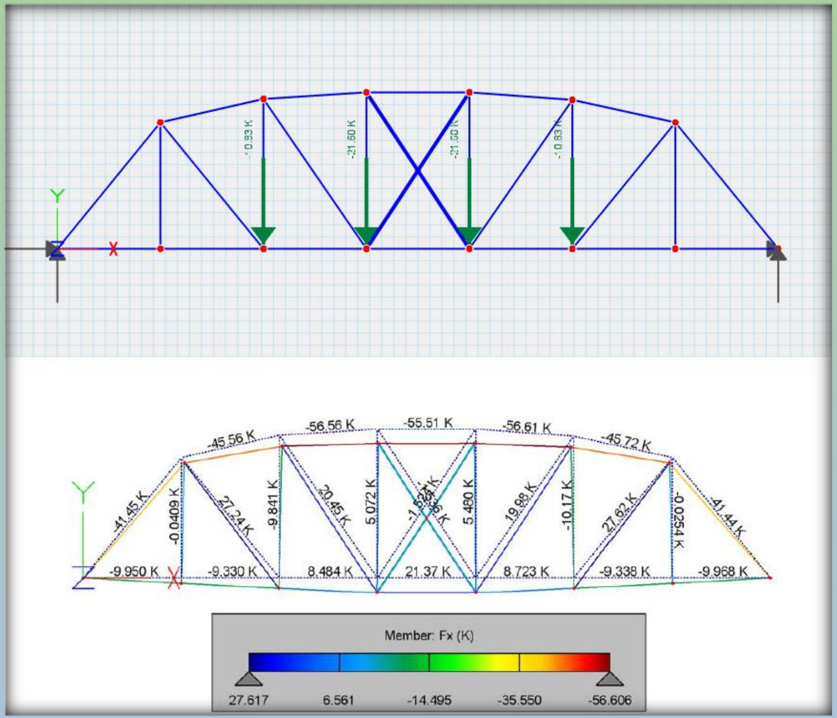
Montana DOT Overload movements.



Dave Warner, P.E.
Structural Engineer.
MDT- Bridge Bureau.
October 2017, Billings MT.

My Background

- Honorable discharge, US Air Force, spring 2001.
- Intern Federal Highway Administration 2003-2005.
- Bachelors Civil Engineering Carroll College earned 2005.
- Started MT-DOT Bridge Bureau January 2006.
- PE exam passed while designing seismic resistant bridges. (7yrs design exp.)
- AASHTO Bridgeware Secretary until 6-year term limit reached (Three) two-year terms. I still participate in developing many software(s).
- MT Rep. to LTBP (Long Term Bridge Performance Prog.) for FHWA currently.
- Oversize Overweight, (OSOW) permit engineer for MT-DOT, 2012 to present. →

Following slides:

- Vehicle weight analysis.
  - EPART website. Vehicle/Routine type.
- 32 J, single trip permits based on bending, ignore shear.
- When shear distress can't be ignored.
- Continuous span bending and vehicle distribution.
- Live Load factor accuracy.
- Simple Span quick check.
- Number of beams.
- Quick way using Design Live loads
- Prestressed beams
- Trunnion axles
- Load Width
- 10mph now, 5mph old.
- AASHTOWare, Impact Factor, zero.
- Travelway distribution factors
- Fundamental number of beams.
- Bending stress.
- More software involved.
- Where is this headed. →

Methods – Vehicle weight analysis.

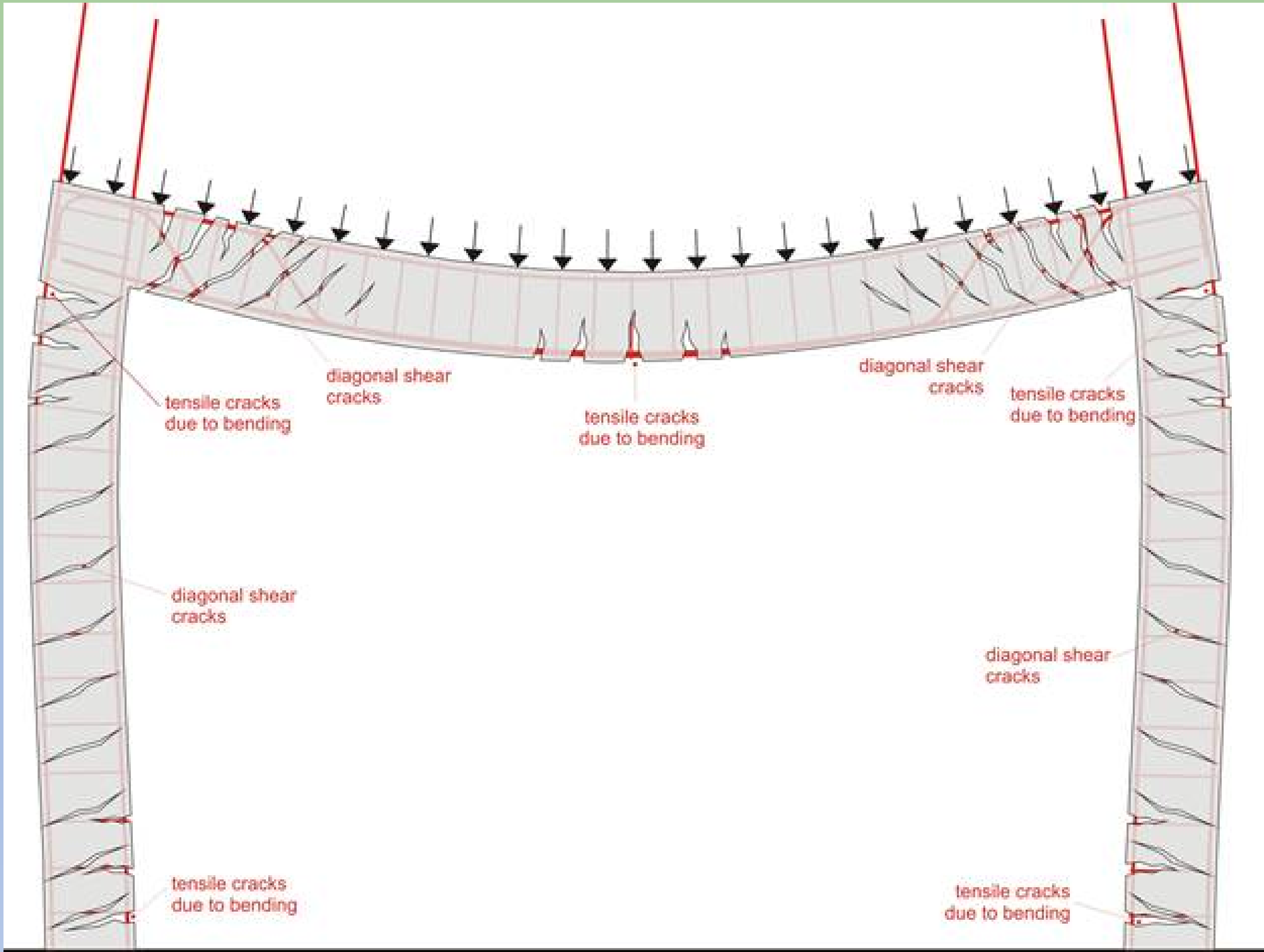
- Montana permitting methods established before my boss started at MT-DOT.
  - When my boss trained me he'd been at the state 34 years, and I was 33 years old. Lot's of knowledge transfer occurred.
- In Montana we have software which grants annual (routine) permits based on bending on a 45 foot simple span.
  - Concrete T beam bridges commonly built at that time.
    - Involves old Inventory and operating steel design stresses.
  - Total Vehicle Weight (TVW) limits protect old, long bridges.
    - 175k Non-Interstate. 250k Interstate.
  - Weights exceed Federal bridge formula at Montana's discretion.
- The new EPart system has the Vehicle Weight Analysis(VWA) integrated.
  - This greatly helps haulers to self issue routine permits from our website in minutes.
  - Written to EPart a few weeks after my boss handed me the permit job and retired.
  - VWA come to me when outside several parameters, TVW, axle spacing, Trunnions.
- When weights exceed a Vehicle Weight Analysis, then a 32J, or single trip permit is needed. →

Single Trip permits – 32J.

- Consistency is key.
  - If Montana changed methods of VWA or 32J permits customers would face negative impacts.
    - If permitting included shear calculations - fewer permits would be issued.
- I’ve spoken to many other DOT permit sections and Montana isn’t common with our method but also not entirely alone in ignoring shear. We use bending mostly for permits and postings.
  - Note: We consider shear! More on this later.
- For in service bridges in good condition showing no shear distress.
  - Bending only considered.
  - This speeds up permit work by 5-10 times. (estimated).
- Basically bending should control before shear in a well designed and good condition structure. →

Shear distress.

- Shear distress:
- Sagging, crushing, warping, shear cracking, torsional bending, distortion. Montana ignores shear for permitting and load posting when bridges show no shear distress, generally. Software for in service bridges often has toggles to ignore shear. If Bridge owners couldn't ignore shear based on good engineering judgement many Interstate bridges would be load posted based on shear equations.
- Design of new bridges includes shear, but older in service bridges in good condition may not pass newer shear calculations, therefore shear often ignored by bridge owners.
- One design I consulted on had only one failure of shear at the 1/3 point of the concrete beam. I've inspected bridges and seen lots of shear photos and the first shear cracks could not appear at 1/3pt. before beam ends. Size of cracks in picture at right shows where cracks should appear first. →

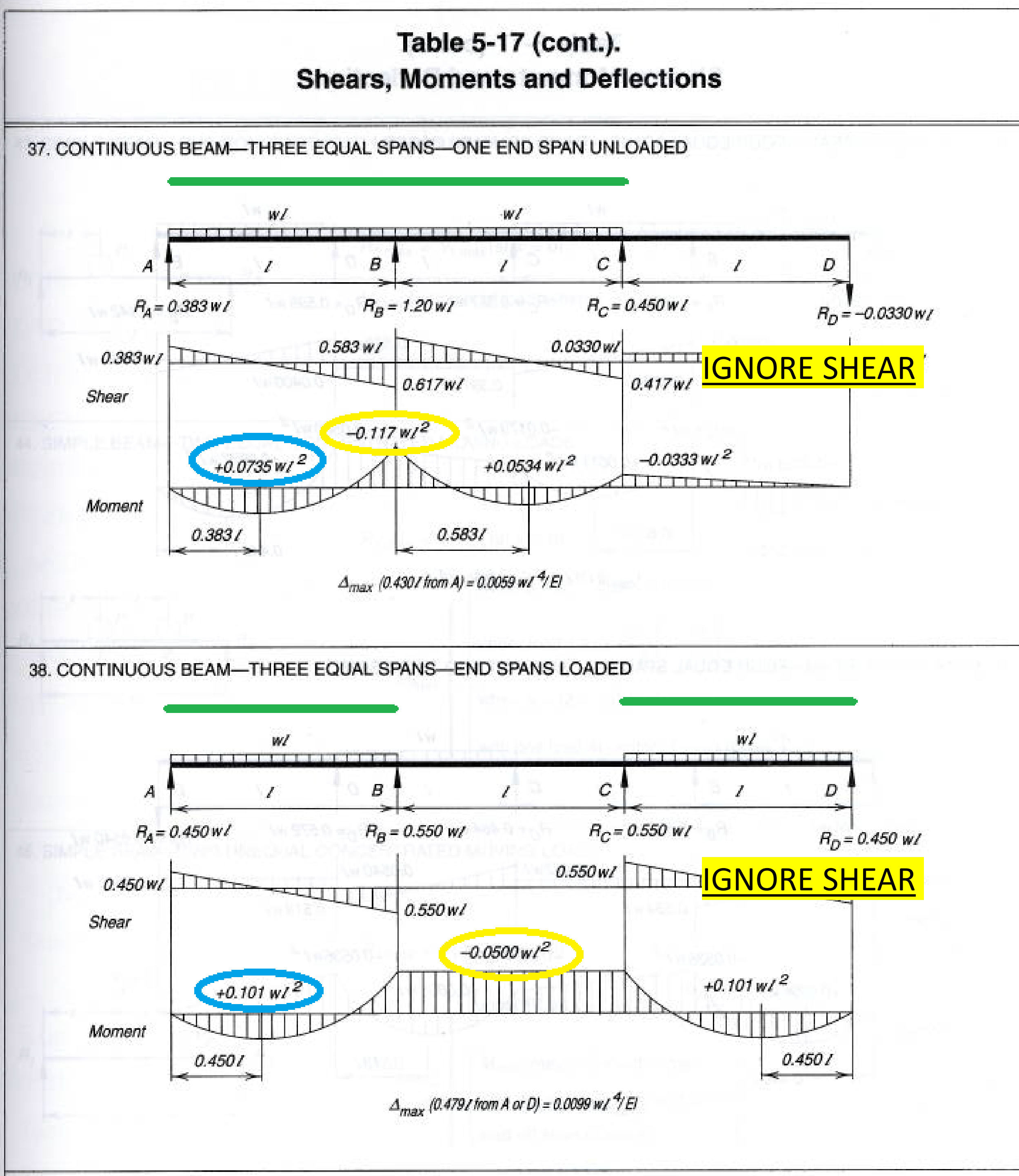


Until beams start showing cracking, shear is ignored for load posting and permitting.

Generally cracking causes load shedding and sagging will be visible right away. Most structures have redundant beams to carry load shedding. If a structure has only a single beam carrying all of a structure generally it's 2-3 times over designed, and other smaller beams should crack first. →

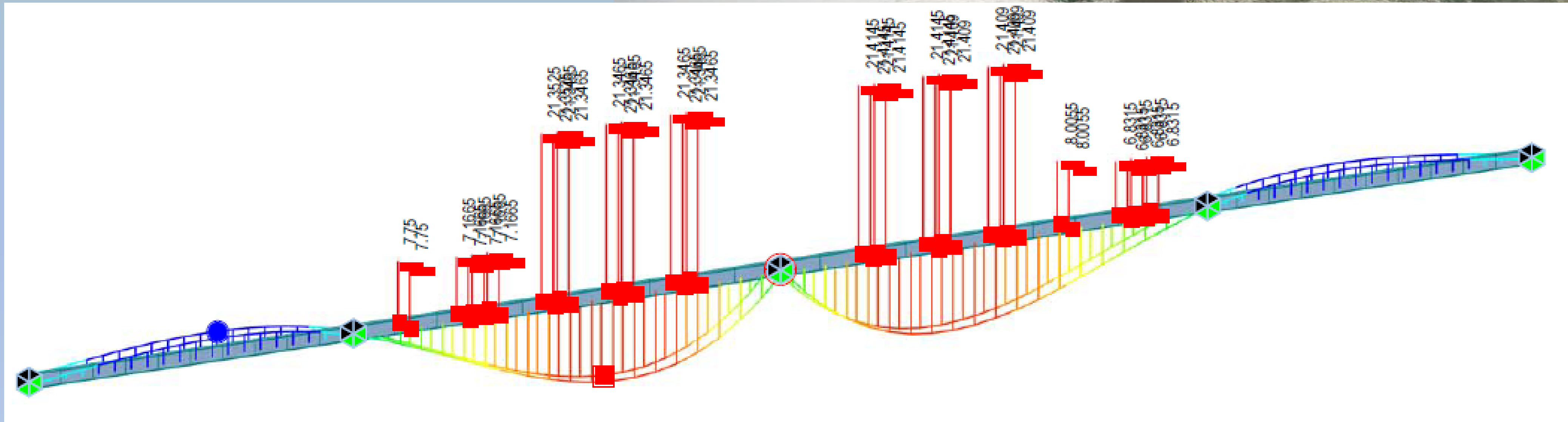
Bending on Continuous span bridges. Bending = Moment.

- Green bar = Vehicle Location.
- Top green bar covers all B support. Ex. Crane
- Bottom green bar splits (Long trailer)
- 134% = (0.117-0.05)/0.05 increased flexure, Crane vs long trailer. Neg bending: Yellow circle
    - Top = 0.117 vs. Bot = 0.050.
- However positive bending worse in bottom picture on end spans by: (0.101-0.0735)/0.0735 = 34%. Pos bending: Blue circle
    - Top = 0.0735 vs. Bot = 0.101.
- Vehicle varieties mixed with continuous span bridge varieties means software required.
- After years of doing this I’ve started to spot the patterns on some bridges.
- A good software for long span bridges is Midas which costs ~ $50,000 per year per screen. →



- For a recent permit I denied. Inspection pics show shear cracks. Integral cast in place concrete bridge. Midas Live Loader results. Finds worst case bending. Compare to ultimate capacity. Pause: Contemplate the risks: If I say yes and I'm wrong… There's a high likelihood this load would've failed this bridge.

The inherent value is preventing loss of life and loss of long bridge. This bridge is $10-15mil to replace. My job is to make sure nothing happens. This load would've been 15% over the bridges ultimate capacity, which doesn't account for those cracks. →



Year to year changes. LRFR.

- 2011 vs 2014.
- 2014 shown at right.
  - 32J's = 1.10.
  - VWA = 1.40.
- 2011 next slide.
  - 32J's = 1.15.
  - VWA = 1.80.
- I'm required to use these codes.
- Adding 5% to 32J's or 40% to VWA is a big difference. I do my best to smooth these changes and keep commerce flowing safely. →

Table ~~6A.4.5.2a-1~~ 6A.4.5.4.2a-1 Permit Load Factors: γ_L.

Permit Type	Frequency	Loading Condition	DF^a	ADTT (one direction)	Load Factor by Permit Weight Ratio[b] GVW / AL < 2.0 (kip/ft)	2.0 < GVW / AL < 3.0 (kip/ft)	GVW / AL > 3.0 (kip/ft)
Routine or Annual Routine or Annual	Unlimited Crossings	Mix with traffic (other vehicles may be on the bridge)	Two or more lanes	>5000	1.4	1.35	1.30
				=1000	1.35	1.25	1.20
				<100	1.30	1.20	1.15
	Unlimited Crossings (Reinforced Concrete Box Culverts)[c]	Mix with traffic (other vehicles may be on the bridge)	One lane	All ADTTs	1.40		
					All Weights		
Special or Limited Crossing	Single-Trip	Escorted with no other vehicles on the bridge	One lane	N/A	1.10		
	Single-Trip	Mix with traffic (other vehicles may be on the bridge)	One lane	ALL ADTTs	1.20		
	Multiple-Trips (less than 100	Mix with traffic (other vehicles may	One lane	ALL ADTTs	1.40		

2011 Live load factors

- LRFR Factors applied to Live Load. →

Table B6A-4—Permit Load Factors: γ_L (6A.4.5.4.2a-1)

Permit Type	Frequency	Loading Condition	*DF*[a]	*ADTT* (one direction)	Load Factor by Permit Weight[b]	
					Up to 100 kips	≥150 kips
Routine or Annual	Unlimited Crossings	Mix with traffic (other vehicles may be on the bridge)	Governing of one lane or two or more lanes	>5000	1.80	1.30
				=1000	1.60	1.20
				<100	1.40	1.10
					All Weights	
Special or Limited Crossing	Single-Trip	Escorted with no other vehicles on the bridge	One lane	N/A	1.15	
	Single-Trip	Mix with traffic (other vehicles may be on the bridge)	One lane	>5000	1.50	
				=1000	1.40	
				<100	1.35	
	Multiple-Trips (less than 100 crossings)	Mix with traffic (other vehicles may be on the bridge)	One lane	>5000	1.85	
				=1000	1.75	
				<100	1.55	

Conservative Designs (1.75) helps Permits @ (1.10)

Revise Table 3.4.1-1 as follows:

Table 3.4.1-1 – Load Combinations and Load Factors

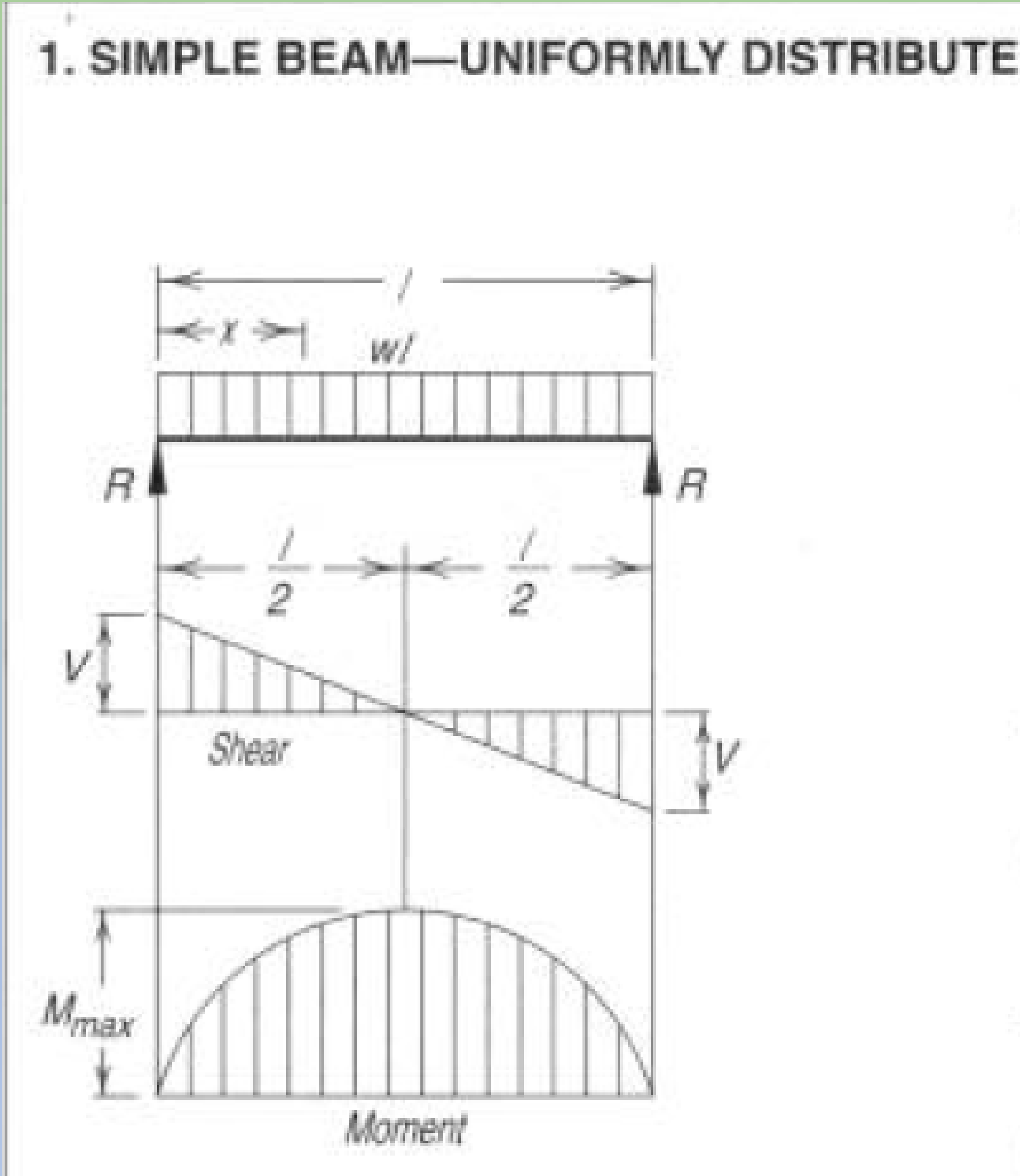
Load Combination Limit State	*DC* *DD* *DW* *EH* *EV* *ES* *EL* ***PS*** ***CR*** ***SH***	LL_{HL93} *IM* *CE* *BR* *PL* *LS*	LL_{Permit} *IM* *CE*	*WA*	*WS*
STRENGTH I	γ_p	1.75	**0.0**	1.0	**0.0**

ADTT (one direction)	Load Factor by Permit Weight Ratio[b]		
	GVW / AL < 2.0 (kip/ft)	2.0 < GVW / AL < 3.0 (kip/ft)	GVW / AL > 3.0 (kip/ft)
>5000	1.4	1.35	1.30
=1000	1.35	1.25	1.20
<100	1.30	1.20	1.15
All ADTTs	1.40		
	All Weights		
N/A	1.10		

After designing new bridges for 7 years I'm now grateful that such high live load factors are applied to design vehicles so that most permit vehicles can pass with just a 1.1 factor. This is due to knowing more closely the exact weight of a vehicle. →

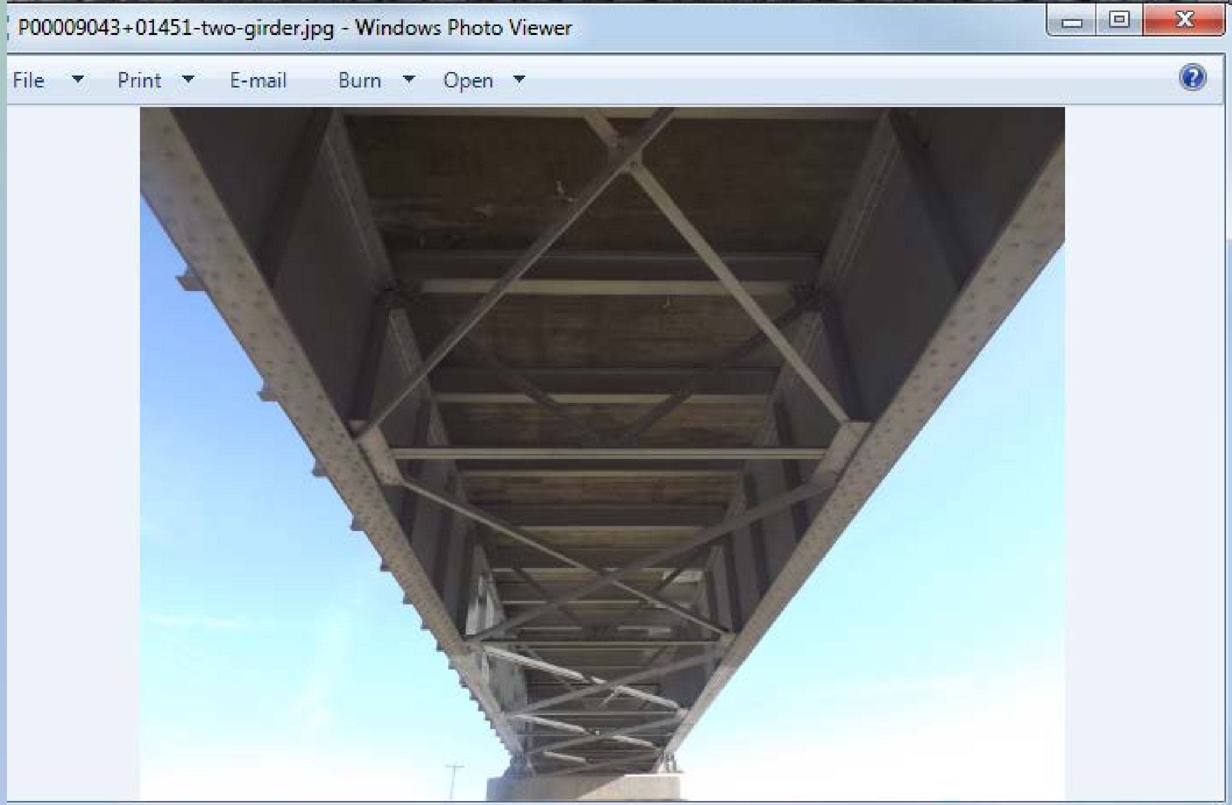
Simple span quick check.

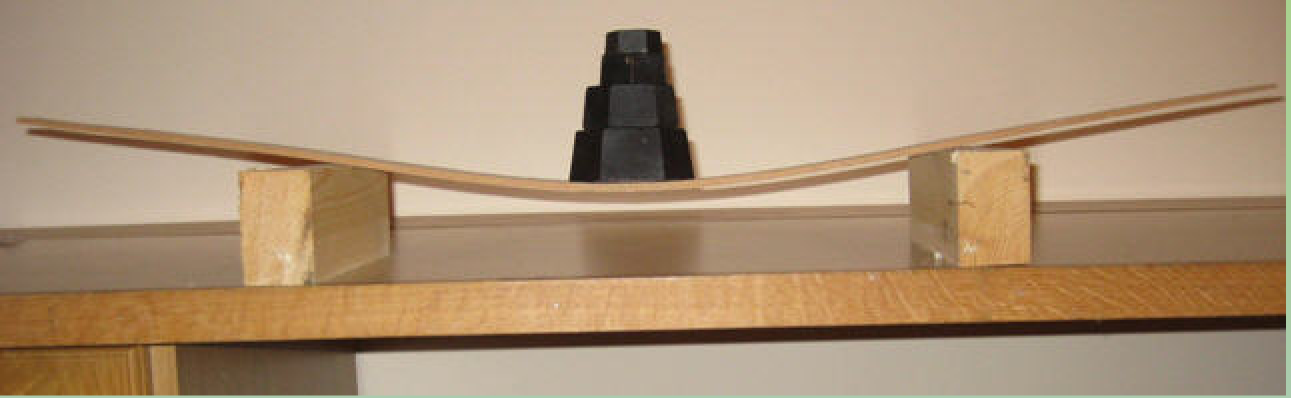
- Simple span bridges need only positive bending checks.
- Equivalent lane/beam portioning
  - Next slide
- If no shear distress, or out of plane bending found by routine inspections, permits based on bending alone.
  - I've never denied a permit on a good (steel, timber, concrete) bridge based on superstructure shear.
    - In my opinion, states who do this are being too conservative.
    - But it's all about life safety decisions and engineers comfort level with maximum capacity.
    - Consider your own comfort level with saying exactly how strong something is then sending a life out on it.
- Timber Bridges are controlled by simple span bending.
  - Can anyone guess the percentage or number of timber bridges on Montana's major roads?
  - It's a lot and about half the permits I deny are over timber bridges. →



Number of beams.

- Top picture not all beams can be loaded. 91ft wide bridge.
- Bottom right each beam ½ loaded when permit solos and centerlines. 2 girder bridge.
- Bottom left… How much load does this beam flange carry? None! Cracked 100% through. Load goes in web.
  - Load shedding, or Load path I learned in seismic engineering. Helps with permitting. →





Some Timber Bridges perfect 80yrs later Bot. R. Full capacity for permits. Other Timber sag and remain deflected under dead load. Danger! Left side pics. We get calls from inspectors under a bridge as a vehicle drives over it and they're flustered that it deflected from the vehicle. We tell them if it went back to flat it's fine. Inspectors and MDT field personnel have stressful jobs. Thank you for being on the front line! →

Other timber bridges… not so good.

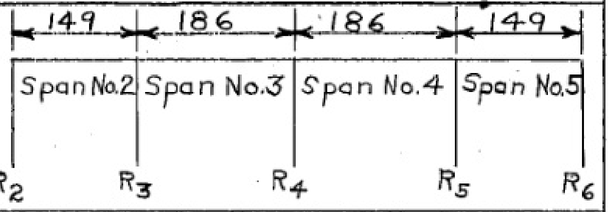
At least this timber bridge failed safely in bending, not shear, giving people time to get clear. Failure in bending generally means a slow sagging occurs and most of the bridge remains intact. →

- Quick way to allow permits:
- Compare to LL design: (shears, reactions, then bending-moment) in that order, from design loads.

DESIGN INFORMATION

D.L. = Dead Load
L.L. = Live Load +Impact

Moment in Kip Ft.
Shears and Reactions in Kips.
Deflections in Inches

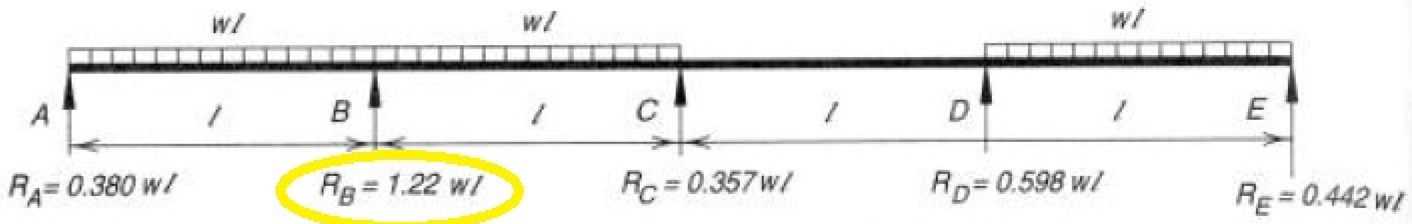


		Span No. 2 ¢ Span No. 5	Span No. 3 ¢ Span No. 4	At R_2 ¢ R_6	At R_3 ¢ R_5	At R_4
Moments	D.L.	2982	2663		-6,424	-6,808
	L.L.	1906	1913		-2,877	-3,163
Reactions	D.L.			108.2	381.0	382.0
	L.L.			67.7	152.5	155.6
Shears	D.L.			108.2	194.5	191.0
	L.L.			67.7	86.8	90.0
Deflections	D.L.	1.66	1.22			
	L.L.	1.51	1.86			

- Ex. permit weighs 150,000lbs.
  - Live load shears for R4 are 2*90 or 180,000lbs.
  - 180>150, I can allow the load now.
- Ex. A heavier permit weighs 260,000lbs and is spread out.
  - Live load reactions for R4 are 2*155.6 or 311,200lbs. Reactions should be about 1.2* vehicle so 260*1.2=311,000lbs.
  - I can allow the load since it matches the reactions the bridge was designed for.

If I can't grant passage by shear or reaction comparisons I use bending. This is much more time consuming. (future slide). →

40. CONTINUOUS BEAM—FOUR EQUAL SPANS—THIRD SPAN UNLOADED



Prestressed beam design for permits – Easy!

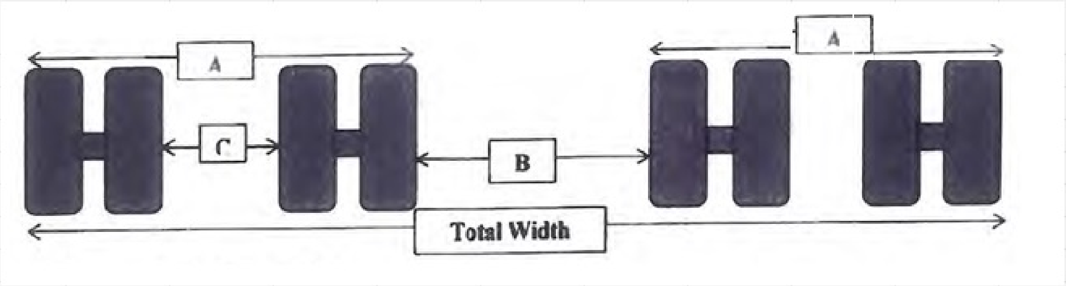
BEAM DESIGN STRESSES		
Beam Length (℄ Brg. to ℄ Brg.)(Horizontal Distance)		43198
Beam D.L. Stresses (MPa @ .5 pt.)	F_t	11.31
	F_b	-11.86
Total D.L. + L.L. + I. Design Stresses (MPa)	F_t	24.85
	F_b	-28.52
Compression Zone ~ Full D.L. (MPa)	F_t	22.22
Compression Zone ~ 0.5 D.L. + L.L. + I. (MPa)	F_t	15.28
Factored Moment @ Section (kN-m)	$*M_u$	11987

$$* \; M_u = 1.3\,[\,D.L. + \tfrac{5}{3}\,(L.L. + I.)\,]$$

I like permitting over prestressed concrete beam bridges. Often only one beam is needed to carry the entire permit load. These bridges (if kept free of salts), should last a very long time. →

Factored ultimate moment(Bending) per beam: Dead loads known (including all reconstructed DL's like a new concrete barrier!), Live load (permit) increased by 10% or 1.1 factor (required by code prior slides). Remove (5/3 or 1.67) design live load multiplier. If 10mph or less, Ignore impact (I), vehicle width (beams driven on) known from trunnion axle width. A cheat sheet I keep at my desk has many simple span beam ultimate live load bending values I will allow over certain bridges for permit vehicles.

Trunnion axle distribution



BRASS/DIST TRUNNION Runs													
No.	File Name	Company	Date	Truck Parameters			Bridge Parameters			Trunnion Factor	Max	Ave	Use
				Trunnion Gage	Transverse Distances	Driving Condition:	Span Leng	Span Structure Type	Beam Spacir				
1	~~concar1~~	*Contractor Cargo*	12/3/2001	~~14 feet~~	~~4.1111,4.1111,4.1111~~	~~DW21~~	~~45 feet~~	~~Concrete Deck on Prestressed Beams~~	~~7.00 feet~~	~~*0.426*~~	NO GOOD		
2	concar2			14 feet	4.1111,4.1111,4.1111	DW21	45 feet	Concrete Deck on Prestressed Beams	7.00 feet	*0.658*	0.658	0.545	0.70
3	concar3			14 feet	4.1111,4.1111,4.1111	DW21	120 feet	Concrete Deck on Prestressed Beams	6.17 and 6.25 ft	*0.485*			
4	concar3a			14 feet	5.0833, 2.1667, 5.0833	DW21	120 feet	Concrete Deck on Prestressed Beams	6.17 and 6.25 ft	*0.491*			
5	burnel_1	*Burnell Contracors*	2/7/2002	10.50 feet	3.3333, 2.1667, 3.3333	DW21	25 feet	Timber Deck on Timber beams	2.095 feet	*0.782*	0.782	0.726	0.80
6	burnel_2			10.50 feet	3.3333, 2.1667, 3.3333	DW21	60 feet	Timber Deck on Steel Stringers	5.00 feet	*0.670*			
7	030602	*Perkins*	3/6/2002	10.00 feet	2.8333, 2.5833, 2.8333	Normal	45 feet	Concrete Deck on Prestressed Beams	7.00 feet	*0.750*	0.801	0.750	0.85
8	030602b			10.00 feet	2.8333, 2.5833, 2.8333	Normal	46.85 feet	Concrete Deck on Steel W Sections	8.3333 feet	*0.720*			
9	030602c			10.00 feet	2.8333, 2.5833, 2.8333	Normal	100 feet	Concrete on Welded Plate Sections	8.3333 feet	*0.730*			
10	030602a			10.00 feet	2.8333, 2.5833, 2.8333	Normal	120 feet	Concrete Deck on Prestressed Beams	6.17 and 6.25 ft	*0.801*			
11	050202	*Mammoet Western*	5/2/2002	20 feet	4.00, 10.00, 4.00	DW21	25 feet	Timber Deck on Timber beams	2.095 feet	*0.465*	0.465	0.465	0.50

- When I started permitting my boss shared his work from BRASS/DIST Trunnion prog. After I thoroughly studied this work I shared it to other structural engineers. Treating these Trunnion axles uniformly is key.
- These types of vehicles are much more common in recent years. Years ago they commonly only moved from NE Wyoming up to Canada through Montana.
- There's a lot of complexity contained in these factors. An experienced structural engineer needs time to interpret these. I suggest enlisting expert licensed structural engineers for interpretation.
- Transverse deck stiffness, beam stiffness, axle widths all must be carefully interpreted when vehicles don't exactly match.
- It's time prohibitive to rerun this program for each vehicle over each bridge. →

Trunnion factors and superstructure types

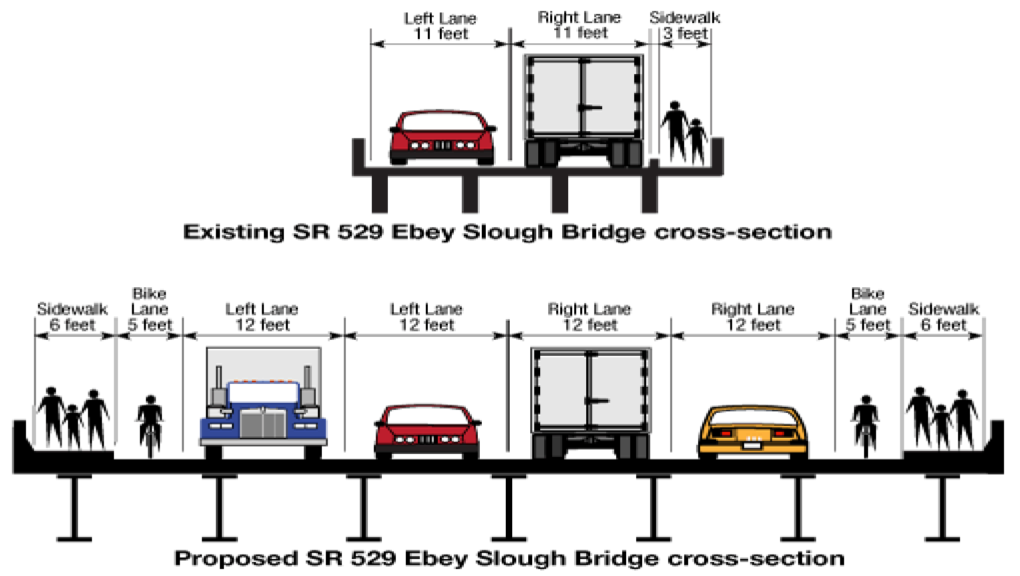
- Bridge designers might work their whole career never seeing these factors permit engineers use.
- Some bridge owners with only design backgrounds may be too conservative with permits until more familiar.
- It took me a while to learn this stuff.

E	F	G	H	I	J	K	L	M	N
BRASS/DIST TRUNNION Runs									
Truck Parameters			**Bridge Parameters**			**Trunnion Factor**	**Max**	**Ave**	**Use**
Trunnion Gage	Transverse Distances	Driving Conditions	Span Lengt	Span Structure Type	Beam Spacin				
~~14 feet~~	~~4.1111,4.1111,4.1111~~	~~DW21~~	~~45 feet~~	~~Concrete Deck on Prestressed Beams~~	~~7.00 feet~~	~~*0.426*~~	NO GOOD		
14 feet	4.1111,4.1111,4.1111	DW21	45 feet	Concrete Deck on Prestressed Beams	7.00 feet	*0.658*	0.658	0.545	0.70
14 feet	4.1111,4.1111,4.1111	DW21	120 feet	Concrete Deck on Prestressed Beams	6.17 and 6.25 ft	*0.485*			
14 feet	5.0833, 2.1667, 5.0833	DW21	120 feet	Concrete Deck on Prestressed Beams	6.17 and 6.25 ft	*0.491*			
10.50 feet	3.3333, 2.1667, 3.3333	DW21	25 feet	Timber Deck on Timber beams	2.095 feet	*0.782*	0.782	0.726	0.80
10.50 feet	3.3333, 2.1667, 3.3333	DW21	60 feet	Timber Deck on Steel Stringers	5.00 feet	*0.670*			
10.00 feet	2.8333, 2.5833, 2.8333	Normal	45 feet	Concrete Deck on Prestressed Beams	7.00 feet	*0.750*	0.801	0.750	0.85
10.00 feet	2.8333, 2.5833, 2.8333	Normal	46.85 feet	Concrete Deck on Steel W Sections	8.3333 feet	*0.720*			
10.00 feet	2.8333, 2.5833, 2.8333	Normal	100 feet	Concrete on Welded Plate Sections	8.3333 feet	*0.730*			
10.00 feet	2.8333, 2.5833, 2.8333	Normal	120 feet	Concrete Deck on Prestressed Beams	6.17 and 6.25 ft	*0.801*			
20 feet	4.00, 10.00, 4.00	DW21	25 feet	Timber Deck on Timber beams	2.095 feet	*0.465*	0.465	0.465	0.50

Concrete deck on P/S beams.
Timber deck on timber beams.
Timber deck on steel beams.
Concrete deck on steel W beams.
Concrete deck on Steel Welded plate
beams. →

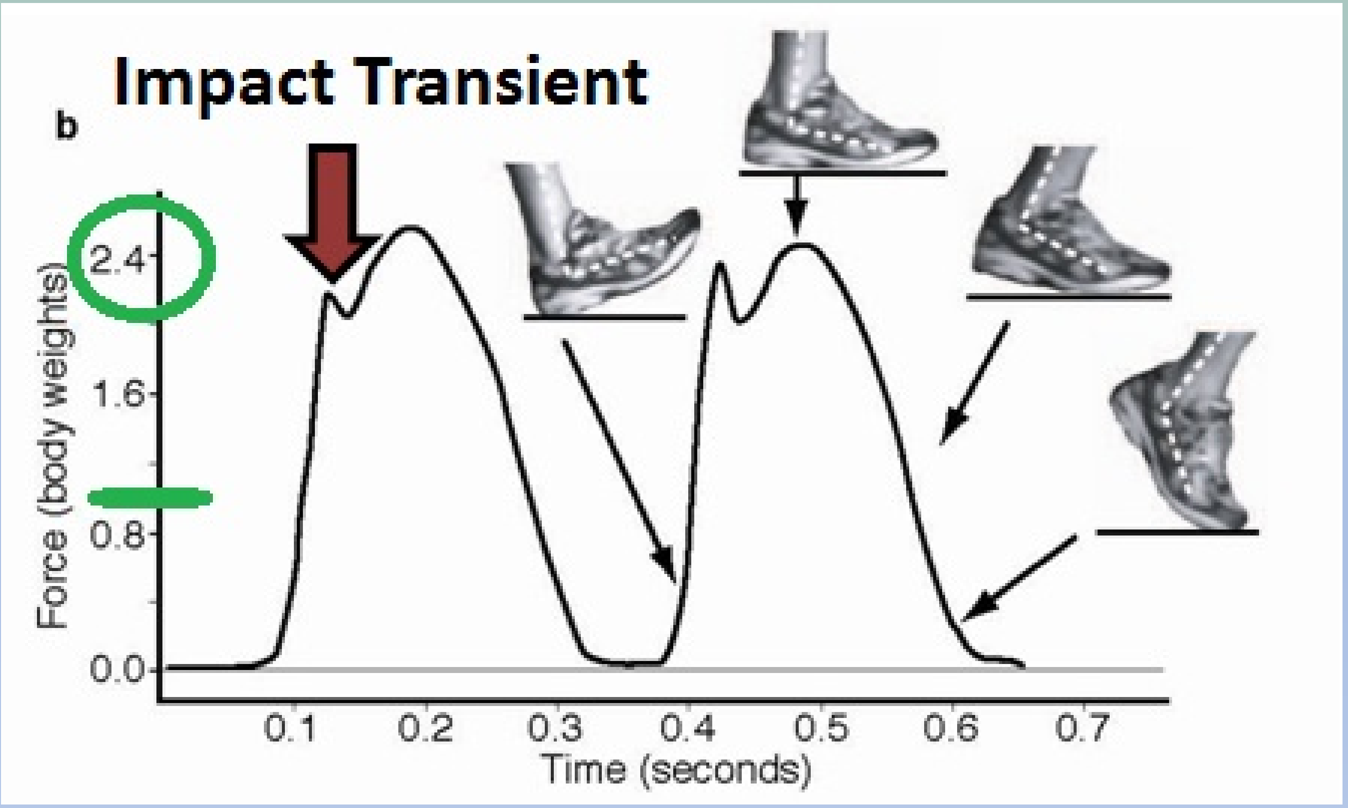
Load width

- Width of load on bridge.
- 20ft wide, or only 10ft?
- For example: 3.5 beams or 1.75 beams under load? →



10-mph slowdown. Think of standing vs running.

- For Montana recently the 5-mph limit was raised to 10-mph by me.
- I used the 2014 Manual for Bridge Evaluation MBE - LRFR.
- Surface irregularity is why impact applies to vehicles. If we ever build a perfectly flat road this can be ignored. Settlement, deformation and thermal effects work against materials.
  - Usually your vehicle shocks/struts insulate you from impact however roads and bridges feel increased weights.
- Ex: A 150lb. runner's foot exerts about 2.4*(150lbs) = 360lbs each time the foot hits the ground.
  - This is dynamic vs static loading. After 7yrs seismic design trust me… loads are sometimes dynamic. →



6A.4.5.5—Dynamic Load Allowance: *IM*

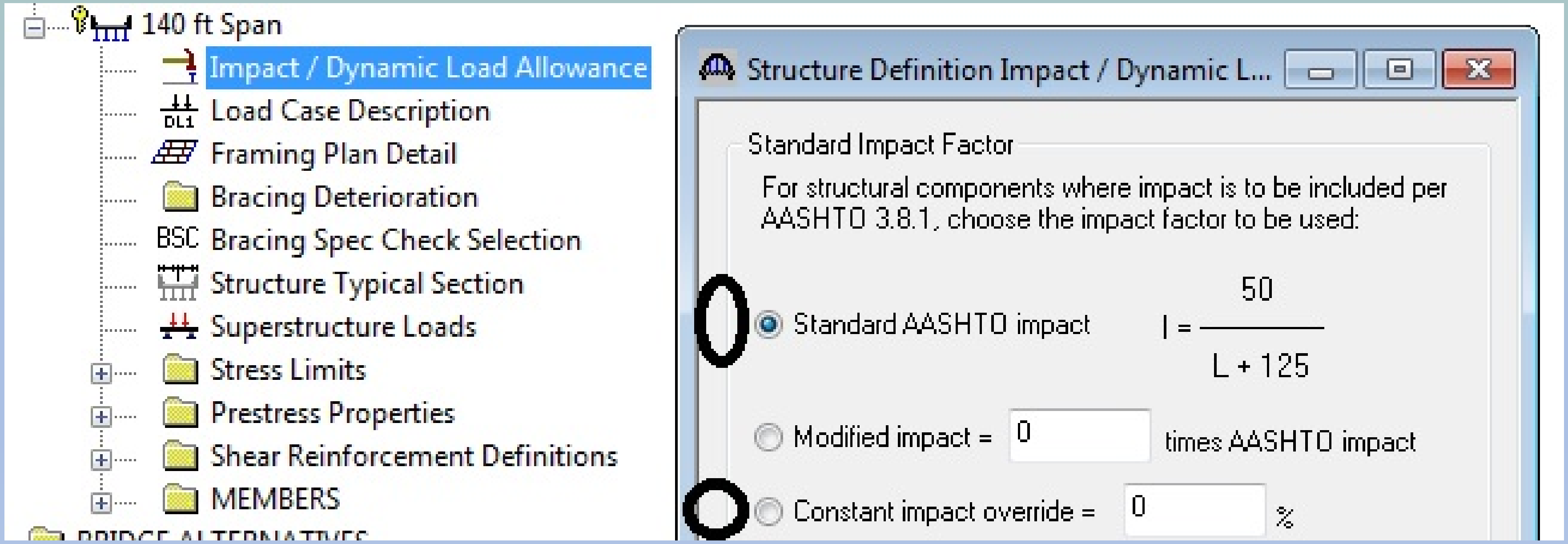
The dynamic load allowance to be applied for permit load rating shall be as specified in Article 6A.4.4.3 for legal loads, except that for slow moving (≤10 mph) permit vehicles the dynamic load allowance may be eliminated.

6B.7.5—Speed Limits

In some cases, lower speed limits will reduce impact loads to the extent that lowering the weight limit may not be required. Consideration of a speed posting will depend upon alignment, general location, volume, and type of traffic. A speed posting should not be considered as a basis for increasing the weight limit in areas where enforcement will be difficult and frequent violations can be anticipated.

AASHTOWare Rating Software (federally – accepted)

- Impact adjusted down to zero from default.
- Not many bridge engineers allowed to change this. I make specific models and label them so. When a vehicle drives 10mph I can ignore impact.
- Otherwise impact is 30-33%. →



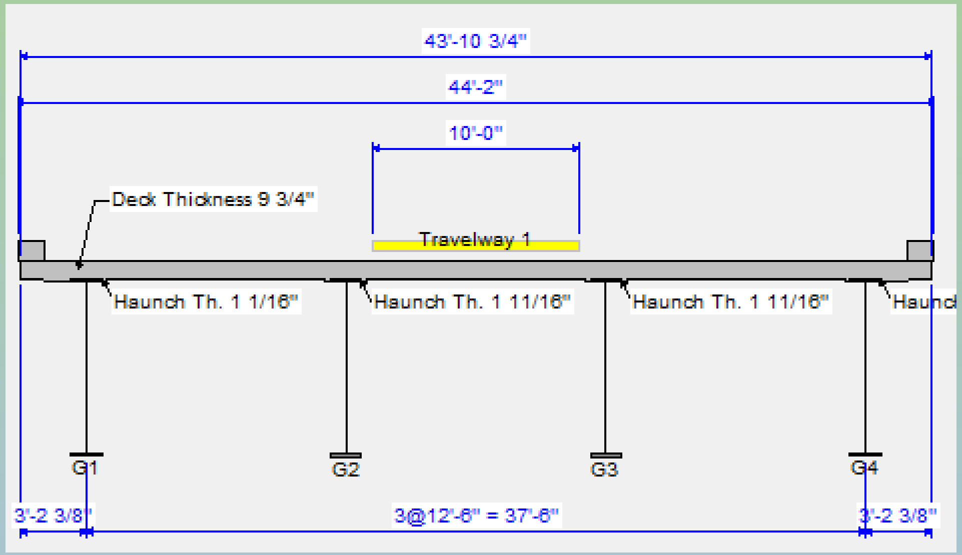
Yellow travelway changes, distribution factors need recalculating.

Notice how distribution (load applied), factors change as the travelway changes.

This is another thing most bridge engineers won't ever change. They make the yellow bar full bridge width.

I may give a presentation soon for AASHTO Bridgeware on this soon.

Software modifications are being voted on by states and may include Montana's input. →



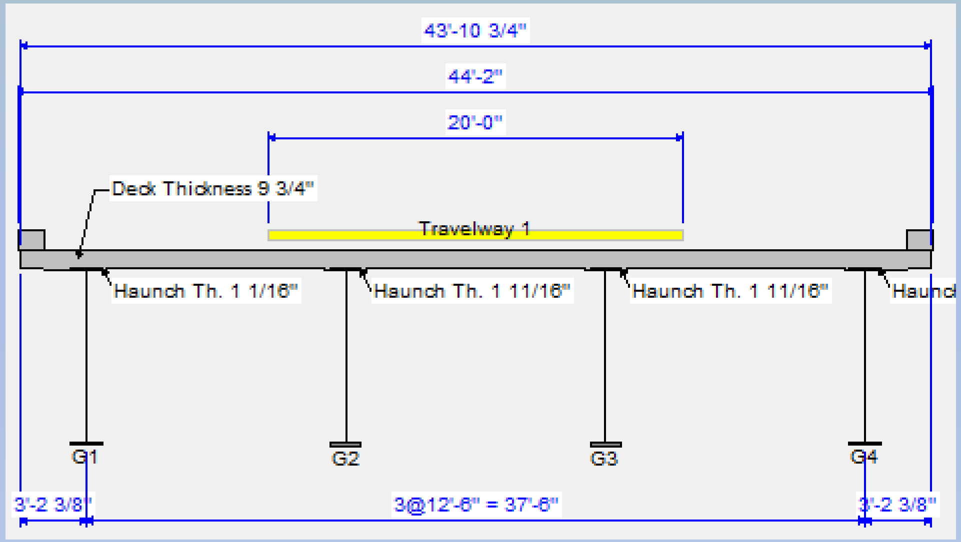
Standard | LRFD

Distribution Factor Input Method

◉ Use Simplified Method ○ Use Advanced Method ○ Use Advanced Method

☐ Allow distribution factors to be used to compute effects of permit loads with routine tra

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1	1	1	0.5
Multi-Lane	1	1	1	1.35



Standard | LRFD

Distribution Factor Input Method

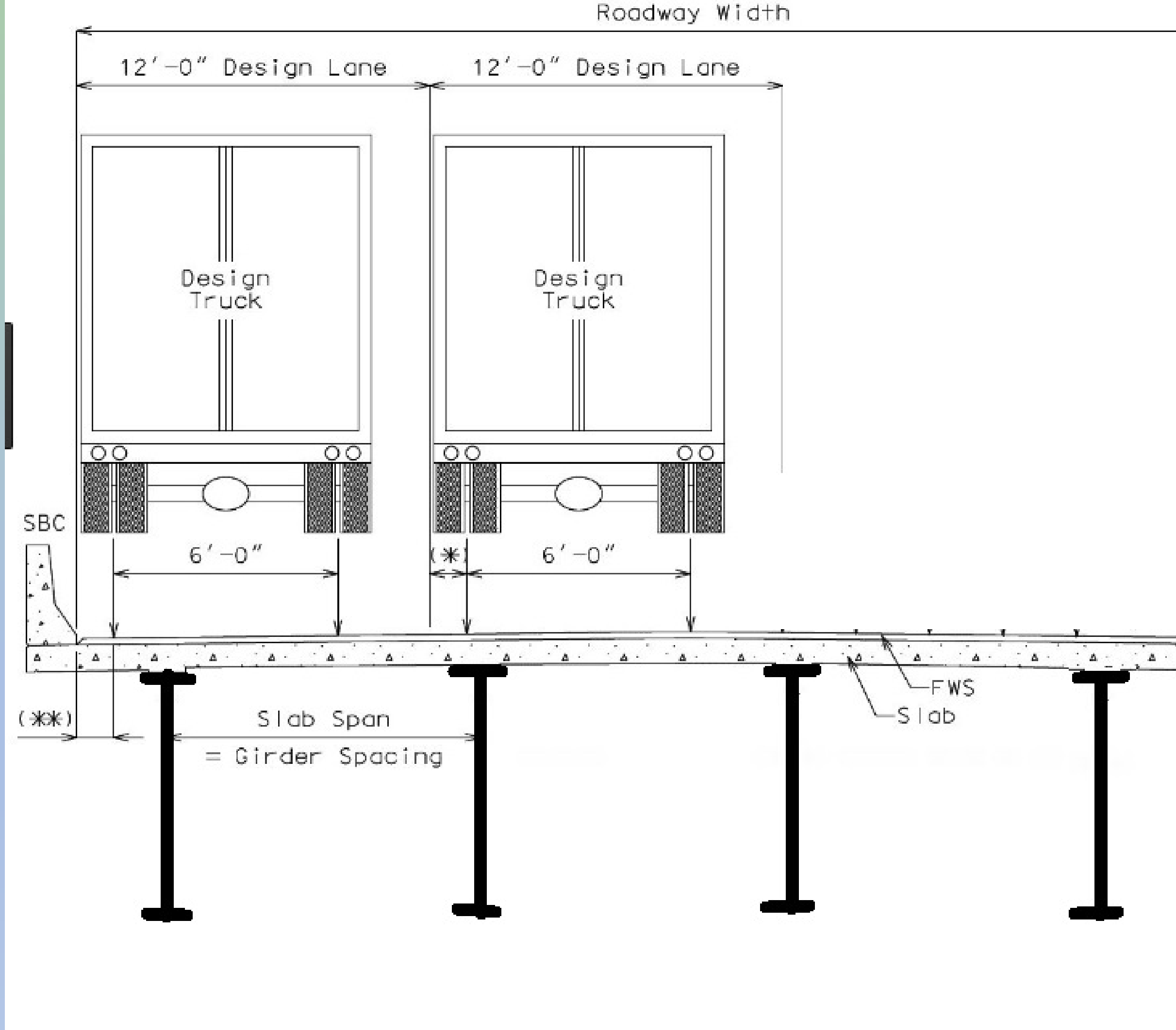
◉ Use Simplified Method ○ Use Advanced Method ○ Use Advanced Metho

☑ Allow distribution factors to be used to compute effects of permit loads with routine tra

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.52	1.52	1.52	0.5
Multi-Lane	2.272727	1.86	2.272727	1

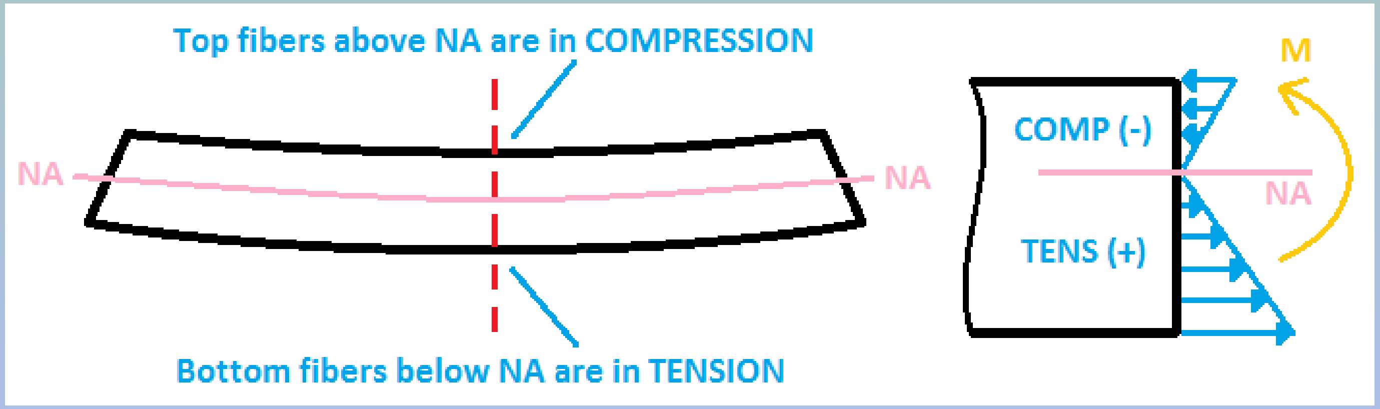
Fundamentals of permit approval.

- Ex: 3.0 beams underneath a wide load, yet only 2.0 beams needed to carry said load… so (3.0/2.0) 1.5 is the capacity/demand ratio. Approved!
- I only say yes when I'm confident enough to stand under a bridge as the load crosses over me.
- There aren't any do overs to mistakes in this job. People could get hurt. →

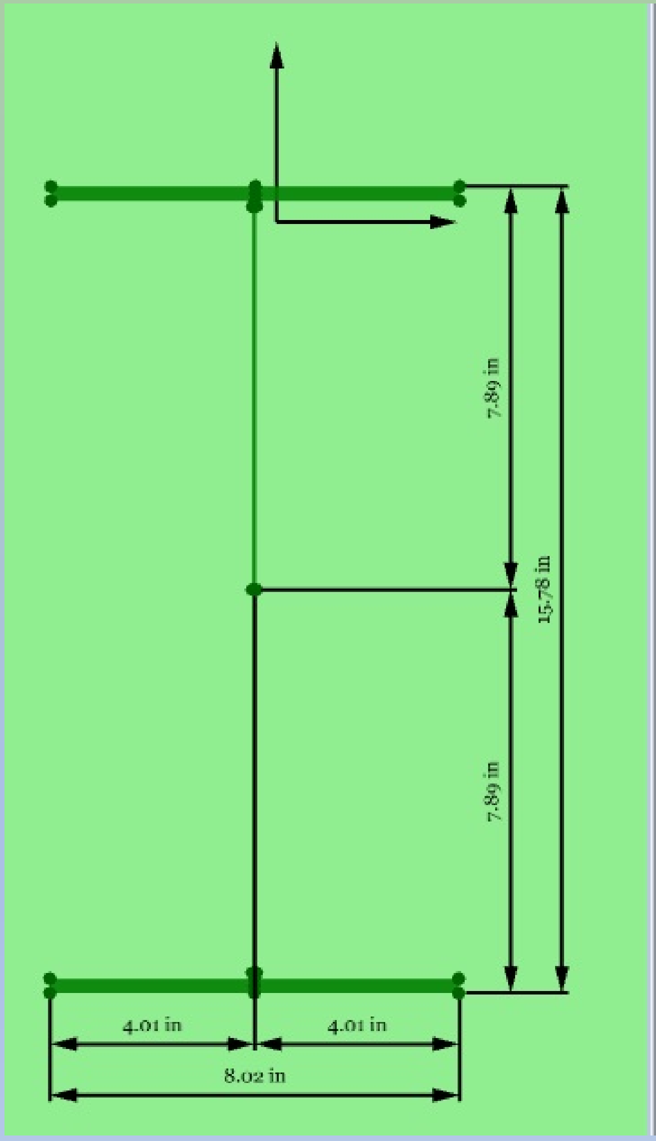


When I deny a permit.

- Section properties with bending applied gives stresses.
  - Timber, steel, all have stress limits.
  - Bending stress is fundamental to flexure.
    - Take a box of pencils and bend each till it breaks,
    - Each new pencil should break in half around the same force each time.
    - Stress = Force/Area.



This is repeatable for future reference however it is time consuming to gather loads after vehicles change their configuration. Lateral and longitudinal distribution changes, vehicle speed changes, where in the driving lane, all affect loading. It takes time. For many years I've developed my own private electronic searchable records of my work with a table of contents. There are about 500 of Montana's 6,000 bridges which often are the weakest link for permits. →



Overall Dimensions

Depth	15.783 in
Width	8.0209 in
Perimeter	63.28 in

Geometric Properties

Area	5.666 in2
Ix	292.07 in4
Iy	23.98 in4
Ixy	0.36468 in4
rx	7.1796 in
ry	2.0572 in
Sx+	37.011 in3
Sx-	37.011 in3
Sy+	5.976 in3
Sy-	5.9826 in3
Xc	-0.42975 in
Yc	-7.1943 in

Principal Properties

I1	292.07 in4
I2	23.979 in4
α	-0.07794 deg
r1	7.1796 in
r2	2.0572 in
S1+	36.985 in3
S1-	36.986 in3
S2+	5.9911 in3
S2-	5.9978 in3

Polar Properties

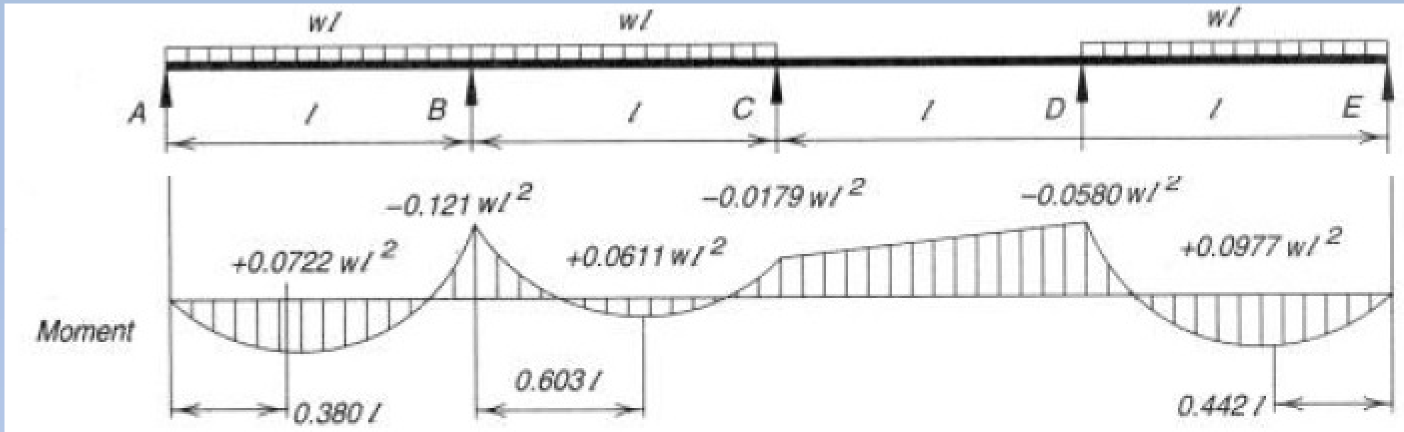
Ip	316.05 in4
rp	7.4685 in

MBE or LRFR Bending Stress limits

Table 6B.5.2.1-2—Operating Rating Allowable Stress, psi

			DATE BUILT-STEEL UNKNOWN			
			Prior to 1905	1905 to 1936	1936 to 1963	After 1963
AASHTO Designation[a]						
ASTM Designation[a]						
Minimum Tensile Strength		F_u	52,000	60,000		
Minimum Yield Point LOAD FACTOR		Load Factor F_y	26,000	30,000	33,000	36,000
Axial tension in members with no holes for high-strength bolts or rivets. Use net section when member has any open holes larger than $1^1/_4$-in. diameter, such as perforations.		Allowable $0.75F_y$	19,500	22,500	24,500	27,000
		$0.60F_u$			NOT APPLICAB	
Axial tension in members with holes for high-strength bolts or rivets and tension in extreme fiber of rolled shapes, girders, and built-up sections subject to bending	ichever naller	Gross* Section $0.75F_y$ Allowable	19,500	22,500	24,500	27,000

This is how complex bending moments can become with long span bridges and variable vehicle configurations.
Software is needed for long bridges under long vehicles. →



Where am I headed with this…

- What am I doing with all this information? Ultimately I'm trying to get more software involved in this process.
  - The old permit engineer asked me to consider where I spend most of my time and constantly evaluate safe, repeatable ways to speed up the process.
- I made (with some expert state programmers), a software which uses google and our databases to quickly find all bridges crossed. Next slide.
  - It returns the current inspector conditions, capacities and other data I need for those bridges.
  - I am trying to automate this further. However all I see are blank stares (or quiet on other ends of phones) by people saying I am bumping into very powerful companies who cost millions of dollars to do the same.
  - I am undeterred. →

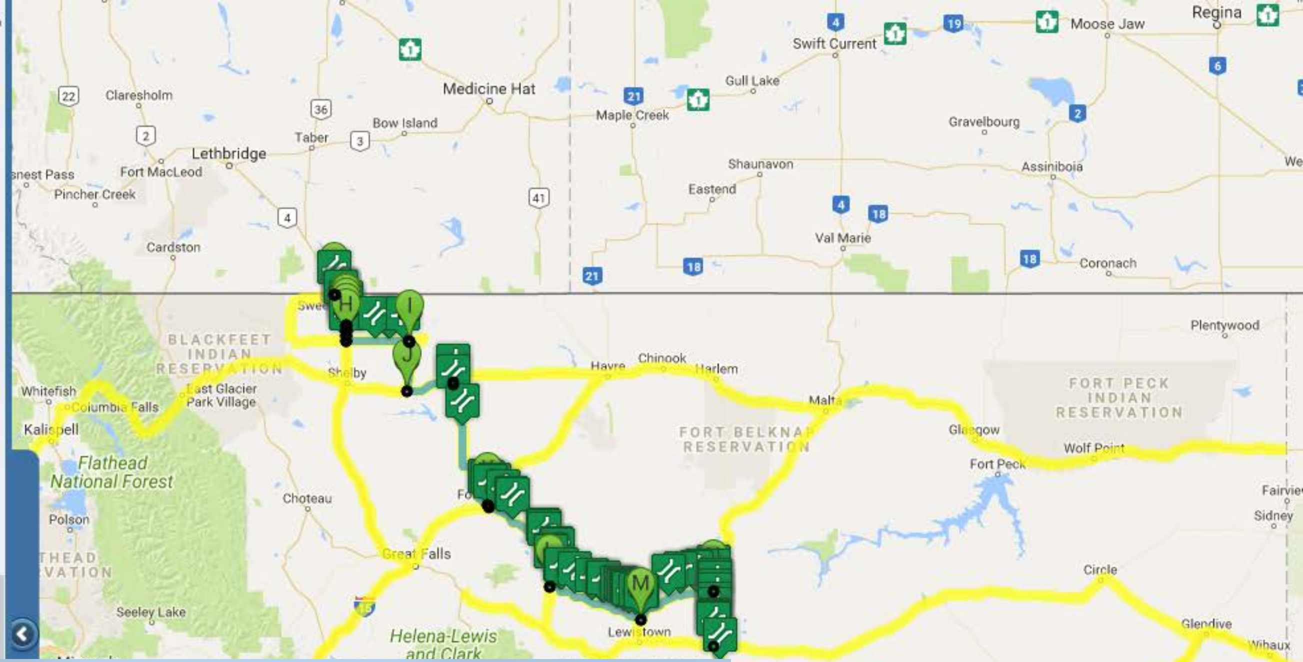
- Map route tool. MDT software.

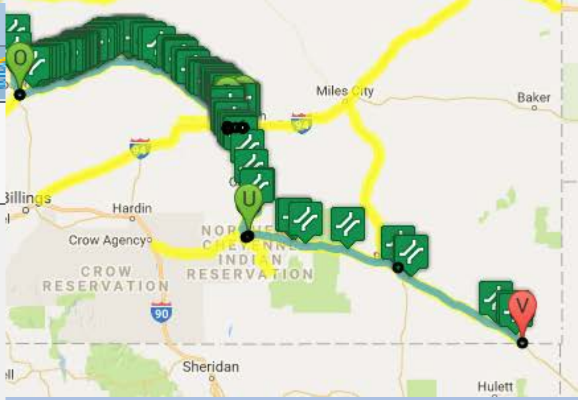
Goal is additional software which compares loads applied by permits to capacities of bridges stored in database. →

Retrieve Bridges

Bridges

Bridge ID	KM Post	Year
I00015379+02551	377.123	1980
I00015389+08151	387.677	1977
I00015389+08152	387.521	1961
I00015390+01711	388.049	1977
I00015390+01712	387.862	1961
I00094088+00981	87.553	1967
I00094088+00982	88.065	1972
I00094092+02621	91.685	1967
I00094092+02622	92.2	1972
L44311001+01001	24.681	1928
L44311002+06001	23.467	1941
L44311005+07001	20.546	1932
L51028004+05001	4.483	1971
L51039000+00001	0.123	1971
L51040004+04301	0.175	1971
P00014174+06061	174.817	1999
P00014175+05111	282.456	1999
P00014176+03491	283.792	1999
P00014177+01001	285.015	1999
P00014177+04631	285.595	2000





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Route Analysis List-Load Rating & Inspection Summary

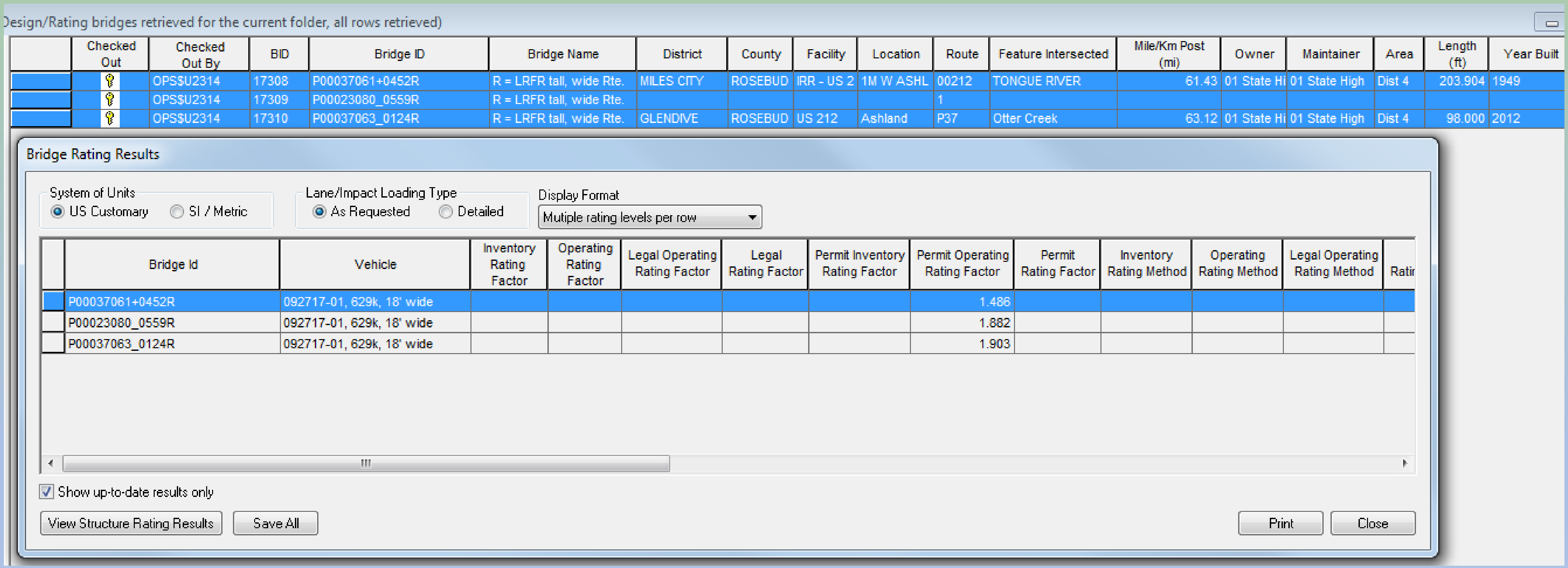
Conditions as of: **6/21/17 2:58 PM**

Route: **I00015**

	Bridge Number	NBI Number	Ref Post	Con Year	Recon Year	Const Draw No.	Loads		Structure Length (ft)	Max Span Length (ft)	Main Span			Approach Span			Deck			Inspection			
							Oper (Tons)	Inv (tons)			Num Span	Dgn	Mat	Num Span	Dgn	Mat	Str Type	Surf Type	Surf Depth (in)	Date	Deck Rate	Sup Rate	Sub Rate
1	I00015379+02551	01292	610.34	1980	0		60.957745	36.0	143.9592	71.9796	3	2	5	0	00	0	1	1	0	2013-07-02	7	7	8
2	I00015389+08151	01294	627.34	1977	0		36.0	36.0	146.9768	66.9776	3	2	5	0	00	0	1	1	0	2015-10-20	7	7	7
3	I00015389+08152	01295	627.34	1961	0		55.99735	36.0	169.9696	66.4856	3	2	5	0	00	0	1	1	0	2015-10-20	6	7	7
4	I00015390+01711	01296	627.92	1977	0		36.0	36.0	335.9048	76.9816	5	2	5	0	00	0	1	1	0	2012-08-14	6	7	7
5	I00015390+01712	01297	627.92	1961	0		56.000874	34.00053	312.912	52.98512	2	2	3	4	02	5	1	1	0	2015-06-17	6	6	6

AASHTOBridgeware. Of which I was secretary.

- I'm working toward making this software into a quick permitting solution.
- The software is optimized for returning bridge ratings to FHWA annually. Not permitting.



What you see above is a 630,000lb load over 3 of the weakest bridges on a route, 1.486, 1.882, 1.903 capacity/demand ratios. All ok, approved. Minutes only needed. Ton's of time needed upfront to make models and teach other engineers how to. →

Can you guess what this vehicle is hauling?

Questions?

- A question I've had from other engineers is how to do this job. It simply takes all your knowledge, lots of practice (with actual permits) and real time deadlines. Simply find each bridge and make sure it can safely pass the load. Easy! Right?
- A trap I see is making a permit into a research project. This grinds commerce to a halt. My boss used to come by my desk frequently with time consuming questions and push me relentlessly until I learned how important timeliness is to this job.
- Permit engineers must handle stress well. The Old permit engineer told me he lost many good engineers when he forced them into permits. →