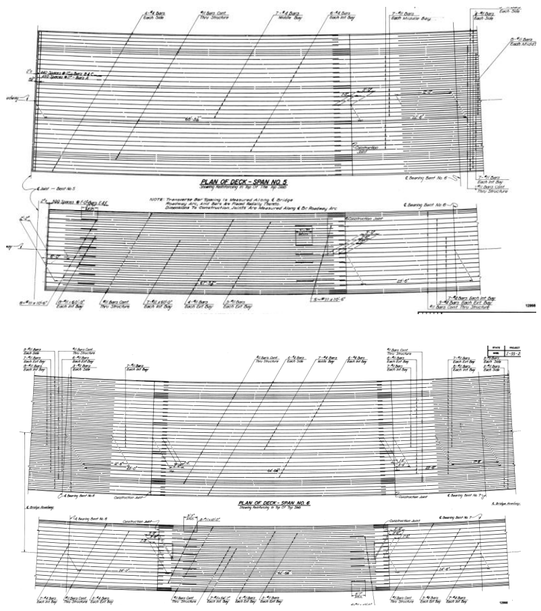
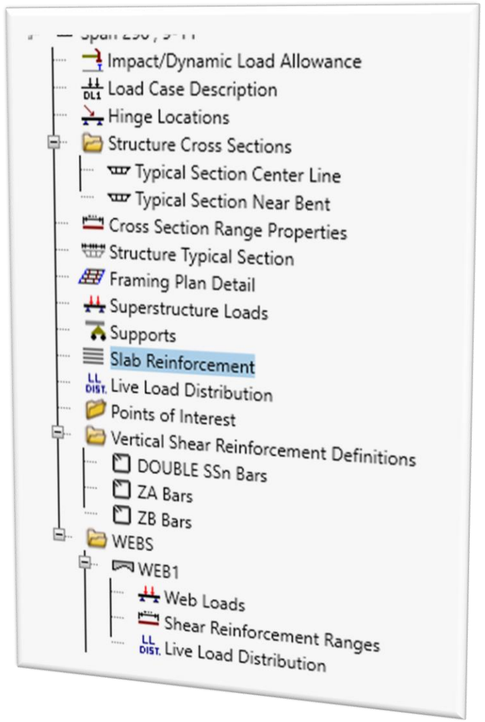
Slab Reinforcement Review



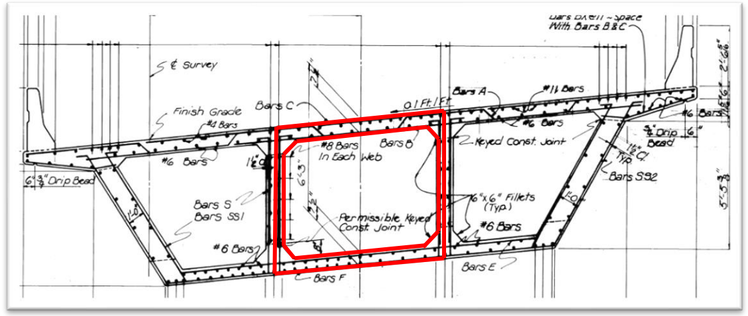
Transverse reference lines | Cells-top slab | Cells-bottom slab | Overhangs

Cell	Material	Reference point	Direction	Start distance (ft)	Length (ft)	End distance (ft)	Number of bars	Number bars for left web	Bar size	Clear cover (in)	Measured from	Bar spacing (in)	Side cover (in)	de
All Exterior Cells	Grade 40	Support 1	Right	0.000	62.750	62.750	6	3.000	4	2.125	Top of Slab	8.000	3.000	
All Interior Cells	Grade 40	Support 1	Right	0.000	62.750	62.750	7	3.500	4	2.125	Top of Slab	14.000	3.000	
All Exterior Cells	Grade 40	Support 1	Right	62.750	53.000	115.750	6	3.000	11	2.125	Top of Slab	8.000	3.000	
All Interior Cells	Grade 40	Support 1	Right	62.750	53.000	115.750	7	3.500	11	2.125	Top of Slab	14.000	3.000	
All Exterior Cells	Grade 40	Support 1	Right	77.000	24.000	101.000	6	3.000	11	2.125	Top of Slab	8.000	3.000	
All Interior Cells	Grade 40	Support 1	Right	77.000	24.000	101.000	7	3.500	11	2.125	Top of Slab	14.000	3.000	
All Exterior Cells	Grade 40	Support 1	Right	115.750	55.500	171.250	6	3.000	4	2.125	Top of Slab	8.000	3.000	
All Interior Cells	Grade 40	Support 1	Right	115.750	55.500	171.250	7	3.500	4	2.125	Top of Slab	14.000	3.000	
All Exterior Cells	Grade 40	Support 1	Right	171.250	54.500	225.750	6	3.000	11	2.125	Top of Slab	8.000	3.000	
All Interior Cells	Grade 40	Support 1	Right	171.250	54.500	225.750	7	3.500	11	2.125	Top of Slab	14.000	3.000	
All Exterior Cells	Grade 40	Support 1	Right	186.000	24.000	210.000	6	3.000	11	2.125	Top of Slab	8.000	3.000	
All Interior Cells	Grade 40	Support 1	Right	186.000	24.000	210.000	7	3.500	11	2.125	Top of Slab	14.000	3.000	
All Exterior Cells	Grade 40	Support 1	Right	225.750	62.250	288.000	6	3.000	4	2.125	Top of Slab	8.000	3.000	
All Interior Cells	Grade 40	Support 1	Right	225.750	62.250	288.000	7	3.500	4	2.125	Top of Slab	14.000	3.000	
All Exterior Cells	Grade 40	Support 1	Right	0.000	62.750	62.750	6	3.000	4	1.500	Bottom of Slab	8.000	3.000	
All Interior Cells	Grade 40	Support 1	Right	0.000	62.750	62.750	7	3.500	4	1.500	Bottom of Slab	14.000	3.000	
All Exterior Cells	Grade 40	Support 1	Right	62.750	53.000	115.750	6	3.000	11	1.500	Bottom of Slab	8.000	3.000	
All Interior Cells	Grade 40	Support 1	Right	62.750	53.000	115.750	7	3.500	11	1.500	Bottom of Slab	14.000	3.000	
All Exterior Cells	Grade 40	Support 1	Right	77.000	24.000	101.000	6	3.000	11	1.500	Bottom of Slab	8.000	3.000	
All Interior Cells	Grade 40	Support 1	Right	77.000	24.000	101.000	7	3.500	11	1.500	Bottom of Slab	14.000	3.000	



Required Input

- Rebar Definition (steel and size)
- Component association (slabs, overhangs)
- Reference line definition (if any)
- Ranges within the spans and development
- Positions in the C.S. and clear covers
- Number of Bars in Cells and Webs
- Spacing and side covers



Cell Selection Options

- All cells ✓
- All exterior cells ✗
- All interior cells ✓
- Cell 2 ✓

? What do all the cells end up receiving?

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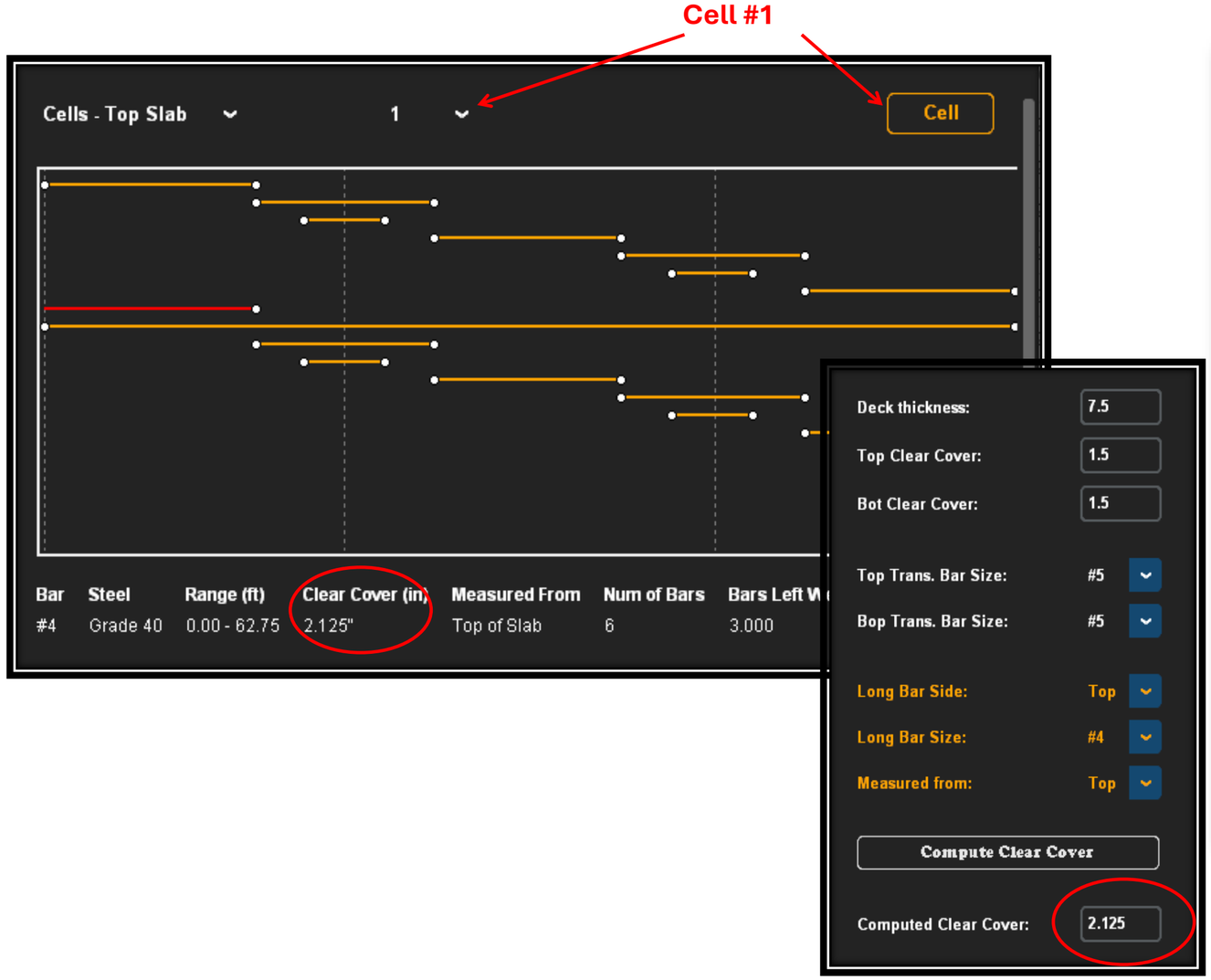
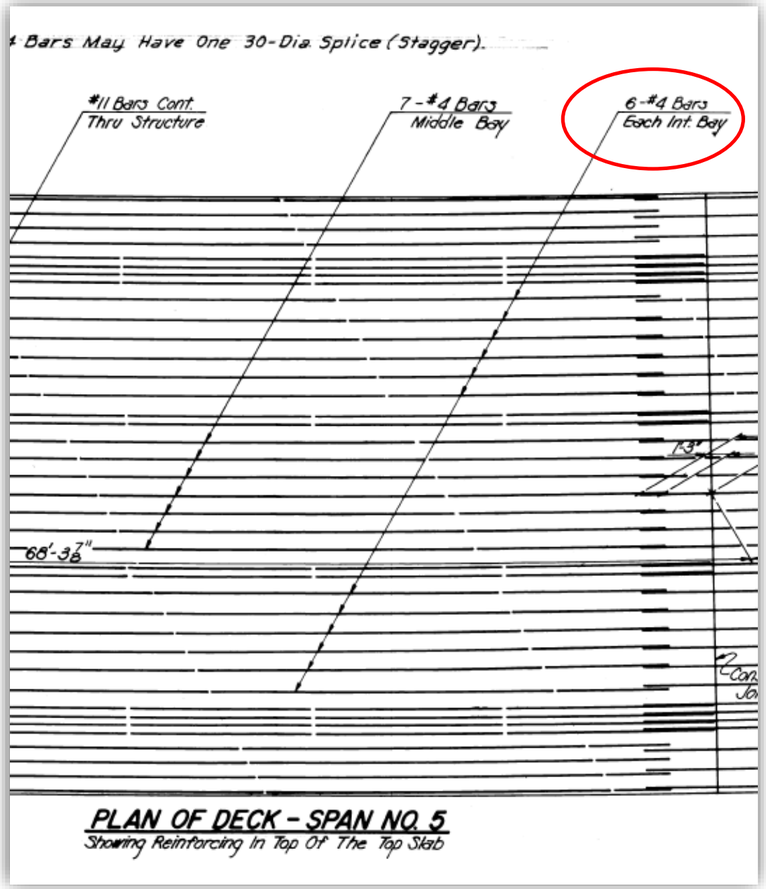
AASHTOWare™ BRIDGE DESIGN AND RATING

Check Reinforcement for Each Individual Cells



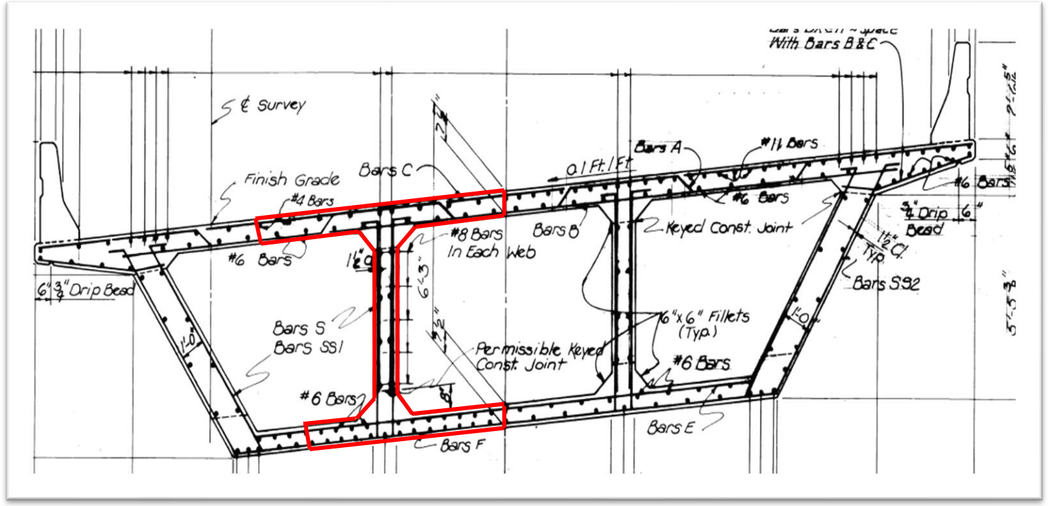


AASHTOWare™ BRIDGE DESIGN AND RATING

Check Reinforcement for Each Individual Webs

Transverse reference lines | Cells-top slab | Cells-bottom slab | Overhangs

Cell	Material	Reference point	Direction	Start distance (ft)	Length (ft)	End distance (ft)	Number of bars	Number bars for left web	Bar size	Clear cover (in)	Measured from	Bar spacing (in)	Side cover (in)	de
All Exterior Cells	Grade 40	Support 1	Right	0.000	62.750	62.750	6	3.000	4	2.125	Top of Slab	8.000	3.000	
All Interior Cells	Grade 40	Support 1	Right	0.000	62.750	62.750	7	3.500	4	2.125	Top of Slab	14.000	3.000	



Possible options to place bars in Web #2

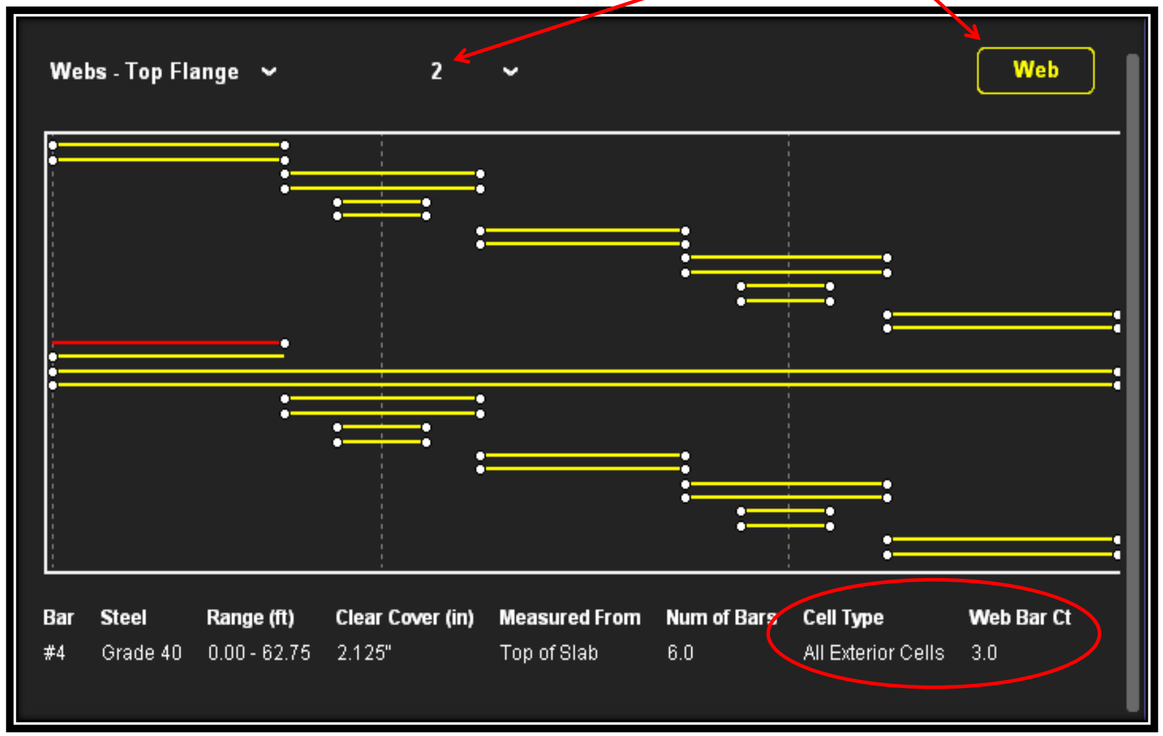
- All cells - left web ✓
- All cells - right web ✓
- All ext. cells - right web ✓
- All int. cells - left web ✓
- Cell #1 - right web ✓
- Cell #2 - left web ✓

? What do all the webs end up receiving?

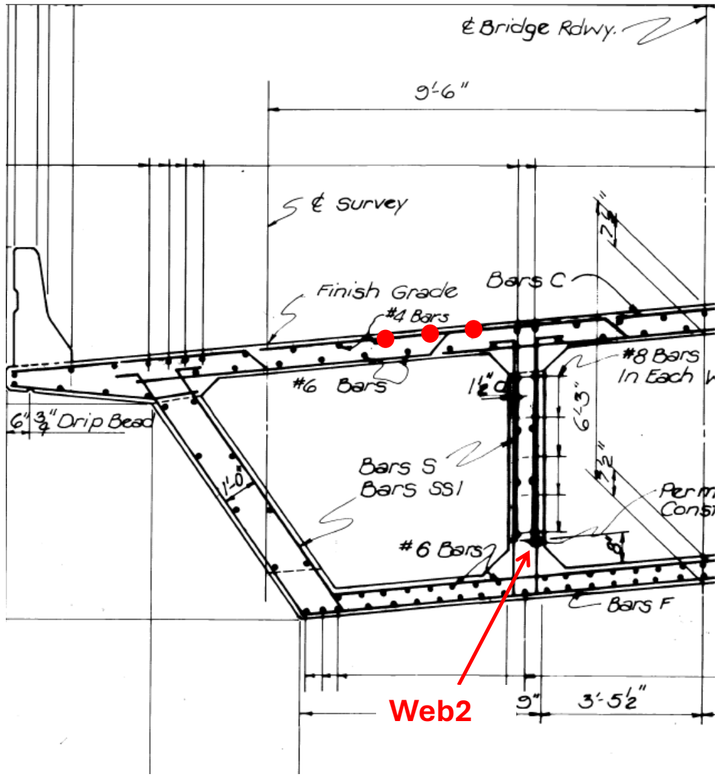
AASHTOWare™ BRIDGE DESIGN AND RATING

Check Reinforcement for Each Individual Webs

Web #2



Bar	Steel	Range (ft)	Clear Cover (in)	Measured From	Num of Bars	Cell Type	Web Bar Ct
#4	Grade 40	0.00 - 62.75	2.125"	Top of Slab	6.0	All Exterior Cells	3.0



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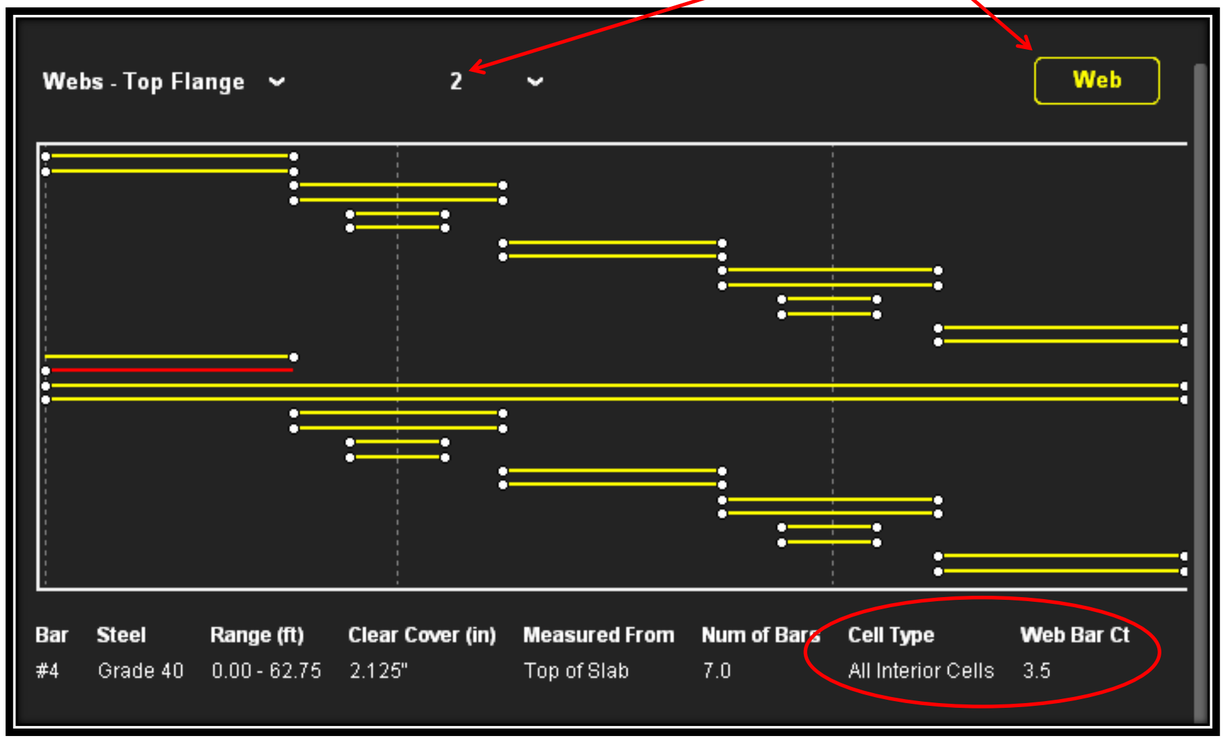
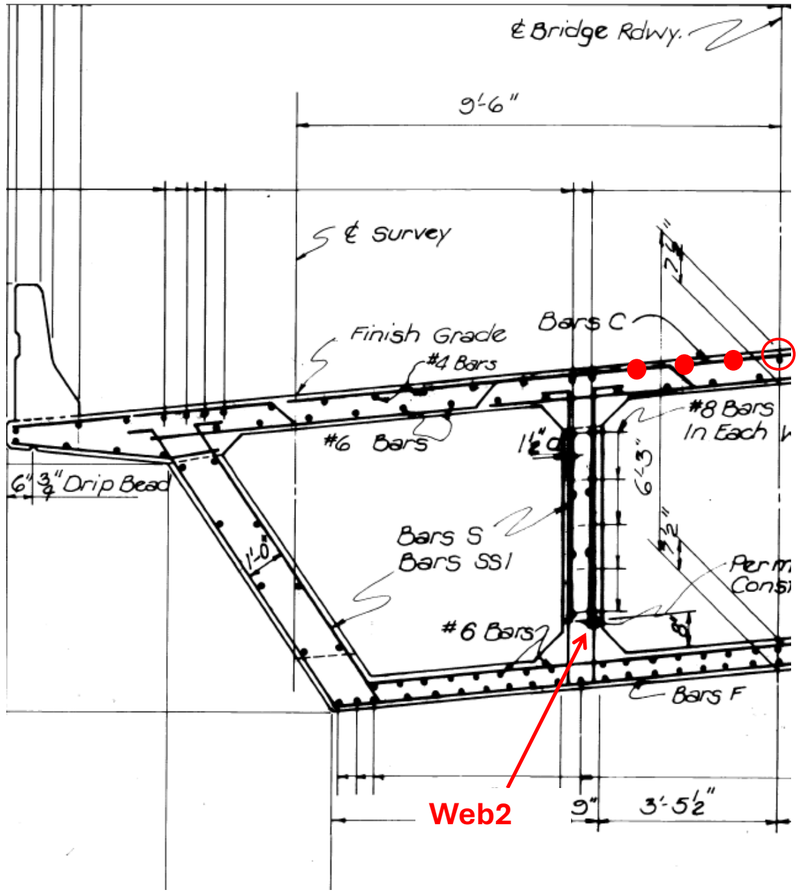
Check Reinforcement for Each Individual Webs

Web #2



Bar	Steel	Range (ft)	Clear Cover (in)	Measured From	Num of Bars	Cell Type	Web Bar Ct
#4	Grade 40	0.00 - 62.75	2.125"	Top of Slab	7.0	All Interior Cells	3.5



AASHTOWare™ BRIDGE DESIGN AND RATING

Understanding the Internal Structure for MCB

```
DoBridge
└── StructDefList (List<DoSuperStructDef>)
    └── DoSuperStructDef : DoMultiCellBoxStructDef
        ├── SuperStructMemberList
        │   └── DoSuperStructSpanningMember
        │       ├── PedestrianLiveLoadForce
        │       ├── MemberDistributedLoadList
        │       ├── MemberConcentratedLoadList
        │       └── SupportList (List<DoSupport>)
        ├── SpanningMemberDefList -> DoSuperStructSpanningMember
        │   └── DoMultiCellBoxBeamDef
        │       ├── MultiCellBoxBeamDefSegmentList
        │       │   └── DoMultiCellBoxBeamDefSegment
        │       │       ├── MultiCellBoxCrossSectionList
        │       │       │   └── DoMultiCellBoxCrossSection
        │       │       │       ├── MultiCellBoxCrossSectionCellList
        │       │       │       │   └── DoMultiCellBoxCrossSectionCell
        │       │       │       └── Concrete, Geometry, Fillet properties
        │       │       ├── MultiCellBoxCrossSectionRangeList
        │       │       ├── MultiCellBoxSegmentDeckRangeList
        │       │       ├── MultiCellBoxSegmentConcreteRailingLocationList
        │       │       ├── MultiCellBoxSegmentConcreteCurbSideWalkList
        │       │       ├── MultiCellBoxSegmentLanePositionList
        │       │       ├── MultiCellBoxSegmentStripedLanePositionList
        │       │       ├── WearingSurface* properties
        │       │       └── MultiCellBoxBeamDefSlabReinforcementList
        │       │                -> DoMultiCellBoxBeamDefSlabReinforcement
        │       ├── BeamHingeLocationList
        │       └── ConcreteBeamDefEffectiveSupportList
        ├── StructureType / PostTensionedInd / AnalyzeWebsOnlyInd
        ├── DefaultAnalysisMethodType / DefaultAnalysisType
        └── SuperStructDefLoadCaseList
```

DộBsîđĝê

DộŇụľţîCêľľBộỵŞţsụçţDêğ

DộŞụřêsŞţsụçţŞřăŋŋîŋĝŇêņčês

DộŇụľţîCêľľBộỵBêăņDêğ

DộŇụľţîCêľľBộỵBêăņDêğŞêĝņêŋţ

DộŇụľţîCêľľBộỵBêăņDêğŞľăčŘêîŋğộsçêņêŋţ

AASHTOWare™ BRIDGE DESIGN AND RATING

Understanding the Internal Structure for MCB

DộŇụĺŧîCêĺĺBộỵBêắṇDêğŞĺắčṚêîŋğộsçêṇêŋŧ

ṚêîŋğŢỳřê CêĺĺŢỳřê CêĺĺṆụṇ ŇêắṣụsêđGsộṇŢỳřê CĺêắsCộŵês ĞêŧṚêčắs Ṇắṇê ĞêŧŞŧêêĺṚêîŋğộsçêṇêŋŧ Ṇắṇê ṆụṇBắsṣ ṆụṇBắsṣĹêğŧẄêč ŞŧắsŧDîṣŧắŋçê Ĺêŋĝŧḥ ŞŧắsŧGụĺĺỳDêŵêĺộřêđÍŋđ ÉŋđGụĺĺỳDêŵêĺộřêđÍŋđ

Transverse reference lines | Cells-top slab | Cells-bottom slab | Overhangs

Cell	Material	Reference point	Direction	Start distance (ft)	Length (ft)	End distance (ft)	Number of bars	Number bars for left web	Bar size	Clear cover (in)	Measured from	Bar spacing (in)	Side cover (in)	Start fully developed	End fully developed
1	Grade 40	Support 1	Right	0.000	65.083	65.083	7	3.500	6	2.125	Top of Slab	12.000	3.000	✓	✓

AASHTOWare™ BRIDGE DESIGN AND RATING

The Process of Developing MCB Review Module

Step 1: Retrieve information – BrDR API (C#)

```
độŇụĺŧîCêĺĺBộỵBêắṇDêğŞĺắčṚêîŋğộsçêṇêŋŧ Ṛêîŋğţỳřê ţộŞŧſsîŋĝ
độŇụĺŧîCêĺĺBộỵBêắṇDêğŞĺắčṚêîŋğộsçêṇêŋŧ ĞêŧſṚêčắs   Ṇắṇê ţộŞŧſsîŋĝ
độŇụĺŧîCêĺĺBộỵBêắṇDêğŞĺắčṚêîŋğộsçêṇêŋŧ Şŧſắsŧſ Dîṣŧſắṇçê ĞêŧſΛắĺụê ĽêŋĝŧſḥÛŋîŧſṣ GŢ
```

Step 2: Print texts as output (C#)

```
Cộŋṣộĺê Ẅsîŧſêĺîŋê
    ṣụřêsṣŧſsụçŧſụsê ŋắṇê   Bắs Cộụŋŧſ  çộụŋŧſês ĺîŋê ŋụṇ   ṣŧſắsŧſ đîṣŧſắṇçê
    độŇụĺŧîCêĺĺBộỵBêắṇDêğŞĺắčṚêîŋğộsçêṇêŋŧ Şŧſắsŧſ Dîṣŧſắṇçê ĞêŧſΛắĺụê ĽêŋĝŧſḥÛŋîŧſṣ GŢ   ğŧſ
```

```
Example output:
Standard BG-5 100'-120'-100' , Bar Count 6, start distance: 88.25 ft
```

Step 3: Build customized programs to present the output

AASHTOWare™ BRIDGE DESIGN AND RATING

Define Truck Template & Run Analysis using BrDR API

```
//Analysis method type
doAnalysisEvent.SetAnalysisMethodType(EVNTANALMET.EVNTLFR);

DoLibVehicleManager doLibVehicleManager = BRIDGEWare.GetManager<DoLibVehicleManager>();
DoLibVehicle doLibVehicle_1 = doLibVehicleManager.RetrieveByName("HS 20-44"); //
DoLibVehicle doLibVehicle_2 = doLibVehicleManager.RetrieveByName("Type 3"); //
DoLibVehicle doLibVehicle_3 = doLibVehicleManager.RetrieveByName("Type 3S2"); //
DoLibVehicle doLibVehicle_4 = doLibVehicleManager.RetrieveByName("Type 3-3"); //
DoLibVehicle doLibVehicle_5 = doLibVehicleManager.RetrieveByName("SU4"); //

//Set vehicle to analysis event
if (!doAnalysisEvent.AddEventVehicleEx(doLibVehicle_1, false, false, 1.0,
    false, 1.0, 0, 0,
    false, 1.0, false, 1.0,
    false, 2, null)) // 1 represents inventory
```

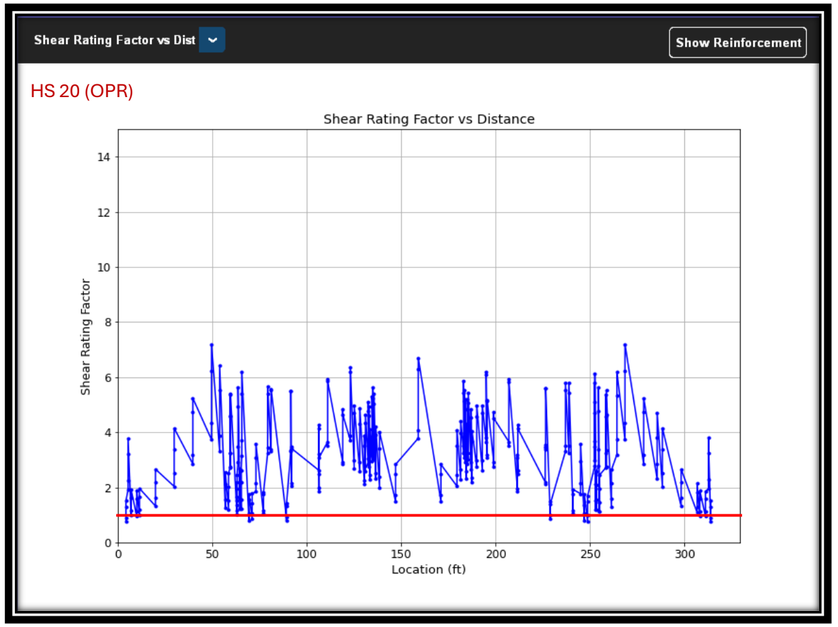
```
C:\LRM\BrR_API_analysis\Example2-1.exe
Please enter the Bridge ID:
12998
Session started!
Message Type: Info - Generating model domain for line girder analysis..
Message Type: Info - Standard Multicell Box Reinforcement Summary:
Message Type: Info -            Cell bottom reinforcement set count: 9
Message Type: Info -            Cell top reinforcement set count: 9
Message Type: Info -            Overhang reinforcement set count: 4
Message Type: Info -            Total reinforcement set count: 22
Message Type: Info - Locating reinforcements and computing development length...
Message Type: Info - Finished generating model domain for line girder analysis..
Message Type: Info - Capacities determined using AASHTO Std Specifications 17th Edition
Message Type: Info - Ratings determined using AASHTO MBE Specifications 3rd Edition, 2023 Interims
Message Type: Info - Analyzing Span 400', 1-4 & 5-8 with 2D AASHTO LFR Engine...
```

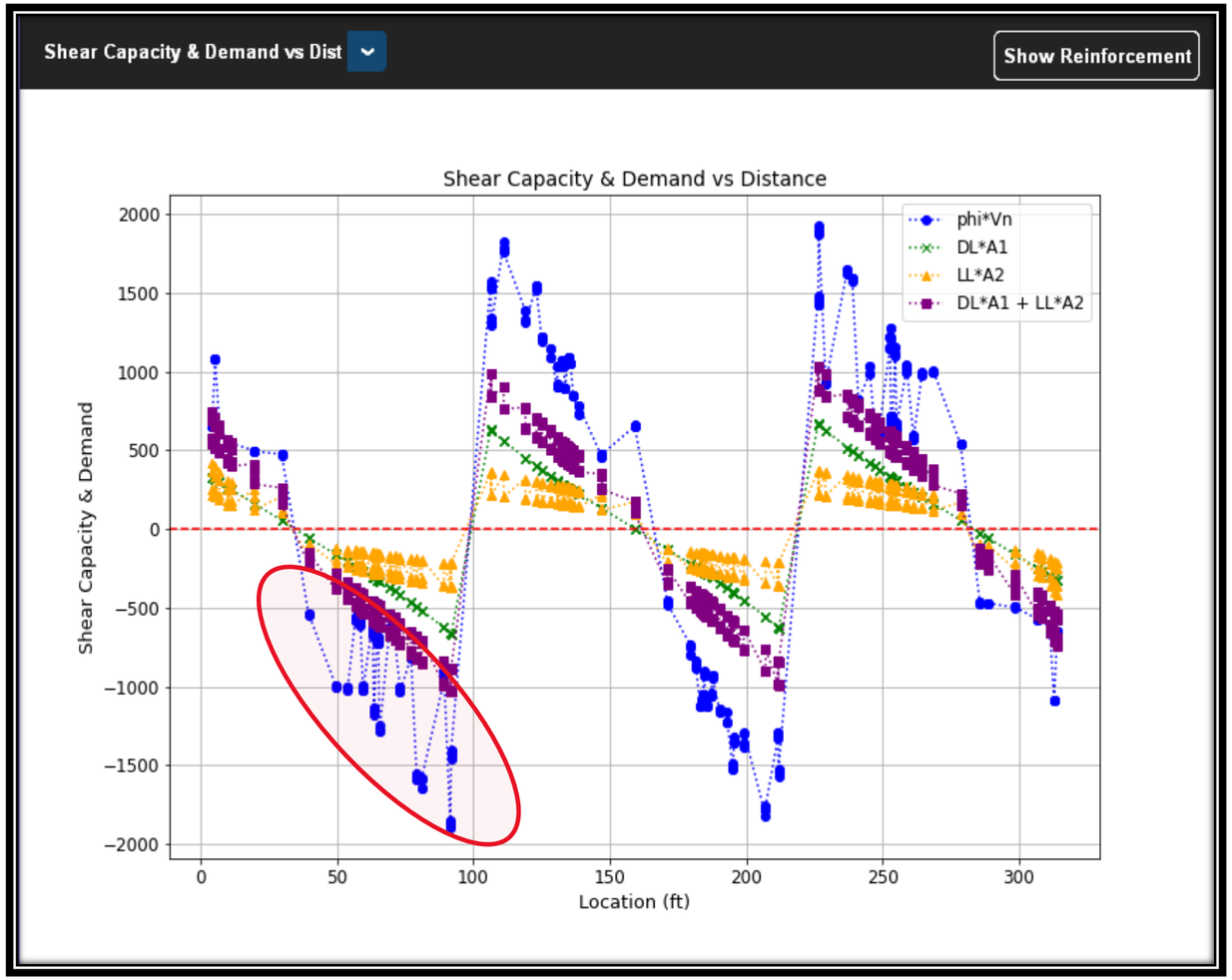
```
Message Type: Info - Populating LFR rating summary..
Message Type: Info - Populating dead load results for non-composite (stage 1)..
Message Type: Info - Populating live load results for composite (short term) (stage 3)..
Message Type: Info - Populating LFR rating summary..
Message Type: Info - Analysis completed!

Session ended!

Press any key to close...
```


AASHTOWare™ BRIDGE DESIGN AND RATING

Understanding Low Rating Results - Shear

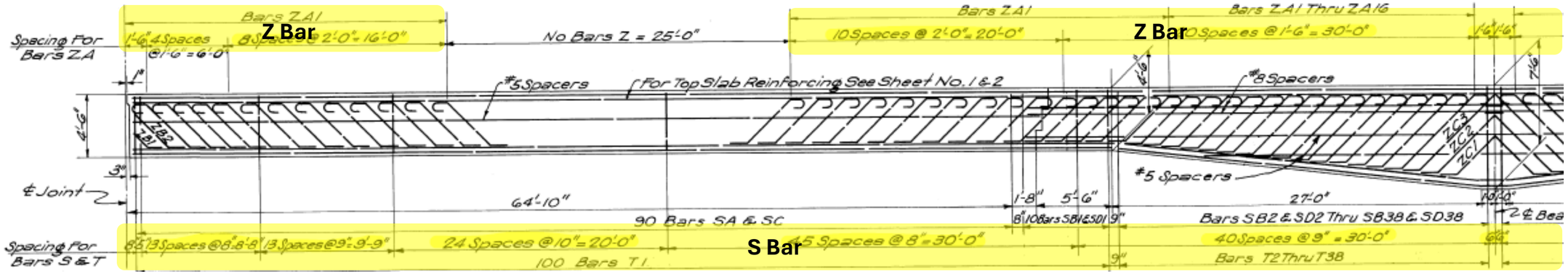
Rating Factor	Location (ft)	Location Span-(%)	Element Name	Limit State
0.554	91.84	1 - (92.7)	WEB3	Design Shear - Concrete
0.829	91.84	1 - (92.7)	WEB3	Design Shear - Concrete
0.457	91.84	1 - (92.7)	WEB3	Design Shear - Concrete
0.742	91.84	1 - (92.7)	WEB3	Design Shear - Concrete

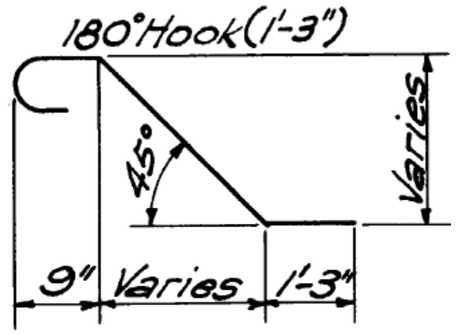




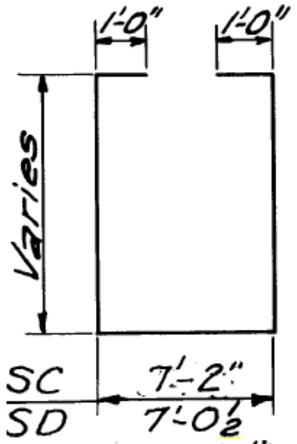
AASHTOWare™ BRIDGE DESIGN AND RATING

Nested Shear Reinforcements

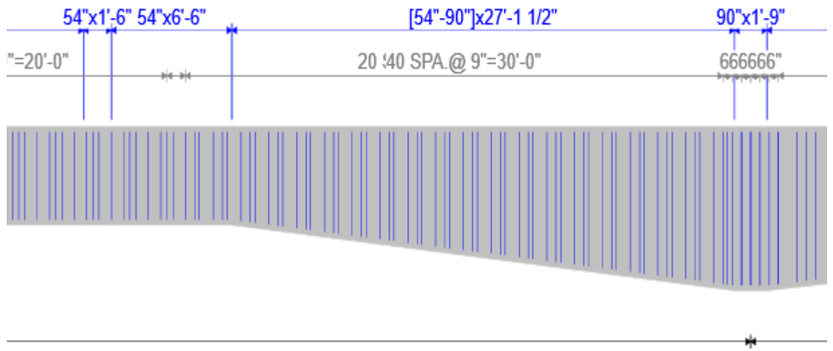




BARS ZA~#9



BARS S~#4

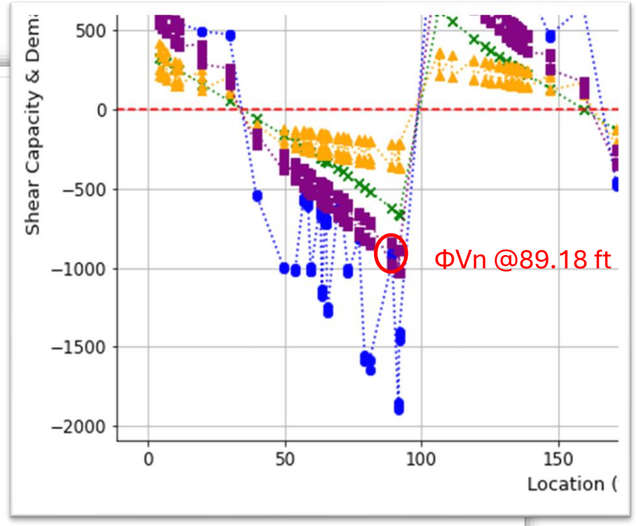


AASHTOWare™ BRIDGE DESIGN AND RATING

Shear Capacity @ 89.18 ft

```
8 Reinforced Concrete
8.16 Strength Design Method (Load Factor Design)
8.16.6 Shear
8.16.6.3 Shear Strength Provided by Shear Reinforcement
(AASHTO Standard Specifications for Highway Bridges, Seventeenth Edition - 2002)

RC MultiCellBox - At Location = 89.1751 (ft) - Left


INPUT:

s      =    9.0000 (in)      Av1    =    1.6000 (in^2)
bw     =   48.0000 (in)      f'c    =    3.0000 (ksi)
fy1    =   40.0000 (ksi)
alpha1 =   90.0000 (Degrees)


      Av1 * fy1 * d
Vs1 = -------------        (8-53)
            s
```

Total Av for S bars (all webs)



Limit State	Load Comb	Governing Action	d (in)	Vs1 (kip)	Vs2 (kip)	Max Vs2 (kip)	Vs (kip)	Max Vs (kip)
Invent~ 1, MAX		Max V	74.94	532.92	0.00	591.08	532.92	1576.21
Invent~ 1, MIN		Min V	74.94	532.92	0.00	591.08	532.92	1576.21
Operat~ 1, MAX		Max V	74.94	532.92	0.00	591.08	532.92	1576.21

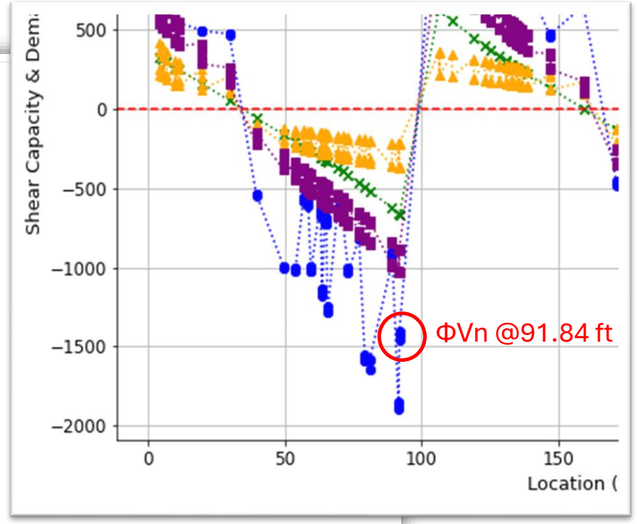
Limit State	Load Comb	Governing Action	Vc (kip)	Vs (kip)	Vn (kip)
Invent~ 1, MAX		Max V	539.07	532.92	1071.98
Invent~ 1, MIN		Min V	536.56	532.92	1069.47
Operat~ 1, MAX		Max V	528.29	532.92	1061.21

AASHTOWare™ BRIDGE DESIGN AND RATING

Shear Capacity @ 91.84 ft

```
8 Reinforced Concrete
8.16 Strength Design Method (Load Factor Design)
8.16.6 Shear
8.16.6.3 Shear Strength Provided by Shear Reinforcement
(AASHTO Standard Specifications for Highway Bridges, Seventeenth Edition - 2002)

RC MultiCellBox - At Location = 91.8392 (ft) - Left

Section located at d distance from support


INPUT:

s      =    9.0000 (in)      Av1    =    2.4000 (in^2)
bw     =   48.0000 (in)      f'c    =    3.0000 (ksi)
fy1    =   40.0000 (ksi)
alpha1 =   65.0000 (Degrees)

|
       Av1 * fy1 * (sin(alpha1) + cos(alpha1)) * d
Vs1 = ---------------------------------------------        (8-54)
                          s
```

Total Av for Z bars (all webs)

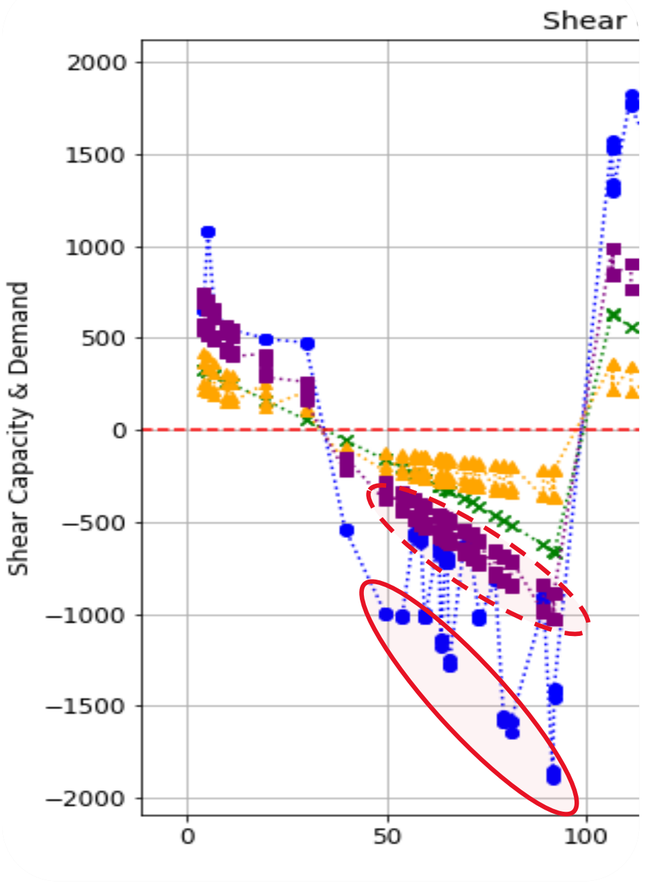


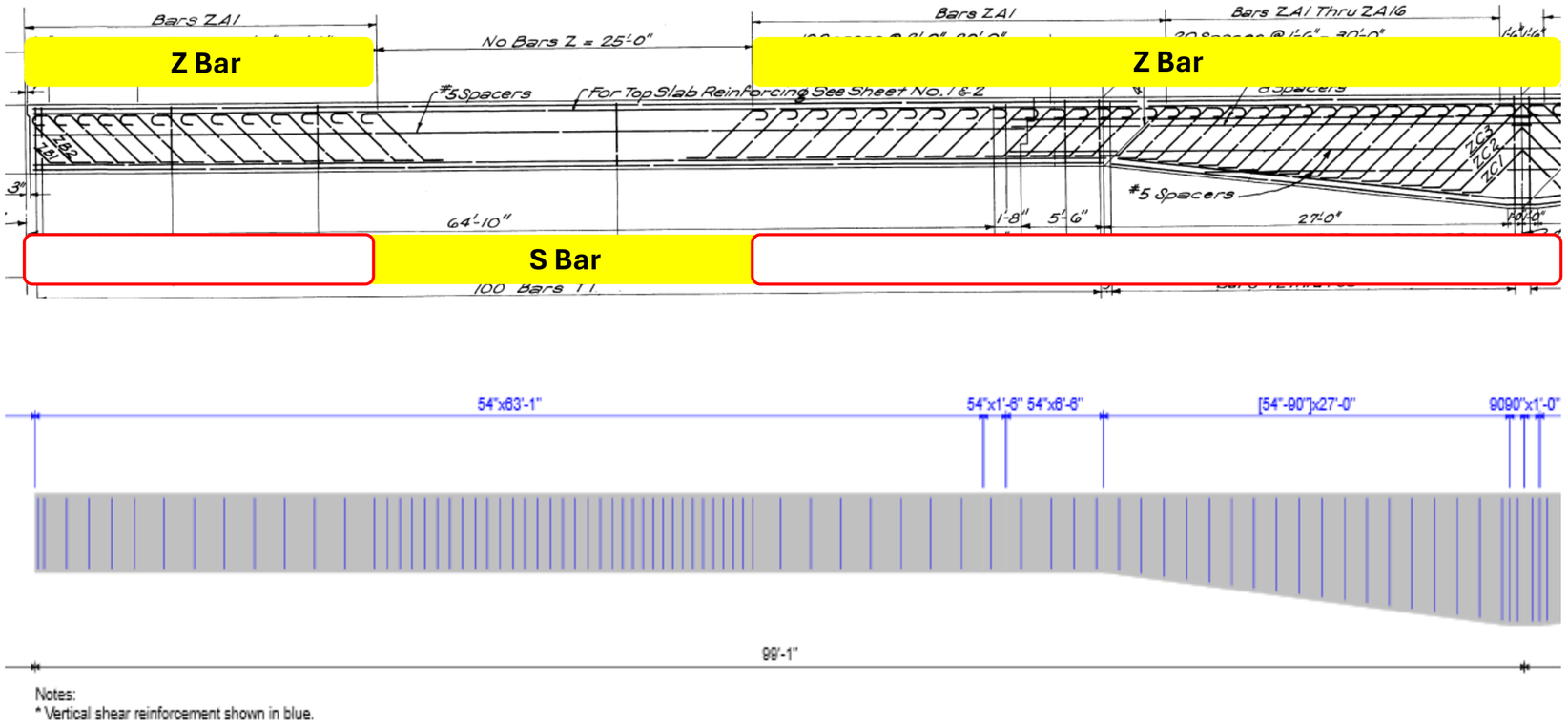
Limit State	Load Comb	Governing Action	d (in)	Vs1 (kip)	Vs2 (kip)	Max Vs2 (kip)	Vs (kip)	Max Vs (kip)
Invent~	1, MAX	Max V	78.48	1112.43	0.00	618.97	1112.43	1650.58
Invent~	1, MIN	Min V	78.48	1112.43	0.00	618.97	1112.43	1650.58
Operat~	1, MAX	Max V	78.48	1112.43	0.00	618.97	1112.43	1650.58
Operat~	1, MIN	Min V	78.48	1112.43	0.00	618.97	1112.43	1650.58

Limit State	Load Comb	Governing Action	Vc (kip)	Vs (kip)	Vn (kip)
Invent~	1, MAX	Max V	550.00	1112.43	1662.43
Invent~	1, MIN	Min V	549.49	1112.43	1661.92
Operat~	1, MAX	Max V	541.64	1112.43	1654.07

AASHTOWare™ BRIDGE DESIGN AND RATING

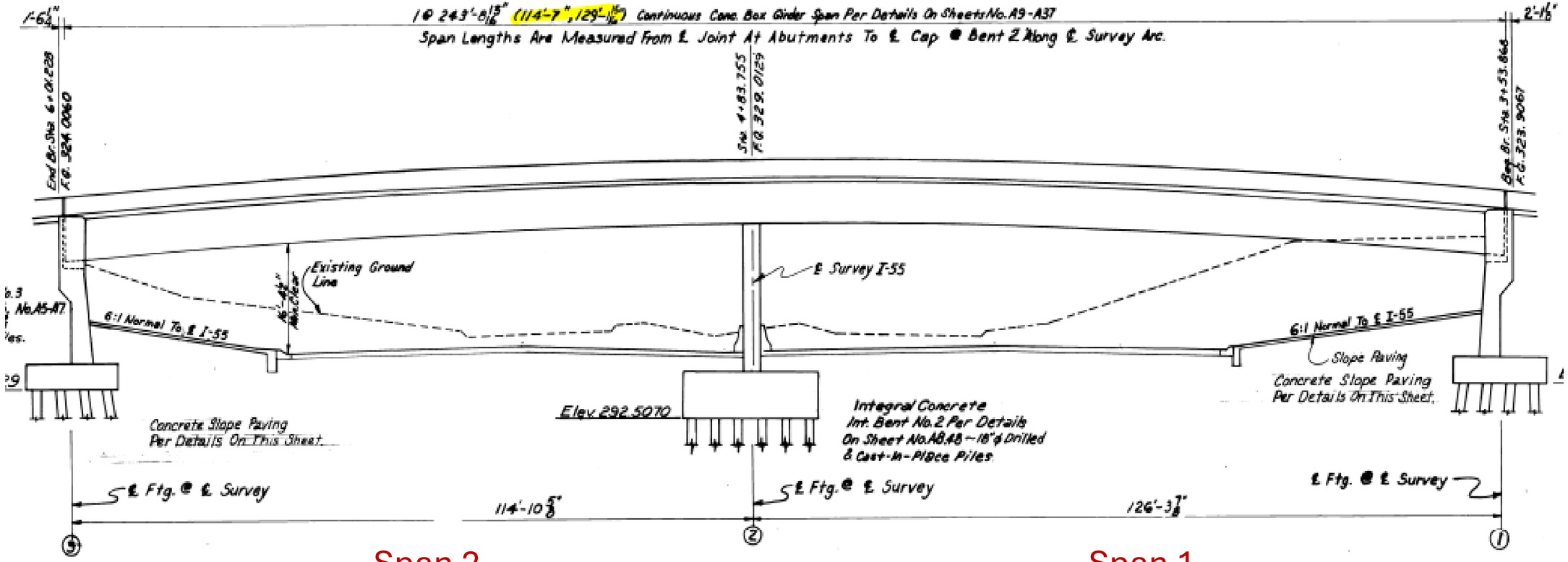
Our Solution for LFR Low Shear Ratings





AASHTOWare™ BRIDGE DESIGN AND RATING

Understanding Low Flexural Rating Results



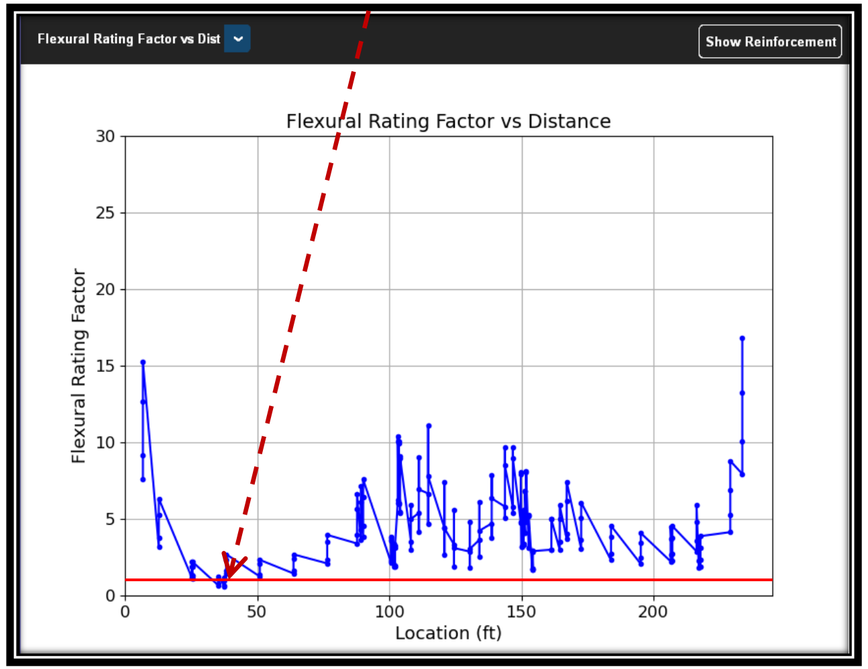
Span 2
(~115')

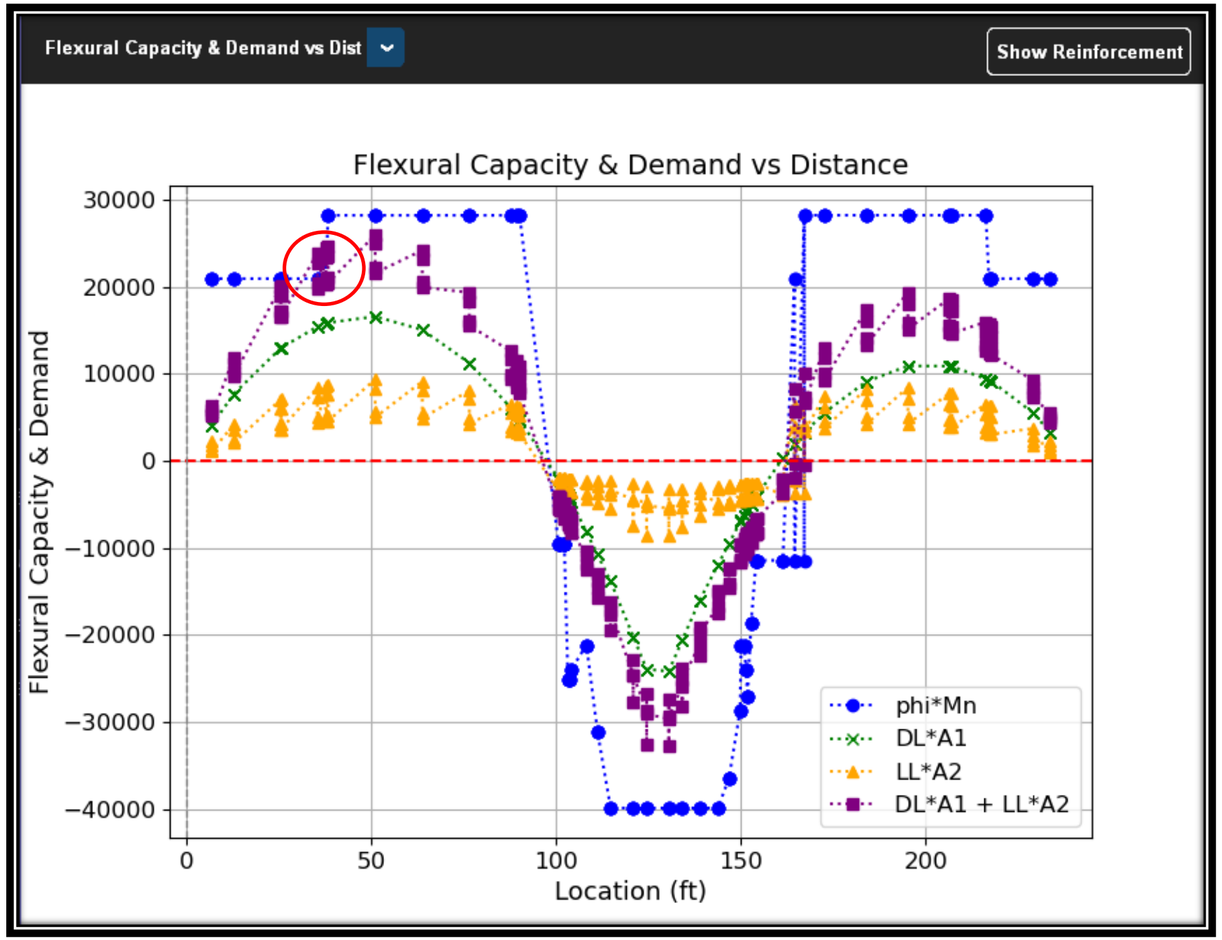
Span 1
(~126')

AASHTOWare™ BRIDGE DESIGN AND RATING

Understanding Low Flexural Rating Results

Rating Factor	Location (ft)	Location Span-(%)	Element Name	Limit State
0.597	37.58	1 - (29.5)	15'-1145834'	Design Flexure - Concrete
0.997	37.58	1 - (29.5)	15'-1145834'	Design Flexure - Concrete
0.681	37.58	1 - (29.5)	15'-1145834'	Design Flexure - Concrete
1.138	37.58	1 - (29.5)	15'-1145834'	Design Flexure - Concrete





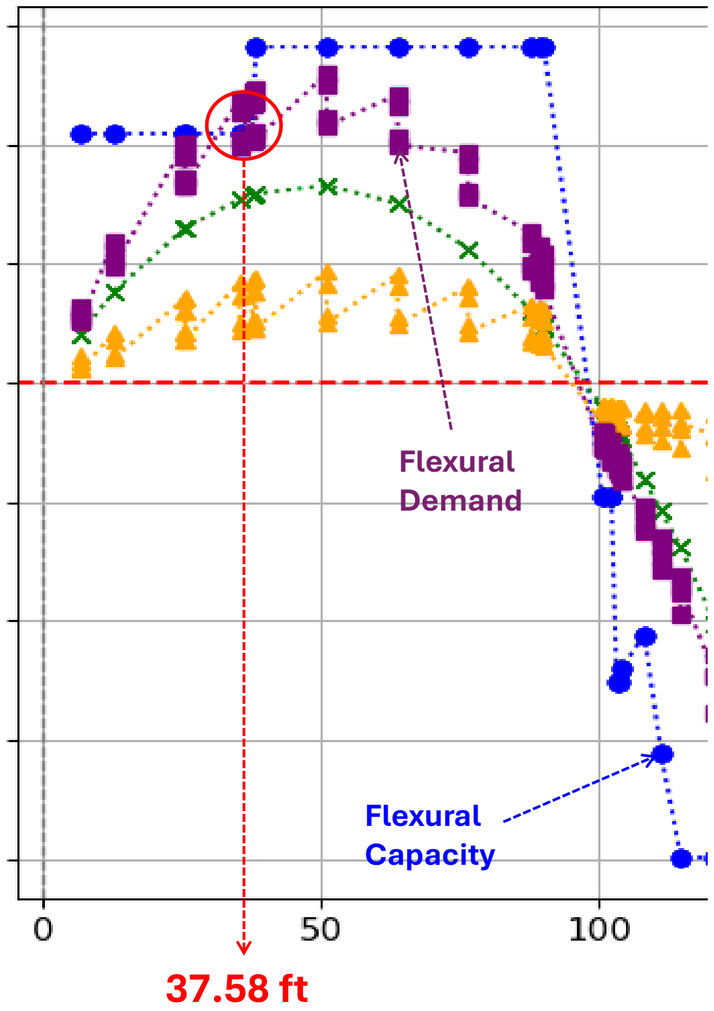
AASHTOWare™ BRIDGE DESIGN AND RATING

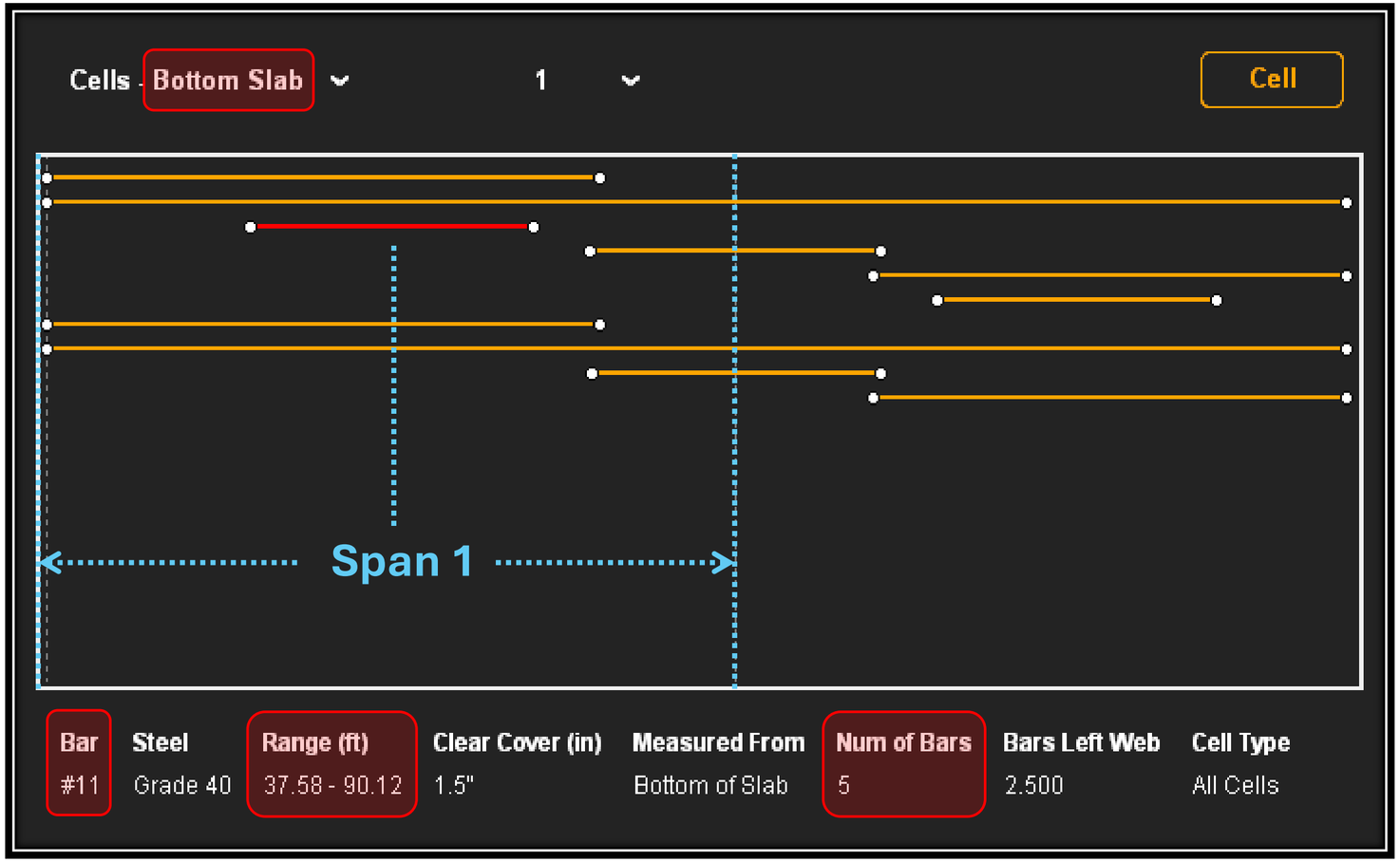
Understanding Low Flexural Rating Results

Transverse reference lines | Cells-top slab | Cells-bottom slab | Overhangs

Cell	Material	Reference point	Direction	Start distance (ft)	Length (ft)	End distance (ft)	Number of bars	Number bars for left web	Bar size	Clear cover (in)	Measured from	Bar spacing (in)	Side cover (in)
A...	Grade 40	Support 1	Right	0.000	102.203	102.203	6	3.000	8	2.625	Top of Slab	9.750	3.000
A...	Grade 40	Support 1	Right	100.870	53.250	154.120	6	3.000	4	2.625	Top of Slab	9.750	3.000
A...	Grade 40	Support 2	Right	25.292	87.625	112.917	6	3.000	8	2.625	Top of Slab	9.750	3.000
1	Grade 40	Support 1	Right	0.000	240.412	240.412	2	2.000	11	2.625	Top of Slab	6.000	3.000
2	Grade 40	Support 1	Right	0.000	240.412	240.412	1	1.000	11	2.625	Top of Slab	6.000	3.000
3	Grade 40	Support 1	Right	0.000	240.412	240.412	1	1.000	11	2.625	Top of Slab	6.000	3.000
4	Grade 40	Support 1	Right	0.000	240.412	240.412	3	1.000	11	2.625	Top of Slab	6.000	3.000
A...	Grade 40	Support 1	Right	0.000	102.203	102.203	6	3.000	11	1.500	Bottom o...	9.750	3.000
A...	Grade 40	Support 1	Right	37.583	52.536	90.120	5	2.500	11	1.500	Bottom o...	13.650	3.000
A...	Grade 40	Support 1	Right	100.620	53.750	154.370	6	3.000	5	1.500	Bottom o...	9.750	3.000
A...	Grade 40	Support 2	Right	25.292	87.625	112.917	6	3.000	11	1.500	Bottom o...	9.750	3.000
A...	Grade 40	Support 2	Right	37.042	51.792	88.833	5	2.500	11	1.500	Bottom o...	13.650	3.000
1	Grade 40	Support 1	Right	0.000	240.412	240.412	2	2.000	11	1.500	Bottom o...	6.000	3.000
2	Grade 40	Support 1	Right	0.000	240.412	240.412	3	3.000	11	1.500	Bottom o...	6.000	3.000
3	Grade 40	Support 1	Right	0.000	240.412	240.412	3	3.000	11	1.500	Bottom o...	6.000	3.000
4	Grade 40	Support 1	Right	0.000	240.412	240.412	5	3.000	11	1.500	Bottom o...	6.000	3.000

Understanding Low Flexural Rating Results





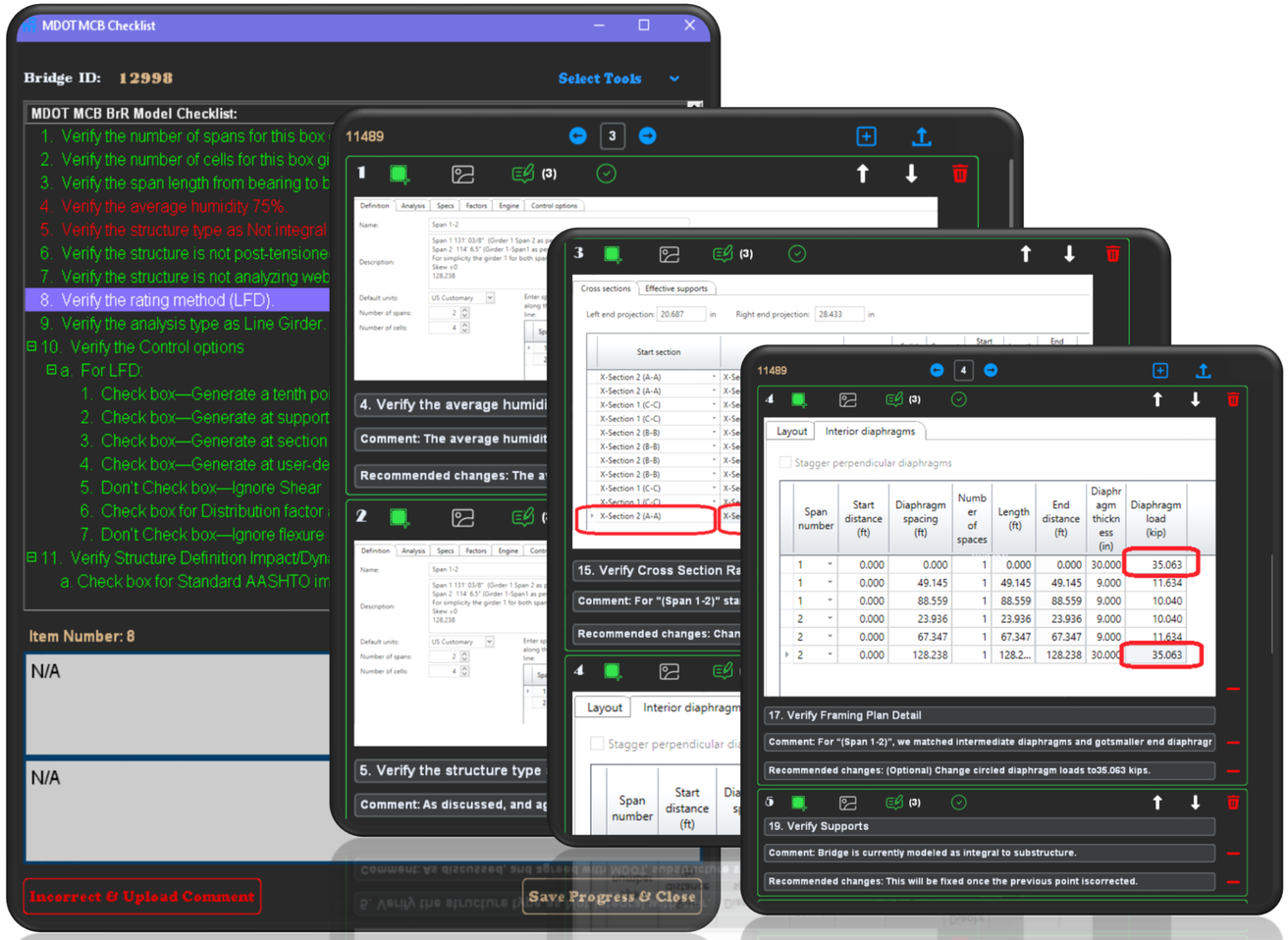
AASHTOWare™ BRIDGE DESIGN AND RATING

More than Just Rating Factors

Use visualizing to better Interpret output help us:

- Further **Minimize** Modeling **Errors**
- Identify **Workarounds** for System Errors
- Understand the **Causes** of Low Ratings
  - Support sound engineering judgment when needed.
  - Identify appropriate monitoring actions, rehab options, and posting decisions.
- Boost **Confidence** in the Bridge Model

Automated Reporting



AASHTOWare™ BRIDGE DESIGN AND RATING

AASHTOWare™ BRIDGE DESIGN AND RATING

Load Rating Management (LRM)

The Central Hub
Bridge query, work distribution & progress tracking

BrDR API Integration
Retrieves required data aligned with MDOT's checklist

Auto-Check
Automated flagging and commenting

User-Check with Visualization
Reviewer-friendly data presentation and visualization

Automated Reporting
Generates consistent reports with minimal manual effort

Future work:

- Expand LRM capabilities to support additional bridge types
- Automate BrDR models for highly repetitive bridge models
- Work to unlock smarter workflows for specific projects

Questions?

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