Michael Baker
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Hope Bridge Load Rating Evaluation

RADBUG Meeting – August 3, 2016

Presentation Highlights

- Complex Bridge Rating using BrR and Hand Calculations
- Parametric Study
  - Standard Vehicles
  - Non-Standard Vehicles
    - Mega-Load
    - Non-Standard Gage
- Convergence Analysis
- Permit Vehicle Rating Criteria

Location

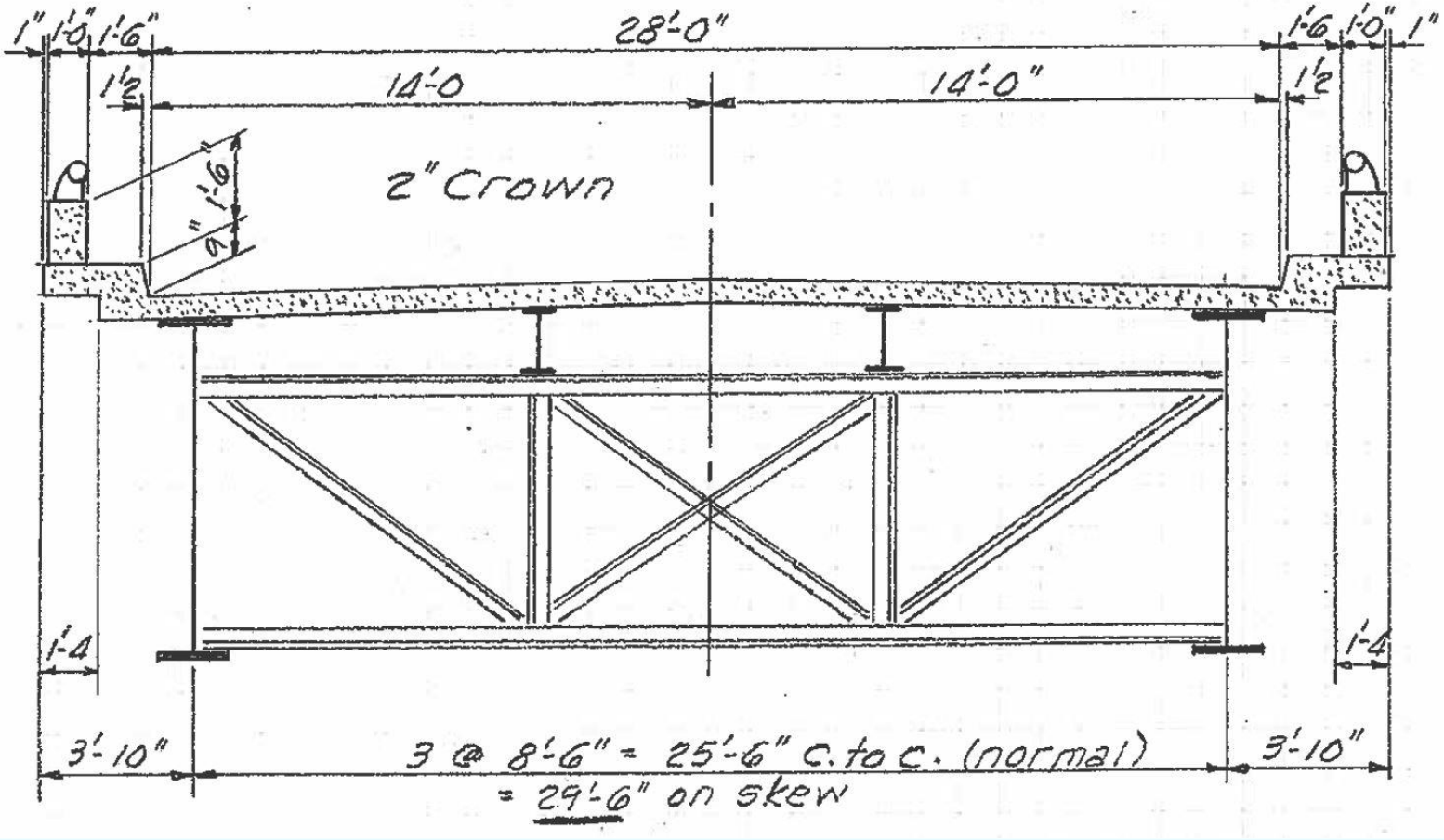

Vancouver
Hope Bridge
Washington
Montana
Oregon
Idaho
Wyoming
Google earth
© 2013 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Data LDEO-Columbia, NSF, NOAA

Location

Bridge Description

- 1,281′ Total Bridge Length
  - Horizontally Curved
- Steel Spans
  - 3 spans: 115′-184′-115′
  - Stringer-Truss Floor Beam System
  - Continuous Exterior Plate Girders
- Concrete Spans
  - 9 spans: 80′-100′-100′-100′-100′-100′-100′-100′-87′
  - Simply Supported Spans
  - Space Frame Bents (Cantilevered Girder Ends)

Bridge Description



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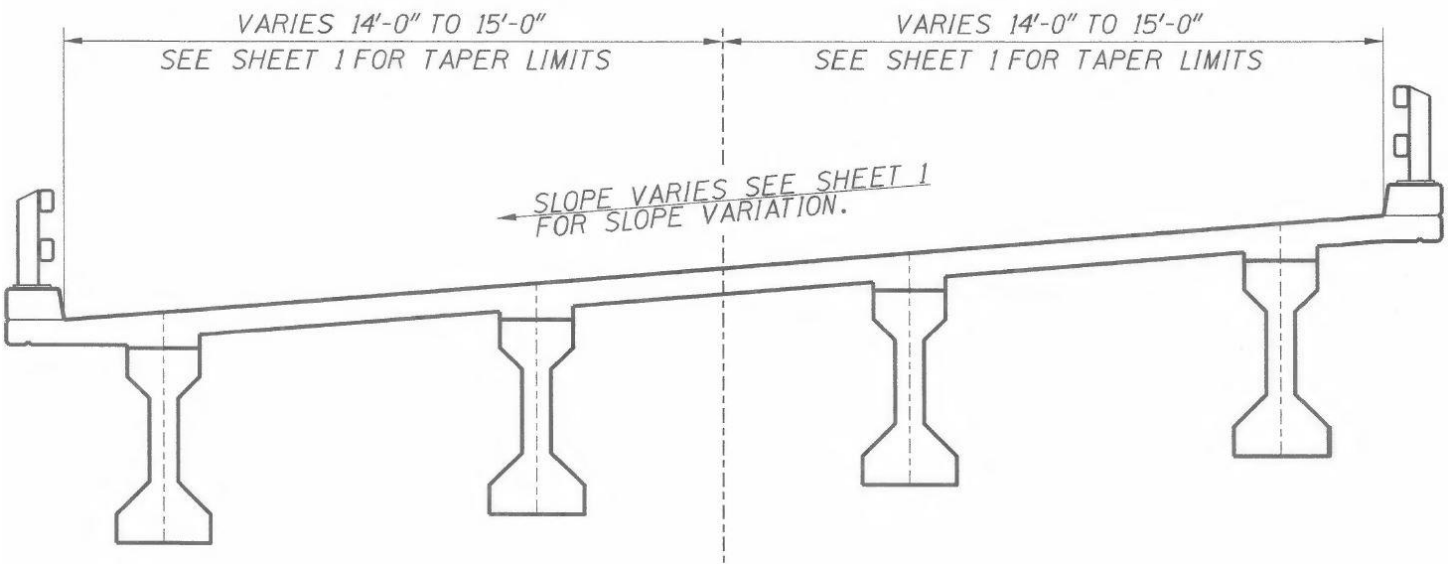

Bridge Description

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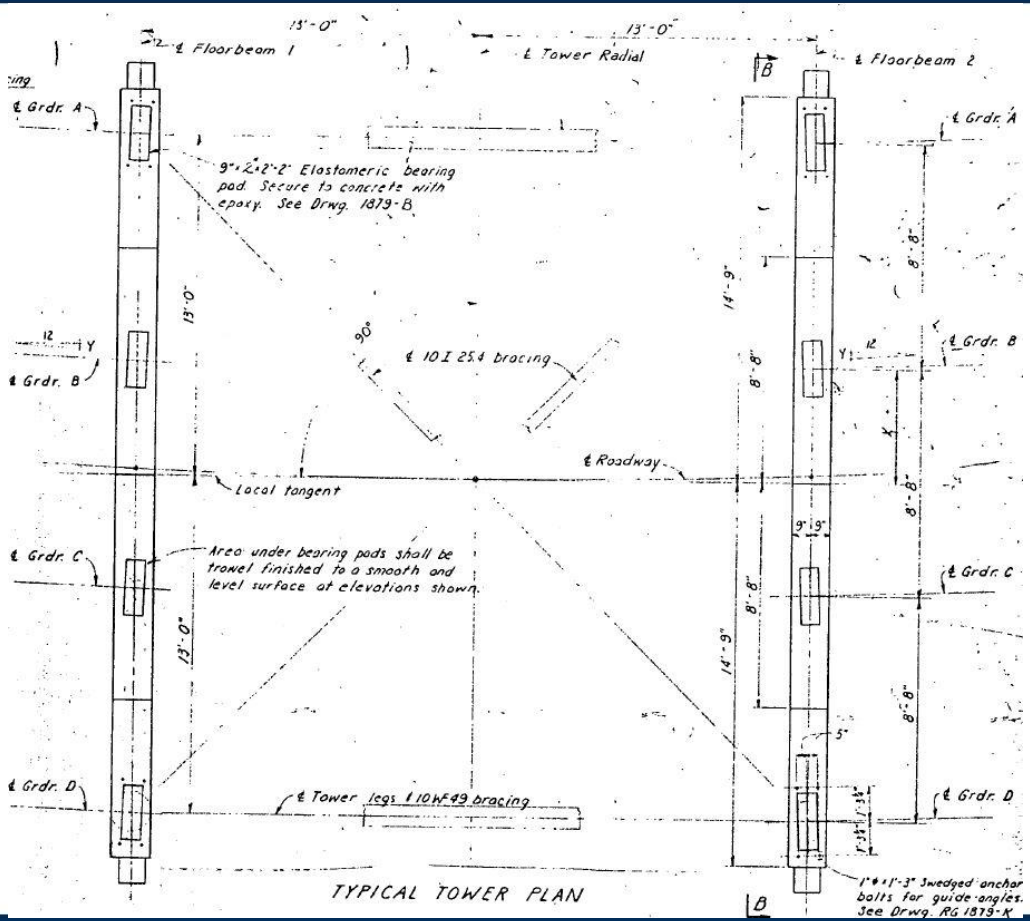
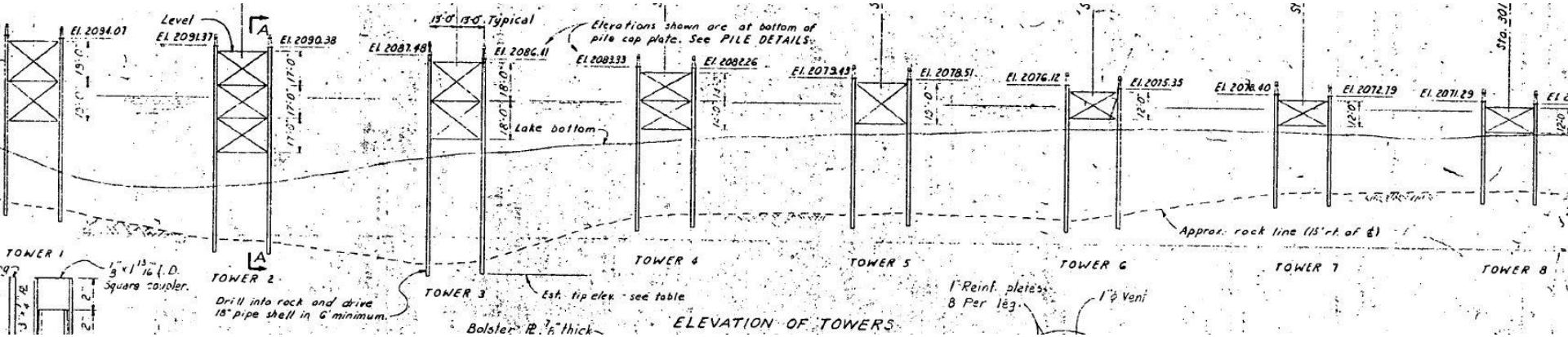
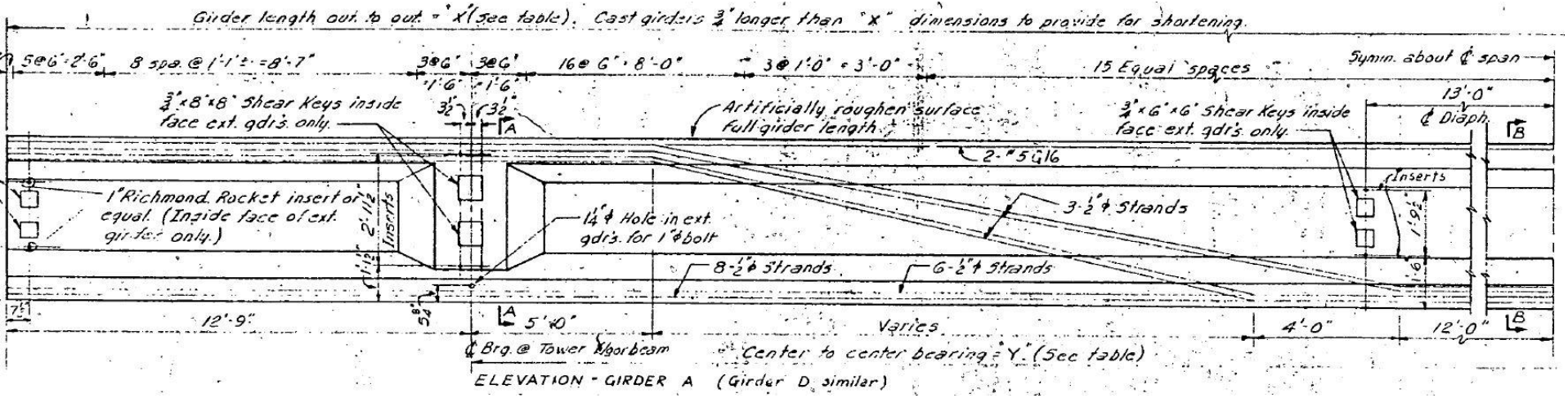


Bridge Description



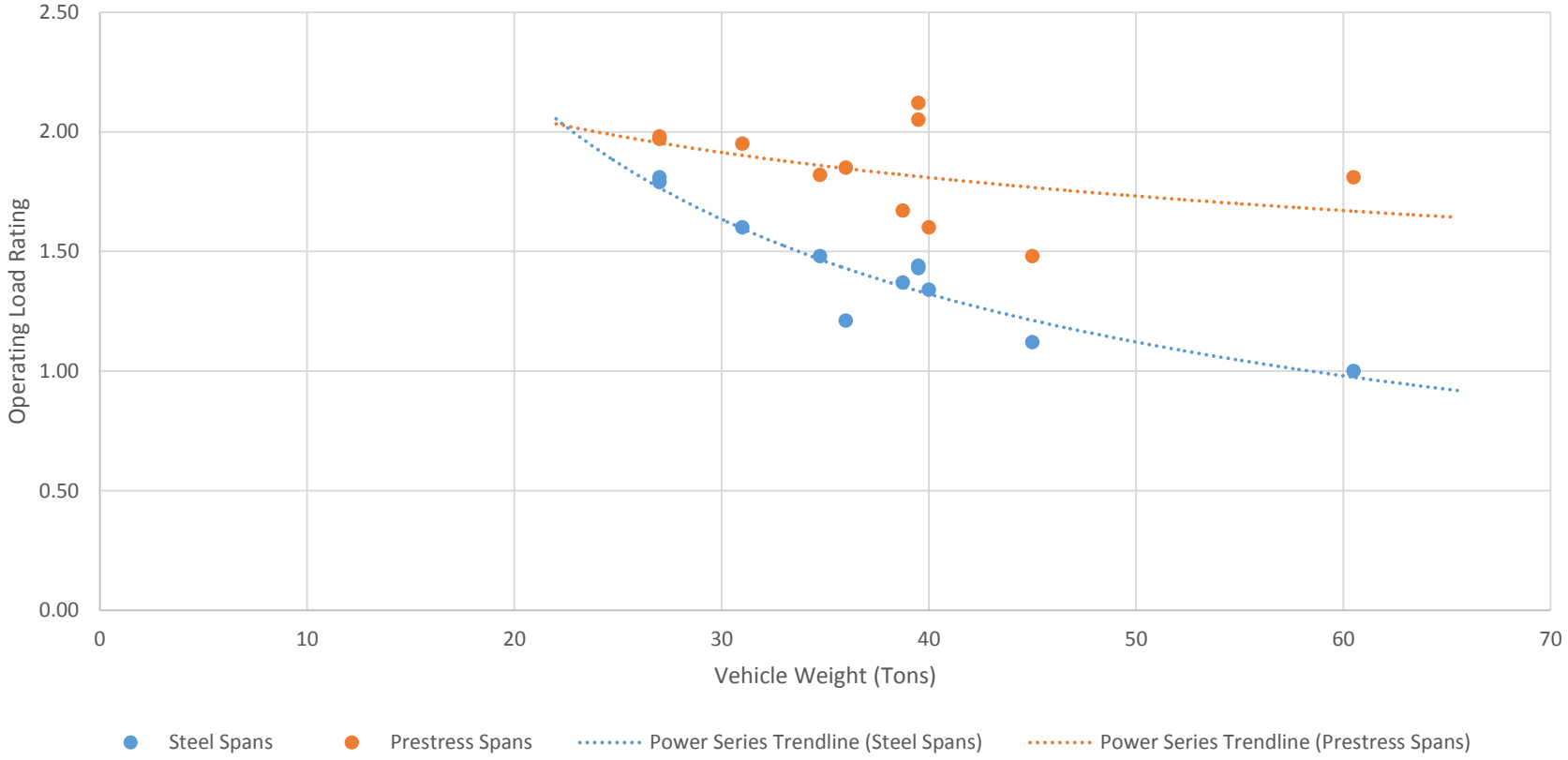
Bridge Description



Standard Vehicle Ratings

Rating Vehicle	Weight (Tons)	Operating Rating Factor		Difference in Rating Factor
		Prestress Concrete	Steel	
HS-25	45	1.48	1.12	0.36
HS-20	36	1.85	1.21	0.64
Idaho - Type 3	27	1.97	1.79	0.18
Idaho - Type 3S2	39.5	2.12	1.44	0.68
Idaho - Type 3-3	39.5	2.05	1.43	0.62
Idaho - 121k	60.5	1.81	1.00	0.81
NRL	40	1.60	1.34	0.26
SU4	27	1.98	1.81	0.17
SU5	31	1.95	1.60	0.35
SU6	34.8	1.82	1.48	0.34
SU7	38.8	1.67	1.37	0.30

Standard Vehicle Ratings



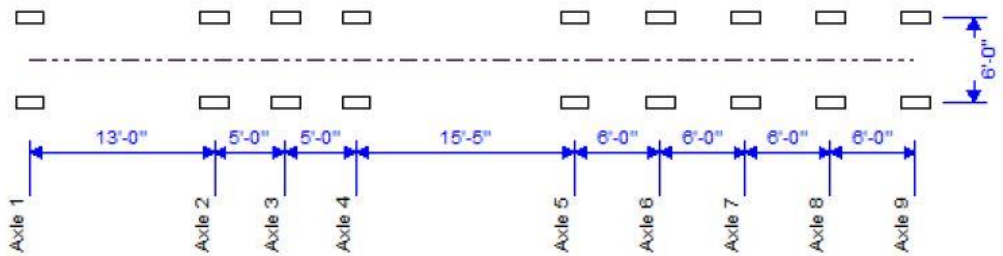
Non-Standard Vehicle Ratings

G N T George Neill Transportat - Unit 90
Vehicle Plan
04/19/12

Axle #	Weight (kips)	Gage Dist. (ft)	Axle Spacing (ft)
1	20.00	6	
2	24.00	6	17.42
3	24.00	6	5.00
4	24.00	6	14.00
5	24.00	6	5.00
6	24.75	6	36.92
7	24.75	6	5.00
8	24.75	6	13.75
9	24.75	6	5.00
Total	215		102.08

Non-Standard Vehicle Ratings

Idaho National Guard - Unit ATB902
Vehicle Plan
05/13/14

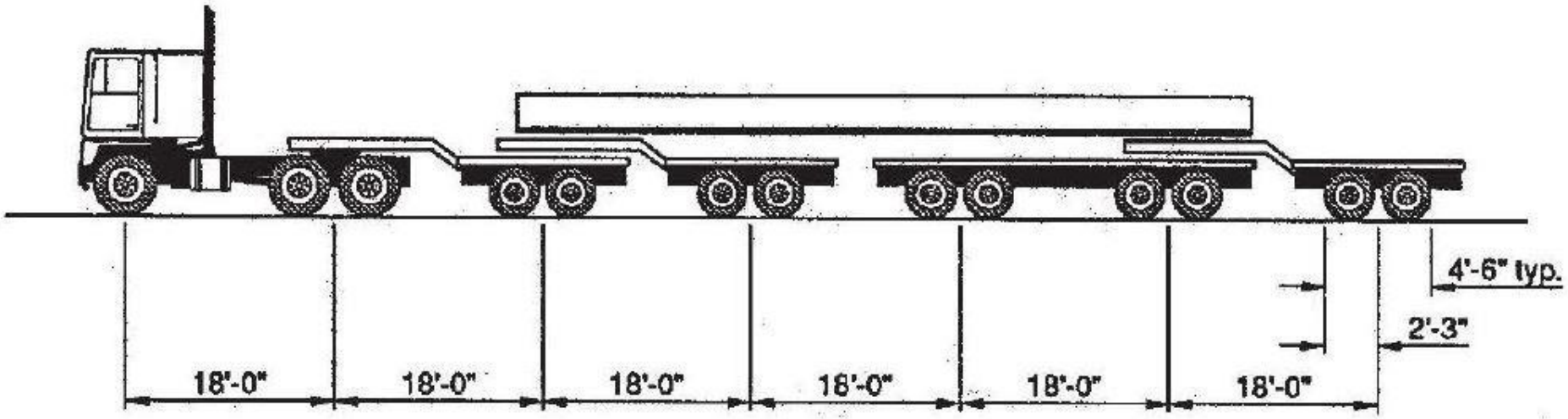


Axle #	Weight (kips)	Gage Dist. (ft)	Axle Spacing (ft)
1	21.12	6.00	
2	21.96	6.00	13.00
3	21.96	6.00	5.00
4	21.96	6.00	5.00
5	36.00	6.00	15.42
6	36.00	6.00	6.00
7	36.00	6.00	6.00
8	36.00	6.00	6.00
9	36.00	6.00	6.00
Total	267		62.42

Non-Standard Vehicle Ratings

Axle #	Weight (kips)	Gage Dist. (ft)	Axle Spacing (ft)
1	11.89	6	
2	5	6	10.33
3	17.52	6	6.75
4	17.52	6	4.50
5	17.52	6	4.50
6	25.66	6	14.08
7	25.66	6	4.50
8	25.66	6	14.08
9	25.66	6	4.50
10	25.66	6	60.00
11	25.66	6	4.50
12	25.66	6	13.83
13	25.66	6	4.50
14	25.66	6	13.83
15	25.66	6	4.50
16	14.64	6	15.75
17	20.68	6	18.08
18	20.68	6	4.50
Total	382.05		202.7498

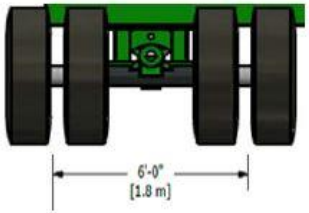
Non-Standard Vehicle Ratings



P13	26K	48K	48K	48K	48K	48K	48K	Max. Veh.

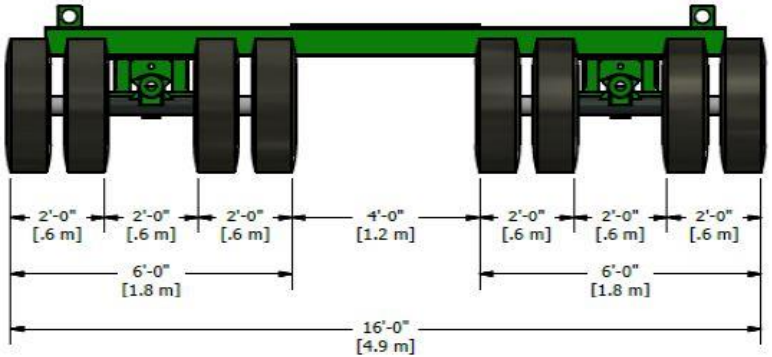
Non-Standard Vehicle Ratings

S = Standard Gage Configuration

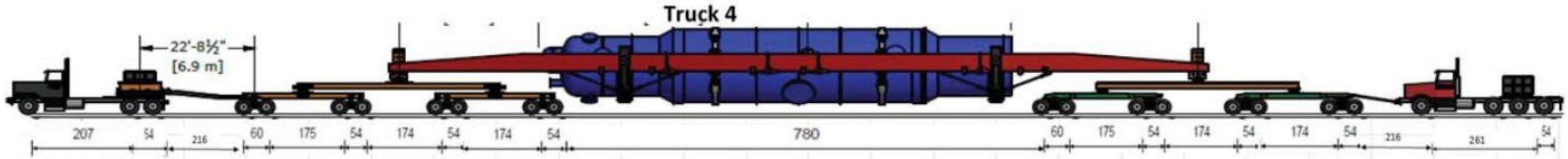


Drive axle shown.
Steer axle has only two tires. Distance between the center of those two tires is 6 ft.

T = Trailer Cross Section (16 ft wide)



Non-Standard Vehicle Ratings



Axle Spacing (in)		207		54		216	60	175	54	174	54	174	54	780	60	175	54	174	54	174	54	216	261	54	
Axle No.	1	2	3	4	5		6	7	8	9	10	11		12	13	14	15	16	17	18	19	20	21	22	23
Axle Wt. (kips)	16	20	20	50	50		50	50	50	50	50	50		50	50	50	50	50	50	50	50	16	20	20	20
Axle Configuration	S	S	S	T	T		T	T	T	T	T	T		T	T	T	T	T	T	T	T	S	S	S	S

S = Standard Gage

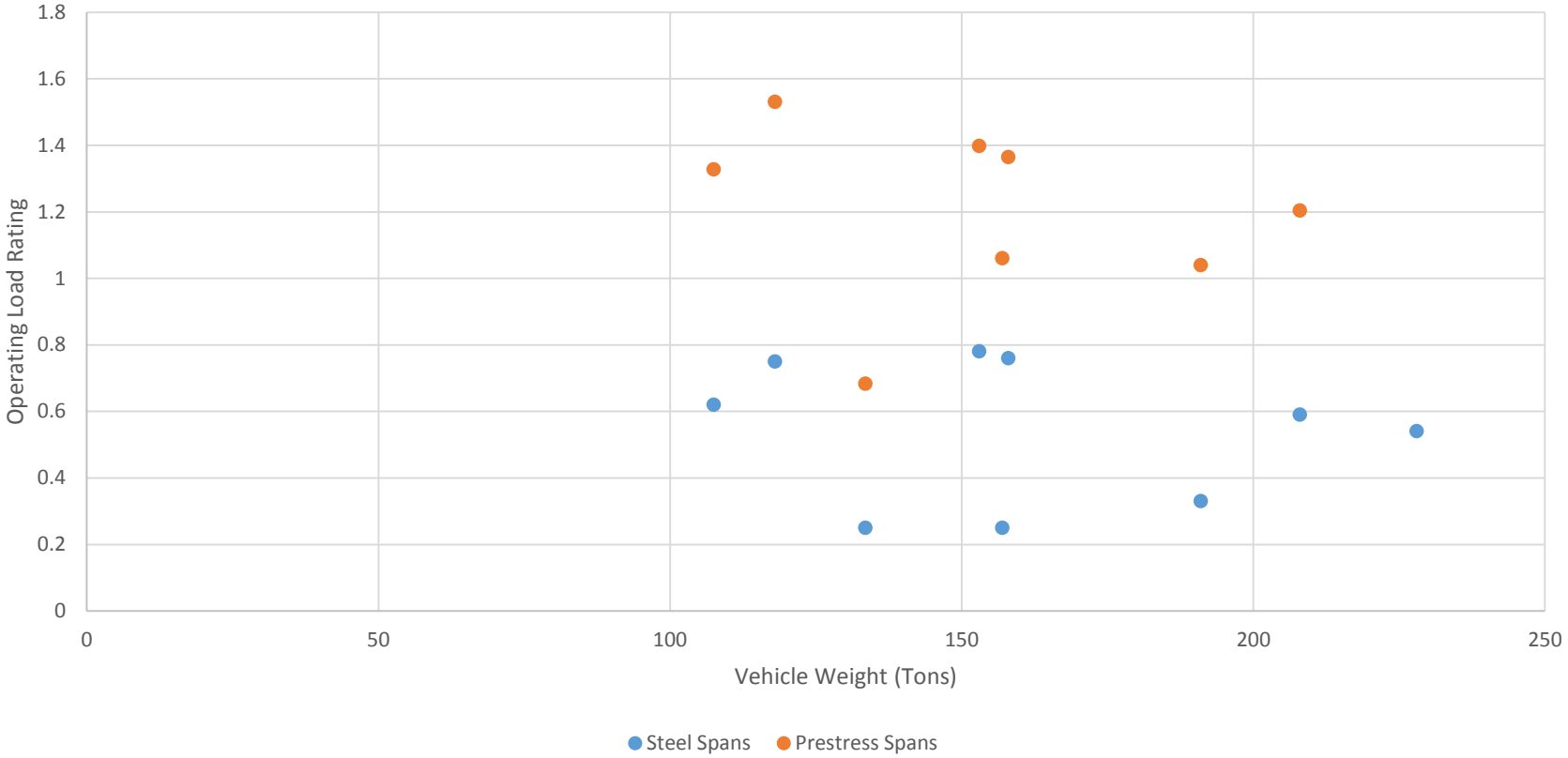
T = Trailer Cross Section (16 ft wide)

Total Wt. (kips)	932

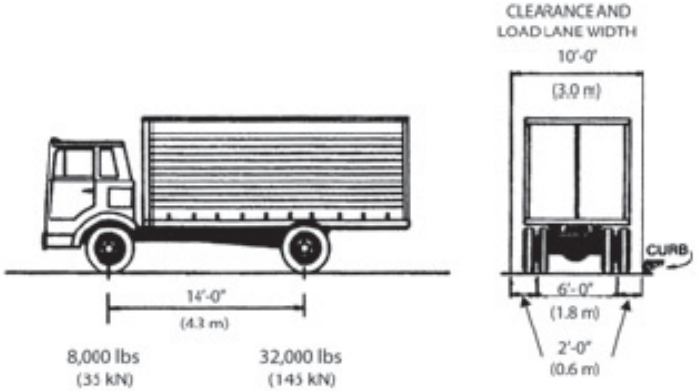
Non-Standard Vehicle Ratings

Rating Vehicle	Weight (Tons)	Operating Rating Factor		Difference in Rating Factor
		Prestress Concrete	Steel	
GNT - Unit 90	107.5	1.33	0.62	0.71
ID National Guard - Unit ATB902	133.5	0.68	0.25	0.43
Action Specialized - Unit 18B-SG	191	1.04	0.33	0.71
California P-13	157	1.06	0.25	0.81
Mega-Load Truck 1	118	1.53	0.75	0.78
Mega-Load Truck 2	158	1.36	0.76	0.60
Mega-Load Truck 3	208	1.20	0.59	0.61
Mega-Load Truck 4	228	1.08	0.54	0.54
Mega-Load Truck 5	153	1.40	0.78	0.62

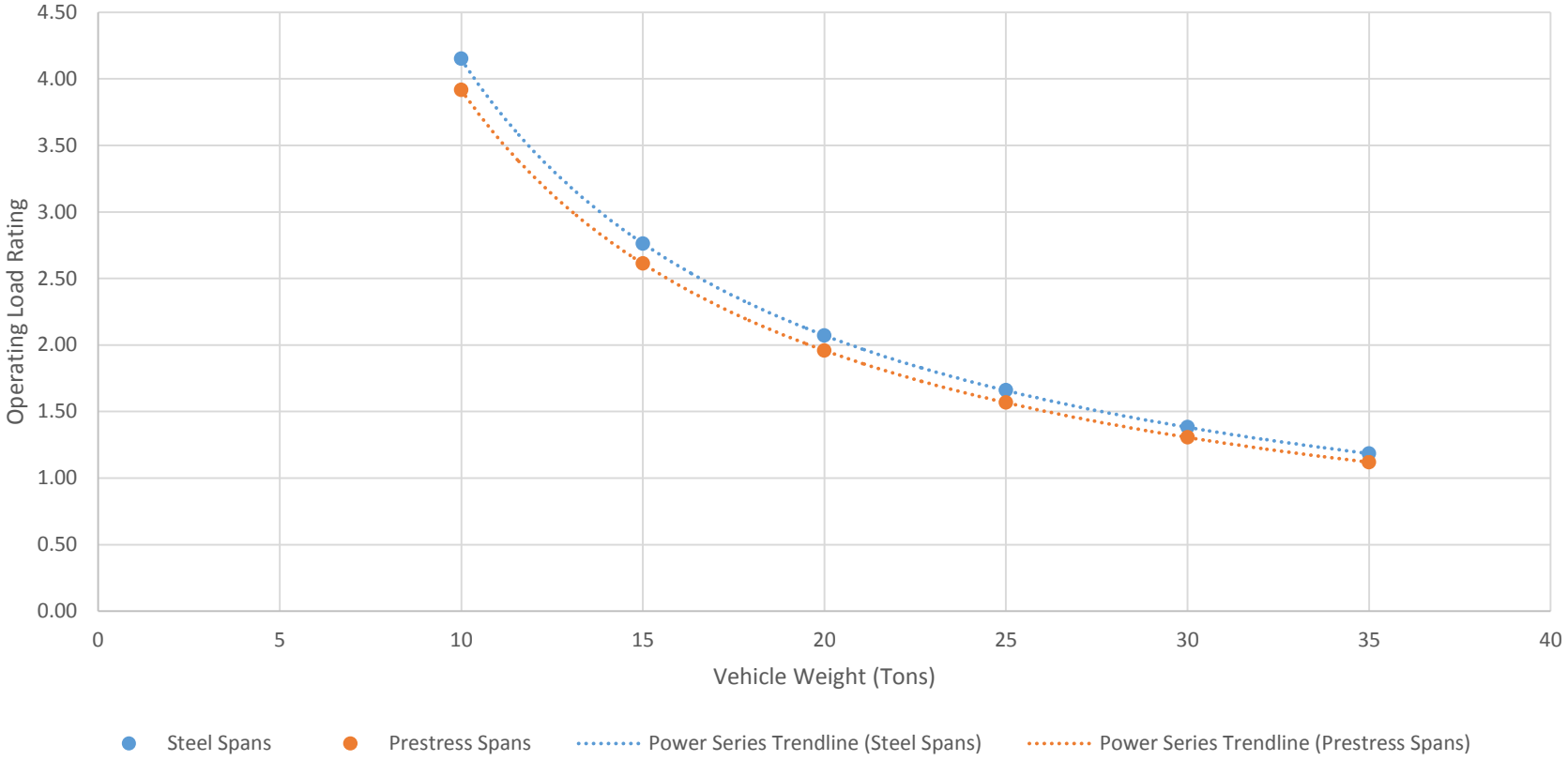
Non-Standard Vehicle Ratings



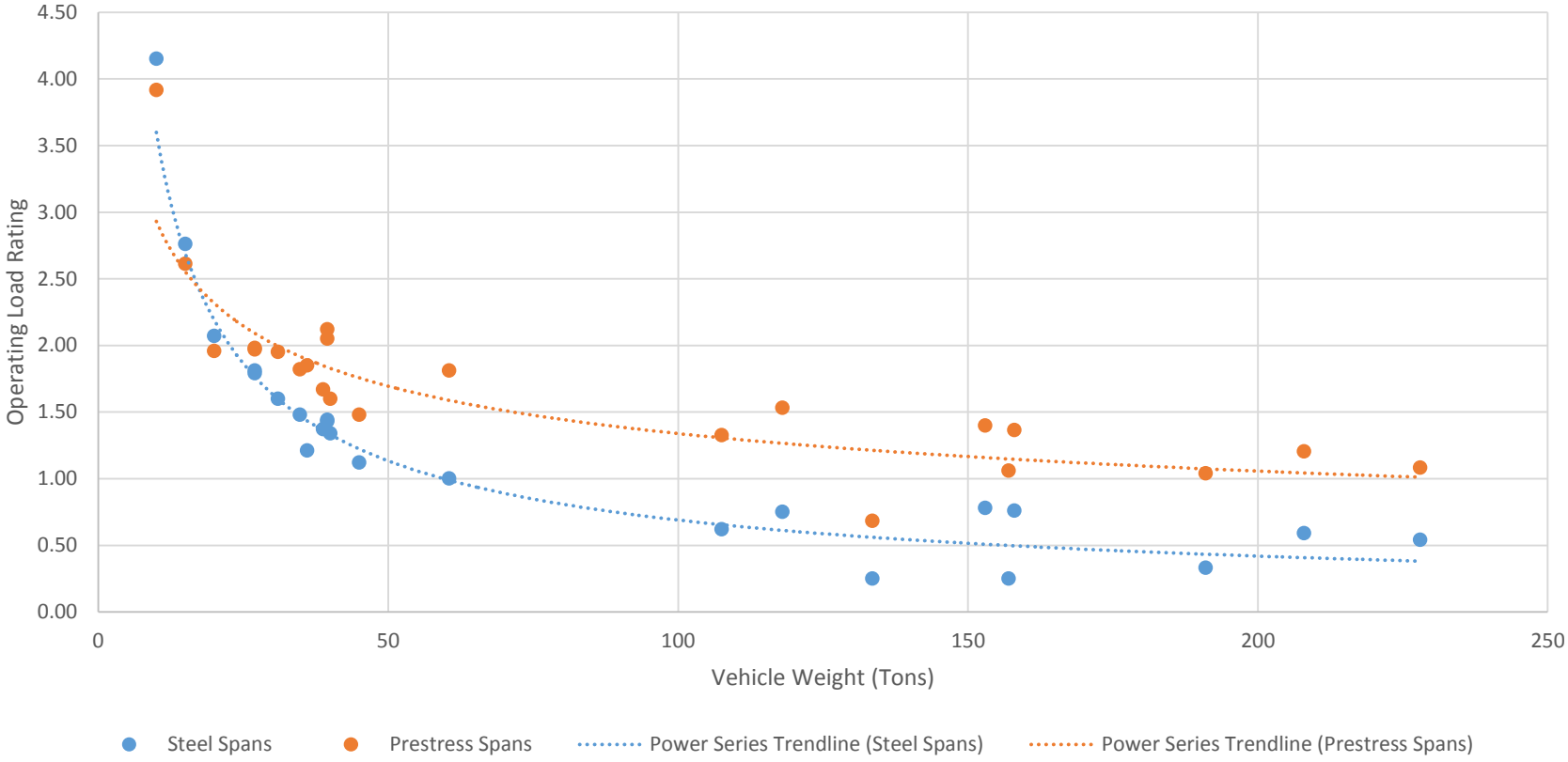
Convergence Analysis



Convergence Analysis



Summary


4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Operating Load Rating
0
50
100
150
200
250
Vehicle Weight (Tons)
Steel Spans
Prestress Spans
Power Series Trendline (Steel Spans)
Power Series Trendline (Prestress Spans)

Summary

Rating Vehicle	Weight (Tons)	Material[1]	Controlling Location	Controlling Limit State	Rating Factor
H-10	10	Prestress Concrete	12.15	Ultimate Strength Moment	3.92
H-15	15	Prestress Concrete	12.15	Ultimate Strength Moment	2.61
H-20	20	Prestress Concrete	12.15	Ultimate Strength Moment	1.96
Idaho - Type 3	27	Steel	1.0	Ultimate Strength Shear	1.79
SU4	27	Steel	1.0	Ultimate Strength Shear	1.81
SU5	31	Steel	1.0	Ultimate Strength Shear	1.60
SU6	34.8	Steel	1.0	Ultimate Strength Shear	1.48
HS-20	36	Steel	1.75	Flexural - Steel Strength	1.21
SU7	38.8	Steel	1.0	Ultimate Strength Shear	1.37
Idaho - Type 3S2	39.5	Steel	1.75	Flexural - Steel Strength	1.44
Idaho - Type 3-3	39.5	Steel	1.75	Flexural - Steel Strength	1.43
NRL	40	Steel	1.0	Ultimate Strength Shear	1.34
HS-25	45	Steel	1.0	Ultimate Strength Shear	1.12
Idaho - 121k	60.5	Steel	1.75	Flexural - Steel Strength	1.00
GNT - Unit 90	107.5	Steel	1.75	Flexural - Steel Strength	0.62
Mega-Load Truck 1	118	Steel	1.75	Flexural - Steel Strength	0.75
ID National Guard - Unit ATB902	133.5	Steel	1.75	Flexural - Steel Strength	0.25
Mega-Load Truck 5	153	Steel	1.75	Flexural - Steel Strength	0.78
California P-13	157	Steel	1.75	Flexural - Steel Strength	0.25
Mega-Load Truck 2	158	Steel	1.75	Flexural - Steel Strength	0.76
Action Specialized - Unit 18B-SG	191	Steel	1.75	Flexural - Steel Strength	0.33
Mega-Load Truck 3	208	Steel	1.75	Flexural - Steel Strength	0.59
Mega-Load Truck 4	228	Steel	1.75	Flexural - Steel Strength	0.54

Summary

Rating Vehicle	Vehicle Length (ft)	Weight (Tons)	Material	Controlling Limit State	Rating Factor
H-10	14	10	Prestress Concrete	Ultimate Strength Moment	3.92
H-15	14	15	Prestress Concrete	Ultimate Strength Moment	2.61
H-20	14	20	Prestress Concrete	Ultimate Strength Moment	1.96
Idaho - Type 3	14	27	Steel	Ultimate Strength Shear	1.79
SU4	18	27	Steel	Ultimate Strength Shear	1.81
SU5	22	31	Steel	Ultimate Strength Shear	1.60
SU6	26	34.8	Steel	Ultimate Strength Shear	1.48
SU7	30	38.8	Steel	Ultimate Strength Shear	1.37
NRL	30 to 38	40	Steel	Ultimate Strength Shear	1.34
HS-20	28 to 44	36	Steel	Flexural - Steel Strength	1.21
HS-25	28 to 44	45	Steel	Ultimate Strength Shear	1.12
Idaho - Type 3S2	43	39.5	Steel	Flexural - Steel Strength	1.44
Idaho - Type 3-3	43	39.5	Steel	Flexural - Steel Strength	1.43
ID National Guard - Unit ATB902	62.4	133.5	Steel	Flexural - Steel Strength	0.25
Idaho - 121k	79.5	60.5	Steel	Flexural - Steel Strength	1.00
GNT - Unit 90	102.1	107.5	Steel	Flexural - Steel Strength	0.62
California P-13	109.1	157	Steel	Flexural - Steel Strength	0.25
Mega-Load Truck 1	178.5	118	Steel	Flexural - Steel Strength	0.75
Action Specialized - Unit 18B-SG	202.8	191	Steel	Flexural - Steel Strength	0.33
Mega-Load Truck 2	232.3	158	Steel	Flexural - Steel Strength	0.76
Mega-Load Truck 5	239.6	153	Steel	Flexural - Steel Strength	0.78
Mega-Load Truck 3	273.2	208	Steel	Flexural - Steel Strength	0.59
Mega-Load Truck 4	273.2	228	Steel	Flexural - Steel Strength	0.54

Load Rating Criteria Recommendations

- Prestress concrete spans control for…
  - Vehicles lighter than 25 tons
  - Vehicles shorter than 14 feet
- Steel girder spans control for…
  - Standard load rating vehicles (Design and Legal)
  - Special crossing permit vehicles
  - Vehicle heavier than 25 tons
  - Vehicle longer than 14 feet

Since the prestress concrete spans never control any significant load rating vehicle...

Hand calculations of the prestress concrete spans are not necessary and BrR can be used to analyze only the steel spans for typical ratings.

- BrR Tools to Remember
  - Complex bridges can be broken down into analysis components – sometimes BrR will be sufficient
  - Non-standard vehicle definitions can be approximated so that line-girder analyses can be used
  - Knowing the function and limitations (and enhancements) allow for work-arounds
  - Provide an analysis narrative when rating is not a simple "plug and chug"

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Questions

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