



LOAD RATING TIMBER BENT CAPS USING BrDR SOFTWARE (A WORKAROUND APPROACH)

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Caltrans

AASHTOWare BrDR 7.4.0

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OUTLINE



- **Brief California Facts**
- **Transverse Beam Cap Analysis Overview**
- **Existing BrDR Floor System modules**
- **Workaround to Floor System Modules to load rate Timber cap members**
- **An Example**
- **Concluding Remarks**



BRIEF CALIFORNIA FACTS

- ▶ **Caltrans Has 498 Timber Bridges**
 - ▶ 12 Timber Trusses
 - ▶ 460 Timber Stringer Bridges (5 State Bridges)
 - ▶ 26 Bridges with Timber Approach Spans
 - ▶ Most of them are Local Agency Bridges
 - ▶ Load Rate Timber Stringers routinely
- ▶ **Working Stress Method**
 - ▶ In House Excel software used for rating
 - ▶ Just started to transition into LRFR
- ▶ **Bent Caps are rated only if,**
 - ▶ Deterioration is found, and/or
 - ▶ Supporting piles are damaged
 - ▶ MBE Article 6.1.5.2



BRDR TIMBER RATINGS' FEATURE

- Introduction of AASHTOWare Timber Engine to BrDR version 7.3.

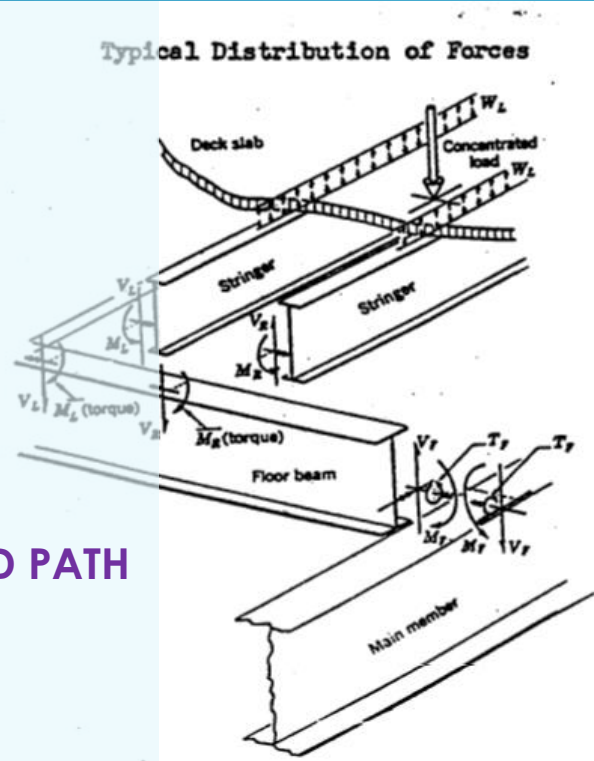
BrDR Timber Rating Capability

- ▶ Stringers
- ▶ ~~×~~ NO Bent Caps

- ▶ Developed a Workaround for Timber CAPs
 - ▶ have both Stringers and Caps rated by the same software
 - ▶ Will be going over the workarounds

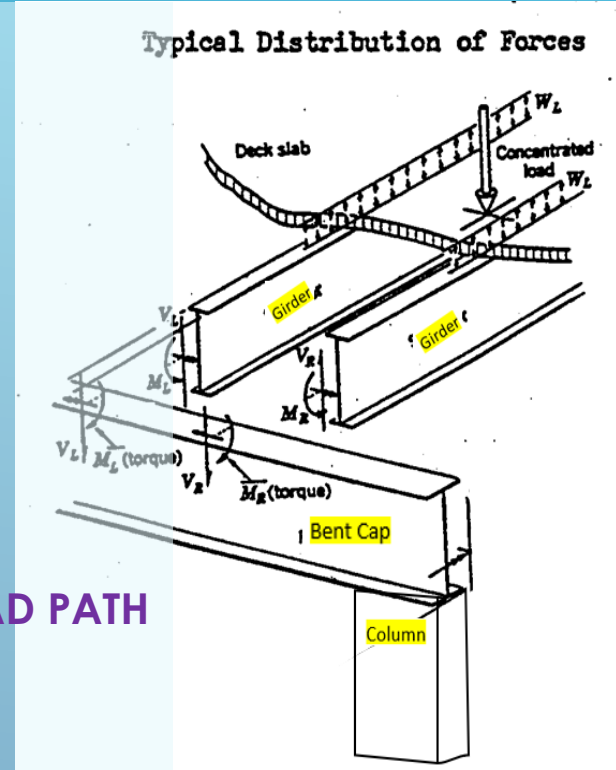
Load Path of a typical Girder System

- ▶ Deck
- ▶ Stringer/Girder (Longitudinal member)
- ▶ Floor beam (transverse member)
- ▶ Longitudinal Girder (Support to FB)



FLOOR BEAM LOAD PATH

- ▶ Deck
- ▶ Girders (Longitudinal member)
- ▶ Bent CAP (transverse member)
- ▶ Column (Support)



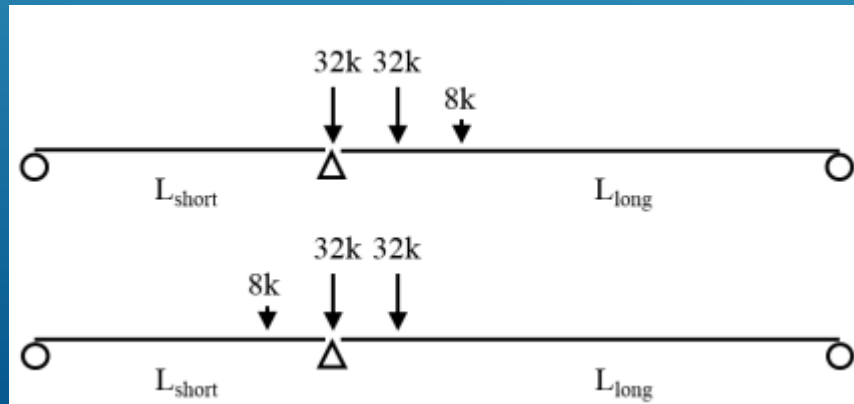
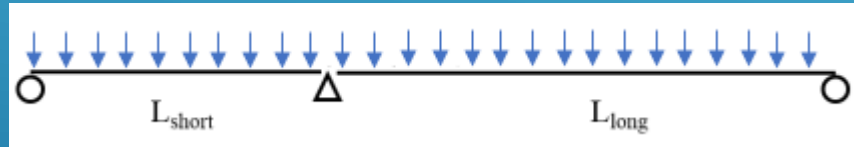
BENT CAP LOAD PATH

FLOOR BEAM vs BENT CAP ANALYSIS

- ▶ Note that, The load factors and resistance factors are the same of Floor beam and Bent cap members.

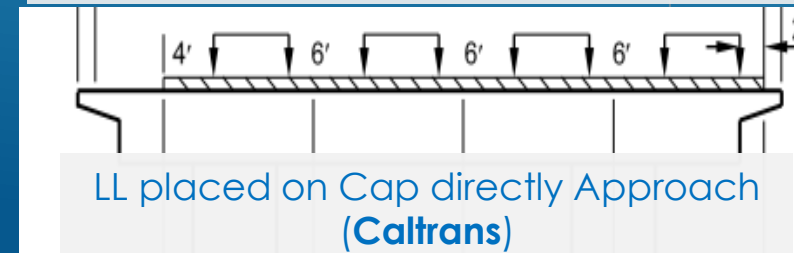
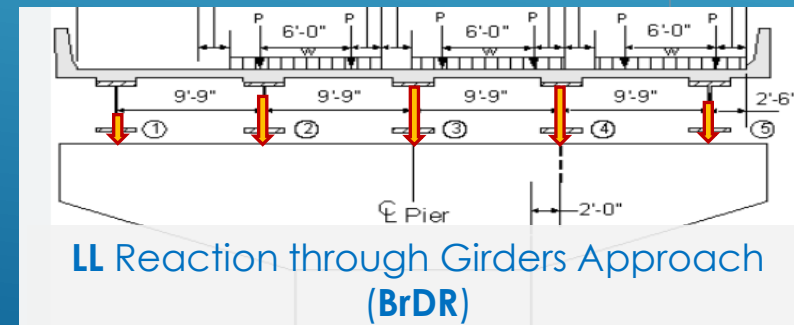
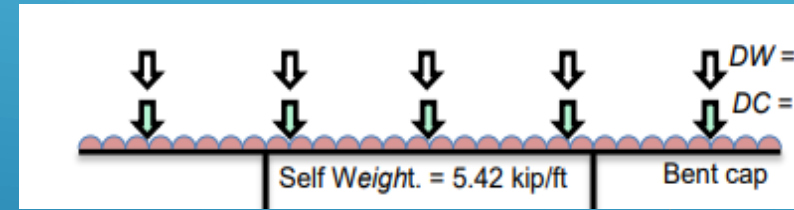
Establish Reaction at Cap

STEP 1: Using longitudinal analysis



Establish Demand on the Cap

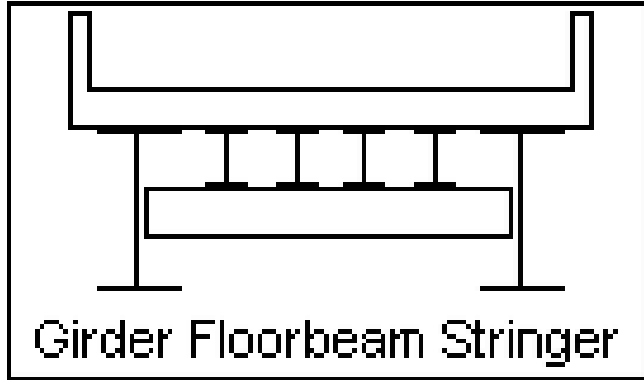
STEP 2: Using transversely spanning analysis



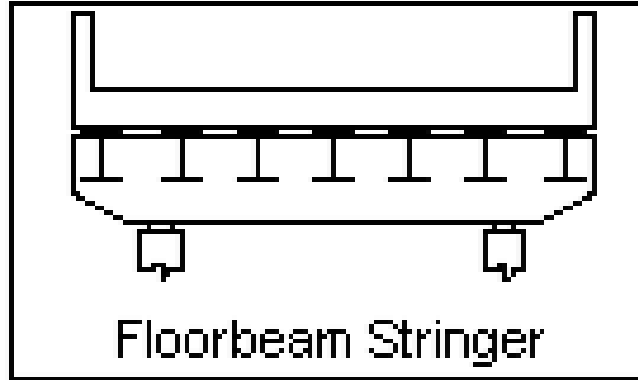
Since BrDR does this effectively for load-rating Floor beams, load rating of Caps can be performed, with **some work arounds!**

TRANSVERSE BEAM ANALYSIS

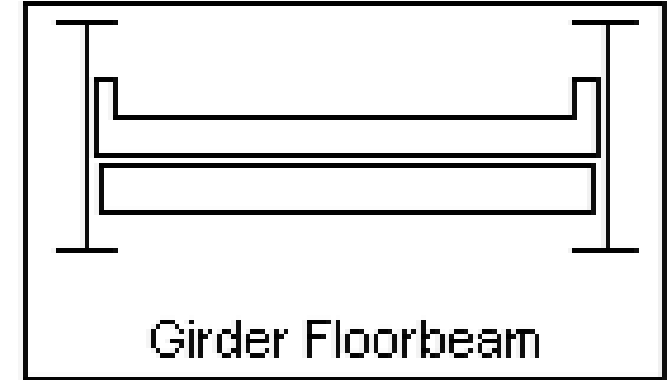
GFS System



FS System



GF-System



▶ Preferred Choice

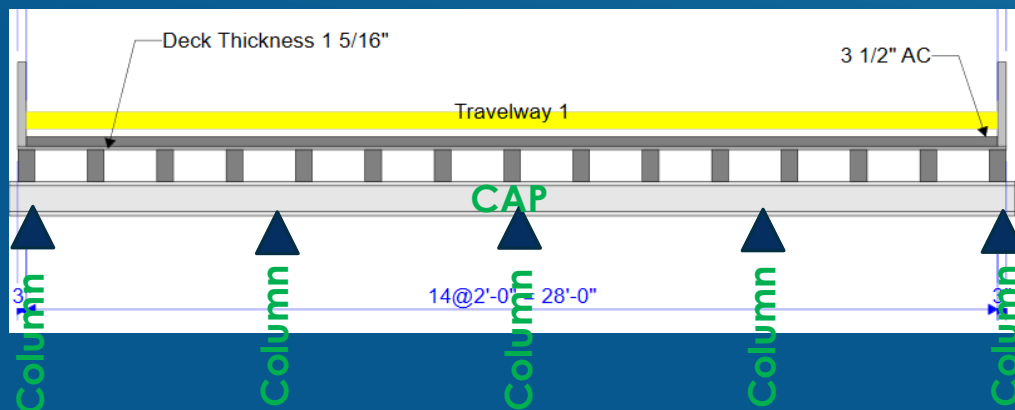
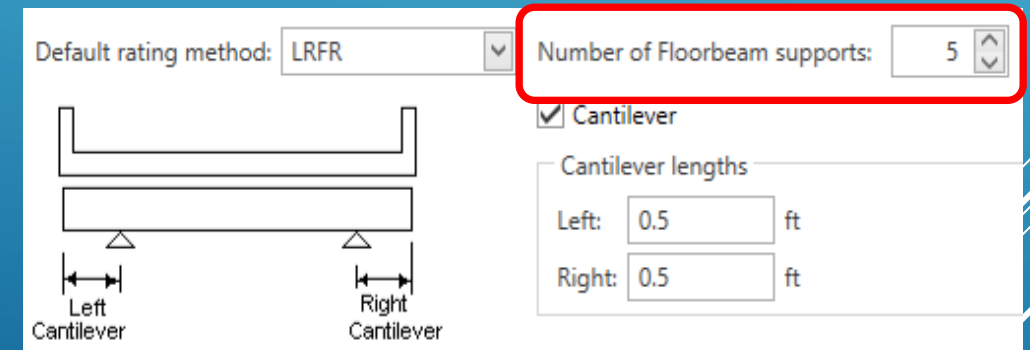
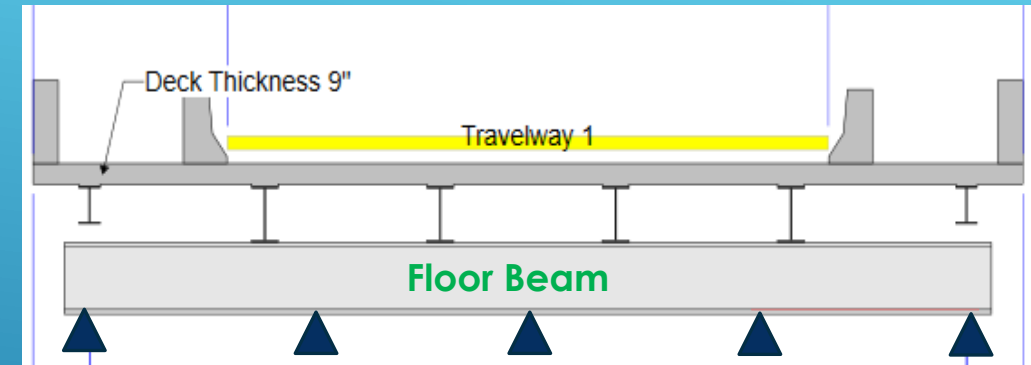
- ▶ Timber Bridges will always have stringers.
- ▶ CANNOT be used for timber bridges

AASHTOWare BrDR FLOOR SYSTEM MODULES



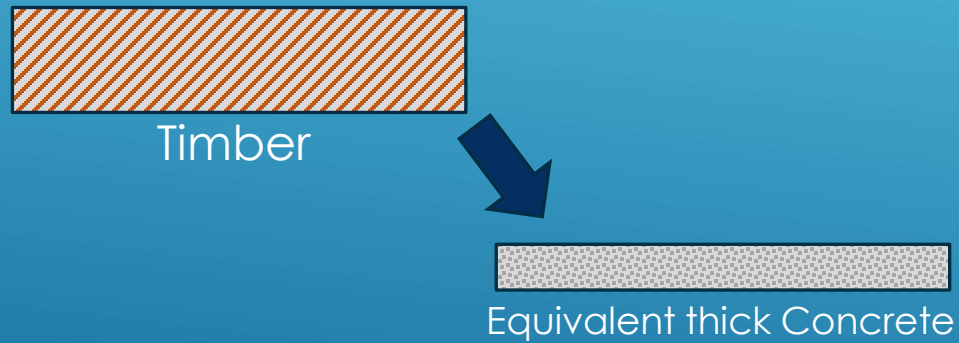
FS (FLOOR BEAM STRINGER) SYSTEM

- ▶ For Floor Beam Analysis
 - ▶ Deck (Concrete/Corrugated steel)
 - ▶ Steel Stringers
 - ▶ Steel Floor beam (Transversely spanning)
 - ▶ **Multiple Supports** for floor beams
 - ▶ **Hinges are allowed** on the Floor Beam



- ▶ For Bent Cap Analysis
 - ▶ Supports will be **Columns**
 - ▶ Floor Beams will be **Bent Caps**

1. Deck Material to be **Concrete**



1. Timber Deck

▶ Equivalent Deck Thickness

- ▶ Density of Concrete **150** lbs/cuft
- ▶ Density of Timber is **50** lbs/cuft.
- ▶ So, Equivalent Deck thickness
 - ▶ = $(50/150)$ x timber deck thickness
 - ▶ **6"** Timber deck = **2"** concrete deck

2. Stringer/FB/Girder are to be "**Steel**"

Bridge Materials - Structural Steel

Name:

Description:

Density: kcf

Modulus of elasticity (E): ksi

2. Steel Member

▶ User Defined Steel

- ▶ Density **50** lbs/cuft
- ▶ Elastic Modulus **1,600** ksi
 - ▶ Depends on the timber material

LIMITATIONS

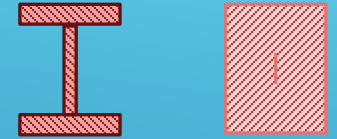
WORK AROUNDS

3. Shape

- ▶ Steel Member is I shape
- ▶ Timber is **Rectangular** Shape

3. Shape

- ▶ Enter Section as Plate Section
- ▶ Set web thickness equal to flange width



4. Capacity

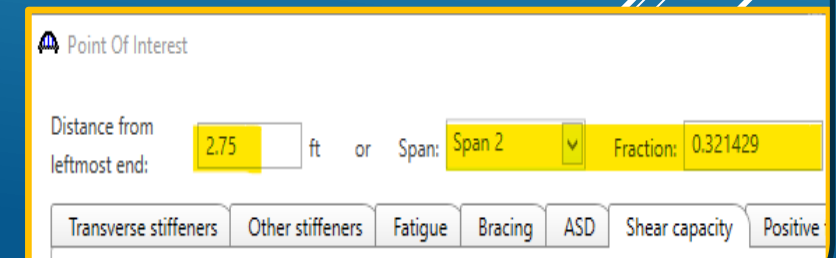
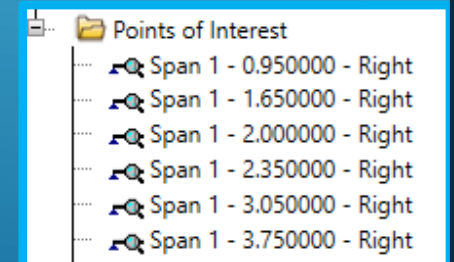
- ▶ Capacity based on steel specification is not applicable.
- ▶ Allowable stress F_b
- ▶ Shear capacity

4. Capacity

▶ Capacity Overwrite at Pt of Interest

- ▶ ALL 10th points
- ▶ Critical Shear locations
 - ▶ Within “d” distance pts,

Enter a very large shear capacity



LIMITATIONS

WORK AROUNDS

ASR CAPACITY OVERRWRITE WORK AROUND

4. Capacity

▶ Capacity Overwrite at Pt of Interest

▶ Inventory and Operating Flexural stress override

The allowable unit stress in bending shall be the tabulated stress adjusted by the applicable adjustment factors given in the following equation:

$$F'_b = F_b C_M C_D C_F C_V C_L C_T C_{fu} C_r \quad (13-2)$$

▶ Inventory and Operating shear capacity override

$$f'_v = \frac{3V}{2bd} \quad (13-9)$$

$$F'_v = F_v C_M C_D \quad (13-11)$$

$$V_c = (2/3) bd f'_v$$

ASD		
<input checked="" type="checkbox"/>	Override ASD capacity	
Comment:		
ASD inv. tension:	<input type="text" value="1.128"/>	ksi
ASD inv. compr.:	<input type="text" value="1.128"/>	ksi
ASD oper. tension:	<input type="text" value="1.5"/>	ksi
ASD oper. compr.:	<input type="text" value="1.5"/>	ksi

ASD		
<input checked="" type="checkbox"/>	Override ASD capacity	
Comment:		
ASD inv.:	<input type="text" value="4.08"/>	kip
ASD oper.:	<input type="text" value="5.43"/>	kip

LRFR CAPACITY OVERTWRITE WORK AROUND

4. Capacity

► Capacity Overwrite at Pt of Interest

► Strength I and Strength II Flexural Capacities

$F_b = F_{bo} C_{KF} C_M (C_F \text{ OR } C_v) C_{fu} C_i C_d C_\lambda$	(8.4.4.1-1)
$M_n = F_b S C_L$	(8.6.2-1)
$M_r = \phi M_n$	(8.6.1-1)
Flexure	$\phi = 0.85$
Shear	$\phi = 0.75$

► Strength I and Strength II Shear Capacities

$F_v = F_{vo} C_{KF} C_M C_i C_\lambda$	(8.4.4.1-2)
$V_n = \frac{F_v b d}{1.5}$	(8.7-2)
$V_r = \phi V_n$	(8.7-1)

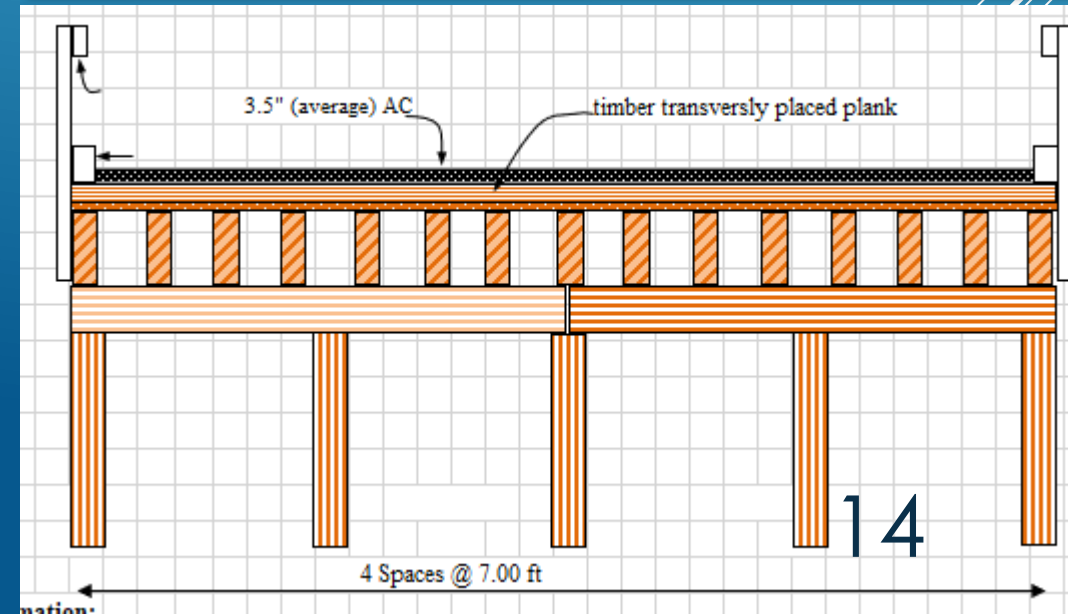
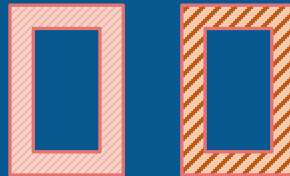
Positive flexural capacity		Negative flexural capacity			
<input checked="" type="checkbox"/> Override LRFR capacity					
Limit state	Over-ride	Moment capacity (kip-ft)	Tension capacity (ksi)	Compr. capacity (ksi)	Phi
► STRENGTH-I	<input checked="" type="checkbox"/>	54.43	3.318	3.318	0.85
STRENGTH-II	<input checked="" type="checkbox"/>	54.43	3.318	3.318	0.85
SERVICE-II	<input type="checkbox"/>				
FATIGUE	<input type="checkbox"/>				

Shear capacity		Over-ride	Capacity (kip)	Phi
Limit state	Over-ride	Capacity (kip)	Phi	
► STRENGTH-I	<input checked="" type="checkbox"/>	13.6	0.75	
STRENGTH-II	<input checked="" type="checkbox"/>	13.6	0.75	
SERVICE-II	<input type="checkbox"/>			
FATIGUE	<input type="checkbox"/>			

EXAMPLE – TWO SPAN TIMBER BRIDGE

▶ BRIEF DETAILS OF THE BRIDGE.

- ▶ Year Built Date Unknown – approx. 1943
- ▶ **Posted** for 10, 16, and 20 Tons for Type 3, Type 3S2, and Type 3-3 respectively based on Stringer Capacity
- ▶ Inspection Cycle is set at 12 months
- ▶ AC Overlay 3" at edge and 4" at CL of the bridge
- ▶ 2 Simple Spans
- ▶ 15 Stringers
- ▶ Bent Cap (Bent 2) is supported by 5 Timber Piles
- ▶ Recent Inspection showed that **Bent Caps** have 'core rot' and load rating is needed



EXAMPLE – TWO SPAN TIMBER BRIDGE

▶ BRIEF DETAILS OF THE BRIDGE.

- ▶ Bent Cap is supporting stringers of Span 1 and Span 2
- ▶ Bent cap beam is discontinuous at Column 3
- ▶ Recent Inspection showed that **Bent Cap** has 'core rot' and load rating is needed

- ▶ Original Size is 12" x 12"

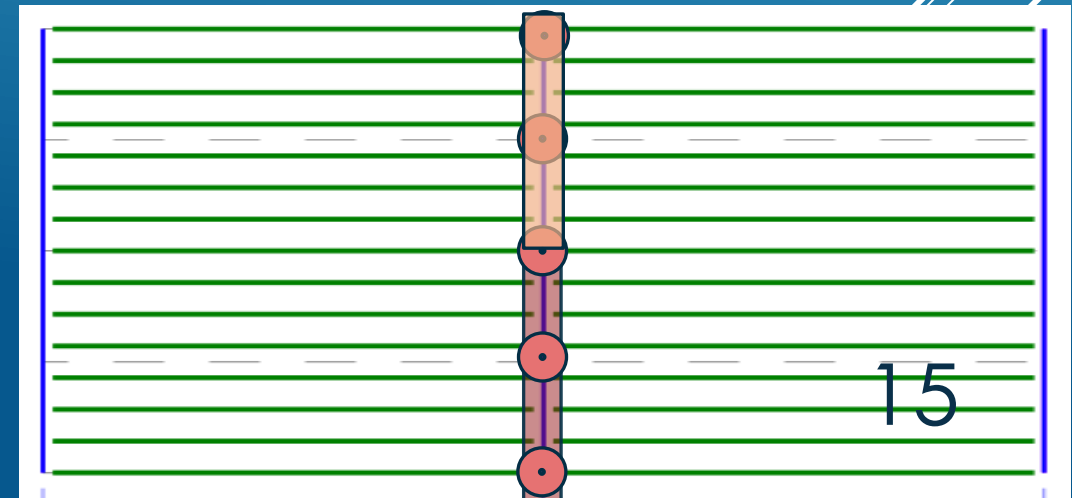
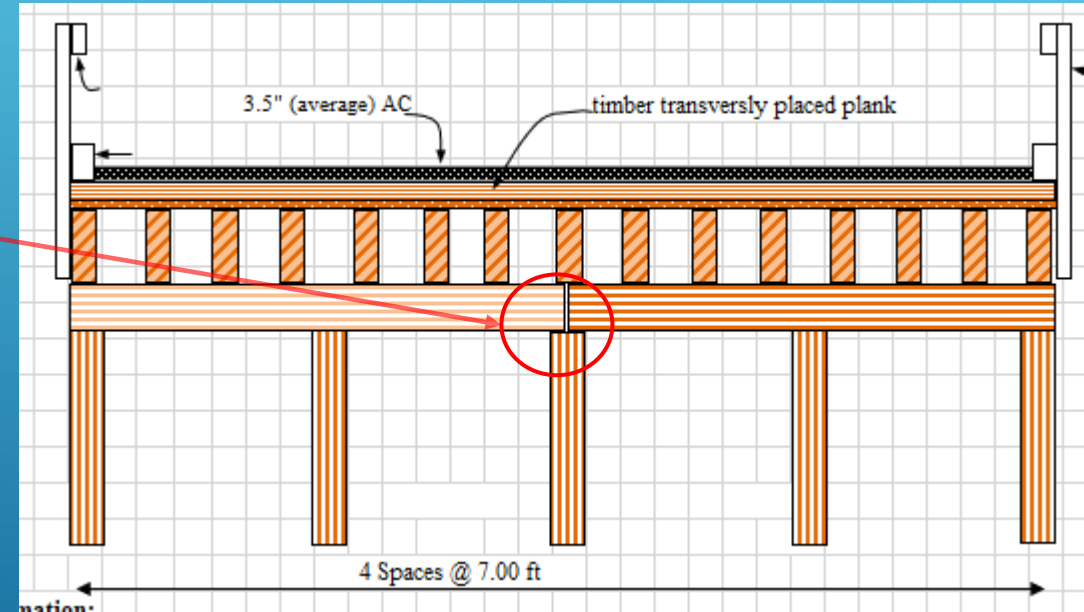
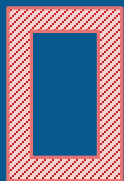
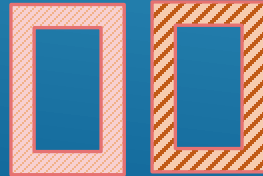
- ▶ 1.5" outside core is intact

- ▶ For Modeling purposes,

- ▶ Top and bottom flange dimension is taken as 12" x 1.5"

- ▶ Web dimension is taken as 3" (w) x 9" (depth)

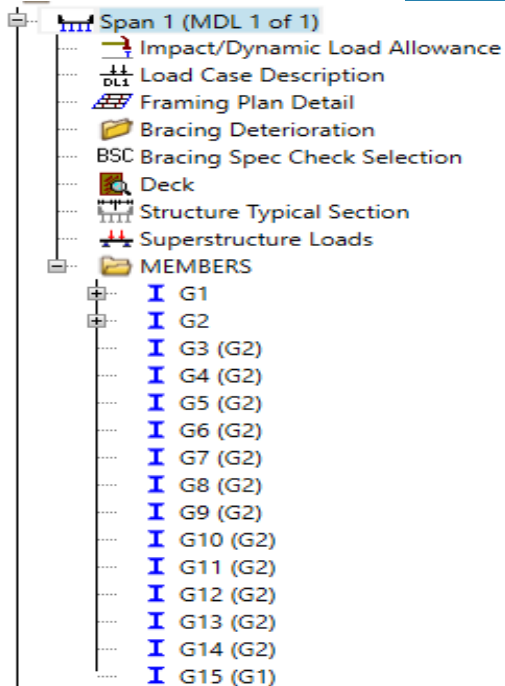
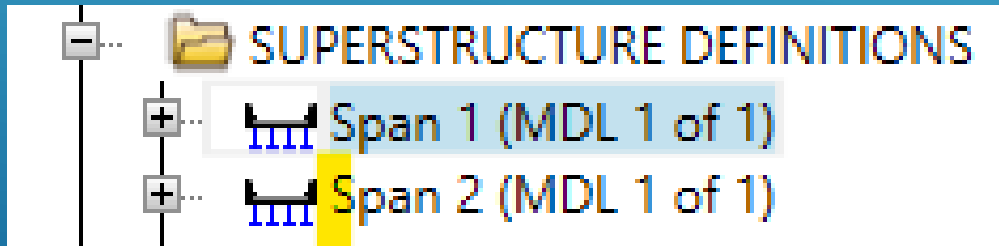
- ▶ This ensures reasonable stiffness is used in the analysis



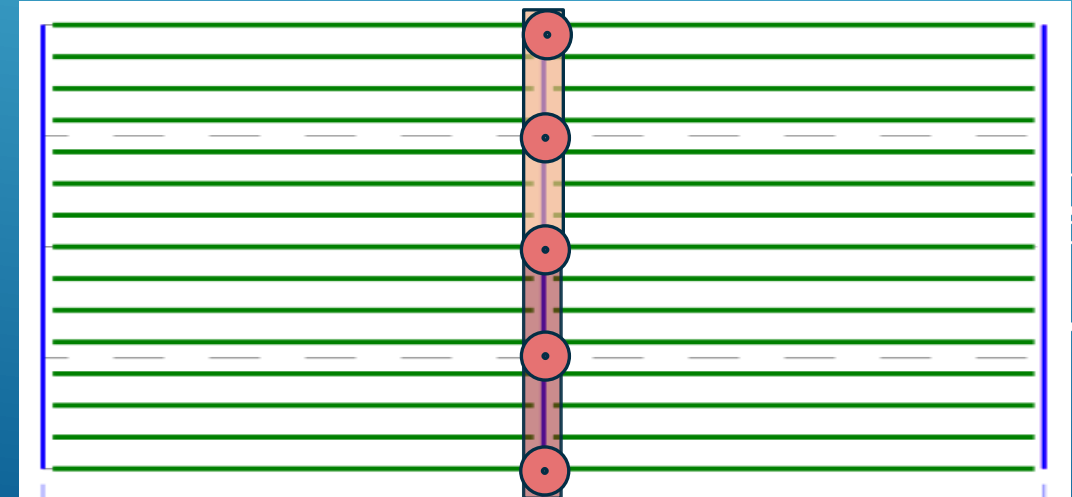
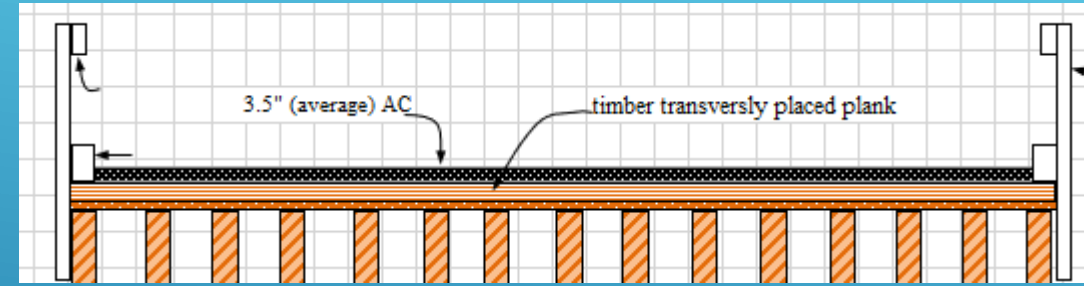
EXAMPLE – TWO SPAN TIMBER BRIDGE

► Load Rating of Timber Stringers

- Stringers of Span 1 and Span 2 are load rated using BrDR Girder System Approach

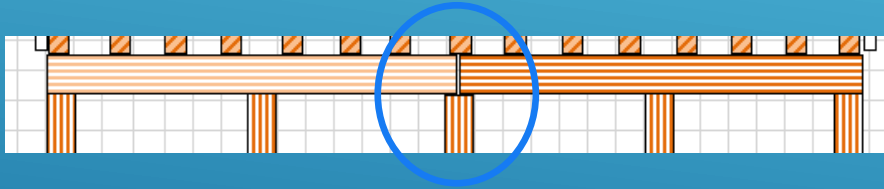


Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	
HS 20-44	Axle Load	ASR	Inventory	7.72	
HS 20-44	Lane		Inventory	10.54	
HS 20-44	Axle Load		Operating	11.93	
HS 20-44	Lane		ASD	Operating	16.28
Type 3	Axle Load		ASD	Operating	10.19
Type 3-3	Axle Load		ASD	Operating	19.80
Type 3S2	Axle Load	ASD	Operating	16.10	

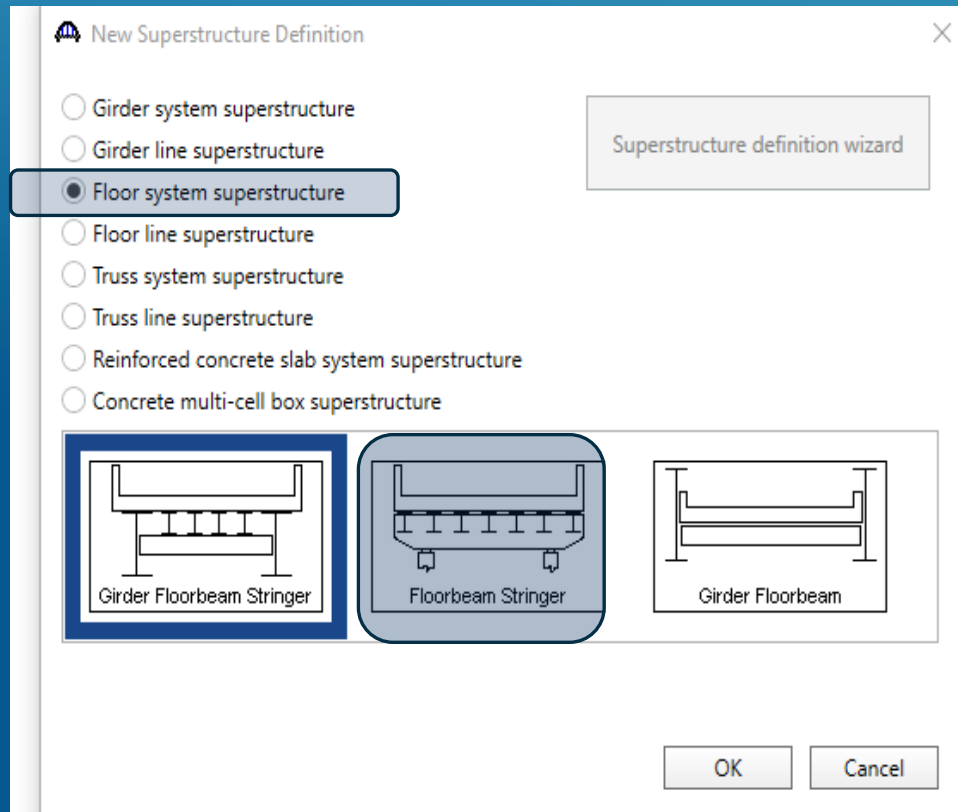


Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	
HL-93 (US)	Truck + Li	LRFR	Inventory	8.25	
HL-93 (US)	Tandem + Li		Inventory	7.07	
HL-93 (US)	Truck + Li		Operating	10.69	
HL-93 (US)	Tandem + Lane		LRFR	Operating	9.16
Lane-Type Legal Load	Truck + Lane		LRFR	Legal	3960.00
Type 3	Axle Load		LRFR	Legal	9.95
Type 3-3	Axle Load	LRFR	Legal	19.34	
Type 3S2	Axle Load	LRFR	Legal	15.72	

EXAMPLE – TWO SPAN TIMBER BRIDGE

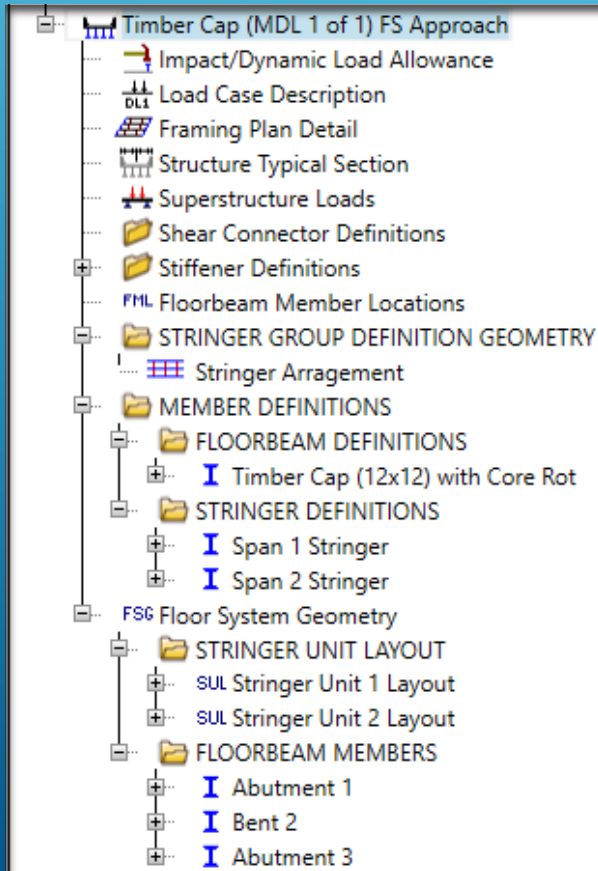


- Cap is cut into two pieces, so It will be treated as a **hinge**



- Only (FB Stringer) **FS** can accept **hinge** when the floor beam FS is chosen

SELECTION OF FLOOR SYSTEM SUPERSTRUCTURE 17



- ▶ Once the software creates the entire tree, the User needs to enter appropriate data within each GUI.
- ▶ A few important data entries are discussed next.

CREATE A FS MODEL

➤ Analysis Tab of Floor System Superstructure Definition

- Vehicle increment in Lane and Lane Increment for transverse loading need adjustments
- Default values of 2 ft and 4 ft are too large for a Timber bridge where stringers are spaced less than 2 ft.
 - If axles are moved greater than stringer spacing, loads demands will not correctly be established
 - **But**, Analysis time will increase with a smaller increment

➤ Impact/DLA to be 0.0

- Std Spec. Article 3.8.1
- LRFD Article 3.6.2.3

Standard impact factor

For structural components where impact is to be included per AASHTO 3.8.1, choose the impact factor to be used:

Standard AASHTO impact: $I = \frac{50}{L + 125}$

Modified impact: times AASHTO impact

Constant impact override: %

LRFD dynamic load allowance

Fatigue and fracture limit states: %

All other limit states: %

Floorbeam Stringer Floor System Superstructure Definition

Definition Analysis Engine

Structural slab thickness

Consider structural slab thickness for rating

Consider structural slab thickness for design

Wearing surface

Consider wearing surface for rating

Consider wearing surface for design

Consider striped lanes for rating

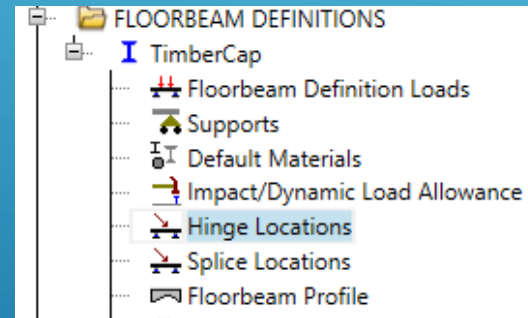
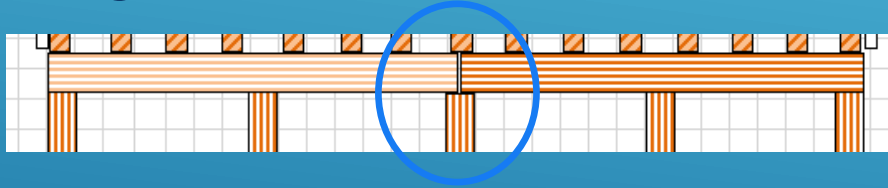
Transverse loading

Vehicle increment in lane: ft

Lane increment: ft

CREATE A FS MODEL

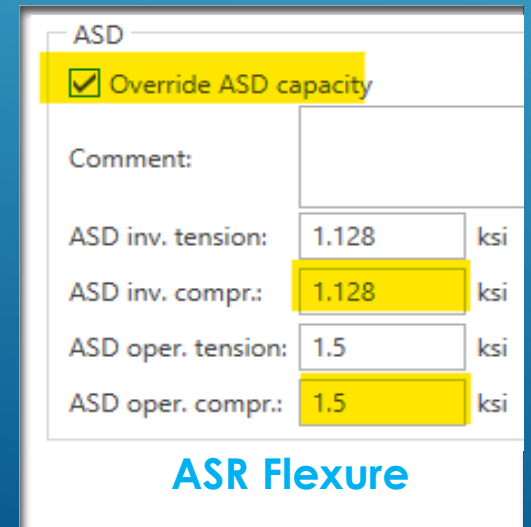
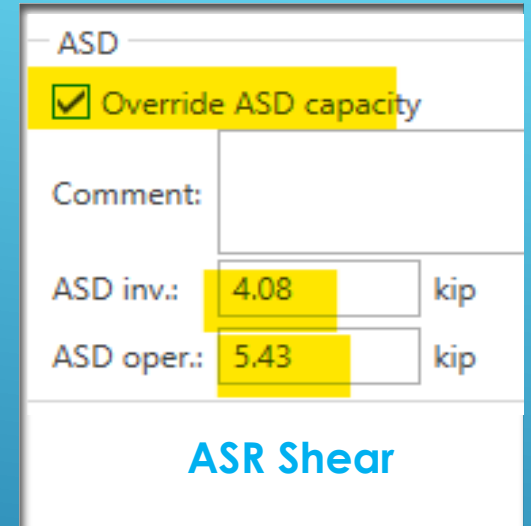
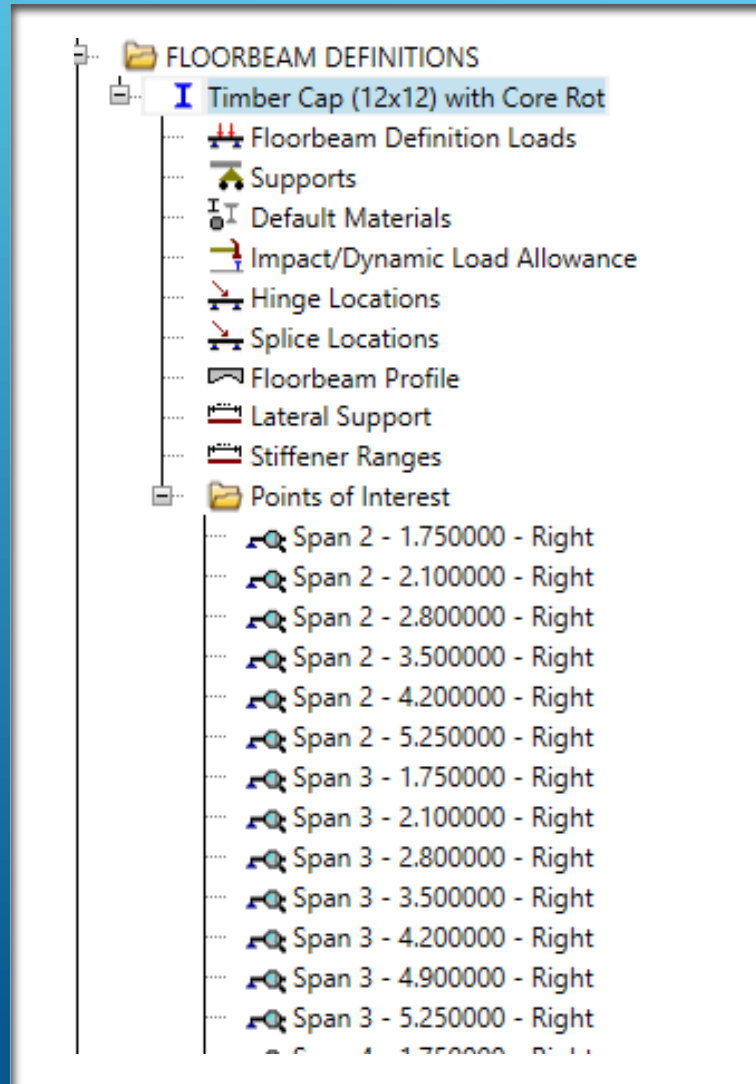
➤ Hinge Location



CREATE A FS MODEL

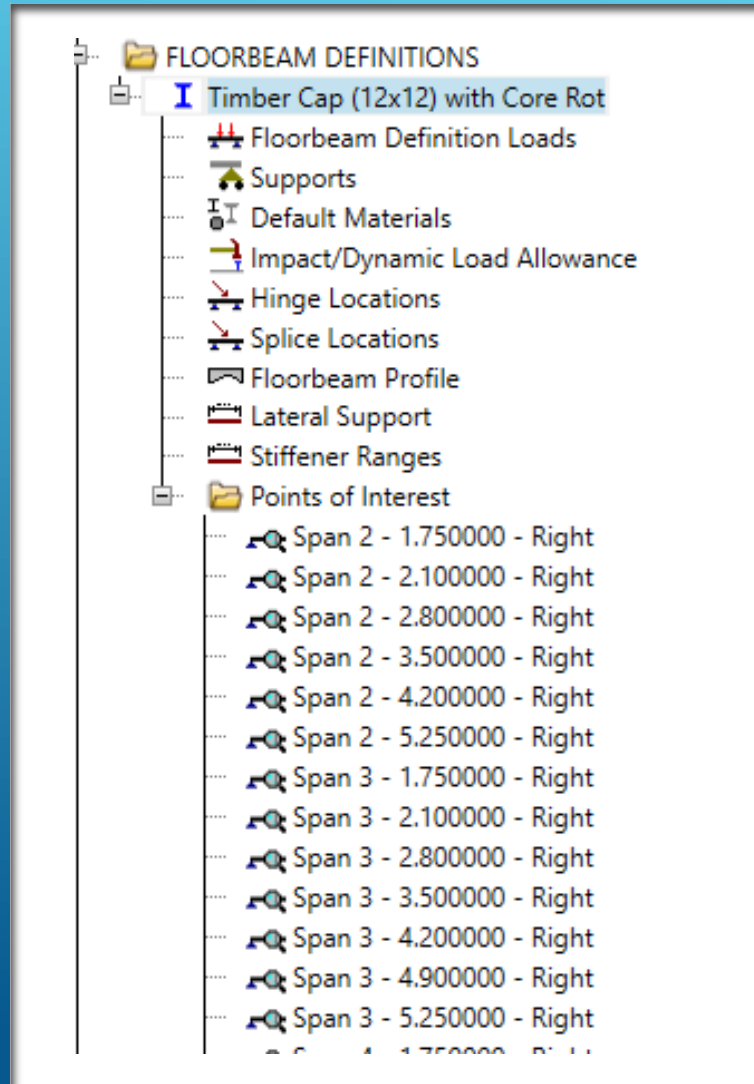
▶ **Point of Interest Within Floor Beam Definitions (For ASD)**

- ▶ All 10th points
- ▶ Critical Shear Location
- ▶ Overwrite the Capacity.
 - ▶ Typically, flexural capacity will be the same at ALL points
 - ▶ shear capacity needs not to be done within “d” distance from the support. Enter a larger capacity so that shear analysis will **NOT** control



▶ Point of Interest Within Floor Beam Definitions (For LRFR)

- ▶ All 10th points
- ▶ Critical Shear Location
- ▶ Overwrite the Capacity.
 - ▶ Typically, flexural capacity will be the same at ALL points
 - ▶ shear capacity needs not to be done within “d” distance from the support. Enter a larger capacity so that shear analysis will NOT control



LRFR

Override LRFR capacity

Comment:

LRFR Shear

Limit state	Over-ride	Capacity (kip)	Phi
STRENGTH-I	<input checked="" type="checkbox"/>	13.6	0.75
STRENGTH-II	<input checked="" type="checkbox"/>	13.6	0.75
SERVICE-II	<input type="checkbox"/>		
FATIGUE	<input type="checkbox"/>		

LRFR

Override LRFR capacity

Comment:

LRFR Flexure

Limit state	Over-ride	Moment capacity (kip-ft)	Tension capacity (ksi)
STRENGTH-I	<input checked="" type="checkbox"/>	54.43	3.31
STRENGTH-II	<input checked="" type="checkbox"/>	54.43	3.31
SERVICE-II	<input type="checkbox"/>		
FATIGUE	<input type="checkbox"/>		

CREATE A FS MODEL

ANALYSIS RESULTS

➤ CAP Rating Results

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)
HS 20-44	Axle Load	ASR	Inventory	2.85
HS 20-44	Axle Load		Operating	6.11
HS 20-44	Lane	ASD	Inventory	3.02
HS 20-44	Lane	ASD	Operating	6.47
Type 3	Axle Load	ASD	Operating	5.19
Type 3-3	Axle Load	ASD	Operating	10.33
Type 3S2	Axle Load	ASD	Operating	7.72

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)
HL-93 (US)	Truck + Lane	LRFR	Inventory	5.56
HL-93 (US)	Truck + Lane		Operating	7.21
HL-93 (US)	Tandem + Lane	LRFR	Inventory	5.05
HL-93 (US)	Tandem + Lane	LRFR	Operating	6.55
Lane-Type Legal Load	Truck + Lane	LRFR	Legal	3960.00
Type 3	Axle Load	LRFR	Legal	7.31
Type 3-3	Axle Load	LRFR	Legal	14.53
Type 3S2	Axle Load	LRFR	Legal	10.86

When placing the wheels on Cap directly, ASR load rating produces **3, 3, 5** Tons for Type 3, 3S2, and 3-3 respectively. Bridge is **currently posted** for **3, 3, 5** Tons.

➤ Support/Column Reactions

Analysis Results - Bent 2 Cap

Print

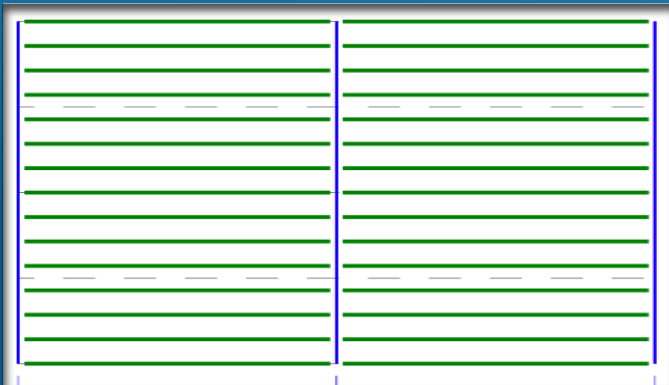
Report type: Live Load Actions Stage: Composite (short term) (Stage 3) Live Load: HS 20-44 Live Load Type: Axle Load

Span	Location (ft)	% Span	Positive Moment (kip-ft)	Negative Moment (kip-ft)	Positive Shear (kip)	Negative Shear (kip)	Positive Axial (kip)	Negative Axial (kip)	Positive Reaction (kip)	Negative Reaction (kip)
1	0.00	0.0	0.00	0.00	11.56	-1.87	0.00	0.00	11.56	-1.87

Support	HS20	Type 3	Type 3S2	Type 3-3
Column 1	11.56	9.44	9.14	7.59
Column 2	29.84	24.35	23.59	19.59
Column 3	25.84	21.09	20.43	16.97
Column 4	29.82	24.34	23.58	19.58
Column 5	11.56	9.44	9.14	7.59

CONCLUDING REMARKS

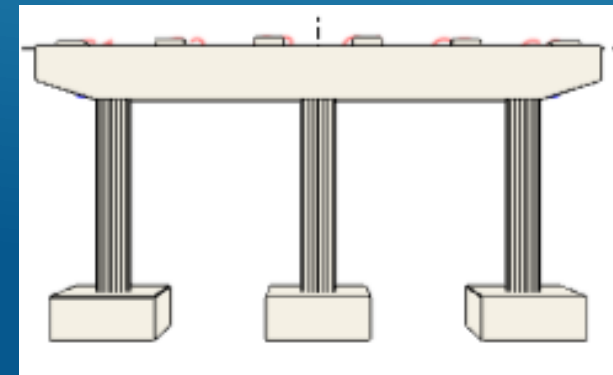
- ▶ No workaround is needed to load **Steel Bent Cap**, except treating the Floor beam as Cap.
- ▶ This workaround will work for Timber Floor Beams
 - ▶ Steel Truss bridges with Timber deck / Stringer / Floor beam System
 - ▶ Suspension bridges with Timber Deck
- ▶ Limitations of this workaround
 1. Number of Stringers in both spans must be the same (BrDR Limitation)
 2. Capacity needs to be established outside of the BrDR software
 - ▶ A girder line model within the BrDR can be used to establish Capacity



CONCLUDING REMARKS

➤ Possible Enhancements

- Modify the software so that GFS and FS floor systems accept “**Timber**” stringers and Floor beams
- Allow different number of Girders in each Structural Unit
- Modify the Substructure Module so that it analyzes Timber Caps



1. DETAILED STEP BY STEP MODELING PROCESS

(SLIDES 34 THROUGH 71)

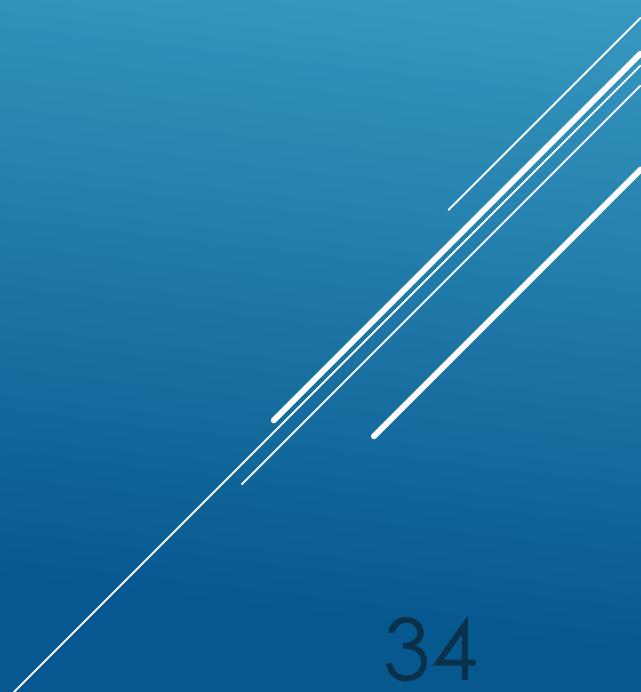
2. ESTABLISHING CAP CAPACITY USING BRDR SOFTWARE

(SLIDES 72 THROUGH 76)

A large steel truss bridge spans across a body of water. The bridge features a prominent central tower with a lattice structure. The sky is a mix of blue and orange, suggesting a sunset or sunrise. The bridge's reflection is visible in the water below.

ANY QUESTIONS?

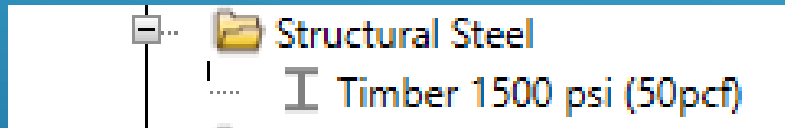
THANK YOU!



STEP BY STEP MODELING PROCESS

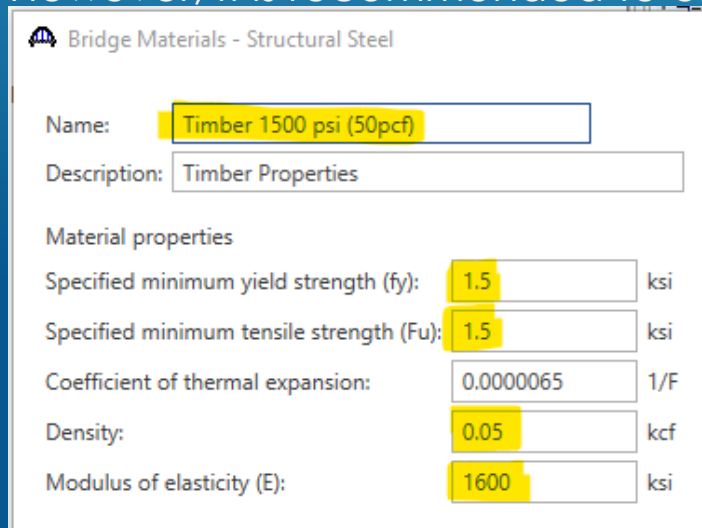
MODELING THE CAP

- ▶ 1. Generate “User Defined” Material Properties
 - ▶ 1.1 Steel Girder Material is changed to match the Timber material properties.



The allowable stress of the Timber Cap can be left as it.

However, It is recommended to enter the “inventory” allowable stress of the timber material

A screenshot of the "Bridge Materials - Structural Steel" dialog box. The "Name" field is "Timber 1500 psi (50pcf)" and the "Description" is "Timber Properties". The "Material properties" section includes:

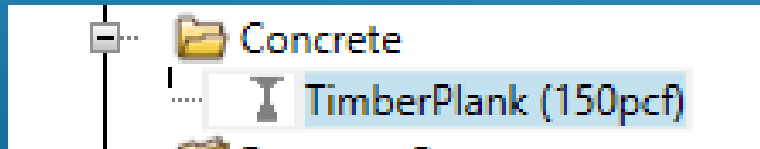
Specified minimum yield strength (fy):	1.5	ksi
Specified minimum tensile strength (Fu):	1.5	ksi
Coefficient of thermal expansion:	0.0000065	1/F
Density:	0.05	kcf
Modulus of elasticity (E):	1600	ksi

MODELING THE TIMBER CAP

- ▶ 1. Generate “User Defined” Material Properties (Cont’d)
 - ▶ 1.2 Create Concrete Material to handle Timber planks

The software will NOT allow the user to enter 50 pcf density concrete

As a result, a concrete deck with 150 pcf density concrete will be generated. The deck thickness will be adjusted to handle the difference in weight.

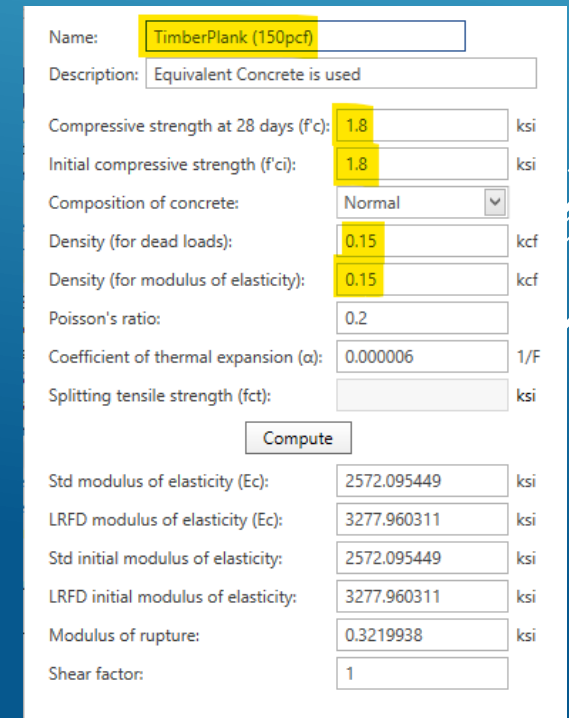


NOTE: Deck is used to establish the dead weight of the spans only.

Be sure to change the Name to reflect the properties used.

Since we are only interested in density, name is set as

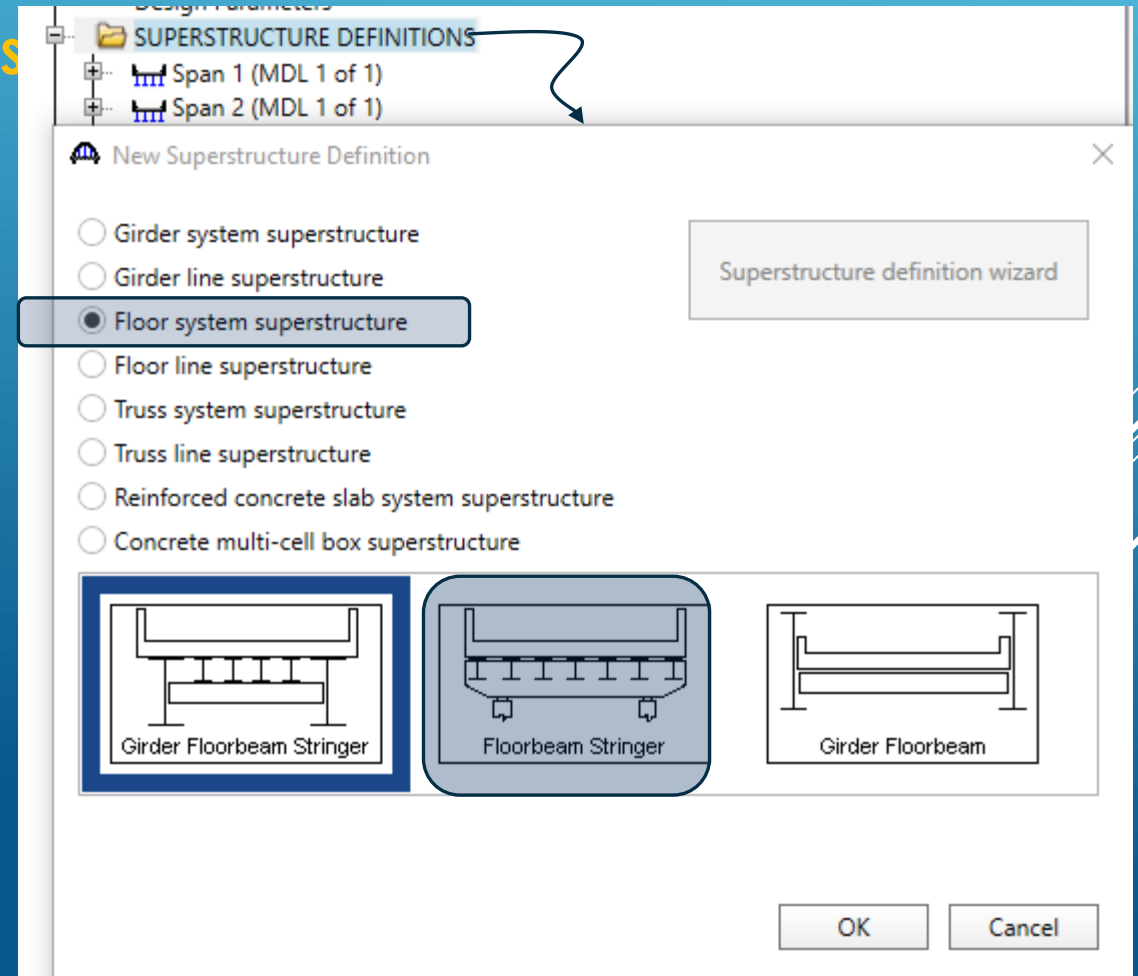
TimberPlank (150 pcf)

A screenshot of a software interface showing the material properties for "TimberPlank (150pcf)". The form includes fields for Name, Description, Compressive strength at 28 days (f'c), Initial compressive strength (f'ci), Composition of concrete, Density (for dead loads), Density (for modulus of elasticity), Poisson's ratio, Coefficient of thermal expansion (alpha), Splitting tensile strength (fct), Std modulus of elasticity (Ec), LRFD modulus of elasticity (Ec), Std initial modulus of elasticity, LRFD initial modulus of elasticity, Modulus of rupture, and Shear factor. The values are: Name: TimberPlank (150pcf), Description: Equivalent Concrete is used, Compressive strength at 28 days (f'c): 1.8 ksi, Initial compressive strength (f'ci): 1.8 ksi, Composition of concrete: Normal, Density (for dead loads): 0.15 kcf, Density (for modulus of elasticity): 0.15 kcf, Poisson's ratio: 0.2, Coefficient of thermal expansion (alpha): 0.000006 1/F, Splitting tensile strength (fct):, Std modulus of elasticity (Ec): 2572.095449 ksi, LRFD modulus of elasticity (Ec): 3277.960311 ksi, Std initial modulus of elasticity: 2572.095449 ksi, LRFD initial modulus of elasticity: 3277.960311 ksi, Modulus of rupture: 0.3219938 ksi, Shear factor: 1. A "Compute" button is located below the density fields.

Name:	TimberPlank (150pcf)
Description:	Equivalent Concrete is used
Compressive strength at 28 days (f'c):	1.8 ksi
Initial compressive strength (f'ci):	1.8 ksi
Composition of concrete:	Normal
Density (for dead loads):	0.15 kcf
Density (for modulus of elasticity):	0.15 kcf
Poisson's ratio:	0.2
Coefficient of thermal expansion (alpha):	0.000006 1/F
Splitting tensile strength (fct):	
Compute	
Std modulus of elasticity (Ec):	2572.095449 ksi
LRFD modulus of elasticity (Ec):	3277.960311 ksi
Std initial modulus of elasticity:	2572.095449 ksi
LRFD initial modulus of elasticity:	3277.960311 ksi
Modulus of rupture:	0.3219938 ksi
Shear factor:	1

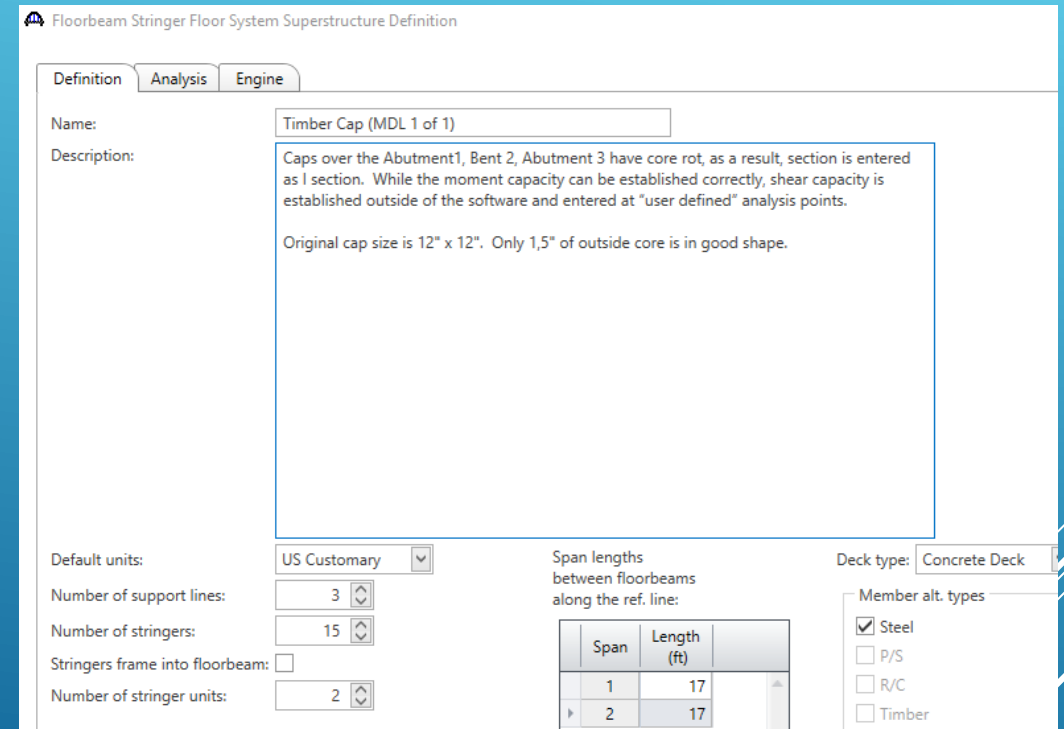
MODELING THE TIMBER CAP

- 2. Create a **FS Model**
 - ▶ Double click on **SUPERSTRUCTURE DEFINITIONS**
 - ▶ Choose **Floor system superstructure**
 - ▶ Select **Floorbeam Stringer** (FS) Picture
 - ▶ Click OK



MODELING THE TIMBER CAP

- 2.1 Create an **FS Model** *Cont'd*
 1. Name = **Timber Cap (MDL 1 of 1)**
 2. Deck Type = **Concrete Deck**
 3. Member Alt Types = **Steel**
 4. Number of support line = **3**
 5. Number of Stringers = **15**
 6. Stringers frame into floorbeam = **NO** (uncheck)
 7. Number of Stringer units = **2**
 8. Span Lengths = **17ft, 17ft**
 9. Description =



Note: Once the user clicks the OK button, most of the selection cannot be modified

MODELING THE TIMBER CAP

- 2.1 Create an **FS Model** Cont'd
 - ▶ 2.1.0 Analysis Tab

Floorbeam Stringer Floor System Superstructure Definition

Definition Analysis Engine

Structural slab thickness

- Consider structural slab thickness for rating
- Consider structural slab thickness for design

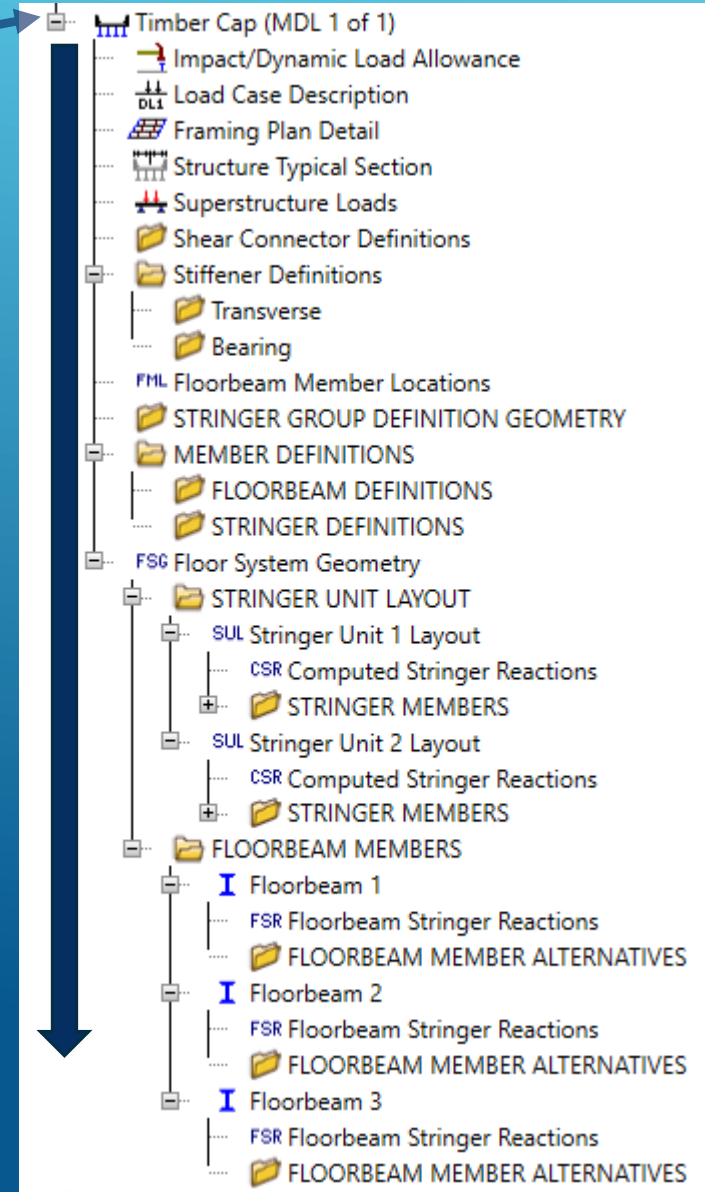
Wearing surface

- Consider wearing surface for rating
- Consider wearing surface for design
- Consider striped lanes for rating

Transverse loading

Vehicle increment in lane: 0.5 ft

Lane increment: 1 ft



MODELING THE TIMBER CAP

➤ 2.1 Create an **FS Model** Cont'd

- ▶ BrDR tree for GFS is shown here. The user needs to enter data from top to bottom.
- ▶ 2.1.1 Impact/DLA

Standard impact factor

For structural components where impact is to be included per AASHTO 3.8.1, choose the impact factor to be used:

50

Standard AASHTO impact: $I = \frac{50}{L + 125}$

Modified impact: times AASHTO impact

Constant impact override: %

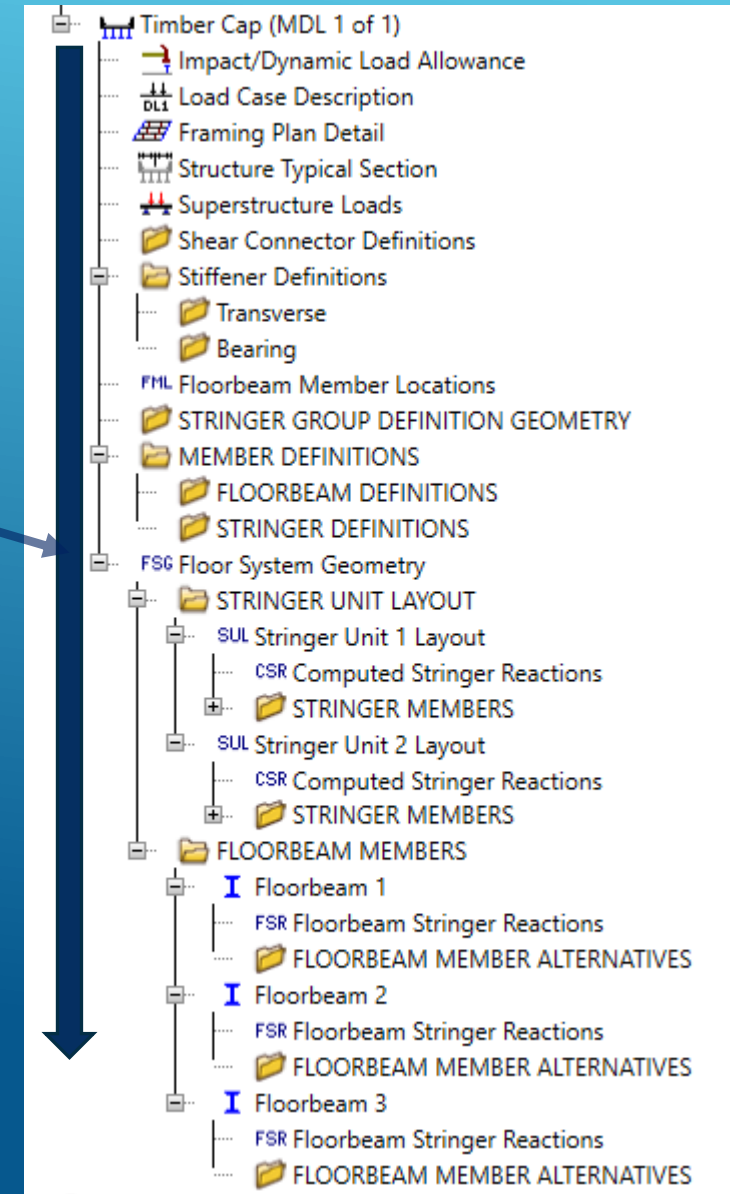
LRFD dynamic load allowance

Fatigue and fracture limit states: %

All other limit states: %

▶ 2.1.2 Load Case Description

Load case name	Description	Stage	Type
▶ DC1	DC acting on non-composite section	Non-composite (Stage 1)	D,DC
DC2	DC acting on long-term composite section	Composite (long term) (Stage 2)	D,DC
DW	DW acting on long-term composite section	Composite (long term) (Stage 2)	D,DW



MODELING THE TIMBER CAP

➤ 2.1 Create an **FS Model** Cont'd

▶ 2.1.3 Framing Plan Details

Structure Framing Plan Details

Number of stringers: 15

Layout

Support skew:

Support	Skew (degrees)
1	0
2	0
3	0

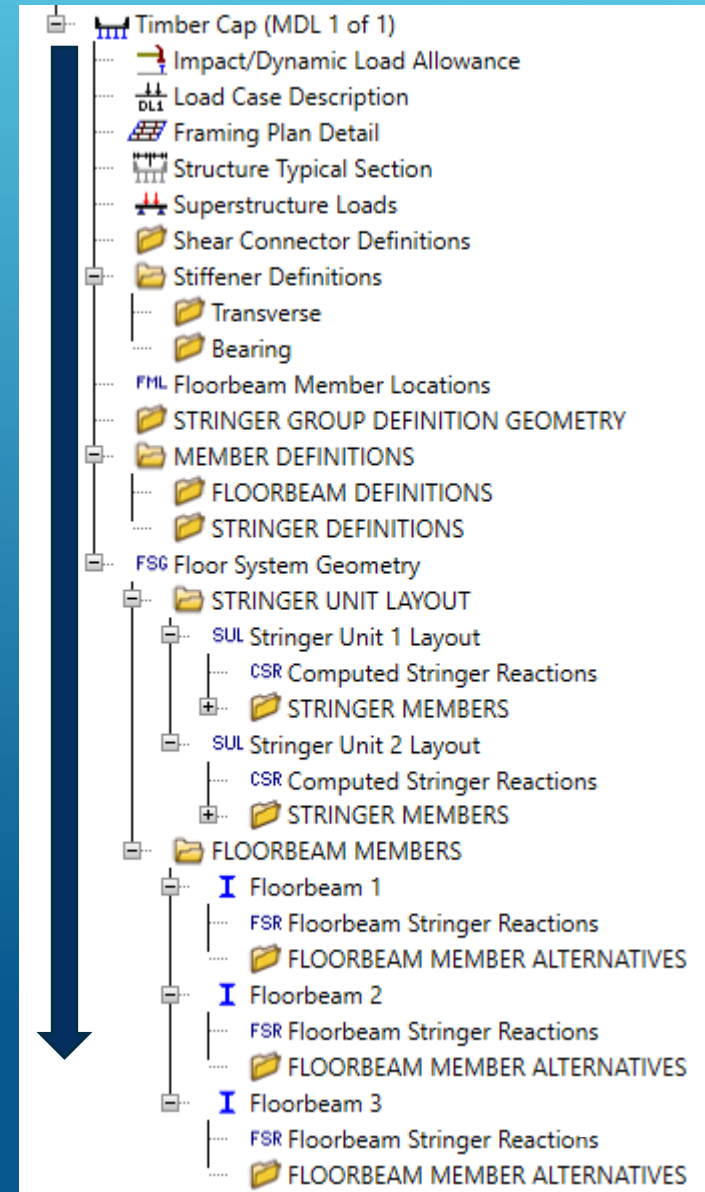
Member spacing orientation

Perpendicular to member
 Along support

Stringer spacing:

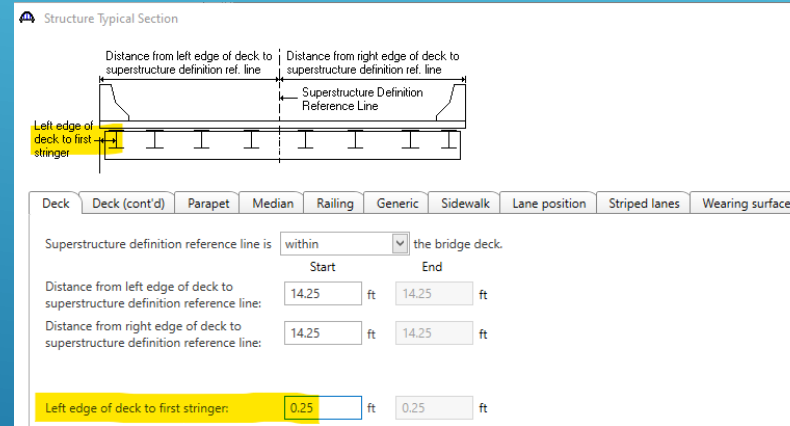
Stringer bay	Stringer spacing (ft)	
	Start of stringer	End of stringer
1	2	2
2	2	2
3	2	2
4	2	2
5	2	2
6	2	2
7	2	2
8	2	2
9	2	2
10	2	2
11	2	2
12	2	2
13	2	2
14	2	2

▶ Stringers have to be parallel to each other.



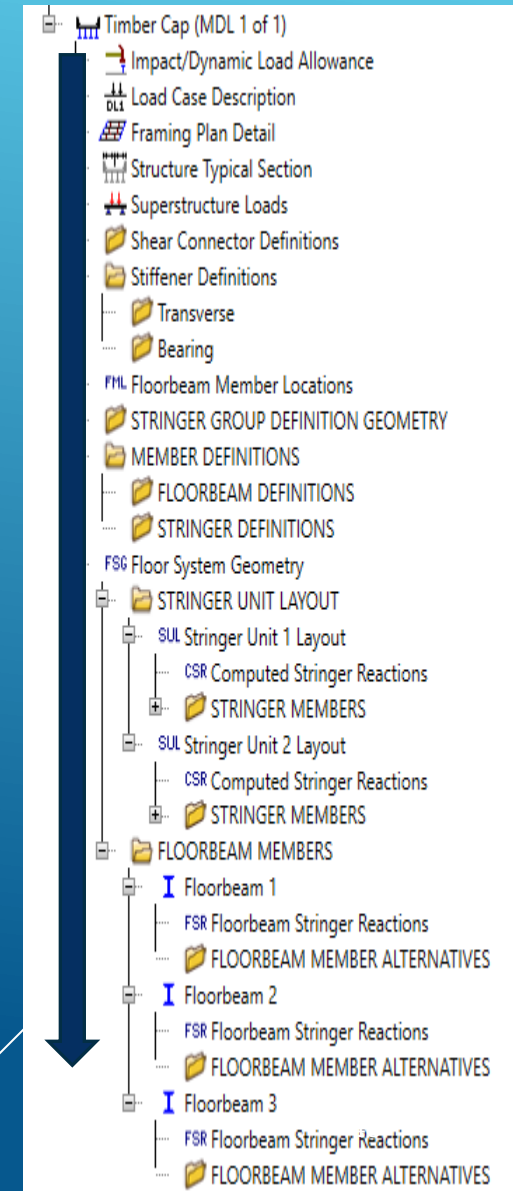
MODELING THE TIMBER CAP

- 2.1 Create a **FS Model** Cont'd
 - ▶ 2.1.4 Structure Typical Section



- ▶ Locate first stringer relative to edge of deck
- ▶ 2.1.4.1 Deck
 - ▶ Equivalent concrete deck for 4.5" Timber deck
 - ▶ = 4.5" x 50pcf / 150pcf = 1.5 inches
 - ▶ Select "user defined" equivalent Deck Concrete

The screenshot shows the 'Deck (cont'd)' tab in a software interface. The 'Deck concrete' dropdown is set to 'TimberPlank (150pcf)'. The 'Total deck thickness' is set to 1.5 in. The 'Load case' is 'Engine Assigned'. The 'Deck crack control parameter' is blank, and the 'Sustained modular ratio factor' is 3.



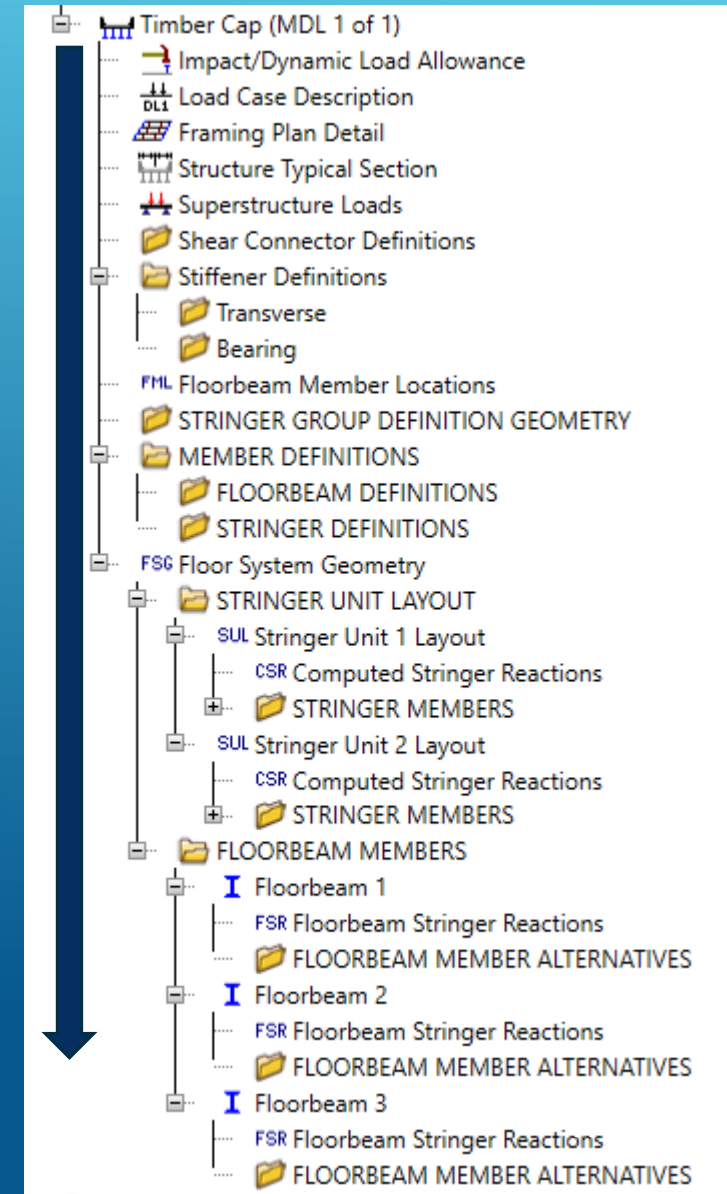
MODELING THE TIMBER CAP

- 2.1 Create a **FS Model** Cont'd
 - ▶ 2.1.4 Structure Typical Section, Cont'd
 - ▶ 2.1.4.2 Barrier (Generic)

Deck	Deck (cont'd)	Parapet	Median	Railing	Generic	Sidewalk	Lane position	Striped lanes	Wearing surface
Name		Load case	Measure to	Edge of deck dist. measured from	Distance at start (ft)	Distance at end (ft)	Front face orientation		
MBGR (Sgl Rail,WD 6x8 POST)		DC2	Front	Left Edge	0.25	0.25	Right		
MBGR (Sgl Rail,WD 6x8 POST)		DC2	Front	Right Edge	0.25	0.25	Left		

- ▶ 2.1.4.3 Lane Position

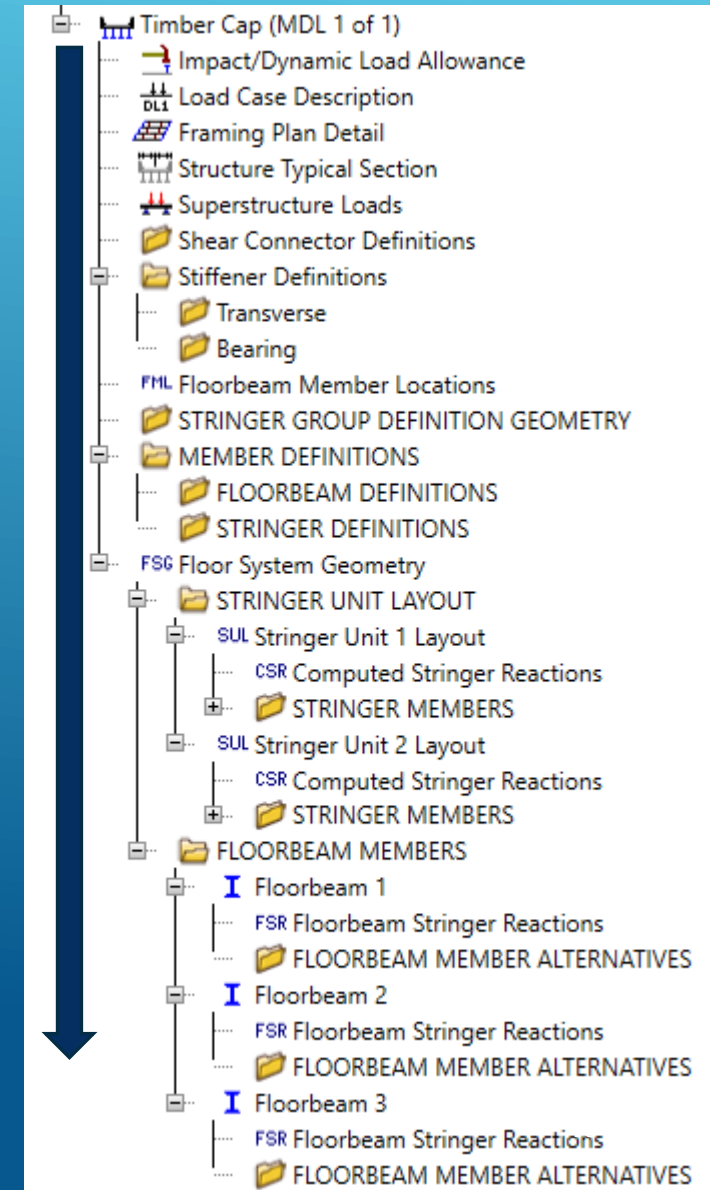
Deck	Deck (cont'd)	Parapet	Median	Railing	Generic	Sidewalk	Lane position	Striped lanes	Wearing surface
Travelway number	Distance from left edge of travelway to superstructure definition reference line at start (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at start (B) (ft)	Distance from left edge of travelway to superstructure definition reference line at end (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at end (B) (ft)					
1	-14	14	-14	14					



MODELING THE TIMBER CAP

- 2.1 Create a **FS Model** Cont'd
 - ▶ 2.1.4 Structure Typical Section, Cont'd
 - ▶ 2.1.4.3 Wearing Surface

Deck	Deck (cont'd)	Parapet	Median	Railing	Generic	Sidewalk	Lane position	Striped lanes	Wearing surface
Wearing surface material:		AC							
Description:		AC Overlay							
Wearing surface thickness:		3.5		in		<input type="checkbox"/> Thickness field measured (DW = 1.25 if checked)			
Wearing surface density:		144		pcf					
Load case:		DW							
Copy from library...									

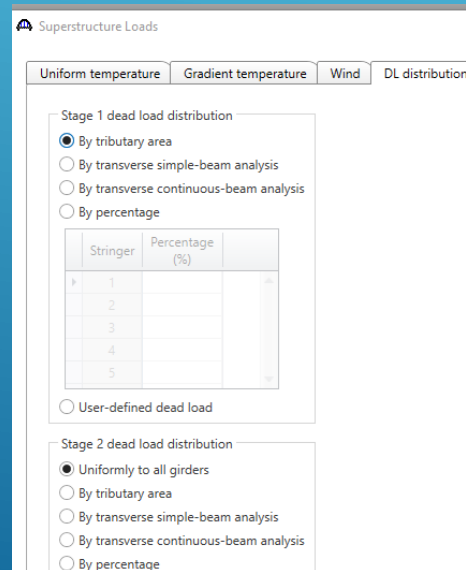


MODELING THE TIMBER CAP

➤ 2.1 Create a **FS Model** Cont'd

▶ 2.1.5 Superstructure Loads

- ▶ No temperature and wind loads
- ▶ DL distribution – use to the default settings

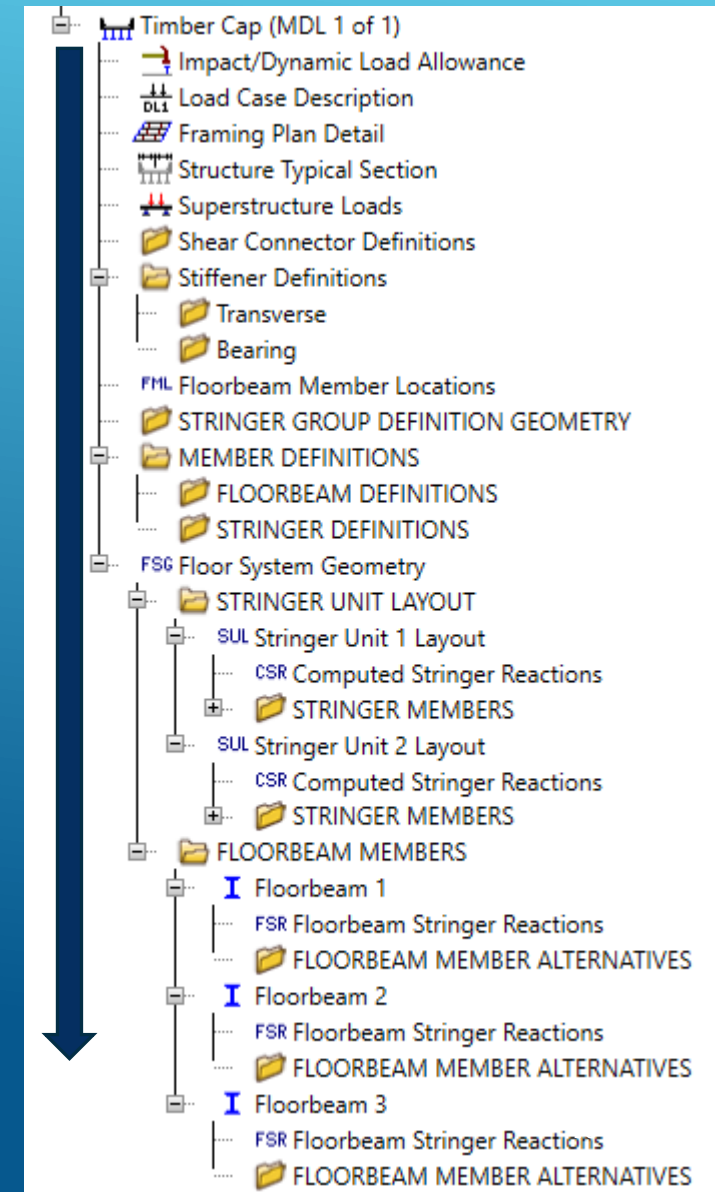


▶ 2.1.6 Shear Connector definition

- ▶ Since deck, stringers, and caps are timber elements there is no need to define these

▶ 2.1.7 Stiffener Definition

- ▶ Since capacities will be overwritten at user-defined pt of interests, there is not to define any stiffeners



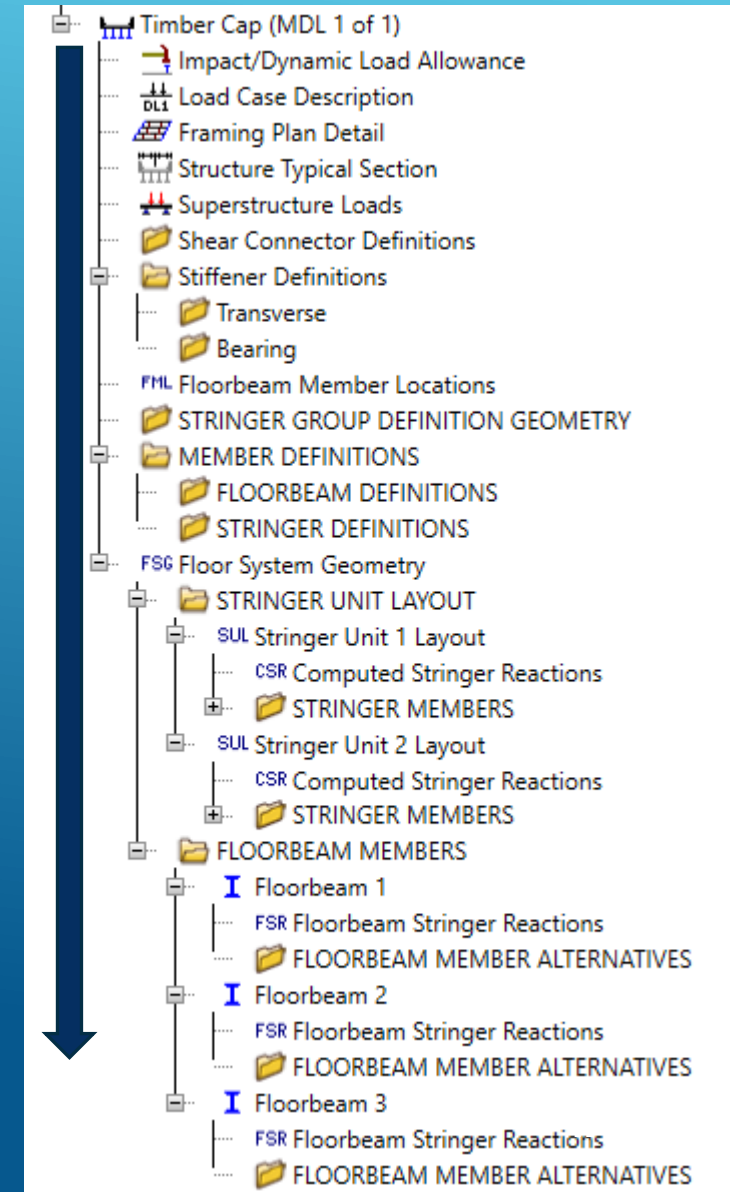
MODELING THE TIMBER CAP

➤ 2.1 Create an **FS Model** Cont'd

▶ 2.1.8 Floorbeam Member Locations

- ▶ Software fills in most of the information needed, however, the user needs to modify it to match the as-built plans.
- ▶ Make sure the Perpendicular distance from the left edge of the deck to the left edge of the floorbeam is correctly entered.
- ▶ Open the GUI and Rename the software defined name to match actual support names.

Floorbeam name	Reference distance (ft)	Offset (ft)	Location (ft)	Skew (degrees)	Perpendicular distance from left edge of deck to left edge of floorbeam (ft)
FloorbeamMbrLocation1	0	0	0	0	
FloorbeamMbrLocation2	17	0	17	0	
FloorbeamMbrLocation3	34	0	34	0	
Abutment 1	0	0	0	0	0
Bent 2	17	0	17	0	0
Abutmen 3	34	0	34	0	0



MODELING THE TIMBER CAP

➤ 2.1 Create an **FS Model** Cont'd

▶ 2.1.9 STRINGER GROUP DEFINITION GEOMETRY

- ▶ Software fills in most of the information needed, however, the user needs to verify and adjust them if needed.
- ▶ Typically, timber stringers are simply supported at bents, so “Stringer support” will be simple.
- ▶ Name is assigned as **Stringer Arrangement**

Stringer Group Definition Geometry

Name: **Stringer Arrangement** Description: **Stringers are NOT continuous**

Stringer span lengths | Diaphragms

Number of floorbeams that support this stringer group definition: 2

All floorbeams are perpendicular to the structure definition reference line: Yes No

Floorbeam spacings

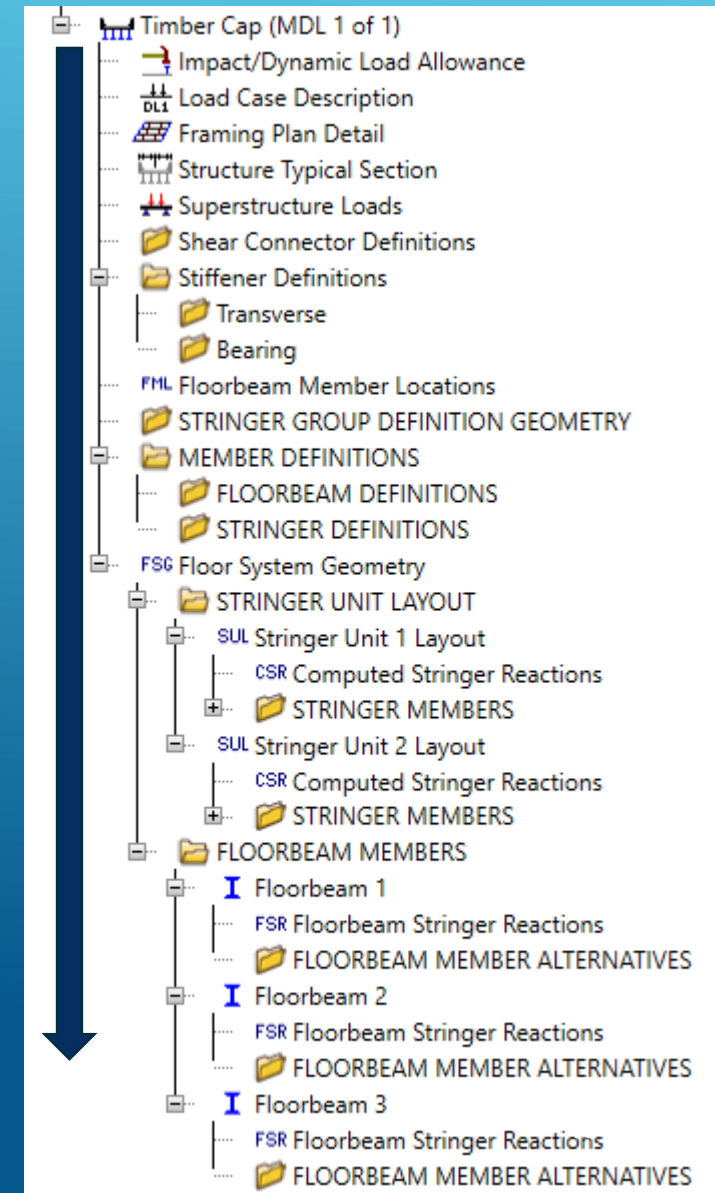
Select the floorbeam spacings which can be used to define the stringer span lengths in this stringer group definition:

Possible floorbeam spacing (ft)

Floorbeam spacing (ft)	Skew angle (degrees)	Stringer support	Offset/cantilever length (ft)
0	0.000	Simple	0
17	0.000	Simple	0

Computed resulting stringer span lengths

Span	Length (ft)	Cantilever span
1	17	<input type="checkbox"/>

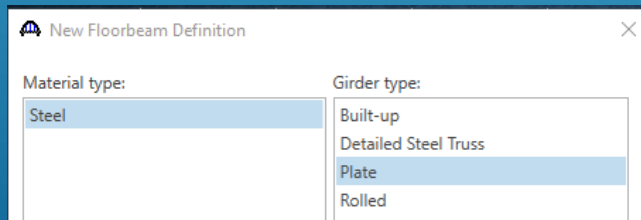


MODELING THE TIMBER CAP

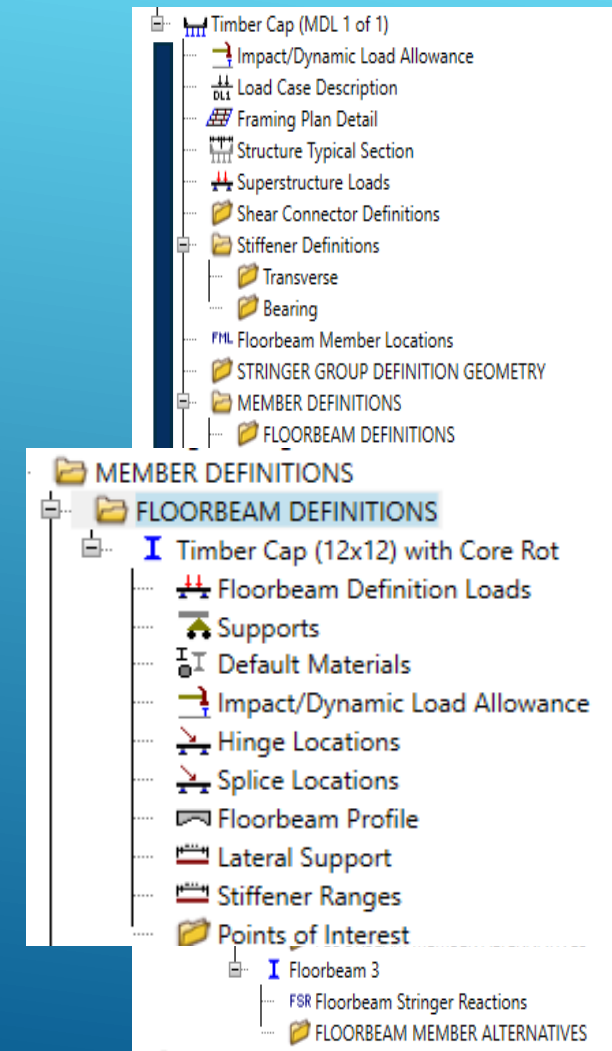
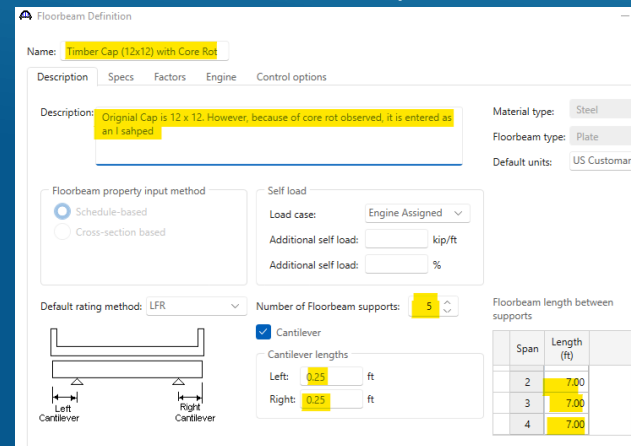
➤ 2.1 Create a **FS Model** Cont'd

▶ 2.1.10 FLOORBEAM DEFINITIONS

- ▶ Note: For this bridge Floorbeam is “Abutment / Bent Cap”
- ▶ Create NEW Floorbeam (rightmouse & new)



- ▶ Floor beam is supported by 5 columns and spacing between the supports are: 7ft, 7ft, 7ft, and 7ft
- ▶ Floor beam is extended 6” beyond the CL of column support (Cantilevered)
- ▶ Name: **Timber Cap (12x12)with Cor Rot**

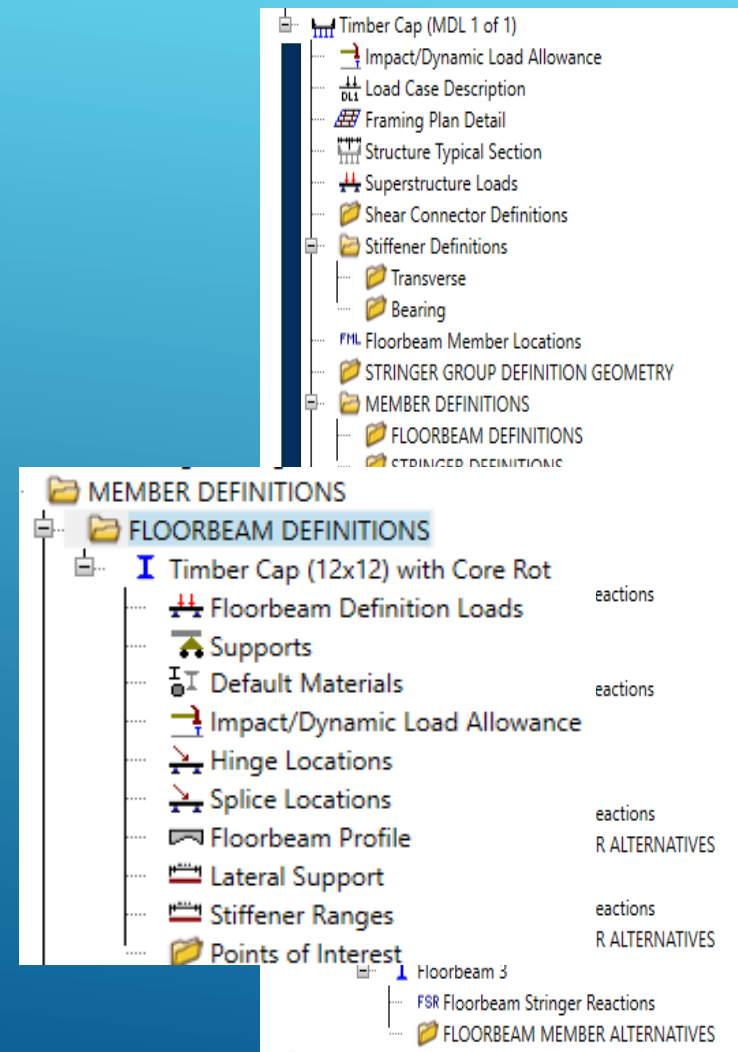
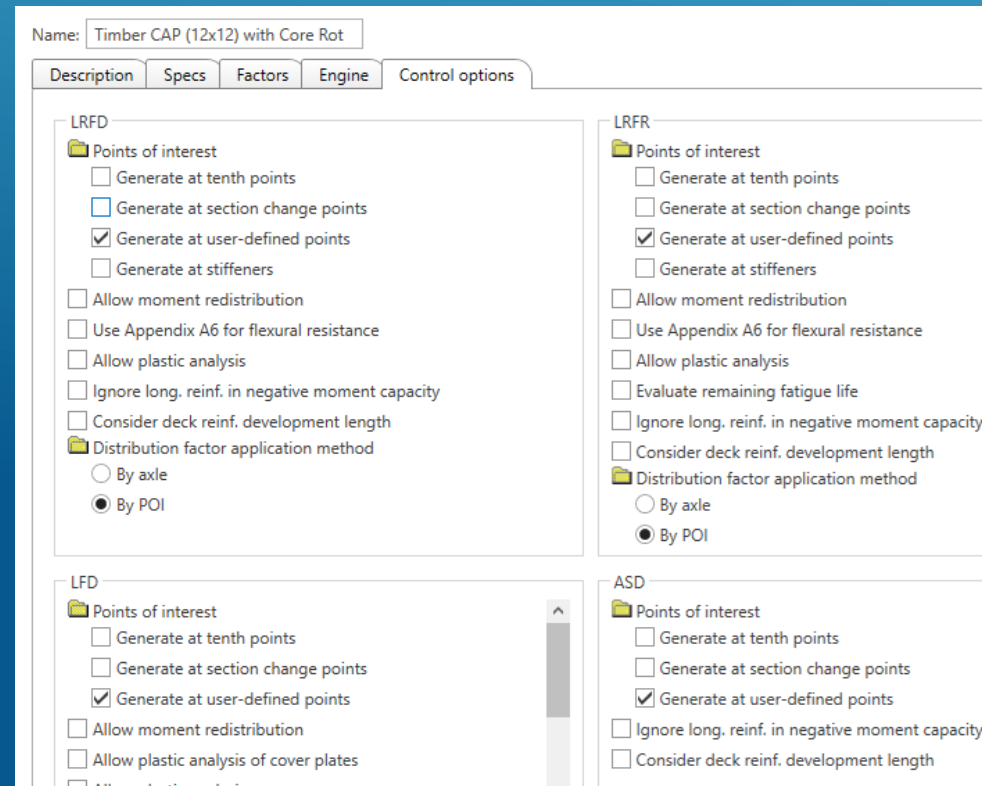


MODELING THE TIMBER CAP

➤ 2.1 Create a **FS Model** Cont'd

▶ 2.1.10 FLOORBEAM DEFINITIONS

- ▶ Change the Control Options to load rate only at the user defined points

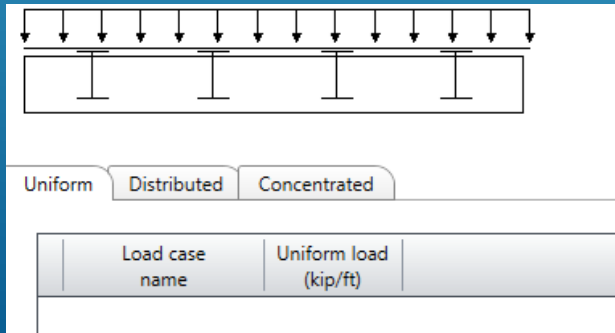


MODELING THE TIMBER CAP

➤ 2.1 Create a **FS Model** Cont'd

▶ 2.1.10 FLOORBEAM DEFINITIONS Cont'd

- ▶ 2.1.10.1: Loads: If any additional loads are directly placed on the bent cap enter it using FI beam Definition Loads



- ▶ 2.1.10.2: View the supports conditions and adjust if needed

- ▶ 2.1.10.4 Ensure that DLA is set to zero for Timber CAP

The screenshot shows the software interface for modeling a timber cap. The model tree on the right includes the following items:

- Timber Cap (MDL 1 of 1)
- Impact/Dynamic Load Allowance
- Load Case Description
- Framing Plan Detail
- Structure Typical Section
- Superstructure Loads
- Shear Connector Definitions
- Stiffener Definitions
- Transverse
- Bearing
- FMB Floorbeam Member Locations
- STRINGER GROUP DEFINITION GEOMETRY
- MEMBER DEFINITIONS
- FLOORBEAM DEFINITIONS
- STRINGER DEFINITIONS
- FSB Floor System Geometry
- STRINGER UNIT LAYOUT
- SUL Stringer Unit 1 Layout
- CSR Computed Stringer Reactions
- STRINGER MEMBERS
- SUL Stringer Unit 2 Layout
- CSR Computed Stringer Reactions
- STRINGER MEMBERS
- FLOORBEAM MEMBERS
- Floorbeam 1
- FSR Floorbeam Stringer Reactions
- FLOORBEAM MEMBER ALTERNATIVES
- Floorbeam 2
- FSR Floorbeam Stringer Reactions
- FLOORBEAM MEMBER ALTERNATIVES
- Floorbeam 3
- FSR Floorbeam Stringer Reactions
- FLOORBEAM MEMBER ALTERNATIVES

The 'MEMBER DEFINITIONS' panel on the left shows the following items:

- FLOORBEAM DEFINITIONS
- Timber Cap (12x12) with Core Rot
- Floorbeam Definition Loads
- Supports
- Default Materials
- Impact/Dynamic Load Allowance
- Hinge Locations
- Splice Locations
- Floorbeam Profile
- Lateral Support
- Stiffener Ranges
- Points of Interest

The 'General' property panel shows the following table:

Support number	Support type	Translation constraints			Rotation constraints
		X	Y	Z	
1	Pinned	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Pinned	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Pinned	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Pinned	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Pinned	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The 'Impact/Dynamic Load Allowance' property panel shows the following options:

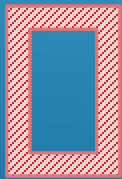
- Modified impact: 0 times AASHTO impact
- Constant impact override: 0 %

The 'LRFD dynamic load allowance' property panel shows the following options:

- Fatigue and fracture limit states: 0 %
- All other limit states: 0 %

MODELING THE TIMBER CAP

- 2.1 Create a **FS Model** Cont'd
 - ▶ 2.1.10 FLOORBEAM DEFINITIONS Cont'd



- ▶ 2.1.10.7 Floorbeam Profile
 - ▶ Top and Bottom flanges are 12" x 1.5"
 - ▶ Web is 3" x 9" (depth)

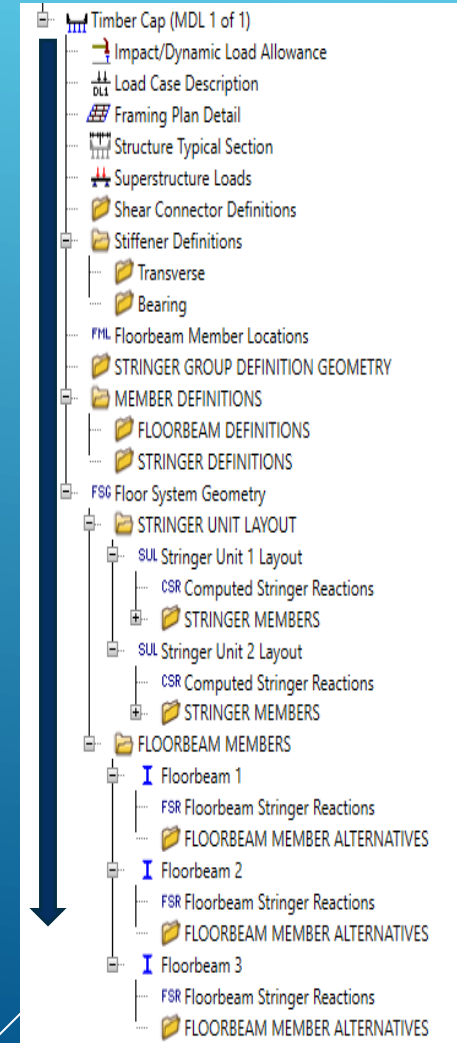
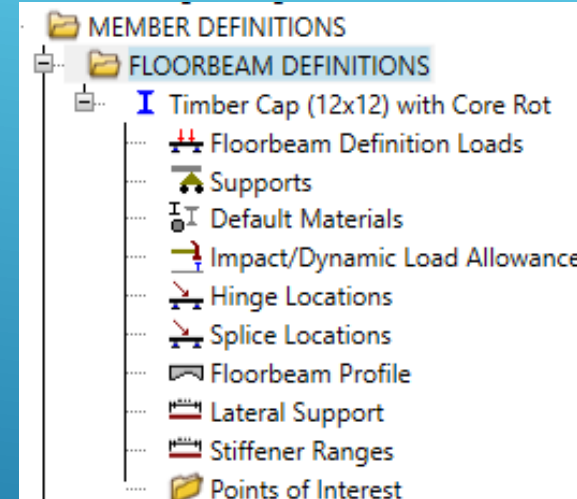


- ▶ Use the "user defined" steel **Timber 1500 psi (50 pcf)**

Web		Top flange		Bottom flange							
Begin depth (in)	Depth vary	End depth (in)	Thickness (in)	Start distance (ft)	Length (ft)	End distance (ft)	Material	Weld at right			
> 9	None	9.0000	3.0000	0.00	28.50	28.50	Timber 1500 psi (50pcf)	-- None --			

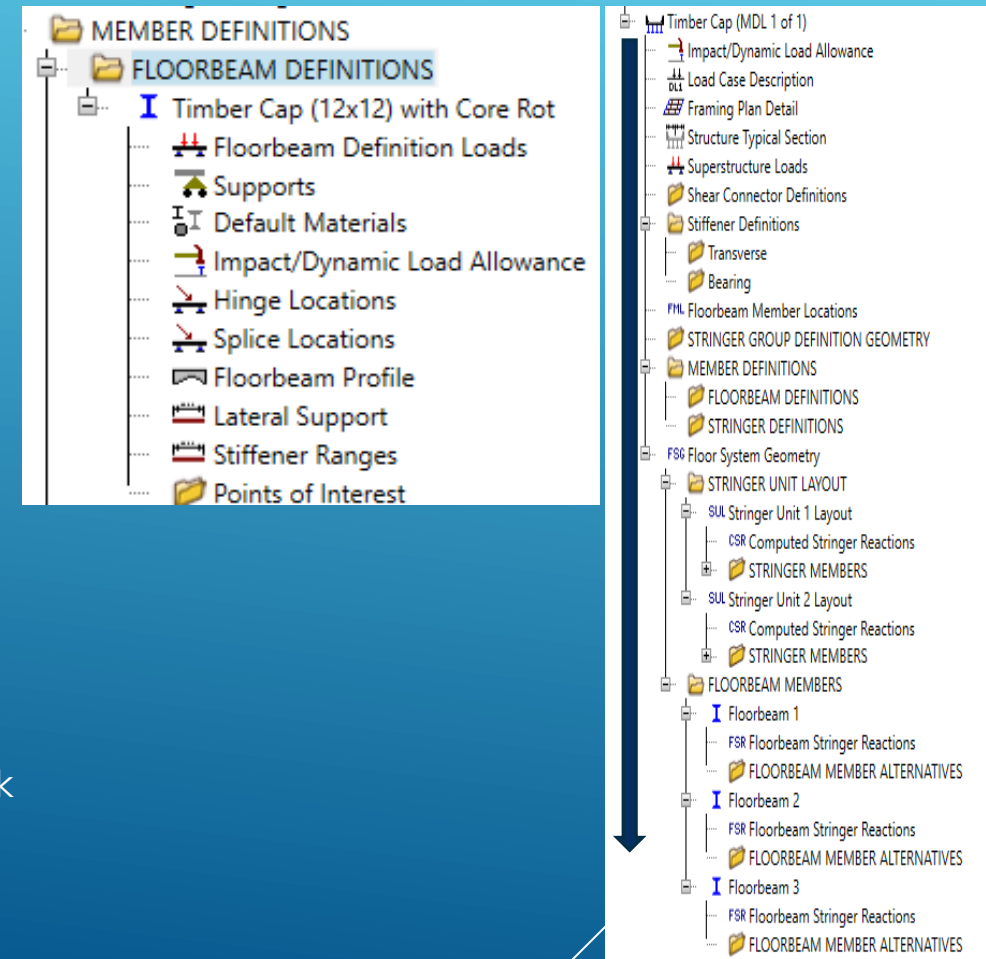
Web		Top flange		Bottom flange							
Begin width (in)	End width (in)	Thickness (in)	Start distance (ft)	Length (ft)	End distance (ft)	Material	Weld				
> 12	12.0000	1.5000	0.00	28.50	28.50	Timber 1500 psi (50pcf)	-- None --				

Web		Top flange		Bottom flange							
Begin width (in)	End width (in)	Thickness (in)	Start distance (ft)	Length (ft)	End distance (ft)	Material	Weld				
> 12	12.0000	1.5000	0.00	28.50	28.50	Timber 1500 psi (50pcf)	-- None --				



MODELING THE TIMBER CAP

- ▶ 2.1 Create a FS Model Cont'd
 - ▶ 2.1.10 FLOORBEAM DEFINITIONS Cont'd
 - ▶ 2.1.10.8 Lateral Support
 - ▶ Since capacity overwrite is used, it can be left blank
 - ▶ 2.1.10.9 Transverse Stiffeners
 - ▶ Again, Since capacity overwrite is used, it can be left blank



MODELING THE TIMBER CAP

➤ 3.1 Establish ASR Flexure and Shear Capacity

- ▶ Capacity needs to be established outside of the software
 - ▶ Inventory and Operating Flexural stress override

The allowable unit stress in bending shall be the tabulated stress adjusted by the applicable adjustment factors given in the following equation:

$$F'_b = F_b C_M C_D C_F C_V C_L C_f C_{fu} C_r \quad (13-2)$$

- ▶ Inventory and Operating shear capacity override

$$f_v = \frac{3V}{2bd} \quad (13-9)$$

$$F'_v = F_v C_M C_D \quad (13-11)$$

$$V_c = (2/3) bd f_v$$

- ▶ Alternatively, By generating a girder line member using timber member, capacity could be established

MODELING THE TIMBER CAP

➤ 3.2 Establish LRFR Flexure and Shear Capacity

- ▶ Capacity needs to be established outside of the software
 - ▶ Strength I and Strength II Flexural Capacities

$F_b = F_{bo} C_{KF} C_M (C_F \text{ OR } C_v) C_{fu} C_i C_d C_\lambda$	(8.4.4.1-1)
$M_n = F_b S C_L$	(8.6.2-1)
$M_r = \phi M_n$	(8.6.1-1)
Flexure	$\phi = 0.85$
Shear	$\phi = 0.75$

- ▶ Strength I and Strength II Shear Capacities

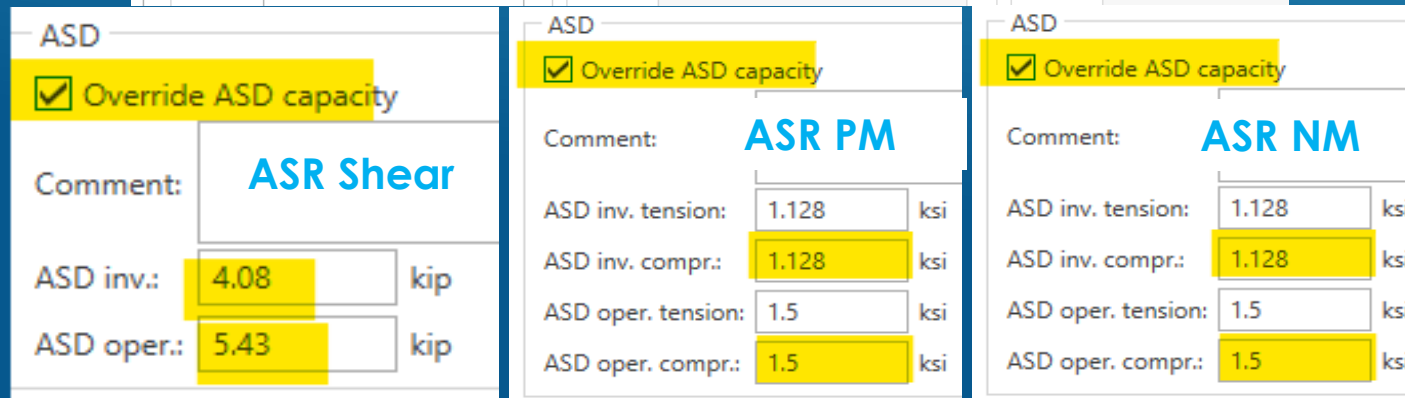
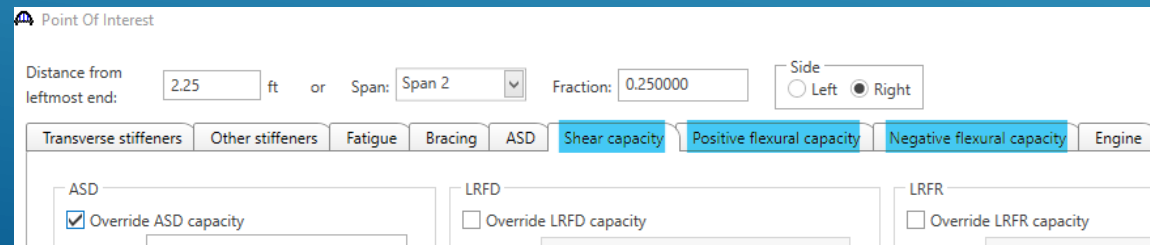
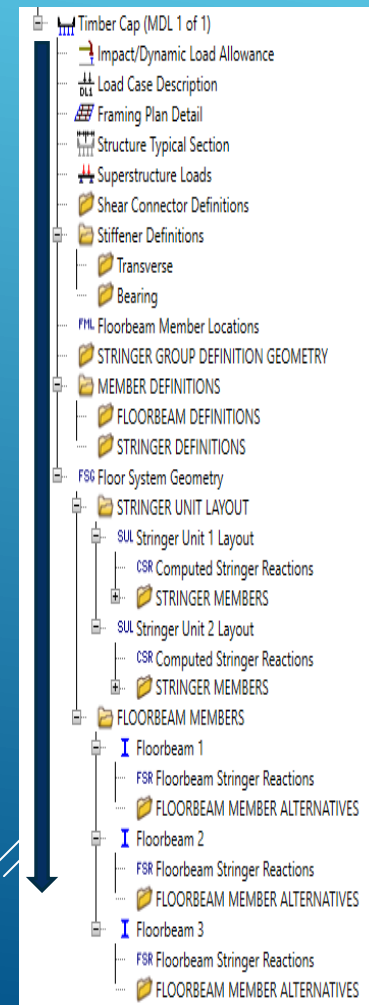
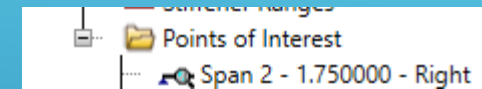
$F_v = F_{vo} C_{KF} C_M C_i C_\lambda$	(8.4.4.1-2)
$V_n = \frac{F_v b d}{1.5}$	(8.7-2)
$V_r = \phi V_n$	(8.7-1)

MODELING THE TIMBER CAP

➤ 2.1 Create a **FS Model** cont'd

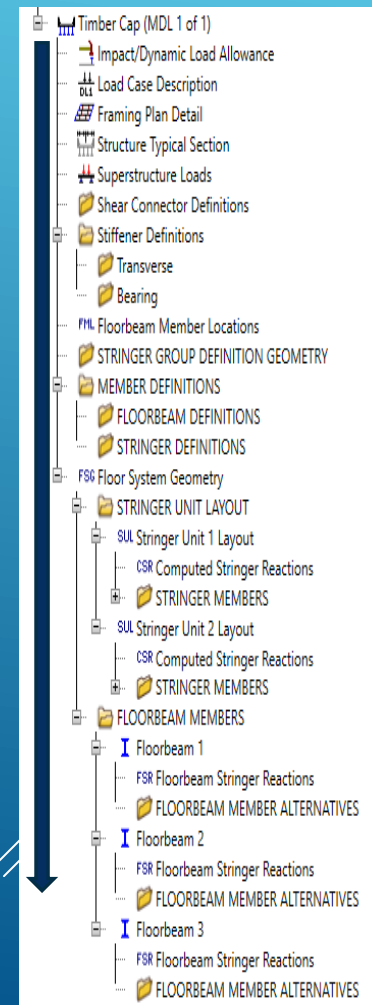
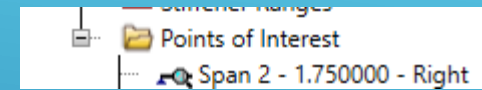
▶ 2.1.10.10 Floorbeam Points of Interest:

- ▶ Create **one** analysis point and overwrite the capacities for ASR and OR LRFR
- ▶ FOR **ASR** method, the user needs to enter inventory and Operating Capacities for Shear, Positive Flexure and Negative Flexure



MODELING THE TIMBER CAP

- 2.1 Create a FS Model cont'd
 - ▶ 2.1.10.10 Floorbeam Points of Interest:
 - ▶ FOR **LRFR** method, the user needs to enter Strength I and Strength II Capacities for Shear, Positive Flexure and Negative Flexure. User need to enter flexural capacity in terms of capacity and maximum stress.



Point Of Interest

Distance from leftmost end: ft or Span: Fraction: Side: Left Right

Transverse stiffeners | Other stiffeners | Fatigue | Bracing | ASD | **Shear capacity** | **Positive flexural capacity** | **Negative flexural capacity** | Engine

ASD Override ASD capacity | LRFD Override LRFD capacity | LRFR Override LRFR capacity

Shear capacity		LRFR Shear	
Limit state	ride	(kip)	Phi
▶ STRENGTH-I	<input checked="" type="checkbox"/>	13.6	0.75
STRENGTH-II	<input checked="" type="checkbox"/>	13.6	0.75
SERVICE-II	<input type="checkbox"/>		
FATIGUE	<input type="checkbox"/>		

Positive flexural capacity		Negative flexural capacity			
LRFR					
<input checked="" type="checkbox"/> Override LRFR capacity					
Limit state	Over-ride	Moment capacity (kip-ft)	Tension capacity (ksi)	Compr. capacity (ksi)	Phi
▶ STRENGTH-I	<input checked="" type="checkbox"/>	54.43	3.318	3.318	0.85
STRENGTH-II	<input checked="" type="checkbox"/>	54.43	3.318	3.318	0.85
SERVICE-II	<input type="checkbox"/>				
FATIGUE	<input type="checkbox"/>				

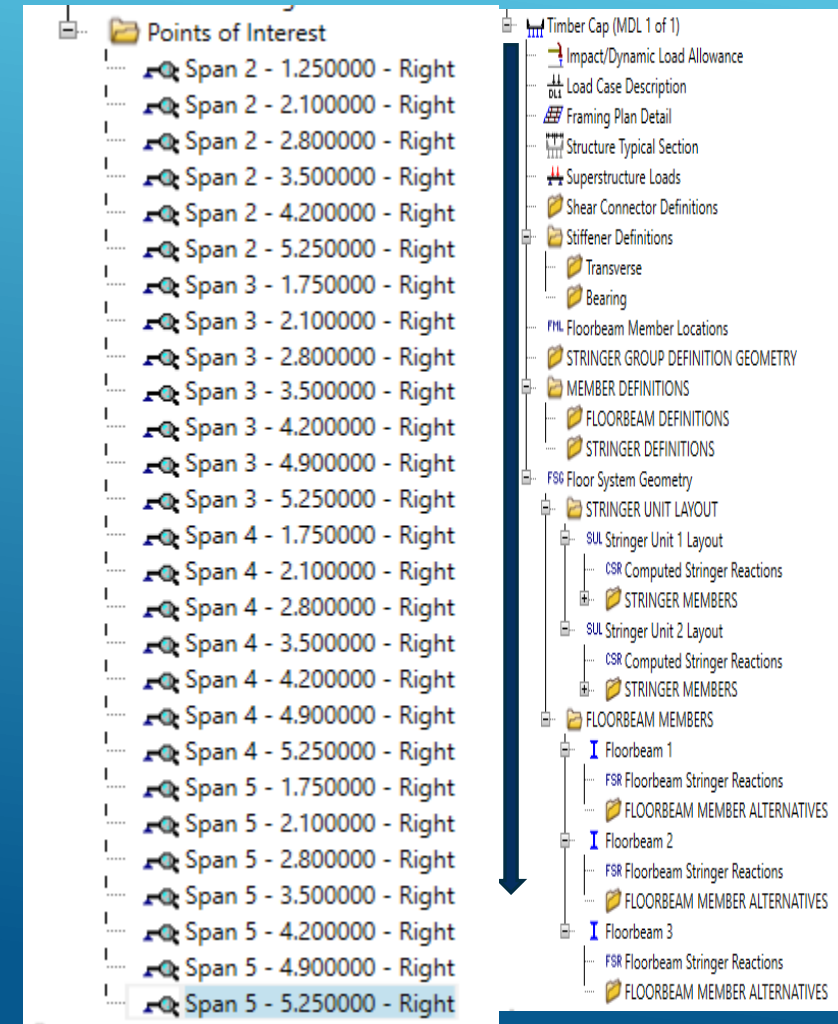
LRFR PM and NM

MODELING THE TIMBER CAP

➤ 2.1 Create a **FS Model** cont'd

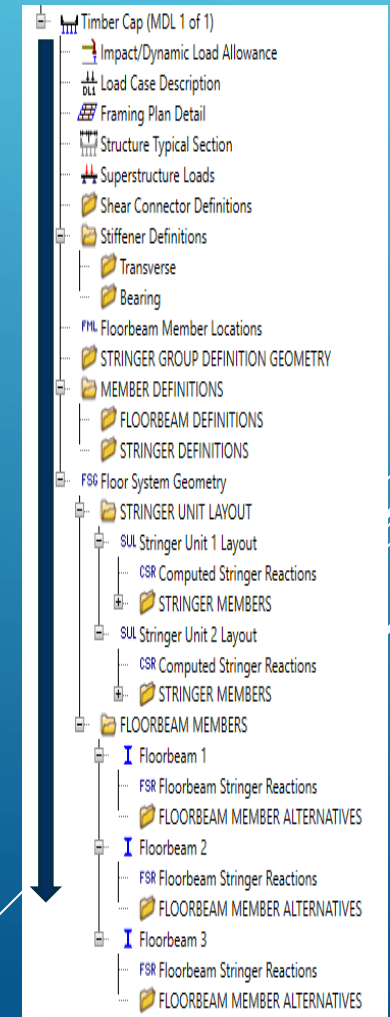
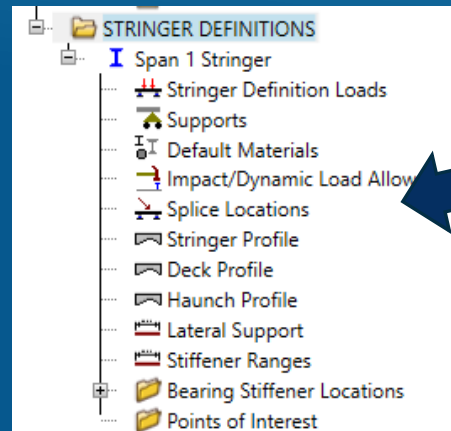
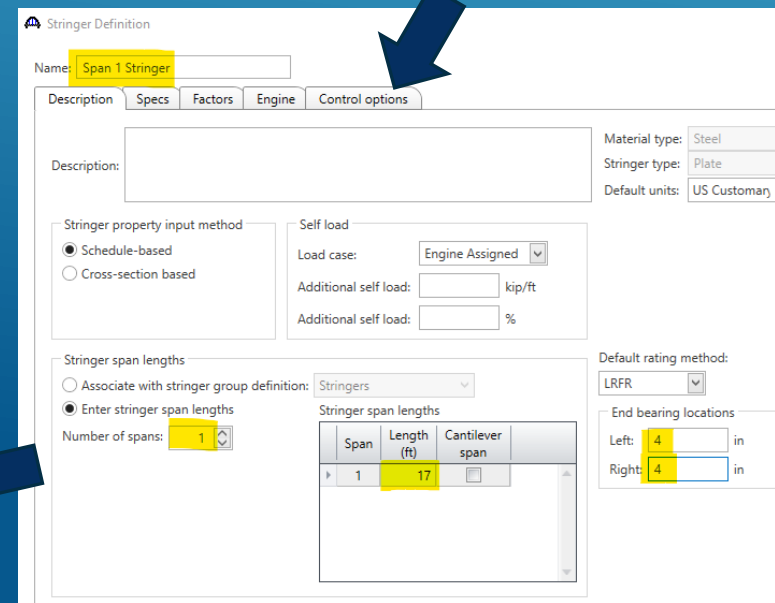
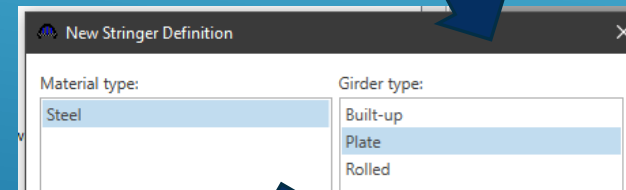
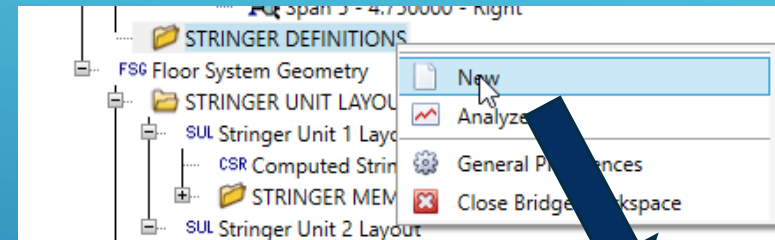
▶ 2.1.10.10 Floorbeam Points of Interest:

- ▶ Typically, timber member capacity remains the same for the entire length.
- ▶ Once first user-defined points is created and capacities are overwritten, Create **Additional Points of Interest**, by copy/paste or drag/drop approach and modify the analysis point locations to cover
- ▶ ALL 10th points
- ▶ Critical Shear locations
 - Shear Capacity for Caps are established at $L/4$ ($7\text{ft}/4 = 1.75\text{ft}$) or $3.0d = 3\text{ft}$ from face of support
 - Column Support is 12" x 12" therefore, critical shear analysis points will be 1.75ft from CL of supports (girders)
- ▶ Within "d" distance pts from support,
 - ▶ Enter a very large shear capacity so that shear will NOT control the rating.
 - ▶ This is because, per the Specification, no analysis is needed.



MODELING THE TIMBER CAP

- 2.1 Create a **FS Model** Cont'd
 - ▶ 2.1.11 Create **STRINGER DEFINITIONS**
 - ▶ Generate Plate Girder
 - ▶ Create NEW
 - ▶ Pick the Girder Type Plate
 - ▶ Enter the Name (**Span 1 Stringer**)
 - ▶ Number of Span = 1
 - ▶ Span Length = 17ft
 - ▶ End bearing = 4 in



MODELING THE TIMBER CAP

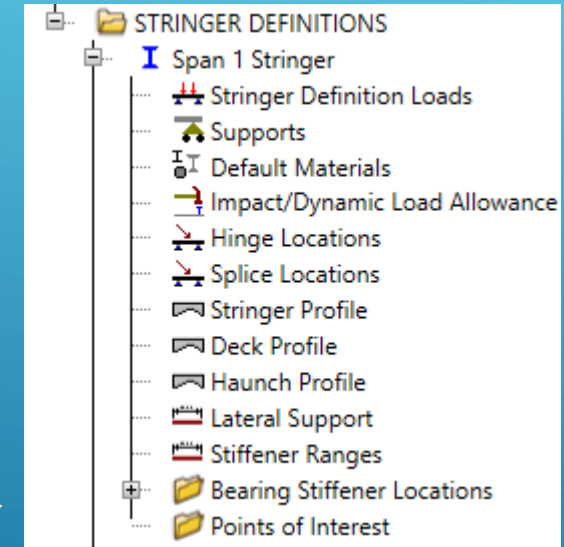
➤ 2.1 Create a **FS Model** Cont'd

▶ 2.1.11.1 Stringer Name: **Span 1 Stringer**

- ▶ Follow the tree and enter the required data.
 - ▶ In general, no change is needed **except for the stringer profile.**

▶ 2.1.11.7 Stringer Profile:

- ▶ Generate the “Plate Section” that produces a rectangular Timber section (5.75” x 11.00”)
- ▶ BrDR software requires web thickness to be less than flange width
- ▶ As a result, **the flange width will be increased by 0.005 inches**



Type: Plate Girder

Web | Top flange | Bottom flange

	Begin depth (in)	Depth vary	End depth (in)	Thickness (in)	Start distance (ft)	Length (ft)	End distance (ft)	Material	Weld at right
I	9	None	9	5.75	0	17	17	Timber 1500 psi (50pcf)	-- None --

Type: Plate Girder

Web | Top flange | Bottom flange

	Begin width (in)	End width (in)	Thickness (in)	Start distance (ft)	Length (ft)	End distance (ft)	Material	Weld	Weld at right
I	5.755	5.755	1	0	17	17	Timber 1500 psi (50pcf)	-- None --	-- None --

Web | Top flange | Bottom flange

	Begin width (in)	End width (in)	Thickness (in)	Start distance (ft)	Length (ft)	End distance (ft)	Material	Weld	Weld at right
▶	5.755	5.755	1	0	17	17	Timber 1500 psi (50pcf)	-- None --	-- None --

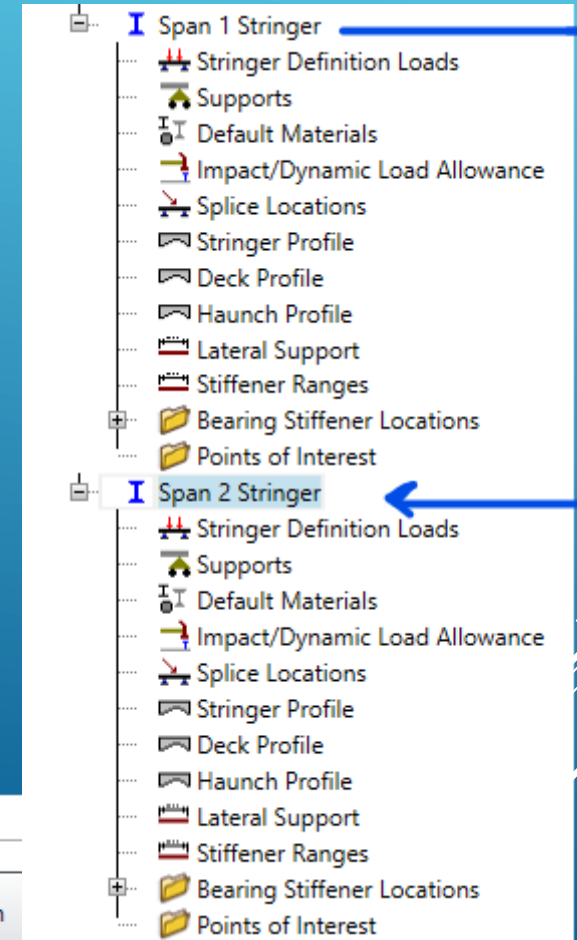
MODELING THE TIMBER CAP

- 2.1 Create a **FS Model** Cont'd
 - 2.1.11.2 Create the Stringer Definition for **Span 2 Stringer**
 - ▶ Duplicate Stringer Definition **Span 1 Stringer** and rename to generate **Span 2 Stringer** profile
 - ▶ Adjust the width and depth to match the Stringer size 5.50" x 11.75"
 - ▶ Steel Material will be **Timber 1500 psi (50 pcf)**

Web								
Top flange								
Bottom flange								
	Begin depth (in)	Depth vary	End depth (in)	Thickness (in)	Start distance (ft)	Length (ft)	End distance (ft)	Material
▶	9.75	None	9.75	5.5	0	17	17	Timber 1500 psi (50pcf)

Web							
Top flange							
Bottom flange							
	Begin width (in)	End width (in)	Thickness (in)	Start distance (ft)	Length (ft)	End distance (ft)	Material
▶	5.505	5.505	1	0	17	17	Timber 1500 psi (50pcf)

Web							
Top flange							
Bottom flange							
	Begin width (in)	End width (in)	Thickness (in)	Start distance (ft)	Length (ft)	Material	
▶	5.505	5.505	1	0	17	17	Timber 1500 psi (50pcf)



MODELING THE TIMBER CAP

➤ 2.1 Create a **FS Model** Cont'd

▶ 2.1.12 FSG Floor System Geometry

➤ Open the GUI and define the stringer groups that define the flooring arrangements

➤ Software produces the following GUI:

Floor System Geometry

Include floorbeams in unit references

Stringer unit number	Stringer group definition	Unit referenced from left end of superstructure or end of previous unit	Distance to stringer group definition workpoint (ft)	Mirror group definition	Include in analysis
Unit 1	None	Left end of structure		None	<input type="checkbox"/>
Unit 2	None	Left end of structure		None	<input type="checkbox"/>

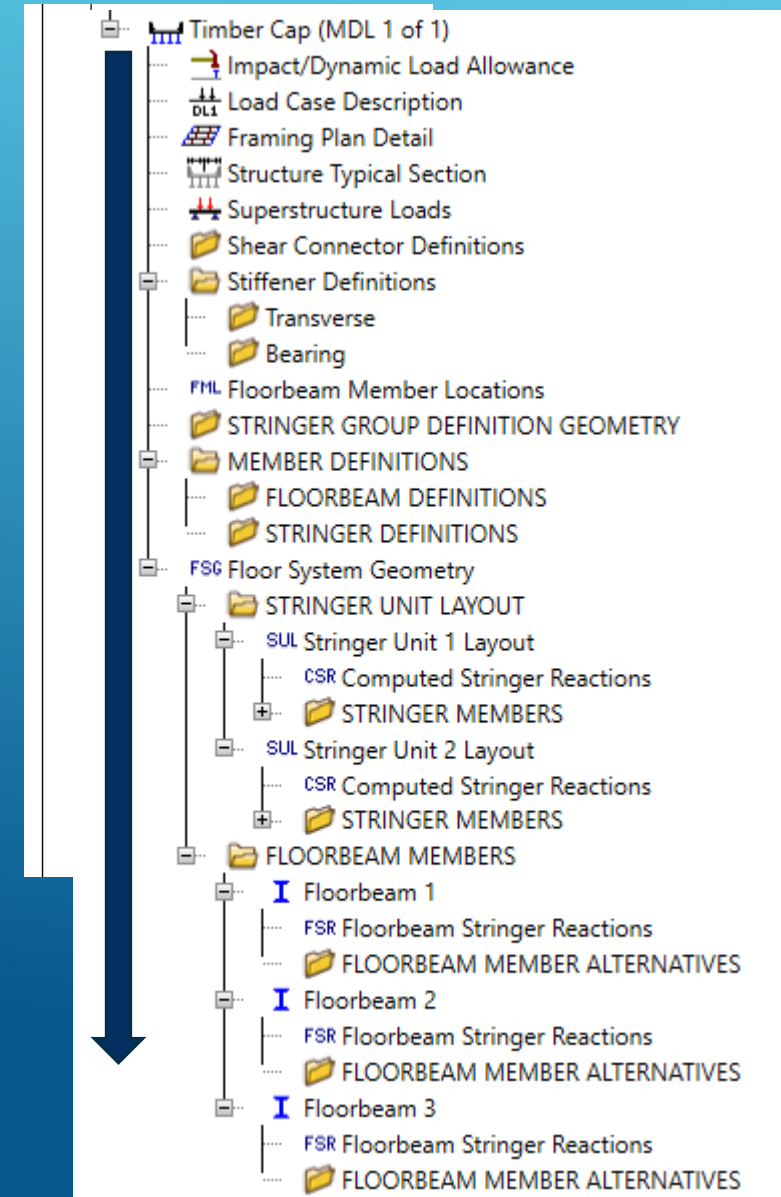
➤ The user needs to update it as follows:

➤ Do not include in analysis (unchecked)

Floor System Geometry

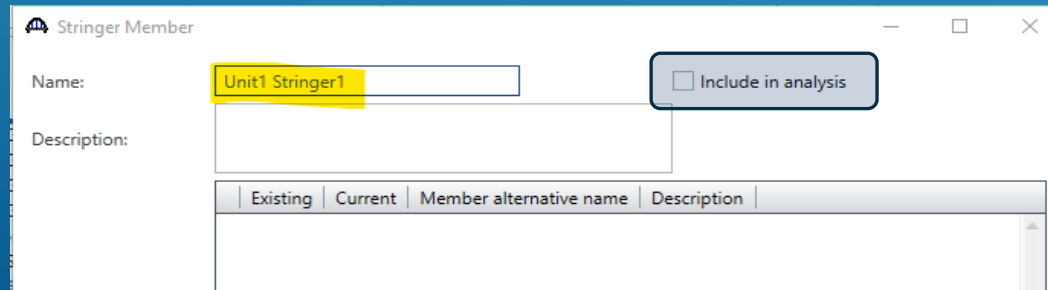
Include floorbeams in unit references

Stringer unit number	Stringer group definition	Unit referenced from left end of superstructure or end of previous unit	Distance to stringer group definition workpoint (ft)	Mirror group definition	Include in analysis
Unit 1	Stringer Layout	Left end of structure	0	None	<input type="checkbox"/>
Unit 2	Stringer Layout	End of Previous Unit	0	None	<input type="checkbox"/>



MODELING THE TIMBER CAP

- 2.1 Create a **FS Model** Cont'd
 - 2.1.12 FSG Floor System Geometry, Cont'd
 - ▶ 2.1.12.1 STRINGER MEMBERS
 - ▶ Update Unit Stringer Data
 - ▶ Open the Unit 1 Stringer 1
 - ▶ Ensure the “include in analysis” unchecked.

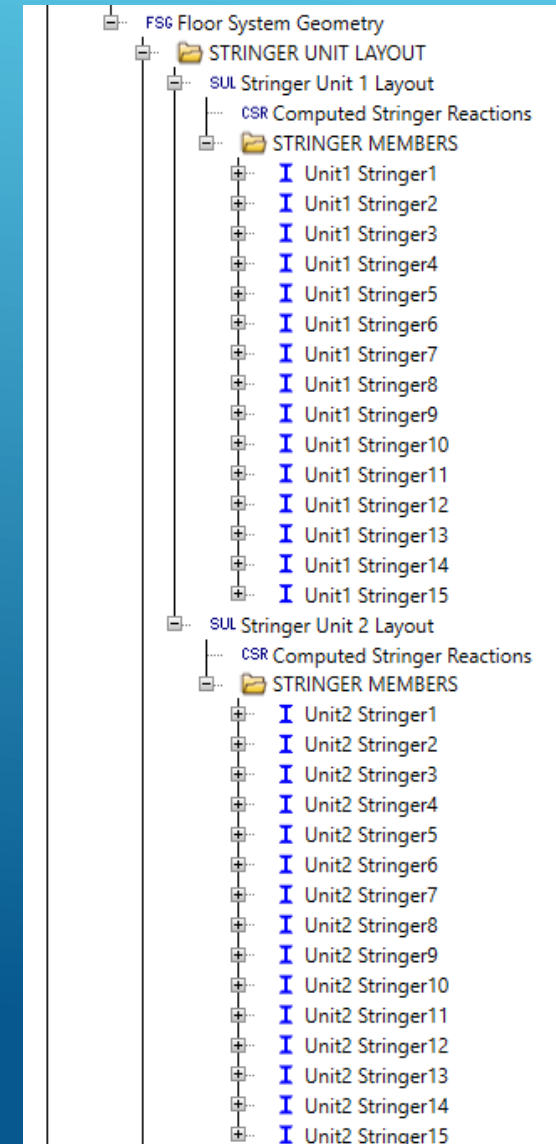


NOTES: The bent cap modeling is a workaround to load rate the bent caps, stringers should **NOT** be included in the analysis.

Software defaults to an “unchecked” case and as a result, the user needs not to visit each stringer GUI.

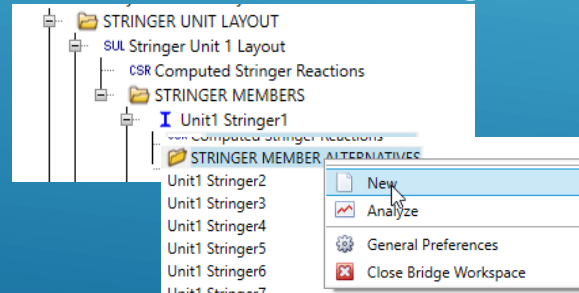
Leave the “include in analysis” unchecked.

Ensure the “include in analysis” is unchecked for all stringer units

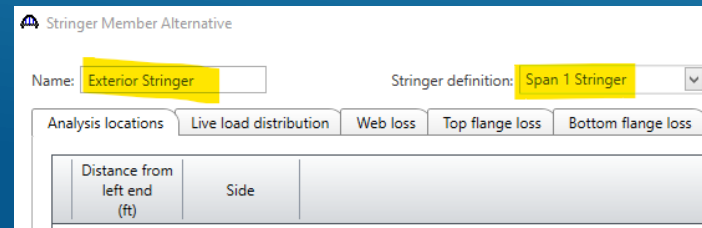


MODELING THE TIMBER CAP

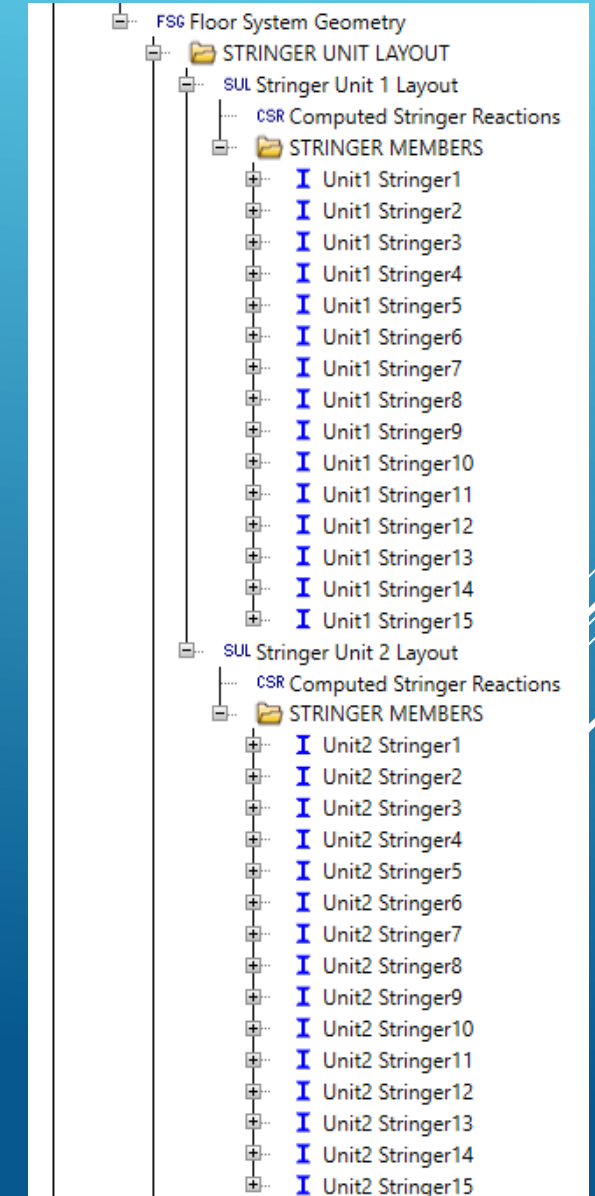
- 2.1 Create a **FS Model** Cont'd
 - ▶ 2.1.12 FSG Floor System Geometry, Cont'd
 - ▶ 2.1.12.2 Expand the Tree and enter data for each stringer



- ▶ Name the Stringer as Exterior Stringer, Interior Stringer, etc.
 - ▶ Example: Select the stringer definition Span 1 Stringer, since span 1 stringers are defined here.



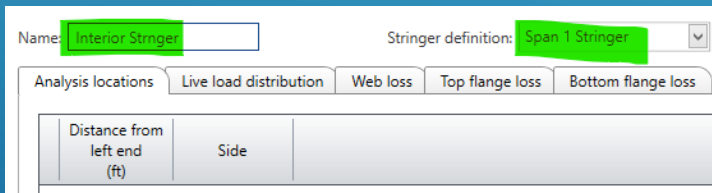
- ▶ NO additional data are to be entered
- ▶ LLDF, Web loss, etc. are not necessary since stringers are NOT load rated.



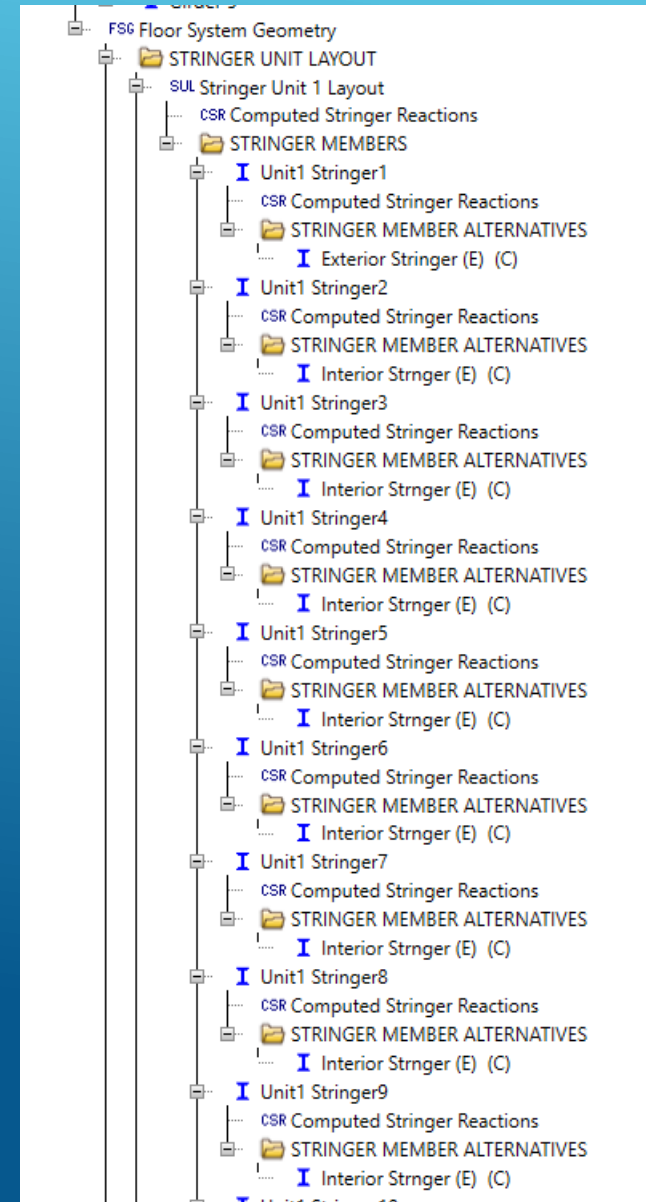
MODELING THE TIMBER CAP

➤ 2.1 Create a **FS Model** Cont'd

- ▶ 2.1.12 FSG Floor System Geometry, Cont'd
- ▶ 2.1.12.3 Repeat and generate data for all stringers in Span 1

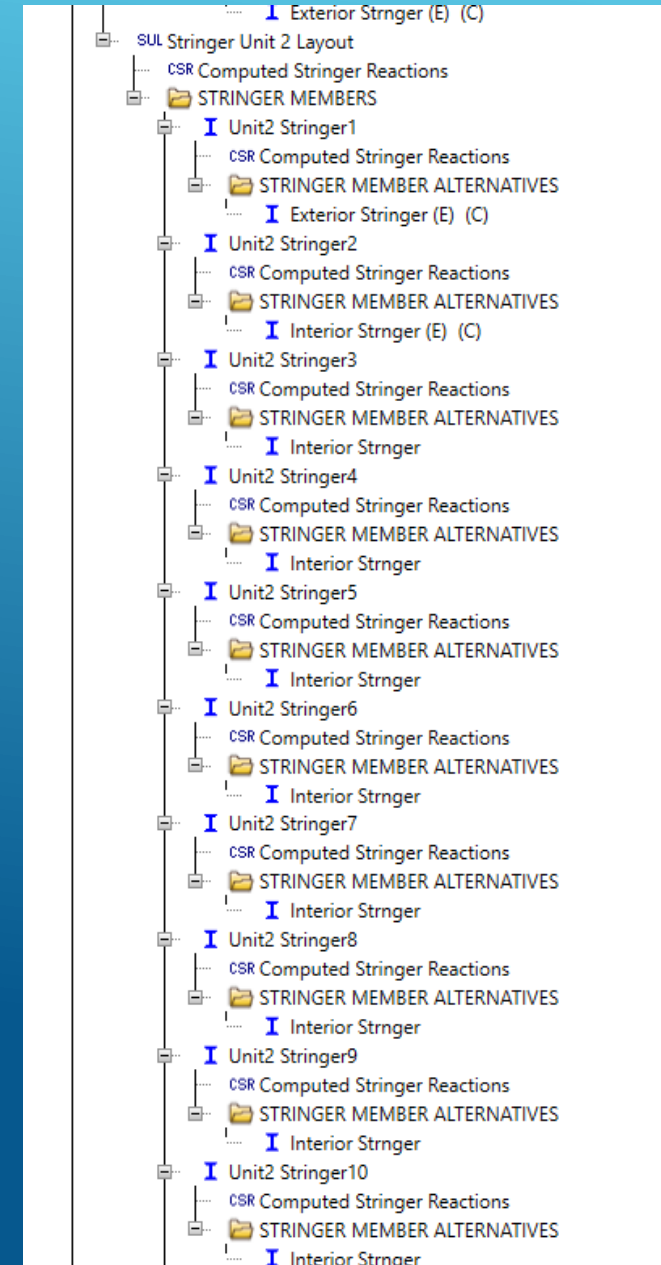
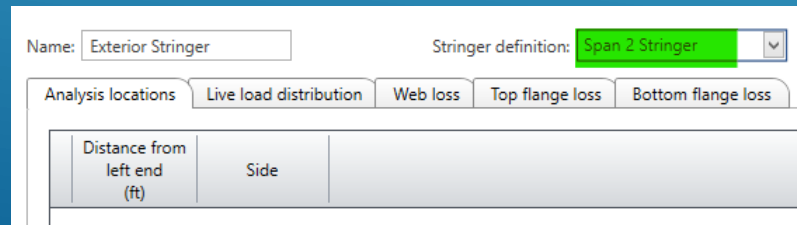


- ▶ Drag and drop the Stringer Member Alternatives of Stringer 2 to all interior stringers may be the faster way to complete this process.
- ▶ NOTE: Each Member alternative be opened, Click OK to Close if drag and drop process is used to ensure data is copied over.
 - ▶ This will ensure that existing (E) and current(C) will be assigned to each alternative.



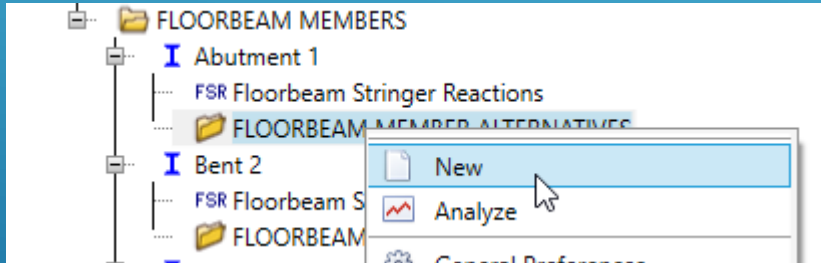
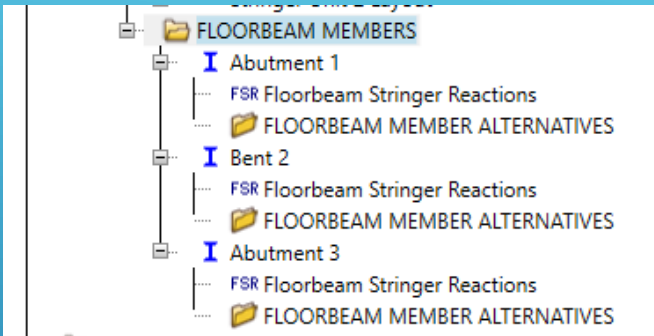
MODELING THE TIMBER CAP

- 2.1 Create a **FS Model** Cont'd
 - ▶ 2.1.12 FSG Floor System Geometry, Cont'd
 - ▶ 2.1.12.4 Repeat the same process of **Stringer Unit 2**, where **Span 2 stringer** be linked.



MODELING THE TIMBER CAP

- 2.1 Create a **FS Model** Cont'd
 - ▶ 2.1.13 FSG Floor System Members
 - ▶ Expand the BrDR Tree
 - ▶ User needs to enter Floorbeam member alternatives for Abutment 1, Bent 2 and Abutment 3 by selection Floor beam definitions
 - ▶ Create New Alternative

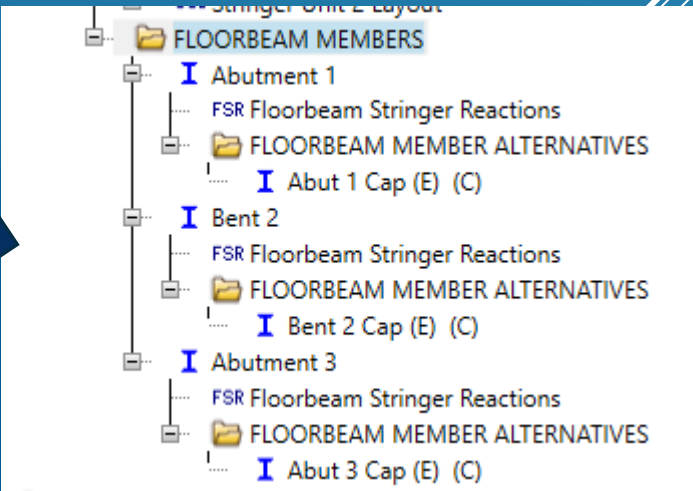


A screenshot of the 'Floorbeam Member Alternative' dialog box. It shows three entries for creating alternatives:

- Name:** Abut 1 CAP (highlighted in yellow)
- Floorbeam definition:** Timber Cap (12x12) wit (highlighted in green)
- Analysis locations:** Web loss, Top flange loss, Bottom flange loss
- Distance from left end:** (field)
- Side:** (field)

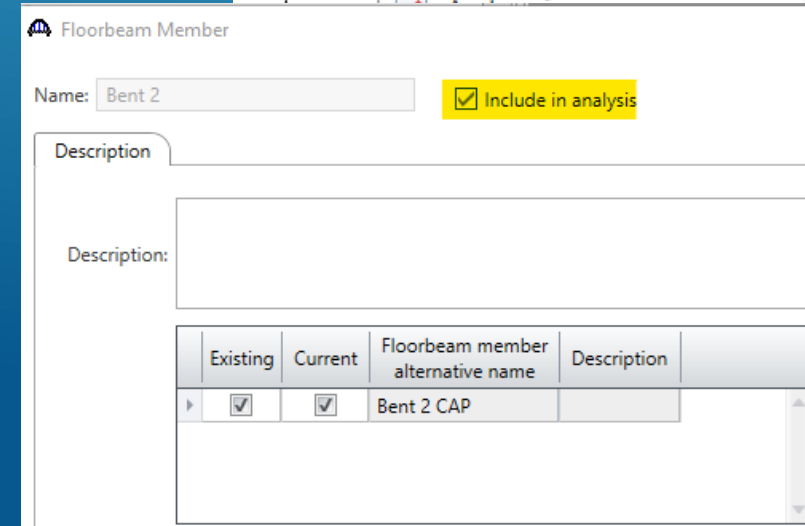
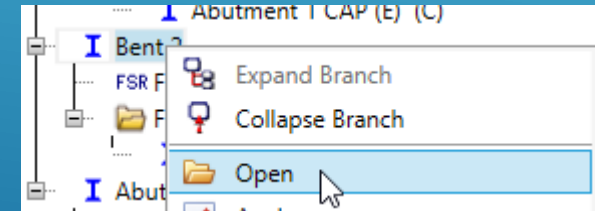
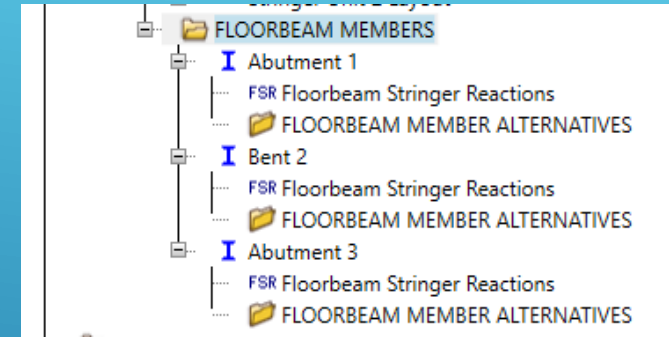
The second entry is 'Bent 2 CAP' (highlighted in blue) with the same definition and analysis locations.

The third entry is 'Abut 3 CAP' (highlighted in pink) with the same definition and analysis locations.



MODELING THE TIMBER CAP

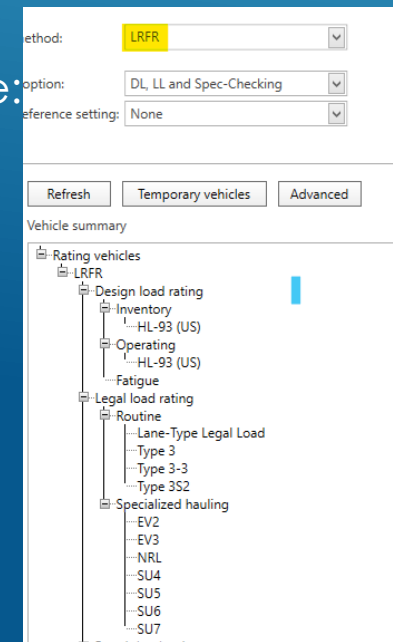
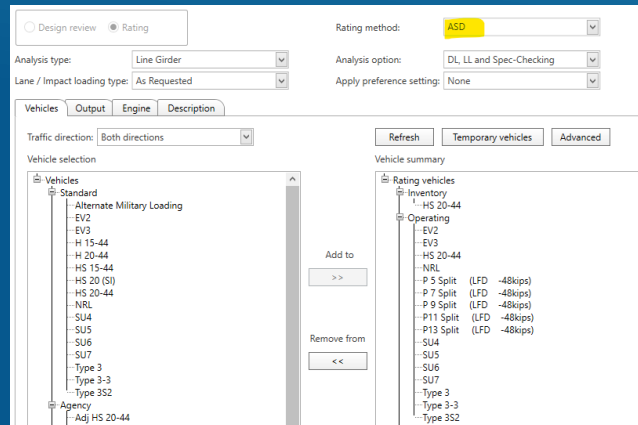
- 2.1 Create a **FS Model** Cont'd
 - ▶ 2.1.13 FSG Floor System Members
 - ▶ Open the Bent CAP
 - ▶ Ensure Analysis of CAP is turned ON.



MODELING THE TIMBER CAP

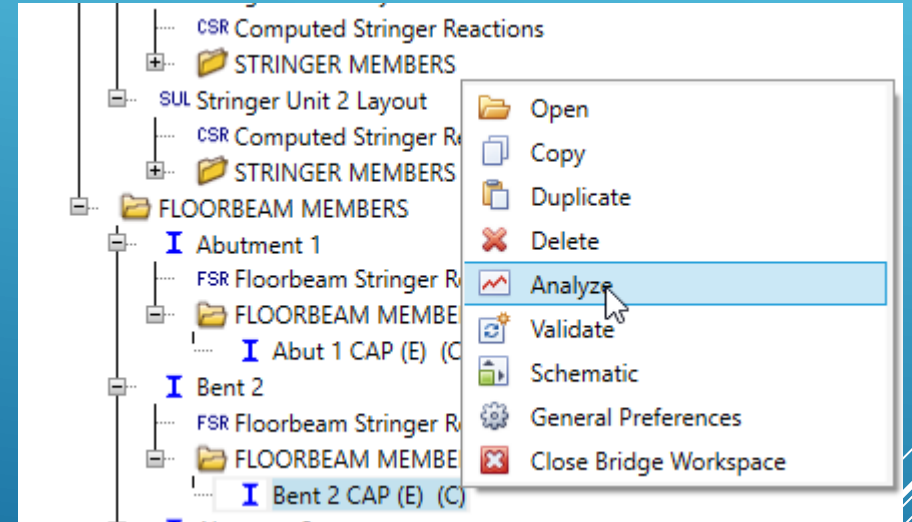
➤ 4. Bent Cap Analysis

- ▶ “Equivalent” steel girders are used to define the Timber Caps.
- ▶ The ASR and LRFR capacity overwrites are included at each points of interests and there fore, ASR and/or LRFR analysis can be performed.
 - ▶ If only the ASR capacity overwrites are entered, only the ASR analysis can be performed.
 - ▶ Similarly, if only the LRFR capacity overwrites are entered only the LRFR analysis can be performed
- ▶ Analysis Settings:
 - ▶ Analysis setting should be very similar the one shown here:



MODELING THE TIMBER CAP

- 4. **Bent Cap Analysis**, Cont'd
- ▶ With settings, analyze the superstructure
 - ▶ Select the **Bent 2 CAP** member alternative,
 - ▶ Rightclick and choose ANALYZE
- ▶ Load rating based on ASR or LRFR analysis will be performed depending on analysis setting.

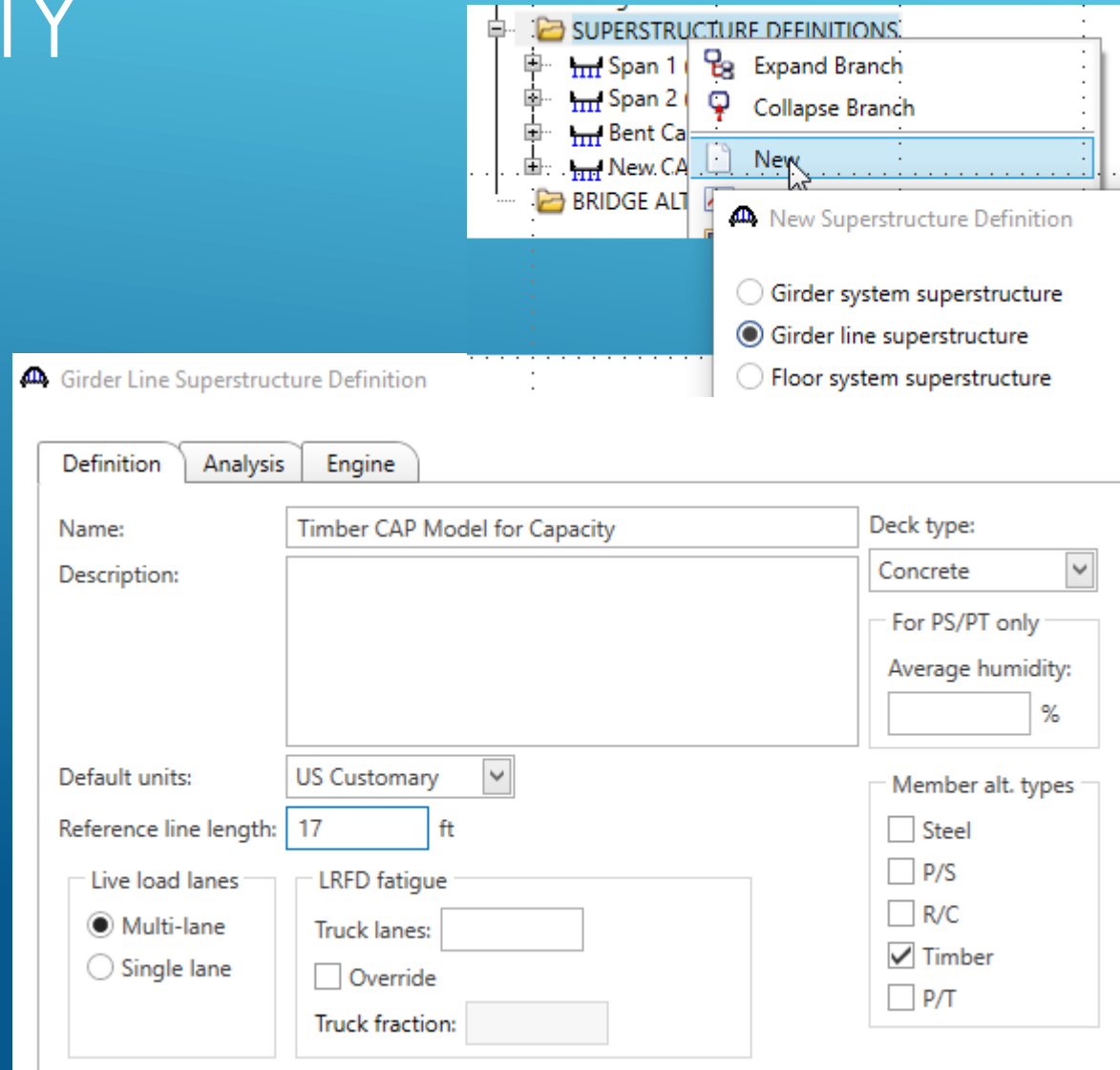


MODELING THE TIMBER CAP

➤ 5. Analysis Results

TIMBER CAP CAPACITY

- 1. Create **Girder Line** CAP
 - Choose Timber.



TIMBER CAP CAPACITY

- 1. Create **Girder Line** CAP Cont'd
 - Tough the CAP has two cantilever portions, the length of cantilever is less than the “d” of the member, it need not be considered
 - So, number of span for this model is 4
 - Span lengths are:
 - 7 ft, 7 ft, 7 ft, and 7ft,
 - Girder spacing = 17 ft (bridge span)

Member name:

Description:

Existing	Current	Member alternative name	Description
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Bent 2 CAP	

Number of spans:

Girder spacing: ft

Span no.	Span length (ft)
1	7
2	7
3	7
4	7

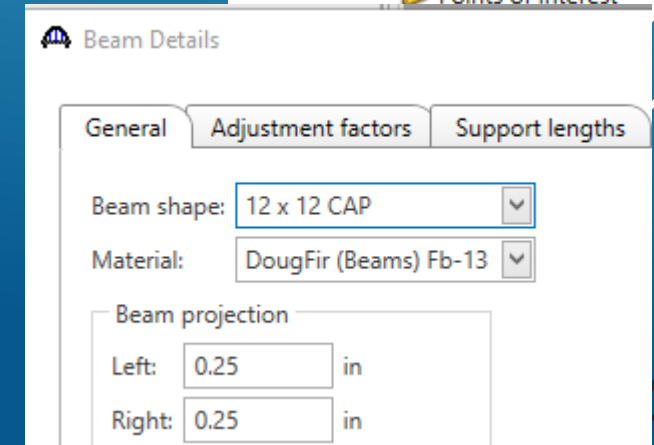
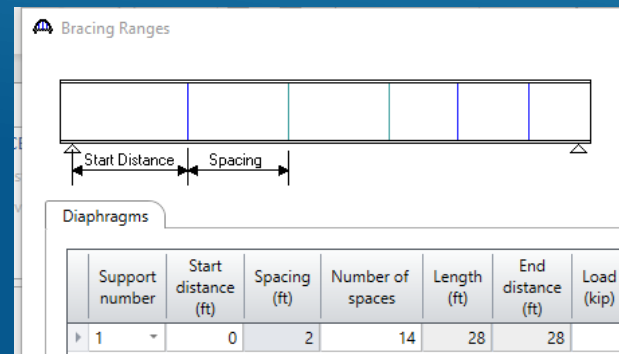
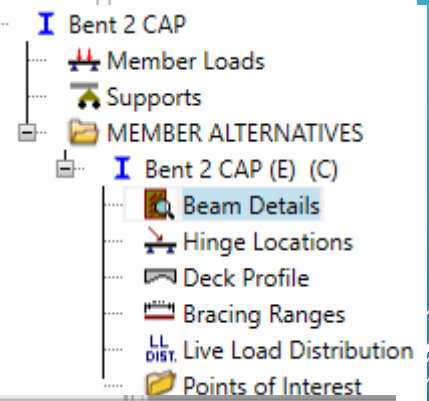
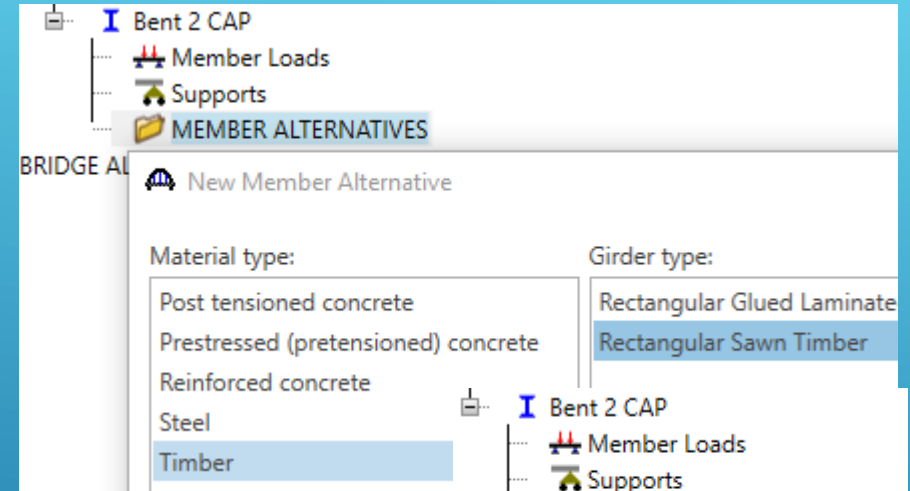
Deck concrete crack control parameter (Z):

Deck exposure factor:

Member location:
 Interior
 Exterior

TIMBER CAP CAPACITY

- 1. Create **Girder Line** CAP Cont'd
- Create Member Alternative
 - Create Timber Rectangular Sawn Timber Stringer
 - Enter Beam Size, 12 x 12 (original)
 - Enter the Adjustment Factors
 - Enter Bracing Ranges (typically, CAP is braced at timber stringer location by NAILS)
 - Bracing plays a role in flexural capacity.



TIMBER CAP CAPACITY

- 1. Create **Girder Line** CAP Cont'd

- Finally, enter a LLDF of 1.0 for Standard and LRFD
 - This will allow the software to trigger Specification articles so that capacity will be established.
 - RF established based on this analysis is NOT correct.

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 traffic

Lanes loaded	Distribution factor (wheels)			
	Shear	Shear at supports	Moment	Deflection
1 Lane	1	1	1	1
Multi-lane	1	1	1	1

Standard LRFD

Distribution factor input method
 Use simplified method Use advanced method

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

Action: Deflection

Support number	Start distance (ft)	Length (ft)	End distance (ft)	Distribution factor (lanes)	
				1 lane	Multi-lane
1	0	28.5	28.5	1	1

Action: Moment

Support number	Start distance (ft)	Length (ft)	End distance (ft)	Distribution factor (lanes)	
				1 lane	Multi-lane
1	0	28.5	28.5	1	1

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

Action: Shear

Support number	Start distance (ft)	Length (ft)	End distance (ft)	Distribution factor (lanes)	
				1 lane	Multi-lane
1	0	28.5	28.5	1	1

TIMBER CAP CAPACITY

- 1. Create **Girder Line** CAP Cont'd
- Review the Analysis Output and obtain the capacities established by the software.