ITD BrR Testing Program

BrR 7.2

BrR 7.5.1

PRESENTERS:

MELISSA HENNESSY, ITD

RYAN SHERMAN, FORSGREN

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ITD BrR Testing Program

Why Test Upgrades?

- Agencies conduct different levels of testing for New Releases
- Objective – To identify how new versions impact ratings
  - Need to explain Decrease/Increase in Route Capacity
- Pinpoint the reasons behind rating changes
  - + Change in AASHTO Codes
  - + Bug Fixed from Previous Versions
  - - New Bug/Issue

ITD BrR Testing Program

Idaho's History of Testing

- ITD Used Internal Resources – 2012 to 2016
  - + Compared Results of All Bridges in Database
  - + In-depth Review of a Representative Sample
- Started Hiring Consultants in 2017
  - + Compared Controlling Ratings for All Bridges
  - + Compared Results of Multiple Vehicles
  - + Developed Procedures for Testing, Upgrading, and Documenting Results

ITD BrR Testing Program

Why Still Using BrR 7.2?

- ITD Consultant Tested BrR 7.3
  - + AASHTO Timber Engine was new and had some bugs
  - + Would have been only state using BrR 7.3 for Automated Permitting
- Lack of resources to do full testing on BrR 7.4
- Avoid potential future issues
- Can be large effort to upgrade – were understaffed

ITD BrR Testing Program

SORRY, NOT SORRY GUYS!

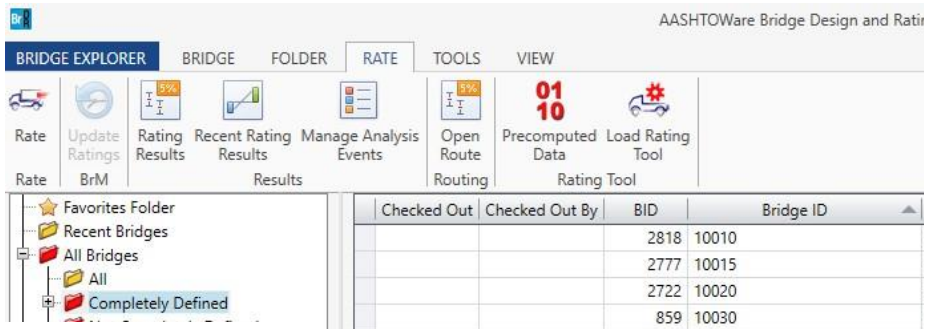
THANK YOU

FOR GIVING MY PRESENTATION FOR ME!!

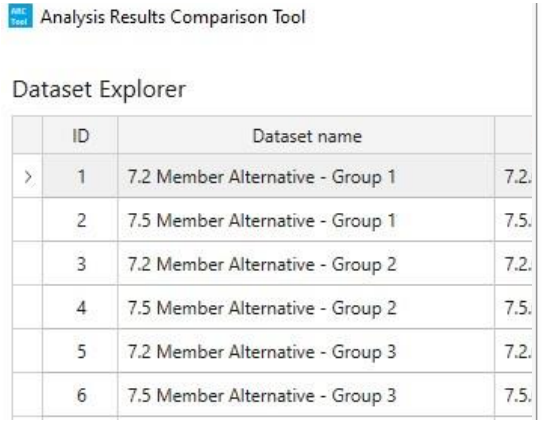
ITD BrR Testing Program

Testing Procedure

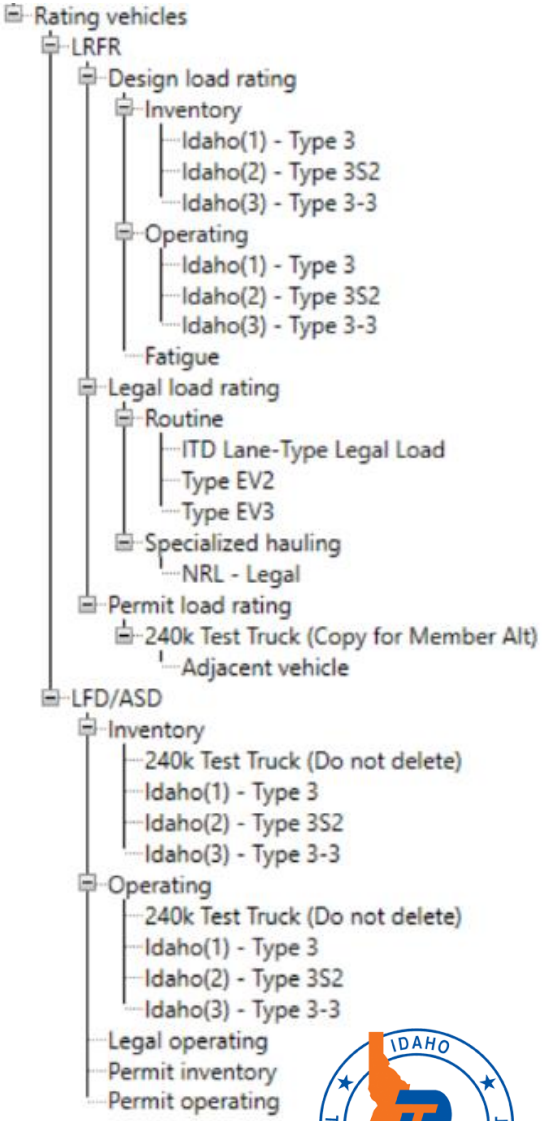
- Phase 1 – Manual Bridge Explorer Analysis
- Phase 2 – Rating Difference Investigation
- Phase 3 – ArcTool Verification



Checked Out	Checked Out By	BID	Bridge ID
		2818	10010
		2777	10015
		2722	10020
		859	10030
		6286	10035
		5783	10040
		1335	10055
		1743	10060
		6014	10061
		1336	10065
		1794	10070
		6527	10081
		6645	10086
		918	10090
		2899	10093
		1337	10095
		1338	10100
		5746	10111
		1339	10115
		3986	10121
		3587	10126
		1340	10131
		5769	10136
		1721	10141
		1413	10145
		1050	10150
		1341	10156
		4193	10161
		4004	10166
		1399	10170
		3415	10176



	ID	Dataset name	
›	1	7.2 Member Alternative - Group 1	7.2.
	2	7.5 Member Alternative - Group 1	7.5.
	3	7.2 Member Alternative - Group 2	7.2.
	4	7.5 Member Alternative - Group 2	7.5.
	5	7.2 Member Alternative - Group 3	7.2.
	6	7.5 Member Alternative - Group 3	7.5.



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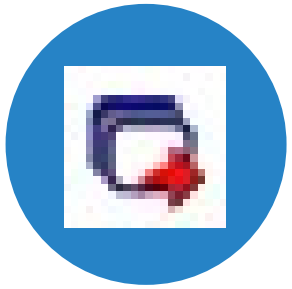
Phase 1 – Manual Bridge Explorer Process



EXPORT XML FILES

ANALYZE **3,253 BRIDGES** IN 7.2 & 7.5.1

COLLECT RATINGS

DOCUMENT ERRORS

ITD BrR Testing Program

Phase 2 – Rating Difference Investigation

COMPARE COLLECTED RATINGS

RATINGS WITHIN 5% TOLERANCE = MATCH

INVESTIGATE LARGER DIFFERENCES

DOCUMENT FINDING

ITD BrR Testing Program

Phase 3 – ArcTool Verification

REMOVE NON-APPLICABLE BRIDGES

CREATE DATASET & RUN ANALYSIS

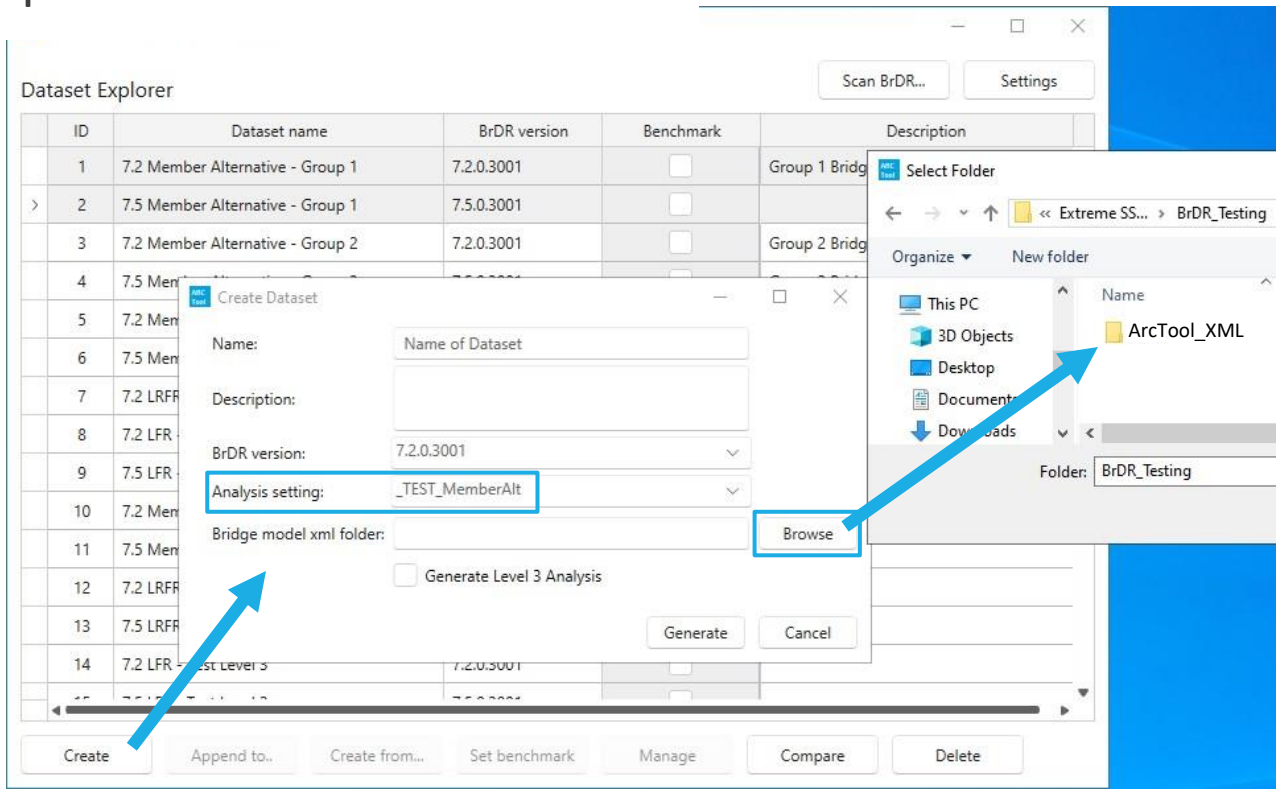
COMPARE TO BRIDGE EXPLORER RESULTS

DOCUMENT FINDING

ITD BrR Testing Program

Procedure With ArcTool

- Create Result File in ArcTool for Both Versions
  - Make sure same template is selected



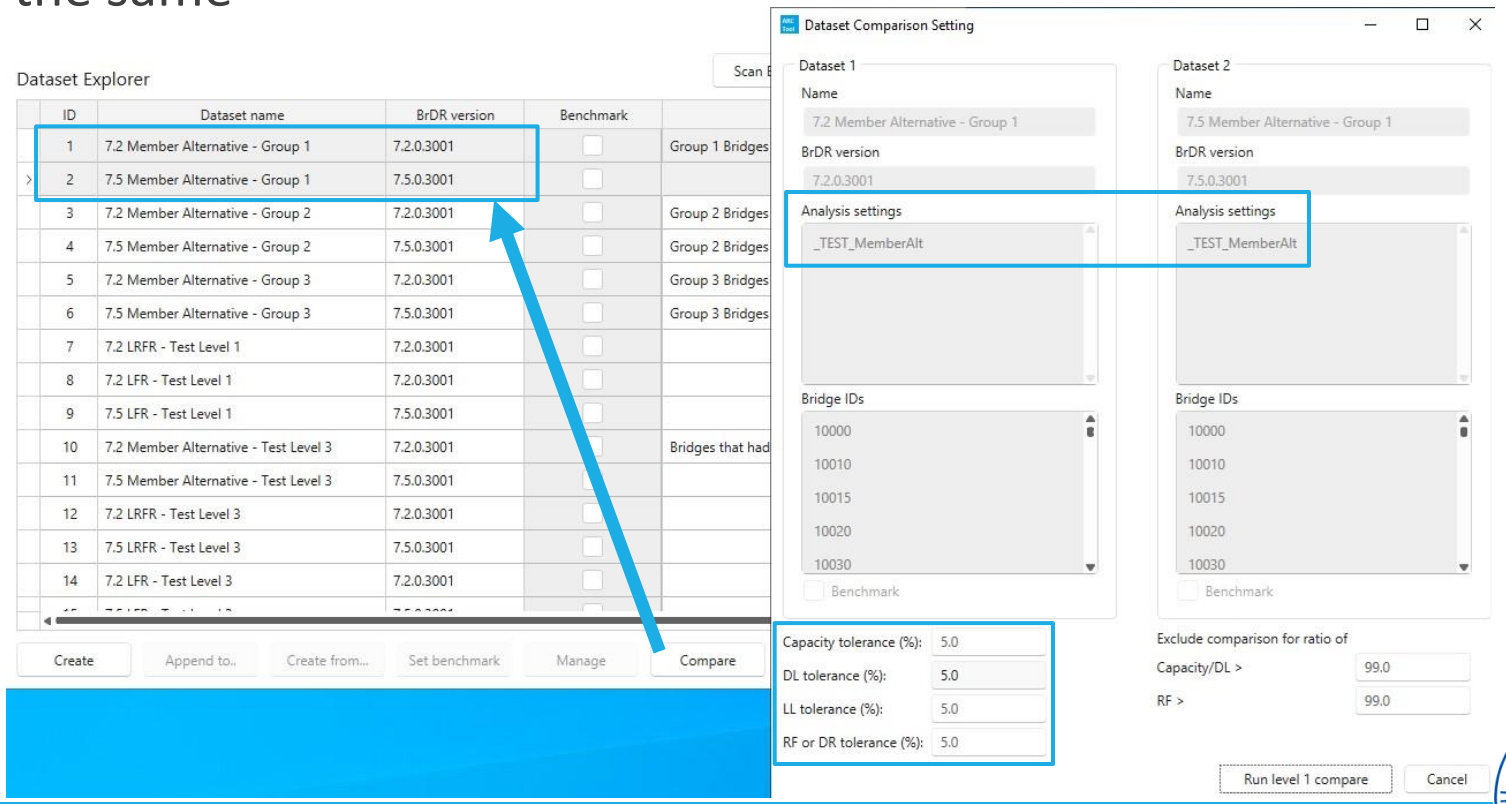
FORSGREN Associates Inc.

IDAHO TRANSPORTATION DEPARTMENT

ITD BrR Testing Program

Procedure With ArcTool

- Select Datasets to Compare
  - Verify Analysis Settings are the same
  - Set Desired Tolerance



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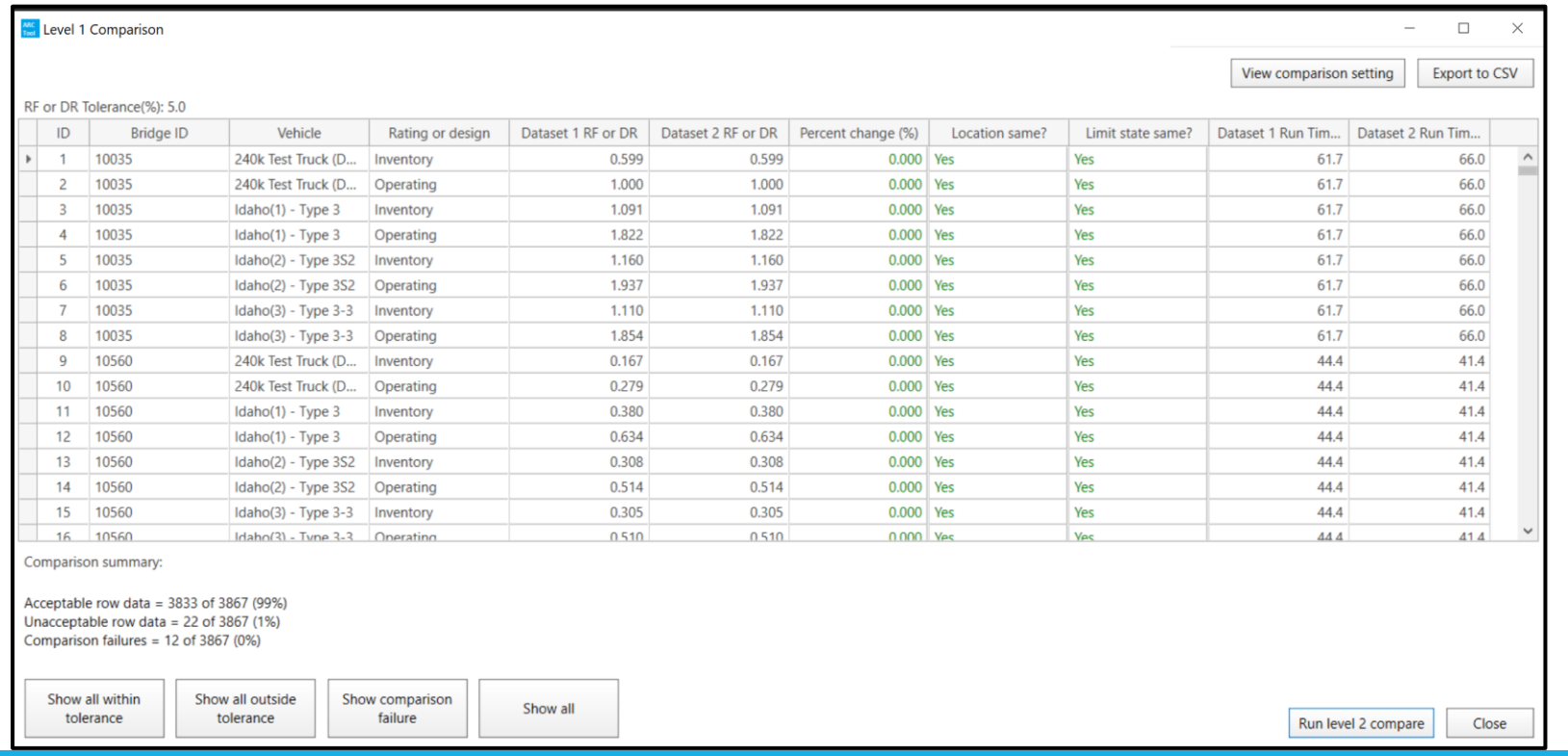
ITD BrR Testing Program

Procedure With ArcTool

- Level 1
  - Overall Bridge Controlling Load Rating



ID	Bridge ID	Vehicle	Rating or design	Dataset 1 RF or DR	Dataset 2 RF or DR	Percent change (%)	Location same?	Limit state same?	Dataset 1 Run Tim...	Dataset 2 Run Tim...
1	10035	240k Test Truck (D...	Inventory	0.599	0.599	0.000	Yes	Yes	61.7	66.0
2	10035	240k Test Truck (D...	Operating	1.000	1.000	0.000	Yes	Yes	61.7	66.0
3	10035	Idaho(1) - Type 3	Inventory	1.091	1.091	0.000	Yes	Yes	61.7	66.0
4	10035	Idaho(1) - Type 3	Operating	1.822	1.822	0.000	Yes	Yes	61.7	66.0
5	10035	Idaho(2) - Type 3S2	Inventory	1.160	1.160	0.000	Yes	Yes	61.7	66.0
6	10035	Idaho(2) - Type 3S2	Operating	1.937	1.937	0.000	Yes	Yes	61.7	66.0
7	10035	Idaho(3) - Type 3-3	Inventory	1.110	1.110	0.000	Yes	Yes	61.7	66.0
8	10035	Idaho(3) - Type 3-3	Operating	1.854	1.854	0.000	Yes	Yes	61.7	66.0
9	10560	240k Test Truck (D...	Inventory	0.167	0.167	0.000	Yes	Yes	44.4	41.4
10	10560	240k Test Truck (D...	Operating	0.279	0.279	0.000	Yes	Yes	44.4	41.4
11	10560	Idaho(1) - Type 3	Inventory	0.380	0.380	0.000	Yes	Yes	44.4	41.4
12	10560	Idaho(1) - Type 3	Operating	0.634	0.634	0.000	Yes	Yes	44.4	41.4
13	10560	Idaho(2) - Type 3S2	Inventory	0.308	0.308	0.000	Yes	Yes	44.4	41.4
14	10560	Idaho(2) - Type 3S2	Operating	0.514	0.514	0.000	Yes	Yes	44.4	41.4
15	10560	Idaho(3) - Type 3-3	Inventory	0.305	0.305	0.000	Yes	Yes	44.4	41.4
16	10560	Idaho(3) - Type 3-3	Operating	0.510	0.510	0.000	Yes	Yes	44.4	41.4

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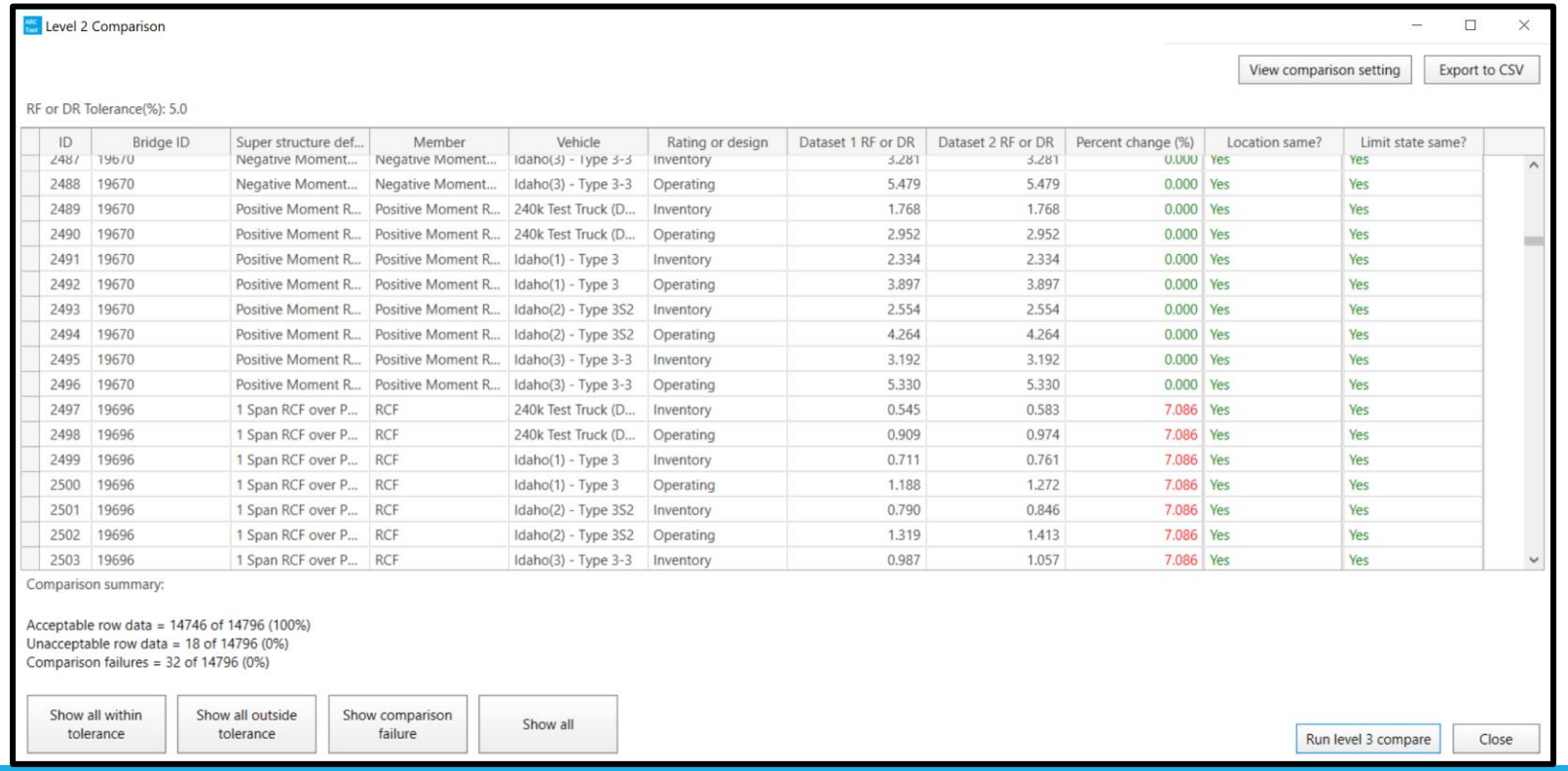
Procedure With ArcTool

- Level 2
  - Bridge Member Controlling Load Rating

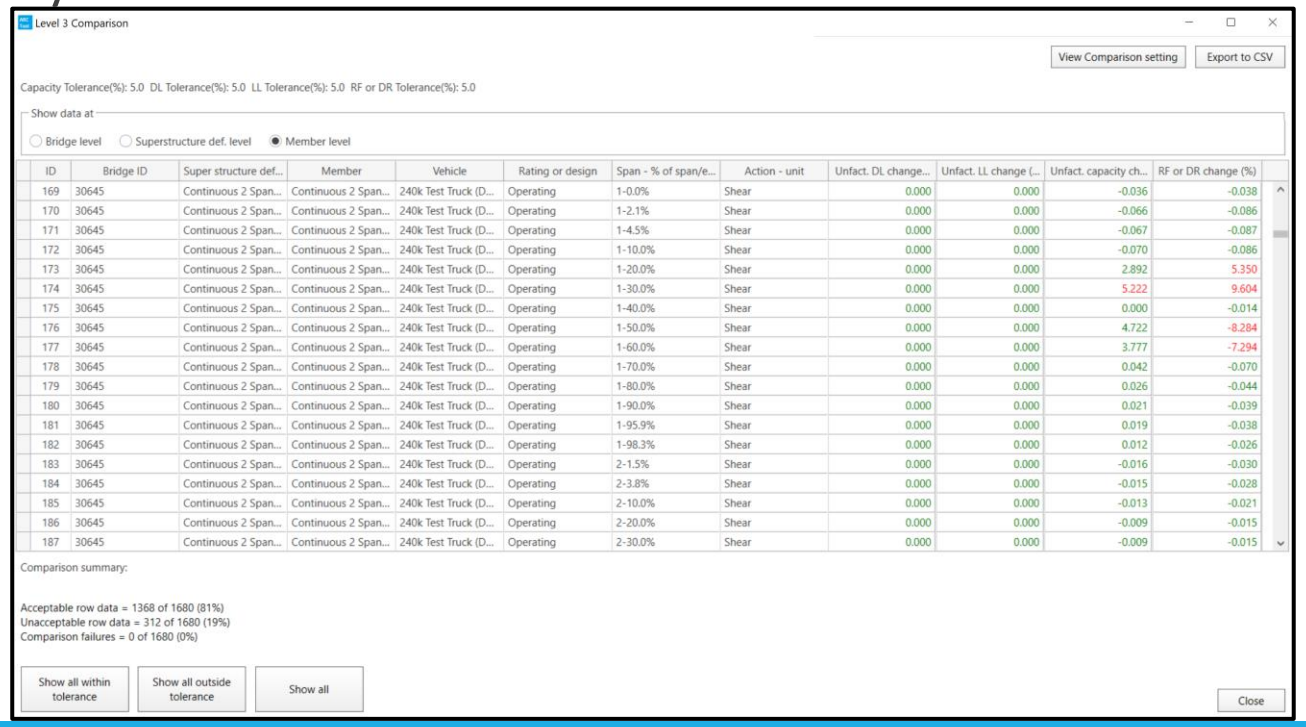


ID	Bridge ID	Super structure def...	Member	Vehicle	Rating or design	Dataset 1 RF or DR	Dataset 2 RF or DR	Percent change (%)	Location same?	Limit state same?
2487	19670	Negative Moment...	Negative Moment...	Idaho(3) - Type 3-3	Inventory	3.281	3.281	0.000	Yes	Yes
2488	19670	Negative Moment...	Negative Moment...	Idaho(3) - Type 3-3	Operating	5.479	5.479	0.000	Yes	Yes
2489	19670	Positive Moment R...	Positive Moment R...	240k Test Truck (D...	Inventory	1.768	1.768	0.000	Yes	Yes
2490	19670	Positive Moment R...	Positive Moment R...	240k Test Truck (D...	Operating	2.952	2.952	0.000	Yes	Yes
2491	19670	Positive Moment R...	Positive Moment R...	Idaho(1) - Type 3	Inventory	2.334	2.334	0.000	Yes	Yes
2492	19670	Positive Moment R...	Positive Moment R...	Idaho(1) - Type 3	Operating	3.897	3.897	0.000	Yes	Yes
2493	19670	Positive Moment R...	Positive Moment R...	Idaho(2) - Type 3S2	Inventory	2.554	2.554	0.000	Yes	Yes
2494	19670	Positive Moment R...	Positive Moment R...	Idaho(2) - Type 3S2	Operating	4.264	4.264	0.000	Yes	Yes
2495	19670	Positive Moment R...	Positive Moment R...	Idaho(3) - Type 3-3	Inventory	3.192	3.192	0.000	Yes	Yes
2496	19670	Positive Moment R...	Positive Moment R...	Idaho(3) - Type 3-3	Operating	5.330	5.330	0.000	Yes	Yes
2497	19696	1 Span RCF over P...	RCF	240k Test Truck (D...	Inventory	0.545	0.583	7.086	Yes	Yes
2498	19696	1 Span RCF over P...	RCF	240k Test Truck (D...	Operating	0.909	0.974	7.086	Yes	Yes
2499	19696	1 Span RCF over P...	RCF	Idaho(1) - Type 3	Inventory	0.711	0.761	7.086	Yes	Yes
2500	19696	1 Span RCF over P...	RCF	Idaho(1) - Type 3	Operating	1.188	1.272	7.086	Yes	Yes
2501	19696	1 Span RCF over P...	RCF	Idaho(2) - Type 3S2	Inventory	0.790	0.846	7.086	Yes	Yes
2502	19696	1 Span RCF over P...	RCF	Idaho(2) - Type 3S2	Operating	1.319	1.413	7.086	Yes	Yes
2503	19696	1 Span RCF over P...	RCF	Idaho(3) - Type 3-3	Inventory	0.987	1.057	7.086	Yes	Yes

ITD BrR Testing Program

Procedure With ArcTool

- Level 3
  - Dead Load, Live Load, and Capacity Comparison
  - Used to help identify the cause of the difference



ID	Bridge ID	Super structure def...	Member	Vehicle	Rating or design	Span - % of span/e...	Action - unit	Unfact. DL change...	Unfact. LL change (...	Unfact. capacity ch...	RF or DR change (%)
169	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-0.0%	Shear	0.000	0.000	-0.036	-0.038
170	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-2.1%	Shear	0.000	0.000	-0.066	-0.086
171	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-4.5%	Shear	0.000	0.000	-0.067	-0.087
172	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-10.0%	Shear	0.000	0.000	-0.070	-0.086
173	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-20.0%	Shear	0.000	0.000	2.892	5.350
174	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-30.0%	Shear	0.000	0.000	5.222	9.604
175	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-40.0%	Shear	0.000	0.000	0.000	-0.014
176	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-50.0%	Shear	0.000	0.000	4.722	-8.284
177	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-60.0%	Shear	0.000	0.000	3.777	-7.294
178	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-70.0%	Shear	0.000	0.000	0.042	-0.070
179	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-80.0%	Shear	0.000	0.000	0.026	-0.044
180	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-90.0%	Shear	0.000	0.000	0.021	-0.039
181	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-95.9%	Shear	0.000	0.000	0.019	-0.038
182	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	1-98.3%	Shear	0.000	0.000	0.012	-0.026
183	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	2-1.5%	Shear	0.000	0.000	-0.016	-0.030
184	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	2-3.8%	Shear	0.000	0.000	-0.015	-0.028
185	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	2-10.0%	Shear	0.000	0.000	-0.013	-0.021
186	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	2-20.0%	Shear	0.000	0.000	-0.009	-0.015
187	30645	Continuous 2 Span...	Continuous 2 Span...	240k Test Truck (D...	Operating	2-30.0%	Shear	0.000	0.000	-0.009	-0.015

ITD BrR Testing Program

PRO:
Neutral:
CON:

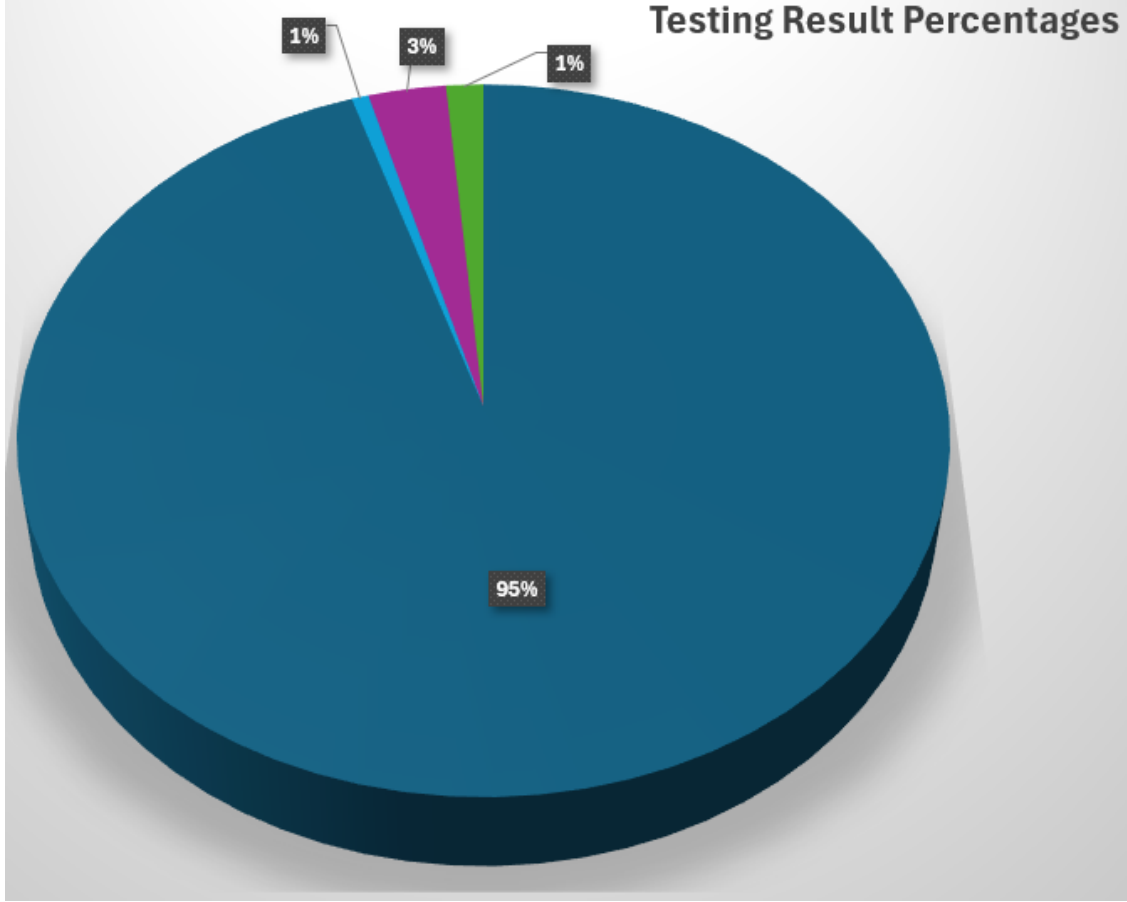
ArcTool Pros/Cons

- ❖Reduce Time in Collecting/Sorting Data
- ❖Reduce Potential Human Error in Copying Data
- ❖Provides More Than Level 1 Results
- ❖Assists in Finding Location and Reason for Difference
- ❖Easier to Find Issues That Don’t Impact Overall Load Rating
- ❖Decreases Time to Test/Upgrade Sooner
- ❖Creates Large Amounts of Temporary Files
- ❖Member Alternative Naming Matters
- ❖Does Not Rate all Bridge Types (254 bridges did not run)
- ❖Does Not Tell You if Superstructures or Members Didn’t Run

ITD BrR Testing Program

Testing Results Overview

- 95% *Considered a Match* *(3,090 out* of 3,253)
- 1% Results are >5% due to current 7.5.1 Bugs (21 out of 3,253)
- 3% Results are >5% due to previous bug fixes (96 out of 3,253)
- 1% Multi-cell boxes will have varied results (46 out of 3,253)

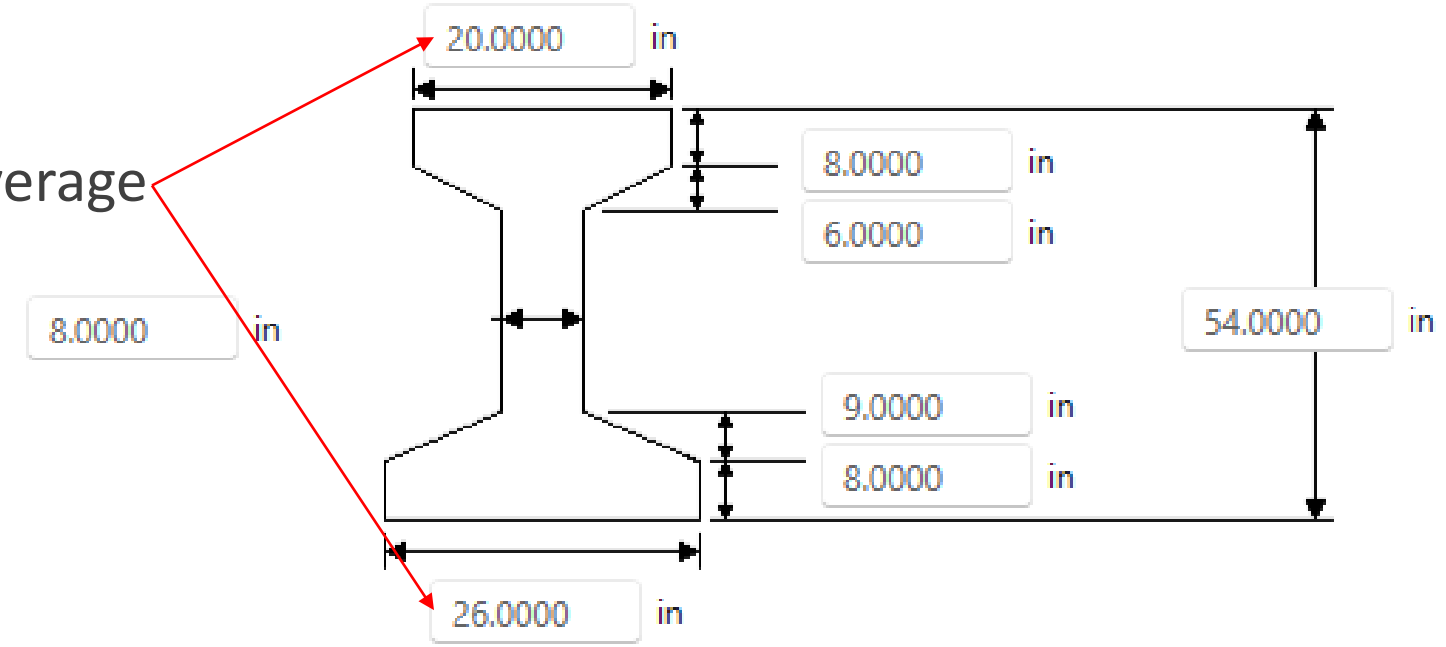


ITD BrR Testing Program

Major Difference Summary btwn 7.2 & 7.5.1

- **Ticket BSSD-3925** – Fix in 7.5.1 to use the correct compression flange width for f*su (36 bridges)

BrR 7.2 uses average



ITD BrR Testing Program

Major Difference Summary btwn 7.2 & 7.5.1

- **Ticket BSSD-1611** – Fix in 7.3 to correct depth ‘d’ to consider the centroid of the negative moment reinforcing (15 bridges)

BrR 7.2

```
INPUT:

f'c =       5.0000 (ksi)
d   =      43.4810 (in)
b'  =       8.0000 (in)
fpe =       0.4429 (ksi)
Md  =    -123.2600 (kip-ft)
I   =  679839.9406 (in^4)

where   d >= 0.8 * h
      Mmax = Mu - Md
        Vi = Simult. Vu - Vd

use d = 49.2000 (in)
```

BrR 7.5.1

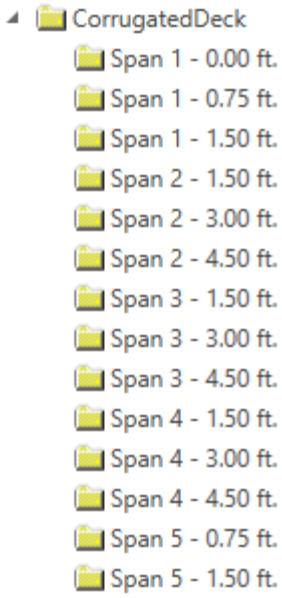
d (in)
49.20
57.60
57.60
57.60
57.60
57.60
57.60
57.60
49.20
57.60
57.60
57.60
49.20
57.60
57.60
57.60

ITD BrR Testing Program

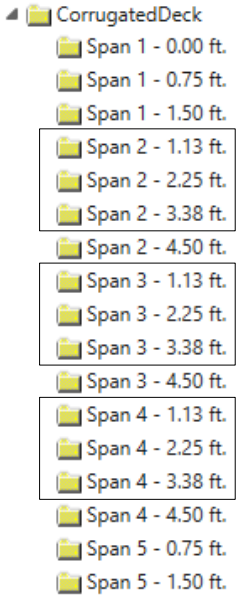
Major Difference Summary btwn 7.2 & 7.5.1

- **Ticket BSSD-4079 & BSSD-3518** – Fix in 7.3 for the corrugated deck analysis & change in 7.5 to add analysis point locations to the corrugated deck analysis (17 bridges)

BrR 7.2



BrR 7.5.1



ITD BrR Testing Program

Major Difference Summary btwn 7.2 & 7.5.1

- **Multi-cell Box Bridges** – Several tickets & enhancements affect these bridges along with previous version workarounds now creating loads that are inaccurate (46 bridges)

BrR 7.2

```
Strand Stress Calculations
------------------------------
Jacking Stress =   195.17 (ksi)
ES losses      =     4.55 (ksi)
Total losses   =    27.74 (ksi)
```

BrR 7.5.1

```
Strand Stress Calculations
------------------------------
Jacking Stress =   195.17 (ksi)
ES losses      =     4.55 (ksi)
FR losses      =     5.83 (ksi)
Total losses   =    33.57 (ksi)
```

ITD BrR Testing Program

Major Difference Summary btwn 7.2 & 7.5.1

- **Madero** Engine **vs AASHTO** Timber ASR Engine (discussed further in the following slides)

Analysis method type	Analysis module
ASR	Madero ASR

VS

Analysis method type	Analysis module
ASR	AASHTO Timber ASR

ITD BrR Testing Program

Timber Modifications

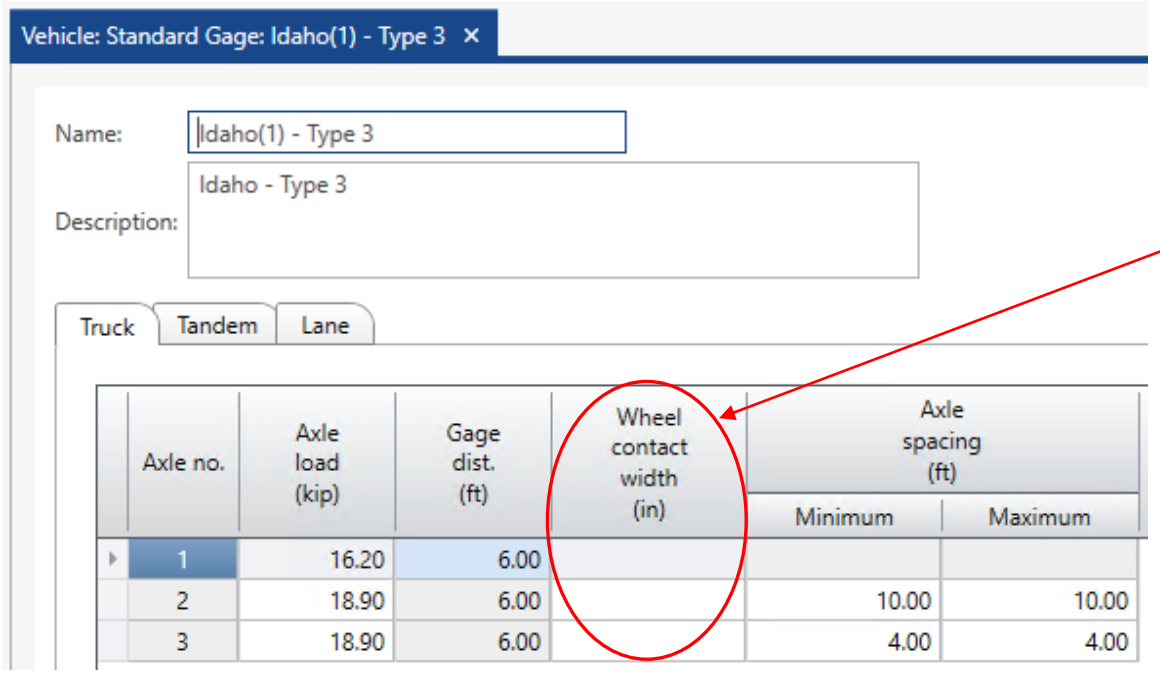
202 Timber/Timber Component Bridges

- Convert – Madero Engine to AASHTO Timber ASR Engine (202 bridges)

ITD BrR Testing Program

Timber Modifications Cont.

- Revise standard ITD truck templates (all bridges with a timber deck)

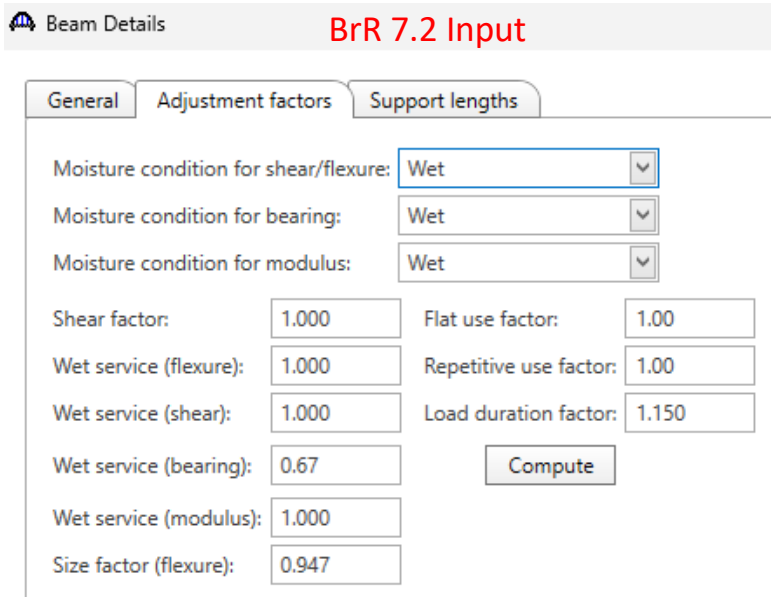


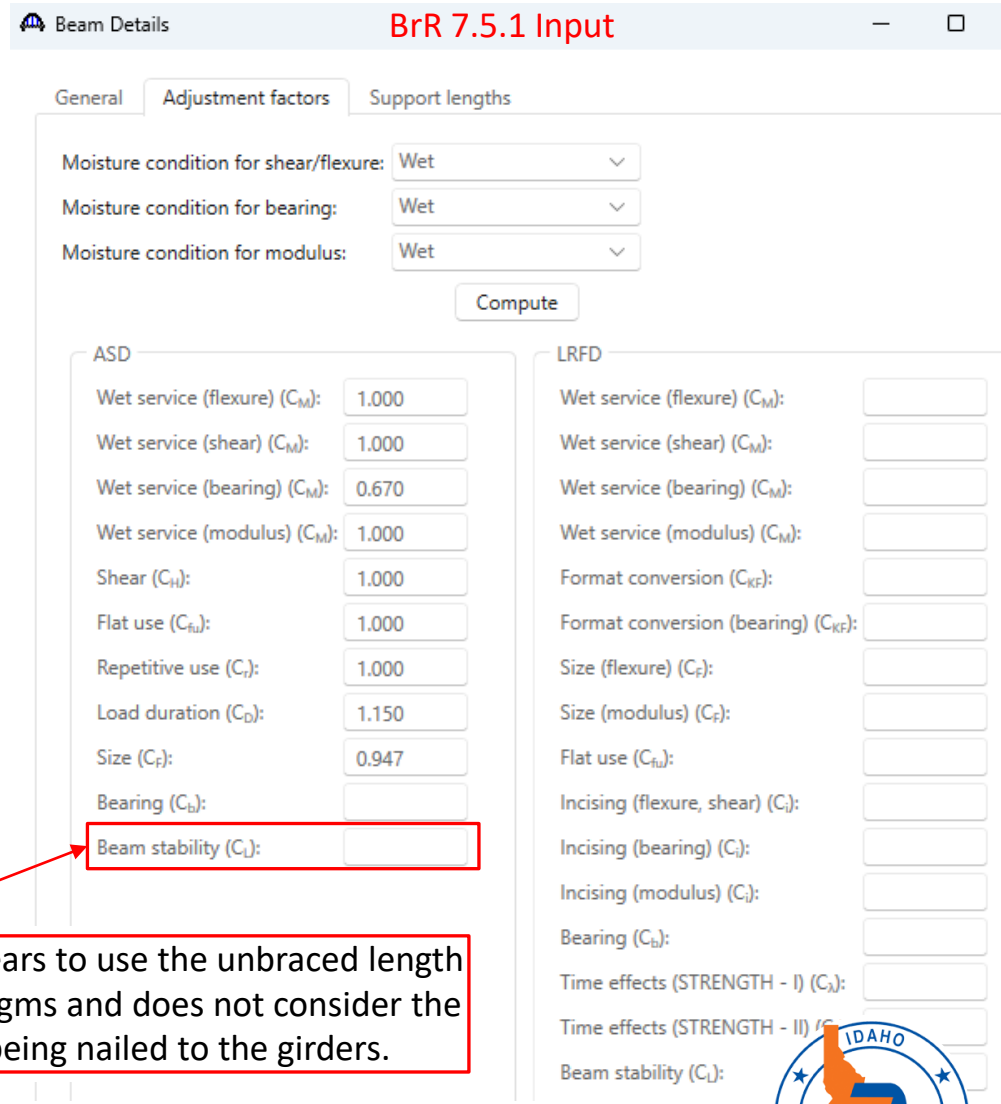
Will need to be entered in BrR 7.5.1

ITD BrR Testing Program

Timber Modifications Cont.

- Beam Stability Factor, C_L – Hard enter correct value in BrR 7.5.1 (121 bridges)



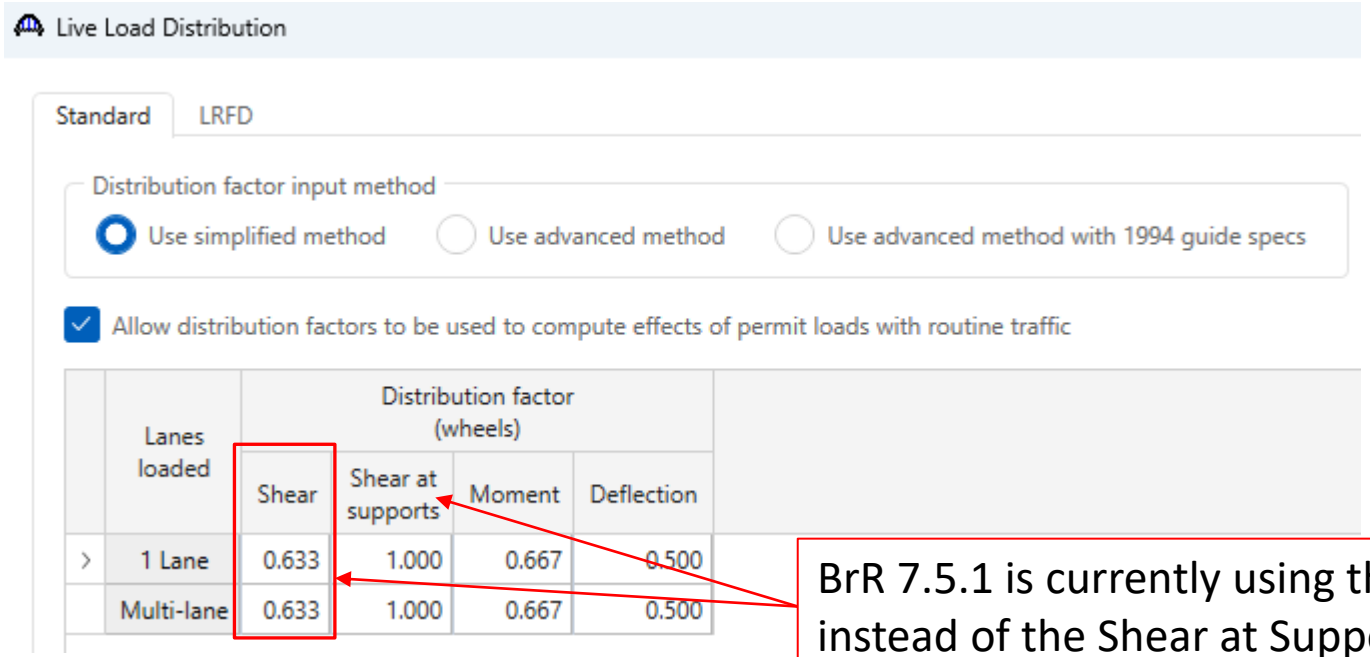


When left blank, 7.5.1 appears to use the unbraced length solely between the diaphragms and does not consider the bracing action of the deck being nailed to the girders.

ITD BrR Testing Program

Timber Modifications Cont.

- Ticket BSSD-4875 – Bearing calculations use the incorrect LLDF's in 7.5.1 (20 bridges)



BrR 7.5.1 is currently using the Shear LLDF's instead of the Shear at Supports

ITD BrR Testing Program

Timber Modifications Cont.

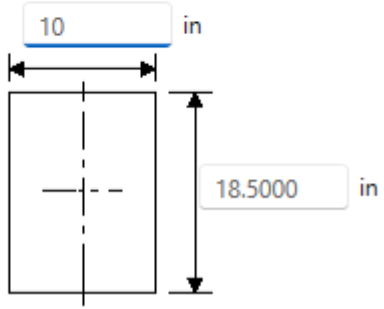
- Section Properties – BrR 7.2 recalculates, BrR 7.5.1 uses entered values (2 bridges)

Timber Shape - Rectangular

Name: 10in Solid Sawn

Description: Beam Section

Dimensions | Properties



BrR 7.2

Dimensions | Properties

Area:	210	in^2
Nominal load:	91.00	lb/ft
Moment of inertia:	7717.5	in^4
CG from bottom:	10.5000	in
Section modulus, top:	735.0	in^3
Section modulus, bottom:	735.0	in^3
Nominal width:	10.00	in
Nominal depth:	21.0000	in

Compute

Manually fix

BrR 7.5.1

Dimensions | Properties

Area:	185	in^2
Nominal load:	91.00	lb/ft
Moment of inertia:	5276.4	in^4
CG from bottom:	9.2500	in
Section modulus, top:	570.4	in^3
Section modulus, bottom:	570.4	in^3
Nominal width:	10.00	in
Nominal depth:	21.0000	in

Recompute

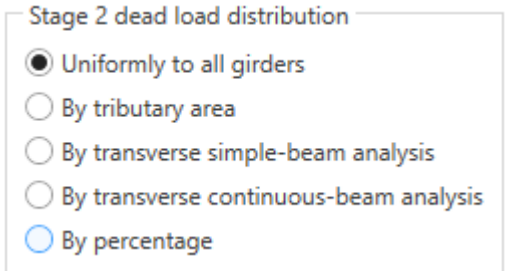
Compute

ITD BrR Testing Program

Timber Modifications Cont.

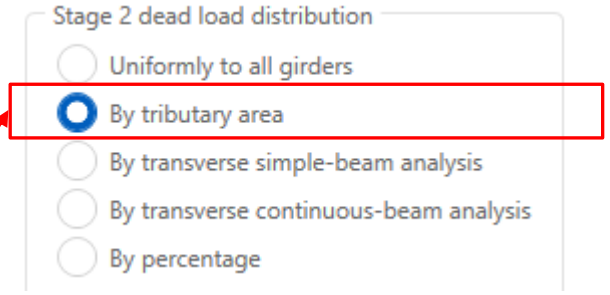
- Tributary Area – BrR 7.2 calcs automatically, BrR 7.5.1 uses selected method (6 bridges)

BrR 7.2



BrR 7.5.1

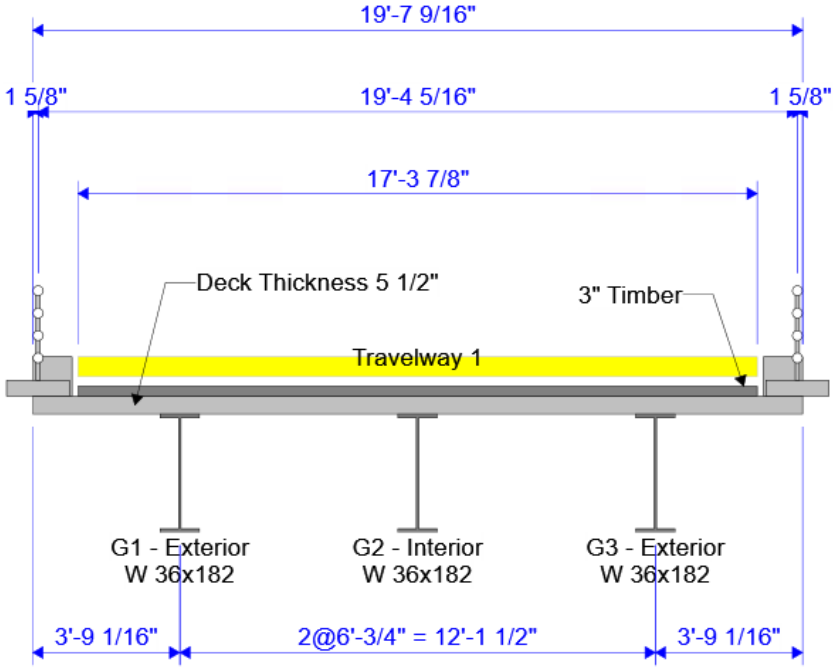
Has to be selected in order to analyze correctly



ITD BrR Testing Program

Timber Modifications Cont.

- Ticket BSSD-4111 – Pre-existing bug in the Madero Engine (1 bridge)

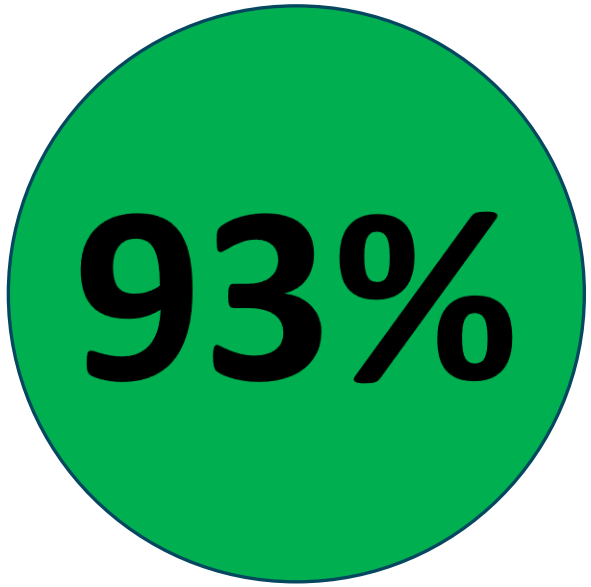


ITD BrR Testing Program

Timber Summary

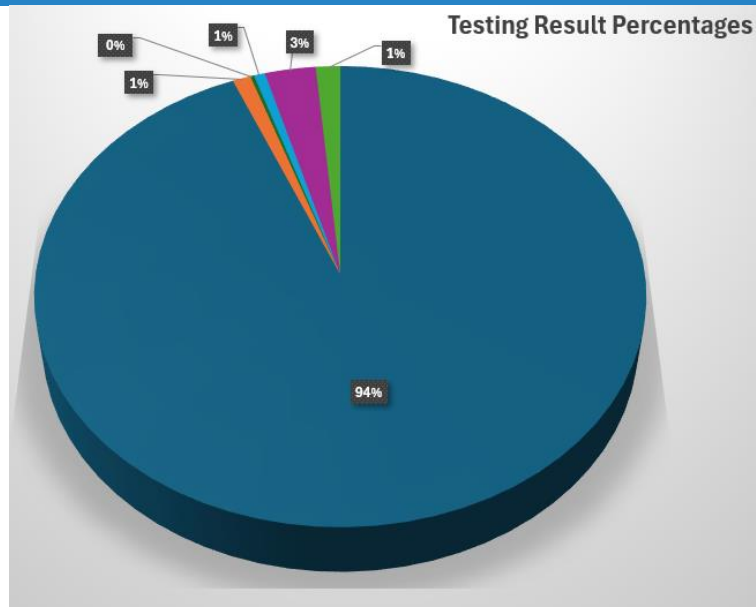
After Revisions or Future Bug Fixes:

- 187 Bridges Considered a Match
- 15 Bridges > 5% due to Madero vs AASHTO differences



ITD BrR Testing Program

Testing Results

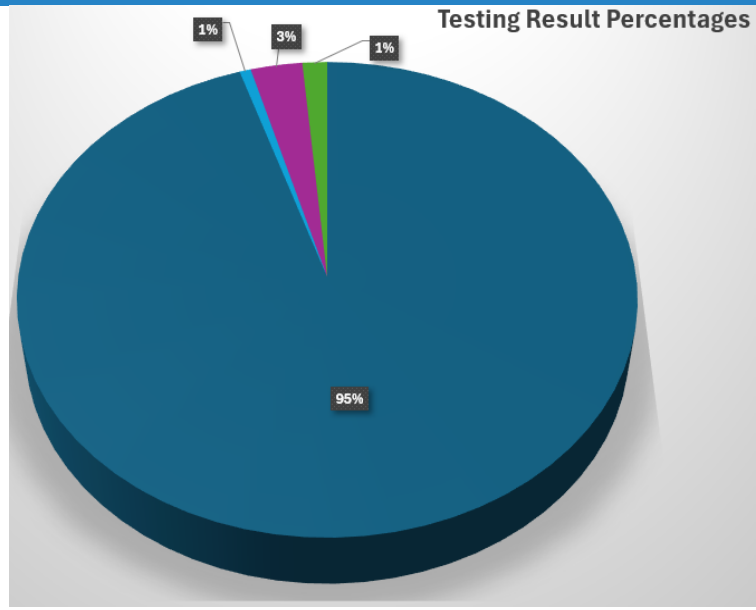


Tested 3,253 Bridges

- 3,049 – Results Matched (93.7%)
- 34 – Require Minor BrR 7.5.1 Modifications to Match (1.0%)
- 7 – Require ITD Modifications to Truck Template to Match (0.2%)
- 21 – Results are >5% due to current 7.5.1 Bugs (0.6%)
- 96 – Results are >5% due to Bug Fixes or Enhancements between 7.2 & 7.5.1 (3.0%)
- 46 – Multi-cell boxes are >5% due to various reasons (1.4%)

ITD BrR Testing Program

Testing Results Cont.



After Revisions:

- 3,090 – Considered a Match (95%)
- 21 – Results are >5% due to current 7.5.1 Bugs (0.6%)
- 96 – Results are >5% but now considered correct (3.0%)
- 46 – Multi-cell boxes will have varied results depending on corrections (1.4%)

ITD BrR Testing Program

Results of BrR 7.5.1 Testing

Thank you!
Contact Information & Questions

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