Using BrR for Rating Bascule Bridges

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AASHTOWare 2023 RADBUG

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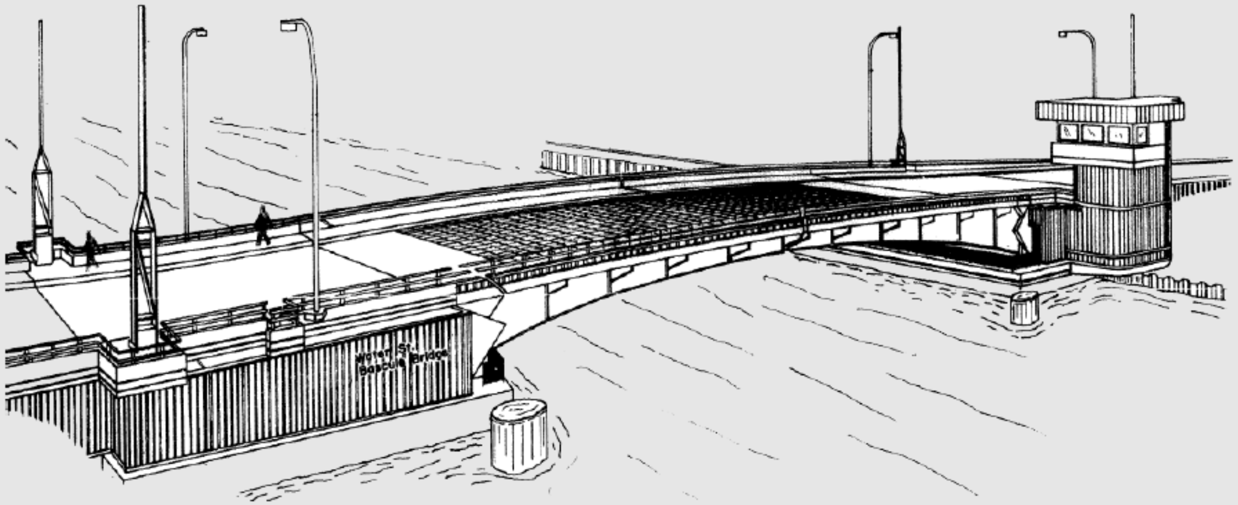
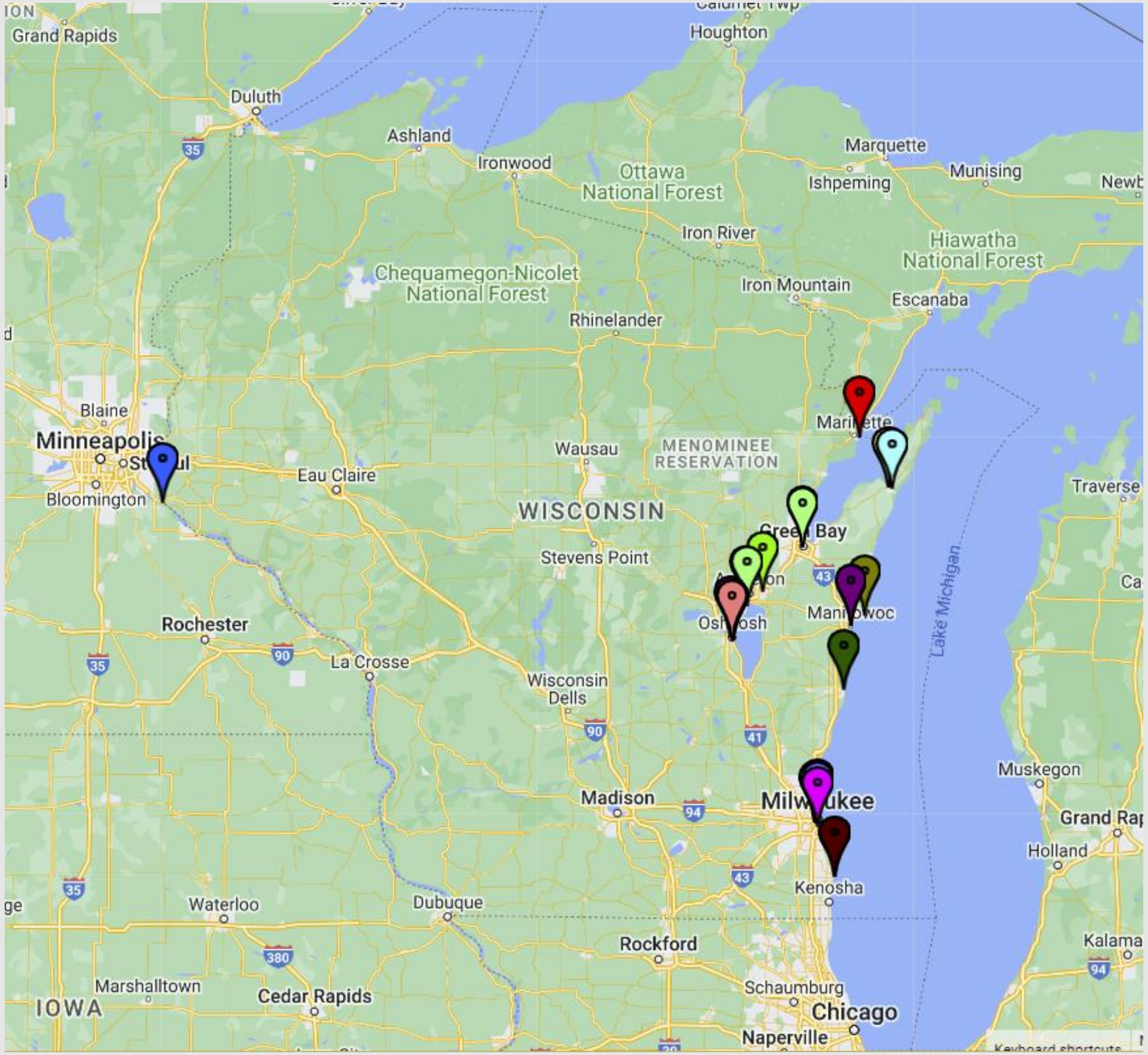


What is a Bascule bridge?

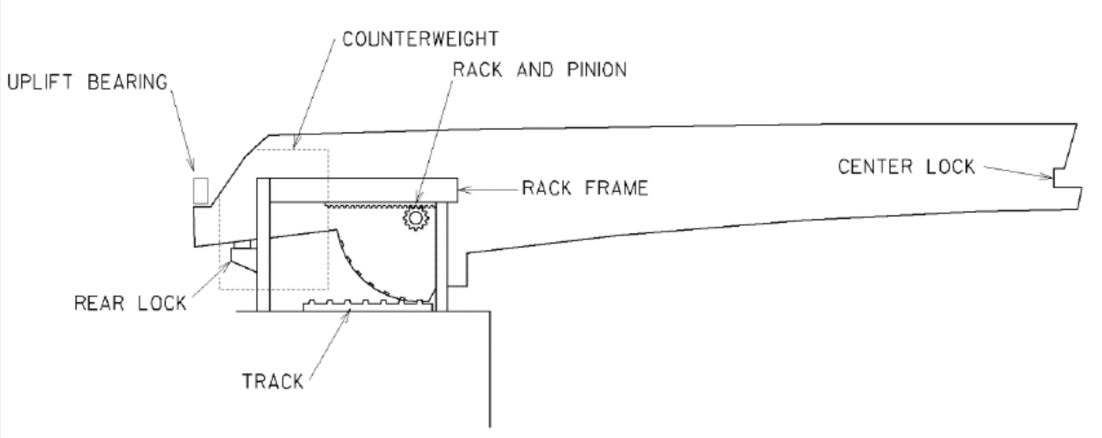
- Type of movable bridge
  - Rotates (or rolls) span to create unlimited vertical clearance
- The lifting span is called a "leaf"
  - May consist of single (shown) or double leaf

- 32 bascule type movable bridges in Wisconsin's inventory
- Located predominantly along Lake Michigan and Fox River Valley communities
  - Supports fishing, manufacturing and shipping industries



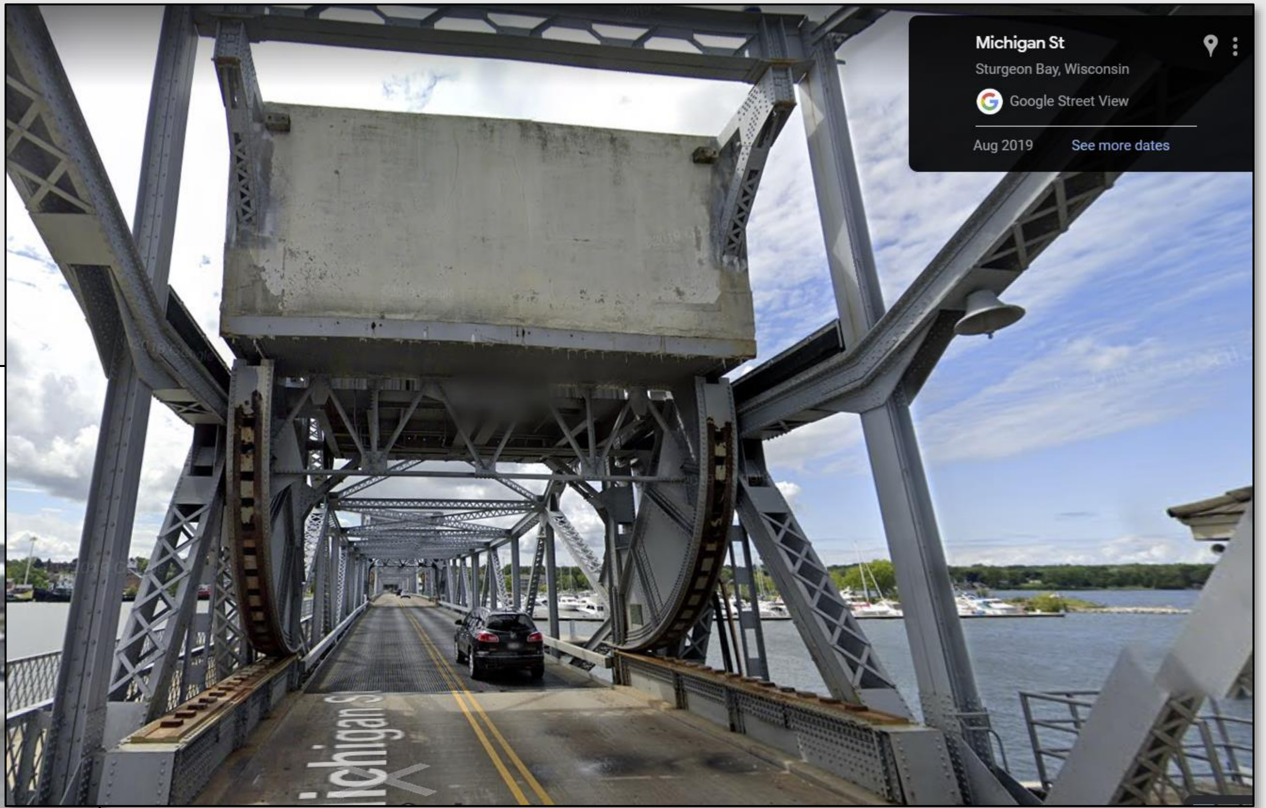
Main Load Carrying Members

- A Girder-Floorbeam-Stringer (GFS) system
  - w/ unique support conditions
- Secondary elements



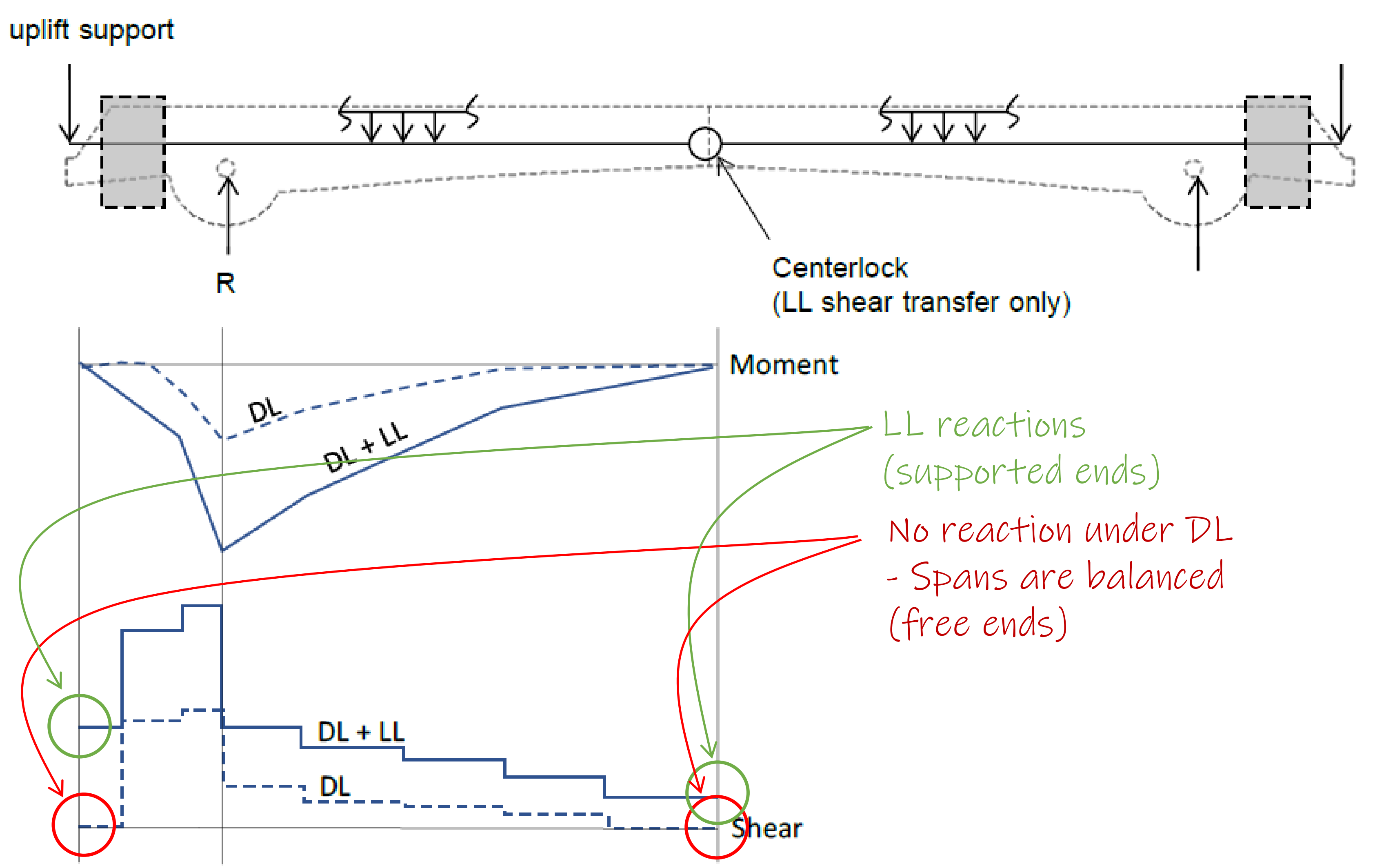
Counterweight

- Massive block of concrete
- Usually below the deck
- Keeps machinery modest

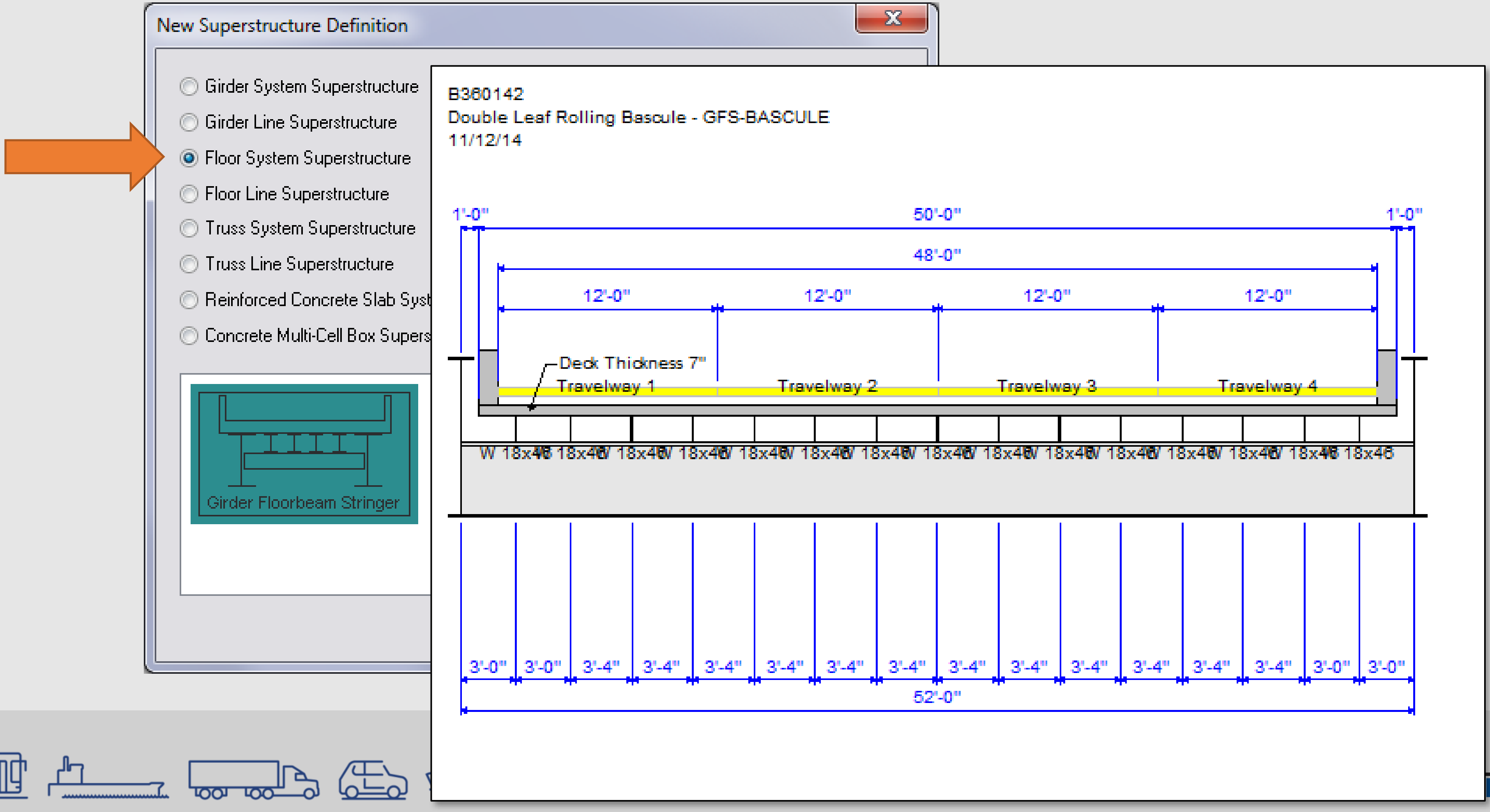


Support Conditions

- Large counterweight balances forward span
  - Girder is balanced under Dead Load
- When closed the two leaves are locked at the center (centerlock)
  - Live Load reactions present at centerlock and uplift bearing



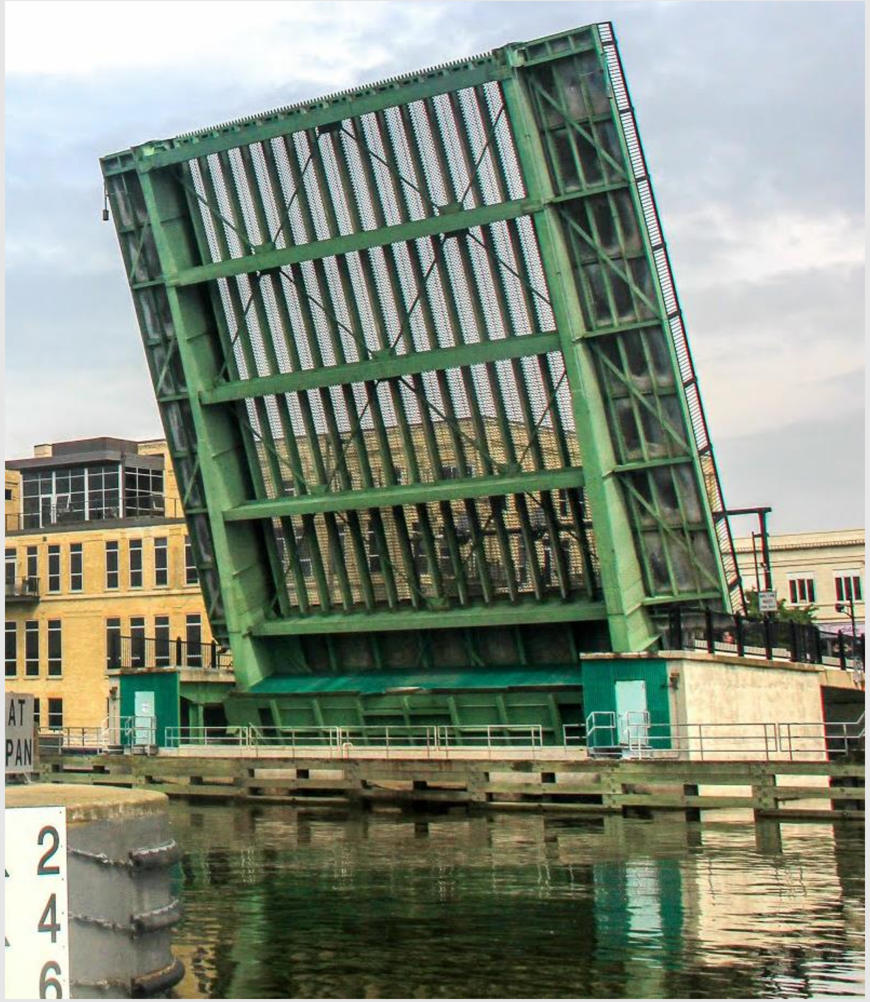
Using BrR to Load Rate a Double-Leaf Bascule



What makes a bascule different than other GFS type structures?

- Stringers
  - Number of stringers can be different between units
  - Concrete and open steel grid deck
- Floorbeams
  - Section varies btwn floorbeams (sometimes a truss FB)
  - Twice the impact applied to end floorbeam (nearest centerlock)
- Bascule Girder
  - Varying section
  - Support conditions

Requires some workaround in BrR



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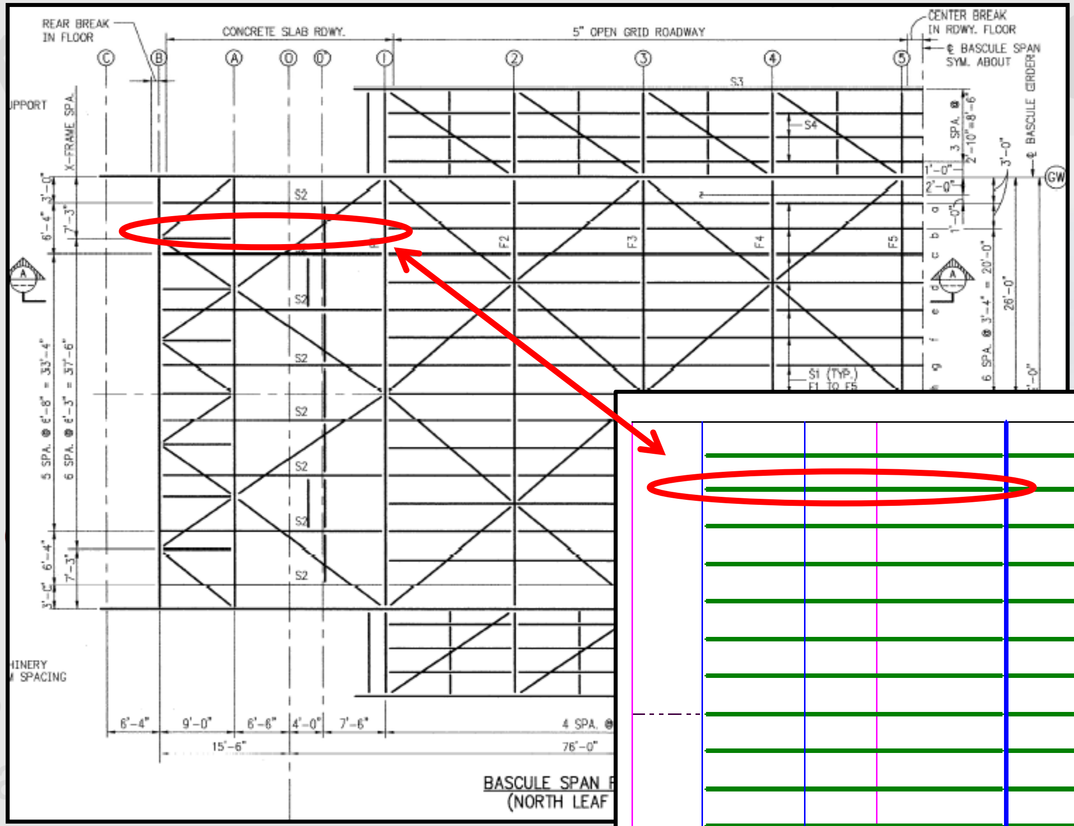
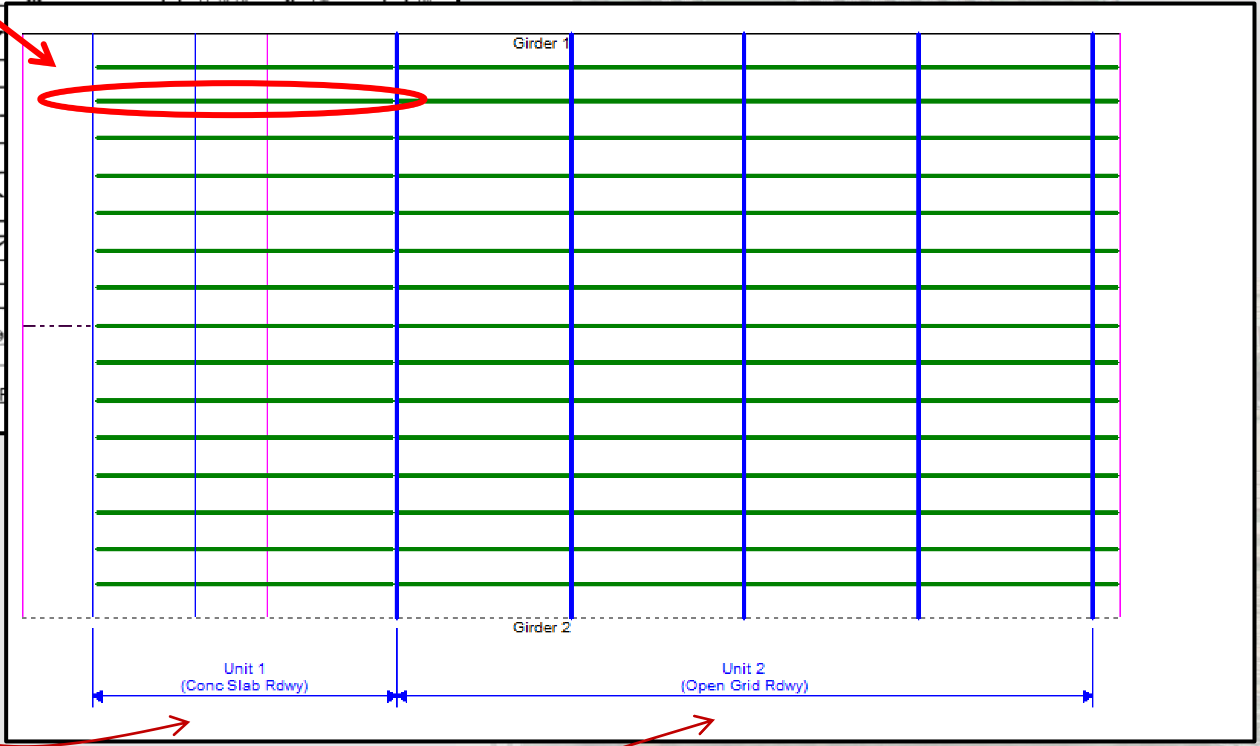


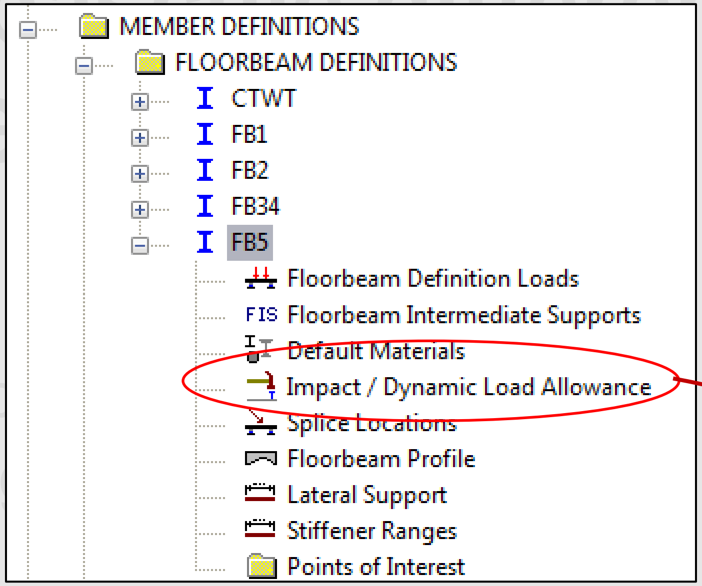
- Number of stringers different between units
  - BrR doesn't allow
- Adjust *ghost* stringer DF to zero
- Adjust actual stringer DF to actual spacing (and increase DL)
  - The additional stringer DL to offset machinery room loading (from plan)



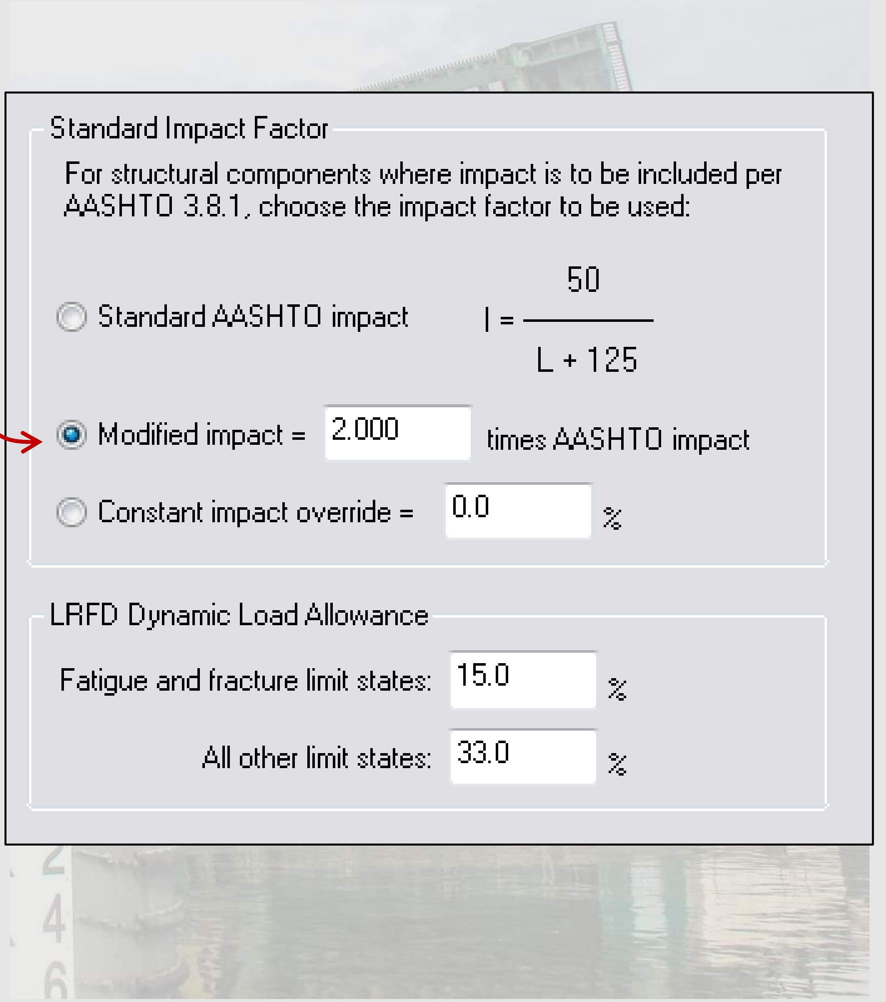
The codified distribution factors for concrete and open steel grid decks are different.
Ta. 3.23.1 (Std Spec – LFR) or Ta.4.6.2.2.2b-1 (LRFD)

What makes a bascule different than other GFS types

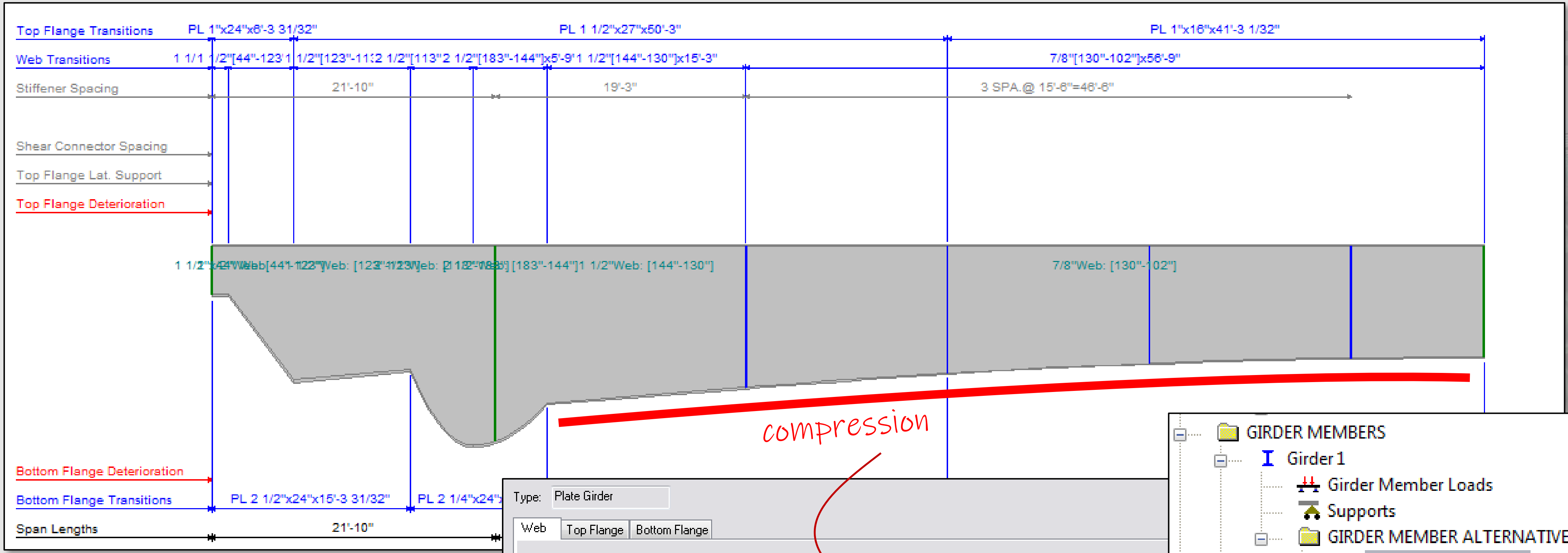
- Stringers
  - Number of stringers can b
  - Concrete and open steel



- Floorbeams
  - Section varies btwn floorbeams (sometimes a truss FB)
  - Twice the impact applied to end floorbeam (nearest centerlock)



- Bascule Girder
  - Varying section
  - Support conditions



- Twice the impact app
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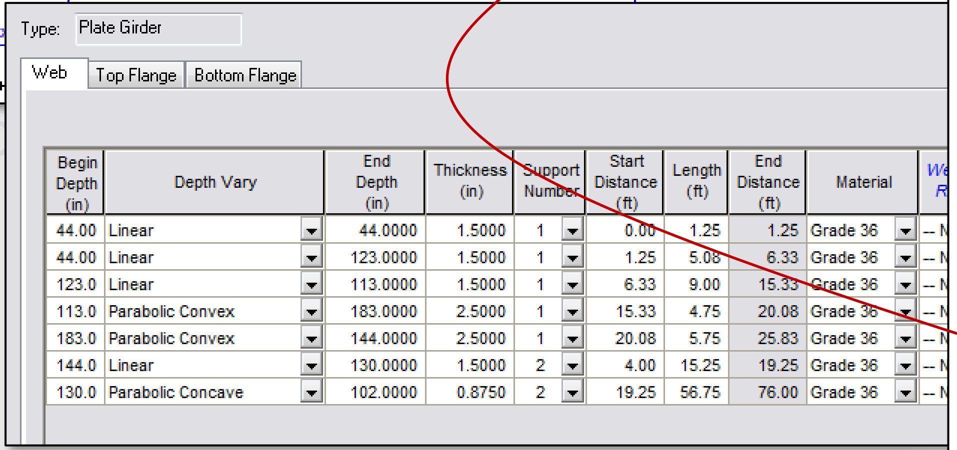
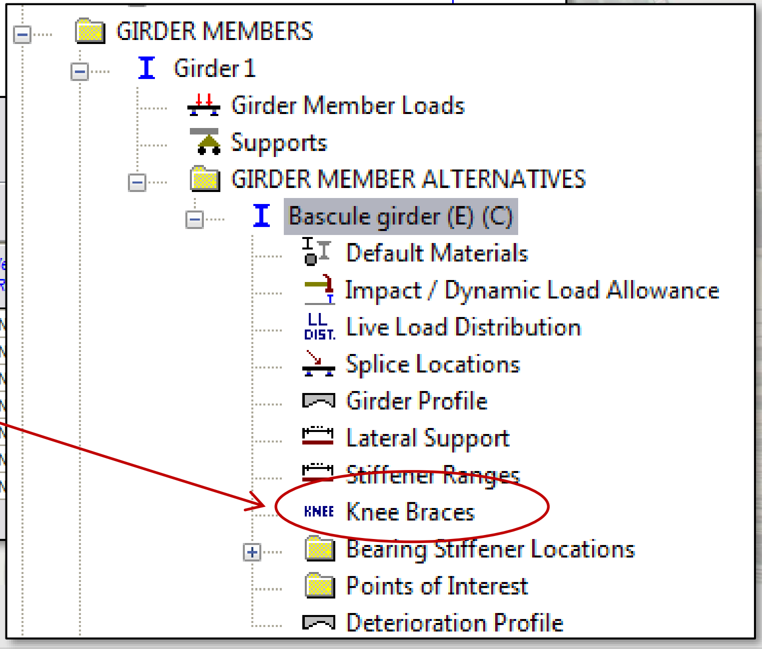


Begin Depth (in)	Depth Vary	End Depth (in)	Thickness (in)	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Material
44.00	Linear	44.0000	1.5000	1	0.00	1.25	1.25	Grade 36
44.00	Linear	123.0000	1.5000	1	1.25	5.08	6.33	Grade 36
123.0	Linear	113.0000	1.5000	1	6.33	9.00	15.33	Grade 36
113.0	Parabolic Convex	183.0000	2.5000	1	15.33	4.75	20.08	Grade 36
183.0	Parabolic Convex	144.0000	2.5000	1	20.08	5.75	25.83	Grade 36
144.0	Linear	130.0000	1.5000	2	4.00	15.25	19.25	Grade 36
130.0	Parabolic Concave	102.0000	0.8750	2	19.25	56.75	76.00	Grade 36



- Bascule Girder
  - Varying section
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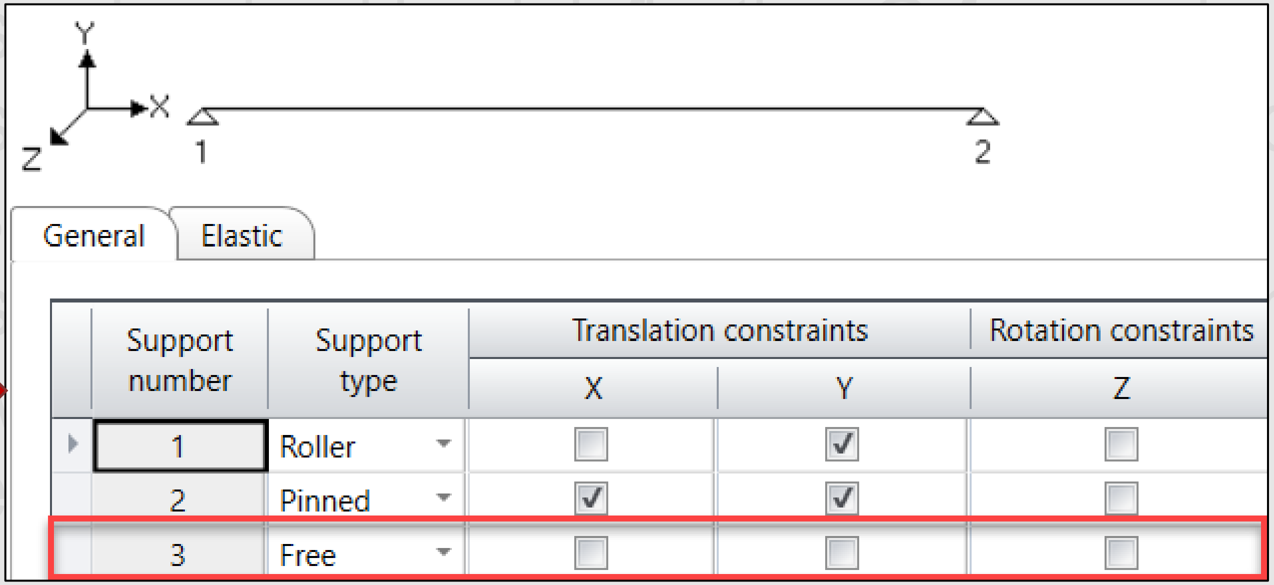
Modeling Steps

- Step 1 – model a single leaf
- Step 2 – balance the bascule girder
- Step 3 – record service dead load deflection @ free end
- Step 4 – record service live load deflection @ free end and calc spring stiffness
- Step 5 – record service dead load deflection with spring and apply corrective DL force
- Step 6 – verify results

Modeling Steps

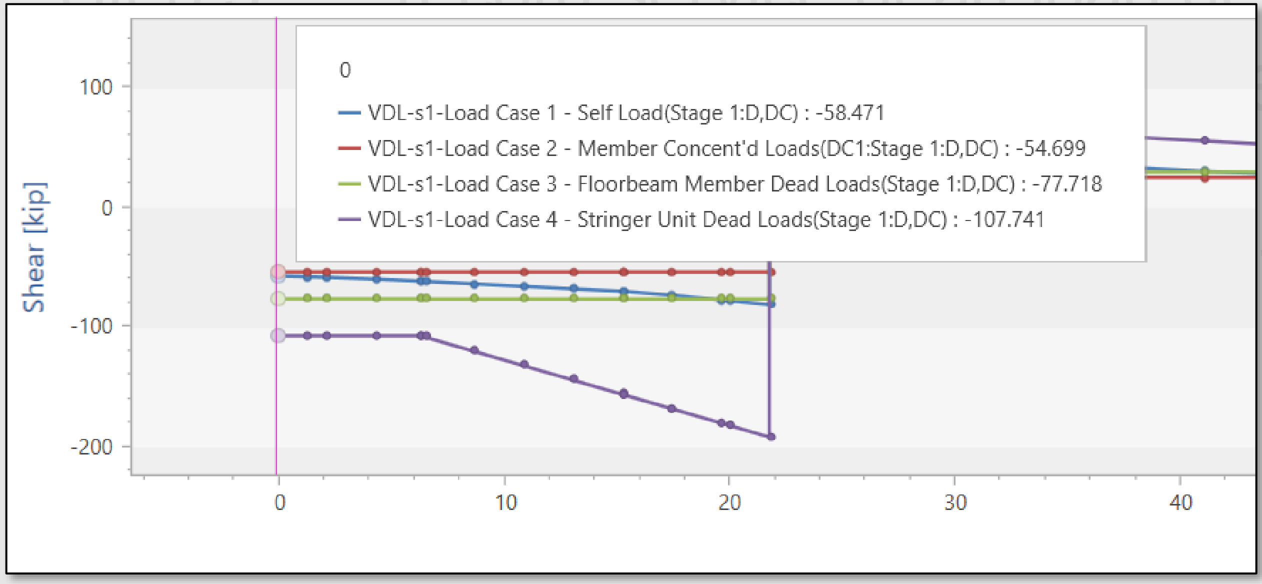
- Step 1 – model a single leaf ← A benefit to this approach is reduced modeling
- Step 2 – balance the bascule girder
- Step 3 – record s
- Step 4 – record s ... d calc spring s
- Step 5 – record s ... nd apply correct
- Step 6 – verify re

Initial support conditions →



Modeling Steps

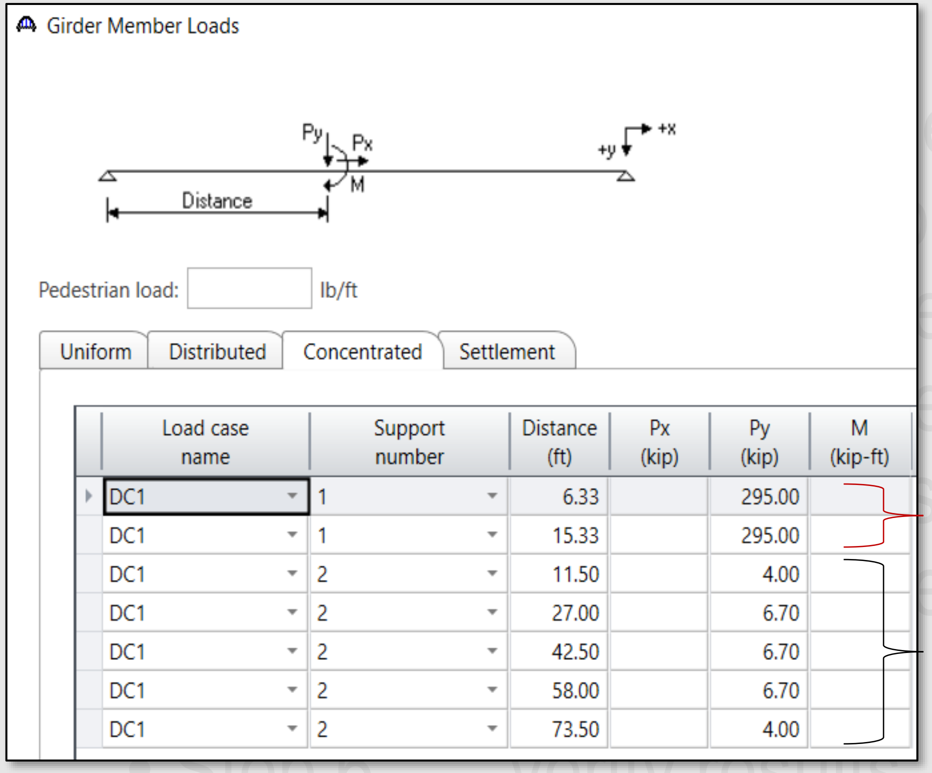
- Step 1 – model a single leaf
- **Step 2 – balance the bascule girder**
- Step 3 – record service dead load deflection @ free end



At this point the bascule self weight should include everything but the counterweight (and machinery room) and will result in a large reaction at the uplift bearing

~298 kips in uplift

Modeling Steps

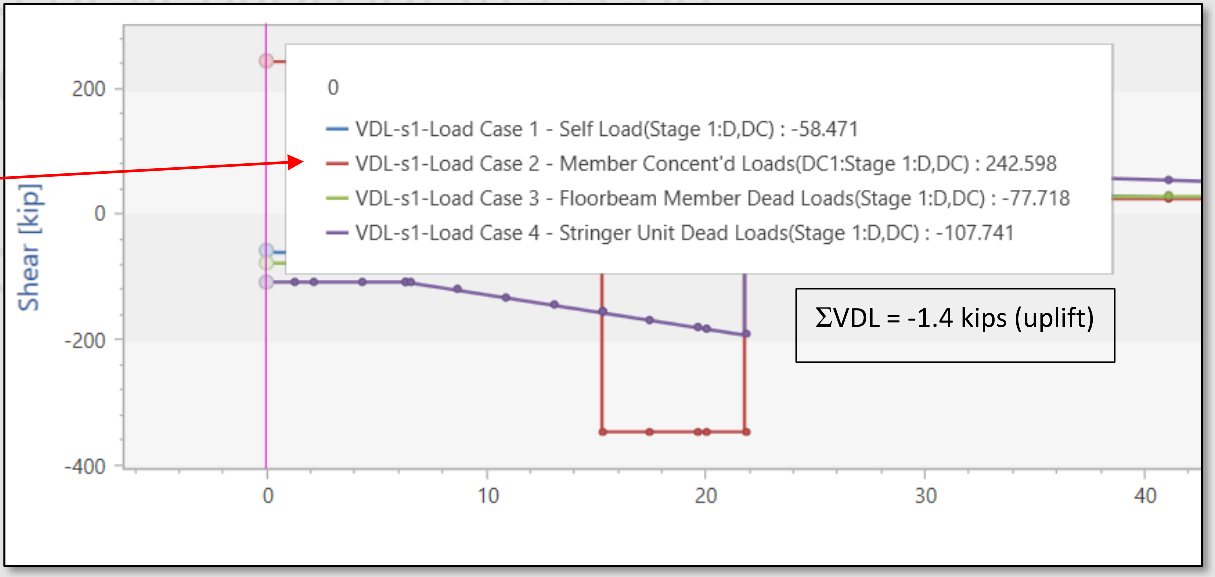


Load case name	Support number	Distance (ft)	Px (kip)	Py (kip)	M (kip-ft)
DC1	1	6.33		295.00	
DC1	1	15.33		295.00	
DC1	2	11.50		4.00	
DC1	2	27.00		6.70	
DC1	2	42.50		6.70	
DC1	2	58.00		6.70	
DC1	2	73.50		4.00	

Counterweight loads

Sidewalk/ppt loads

Add until small uplift ~2 kips
Appropriate (tip heavy)

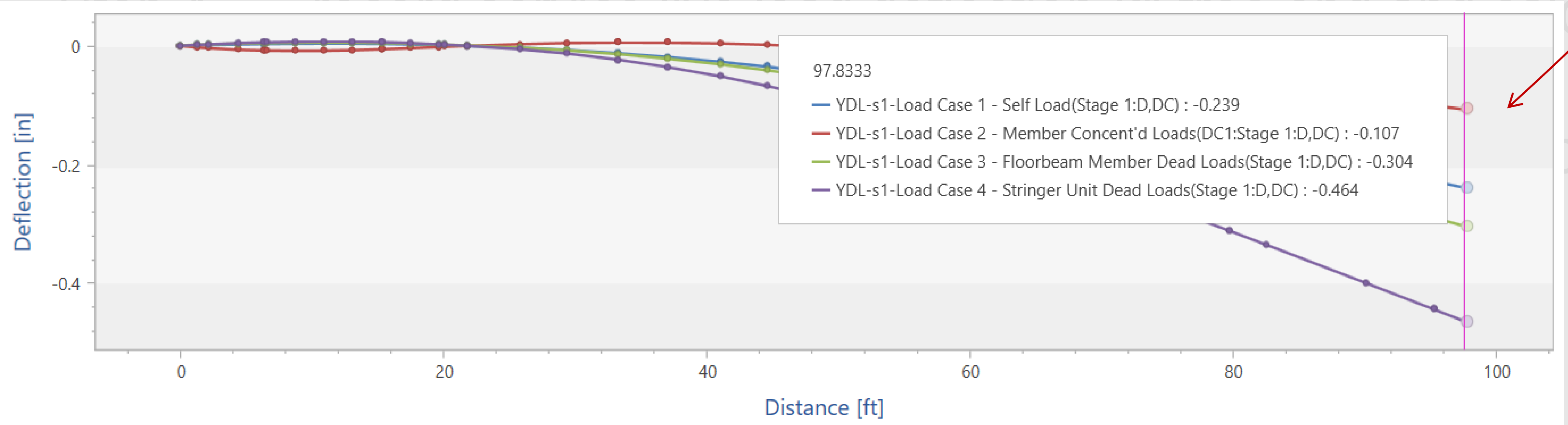


ΣVDL = -1.4 kips (uplift)

Modeling Steps

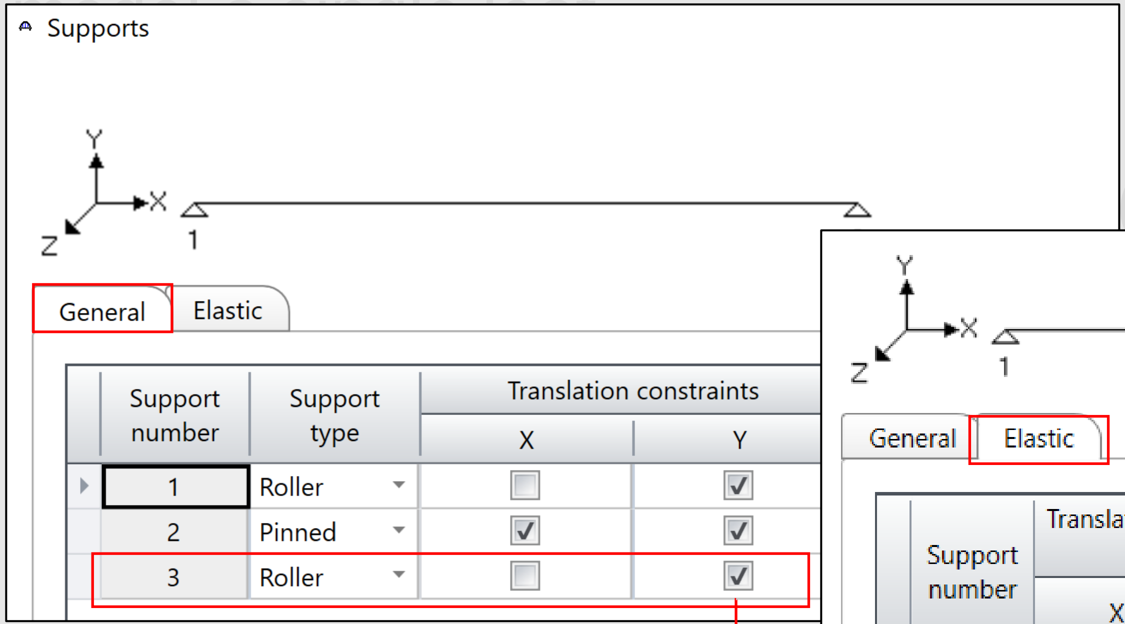
- Step 1 – model a single leaf
- Step 2 – balance the bascule girder
- **Step 3 – record service dead load deflection @ free end**

Δtip = 1.11”

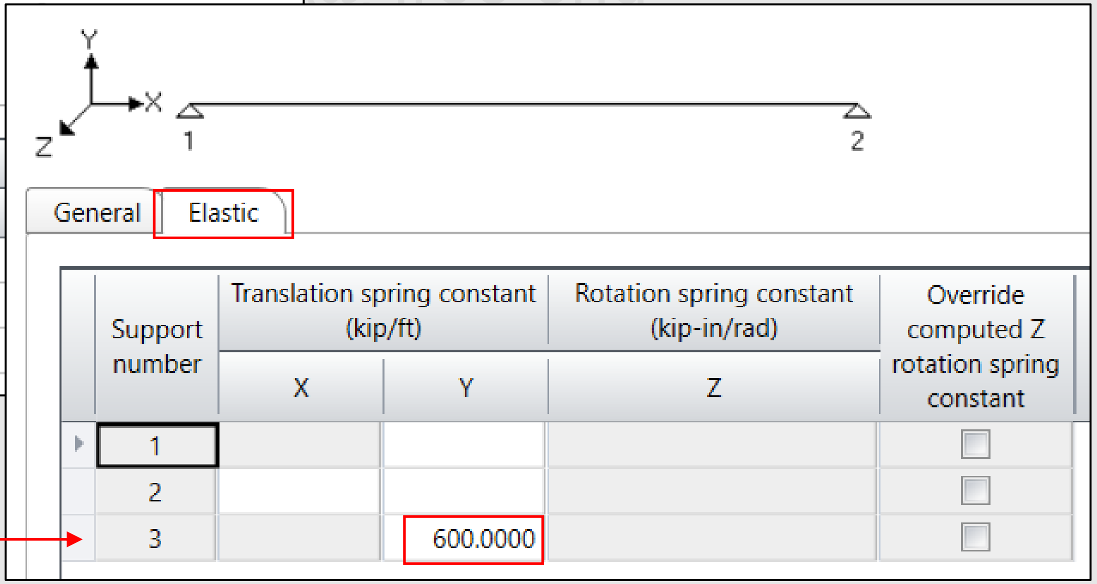


Modeling Steps

- Step 1 –
- Step 2 –
- Step 3 –
- **Step 4 –**
- Step 5 –
- Step 6 – verify results



	Support number	Support type	Translation constraints X	Translation constraints Y
▸	1	Roller	☐	☑
	2	Pinned	☑	☑
	3	Roller	☐	☑



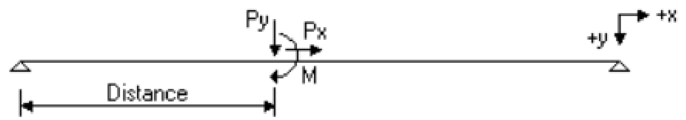
	Support number	Translation spring constant (kip/ft) X	Translation spring constant (kip/ft) Y	Rotation spring constant (kip-in/rad) Z	Override computed Z rotation spring constant
▸	1				☐
	2				☐
	3		600.0000		☐

Iteratively adjust spring stiffness to cut LL deflection in half (or consider 40% reduction)

The live load deflection in the cantilevered state represents the stiffness of a single leaf (no assistance from the second leaf – because it isn't modeled)

Were the second leaf modeled, we'd expect the maximum deflection to be cut in half (or nearly)

Girder Member Loads



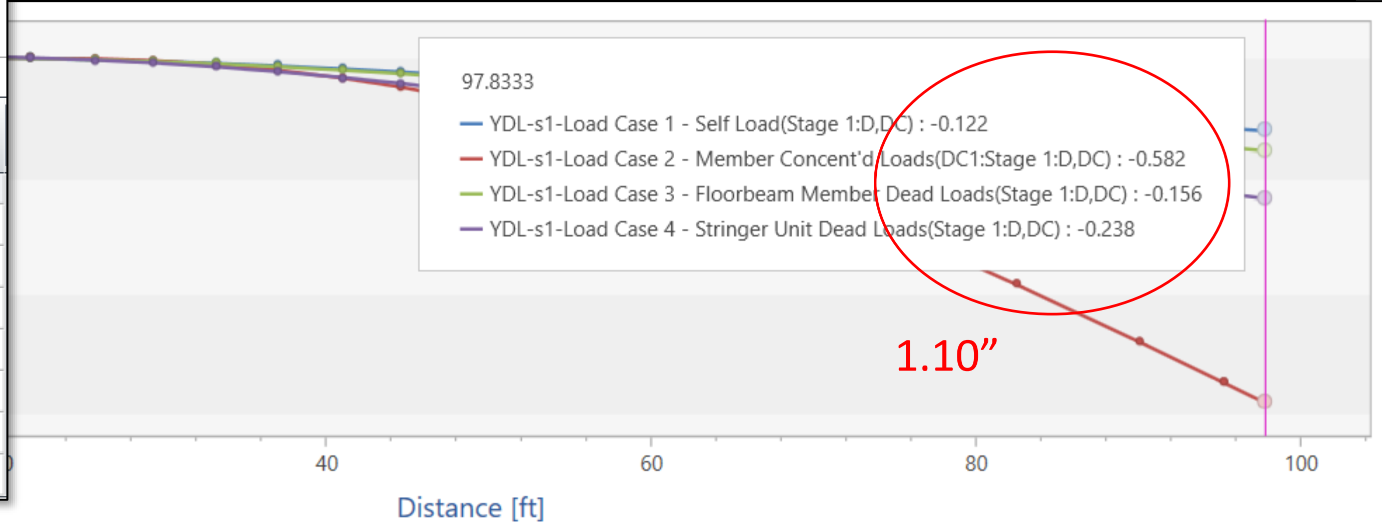
Pedestrian load: lb/ft

Uniform | Distributed | Concentrated | Settlement

Load case name	Support number	Distance (ft)	Px (kip)	Py (kip)	M (kip-ft)
DC1	2	11.50		4.00	
DC1	2	27.00		6.70	
DC1	2	42.50		6.70	
DC1	2	58.00		6.70	
DC1	2	73.50		4.00	
DC1	1	6.33		295.00	
DC1	1	15.33		295.00	
DC1	2	76.00		54.00	

...deling Steps

The addition of a spring will reduce the DL deflection. This needs to be offset with a concentrated load at the tip

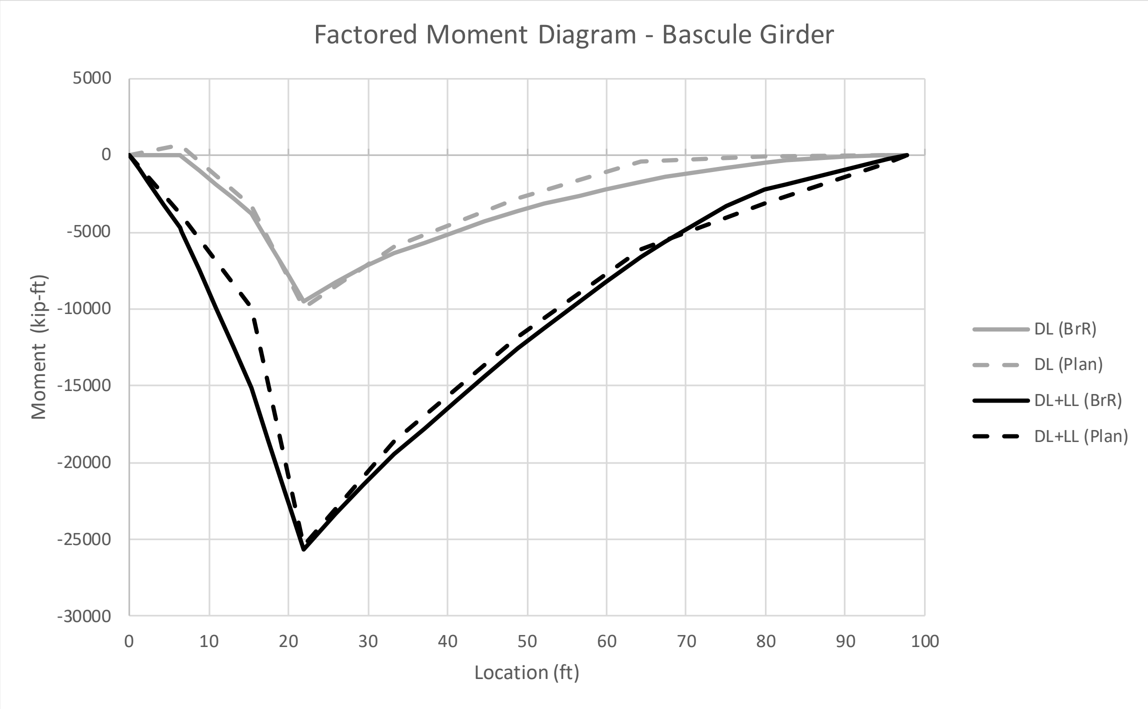


- Step 5 – record service dead load deflection with spring and apply corrective DL force
- Step 6 – verify results

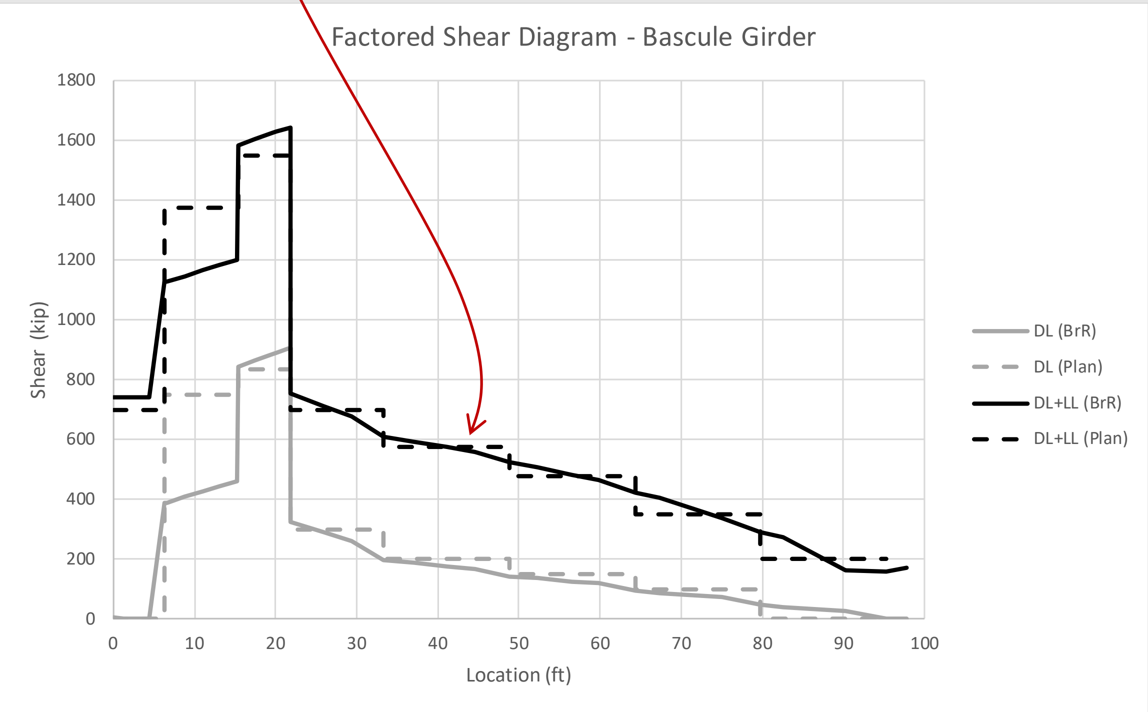
You can determine the corrective force by taking the difference between deflection recorded in step 3 (1.11") and here (0.57"), multiplied by the spring constant
...(x2 because two leaves)

(1.11-0.57)/(12"/')*600*2=54k

Modeling Steps



BrR distributes load uniformly instead of discrete FB locations



- Step 6 – verify results

Thank you! Questions?

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