Load Rating the NDOT Bridge Inventory

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Western Bridge Engineers Seminar

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Load Rating the NDOT Bridge Inventory

- Project overview
- Administering and managing the ratings
- Results overview
- Common technical challenges
- Observations & Recommendations

Project Overview

- **2 Contracts**
  - Contract 1: 361 ratings/509 bridges.
    - *15 month contract*
    - *All NDOT structures*
    - *No culverts*
    - *All LFR*

Project Overview

- **2 Contracts**
  - Contract 2: 1011 ratings/1143 bridges
    - *27 month contract*
    - *Mix of NDOT & local structures*
    - *60% culverts*
    - *Mix of LFR and LRFR*

Project Overview

- **Structure types rated**
  - Bread and butter
    - *Girder, Tee Beam, Box Girder, Slab*
  - Unique
    - *Truss, arch, flexible culvert, segmental, spliced girder, curved steel, hybrid*
- **Software used**
  - BRASS suite, MDX, SAP2000, CANDE

Project Administration

- **Scoping the work**
  - NBI data (structure type, widening) used to scope the effort
  - “Widget” approach for hour estimates
  - Scoping issues
    - *Variable girder length within span?*
    - *Curved?*
    - *Arch or flexible culvert?*
    - *NBIS mis-coding*

Project Administration

- **Data management/collection**
  - Large data volume to be collected/shared
    - *As-built plans*
    - *Inspection reports & photos*
    - *Field data*
      - Culvert fill depth
      - Overlay thickness
      - Structures with incomplete/missing plans
      - Deteriorated structures

Project Administration

- **Delivering the work**
  - 12 offices plus subconsultant participating in ratings
  - Standardized approach required
    - *Software*
    - *Electronic file format*
    - *Deliverable format*
  - Tracking tools to monitor progress and results

Project Administration

NDOT Load Rating Structure Control Spreadsheet Ver. 4

Bridge No: B 589

NBI Type:	113
Complexity:	Simple
Rating Budget:	8 hrs
QC Budget:	3 hrs

Rating Information

Load Rating Status (ready to submit (Date)) —

Special Flags:

- ☐ Increase Complexity
- ☐ Rail or Railing Plans, Photos or Inspection Report
- ☐ Has deck overlay or mill fill and field measurements not available
- ☐ Requires special rating

Load Rating Comments

Describe why the load rating is on hold and any special notes regarding the load rating results (viewed internally only)

Actions

Hey Chris, just set this into an LRR for me!

I'm feeling lazy, can you make a cover sheet for me too?

Paths

LRR Template	S:\projects\PTP\NDOT Load Rating\Allocation Files - For Chris Only\
Cover Template	S:\projects\PTP\NDOT Load Rating\Allocation Files - For Chris Only\

Load Rating Assumptions

	Deck	Girders	
Concrete f'c (psi)=	NA	3,000	Rater Input
Reinforcing Steel Fy (psi)=	NA	40,000	Rater Input
Structural Steel Fy (psi)=	NA	NA	Rater Input
Prestressing Steel Fs (psi)=	NA	NA	Rater Input

Method of Analysis: MDOT Load Version 2.1.0 — Rater Select

Analysis By:	J. Gifford	Date:		Rater Input
Checked By:	P. Bender	Date:	4/25/2013	Rater Input
Report By:	J. Gifford	Date:	5/2/2013	Same as "Analysis By"

Comments: — Rater Input

Analysis Criteria

Rating performed using LFD
Analyzed structure under "rotating" conditions
Bridge is a reinforced concrete box (RCB) structure
Assumed an "at-rest" pressure of 60 psf/ft/ft and 30 psf/ft/ft acting on the abutment walls
Applied a 3 Kips load surcharge load
Fy=40,000 psi per original construction plans
Fy=40,000 psi per AASHTO Manual for Condition Evaluation of Bridges for intermediate grade reinforcement
Used a max and min fill depth of 2.0 ft & 1.0 ft, based on original plans
Model includes only 1 cells

Rater Input / Sample Criteria Below

Comments

Comments added here fill in the comments box on the LRR sheet
Typically used only to note results for interior girders when a rating was governed by an exterior girder and load rating factors <1.0

Sample Comments Below — Rater Input

Load Rating Results

	Standard Rating Items		Governing Rating Items		Special Rating Items	
	Deck	Girders	Analysis Case	Limiting Action	Rating	Item/Action
INVENTORY RATING						
RATING FACTOR for HS20=		0.73	Midspan	Top Bars	NA	NA
OPERATING RATING						
RATING FACTOR for HS20=		1.21	Midspan	Top Bars	NA	NA
RATING FACTOR for P4 =		0.91	Midspan	Top Bars	NA	NA
RATING FACTOR for P5 =		0.81	Midspan	Top Bars	NA	NA
RATING FACTOR for P13 =		0.91	Midspan	Top Bars	NA	NA

Structure Information

ROUTE INVENTORY	1000	
Truncated Route Number	1000	DON'T TOUCH
Local Name	Mitchell Creek Br. over Mitchell Creek	Rater Verify
Contract 1	00	
Contract 2	2111	
Contract 3		
Contract 4		
Contract 5		
Contract 6		
Contract 7		
County	Clark	3
Route	95	
Direction	I	
Mileage	44.73	44.7300154
Year Constructed	1963	
Deck Rating	6	
Superstructure Rating	6	
Substructure Rating	6	
Culvert Rating	0	
Channel Rating	6	
Vertical Clearance	N/A	NA
Structure Depth	2.0-1.0	Rater Input
Width	40'-0"	40.0
Length	28'-1.25"	28.1041667
Structure Type	7 Span Concrete Culvert	Rater Verify
Overlay Description	Asphalt	Rater Input
Est. Remaining Life (Yrs)	10	Rater Input
Structure Posted? (Y/n/blk)	N	
Date of Inspection	10/1/2012	
Inspection Type	Routine	Rater Select

Structure Information		
PONTIS MATCH?	YES	
Truncated Bridge Numbe	B589	*DON'T TOUCH*
Local Name:	SR604/LAS VEGAS B Lover VANDENBERG WASH	*Rater Verify*
Contract 1:	983	
Contract 2:	3119	
Contract 3:		
Contract 4:		
Contract 5:		
Contract 6:		
Contract 7:		
County:	Clark	3
Route:	604	
District:	1	
Milepost:	36.22	36.22221148
Year Constructed:	1957	
Deck Rating:	N	
Superstructure Rating:	N	
Substructure Rating:	N	
Culvert Rating:	6	
Channel Rating:	6	
Vertical Clearance	NA	NA
Structure Depth:	0'-9.5"	*Rater Input*
Width:	96' - 6"	96.5
Length:	95' - 1 3/4"	95.14435696
Structure Type:	7 Span Concrete Culvert	*Rater Verify*
Overlay Description:	variable fill	*Rater Input*
Est. Remaining Life (Yrs):	10	*Rater Input*
Structure Posted? [Yes/No]:	No	
Date of Inspection:	12/1/2008	
Inspection Type:	Routine	*Rater Select*

Bridge No: B 589

NBI Type: 119
Complexity: Simple
Rating Budget: 8 **hrs**
QC Budget: 3 **hrs**

Status Information

Load Rating Status: Ready to Submit (Rater)

Special Flags:

- ☐ Incorrect Complexity
- ☐ Bad or Missing Plans, Photos or Inspection Report
- ☐ Has deck overlay or soil fill and field measurements not available
- ☐ Requires special rating

Load Rating Comments

Describe why the load rating is on hold and any special notes regarding the load rating results (viewed internally only)

Load Rating Information

	Deck	Girders	
Concrete F'c (psi)=	NA	3,000	*Rater Input*
Reinforcing Steel Fy (psi)=	NA	40,000	*Rater Input*
Structural Steel Fy (psi)=	NA	NA	*Rater Input*
Prestressing Steel F's (psi)=	NA	NA	*Rater Input*

Method of Analysis:	BRASS Culvert Version 2.2.8			*Rater Select*
Analysis By:	J. Stith	Date:		*Rater Input*
Checked By:	P. Baxter	Date:	4/27/2010	*Rater Input*
Report By:	J. Stith	Date:	1/0/1900	*Same as "Analysis By"*
Widenings:				*Rater Input*

Analysis Criteria:

Rater Input
Sample Criteria Below

Rating performed using LFD
Analyzed structure under "existing" conditions
Bridge is a reinforced concrete box (RCB) structure
Assumed an "at-rest" pressure of 60 pcf max and 30 pcf min acting on the abutment walls
Applied a 2 ft live load surcharge load
F'c=3,000 psi per original contract plans
Fy=40,000 psi per AASHTO Manual for Condition Evaluation of Bridges for intermediate grade reinforcement
Used a max and min fill depth of 2.6 ft. & 1.8 ft. based on original plans
Model includes only 4 cells

Comments:

Sample Comments Below

Rater Input

Comments added here fill in the comments box on the LRR sheet. Typically used only to note results for interior girders when a rating was governed by an exterior girder and had rating factors <1.0

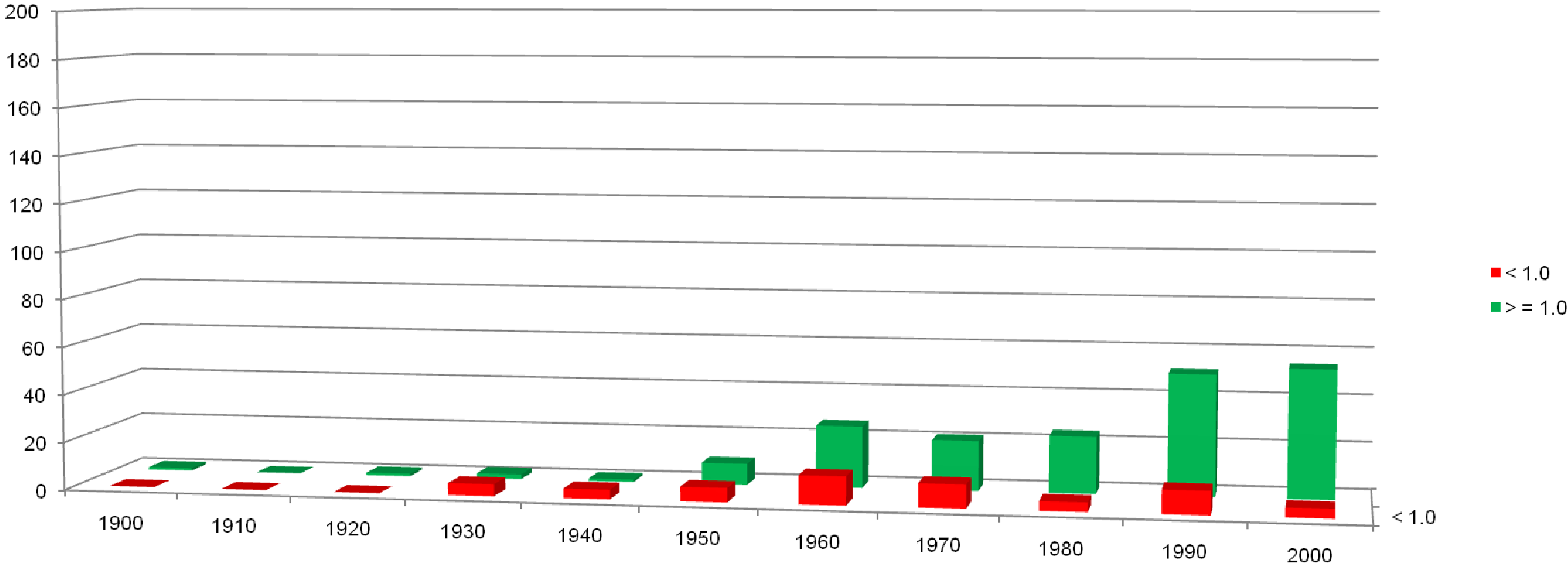
Load Rating Results

	Standard Rating Items		Controlling Girder Action		Special Rating Items	
INVENTORY RATING:	Deck	Girders	Analysis Point	Critical Action	Rating	Item/ Action
RATING FACTOR for HS20 =		0.73	Midpoint	Top Slab	NA	NA
OPERATING RATING:						
RATING FACTOR for HS20 =		1.21	Midpoint	Top Slab	NA	NA
RATING FACTOR for P5 =		0.81	Midpoint	Top Slab	NA	NA
RATING FACTOR for P9 =		0.81	Midpoint	Top Slab	NA	NA
RATING FACTOR for P13 =		0.81	Midpoint	Top Slab	NA	NA

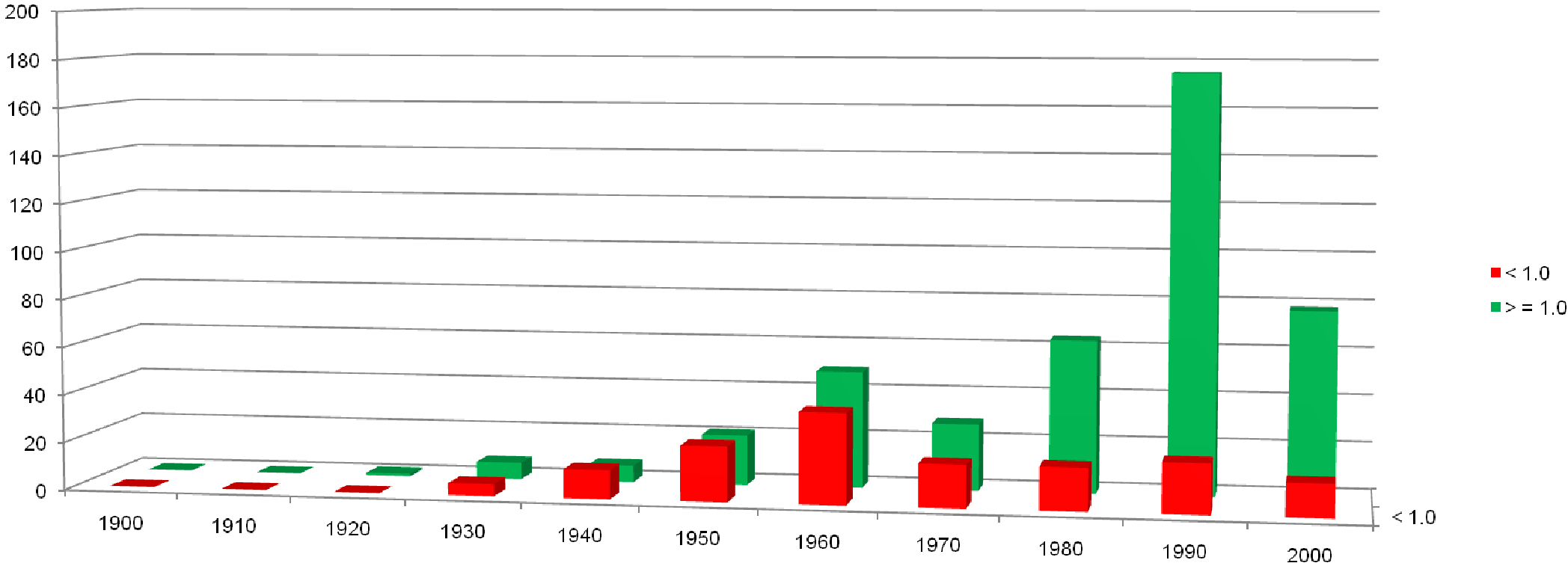
Results Overview

- Bridge rating factors
- Culvert rating factors
- Percent of structures with rating factors < 1.0
- Rating factor by consultant

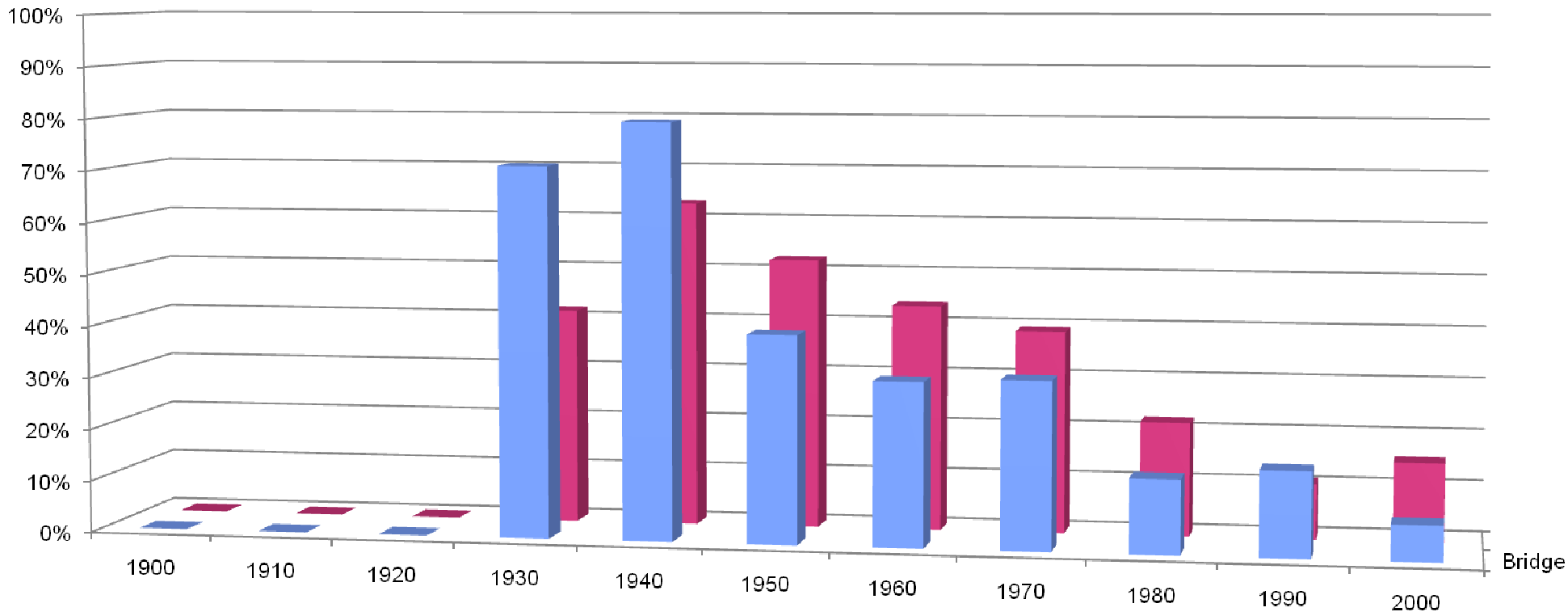
Bridge Inventory Rating Factor



Culvert Inventory Rating Factor



% Structures with RF < 1.0



25% Structures with Inventory RF < 1.0

3% Structures with Operating RF < 1.0

Technical Challenges

- **Bridges**
  - Railroad car bridges
    - *No as-built plans*
    - *Unknown steel yield (when built?)*
    - *Damage from prior use*
    - *Complicated load path – which member will govern?*

Technical Challenges – Railroad Car Bridges

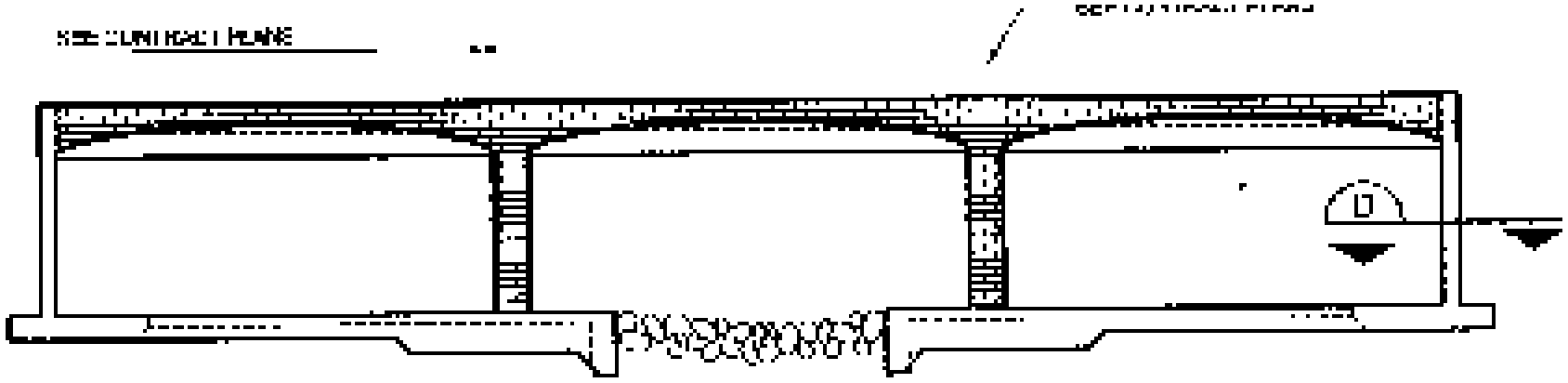
Technical Challenges

- **Bridges**
  - Segmental
    - *Construction sequence*
    - *Construction equipment*
    - *Contractor changes*

Technical Challenges

- **Culverts**
  - Rigid culverts
    - *Lateral pressures*
    - *Software limitations*
      - Variable cover
      - Variable haunch configuration
      - Variable material properties
      - Variable wall/slab thickness

Technical Challenges



Technical Challenges

- **Culverts**
  - Flexible culverts
    - *Structures that rely on soil-structure interaction for stability*
      - Pipe (concrete & steel)
      - Arch (concrete & steel)
    - *Typically detailed with a size and a performance specification – no knowledge of actual system installed*

Technical Challenges

- **Culverts**
  - Flexible culverts
    - *Assumptions required to perform rating*
      - Geometry
      - Soil properties
      - Material properties

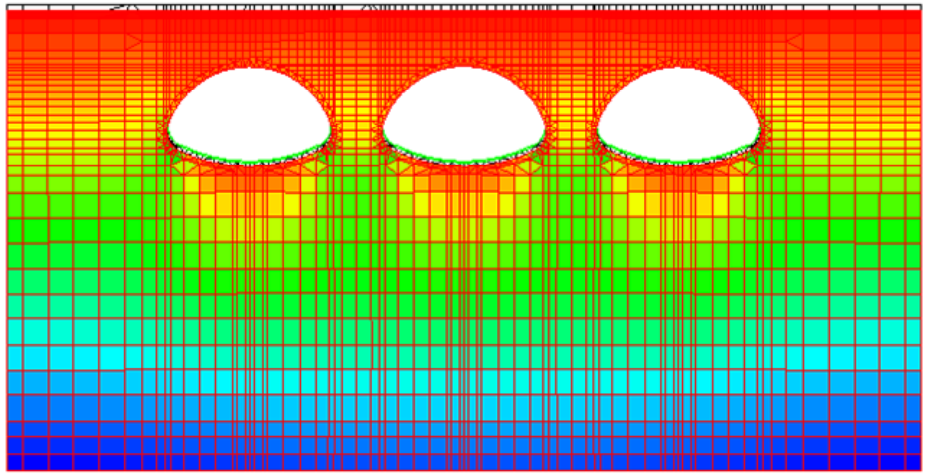
Technical Challenges

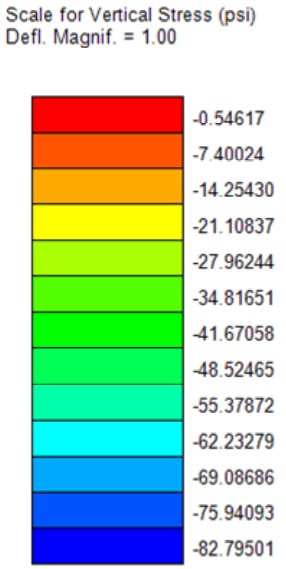
- **Culverts**
  - Flexible culverts
    - *Software limitations*
      - Used CANDE (Culvert ANalysis and DEsign)
        - "Easy" interface elements
        - Versatile
      - Not a rating tool. Requires extra work to develop rating factors from results
      - Modeling effort significant. Minor changes to model once started very laborious.

Technical Challenges

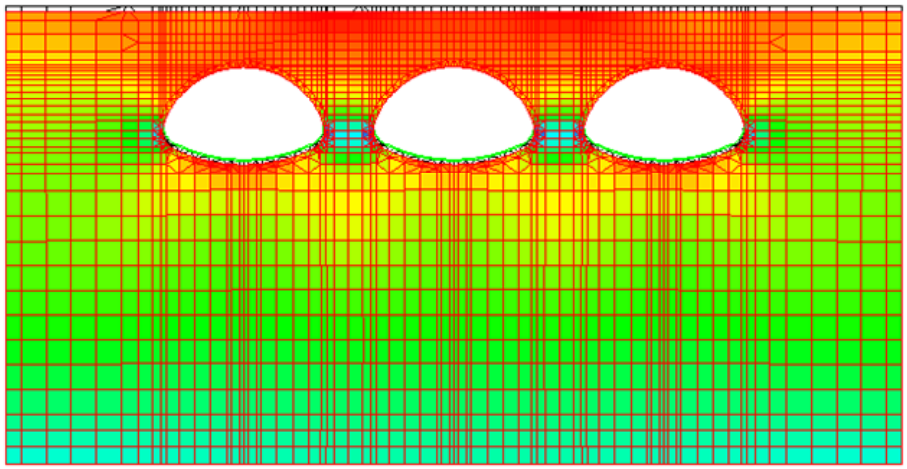
- **Culverts**
  - Flexible culverts
    - *Software Limitations*
      - Limited ability to auto generate the mesh
      - Time consuming to debug
      - Run times up to 10 minutes
      - No live load generator. Must move live loads manually.

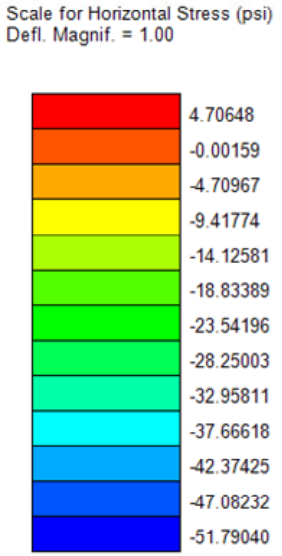
Flexible Culvert - Sample Vertical Stress Plot





Flexible Culvert – Sample Horizontal Stress Plot





Technical Challenges

- **General**
  - Structures without plans
    - *Field measurements to establish dimensions, component sizes*
    - *MBE provisions for “no-plans” rating*

Technical Challenges

- **General**
  - Deteriorated structures
    - *NDOT structures in generally good shape.*
      - Bent caps under joints
      - Overhangs
    - *Inspection ratings not always a good indicator of structural problems*
      - Deterioration often isolated
      - Deterioration often does not lead to a capacity reduction

Technical Challenges

- **General**
  - Deteriorated structures
    - *Incorporation of deterioration is difficult, requires significant judgment*

Technical Challenges

Technical Challenges

Technical Challenges

- **General**
  - Low ratings
    - *Some ratings come in very low on structures that show no signs of distress*
    - *Skew is a common source of low ratings*
      - Provide interior girder result
    - *Culverts can be extremely sensitive to depth of overburden*
      - Test sensitivity to soil density
      - Check only under travelled way

Observations/Recommendations

- The structures generally rated well
- Load raters need to observe structural deterioration to incorporate it properly
- Load rating software can be a blessing and a curse

Observations/Recommendations

- **Software**
  - Load rating software is very efficient for specific conditions
  - Variations from specific conditions results in significant increases in labor and complexity of documentation

Observations/Recommendations

- **Software**
  - Software “wish-list”
    - *BRASS incorporate continuous PT box-girders*
    - *BRASS accommodate variations in culvert section*
    - *CANDE perform rating calculations for flexible culverts*
    - *CANDE gets increased auto meshing functionality*

Acknowledgements

- **Dave Severns/NDOT PM**
- **George Klockzien/NDOT Technical Lead**
- **Mike Cooper/CH2M HILL PM**
- **Load Rating Team**
  - BRG Engineering

Why Everyone Should Love Load Ratings

- Exposure to wide variety of structures and structure types
- Intense exposure to code provisions for load distribution and capacity
- Gives engineers great perspective on how structures perform
- Debugging low ratings is fun!

Load Rating the NDOT Bridge Inventory

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