Orlando, FL

November 7-8, 2024

2024 TRANSPORTATION SYMPOSIUM

Load Rating in Florida and AASHTOWare BrR

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FDOT Office of Maintenance

FDOT

FDOT safety message: adopt a road rage mantra.
"This too shall pass" or
"That vehicle too shall pass"

Load rating analysis approximates safe carrying capacity for bridges, establishes posting restrictions, and estimates strength for permit routing. Such analysis directly supports the Department's Mission, to "… provide a safe transportation system that ensures the mobility of people and goods, enhances economic prosperity, and preserves the quality of our environment and communities."

load rating - definition

1. SUMMARY. Load rating summary form (Excel), sealed by a Florida P.E.
2. NARRATIVE. Brief description of inspection findings, methodology, and assumptions.
3. PLANS. Plan sheets required to perform the analysis (not the entire plan set).
4. CALCULATIONS. Inputs, intermediate calculations, and summarized outputs.
5. QUICK CHECK. At a minimum, confirmation of the governing HS20 or HL93 Operating Rating; show the factored components of the rating factor equation. A more comprehensive check is recommended, especially when results significantly differ from the original Design Load increased to the Operating Level.

Additionally, submit all software inputs in native ready-to-run format. The District may request QC documents, as well.

load rating - complete

QUICK CHECK

$L = 14ft$ & $W = 30.5ft$ effective length and width

$t_{overlay} := 3.5in$ - thickness of the asphalt overlay

$t_{slab} := 10.5in$ - effective slab thickness

$A_s := 0.44in^2 \cdot \frac{12in}{5in} = 1.056 in^2$ - area of steel

$d := t_{slab} - \left(1.25in + \frac{1}{2}\cdot\frac{6}{8}in\right) = 8.88 in$ - depth to the centroid of steel

$\psi Mn := 1.00 \cdot 0.90 \cdot 40ksi \cdot A_s \cdot \left(d - \frac{1}{2}\cdot\frac{40ksi \cdot A_s}{0.85 \cdot 3ksi \cdot ft}\right) = 25.93 kip \cdot ft$ - factored flexural strength

$\omega_{DC} := 150pcf \cdot t_{slab} \cdot ft = 131 \cdot plf$ - slab dead load

$\omega_{DW} := 145pcf \cdot t_{overlay} \cdot ft \cdot \frac{28ft}{W} = 39 \cdot plf$ - wearing surface dead load

$DL_{1.45} := \frac{\omega_{DC} + \omega_{DW}}{2} \cdot \left[L \cdot 0.45 L - (0.45 L)^2\right] = 4.13 kip \cdot ft$ - dead load at 45% span length

$DL_{1.50} := (\omega_{DC} + \omega_{DW}) \cdot \frac{L^2}{8} = 4.17 kip \cdot ft$ - dead load at 50% span length

$HL93 := (1 + 20\%) \cdot 25kip \cdot 0.45 \cdot L \cdot \left(\frac{L - 0.45 \cdot L}{L} + \frac{L - 0.45 \cdot L - 4ft}{L}\right) + \frac{0.64klf}{2} \cdot \left[L \cdot 0.45 L - (0.45 L)^2\right] = 169.42 kip \cdot ft$ - HL93 LL at 1.45

$E_{Single.Lane} := 10in + 5in \cdot \sqrt{\min\left(L \cdot ft^{-1}, 60\right) \cdot \min\left(W \cdot ft^{-1}, 30\right)} = 112.470 in$ - one-lane equivalent strip width (LRFD 4.6.2.3-1)

$E_{Multilane} := 84in + 1.44in \cdot \sqrt{\min\left(L \cdot ft^{-1}, 60\right) \cdot \min\left(W \cdot ft^{-1}, 60\right)} = 113.756 in$ - multilane equivalent strip width (LRFD 4.6.2.3-2)

$$RF_{HL93.Operating} := \frac{\psi Mn - 1.25 \cdot DL_{1.45}}{1.35 \cdot \frac{ft}{E_{Single.Lane}} \cdot HL93}$$

$RF_{HL93.Operating} = 0.851$

$$RF_{SU4.Operating} := \frac{\psi Mn - 1.25 \cdot DL_{1.50}}{1.35 \cdot \frac{ft}{E_{Single.Lane}} \cdot (1 + 20\%) \cdot \left(18.7kip \cdot \frac{L}{2}\right) \cdot \left(\frac{1}{2} + 2 \cdot \frac{L - 0.50 \cdot L - 4.17ft}{L}\right)}$$

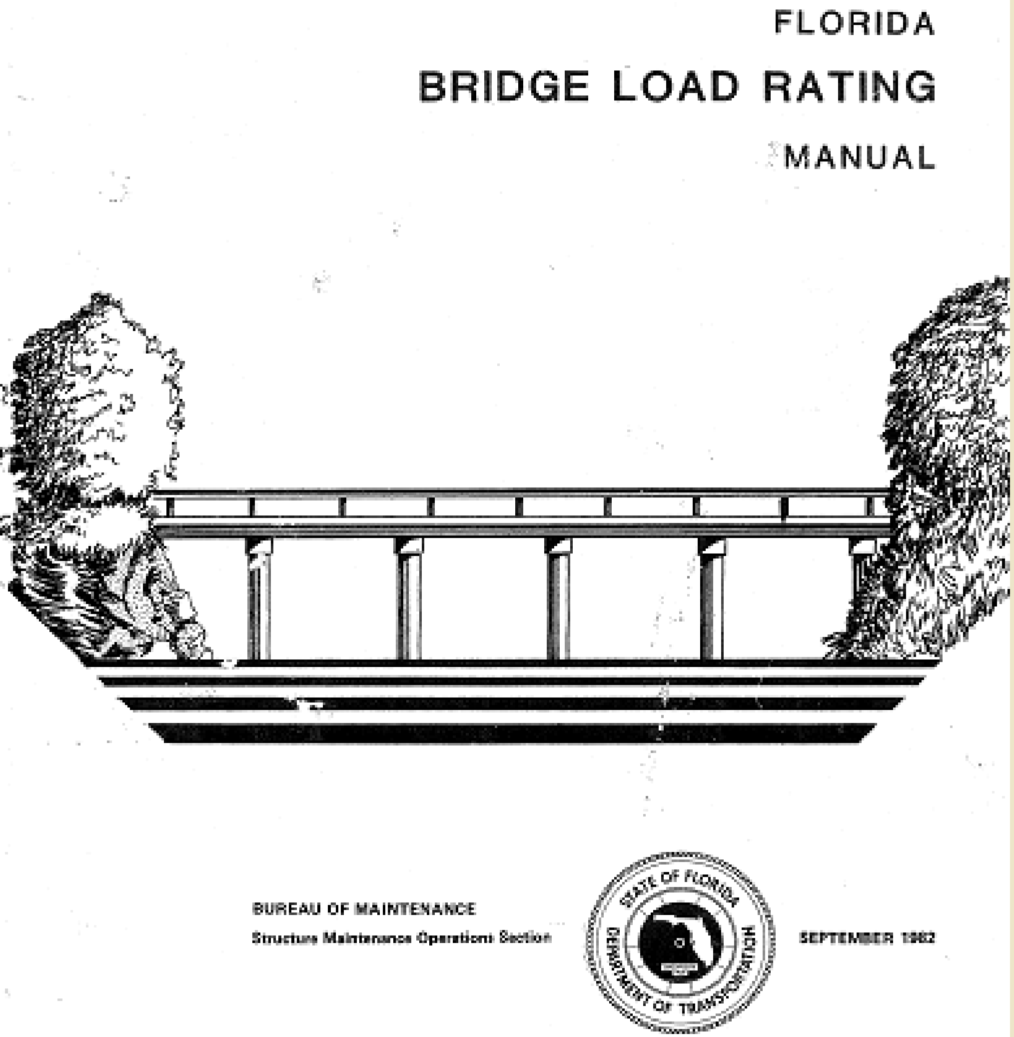
$RF_{SU4.Operating} = 1.013$

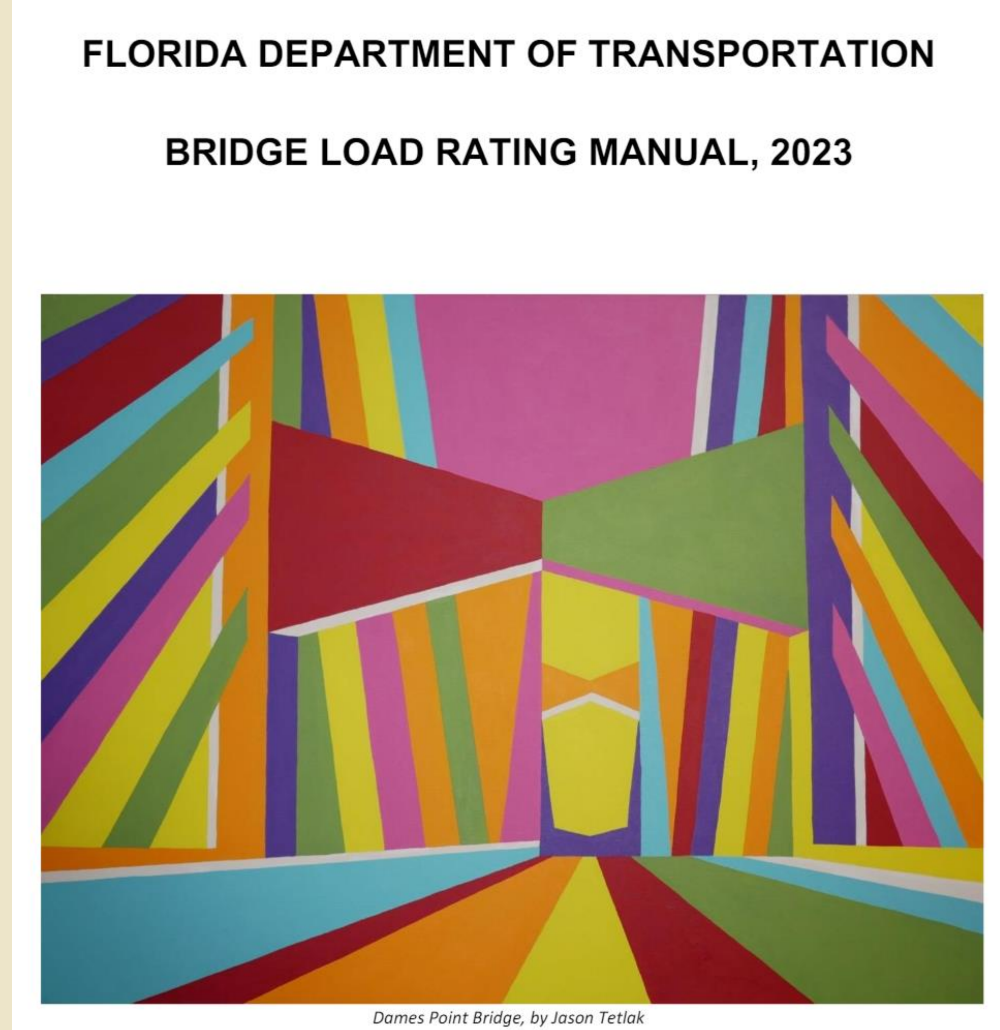
$$RF_{FL120} := \frac{\psi Mn - 1.25 \cdot DL_{1.50}}{1.35 \cdot \frac{ft}{E_{Multilane}} \cdot (1 + 20\%) \cdot 53.3kip \cdot 0.25 \cdot L}$$

$RF_{FL120} = 0.650$

example

- history
- inventory
- rationale
- BrR
- tips


FLORIDA
BRIDGE LOAD RATING
MANUAL
BUREAU OF MAINTENANCE
Structure Maintenance Operations Section
STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION
SEPTEMBER


FLORIDA DEPARTMENT OF TRANSPORTATION
BRIDGE LOAD RATING MANUAL, 2023
Dames Point Bridge, by Jason Tetlak

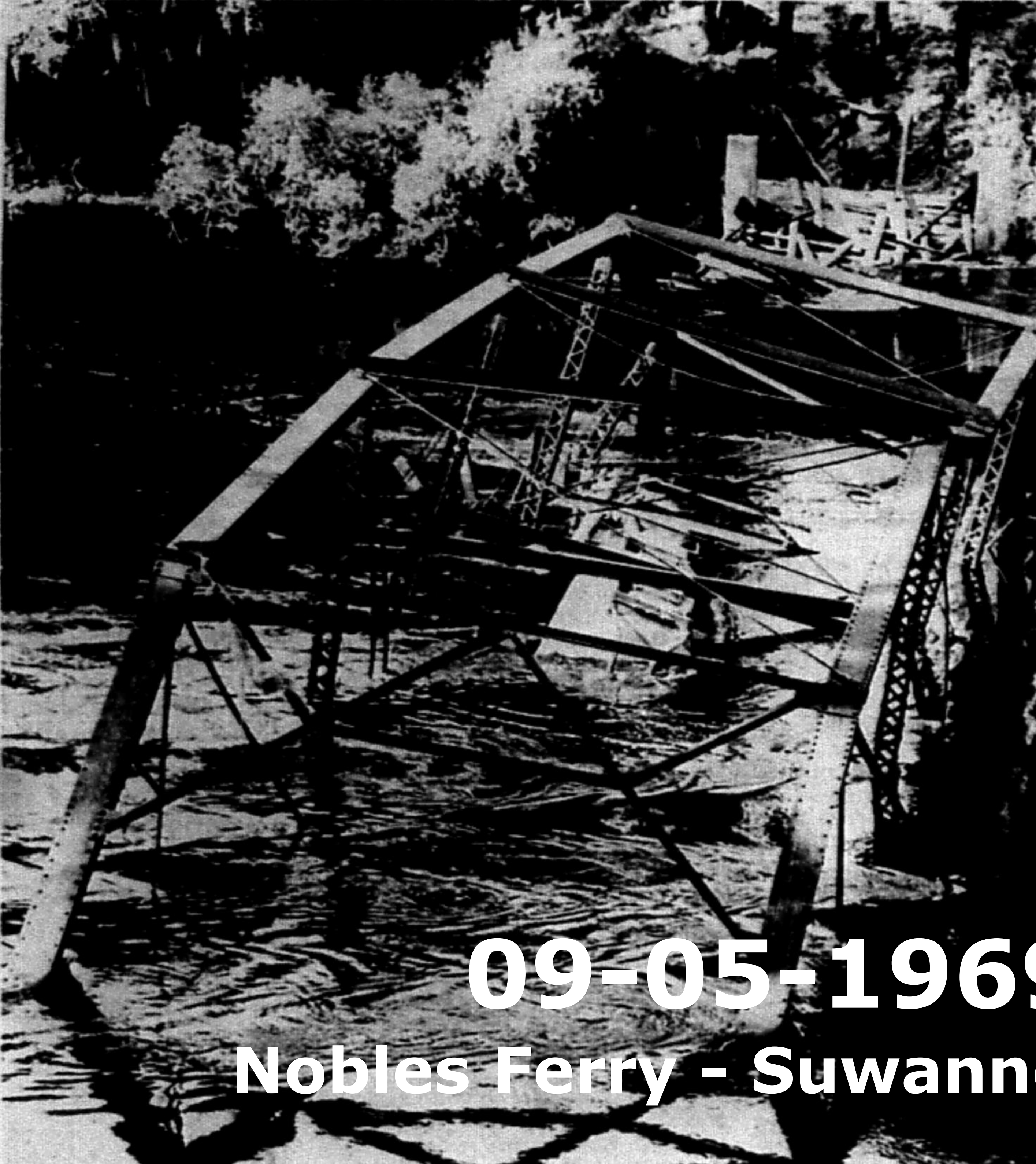
HISTORY

One Killed as Bridge Collapses

Everett said the crack in the bridge between Longboat and Anna Maria, was discovered by a fisherman who noticed he could see the water through what should have been solid concrete, while fishing from the bridge. Everett said he

01-08-1969

Longboat Key



09-05-1969

Nobles Ferry - Suwannee River

1967 Silver River

1968 Federal Highway Act compels bridge inspection

1968 US19 over Anclote River, corrosion

1969 Longboat Key, pile cap shift

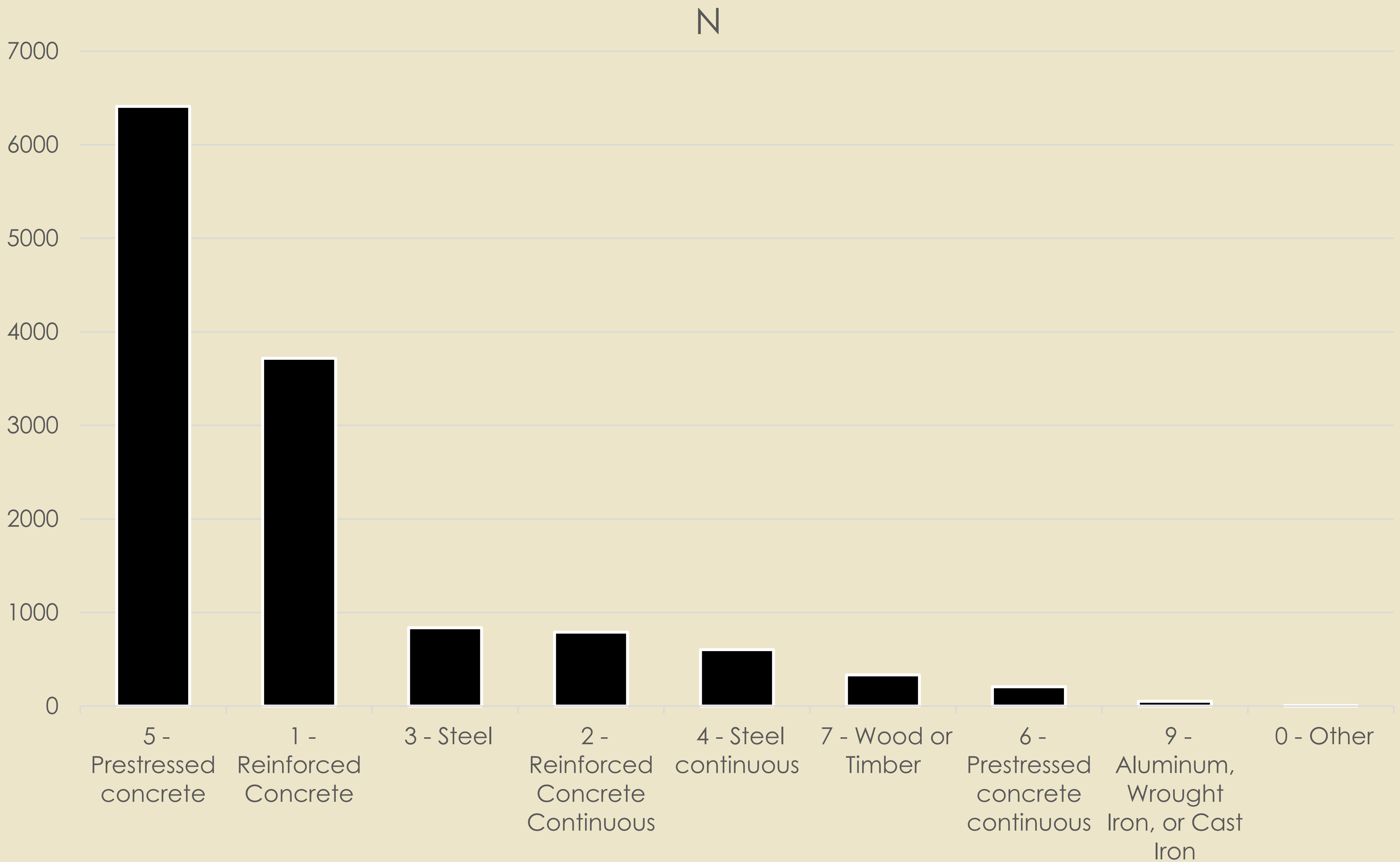
1969 Noble's Ferry over Suwannee, overload

1971 National Bridge Inspection, Federal Aid System

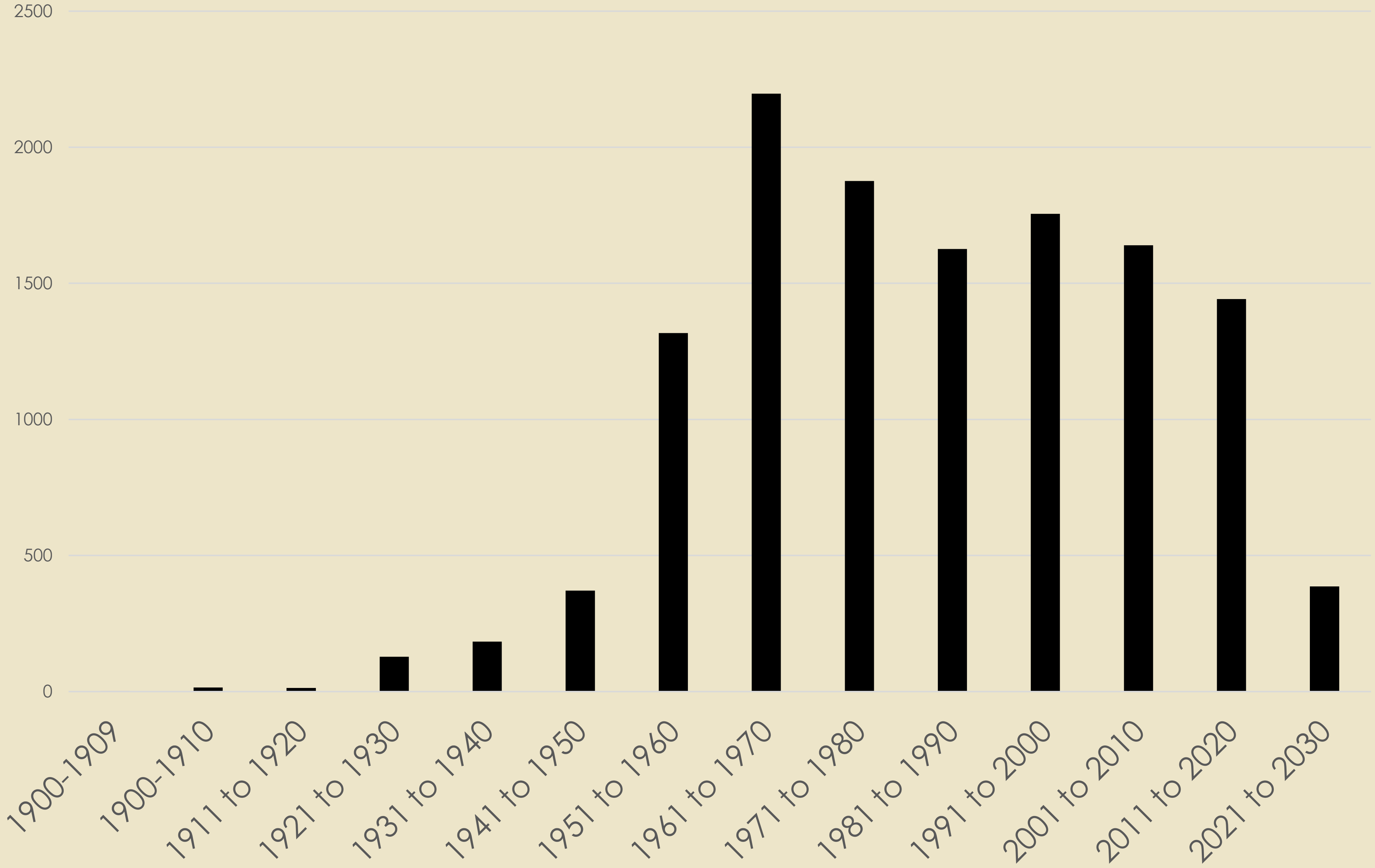
1978 NBI, all public bridges over 20 feet in length

Florida funded an inspection and repair program

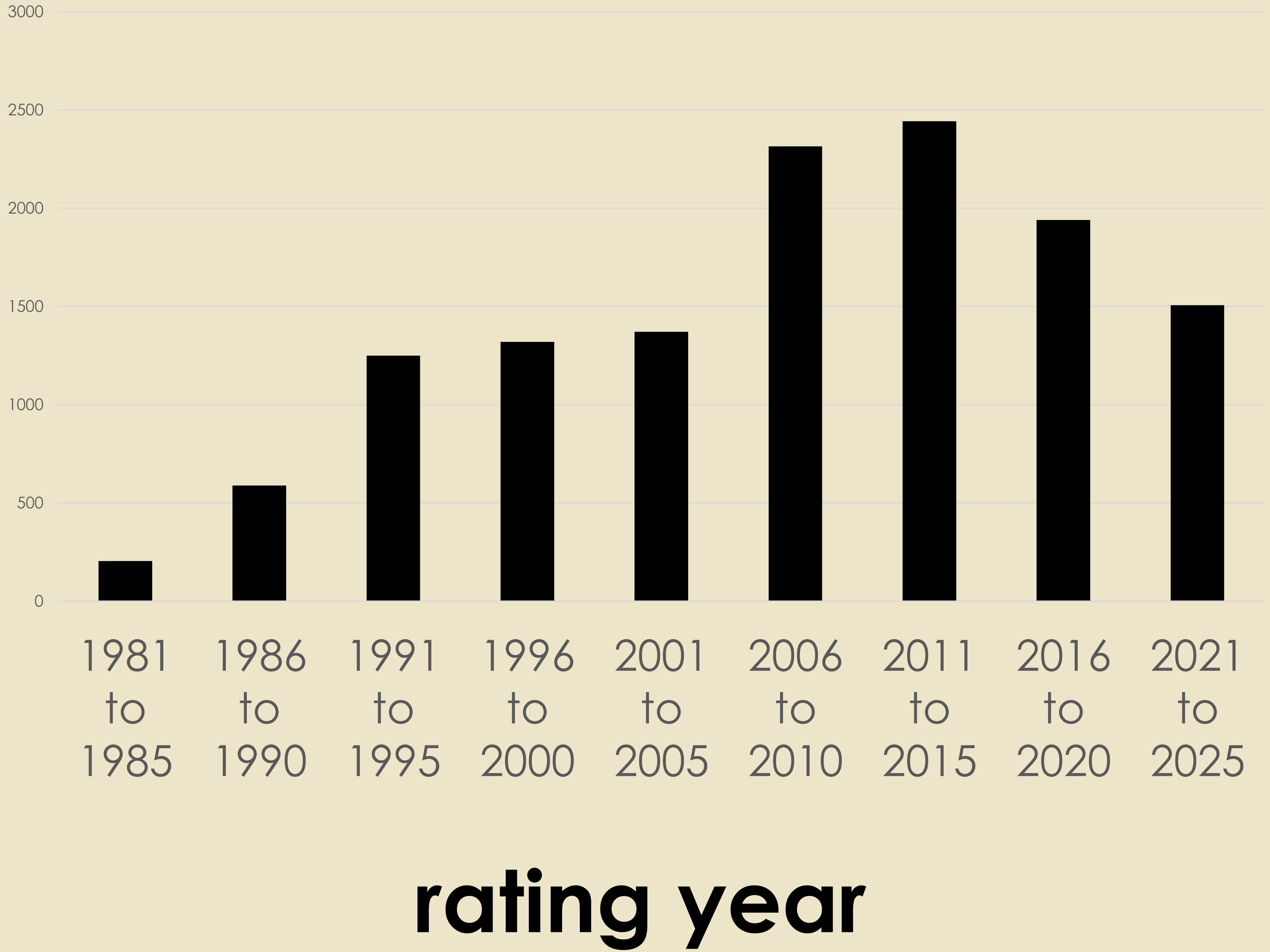
INVENTORY


N
7000
6000
5000
4000
3000
2000
1000
0
5 - Prestressed concrete
1 - Reinforced Concrete
3 - Steel
2 - Reinforced Concrete Continuous
4 - Steel continuous
7 - Wood or Timber
6 - Prestressed concrete continuous
9 - Aluminum, Wrought Iron, or Cast Iron
0 - Other

material


2500
2000
1500
1000
500
0
1900-1909
1900-1910
1911 to 1920
1921 to 1930
1931 to 1940
1941 to 1950
1951 to 1960
1961 to 1970
1971 to 1980
1981 to 1990
1991 to 2000
2001 to 2010
2011 to 2020
2021 to 2030

built



3000
2500
2000
1500
1000
500
0
1981 to 1985
1986 to 1990
1991 to 1995
1996 to 2000
2001 to 2005
2006 to 2010
2011 to 2015
2016 to 2020
2021 to 2025
rating year

RATIONALE

load rating – why do it?

```
SELECT SUM(CASE WHEN ROADWAY.ON_UNDER='1' THEN
ADTTOTAL*TRUCKPCT/100*365
ELSE 0 END) As 'Annual_Truck_Crossings'
FROM dbo.BRIDGE BRIDGE, dbo.ROADWAY ROADWAY
WHERE (BRIDGE.BRKEY = ROADWAY.BRKEY AND  BRIDGE.BRKEY Not Like '%Q%' AND ROADWAY.ON_UNDER='1' AND
BRIDGE.SERVTYPON IN ('1','4','5','6','7','8') AND BRIDGE.DISTRICT<>'09')
```

1/10 penny per truck crossing is $9 million per year

9 billion truck crossings per year

TABLE 2-1—EXISTING BRIDGES

PHASE	ACTION
NBI Inspection	In BrM Inspection Notes, state whether the current load rating is complete and applicable. The note should indicate who made the determination, and when.

. Annually update a load rating work plan that identifies ratings in need of revision. Include ratings that are inadequately documented, and ratings older than 30 years.

7.1.1 Load Rating

A. Before preparing widening or rehabilitation plans, review the inspection report and the existing load rating. If the existing load rating is inaccurate or was performed using an older method (e.g. Allowable Stress or Load Factor), perform a new ***LRFR*** load rating (***MBE*** Section 6, Part A) of the existing bridge in accordance with ***SDG*** 1.7. If any ***LRFR*** design Inventory or any FL120 Permit rating factors are less than 1.0,

TRIGGERS

(1) condition – inspections/widenings/rehabs
(2) posting
(3) permits, inferred ratings

CONDITION


CONDITION
law, repairs, operations


CONDITION


CONDITION
09/23/2009

POSTING

POSTING, 1950s


WEIGHT
LIMIT
10T
15T
17T


WEIGHT
LIMIT
4
TONS
NO
LITTERING
FLA LAW 403.413


WEIGHT
LIMIT
22
TONS

POSTING


WEIGHT
LIMIT
3T
4T
6T


HIRING

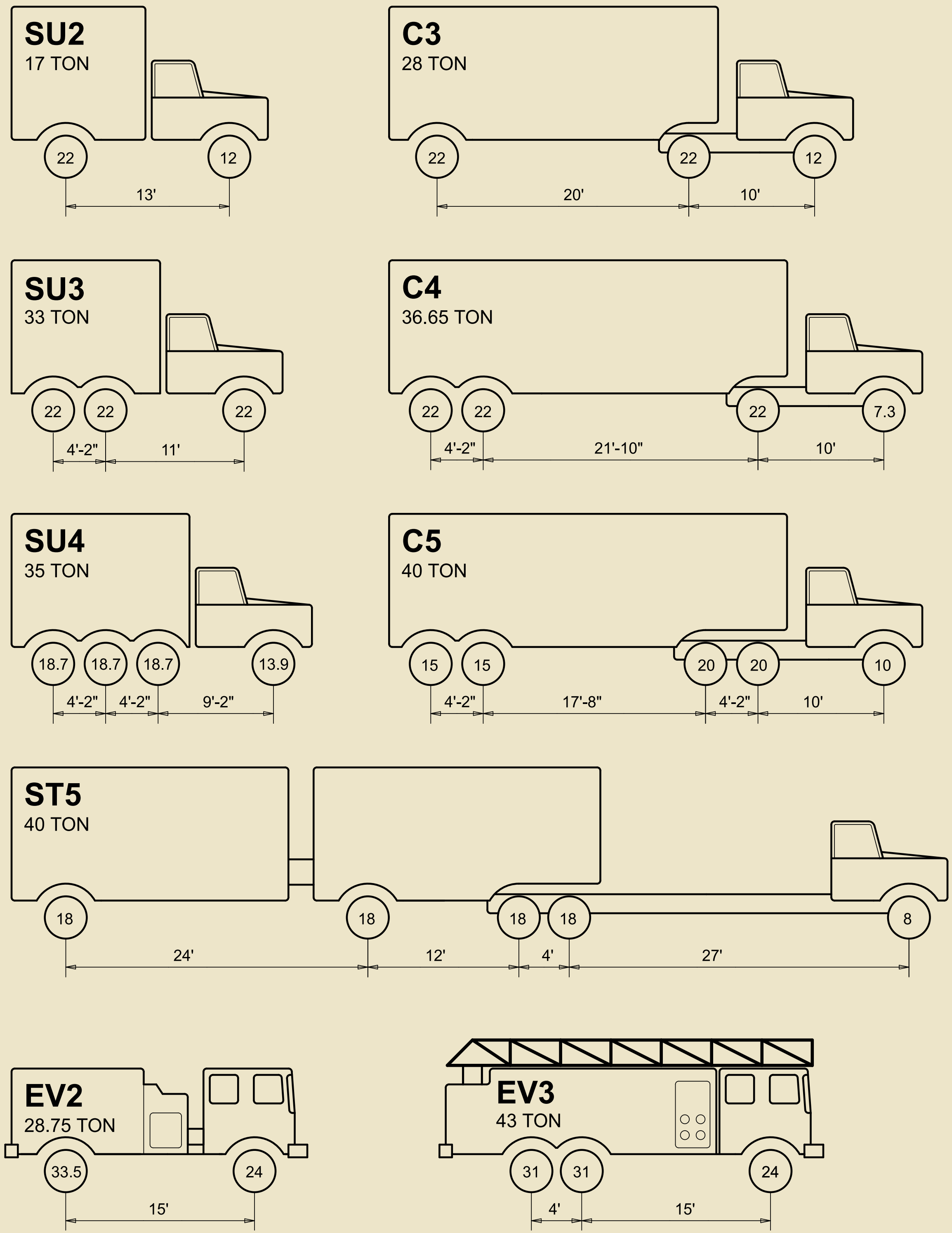

WEIGHT
LIMIT
5
TONS
NO
SEMI
TRUCKS


RAMADA


AULICK
inspired innovation.
A66984


NEWS
follow us on

LEGAL LOAD MODELS



Florida legals

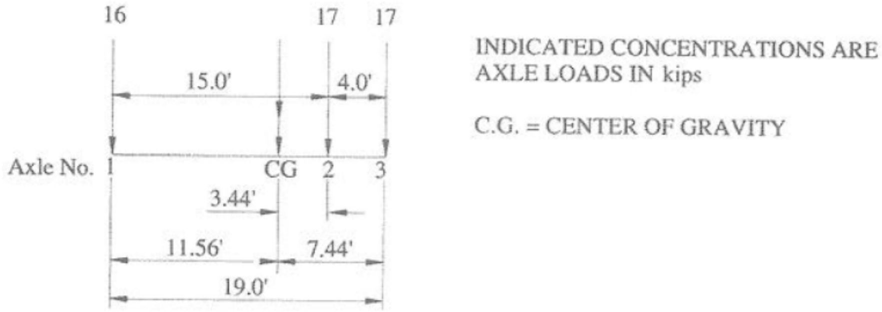


Figure D6A-1—Type 3 Unit; Weight = 50 kips (25 tons)

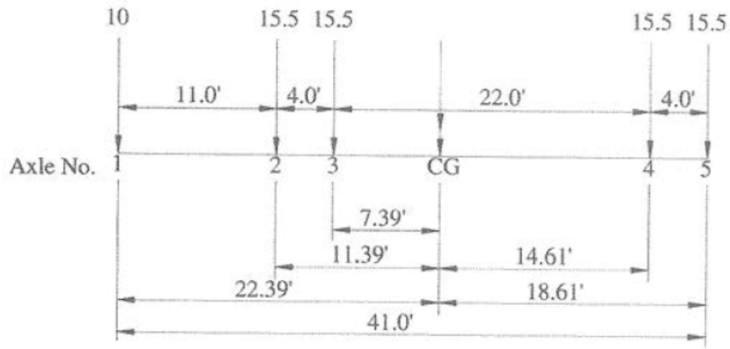


Figure D6A-2—Type 3S2 Unit; Weight = 72 kips (36 tons)

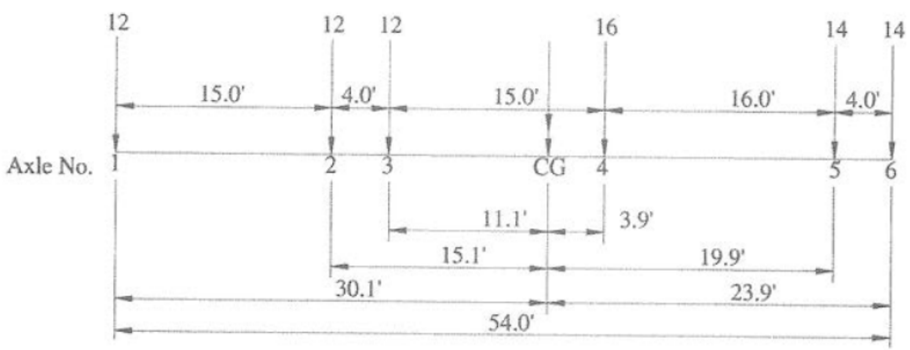
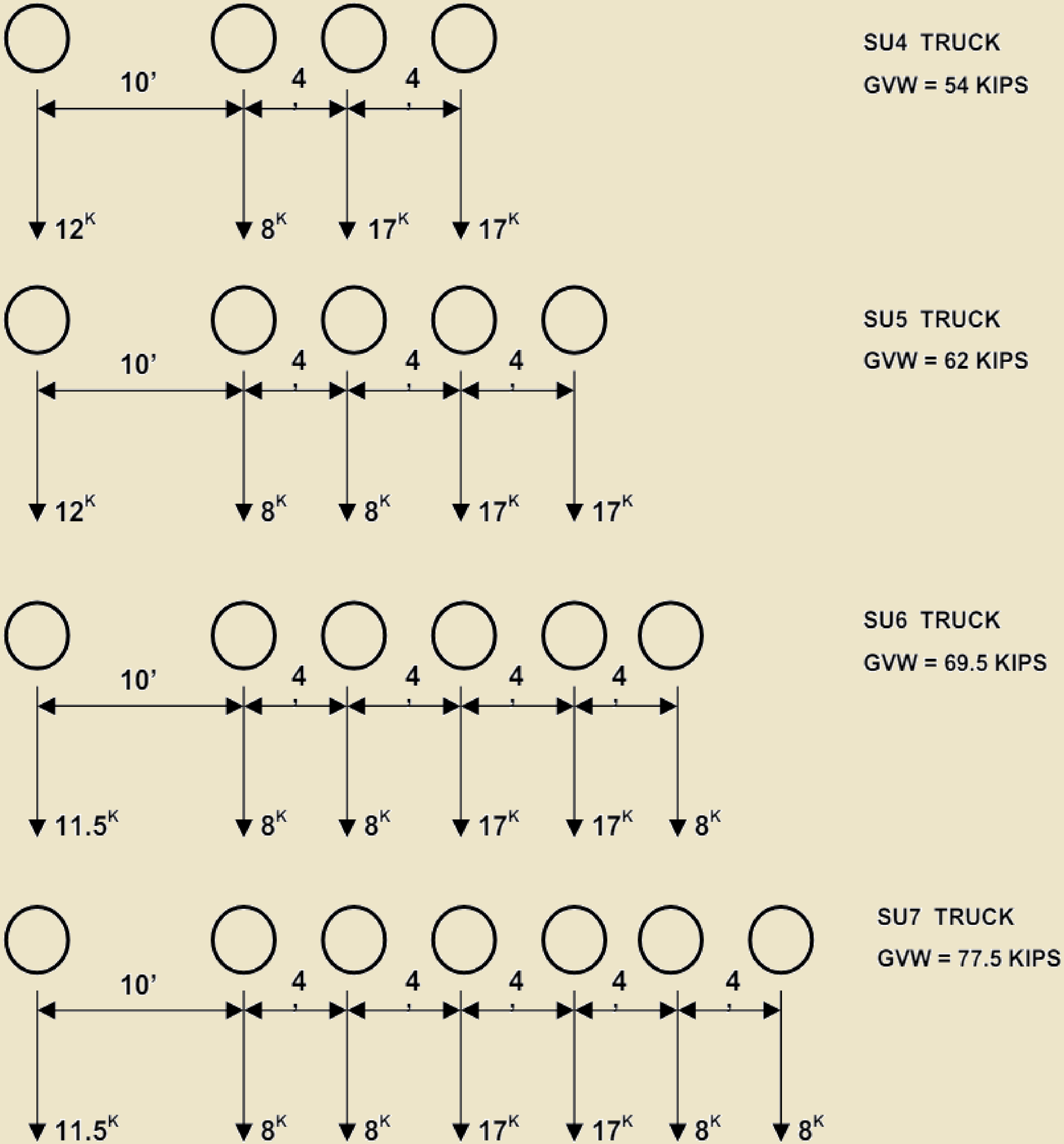


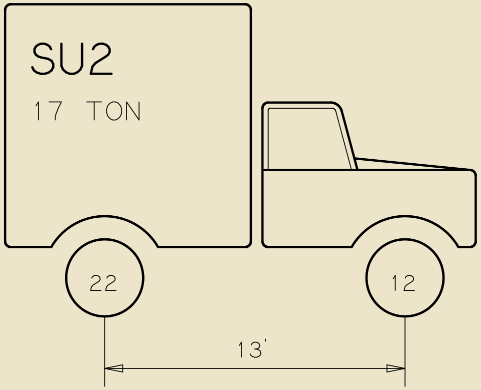
Figure D6A-3—Type 3-3 Unit; Weight = 80 kips (40 tons)

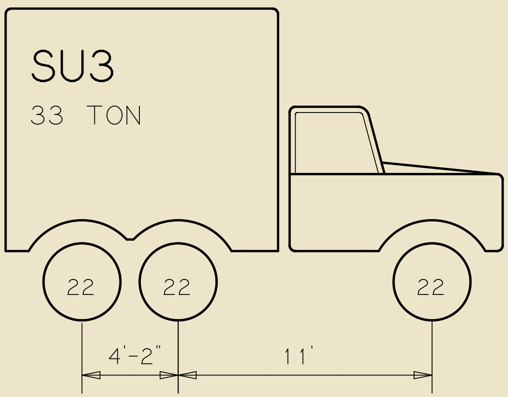
AASHTO legals

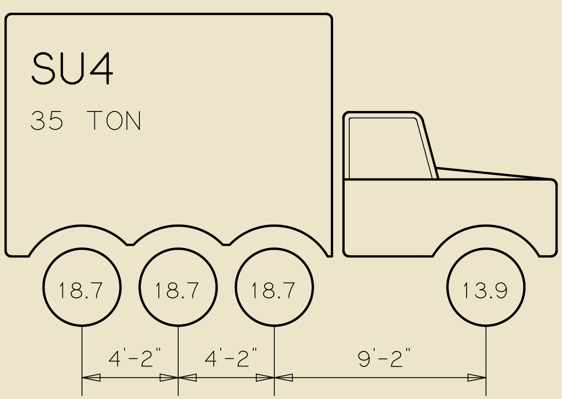


AASHTO SHVs

Figure D6A-7—Bridge Posting Loads for Single-Unit SHVs that Meet Federal Bridge Formula B


SU2
17 TON
22
12
13'


SU3
33 TON
22
22
22
4'-2"
11'


SU4
35 TON
18.7
18.7
18.7
13.9
4'-2"
4'-2"
9'-2"

FDOT SUs


CONCRETE PRODUCTS
CO. INC.
TEL. 222•3367


KENWORTH
DEVCON
USDOT#3447256
TRUCKPLANET

317.96 Reregistration of certain motor vehicles not conforming with §317.77.—Any

quirements of §317.77, provided that such vehicles or combination of vehicles shall be limited to a total gross load, including weight of vehicle, of twenty thousand pounds per axle plus scale tolerances and shall not exceed five

hundred fifty pounds per inch width of tire surface. Such vehicles equipped with more than three axles shall not exceed a gross weight, including the weight of the vehicle and scale tolerances of seventy thousand pounds provided such gross weight shall not exceed twenty thousand pounds per axle and five hundred fifty pounds per inch width of tire surface plus scale tolerances. Such reregistration may be made only by the said commissioner and shall show that the license is a specially issued one. Dump trucks, concrete mixing trucks, fuel oil and gasoline trucks designed and constructed for special type work or use need not be registered as required herein, but shall meet the requirements of this section as to load limits. Any vehicle violating the weight provisions of this section shall be penalized as provided in §317.80.

History.—§1, ch. 26331, 1949; am. §3, ch. 28239, 1953.

317.80 Weight and load unlawful; inspection; penalty; review.—

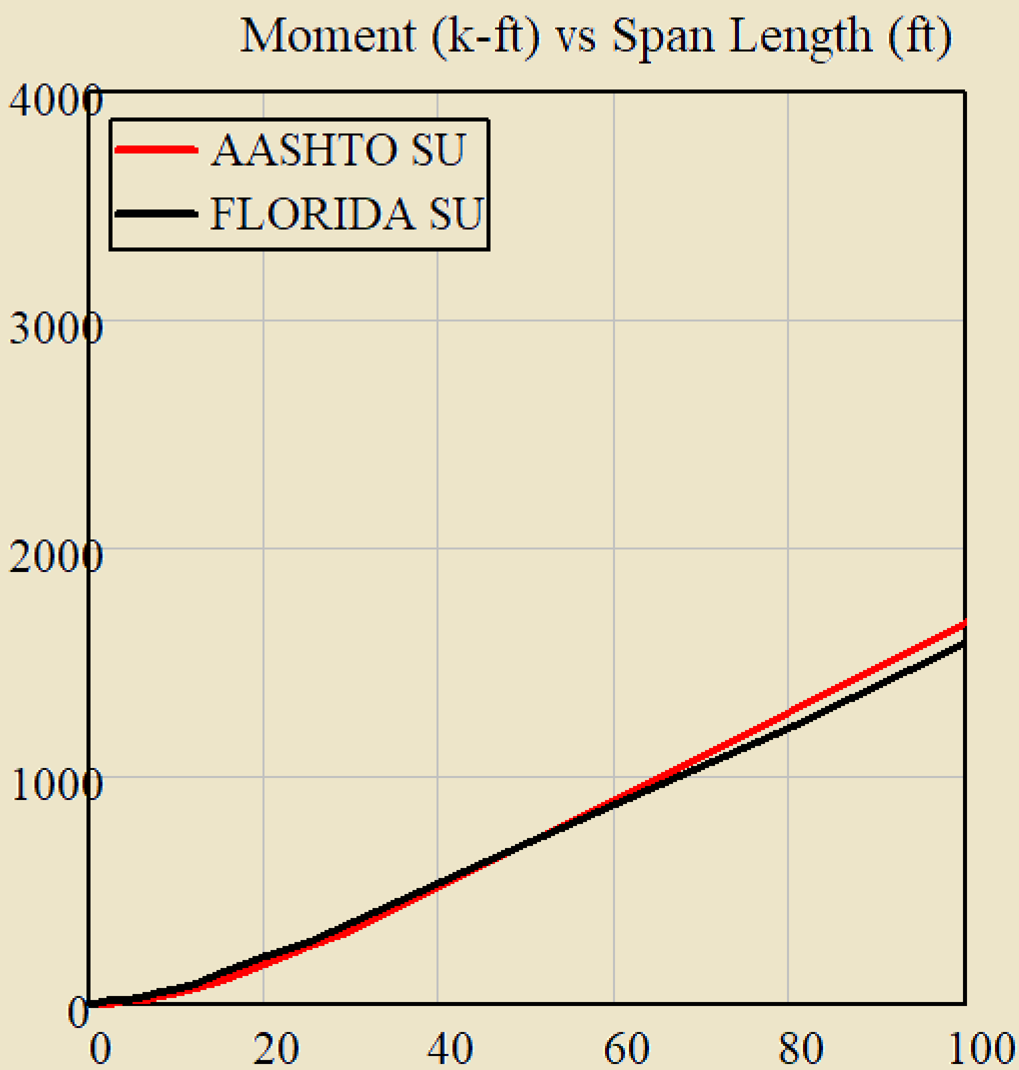
Five cents per pound for each pound of weight in excess of the maximum herein provided when the excess weight exceeds one hundred pounds.

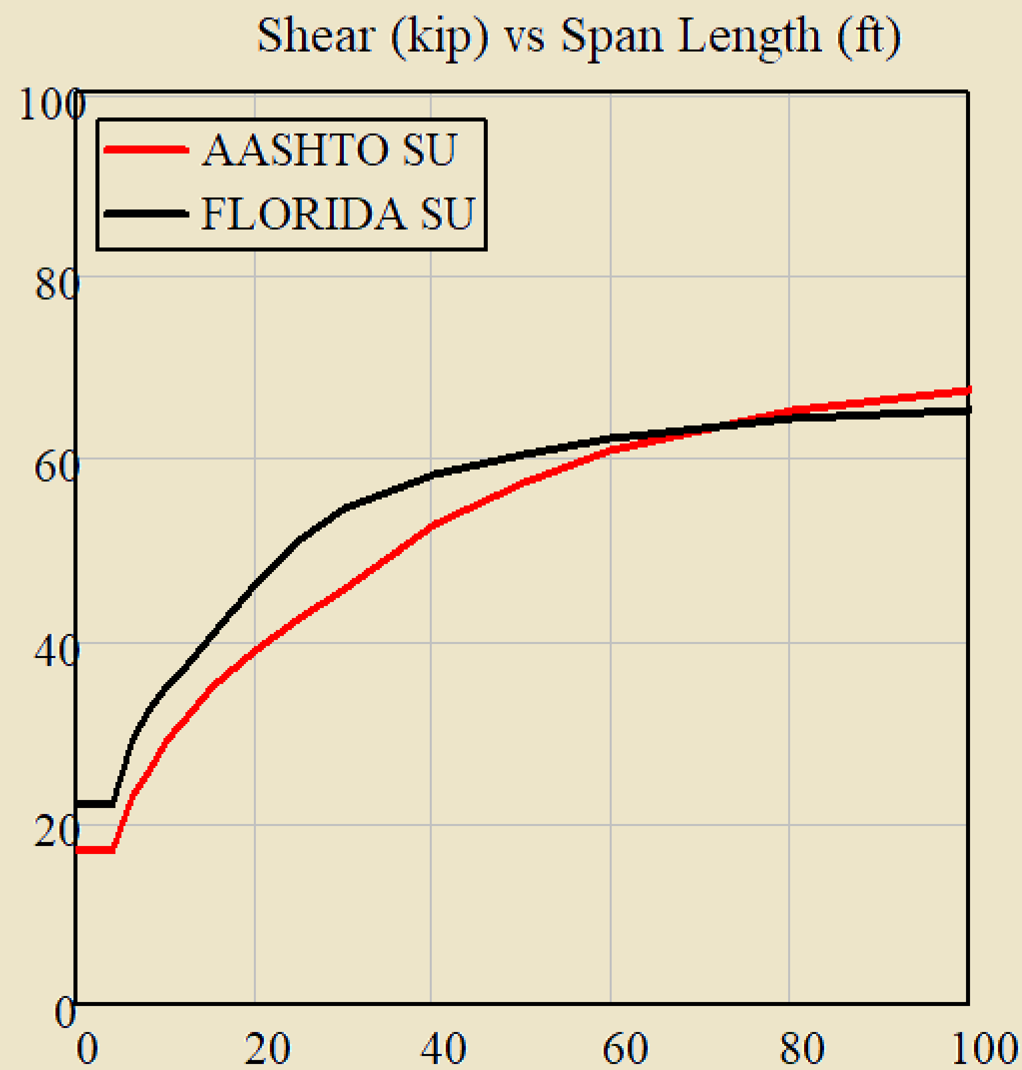
https://library.law.fsu.edu/Digital-Collections/FLStatutes/docs/1961/1961TXXIIC317.pdf

"Dump trucks... ... ... *70,000 pounds*"
FS 316.535(6)

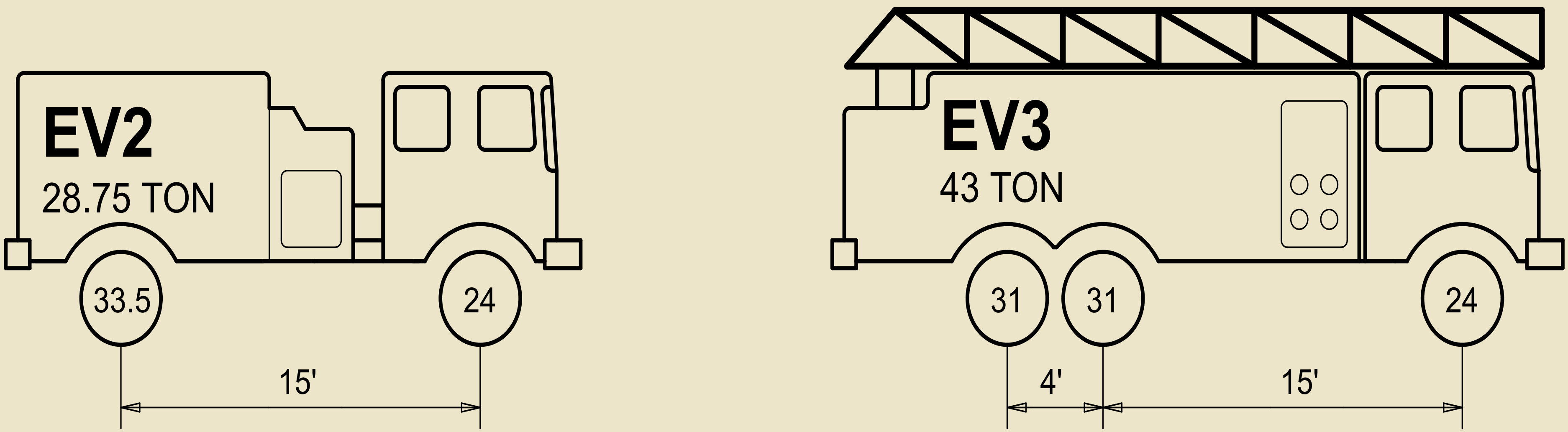
"*Five cents per pound* for each pound of weight in excess of the maximum provided..."
FS 316.545(3)(a)2

1961-2024 Florida Statutes





SHVs OK
FDOT vs AASHTO



https://www.fdot.gov/maintenance/LoadRating.shtm
Florida Bridge Classification for Emergency Vehicles

EVs

EV > SU4, limited to interstate & 1 mile access

PROCEDURE, EXISTING BRIDGES

For LRFR, perform HL93 Inventory, HL93 Operating, and FL120 Permit ratings. If $RF_{HL93\ Operating} \leq 1.30$, also rate the 7 Florida Legal Loads and 2 Emergency Vehicles.

For LFR or ASR, perform HS20 Inventory and HS20 Operating ratings. Also rate the 7 Florida Legal Loads and 2 Emergency Vehicles.

PROCEDURE, WIDENINGS REHABILITATIONS & NEW STRUCTURES

Perform an LRFR rating in accordance with the SDG and this ***Manual***. Report HL93 Inventory, HL93 Operating, and FL120 Permit ratings.

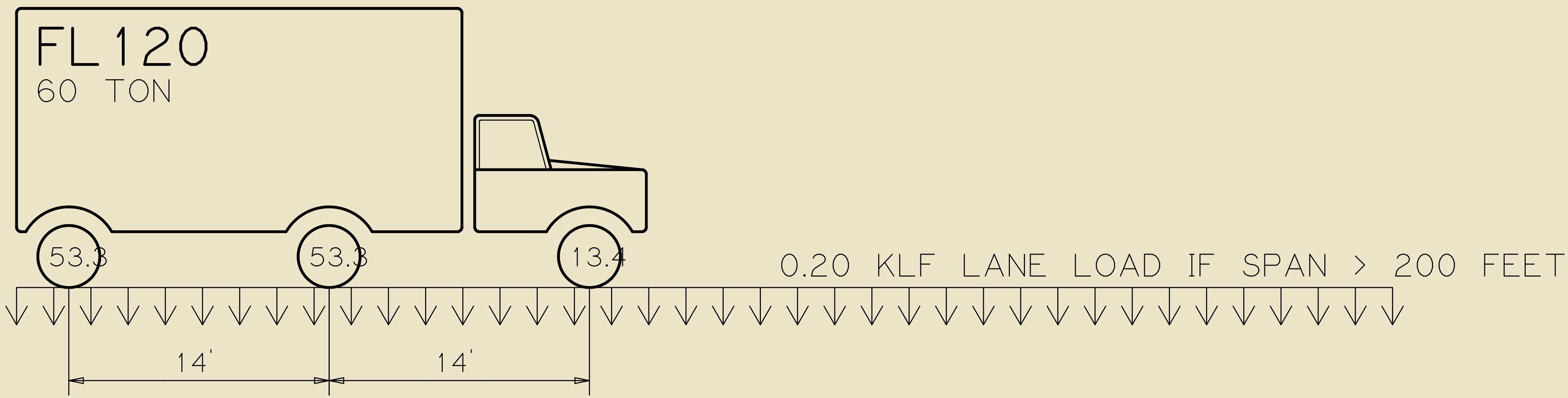
Alternatively, for LFR ratings under SDG Figure 7.1.1-1—Widening/Rehabilitation Load Rating Flow Chart, (1) follow the SDG and this ***Manual***, (2) assess HS20 Inventory, HS20 Operating, 7 Florida Legal Loads, and 2 Emergency Vehicles, (3) ensure that

EVs

PERMITS

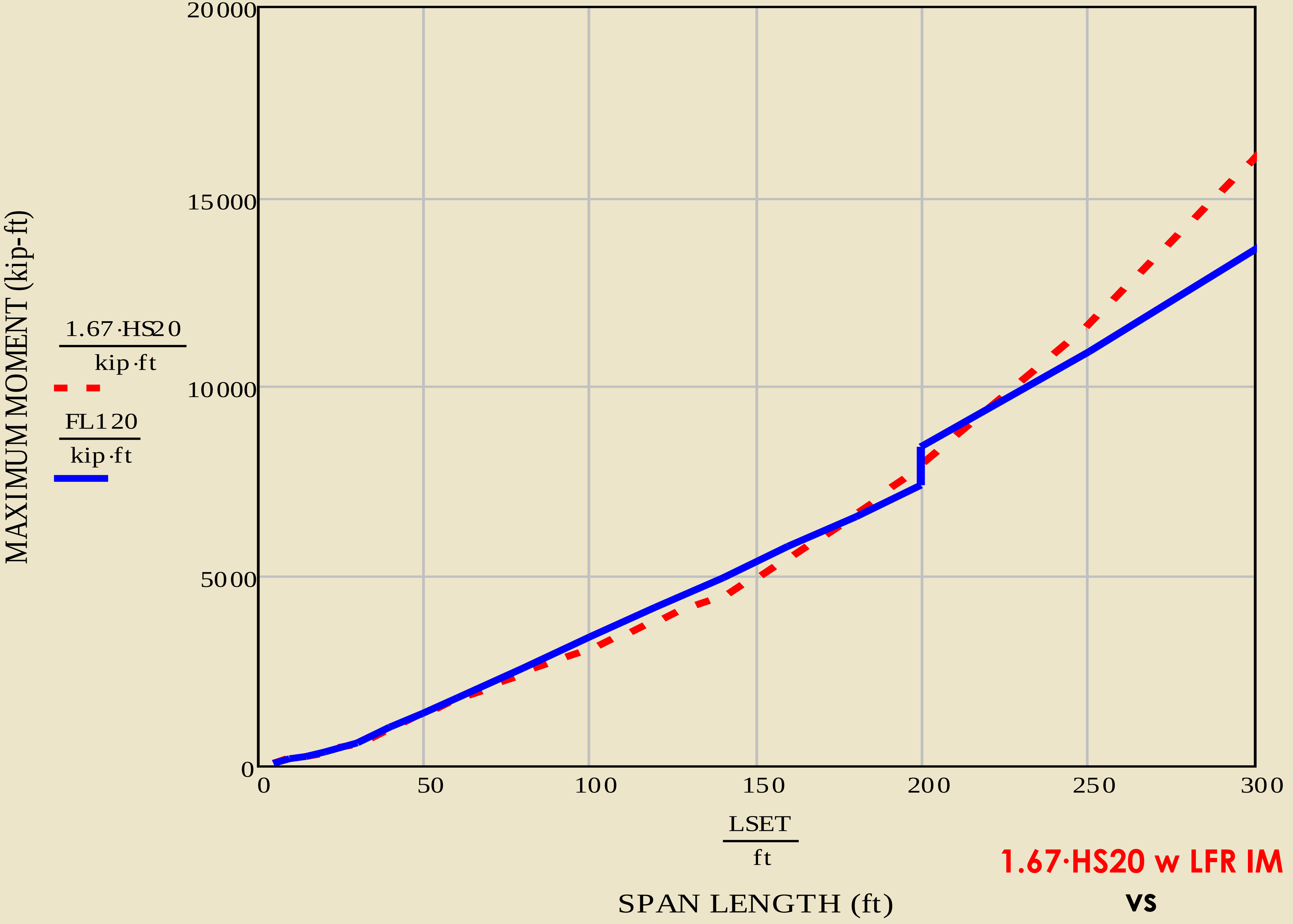
OSOW permits

OSOW permits



FL120 ~ 2.17/1.30·HS20

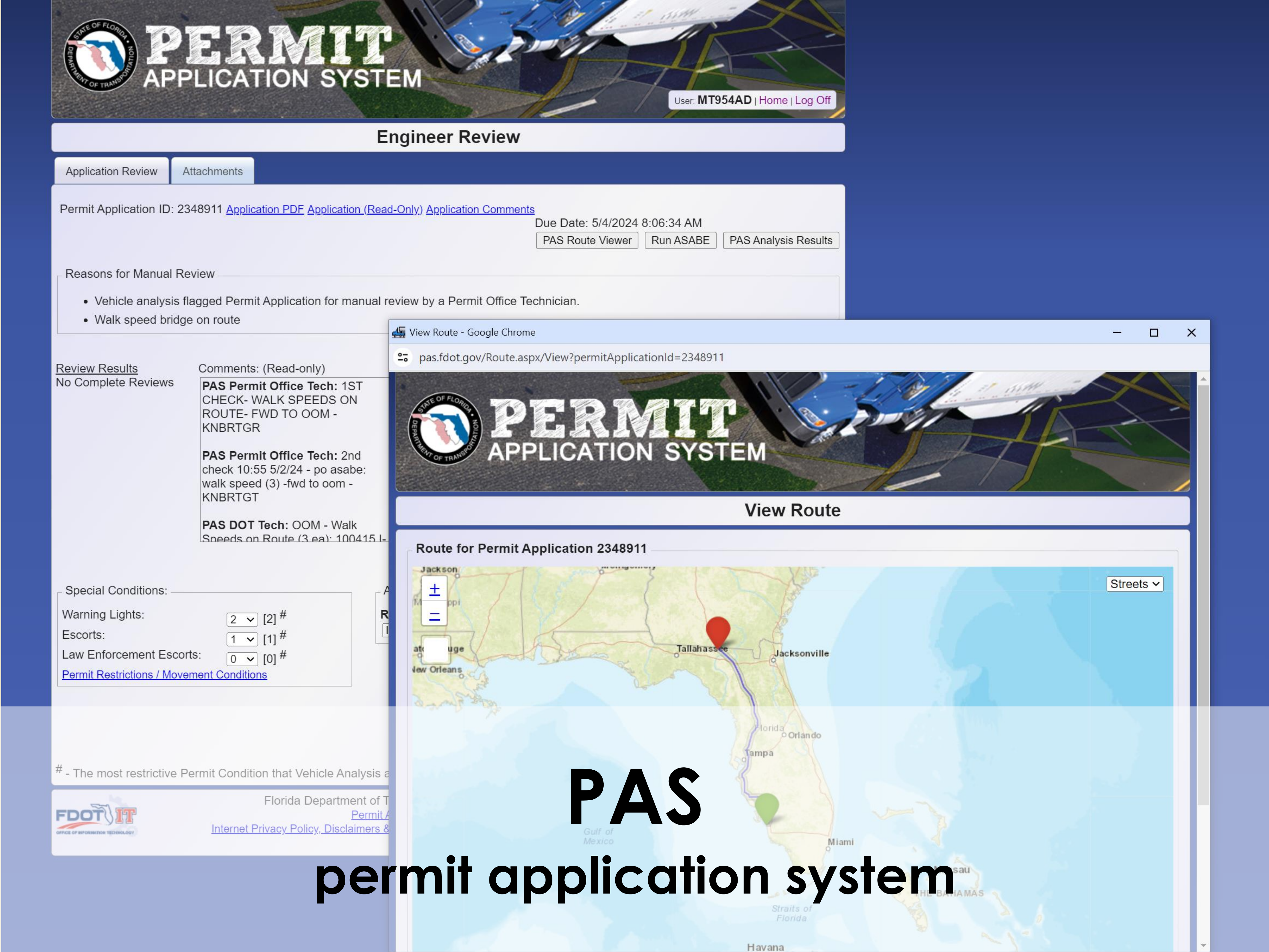
routine permit reference truck



1.67·HS20 w LFR IM

vs

FL120 w LRFR IM



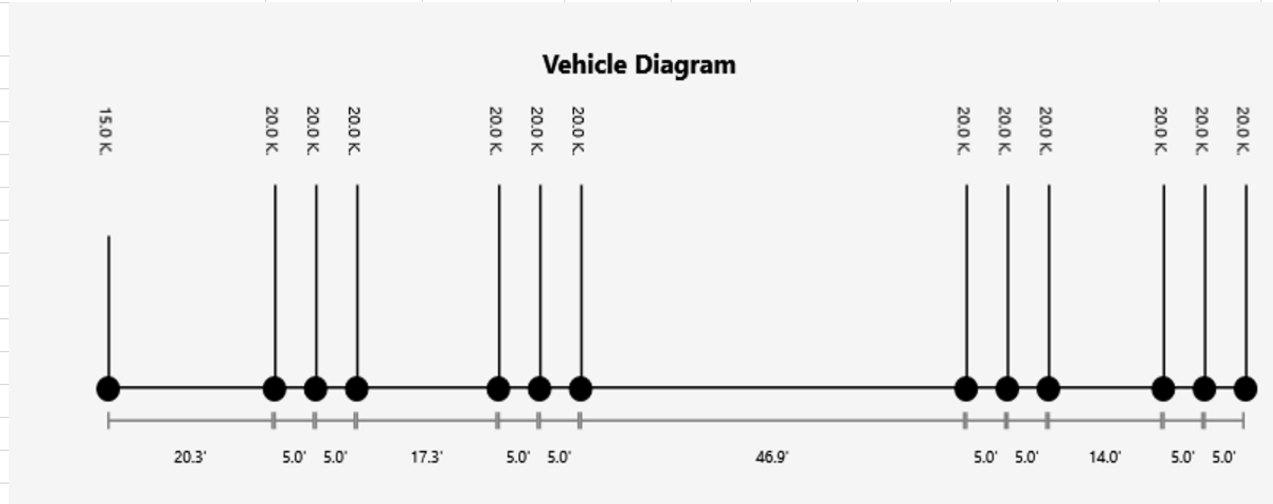
PAS

permit application system

Analysis Creation:	5/2/2024 11:03	Number of Bridges:	188
Permit Application:	2348911	Number of Walk Speed Bridges:	3
Business Name:	MORRIS SHEA BRIDGE COMPANY INC	Number of Failing Bridges:	0
Route Beginning:	5202 MAMIE ST BONITA SPGS, 34134	Number of Special Bridges:	0
Route Ending:	ST_BNDRY: I-75 - AT GEORGIA LINE	Number of Overridden Bridges:	0
Analysis Name:		Technician UserID:	MT954DS
Date Printed:	5/2/2024 11:04		

Vehicle Configuration

Axle Number	Weight (lbs.)	Spacing (ft.)
1	15000	0
2	20000	20.25
3	20000	5
4	20000	5
5	20000	17.25
6	20000	5
7	20000	5
8	20000	46.92
9	20000	5
10	20000	5
11	20000	14
12	20000	5
13	20000	5
	255000	138.42



Bridge Analysis

Bridge	Status	Speed Limit	District	On Interstate	Bridge Type	Display Name	
010001	Pass	55 mph	1	FALSE	Culvert	US-41 (SR-45)/CRES	
Span	Status	Notes	Span Length	OR	PTE	IF	PTEW
Gov	Pass		12	99	28.8	33	23.44
Max	Pass		12	129.2	28.8	33	23.44
010026	Pass	50 mph	1	FALSE	Culvert	US-41 (SR-45)/ELKH	
Span	Status	Notes	Span Length	OR	PTE	IF	PTEW
Gov	Pass		11	89.3	26.76	33	21.78
Max	Pass		14	89.3	32.08	33	26.11
010028	Pass	45 mph	1	FALSE	Culvert	US-41 (SR-45)/HAR	
Span	Status	Notes	Span Length	OR	PTE	IF	PTEW
Gov	Pass		11	51.8	26.76	33	21.78
Max	Pass		[illegible]	51.8	26.76	33	21.78
010042	Pass	45 mph	[illegible]	[illegible]	Slab	US-41 (SR-45)/SUN	
Span	Status	Notes	Span Length	[illegible]	PTE	IF	PTEW
Gov	Pass		24	68.4	38.68	33	31.48
Max	Pass		25	68.4	38.99	33	31.73
010043	Pass	45 mph	[illegible]	[illegible]	Culvert	US-41 (SR-45)/SOU	
Span	Status	Notes	Span Length	OR	PTE	IF	PTEW
Gov	Pass		11	78.4	26.76	33	21.78
Max	Pass		11	78.4	26.76	33	21.78

Key
Culvert
Slab

PAS output

METHODS
and
SOFTWARE

The load factor method is the required method for load rating structures, unless circumstances dictate that other methods be used. The Federal Highway Administration (FHWA) mandated that Bridge Management Inventory Items H9(64) Operating Rating, and H10(66) Inventory Rating be reported in values calculated using the load factor method. All new load ratings and any reanalysis required due to change in condition are to be calculated using the load factor method. The FHWA has set a goal of having all structures on the National Highway System load rated by the load factor method by the time the Department submits the National Bridge Inventory data in 1995. The Department has agreed to try to have all structures that are functionally obsolete or structurally deficient on the National Highway System load rated by the load factor method when the Department submits the National Bridge Inventory data to the FHWA in 1995. Some short span

BLRM 1995

methodology – LFR

(F) The load and resistance factor rating method as modified by the Department is the required method for load rating new structures designed with the Load and Resistance Factor Design method. The LRFR method is the preferred method of analysis. Load Factor Rating may be used for existing structures not Designed using the LRFD method. When a load test has been performed on a structure the load ratings determined by the load test should be entered in the database.

BLRM 2006

methodology – LRFR/LFR

METHODOLOGY, ALL BRIDGES

LRFR is preferred. Existing bridges may use LFR when the maximum span length is less than 200 feet. Existing bridges may also use ASR when the material is timber or corrugated steel.

BLRM 2019

methodology – LRFR/LFR

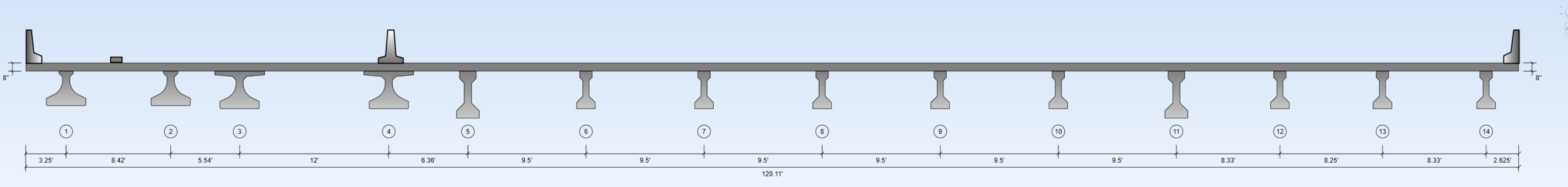
before 2005, BARS was ubiquitous

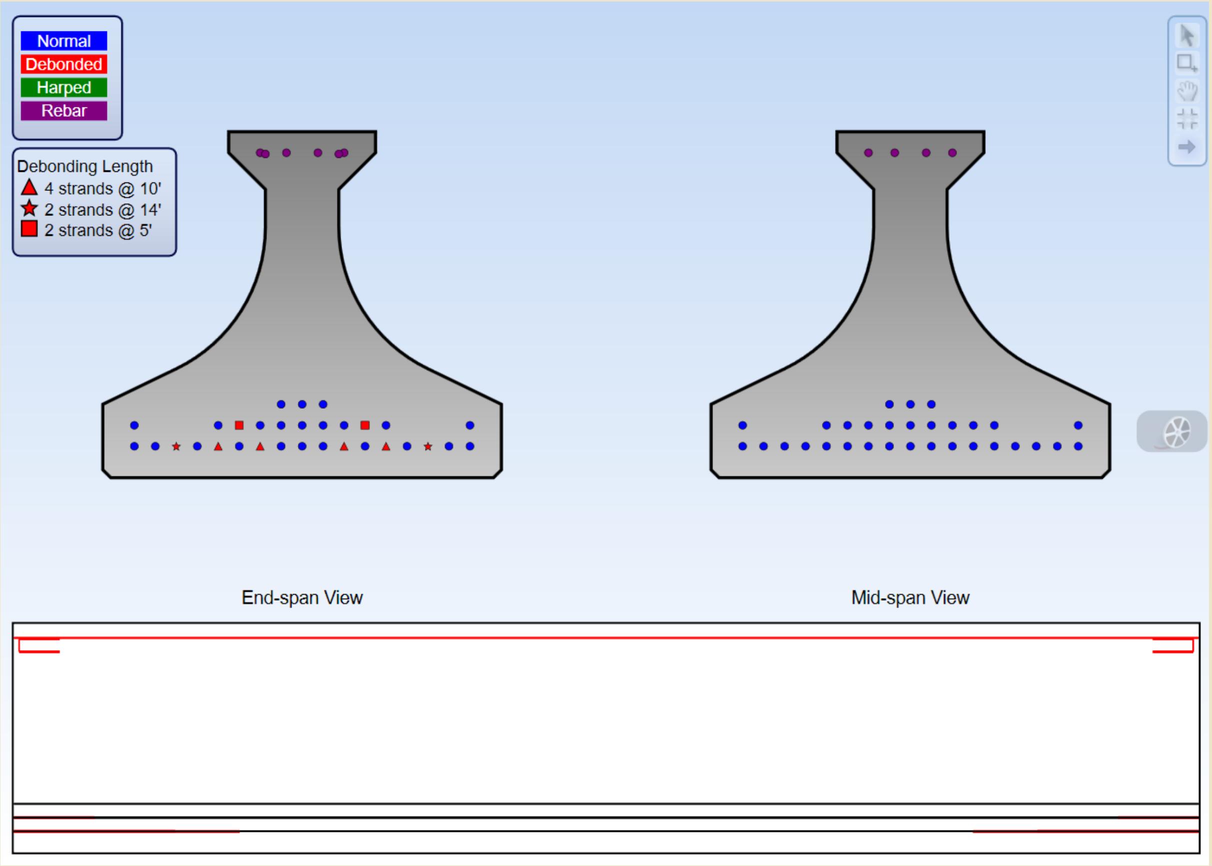
The Bridge Analysis and Rating System (BARS) is the preferred analysis program to load rate all bridge structures unless the BARS system is incapable of rating the bridge. The BARS and other bridge analysis input data shall be stored on the main frame computer disk pack for future analysis, including overload permit analysis. The BARS program is now available on

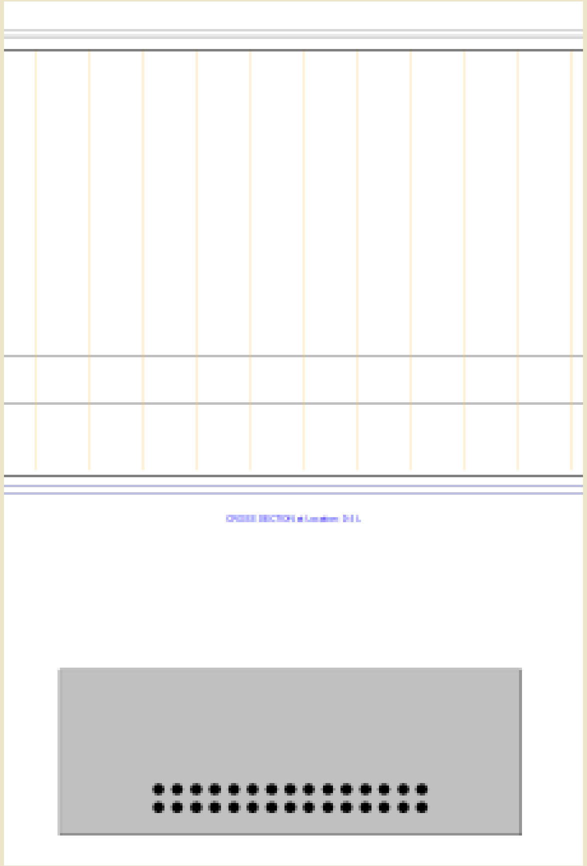
after 2006 – Virtis by rule, not practice

The AASHTO supported software VIRTIS is the preferred load rating program to load rate all bridges that meet the bridge configurations and capabilities of the program.

LFR software – BARS & Virtis







software – anything goes

BENEFITS OF OPEN SOFTWARE POLICY

- Exciting
- Competitive
- Forces cross-checking
- Cheap for small firm one-offs
- Can be cheaper the first time
- Highly-tuned templates (especially culverts, FSBs)

BENEFITS OF SPECIFYING SOFTWARE

- Consistent
- Reusable
- Checkable
- Customizable
- Emergency response (assign damage and share)
- Competitive for Design and Construction, esp. DB
- Opportunities for freight and permitting
- Competitive if import-export door is open to others

1985 BARS

2005 LRFD

##0052 Interior (Beam Bridge)

OPERATING	Method	Level	Vehicle	LEAP RATING FACTORS (Operating)			SDR RATING FACTORS (Operating)			CORVEN RATING FACTORS (Operating)		
				Service I	Service III	Strength	Service I	Service III	Strength	Service I	Service III	Strength
Flexure @ centerline	LFD	Design	HS20 truck	8.06	1.42	2.21	6.34	1.24	2.24	7.41	1.04	2.19
		Permit	T160	5.38	0.95	1.48	4.28	0.83	1.50	4.66	0.65	1.51
	LRFR	Design	HL-93	5.88	1.29	1.59	4.72	1.13	1.57	5.47	0.96	1.59
		Legal	HS-33	4.97	1.11	1.37	4.00	0.96	1.33	4.71	0.82	1.37
		Permit	HS-33	5.39	1.18	1.07	4.27	1.03	1.70	5.01	0.88	1.62
		Permit	T160	5.71	1.25	1.13	4.55	1.10	1.89	5.20	0.91	1.72
Shear @ critical section (h/2)	LFD	Design	HS20 truck			2.92			3.01			4.26
		Permit	T160			1.70			1.81			3.36
	LRFR	Design	HL-93			1.88			2.80			2.83
		Legal	HS-33			1.43			2.31			2.37
		Permit	HS-33			1.96			3.07			3.13
		Permit	T160			2.00			3.16			3.18

				LEAP	SDR	CORVEN Service I	CORVEN Service III	CORVEN Strength
Flexure	LFD	Design	HS20 gov			4.30	0.60	1.27
Shear	LFD	Design	HS20 gov					2.65

BrR! Why?

This is from 2005, and it hasn't gotten much better.

BrR

ALL BRIDGES

For all calculations starting after May 2024, provide a load rating input file legible to AASHTOware BrR. This only applies to structure types that BrR can natively assess.

The LRFR methodology is preferred. Existing bridges may use LFR when the maximum span length is less than 200 feet.

BLRM 2024

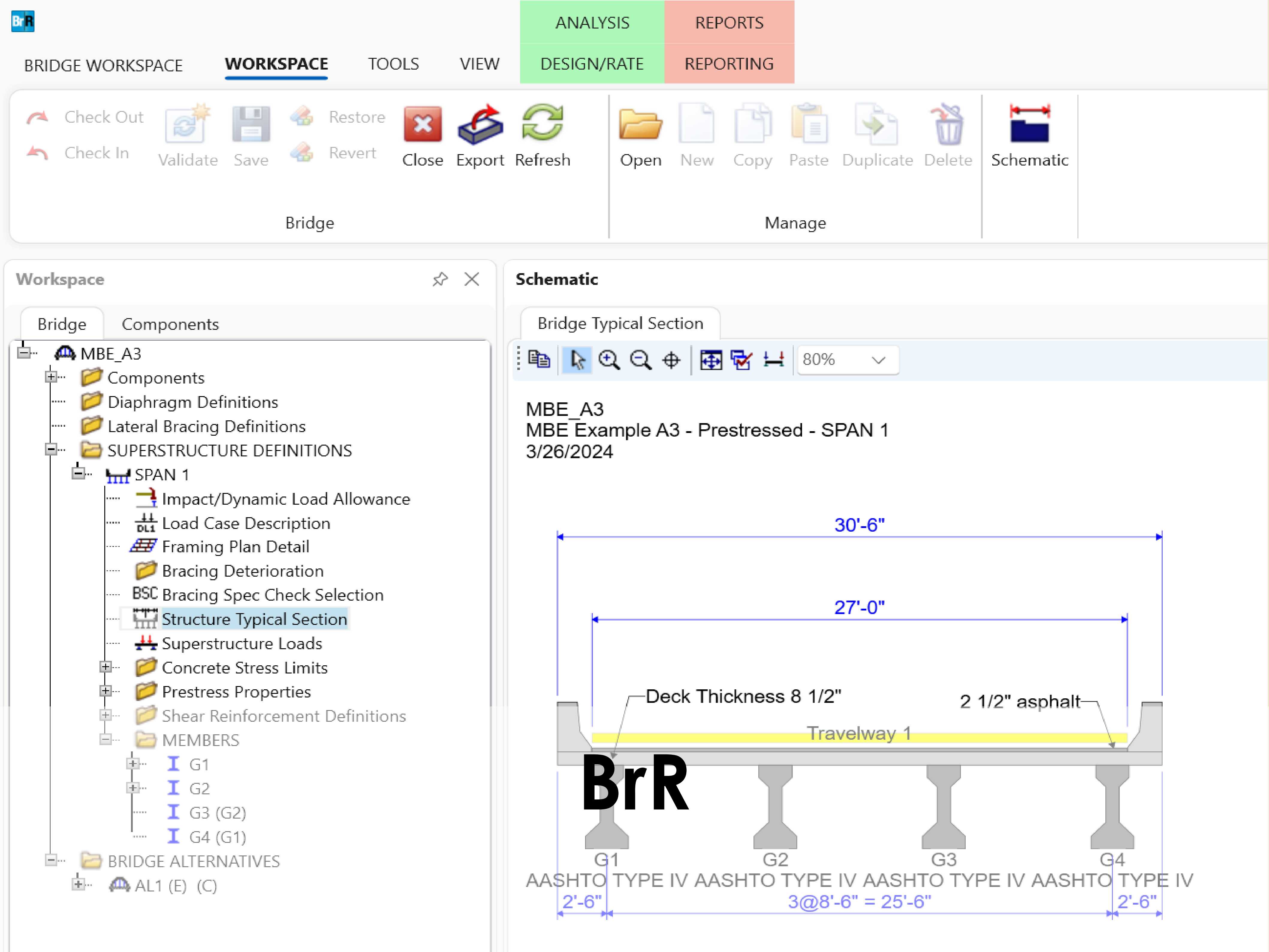
proposed

- Steep learning curve
- Reports & graphics are poor
- Lacks elegance because it satisfies so many requirements (many states, many specifications, coupled with BrDr design, legacy interface), and chases too many structure types
- Users have too much faith in the software

BrR - Cons

- Open candor, about bugs
- Community support and checking with “Jira”
- Ubiquitous, with a portable skill set
- Assesses most structure types
- Spec check outputs are candid and verbose
- Keeps up with code
- Plays well with others (PG Super, permits)
- We own it, literally
- Know what you are getting (widenings, esp.)
- Research inventory – effects of proposed code changes, new laws, new trucks etc.
- Natural segue to permitting
- Capable & correct, for prestress shear, and pliable
- Enhancements by democracy or dollars

BrR - Pros



ANALYSIS
REPORTS
BRIDGE WORKSPACE
WORKSPACE
TOOLS
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DESIGN/RATE
REPORTING
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Check In
Validate
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Restore
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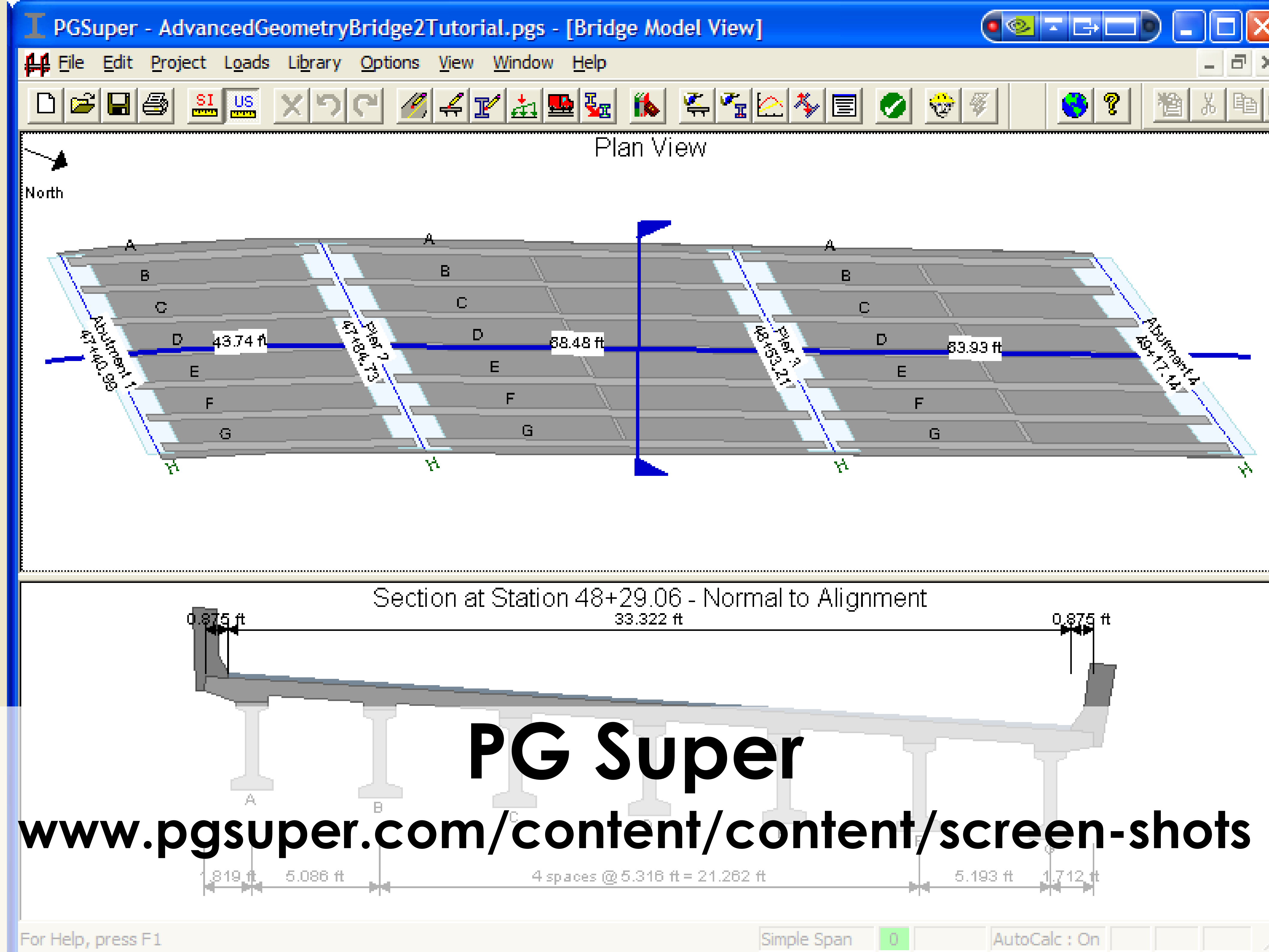
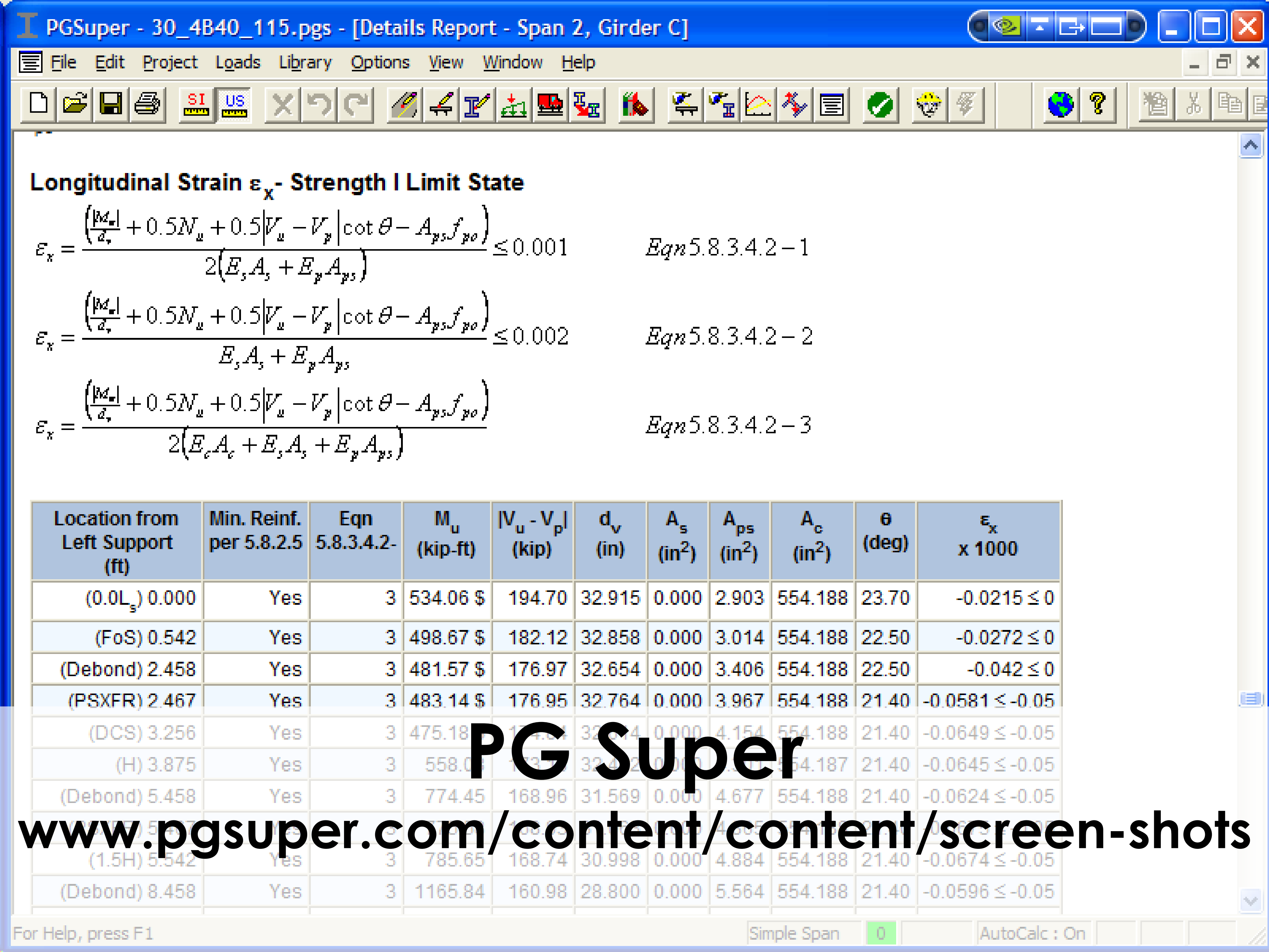
MBE_A3
Components
Diaphragm Definitions
Lateral Bracing Definitions
SUPERSTRUCTURE DEFINITIONS
SPAN 1
Impact/Dynamic Load Allowance
Load Case Description
Framing Plan Detail
Bracing Deterioration
Bracing Spec Check Selection
Structure Typical Section
Superstructure Loads
Concrete Stress Limits
Prestress Properties
Shear Reinforcement Definitions
MEMBERS
G1
G2
G3 (G2)
G4 (G1)
BRIDGE ALTERNATIVES
AL1 (E) (C)
Schematic
Bridge Typical Section
80%
MBE_A3
MBE Example A3 - Prestressed - SPAN 1
3/26/2024
30'-6"
27'-0"
Deck Thickness 8 1/2"
2 1/2" asphalt
Travelway 1
BrR
G1
G2
G3
G4
AASHTO TYPE IV AASHTO TYPE IV AASHTO TYPE IV AASHTO TYPE IV
2'-6"
3@8'-6" = 25'-6"
2'-6"



PG Super

www.pgsuper.com/content/content/screen-shots



Longitudinal Strain ε_x - Strength I Limit State

$$\varepsilon_x = \frac{\left(\frac{|M_u|}{d_v} + 0.5N_u + 0.5|V_u - V_p|\cot\theta - A_{ps}f_{po}\right)}{2(E_sA_s + E_pA_{ps})} \le 0.001 \qquad Eqn\,5.8.3.4.2-1$$

$$\varepsilon_x = \frac{\left(\frac{|M_u|}{d_v} + 0.5N_u + 0.5|V_u - V_p|\cot\theta - A_{ps}f_{po}\right)}{E_sA_s + E_pA_{ps}} \le 0.002 \qquad Eqn\,5.8.3.4.2-2$$

$$\varepsilon_x = \frac{\left(\frac{|M_u|}{d_v} + 0.5N_u + 0.5|V_u - V_p|\cot\theta - A_{ps}f_{po}\right)}{2(E_cA_c + E_sA_s + E_pA_{ps})} \qquad Eqn\,5.8.3.4.2-3$$

Location from Left Support (ft)	Min. Reinf. per 5.8.2.5	Eqn 5.8.3.4.2-	M_u (kip-ft)	$\lvert V_u - V_p \rvert$ (kip)	d_v (in)	A_s (in^2)	A_{ps} (in^2)	A_c (in^2)	θ (deg)	ε_x x 1000
($0.0L_s$) 0.000	Yes	3	534.06 $	194.70	32.915	0.000	2.903	554.188	23.70	-0.0215 ≤ 0
(FoS) 0.542	Yes	3	498.67 $	182.12	32.858	0.000	3.014	554.188	22.50	-0.0272 ≤ 0
(Debond) 2.458	Yes	3	481.57 $	176.97	32.654	0.000	3.406	554.188	22.50	-0.042 ≤ 0
(PSXFR) 2.467	Yes	3	483.14 $	176.95	32.764	0.000	3.967	554.188	21.40	-0.0581 ≤ -0.05
(DCS) 3.256	Yes	3	475.18 [illegible]	[illegible]	[illegible]	0.000	4.154	554.188	21.40	-0.0649 ≤ -0.05
(H) 3.875	Yes	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21.40	-0.0645 ≤ -0.05
(Debond) 5.458	Yes	3	774.45	168.96	31.569	0.000	4.677	554.188	21.40	-0.0624 ≤ -0.05
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(1.5H) 5.542	Yes	3	785.65	168.74	30.998	0.000	4.884	554.188	21.40	-0.0674 ≤ -0.05
(Debond) 8.458	Yes	3	1165.84	160.98	28.800	0.000	5.564	554.188	21.40	-0.0596 ≤ -0.05

PG Super

www.pgsuper.com/content/content/screen-shots

BrR FDOT customization

https://www.fdot.gov/maintenance/LoadRating.shtm

AASHTOware BrR training examples

https://www.aashtowarebridge.com/bridge-rating-and-design/training/

Michigan Tech BrR training

https://www.loadrating.michiganltap.org/

BrR catalog

https://www.aashtoware.org/wp-content/uploads/2024/05/FY-2025-AASHTOWare-Catalog_web.pdf#page=32

BrR resources

TIPS

CONTACTS

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contacts

www.fdot.gov/maintenance/loadrating.shtm

FDOT Table 6A.4.2.2-1—LRFR Limit States and Load Factors

Bridge Type	Limit	DC[7]	LL Inventory	LL Operating	LL Legal	LL FL120	LL EV
Steel[3]	Strength[1]	1.25/0.90	1.75	1.35	1.35	1.35	1.30
	Service[2] II	1.00	1.30	1.00	1.30	0.90	0.90
Reinforced Concrete[4]	Strength[1]	1.25/0.90	1.75	1.35	1.35	1.35	1.30
	Service[2] I	NA	NA	NA	NA	NA	NA
Prestressed Concrete[5]	Strength[1]	1.25/0.90	1.75	1.35	1.35	1.35	1.30
	Service[2] III	1.00	0.80	NA, 0.80[5]	NA, 0.80[5]	NA, 0.70[5]	NA, 0.70[5]

summary - BLRM factors and live load tables

www.fdot.gov/maintenance/loadrating.shtm

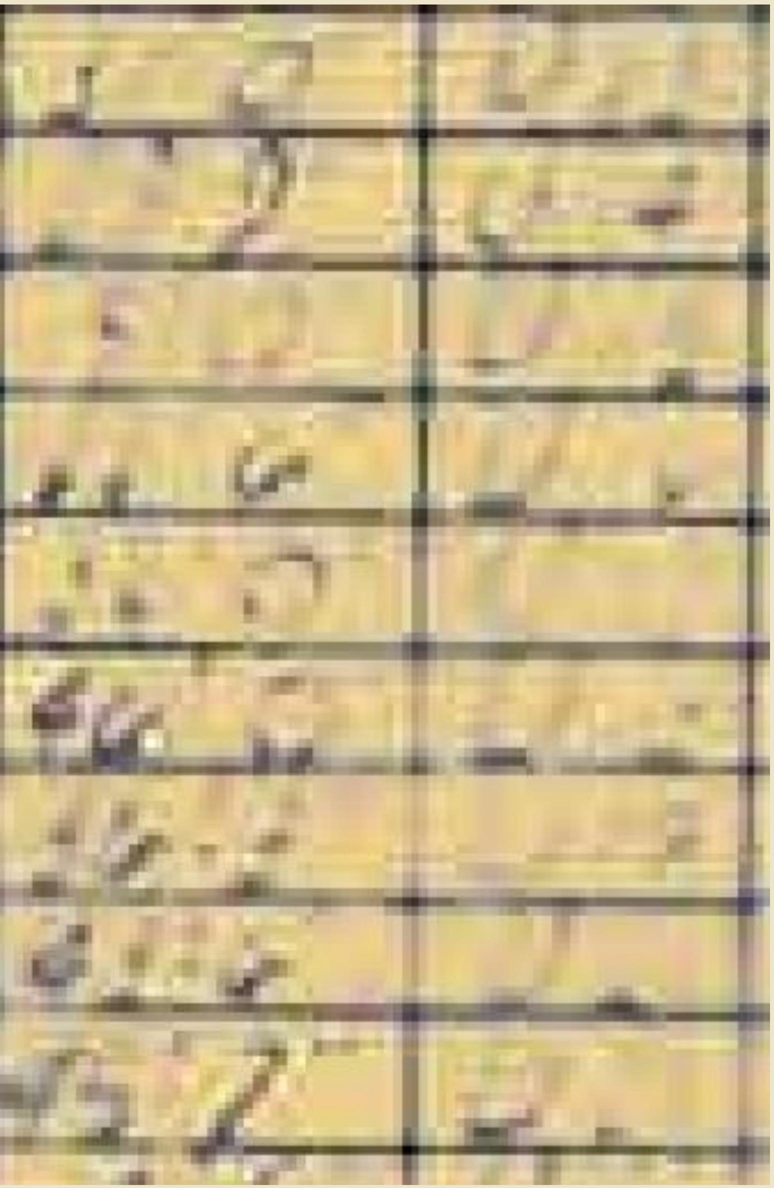
BrR FDOT Customization

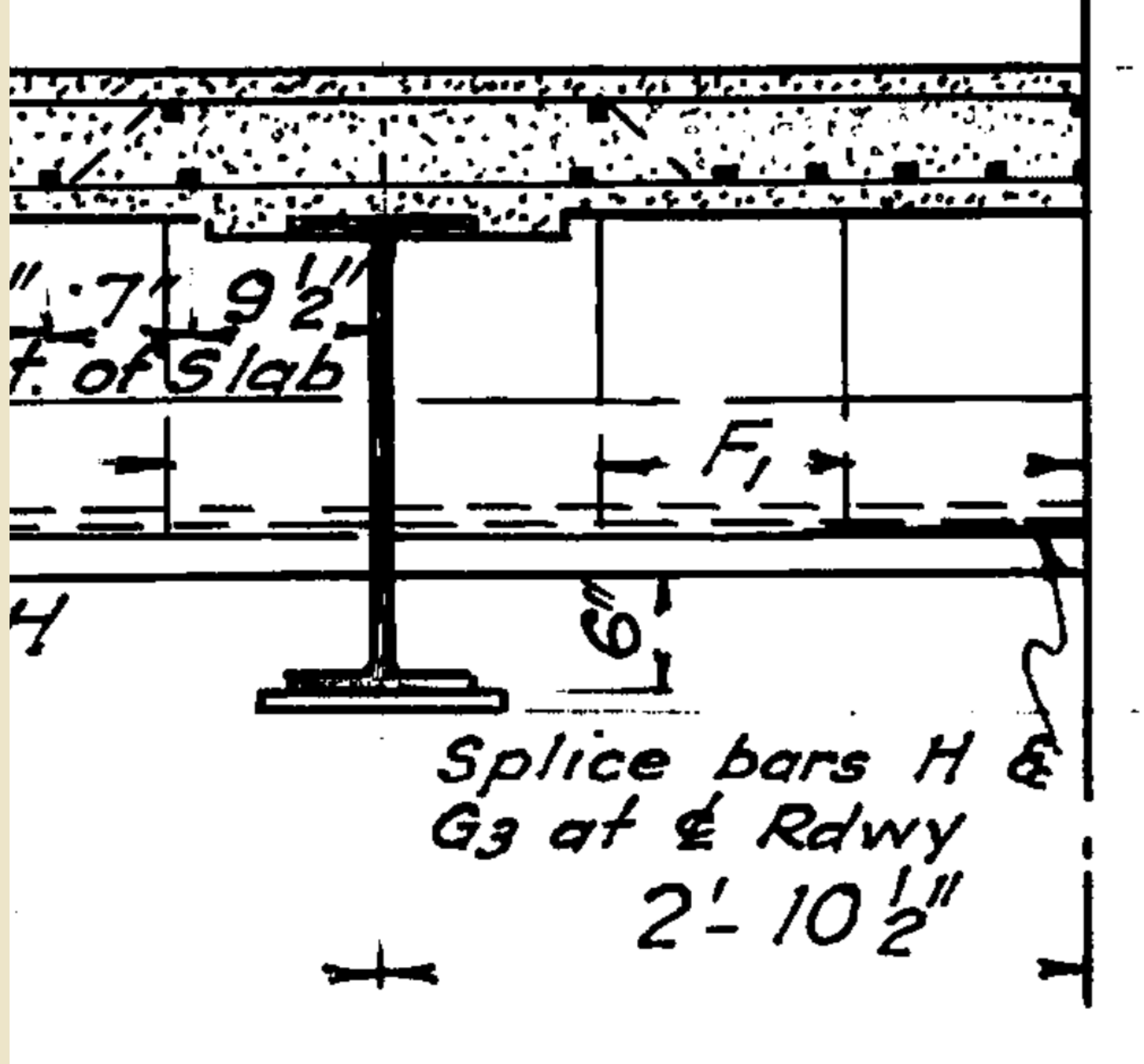
Example, Hinged-End Culvert

Example, Segmental

examples

www.fdot.gov/maintenance/loadrating.shtm





get good plans

- maintenance office
- standard indexes
- as-built plans
- district microfilm

REINFORCING STEEL: Intermediate or Hard Grade

60	HILLSBOROUGH		10110 - 3512
	Names	Dates	APPROVED BY
Detailed by	M.L.H.	3-68	

REINFORCING STEEL: Grade 40 or Grade 60 in Prestressed Beams and Piles, Grade 60 elsewhere.

ROAD NO.	COUNTY		PROJECT NO.
S.R.415	VOLUSIA		79120-3501
	Names	Dates	APPROVED BY
Designed by	L.A.L.	12-74	

for 40 ksi vs 60 ksi stirrups

From: Womble, Steve

Sent: Tuesday, July 20, 2010 1:49 PM

To: Pouliotte, Jeffrey

Cc: Ducher, Jean; Kerr, Richard; Deese, Gregory; Garcia, Jose

Subject: Prestressed beams; shear capacity

Many years ago we did hundreds of load ratings on BARS, and most of those early analyses did not include shear ratings. I think there were some problems with the program, or for other reasons (too far back now to recall), we routinely did not do the shear ratings. But as you know, we're in process of updating all of the ratings by either coming up with the BARS backup for old ratings, obtaining backup for existing ratings from consultants, or in many cases doing a "start to finish" updated rating. We are routinely using Smart Bridge and Virtis, and are typically including a shear analysis, which brings me to the purpose of this note. In many cases shear governs, and in some cases the drop in tons is significant, and this has continued to concern us. Typically we do not have site conditions that indicate problems in shear, so we've continued to discuss the matter, such as the implications of a note found in most plans from the 1970s into the 1990s(?). That note says, with regards to shear steel in the beams, "use grade 40 or grade 60." For a mid-80s bridge, and based on some discussion with your office, we today changed the shear steel strength to grade 60 (where that routine note is present), and the O.R. went from the high 40s to just over 60 tons, for a Cross Town Exwy bridge. The Inventory Rating came out almost perfectly at 36 tons, the weight of the design truck, which is what we would ideally expect. But I still had questions about older bridges such as the 70s decade, since we've seen very similar low shear rating results on many bridges from that period.

So, I called the FPCA earlier today, and was given a few Florida sources for precast concrete construction, and with that info I did some follow up. I called Coreslab Structures in Tampa, and was directed to a former staff member that had recently retired, David L. Bracewell. There is a nice article in the PCI Journal, Fall 2009, on David's retirement, and here is the sum of that article: "David L. Bracewell retired from Coreslab Structures, Inc., this summer after 50 years of service to the precast-prestressed industry. Bracewell was chief engineer for Coreslab/Tampa since the plant was acquired in 1993. He was continuously affiliated with this plant under various business names and ownerships since 1959. Bracewell began his prestressed concrete career with Florida Prestressed Concrete and Douglas Cone, the first PCI chairperson, in 1959. In these early industry years Bracewell was involved in all phases of plant operations, primarily for piling, bridge girders, and railroad bridge slabs."

I had a good chat with David Bracewell, and his is still quite sharp, with a good recall. On the question of the use of various grades of steel for prestressed beam construction, he said that in the late 1960s there was a shift from grade 40 to grade 60 for such beams, and he said that grade 60 was regularly used from then on, since if grade 40 was used, the precaster had to change the stirrup spacing. In other words, the spacing in such plans was based on grade 60, and if a lower grade was used, a correction had to be made on the rebar spacing. That said, I would like to suggest that we here (and others elsewhere?) begin routinely using grade 60 rebar in all of our prestressed load ratings from 1968 (the earlier date David used) onward, and this will improve our Operating Ratings on a large number of prestressed bridges. We typically check the BIR files for any indication of problems (i.e., shear cracks), and such problems are extremely rare (except for the Skyway trestle spans, as you are aware). Jean, what do you think about including this issue in the next Load Rating Steering Committee meeting?

best-available history

Replace Table 6A.5.2.2-1 with:

FDOT Table 6A.5.2.2-1—Yield Strength of Reinforcing Steel

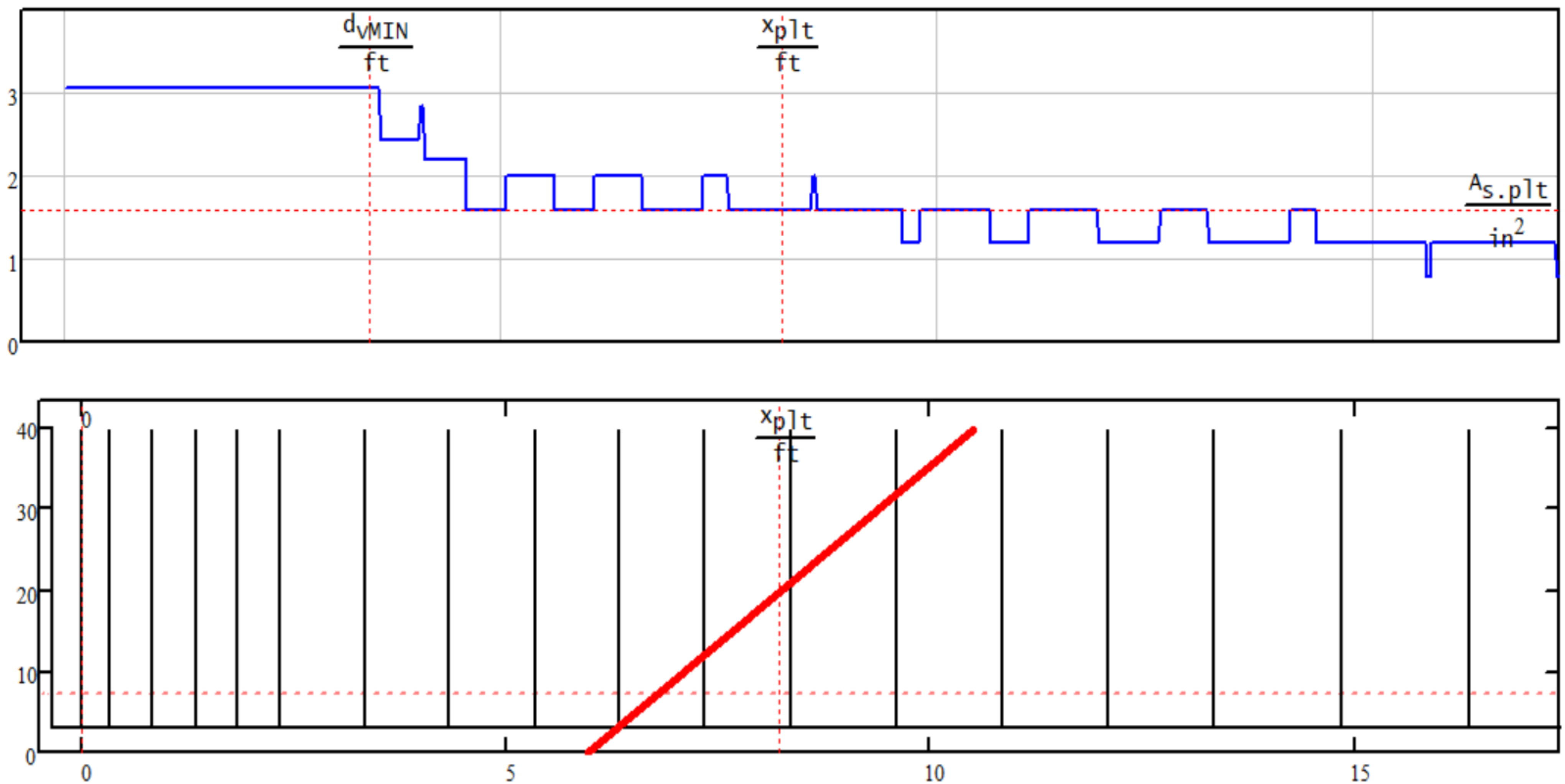
Reinforcing Type	Yield, f_y (ksi)
Unknown, constructed prior to 1954	33
Structural grade	36
Unknown, constructed between 1954 and 1972: billet or intermediate grade	40
Rail or hard grade	50
Unknown, constructed after 1972	60

BLRM

For prestressed members with $RF_{FL120.Shear} < 0.90$, use the Ultimate Demand Based Capacity (UDBC) approach for the FL120. To compute the FL120 shear rating with LRFD 5.7.3.3, (1) Adjust the FL120 live load factor until $RF_{FL120.Shear.Temp}=1.00$, and (2) Divide the adjusted FL120 live load factor by 1.35. For example, $RF_{FL120.Shear.Temp(Load\ Factor=1.20)}=1.00$, so $RF_{FL120.Shear(Load\ Factor=1.35)}=1.20/1.35=0.89$; $0.89 \cdot 60$ tons=53.4 tons.

$RF_{Shear\ 100\%FL120(60.0\ tons)}$	= 0.77, and 100%·60 tons·0.77	= 46.2 tons
$RF_{Shear\ 95\%FL120\ (57.0\ tons)}$	= 0.86, and 95%·60 tons·0.86	= 49.0 tons
$RF_{Shear\ 90\%FL120\ (54.0\ tons)}$	= 0.98, and 90%·60 tons·0.98	= 52.9 tons
$RF_{Shear\ 89\%FL120\ (53.4\ tons)}$	= 1.00, and 89%·60 tons·1.00	= 53.4 tons
$RF_{Shear\ 85\%FL120\ (51.0\ tons)}$	= 1.13, and 85%·60 tons·1.13	= 57.6 tons

Ultimate Demand Based Capacity (UDBC)



UDBC

- Unnecessary for yes/no pass/fail design, or where RF=1.0.
- No effect where $\varepsilon \sim 0$ or RF~1.0; otherwise, closer to RF=1.0.

$$\varepsilon = \frac{\frac{|M_u|}{d_v(x)} + (|V_u - V_p|) - A_{ps}(x) \cdot f_{po}}{28500\text{ksi} \cdot A_{ps}(x)}$$

$$RF = \frac{\text{Capacity} - DL}{LL}$$

- MCFT shear capacity is load dependent.
- Higher loads can reduce capacity.
- UDBC just matches the capacity to the load.

$0.73 \cdot 120\,kip = 43.8\,tonf$

$RF_{DETAILS}$

"γ.LL "	1.35
"VEHICLE"	FL120
"x.test "	$\frac{xplt}{ft}$
"CHOOSE 1/3/4"	3

=

""		""
"	SELECTED CASE. RF:"	0.73
"	SELECTED COL/CASE IS:"	" +V"

"A.ps"	"d.v"	"mSTRAIN"	"β"	"THETA"	"|V.c|"	"V.p"	"|V.s|"	"PHI V"
1.718	38.973	2.183	1.82	36.64	30.097	0	64	84.687

"x"	"br inc"	"iDL"	"TRK#"	"iMIRR"	"iAXL"
8.23	1.24	1	1	0	3

"MMVV"	"φC"	"γDL"	"γLL"	"RF"	"γDL+γLL"
" +M"	1229.78	176.114	788.594	1.336	964.709
" -M"	0	0	0	0	0
" +V"	84.687	14.641	95.918	0.73	110.56
" -V"	−126.291	14.641	9.64	999	24.282

44 tons

FL120, $\gamma_{LL} = 1.35$

$\varepsilon_{eq.1.35\cdot 60\ tons} > \varepsilon_{result\ 1.35\cdot 44\ tons}$

$0.998 \cdot 102\,kip = 50.9\,tonf$

$RF_{DETAILS}$

"γ.LL "	1.35
"VEHICLE"	FL102
"x.test "	$\frac{xplt}{ft}$
"CHOOSE 1/3/4"	1

=

""		""
"	SELECTED CASE. RF:"	1.572
"	SELECTED COL/CASE IS:"	" +M"

"A.ps"	"d.v"	"mSTRAIN"	"β"	"THETA"	"|V.c|"	"V.p"	"|V.s|"	"PHI V"
1.718	38.973	1.145	2.582	33.008	42.696	0	64	96.026

"x"	"br inc"	"iDL"	"TRK#"	"iMIRR"	"iAXL"
8.23	1.24	1	1	0	3

"MMVV"	"φC"	"γDL"	"γLL"	"RF"	"γDL+γLL"
" +M"	1229.78	176.114	670.305	1.572	846.42
" -M"	0	0	0	0	0
" +V"	96.026	14.641	81.531	0.998	96.172
" -V"	−158.711	14.641	8.194	999	22.836

51 tons

FL102, $\gamma_{LL} = 1.35$

$\varepsilon_{eq.1.35\cdot 51\ tons} = \varepsilon_{result\ 1.35\cdot 51\ tons}$

$0.999 \cdot 120\,kip \cdot 1.147 \div 1.35 = 50.9\,tonf$

$RF_{DETAILS}$

"γ.LL "	1.147
"VEHICLE"	FL120
"x.test "	$\frac{xplt}{ft}$
"CHOOSE 1/3/4"	1

=

""		""
"	SELECTED CASE. RF:"	1.573
"	SELECTED COL/CASE IS:"	" +M"

"A.ps"	"d.v"	"mSTRAIN"	"β"	"THETA"	"|V.c|"	"V.p"	"|V.s|"	"PHI V"
1.718	38.973	1.143	2.585	32.999	42.74	0	64	96.066

"x"	"br inc"	"iDL"	"TRK#"	"iMIRR"	"iAXL"
8.23	1.24	1	1	0	3

"MMVV"	"φC"	"γDL"	"γLL"	"RF"	"γDL+γLL"
" +M"	1229.78	176.114	670.013	1.573	846.128
" -M"	0	0	0	0	0
" +V"	96.066	14.641	81.495	0.999	96.137
" -V"	−158.716	14.641	8.191	999	22.832

51 tons

FL120, $\gamma_{LL} = 1.147$

$\varepsilon_{eq.1.147\cdot 60\ tons} = \varepsilon_{result\ 1.35\cdot 60\ tons}$

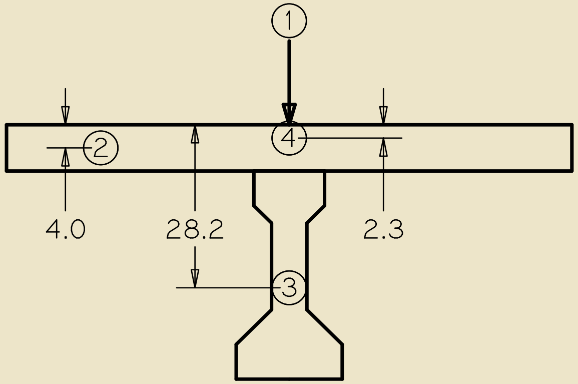
$$RF_{FL120.1.35} := \frac{\boxed{84.687} - 14.641}{95.918} = 0.73 \qquad 0.73 \cdot 120\,kip \cdot \frac{1.35}{1.35} = \underline{44\,tonf}$$

$$RF_{FL102.1.35} := \frac{\boxed{96.026} - 14.641}{81.531} = 0.998 \qquad 0.998 \cdot 102\,kip \cdot \frac{1.35}{1.35} = \underline{51\,tonf}$$

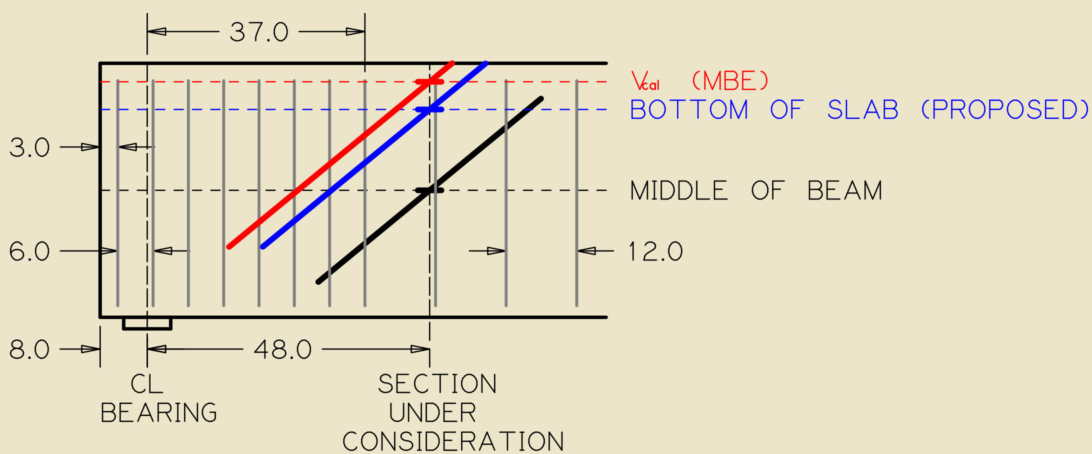
$$RF_{FL120.1.147} := \frac{\boxed{96.066} - 14.641}{81.495} = 1.00 \qquad 1.00 \cdot 120\,kip \cdot \frac{1.147}{1.35} = \underline{51\,tonf}$$

UDBC

(1) Report RF_{FL120} = 0.85 at γLL = 1.35; 0.85·60=51 tons.
(2) Know non-UDBC MCFT RF_{shear} > 1.00 is unconservative.
(3) BrR can perform UDBC natively



1. 51 kip LIVE LOAD
2. 8" x 96 " SLAB
3. AASHTO TYPE II BEAM
4. V.cal - VERTICAL CENTROID OF APPLIED LOADS



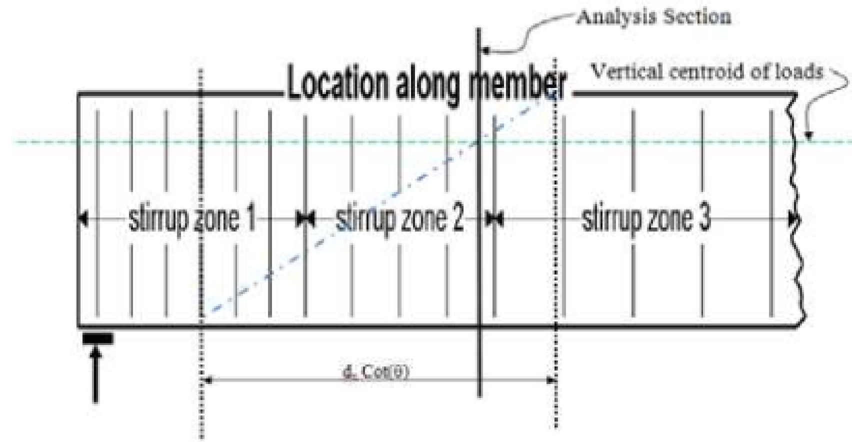


Figure C6A.5.8-1

The relationship between the location of the analysis section and longitudinal zone of stirrups that resist the shear at that section is a function of the vertical position of the load applied to the member, including its self-weight. Ideally, a shear crack inclined at an angle θ intersects the vertical centroid of the applied load as shown in Figure C6A.5.8-1. However, since establishing the vertical centroid requires additional resources and is difficult to implement within software, it is recommended to assume that the shear failure plane intersects the section at mid depth of the member, which will yield conservative capacity.

MBE C6A.5.8-1

Thanks to Chad Smith of HDR for researching

For #170082 FL120-LRFR, I got:

- **57** tons Conspan Ver 20 HDR model with approximate distribution, unmodified general method
- **37** tons Conspan Ver 22 HDR model with approximate distribution, unmodified general method

Conspan Versions

$$\varepsilon_s = \frac{\left(\frac{|M_u|}{d_v} + 0.5N_u + |V_u - V_p| - A_{ps} f_{po}\right)}{E_s A_s + E_p A_{ps}} \qquad (5.7.3.4.2\text{-}4)$$

Since the section is outside the transfer length, the full value of f_{po} will be used in calculating the shear resistance.

MBE 2022 Interims A-120.2

Internally at file://codata/Shares/CO/OOM/Structures/MANUALS/AASHTO%20MBE%202022%20Interims.pdf#page=546

Since the transfer length, $L_{transfer} = 3\ ft$, is less than the shear check location, $ShearChk = 3.2\ ft$, from the end of the beam, the full force of the strands are effective.

FDOT LRFD Design Example #12

https://www.fdot.gov/docs/default-source/structures/structuresmanual/currentrelease/precastbeamexample.pdf#page=85

Old Conspan per MBE, per FDOT

$$\varepsilon_s = \frac{\left(\frac{|M_u|}{d_v} + 0.5N_u + |V_u - V_p| - A_{ps} f_{po}\right)}{E_s A_s + E_p A_{ps}} \quad (5.7.3.4.2\text{-}4)$$

A_{ps} = area of prestressing steel on the flexural tension side of the member, as shown in Figure 1 (in.^{2})

A_s = area of nonprestressed steel on the flexural tension side of the member at the section under consideration, as shown in Figure 1. In calculating A_s for use in this equation, bars which are terminated at a distance less than their development length from the section under consideration shall be ignored (in.^{2})

In the use of Eqs. 1 through 5, the following should be considered:

- In calculating A_s and A_{ps} the area of bars or tendons terminated less than their development length from the section under consideration should be reduced in proportion to their lack of full development.

2004 LRFD 3rd Ed

2008 LRFD Interims

New Conspan per LRFD Design Interims

1. Propose adjustments.
2. Consult with authors and critics of MCFT.
3. Make a determination.
4. Tune the program accordingly.

FDOT BrR?

QUESTIONS & REQUESTS?

andrew.devault@dot.state.fl.us, 850-410-5531