# **MDOT Camelback Bridge Example**

AASHTOWare Bridge Rating 6.4.1

July 8, 2013

# Contents

N	DOT Camelback Bridge Example AASHTOWare Bridge Rating 6.4.1	1
	Background	2
	Assumptions/Limitations	2
	General Bridge Information	3
	Material Properties	4
	Superstructure Definition	6
	Load Case Descriptions	8
	Framing Plan Details	9
	Typical Section	11
	Shear Reinforcement	15
	Member Descriptions	16
	Cross Sections	19
	Bridge Alternatives	34
	Analysis	36
	Vehicle Selection	36
	Analysis	37
	Reporting	37

This tutorial was created on behalf of MDOT by the Center for Technology & Training, please contact <u>loadrating@mtu.edu</u> for assistance or visit <u>http://loadrating.michiganltap.org/</u> for more information.





# Background

What follows is a general guide for modeling a camelback bridge in AASHTOWare Bridge Rating (BR) 6.4.1. The sample bridge was taken from a set of MDOT standard plans for a 60-ft reinforced concrete girder with a 22-ft roadway. A similar approach can be applied to other standard lengths. The tutorial methodology should be adapted accordingly for any modifications to the standard plan and for the specific rebar present in the bridge.

This tutorial is being provided by the Michigan Department of Transportation (herein referred to as MDOT) as a courtesy service to contractors, consultants and local agency bridge owners. In preparation of this tutorial, MDOT has endeavored to offer current, correct and clearly expressed information. However, error may occur. MDOT expressly disclaims any liability, of any kind, for any reason, that might arise out of the use of this tutorial.

# Assumptions/Limitations

This tutorial is prepared based on the assumption that the bridge is in a pristine, un-deteriorated state and was built in accordance with the construction plans. All load ratings must reflect the current condition of the structure. The load rating engineer should perform a field evaluation to confirm the correctness of the plans and use engineering judgment to determine whether any observed deterioration may affect the structural capacity of the bridge.

In a more traditional girder arrangement the compression zone of each girder is laterally braced by the bridge deck. The camelback bridge design results in an un-braced compression zone. This situation is not addressed by BR 6.4.1. Should there be evidence of distress in the compression zone of a camelback beam; a more detailed finite element model may be warranted.

The deck is conservatively considered for weight only, and contributes no structural capacity to the bridge as modeled in this tutorial. For situations where additional capacity is needed in the bridge, a portion of the deck slab can be considered as a structural part of the girder, subject to the limitations of AASHTO Section 8. Note that BR calculates the weight of the structural portion of the deck, so it should be deducted from the additional self-load entered on the Member Alternative Description screen.

Material properties have been assumed, according to the age of the bridge, using the Michigan Bridge Analysis Guide (BAG). The most recent bridge design revision date from the standard plans was 1922, which was assumed to coincide with construction for the purpose of determining material properties.

BAG, Table 10.28: 1922-1935 Grade A Concrete: f'c = 3 ksi Es/Ec = n = 12

BAG, Table 10.26: Structural or unknown grade prior to 1954: fy = 33 ksi







# **General Bridge Information**

From BR's Bridge Explorer window, create a new bridge by selecting *File/New/New Bridge* and enter the following description data:

🕰 Camelback		
Bridge ID: Camelback	NBI Structure ID (8): Camelback Template Superstructures Bridge Completely Defined Culverts	Î
Description Description		
Name:	Sample of a Camelback Bridge Load Rating Year Built: 1922	
Description:	Based on MDOT standard plans for a 60-ft reinforced concrete camelback bridge with a 22 ft roadway.	
Location:	Michigan Length: 60.00 ft	=
Facility Carried (7):	Route Number: 01	
Feat. Intersected (6):	Mi. Post	
Default Units:	US Customary	
BridgeWare Associatio		
		Ŧ

Close the window by clicking **OK**. This saves the data to memory and closes the window.





# **Material Properties**

Enter the materials to be used by members of the bridge by clicking on + to expand the tree for Materials. The tree with the expanded Materials branch is shown below:

🖃 🛲 Camelback	-
🗄 🧰 Materials	ſ
🚞 Structural Steel	
🚊 🚞 Concrete	
T Concrete - 1922	
🚊 🚞 Reinforcing Steel	
📃 🔵 Unknown grade prior 1954	
🚞 Prestress Strand	
🚊 📖 🚞 Timber	
Sawn	
Soil	

To add a new concrete material click on **Concrete** in the tree and select *File/New* from the menu (or right mouse click on **Concrete** and select *New*).

Enter the data shown in the window below.

Name:	Concrete - 1922 Des	cription:	Estimate	d from the BAG Table 10.28
	Compressive strength at 28 days (f'c) =	3.000		ksi
	Initial compressive strength (f'ci) =	1		ksi
	Coefficient of thermal expansion =	0.0000	060000	1/F
	Density (for dead loads) =	0.150		kcf
	Density (for modulus of elasticity) =	0.150		kcf
	Modulus of elasticity (Ec) =	3320.5	6	 ksi
	Initial modulus of elasticity =	0.00		 ksi
	Poisson's ratio =	0.200		
	Composition of concrete =	Norma	I	•
	Modulus of rupture =	0.416		ksi
	Shear factor =	1.000		





Click **OK** to save the data to memory and close the window.

Double click on **Reinforcing Steel** in the bridge tree. The reinforcing steel may be copied from the library. Select the **Copy from Library...** button and choose the appropriate material from the list. The window will look like that shown below:

Name:	Unknown grade prior 1954 Desi	cription:	Structural or unknown grade prior to 1954
	Material Prope	rties	
	Specified yield strength (Fy) =	33.000	ksi
	Modulus of elasticity (Es) =	29000.	00 ksi
	Ultimate strength (Fu) =	60.000	ksi
	Type Plain Epoxy Galvanized Other	I	

Click **OK** to save the data to memory and close the window.





# **Superstructure Definition**

The default impact factors will be used so we can skip to **Structure Definition**.

Bridge Workspace - I-beam example	
🖃 🚧 I-beam example	
🗄 📖 Materials	
🖅 🖮 🛅 Beam Shapes	
🚛 💼 Appurtenances	
📑 Impact / Dynamic Load Allowance	
🗄 🔤 Factors	
SUPERSTRUCTURE DEFINITIONS	
🖶 🛶 🧰 BRIDGE ALTERNATIVES	

Doubleclick on **SUPERSTRUCTURE DEFINITIONS** to create a new structure definition. The following dialog will open.

New Superstructure Definition	×
Girder System Superstructure	
🔘 Girder Line Superstructure	
Floor System Superstructure	
Floor Line Superstructure	
Truss System Superstructure	
🗇 Truss Line Superstructure	
	OK Cancel

Select **Girder System Superstructure** and the Structure Definition window will open. Enter the data shown below:





Name:	camelback			Simplified Definition
Description:			*	Deck type:
				Concrete 👻
				·/
			*	
Default Units:	LIS Customary	Enter Span Lengths		
Number of spans:	1	Along the Reference Line:		For PS only
		Snan Length		Average humidity:
Number of girders:	2	(ft) 1 60.00		%
				Member Alt. Types
				P/S
				🔽 R/C
				Timber

Click  $\ensuremath{\textbf{OK}}$  to save the data to memory and close the window.





### **Load Case Descriptions**

Click **Load Case Description** in the bridge tree by expanding the Superstructure Definition branch to define the dead load cases. Select **Add Default Load Case Descriptions**. The completed Load Case Description window is shown below.

Load Case Name	Description	Stage			Туре	Time (Day	e* /S)	
DC1	DC acting on non-composite section	Non-composite (Stage 1)	-	D,DC				
0C2	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		-		
SIP Forms	Weight due to stay-in-place forms	Non-composite (Stage 1)	-	D,DC				

Click **OK** to save the data to memory and close the window.





### **Framing Plan Details**

Double-click **Framing Plan Detail** in the tree to describe the framing plan. Enter the data shown below.

A Structure Framing Plan Detail	s — • X
	Number of spans = 1 Number of girders = 2
Layout Diaphragms	
Support Skew (Degrees)	Girder Spacing Orientation <ul> <li>Perpendicular to girder</li> <li>Along support</li> </ul>
1 0.0000 2 0.0000	Girder Spacing
	Bay Start of End of Girder 1 24.00 24.00
	OK Apply Cancel

Select **OK** to close the window.

It is always a good idea to check the schematic after entering the framing plan detail information. Do this by selecting the **schematic** button while **framing plan detail** is highlighted in the bridge workspace tree. Alternatively, you may select *Bridge/schematic* while the **framing plan detail** is highlighted.











## **Typical Section**

Next define the structure typical section by double-clicking **Structure Typical Section** in the Bridge Workspace tree. Input the data describing the typical section as shown below.

### Deck Geometry

A Structure Typical Section				
Distance from left edge superstructure definitio	e of deck to n ref. line eck ckness	Distance fro superstruct	om right edg ure definitior ructure Defir ce Line	e of deck to n ref. line
Left overhang			L	∷: k→ Right overhang
Deck Deck (Cont'd) Parapet Median	Railing Ge	eneric Sidew	valk Lane	Position Wearing Surface
Superstructure definition reference line is	within		e bridge deo	sk.
Distance from left edge of deck to superstructure definition reference line =	Start 13.00	ft	End 13.00	ft
Distance from right edge of deck to superstructure definition reference line =	13.00	ft	13.00	ft
Left overhang =	1.00	ft	1.00	ft
Computed right overhang =	1.00	ft	1.00	ft
				JK Apply Cancel

The **Deck (cont'd)** tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described in the Background section.





Structure Typical Section	
Distance fro superstructur Left overhang Deck Deck (Cont'd) Parapet Deck concrete: Total deck thickness: Deck crack control parameter: Sustained modular ratio factor: Deck exposure factor:	m left edge of deck to re definition ref. line Deck thickness Beference Line Reference Line Right overhang Median Railing Generic Sidewalk Lane Position Wearing Surface Concrete - 1922 18.0000 in kip/in 3.000
	OK Apply Cancel





#### Lane Positions

Select the Lane Position tab. Manually enter the width of the travelway as shown in the figure below

A Structure Ty	pical Section											
	(A) (B) (B) (B) (C) (C) (C) (C) (C) (C) (C) (C											
Deck Deck	k (Cont'd)   Parapet   Median   F	ailing Generic Sidewalk L	ane Position 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	-11.00	11.00	-11.00	11.00								
LRFD Fati Lanes av	igue vailable to trucks: e Truck fraction:	Compute	New OK	Duplicate Delete								

Click **OK** to save the data to memory and close the window.

It is also a good idea to check the schematic after entering the structure typical section information. This is done in the same manner as was used to check the schematic of the framing plan details. Note that for reinforced concrete structures a generic beam shape is used to represent the beam.











#### **Shear Reinforcement**

Now define the vertical shear reinforcement by double-clicking on **Vertical** (under **Shear Reinforcement Definitions** in the tree). Define the reinforcement as shown below.



Click **OK** to save to memory and close the window.





#### **Member Descriptions**

The Member window shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this member (as shown below).

A Member					- • ×
Member name:	<u>61</u>		Link with:	None 🔻	
Description:				*	
				Ŧ	
	Existing Current	Member Alternative Na	me Description		
		camelback beam			
Number of spans:	1	Span Span No. Length (ft) 1 60.00		Pedestrian loa	id: Ib/ft
					ply Cancel

Double-click **MEMBER ALTERNATIVES** in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select **Reinforced Concrete** for the Material Type and **Reinforced Concrete I** for the Girder Type.

New Member Alternative	
Material Type: Reinforced Concrete 💌	Girder Type: Reinforced Concrete I 💌
	OK Cancel

Click **OK** to close the dialog and create a new member alternative.





The Member Alternative Description window will open. Enter the appropriate data as shown below. Note: BR 6.4.1 will not automatically calculate and include the self-weight of the deck. Therefore, you must estimate the weight of the deck and apply it to the beam as an additional self-load. In this example, the deck is 1.5 feet thick and spans 22 feet between beams. Therefore, the additional self-load can be approximated as 11 ft\*1.5 ft\*0.150 k/ft<sup>3</sup> = 2.475 k/ft, which is entered below.

By entering the deck weight at this location you are assuming that the deck and slabs were cast as a single unit while supported by false work. If this condition does not appear to be true for your particular bridge you should instead add the deck weight as an additional uniform load under the **Member Loads** tab.

Description: Girder property input method	End bearin	g locations	Material Type: Girder Type: Default Units:	Reinforced Concrete Reinforced Concrete I US Customary 👻
<ul> <li>Cross-section based</li> </ul>	Left: Right:	in		
Additional Self Load Additional self load = 2.475	kip/ft	Default rating	method:	
Additional self load = Crack control parameter (Z)	%			
Exposure factor	p/in			
Bottom of beam:				





Expand **Member Alternatives** and **camelback beam (E)(C)** portions of the tree. The default materials for the member alternative must be defined. Enter data as shown in the figure below.





Open the Live Load Distribution window from the tree beneath camelback beam.

A Li	tandard LR Distribution Ouse	FD Factor Input Method Simplified Method	🔿 Use Adva	nced Method		
	Lanes		Distribution (Whee	n Factor els)		
	Loaded	Shear	Shear at Supports	Moment	Deflection	
	1 Lane	1.500000	1.500000	1.500000	1.000000	
	Multi-Lane	2.083333	2.083333	2.083333	2.000000	
	Compute fr Typical Sec	om tion	]		ОК	Apply Cancel

If we try to use the **Compute from Typical Section** button on the Live Load Distribution **Standard tab** to populate the LFD live load distribution factors for this member alternative, we will receive a message that BR cannot calculate the distribution factors because beam shapes are not assigned to adjacent member alternatives.

You must revisit this window after the member alternative has been created for the other side of the bridge. Then the **Compute from Typical Section** button will compute the distribution factors for you.

#### **Cross Sections**

The camelback shape will be modeled as a series of cross sections located at discrete points. Cross sections should be determined for 10<sup>th</sup> points along the length of the bridge. An elevation of half the bridge and half sections for the end and center of the bridge are shown below along with a rebar schedule for interpretation of the reinforcing steel identified in the half sections. The cross section can be modeled as an I-beam. Use the elevation to determine the flange and web heights and the half section to determine the flange and web width and the rebar placement. If the section contains square reinforcing bars substitute those with the largest modern rebar size that produces an equal or lesser cross sectional area. In this example; No. 11 rebar (1.56 in<sup>2</sup>) was used to represent 1.25-in square rebar (1.56-in<sup>2</sup>). Additional rebar could be added to bring the total cross sectional area of steel in the model to what is found in the bridge provided no deterioration has occurred. Pay careful attention to any changes in rebar placement at the different cross sections. Steel reinforcing plans and elevations along with bending diagrams have been shown to provide the necessary information to ensure proper rebar locating at each section.







$\begin{array}{c c c c c c c c c c c c c c c c c c c $			1960 a.e. 197	H	41		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		-		- Million	1977 - 19	A.	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	F				17.19		470
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	6			1	₹Î, î in	10	3
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		i -		144	$\xi_{ij} \sim 0$	9	9
GU, to       Guny       Bors $78\%$ Mork       No.       H       Lenge       Weight         GU.       1 $8^27$ $20^{\circ0}$ $164$ $20^{\circ0}$ "2       4 $8^27$ $20^{\circ0}$ $164$ $20^{\circ0}$ "2       4 $8^27$ $20^{\circ0}$ $164$ $20^{\circ0}$ "2       4 $8^27$ $19^{\circ0}$ $153$ "4       1'!!! $18^{\circ0}$ $19^{\circ0}$ $153$ "4       1'!!! $18^{\circ0}$ $19^{\circ0}$ $149$ "6       1''!!! $17^{\circ0}$ $17^{\circ0}$ $146^{\circ0}$ "6       1''!!! $17^{\circ0}$ $17^{\circ0}$ $199^{\circ0}$ "8       1''!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!	1			10	÷14	小明小月	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	[	GU, †	O Gua	y Bo	15 2	970 F	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		Mark	No.	Hs	Lengt	Weight	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		GU,	4	8-7	20:00	164 -	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		" R	1	8.4	19:6	159	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		" 3	4	8-2"	19:2	157	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		24	4	7:11"	18:8	153	14
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		+ 5	4	78"	18-2"	149	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	_	~6	4	7-6	17-10	146	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		7	9	7:3"	17-1-	192	<u>* 196</u>
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		8	1	7-1"	17:00	139	11
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		×9	1	6.10	16:61	1350;	1
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$			1	6:7	16:0"	131	- 32
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$			19	6:5"	15-8-	128	200
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		-12	1	6-3	15:4	125	1
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		-13	4	6-3	15-4	125	-
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		- 14	4	C:5*	15:8	128	<u></u>
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		-13	9	6:6"	15:10	129	-1.
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		-10	4	6.8	1612	132	-
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		· /Z	4	6-10	16:6	135	<u>1.</u>
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		+ 1A	4	7-0	16:10	138	- 5
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		~ 19	1	7-3"	17-4"	142	2 1
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		~20	4	7-6"	1740	146	
"22 4 7-10" 18:6 151 "23 4 8:1" 19:0" 155 "24 4 8:2" 19:2" 157 70:101 34 154		+21	4	7'8	18:2"	/49	
123 4 811 1910 155 124 4 82 1912 157 70101 34154		"22	4	7-10	18-6	151 .	
"24 4 8:2" 1912" 157 Tolol 34154			4	8:1	19'0"	155	4 4
Tolal 34154		"24	1	8:2	1912	157	- '
		10/01	_			34151	









### **Longitudinal Steel Placement**

Note: From the elevation we see that the rebar in the third row from the bottom changes depth over the length of the bridge. The two outer bars (GLE) are located higher in the section and then drop down, followed by the





two inner bars (GLF). The center bar (GLC/CLD) remains at the same location over the length. This has been reflected in the cross sections modeled in BR (details on the next page).

	4.4		P	0	0	15	71	10	0	No	9.00	Wind	Leagth	Waraht
CONTION	/T/ARK	11	0		<u> </u>		V	111	14	in	UME:	( SINC	Lengin	rienym
GIRDER	GLA	20'0	1.1	1	1. J. E	75"	1.1	5"		10	142	DER	2115"	1138
	GLB	-79-E		. N		76	di	· 5"	· .	10	140	- #	45:7"	2122
	GLC	25:0		10	1. T	21, 1			1.1	12	140	· · ·	25-0"	1594
	GLD	39'6'	· · · · ·	Q 1	1.1	<u></u>	, "h	- 3		12	140		39-6"	2518
	GLE		4:10"	440	5:0"	75"	440	5"	610-	8	142	<u>а</u>	18:1-	768
	GLF		9:10	410	510"	26	440	5*	6-10-	8	1400	$\mathcal{L}^{(n)}$	23:1"	981
	GLG	29'5		1.1	医肌肉	(4))))))	1.18	4.20		4	14.0	ð d	2946"	627
	GLH	39:6	1.14	116	154	、施制	16 C	12	医囊肌	1	14"	1	39:6"	839
	GLU	12:9	14	662	18-31	76	il A	5"	$(\mathbf{r}_{1}) \in \mathbf{H}$	76°	1400	(왕씨)	15:7"	1324
	GT	320	1. 24	19.4	17 3	1.1	()香	180	$\leq 1^{2}$	184	5.4	$\sim r_{s}$	3240"	218
	GU 3	See	Tehe	offe	WB	13	10000	54.5	\$2.5	法律	10.55	件之		3,415
	GHA		14	1.10	8 / · ·	10.03	1475		1.12	32	10	1.1	66-11"	188
	GVA	90		1.720	8 G.	3461	334	19	1940	10	100.	1.00	940-	490

BILL OF STEEL BARS



# Description and Bending Details of Longitudinal Girder Reinforcing Steel

#### **Cross Section Locations:**

End - GLE and GLF both up 4'-10" from the 3rd row (70" from bottom of beam) 10% - GLE @ 3'-8" from the 3rd row (56" from bottom), GLF @ 4'-10" from 3rd row (70" from bottom)





20% - GLE @ 3rd row (12" from bottom), GLF @ 2'-8" from 3rd row (44" from bottom) 30% - GLE and GLF @ 3rd row (12 inches from bottom of beam)

Next describe the beam by double-clicking on **Cross Sections** in the tree. The Cross Sections windows with the cross sections identified from the plans are shown below. Remember to enter rebar locations as appropriate for the cross section, keeping in mind that these may change over the length of the bridge. In the following cross sections, the #4 rebar at the top of the section was assumed based on scale from the plans.

🕰 Cross Sections			
Name: End	Туре:	Reinforced Concrete I	
Dimensions Reinforcement			
Tributary width: 24.0000 in	30.0000 in	Top Flange	
<del>(</del>	→ <u> </u>	Material:	Concrete - 1922 🔹
		Modular Ratio:	12.0
24.0000 in	78 0000	. Eff. width (Std):	24.0000 in
	10.0000	in Eff. width (LRFD):	24.0000 in
	-	Struct, thick.:	30.0000 in
↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓	37.0000	Other Parts	
24.0000 in		n Material:	Concrete - 1922 👻
A = 0.0000 in B	= 0.000 ii	n Modular Ratio:	12.0
		ОК	Apply Cancel
1			













Cross Sections											
Name: 10%	Name: 10% Type: Reinforced Concrete I										
Dimensions Reinforcement											
Distance from top of beam	Row	Std Bar Count	LRFD Bar Count	Bar S	ze	Distance (in)	Material		Bar Spacing (in)		
↑ ↑	Bottom of Girder 💌	5.00	5.00	11	•	4.0000	Unknown grade prior 1954	-	4.0000		
	Bottom of Girder 💌	5.00	5.00	11	•	8.0000	Unknown grade prior 1954	•	4.0000		
	Bottom of Girder 💌	1.00	1.00	11	Ŧ	12.0000	Unknown grade prior 1954	•	4.0000		
	Bottom of Girder 💌	2.00	2.00	11	•	56.0000	Unknown grade prior 1954	•	16.0000		
	Bottom of Girder 💌	2.00	2.00	11	•	70.0000	Unknown grade prior 1954	•	8.0000		
↓	Top of Girder 🔹	2.00	2.00	4	Ŧ	4.0000	Unknown grade prior 1954	•	8.0000		
Distance from bottom											
	New Duplicate Delete										
							ОК		Apply	Cancel	

Cross Sections			
Name: 20%	Туре:	Reinforced Concrete I	
Dimensions Reinforcement			
Tributary width: 24.0000 in	33.3750 in	Top Flange	
<u> ←</u>		Material:	Concrete - 1922
	Î.	Modular Ratio:	12.0
16.0000 in	86.7500	Eff. width (Std):	24.0000 in
		Eff. width (LRFD):	24.0000 in
		Struct, thick.:	30.0000 in
	37.0000	Other Parts	
24.0000 in		"' Material:	Concrete - 1922 -
A = 0.0000 in B =	. 0.000 ji	n Modular Ratio:	12.0
		ОК	Apply Cancel
]			





A Cross Sections										. • <b>×</b>
Name: 20%	Туре:	Reinforced	Concrete I							
Dimensions Reinforcement										
Distance from top	Row	Std Bar Count	LRFD Bar Count	Bar S	Size	Distance (in)	Material		Bar Spacing (in)	
	Bottom of Girder 💌	5.00	5.00	11	•	4.0000	Unknown grade prior 1954	-	4.0000	
	Bottom of Girder 📼	5.00	5.00	11	-	8.0000	Unknown grade prior 1954	-	4.0000	
	Bottom of Girder 📼	1.00	1.00	11	-	12.0000	Unknown grade prior 1954	-	4.0000	
	Bottom of Girder 🛛 💌	2.00	2.00	11	-	12.0000	Unknown grade prior 1954	-	16.0000	
	Bottom of Girder 🛛 💌	2.00	2.00	11	-	44.0000	Unknown grade prior 1954	-	8.0000	
*	Top of Girder 📃 💌	2.00	2.00	4	•	4.0000	Unknown grade prior 1954	-	8.0000	
Distance from bottom							New	Du	plicate	Delete
							ОК		Apply	Cancel

A Cross Sections		
Name: 30%	Туре:	Reinforced Concrete I
Dimensions Reinforcement		
Tributary width: 24.0000 in	30.0000 in	Top Flange
<u>+</u>		Material: Concrete - 1922 💌
		Modular Ratio: 12.0
	94.1250	Eff. width (Std): 24.0000 in
		Eff. width (LRFD): 24.0000 in
		Struct. thick.: <sup>30,0000</sup> in
i i i i i i i i i i i i i i i i i i i	37.0000	in Other Parts
24.0000 in		Material: Concrete - 1922 💌
A = 0.0000 in B =	0.000 i	in Modular Ratio: 12.0
		OK Apply Cancel





A Cross Sections							_ • •	
Name: 30%	Туре:	Reinforced (	Concrete I					
Dimensions Reinforcement								
Distance from top	Row	Std Bar Count	LRFD Bar Count	Bar Siz	e Distance (in)	Material	Bar Spacing (in)	
↑	Bottom of Girder 💌	5.00	5.00	11	4.0000	Unknown grade prior 1954 👻	4.0000	
	Bottom of Girder 💌	5.00	5.00	11	8.0000	Unknown grade prior 1954 👻	4.0000	
	Bottom of Girder 💌	5.00	5.00	11	12.0000	Unknown grade prior 1954 👻	4.0000	
	Top of Girder 🛛 👻	2.00	2.00	4	4.0000	Unknown grade prior 1954 👻	8.0000	
Listance from bottom								
						New Du	plicate Delete	
	OK Apply Cancel							

Cross Sections		
Name: 40%	Туре:	Reinforced Concrete I
Dimensions Reinforcement		
Tributary width: 24.0000 in	30.0000 in	Top Flange
<u> </u> ←→		Material: Concrete - 1922 💌
		Modular Ratio: 12.0
16.0000 in	102.2500	in Eff. width (Std): 24.0000 in
16.0000 in +B H	T	Eff. width (LRFD): 24.0000 in
		Struct. thick.: 30.0000 in
i←→i   24,0000	37.0000 j	Other Parts
in		Material: Concrete - 1922 💌
A = 0.0000 in B =	= 0.000 ir	n Modular Ratio: 12.0
		OK Apply Cancel





4	Cross Sections							
l	Name: 40%	Туре:	Reinforced	Concrete I				
l	Dimensions Reinforcement							
	Distance from top	Row	Std Bar Count	LRFD Bar Count	Bar Si	e Distance	Material	Bar Spacing (in)
L	↑ ↑ • • • • • • • • • • • • • • • • • •	Bottom of Girder 💌	5.00	5.00	11	4.0000	Unknown grade prior 1954	4.0000
L		Bottom of Girder 💌	5.00	5.00	11	▼ 8.0000	Unknown grade prior 1954	4.0000
		Bottom of Girder 💌	5.00	5.00	11	<ul> <li>12.0000</li> </ul>	Unknown grade prior 1954	4.0000
		Top of Girder 🔹	2.00	2.00	4	<ul> <li>4.0000</li> </ul>	Unknown grade prior 1954	· 8.0000
	Distance from bottom							
							New	uplicate Delete
							ОК	Apply Cancel

Cross Sections	
Name: 50% Type: Reinforced Concret	te l
Dimensions Reinforcement	
Tributary width: 24.0000 in 30.0000 in	lange
	Material: Concrete - 1922 🔻
Mo	dular Ratio: 12.0
16.0000 in Eff.	width (Std): 24.0000 in
16.0000 in Bit Eff. with	dth (LRFD): 24.0000 in
St St	ruct. thick.: 30.0000 in
→ 0000 37.0000 in Other	Parts
24.0000 in	Material: Concrete - 1922 🔹
A = 0.0000 in B = 0.000 in Mo	dular Ratio: 12.0
	OK Apply Cancel
1	





A Cross Sections								
Name: 50%	Туре:	Reinforced (	Concrete I					
Dimensions Reinforcement								
Distance from top	Row	Std Bar Count	LRFD Bar Count	Bar Siz	e Distance (in)	Material	Bar Spacing (in)	
T	Bottom of Girder 💌	5.00	5.00	11	4.0000	Unknown grade prior 1954	<ul> <li>4.0000</li> </ul>	
	Bottom of Girder 📼	5.00	5.00	11	8.0000	Unknown grade prior 1954	▼ 4.0000	
	Bottom of Girder 📼	5.00	5.00	11	12.0000	Unknown grade prior 1954	✓ 4.0000	
	Top of Girder 🖉 💌	2.00	2.00	4	4.0000	Unknown grade prior 1954	▼ 8.0000	
Distance from bottom								
						New	Puplicate	Delete
						OK	Apply	Cancel





Now that the cross sections have been entered we must assign them to the appropriate locations along the beam. Open the **Cross Section Ranges** window. The cross sections were identified for the end of the beam and then every 6 feet along the bridge length (10<sup>th</sup> points). Starting with the end of the beam select the start and end cross sections and then corresponding length between these sections. This model can be further refined with more cross section descriptions and shorter length between cross sections.

🗛 Cro	Cross Section Ranges											
	Start Distance Start End Section Section											
Sta	rt Section	End Sect	tion		Web Variation		Supp Numt	ort ber	Start Distance (ft)	Length (ft)	End Distance (ft)	
End		10%	•	Linear		•	1	•	0.000	6.000	6.000	
10%	6 💌	20%	-	Linear		-	1	-	6.000	6.000	12.000	
20%	6 💌	30%	•	Linear		-	1	-	12.000	6.000	18.000	
30%	6 💌	40%	-	Linear		-	1	-	18.000	6.000	24.000	
40%	6 💌	50%	-	Linear		-	1	•	24.000	6.000	30.000	_
50%	6 💌	40%	-	Linear		-	1	-	30.000	6.000	36.000	
40%	6 💌	30%	-	Linear		-	1	•	36.000	6.000	42.000	_
30%	6 💌	20%	-	Linear		-	1	-	42.000	6.000	48.000	
20%	6 💌	10%	-	Linear		-	1	-	48.000	6.000	54.000	
10%	6 💌	End	-	Linear		-	1	•	54.000	6.000	60.000	
	New Duplicate Delete											





Open the **Shear Reinforcement Ranges** window and define the location and spacing of shear reinforcement as determined from the plans.

🗛 RC Shear Reinforcen	RC Shear Reinforcement Ranges								
Start Distance									
Name	Supp Num	ort ber	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)	-	
Shear Stirrups 💌	1	Ŧ	2.33	1	0.0000	0.00	2.33		
Shear Stirrups 📼	1	•	2.33	6	8.0000	4.00	6.33		
Shear Stirrups 💌	1	•	6.33	5	10.0000	4.17	10.50		
Shear Stirrups 💌	1	•	10.50	6	12.0000	6.00	16.50		
Shear Stirrups 💌	1	•	16.50	3	18.0000	4.50	21.00		
Shear Stirrups 💌	1	•	21.00	3	30.0000	7.50	28.50		
Shear Stirrups 💌	1	•	28.50	1	36.0000	3.00	31.50		
Shear Stirrups 💌	1	•	31.50	3	30.0000	7.50	39.00		
Shear Stirrups 💌	1	•	39.00	3	18.0000	4.50	43.50		
Shear Stirrups 💌	1	•	43.50	6	12.0000	6.00	49.50		
Shear Stirrups 💌	1	•	49.50	5	10.0000	4.17	53.67		
Shear Stirrups 💌	1	•	53.67	6	8.0000	4.00	57.67		
Stirrup Wizard	Stirrup Wizard New Duplicate Delete								





Next, copy G1 to G2. Do this by right clicking on *camelback beam (E)(C)*, select copy, then right click on **MEMBER ALTERNATIVES** under G2 and select paste.



Now that all beams within the span have been defined we are able to go back to windows within the bridge tree that will require updating.

The Live Load Distribution window for both G1 and G2 needs to be updated, select Compute from Typical Section.





Live Load Dis Standard LR Distribution © Use	FD Factor Input Method Simplified Method	🔘 Use Adva	nced Method			
Lanes		Distribution (Whee	Factor			
Loaded	Shear	Shear at Supports	Moment	Deflection		
1 Lane	1.500000	1.500000	1.500000	1.000000		
Multi-Lane	2.083333	2.083333	2.083333	2.000000	]	
Compute fro Typical Sect	om View Calcs	]		ОК	Apply	Cancel

# **Bridge Alternatives**

Now that the superstructure definitions are modeled, Bridge Alternatives must be created. This makes it possible to rate the entire bridge at one time and also perform batch processes in the Bridge Explorer workspace, which is important for permitting issues.

For load rating, there will typically be only one Bridge Alternative. Another Bridge Alternative could be created for a proposed bridge or rehabilitation project, but only one bridge alternative should be existing/current at a time. Each superstructure that was entered above now needs its own definition in the Bridge Alternative. Select the superstructure wizard. Enter the number of superstructures. Enter the superstructure and superstructure alternative names and then select the superstructure definition that you want to link to each alternative.

The bridge alternative portion of the tree may be created manually by double-clicking on each branch and assigning the necessary bridge components to each branch as shown above (**Superstructure Wizard...** button may be selected to aid in this process). Double-click **BRIDGE ALTERNATIVES** and enter the Alternative Name, then select the **Superstructure Wizard...** button and enter the data shown in the window below.





Alternative Name: cam	ielback					
Description	Superstructure Wiza	rd		-		×
Description: Reference Line Reference Line Le Starting S Be Superstructure	This wizard allows Definitions to the n Number of superst Prefix to Use Wh Sup Superstructure	you to create 3 ew alternatives nuctures 1 en Generating perstructure pre	Superstructures, Superstr s. The wizard will also cre v Names efix: Superstructure % efix: Superstructure Alt s	vucture Alternative eate Piers if you an %	es and assign Superstruc re running Opis Substruc Generate Superstructur Names Generate Superstructur Alternative Names	cture cture. re
Wizard	Superstructure Name camelback	Distance Su (ft)	uperstructure Alternative Name camelback	Superstructure Definition camelback		
			(	Finish	Cancel	Help

Click **Finish** to close the Superstructure Wizard and **OK** to save the Bridge Alternative data to memory and close the window.





# Analysis

### **Vehicle Selection**

From the *Bridge* menu, select *Analysis Settings* and load the following vehicles into the rating column:

Analysis Settings			
Design Review	Batin	ng Method:	LFD •
Analysis Type: Line Girder  Lane/Impact Loading Type: As Requested  Vehicles Reducted	Apply Preference	ce Setting:	None
Vehicle Selection: Wichigan 3 Unit Truck 22-N Michigan 3 Unit Truck 23-D Michigan 3 Unit Truck 23-D Michigan 3 Unit Truck 23-N Michigan 3 Unit Truck 24-D Michigan 3 Unit Truck 24-D Michigan 3 Unit Truck 25-D Michigan 3 Unit Truck 25-D Michigan Overload Truck 07 Michigan O	fic Direction: th directions   IL	Add to )perating >> Remove from Analysis	Refresh       Temporary Vehicles       Advanced         /ehicle Summary:        Advanced         Rating Vehicles           Inventory           HS 20-44        Operating         HS 20-44        Michigan 1 Unit Truck 05-DL         Michigan 2 Unit Truck 18-DL          Michigan 3 Unit Truck 23-DL
Reset Clear Open Templa	te Save Template	]	OK Apply Cancel

#### Select OK

Note: MDOT trucks 5-DL, 18-DL and 23-DL are used in this analysis as they are the commonly controlling 1-unit, 2-unit and 3-unit trucks, respectively. The load rating engineer should evaluate the list of legal vehicles to determine whether others may control and include them in the analysis if necessary. In addition, if posting is required, all legal loads must be analyzed to determine the lowest tonnage for each vehicle category.





### Analysis

Go to *Bridge/Analyze*. You will be informed regarding progress and completion of the analysis.

Ar	alysis Progress			
	Analysis Event  Camelback  Camel	<ul> <li>Location - 42.0000 (ft)</li> <li>Location - 44.7500 (ft)</li> <li>Location - 48.0000 (ft)</li> <li>Location - 50.7500 (ft)</li> <li>Location - 53.7500 (ft)</li> <li>Location - 54.0000 (ft)</li> <li>Location - 60.0000 (ft)</li> <li>Location - 5.8333 (ft)</li> <li>Location - 54.1667 (ft)</li> <li>Completed Specification Check.</li> <li>Info - Finished LFR specification checking</li> <li>Info - Finished populating specification checking results</li> <li>Info - Analysis completed!</li> </ul>		m
	< >			-
	View Rating Log		Print OK	

### Reporting

Results of the analysis may be viewed using the *Report Tool* located within the *Bridge* menu.

🗛 Camelback	< - LFD Report	- • ×
Report Type:	LFD Analysis Output <ul> <li>Advanced</li> <li>Begin each topic on a new</li> </ul>	v page when printed
New	Open Merge Save Save As	Generate
<ul> <li>✓ Overall St</li> <li>☐ Individual</li> <li>☐ Reactions</li> <li>☐ Moments</li> <li>☐ Shears</li> <li>☐ Cross Sec</li> <li>☐ Detailed F</li> </ul>	IVehicle Rating Summary s stion Properties Rating Results	
Clear All	Select All Delete	Close

Select Generate.





**Bridge Name:** Sample of a Camelback Bridge Load Rating **NBI Structure ID:** Camelback **Bridge ID:** Camelback

Analyzed By: Virtis Analyze Date: Friday, June 14, 2013 14:48:10 Analysis Engine: AASHTO LFR Engine Version 6.4.1.3001 Analysis Preference Setting: None

**Report By:** virtis **Report Date:** Friday, June 14, 2013 14:50:03

Structure Definition Name: camelback Member Name: G1 Member Alternative Name: camelback beam

#### Load Factor Rating Summary

		Rating		Capacity		Location			
Live Load		Factor	Controls	(Ton)	Span	( <b>ft</b> )	Percent	Impact	Lane
HS 20-44	Inventory	1.098	Design Flexure - Concrete	39.52	1	36.00	60.0	As Requested	As Requested
	Operating	1.834	Design Flexure - Concrete	66.01	1	36.00	60.0	As Requested	As Requested
Michigan 1 Unit Truck 05-DL	Inventory	**	**	**	**	**	**	**	**
	Operating	1.673	Design Flexure - Concrete	70.26	1	30.00	50.0	As Requested	As Requested
Michigan 2 Unit Truck 18-DL	Inventory	**	**	**	**	**	**	**	**
	Operating	1.114	Design Flexure - Concrete	85.74	1	30.00	50.0	As Requested	As Requested
Michigan 3 Unit Truck 23-DL	Inventory	**	**	**	**	**	**	**	**
	Operating	1.195	Design Flexure - Concrete	91.98	1	30.00	50.0	As Requested	As Requested

Note:

"N/A" indicates not applicable

"\*\*" indicates not available

Bridge Name: Sample of a Camelback Bridge Load Rating

**NBI Structure ID:** Camelback

Bridge ID: Camelback





Analyzed By: Virtis Analyze Date: Friday, June 14, 2013 14:48:10 Analysis Engine: AASHTO LFR Engine Version 6.4.1.3001 Analysis Preference Setting: None

**Report By:** virtis Report Date: Friday, June 14, 2013 14:50:03

**Structure Definition Name:** camelback Member Name: G2 Member Alternative Name: Copy of camelback beam

Load Factor Rating Summary									
		Rating		Capacity		Location			
Live Load		Factor	Controls	(Ton)	Span	( <b>ft</b> )	Percent	Impact	Lane
HS 20-44	Inventory	1.098	Design Flexure - Concrete	39.52	1	36.00	60.0	As Requested	As Requested
	Operating	1.834	Design Flexure - Concrete	66.01	1	36.00	60.0	As Requested	As Requested
Michigan 1 Unit Truck 05-DL	Inventory	**	**	**	**	**	**	**	**
	Operating	1.673	Design Flexure - Concrete	70.26	1	30.00	50.0	As Requested	As Requested
Michigan 2 Unit Truck 18-DL	Inventory	**	**	**	**	**	**	**	**
	Operating	1.114	Design Flexure - Concrete	85.74	1	30.00	50.0	As Requested	As Requested
Michigan 3 Unit Truck 23-DL	Inventory	**	**	**	**	**	**	**	**
	Operating	1.195	Design Flexure - Concrete	91.98	1	30.00	50.0	As Requested	As Requested

Note:

"N/A" indicates not applicable

"\*\*" indicates not available



