AASHTOWare BrDR 7.5.0 Substructure Tutorial Pier3 - Frame Pier Example















Section A-A



Section B-B

Pier3 - Frame Pier Example

BrDR Substructure Training

Example features:

- Reinforced concrete, three column frame pier, spread footings
- Pier skew 0 degrees
- Specification checking of reinforcement

Items covered in this series:

Topic 1:

- BrDR Substructure Capabilities
- Locating Substructure Units

Topic 2:

- Bridge Data Related to Piers
- Pier Alternatives
- Pier Geometry
- Pier 3D Schematic
- Validating a Pier Alternative

Topic 3:

- Superstructure Loads
- Superstructure Environmental Loads
- Substructure Loads
- Load Calculation Reports

Topic 4:

- BrDR Substructure Toolbar
- Finite Element Model
- Pier Analysis
- Specification Checks
- Footing Analysis
- Tabular Results
- Viewing Results in 3D Schematic
- Additional Reports
- Method of solution

Using AASHTO LRFD Bridge Design Specifications, 5th Edition, with 2010 interims

Note: It is assumed that users are familiar with the BrDR Superstructure module and as such this example does not go into detail describing BrDR Superstructure windows or bridge workspace navigation.

Topic 1 - Pier 3 – Frame Pier Example

This topic is the first of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, a two span continuous steel superstructure is supported by a 3 column frame pier.

BrDR Substructure Capabilities

The BrDR Substructure module currently has the capability to describe the pier gross geometry and reinforcement, compute loads acting on the pier, perform a finite element analysis of the pier, compute the load combination results, and perform specification checks for the reinforcement. Four types of reinforced concrete pier alternatives can be described: solid shaft (hammerhead) piers, frame piers, wall piers and pile bent piers.



A three-dimensional schematic is available to view a to-scale drawing of the pier alternative. BrD can compute the loads acting on the pier or the user can enter override forces. Superstructure dead load and live load reactions are computed based on the superstructure definition assigned to the superstructure supported by the pier. BrD generates a three-dimensional finite element model of the pier based on modeling parameters input by the user. A finite element analysis of the pier is performed, and load combination results are generated based on the user chosen limit states . The analysis results can be viewed in a text output and be viewed on the three-dimensional schematic of the pier. Detailed specification check results can be viewed, and summary reports of the specification results can be generated.

Locating Substructure Units

In BrDR, substructures are defined relative to bridge alternatives and the superstructures in a bridge alternative. Through this arrangement, loads from the superstructure can be carried down to the substructures.



This example has the following bridge layout:

In this tutorial, a bridge alternative and pier will be described in the BrDR Substructure module by adding a bridge alternative to the bridge **BID 20** in the sample database. From the **Bridge Explorer**, double click on **BID20** to open the bridge. The partially expanded **Bridge Workspace** tree is shown below. This bridge already contains several superstructure definitions and bridge alternatives. The superstructure definitions will be reused, and a new bridge alternative and a new pier will be created.



Pier3 - Frame Pier Example

Bridge

Open the **Bridge** window for this bridge by double clicking on **LRFD Substructure Example 1** on the **Bridge Workspace** tree.

A LRFD Substructure Examp	ble 1						- 0	×
Bridge ID: LRFD Subs	tructure Exampl NBI	structure ID (8):	LRFD_EX1_sub		Template Bridge compl	etely defined	Bridge Workspace View Superstructures Culverts Substructures	
Description Desc	ription (cont'd) Alter	natives Globa	al reference point	Traffic	Custom agency fie	lds		
Name:	LRFD Substructure Exa	mple 1]	Year built:			
Description:	LRFD Substructure Exa	mple 1						
Landian							6	
Facility carried (7):		_			Route number:		π	
Feat. intersected (6):					Mi. post:			
Default units:	US Customary	\sim						
Bridge associa	ation BrR	BrD BrN	1					
						ОК	Apply Canc	el

No change of data is required on the **Description** tab of this window.

Pier3 - Frame Pier Example

Navigate to the **Global reference point** tab.

🕰 LRFD Substruc	cture Example	1					- 0	×
Bridge ID:	LRFD Substru	icture Exampl	NBI structure	ID (8): LRFD_EX1_su	b	Template Bridge completely defined	Bridge Workspace View Superstructures Culverts Substructures	
Descriptio	on Descrip	otion (cont'd)	Alternatives	Global reference po	int Traffic	Custom agency fields		
X:	0	ft						
Y:	0	ft						
Elevation:		ft						
Longitude	:	Degrees						
Latitude:		Degrees						
	Open loc	ation						
Bri	idge associatio	on	BrR 🗹 BrD	BrM				
						ОК	Apply Canc	el

This tab contains an **X** and **Y** coordinate field for the bridge global reference point. This data could be used to describe the state plane coordinates for the bridge. When reviewing the **Pier** window later in this example, it is worth noting that, BrDR computes the coordinates for the pier based on this bridge global reference point. For this example, leave the X and Y coordinates as zero. Click **Cancel** to close the **Bridge** window without making any changes to it.

Bridge Alternatives

Double click on the **BRIDGE ALTERNATIVES** node in the **Bridge Workspace** tree to create a new bridge alternative and enter the following information.

sitioning		g Alt :tures	Alternative name: Trainin Description Substru
sitioning		tures	Description Substru
sitioning			Description
sitioning			Description.
isidoning	Global position	e	Horizontal curvatu
ft	Distance:	260 ft	Reference line length:
ft	Offset:	End bearing	O Start bearing
: ft	Elevation:	0 ft	Starting station:
		N 90^ 0' 0.00" E	Bearing:
t length: ft	Start tangent ler		Bridge alignment
h: ft	Curve length:		Curved
ft	Radius:	, tangent	Tangent, curve
Left 🗸	Direction:		Tangent, curve
t length: ft	End tangent len	t	Curved, tanger
Left ~	Direction: End tangent len		Curved, tanger

The data on this tab orients the bridge alternative reference line. The substructure units for this example will be located with respect to this bridge alternative reference line. The bridge alternative is 260.0 feet long and the starting station is 0+00. The default bearing of N 90^o 0° 0° E is acceptable for this example. The **Global positioning** data orients the bridge alternative reference line with respect to the bridge global reference point. since this bridge alternative is not offset to the bridge global reference point, this section can be left blank in this tutorial.



Switch to the **Substructures** tab and enter the following information to locate the abutments and piers. The substructure units are located by entering the location of the substructure unit reference point relative to the bridge alternative reference line. The substructure unit reference point is the point where the superstructure reference line intersects the pier longitudinal axis or centerline of bearing at an abutment. The location of abutments in BrDR Substructure can be specified but cannot currently describe the geometry of the abutments.

Brid	ge Alternative				_		×	
Alterna	ative name: Tra	ining Alt						
Desc	cription Subs	structures						
	Substructure unit name	Station (ft)	Offset (ft)	Unit type				
	Abut1	0	0	Abutment 🗠		-		
	Pier1	130	0	Pier 🗸	(\mathcal{P})			
>	Abut2	260	0	Abutment 🗠	Click	F1	while	the
< OK	to apply the da	ta and close	the wind	low.	Substruct open the which co	ures tal e BrDl ontains	b is acti R Help example	ve to file s for
	to apply the da	ta anu ciose	the wind	low.	locating s	substruc	ture uni	ts.

The partially expanded Bridge Workspace is shown below.



Superstructure

Double click the **SUPERSTRUCTURES** node (or click **New** from the **WORKSPACE** ribbon or right click and select **New**) to create a new superstructure. Enter the following information to describe the superstructure in this bridge alternative.

A Superstructure							-		×
Superstructure nan	ne:	Superstru	icture						
Description	Alter	natives	Vehicle path	Engine	Substructures				
Description:									
Reference lir	ne								
Distance:		0	ft						
Offset:		0	ft						
Angle:		0	Degrees						
Starting stat	ion:	0	ft						
						OK	Apply	Canc	el

۵	Supe	erstructure							-		Х
Su	perst	ructure nar	me: Superstr	ucture							
	Desc	ription	Alternatives	Vehicle path Eng	ine Substructures						
	Sele	ect the sub	structure supp	oorts:							
		Support	Substructur support	e							
		1	Abut1 >	/							
		2	Pier1 >	·							
	>	3	Abut2 \	,							
								New		Delete	
							OK			C	
							UK	Арр	iy	Cance	:

This superstructure is located at the start of the bridge alternative reference line, so no data is required for the reference line distance or offset. Enter the span length of the superstructure and select the substructure supports. Click **OK** to apply the data and close the window.



Superstructure alternatives

Double click the **SUPERSTRUCTURE ALTERNATIVES** node under **Superstructure** to create a new superstructure alternative. It is important to assign a superstructure definition to the alternative so BrDR will know what superstructure definitions are carried by the pier. Enter the following data and click **OK**.

Bridge Workspace - LRFD Substructure Example 1	ANALYSIS	REPORTS		? –	
BRIDGE WORKSPACE TOOLS VIEW	DESIGN/RATE	REPORTING			
Check Out 👸 🔛 🍪 Restore 🔀 🎸 Check In Validate Save 🎯 Revert Close Export Bridge	Refresh	New Copy Paste Duplicate De	lete Schematic		
Workspace	\$ X \$	Schematic	☆ × Report		\$ ×
Bindge Components → ALRDS Substructure Example 1 → Daphragm Definitions → Dephragm Definitions → TURED Multiple Presence Factors → EVENTMONENTED Conditions	A Superstructure Alter	mative		_	- ×
	Alternative name: Description: Superstructure definition Superstructure type: Number of main memb	Alt 1 2 Continuous span Girder 6	×		
Superstructure Superstructure Superstructure Alternatives Superstructure Alternatives Superstructure Superstructure TI Stiffness Analysis Derss Derss Derss	Span Length (ft) 1 130 2 130		OK	Apply	Cancel
l					

The partially expanded bridge workspace is shown below.



Topic 2 - Pier 3 – Frame Pier Example

This topic is the second of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, a two span continuous steel superstructure is supported by a 3 column frame pier.

Note: Topic 1 must be competed in the series before entering this topic. It is assumed that users are familiar with the BrDR Superstructure module and as such this example does not go into detail describing BrDR Superstructure windows or bridge workspace navigation.

Bridge Data Related to Piers

This bridge already contains the following materials. **Class A (US)** concrete and **Grade 60** reinforcing steel will be used in this pier alternative, so no new material need to be added. The partially expanded Bridge Workspace tree is shown below. Verify the properties of the concrete material as shown below.



A Bridge Materials - Co	ncrete					_		×
Name: Class A (l	US)							
Description: Class A c	ement concret	e						
Compressive strength a	at 28 days (f'c):	4.0000006	ksi					
Initial compressive stree	ngth (f'ci):	3	ksi					
Composition of concret	te:	Normal						
Density (for dead loads):	0.15	kcf					
Density (for modulus of	f elasticity):	0.145	kcf					
Poisson's ratio:	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	0.2						
Coefficient of thermal e	expansion (α):	0.000006	1/F					
Splitting tensile strengt	h (fct):		ksi					
LRFD Maximum aggreg	ate size:		in					
	Compute							
Std modulus of elasticit	ty (Ec):	3644.149254	ksi					
I RED modulus of elastic	city (Ec):	3644 149254	ksi					
Std initial modulus of el	lasticity:	3155 92425	ksi					
I RFD initial modulus of	elasticity:	3155 92425	ksi					
Std modulus of rupture	e e e e e e e e e e e e e e e e e e e		ksi					
LRED modulus of runtu	re:	0.470857	ksi					
Shear factor:		1						
	Сору	to library Cop	y from library	ОК	Apply	/	Cano	el
🕰 Bridge Materials - R	leinforcing Ste	el			-	-		×
Name: Grade 6	60							
Description: 60 ksi n	einforcing ste	el						
Spacified viold strong	th (6.)	00007						
Specified yield streng	(F)	000087 KS						
Modulus of elasticity	(ES): 2900	0.004206 KS						
Ultimate strength (Fu)): 90.00	000131 ks						
Туре								
O Plain								
Ероху								
Galvanized								
	Conv to libra	ny Convitron	library	ĸ	Apply		Canco	
	2007 10 1010				עיקייי		cance	

LRFD Multiple Presence Factors

Double click on the **LRFD Multiple Presence Factors** node in the **BWS** tree. This window displays the multiple presence factors from AASHTO LRFD Table 3.6.1.1.2-1. These factors will be used when BrDR Substructure combines multiple loaded lanes. No adjustment to these values are needed currently so click **Cancel** to close the window.

А Ц	RFD Multiple Pr	esence Factors				-		×
	Number of loaded lanes	Multiple presence factors "m"						
>	1	1.2						-
	2	1						
	3	0.85						
	>3	0.65						
	Reduce based	on ADTT if app	licable					
				OK	Appl	у	Cano	el

LRFD Substructure Design Settings

LRFD Substructure Design Settings contain a set of LRFD factors, limit states to be included in the analysis and vehicles to be used in the analysis. BrDR Substructure uses these design settings when analyzing a pier.

BrDR has system default LRFD Substructure Design Settings as specified on the **System Defaults** window in the **Configuration** Browser shown below.

BRIDGE EXPLORER CONFIGURATION	AASHTOWare Bridge Design and Rating	? – 🗆 ×
Rev Rename Delete New Open Delete Group User Manage		
Design Explorer: Anag Explorer: Anag Explorer: Anag Explorer: Acces Privates: Acces Private: Acce	System Defaults X General Bridge workspace Superstructure analysis Solutions Subtructure analysis Tolerance Core New bridge System of Junks US Customary Perliminary mode design setting Perliminary mode design setting Perliminary mode design setting Perliminary mode design setting Final Design Setting (US) Final Design Setting (US)	atom agency fields Rating tool settings a

These default design settings will be used in this example. The following window in **LIBRARY** of BrDR shows the default **Preliminary Design Setting (US).**

W Depleter Open Units Server Ministry W Depleter Open Units Server Ministry W Depleter Open Units Server Ministry P Server Ministry Server Ministry Server Mini	LIBRAR GE EXPLORER LIBRAF	Y Y		AASHTOWare Brid	lge Design and f	Rating		? -	. 🗆	>
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Preiminery Design Setting (US) Preiminery Design Setting (US) Preiminery Design Setting (US) Statudet US Customary Final Design Setting (US) Preiminery Design Setting (US) Statudet US Customary Final Design Setting (US) Final Design Setting (US) Statudet US Customary Final Design Setting (US) Final Design Setting (US) Statudet US Customary Final Design Setting (US) Final Design Setting (US) Statudet US Customary Final Design Setting (US) Final Design Setting (US) Statudet US Design Setting (US) Final Design Setting (US) - (RFD Substructure Design Setting (US) Store units as US Substructure Design Setting (US) - (Veriminary Design Setting (US) Store units as US Substructure Design Setting (US) - (Veriminary Design Setting (US) US Store units as US Standard Preiminary Veriminary Design Setting (US) US US Standard Preiminary Veriminary Design Setting (US) US Standard VS Standard Umits tates Veriminary Design Setting (US) US Standard VS Standard <td< th=""><th>Appurtenances</th><th></th><th>Library</th><th>Units</th><th>Name</th><th></th><th>Description</th><th></th><th></th><th></th></td<>	Appurtenances		Library	Units	Name		Description			
Standard Standard Standard Preliminary Design Setting (05) Preliminary Design Setting (05) Standard US Customary Final Design Setting (05) Final Design Setting (05) Concognited Mars Brand Standard US Customary Final Design Setting (05) Concognited Mars Brand Standard US Customary Final Design Setting (05) Concognited Mars Brand Standard Standard Standard Concognited Mars Brand Standard Standard Concognited Mars RFD Substructure Design Setting (US) Store units as Ubray Design setting for Preliminary Vehicles Substructure loading Store units as Standard Preliminary Choose the limit states to be included in the analysis Standard Standard Standard Standard STRENGTH-HV StreNGTH-HV Standard Stan	🧭 Generic 🍘 Median		> Standard	US Customary	Preliminary De	esign Setting (US)	Preliminary Design Setting (US)		
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RFD 5 Applicability Renge Materials Materials IRRD Substructure Design Settings: Preliminary Design Setting (US) Image: Preliminary Design Setting (US) Description: Preliminary Design Setting (US) Standard Initis states Vehicles Substructure loading Choose the limit states to be Included in the analysis: Stription: Striptio	Bolt Naii Corrugated Metal Panel Factors Er LRFD LRFR		Standard	SI / Metric	Final Design S	ietting (SI)	Final Design Setting (SI)			
Name: Preliminary Design Setting (US) Store units as Library Design setting type Duscription: US Standard Preliminary Init states Vehicles Substructure loading Imit states Vehicles Substructure loading Init states Vehicles Substructure loading Imit states Vehicles Substructure loading Imit states Vehicles Substructure loading Choose the limit states to be INFD Sth 20101 2010 AASHTO LRFD Specifications Choose the limit states to be INFD Sth 20101 2010 AASHTO LRFD Specifications Strendsth-H Strendsth-H Advance Strendsth-H Strendsth-H Advance Strendsth-H Strendsth-H Strendsth-H Strendsth-H Strendsth-H Strendsth-H Strendsth-V Strendsth-H Strendsth-H Strendsth-H Strendsth-H Strendsth-H Strendsth-H Strendsth-H Strendsth-H Strendsth-V Strendsth-H Strendsth-H Strendsth-V Strendsth-H Strendsth-H Strendsth-V	LRFD DF Applicability Ran LRFD Substructure Design Materials FD Substructure Desi	ges Settings gn Settings: Preli	minary Design 9	Setting (US)						— c
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SI Agency defined Final Limit states Vehicles Substructure loading Analysis method Analysis Spec version Factors Vppe AASHTO LRFD LRFD 5th 2010i 2010 AASHTO LRFD Specifications Image: Choose the limit states to be included in the analysis: Choose the limit states to be included in the analysis: STRENGTH-I StrENGTH-I StrENGTH-I STRENGTH-II StrENGTH-II Fatigue and fracture limit states: 15 % STRENGTH-IV SERVICE-II SERVICE-III SERVICE-III SERVICE-III	,	5 5.				211	Standard	D. D.	elimina	
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Choose the limit states to be included in the analysis: STREINGTH-I STREINGTH-II STREINGTH-III STREINGTH-IV STREINGTH-IV STREINGTH-V SERVICE-II SERVICE-III SERVICE-IV	imit states Vehicle Analysis method type	s Substructure	IS) Ioading Iysis dule	Spec	version	sı	Agency defined	Fi	nal	Ŋ
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Navigate to the **Components** tab of the **BWS** tree, expand **LRFD Substructure Design Settings** node and double click on **Design setting 1** (or click and select **Open** from the **WORKSPACE** ribbon) as shown below.

DGE WORKSPACE WOR	KSPACE TOOLS	VIEW C			S 7	22				
Check In Validate Save	, 💰 Revert Clo Bridge	se Export Refre	esh Open	New Copy Past	Duplicate De	elete Sche	matic			
kspace	¢ × Sď	hematic	ź	≻ × Report			× ×			
idge Components Compo										
 ² Connectors ⇒ Factors → ↓ FR ⇒ ↓ FR ⇒ ↓ RFD ⇒ ↓ RFR ⇒ ↓ RFR ⇒ ↓ RFR ⇒ ↓ RFR ∪ Substructure D → ↓ RFR ⇒ ↓ RFR ∪ Substructure D → ↓ RFR ∪ Substructure D 	esign Settings	alysis					×			
LRFD Substructure Desi	gn Settings							 _		>
								- Desi	an settina t	vpe
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ame: Design set escription: Limit states Vehicle Analysis method type > LRFD	s Substructure Analysis module AASHTO LRFD	e loading Spo V LRFD 5	ec version ith 2010i V	2004 AASHTC	Factors LRFD Specifi	ications	~		gn setting t Preliminary Final	ype /
ame: Design set escription: Limit states Vehicle Analysis method type > LRFD Choose the limit state: included in the analysi STRENGTH-II STRENGTH-II STRENGTH-III STRENGTH-IV STRENGTH-IV	s Substructurn Analysis module AASHTO LRFD s to be s:	e loading Spr V LRFD 5 Dynamic le Fatigue a All other	ec version ith 2010i v pad allowance ind fracture lim limit states:	2004 AASHTC it states: 15 33	Factors LRFD Specifi % %	ications	× .		gn setting t	ype
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The limit states belonging to the factor are displayed. Since this design setting is for use in the Preliminary mode, only the Strength-I limit state is selected. When the pier is analyzed with this design setting only the Strength-I limit state load combinations will be computed. This can save significant time in the analysis in the preliminary pier geometry sizing stage.

Pier3 - Frame Pier Example

The vehicles to	be used in	the analysis are	chosen on the	Vehicles tab.

lame:	Design settin	g 1			Design setting type
escription:			A		Final
Limit state	s Vehicles	Substructure loading			
LRFD fac	tors:				
2004 AA	SHTO LRFD Sp	ecifications			
Vehicle se	election:			Vehicle summary:	
-Ager User No v	ites tandard — Alternate Mil — EV2 — EV3 — HL-93 (SI) — HS-93 (SI) — HS-20 (SI) — HS 20 (SI) — HS 20-44 — LRFD Fatigue cy Defined Defined ehicle	itary Loading Truck (SI) Truck (US)	>>	 Final innit states except strength-II and Patigue -Hi-B3 (US) -Strength-II limit state -Fatigue limit state 	
v	ehicle Con desi	sider pair of gn tandems			
> HL-9	3 (US)				A

The **Substructure loading** tab allows to describe how the vehicle single lane reactions are applied to the substructure. If the axle load P is entered as zero, the entire single lane reaction will be applied to the deck as a uniform load spread over the lane width. If a value other than zero is entered, the single lane reaction applied to the deck will contain two concentrated loads each equal to P/2 at the wheel locations within the lane width and the remainder of the single lane reaction will be applied as a uniform load spread over the lane width.

ame:	Design setting	n 1						De	sign	setting t	ype
		, ·						~	Pre	liminary	
escription:				-				\sim	Fin	al	
Limit state	es Vehicles	Substructur	e loading								
Vehicle sin applied to	gle lane reactio the deck as sho P/2 P/	ns will be own below: 2	Vehicle	Vehicle type	Axle Ioad P (kip)						
تما	2-0" 6'-0"	2'-0"	HL-93 (US)	Design Truck	32						6
			HL-93 (US)	Design Tandem	25						
¥	+ + +	· •	HL-93 (US)	Design Lane	0						
ł	10'lane w= (<u>Reaction-P)</u> 10'	→	> HL-93 (US)	Truck Pair	32						
ŀ	10 [°] lane w= (<u>Readion-P)</u> 10 [°]		> HL-93 (US)	Truck Pair	32						

Environmental Conditions

Double click on the Environmental Conditions node in the BWS tree. The following window appears.

Vind l	oad basis	Eastart mile	rnord								Store unit	as		
	ust speed	Fastest-mile	speed								Us	0 51		
/ind-g	ust Wind-fa	stest Tem	perature Stream											
Win	d exposure cate	gory		Table	3.8.1.2.1-2					_				
0	в 🔿 с 🔾) D		Dra	ig coefficient, C	D					\bigcirc			
able 3	8112-1					Component		Windward	Leeward		Y		_	-
- Des	ign 3-second gu	ist wind spee	d	>	I-girder and	l box-girder bridge	superstructures	1.3	N//	Α	🛡 Sp	ecify	the	surfac
			-second aust wind		Truss colum	ns and arches-sharp	p edged member	2			condit	ions	for th	e bridg
	Load combina	ations	speed, V		Truss col	umns and arches-ro	ound member	1	0.5	5	A 11			.1.
			(mph)			Bridge substructu	ure	1.6	N//		All of	iner a	ata on	this ta
>	Strength	ш	value from system default			Sound barriers		1.2	N/A		defaul	ts to	the A	ASHT
	Strength	v	80								snecs			
	Service	1	70	Table	3.8.1.2.3a-1						spees.			
				, Ske	w coefficients	for various skew an	gles of attack			L				
							more and archer		Circ					
	01211				Skew angle	Irusses, colur	nns, and arches		Girc	lers				
able 3 Gus	3.8.1.2.1-1 t effect factor				Skew angle of wind (Degrees)	Transverse skew coefficient	Longitudinal skev	v Transver	se skew cient	Longitudii coeffic	nal skew cient			
able 3 Gus	3.8.1.2.1-1 t effect factor	Gust	offect		Skew angle of wind (Degrees)	Irusses, colur Transverse skew coefficient	Longitudinal skev coefficient	v Transver coeffi	se skew cient	lers Longitudii coeffic	nal skew cient 0			
Gus	8.8.1.2.1-1 t effect factor Structure typ	pe Gust facto	effect or, G	>	Skew angle of wind (Degrees) 0 15	Transverse skew coefficient 1 0.933	Longitudinal skev coefficient	v Transver coeffi 0	se skew cient 1 0.88	lers Longitudii coeffic	nal skew cient 0 0.12	•		
Gus	8.8.1.2.1-1 t effect factor Structure typ Sound barrie	pe Gust fact	effect or, G 0.85	>	Skew angle of wind (Degrees) 0 15 30	Transverse skew coefficient 1 0.933 0.867	Longitudinal skev coefficient 0.1 0.37	v Transver coeffi 0 6 3	se skew cient 1 0.88 0.82	lers Longitudii coeffic	nal skew cient 0 0.12 0.24	•		
fable 3 Gus	8.8.1.2.1-1 t effect factor Structure typ Sound barrie All other struct	pe Gust fact tures	effect or, G 0.85 1	>	Skew angle of wind (Degrees) 0 15 30 45	Transverse skew coefficient 0.933 0.867 0.627	Longitudinal skev coefficient 0.1 0.37 0.54	v Transver coeffi 0 6 3 7	se skew cient 1 0.88 0.82 0.66	lers Longitudii coeffic	nal skew cient 0 0.12 0.24 0.32	•		
Gus	8.8.1.2.1-1 t effect factor Structure typ Sound barrie All other struct	pe Gust fact ers tures	effect or, G 0.85 1	>	Skew angle of wind (Degrees) 0 15 30 45 60	Transverse skew coefficient 0.933 0.867 0.627 0.32	Longitudinal skev coefficient 0.1 0.37 0.54 0.66	V Transver coeffi 6 3 7 7	se skew cient 1 0.88 0.82 0.66 0.34	lers Longitudii coeffic	nal skew cient 0 0.12 0.24 0.32 0.38	•		
Gus	3.8.1.2.1-1 t effect factor Structure typ Sound barrie All other struct	pe Gust fact tures	effect or, G 0.85 1		Skew angle of wind (Degrees) 0 15 30 45 60	Irusses, colur Transverse skew coefficient 1 0.933 0.867 0.627 0.32	Longitudinal skev coefficient 0.1 0.37 0.54 0.66	v Transver coeffi 6 3 7 7	se skew cient 1 0.88 0.82 0.66 0.34	lers Longitudii coeffic	nal skew cient 0 0.12 0.24 0.32 0.38	•		
Fable 3	3.8.1.2.1-1 t effect factor Structure typ Sound barrie All other struct	pe Gust facti ers tures	effect or, G 0.85 1	>	Skew angle of wind (Degrees) 0 15 30 45 60 tical upward wi	Transverse skew coefficient 0.933 0.867 0.627 0.32	Longitudinal skev coefficient 0.1 0.37 0.54 0.66	Transver coeffi 6 3 7 7	se skew cient 1 0.88 0.82 0.66 0.34 0.34	lers Longitudii coeffic	nal skew cient 0 0.12 0.24 0.32 0.38	*		
Fable 3	8.8.1.2.1-1 t effect factor Structure typ Sound barrie All other struct 0.8.1.3-1 d components o	pe Gust fact tures	effect or, G 0.85 1	Ver	Skew angle of wind (Degrees) 0 15 30 45 60 tical upward w ength III: 0.02	Irusses, colur Transverse skew coefficient 1 0.933 0.867 0.627 0.32 nd pressure	Longitudinal skev coefficient 0.1 0.37 0.54 0.66	v Transver coeffi 6 3 7 7 7	se skew cient 1 0.88 0.82 0.66 0.34 0.34	lers Longitudii coeffic	nal skew cient 0.12 0.24 0.32 0.38	* *		
Fable 3 Gus	8.8.1.2.1-1 t effect factor Structure ty Sound barrie All other struct 8.8.1.3-1 d components o	pe Gust fact tures -	effect or, G 0.85 1	Ver Str	Skew angle of wind (Degrees) 0 15 30 45 60 tical upward wi ength III: 0.02 ength IV: 0.07	Irusses, colur Transverse skew coefficient 1 0.933 0.867 0.627 0.32 0.32 nd pressure ksf ksf	Longitudinal skev coefficient 0.1 0.37 0.54 0.66	Transver coeffi 3 7 7	See skew Cient 1 0.88 0.82 0.66 0.34 0.34	lers Longitudii coeffic	nal skew cient 0.12 0.24 0.32 0.38	A.		
Fable 3 Gus	8.8.1.2.1-1 t effect factor Structure typ Sound barrie All other struct 8.8.1.3-1 d components of Skew angle (Degrees)	pe Gust fact ers tures	Parallel component	> Ver Stri Stri	Skew angle of wind (Degrees) 0 15 30 45 60 tical upward w ength III: 0.02 ength IV: 0.07	Irusses, colur Transverse skew coefficient 1 0.933 0.867 0.627 0.32 nd pressure 2 ksf ksf	Longitudinal skev coefficient 0.1 0.37 0.54 0.66	Transver coeffi 3 7 7	se skew 1 0.88 0.82 0.66 0.34	lers Longitudii coeffic	nal skew cient 0.12 0.24 0.32 0.38	*		
Fable 3 Gus	8.8.1.2.1-1 t effect factor Structure typ Sound barrie All other struct 8.8.1.3-1 d components o Skew angle (Degrees)	pe Gust fact ers tures on live load Normal component (kip/ft)	Parallel component (kip/ft)	Ver Str Str	Skew angle of wind (Degrees) 0 15 30 45 60 tical upward wi ength III: 0.02 ength IV: 0.07	Irusses, colur Transverse skew coefficient 1 0.933 0.867 0.627 0.32 nd pressure ksf ksf ading	Longitudinal skev coefficient 0.1 0.37 0.54 0.66	v Transver coeffi 6 3 7 7 7	cient 1 0.88 0.82 0.66 0.34	lers Longitudii coeffic	nal skew cient 0.12 0.24 0.32 0.38	*		
Fable 3	8.8.1.2.1-1 t effect factor Structure typ Sound barrie All other struct 0.8.1.3-1 d components of Skew angle (Degrees) 0 15	pe Gust fact tures n live load Normal (kip/ft) 0.1	Parallel component (kip/ft) 0	Ver Str Str Tra	Skew angle of wind (Degrees) 0 15 30 45 60 tical upward w ength III: 0.02 ength IV: 0.07	Irusses, colur Transverse skew coefficient 1 0.933 0.867 0.627 0.32 nd pressure 2 ksf ksf ading n superstructure, %	Longitudinal skew coefficient 0.1 0.37 0.54 0.66	v Transver coeffi 6 3 7 7 7 e: 100	se skew cient 1 0.88 0.82 0.66 0.34	lers Longitudii coeffic	nal skew cient 0.12 0.24 0.32 0.38			
Fable 3	8.8.1.2.1-1 t effect factor Structure typ Sound barrie All other struct 8.8.1.3-1 d components of Skew angle (Degrees) 0 15 30	pe Gust fact tures tures on live load – Normal component (kip/ft) 0.18 0.088	Parallel component (kip/ft) 0.0.012 0.024	Ver Str Str Tra Lor	Skew angle of wind (Degrees) 0 15 30 45 60 tical upward wi ength III: 0.02 ength IV: 0.01 mplified wind Io insverse wind o inspitudinal wind	Irusses, colur Transverse skew coefficient 1 0.933 0.867 0.627 0.32 nd pressure ksf ksf ading n superstructure, %	Longitudinal skev coefficient 0.1 0.37 0.54 0.66	 Transver coeffi Coeffi G G<td>se skew 1 0.88 0.82 0.66 0.34</td><td>lers Longitudii coeffic</td><td>nal skew 0 0.12 0.24 0.32 0.38</td><td>•</td><td></td><td></td>	se skew 1 0.88 0.82 0.66 0.34	lers Longitudii coeffic	nal skew 0 0.12 0.24 0.32 0.38	•		
Fable 3	8.8.1.2.1-1 t effect factor Structure typ Sound barrie All other struct 8.8.1.3-1 d components of (Degrees) 0 15 30 45	pe Gust fact ers tures tures on live load Normal component (kip/ft) 0.1 0.088 0.082 0.066	effect or, G	Ver Str Str Lov Wi	Skew angle of wind (Degrees) 0 15 30 45 60 tical upward wi ength III: 0.02 ength IV: 0.07 nplified wind lo insverse wind o ngitudinal wind nd on live load	Irusses, colur Transverse skew coefficient 1 0.933 0.867 0.627 0.32 nd pressure ksf ksf ading n superstructure, % on superstructure, transverse:	Longitudinal skev coefficient 0.1 0.37 0.54 0.66	v Transver coeffi 6 3 7 7 7	se skew	/ft	nal skew cient 0.12 0.24 0.32 0.38	×		

This window lists the environmental conditions acting on the bridge. The wind pressure values on the **Wind** tab default to values from the AASHTO LRFD Specifications.

Navigate to the **Temperature** tab. The temperature ranges on this tab default to those in AASHTO LRFD Table 3.12.2.1-1. Enter the setting temperature and select the climate type as shown below.

Ind load basis Store unit as Gust speed Image: Store unit as ind-gust Wind-fastest Temperature: 68 F Image: Cold Climate Image: Cold Specify the setting temperature ranges Climate Climate Image: Cl	nvironr	mental Condi	tions							- 0	×
Ind-gust Wind-fastest Temperature Stream Itetting temperature: 68 F Itemperature: Specify the setting temperature ranges Image: Temperature ranges Image: Temperature ranges Itemperature ranges Specify the setting temperature and climate for the bridge. All other data or this tab defaults to the bridge. All other data or this tab defaults to the AASHTO specs.	Wind loa	ad basis st speed 🕻	Fastest-mile	speed					Store unit as		
ietting temperature: 68 F Image Moderate O Cold Specify the setting temperature ranges Image: Temperature ranges Image: Temperature range Image:	Nind-gu	ıst Wind-	fastest Ten	perature S	tream						
Imperature ranges Climate Min (Degrees F) Max (Degrees F) Max (Degrees F) Max (Degrees F) temperature and climate f the bridge. All other data of this tab defaults to th AASHTO specs.	Setting	temperature:	68	F	Climate Moder Cold	rate			Specif	y the	setting
Steel or aluminium Concrete Wood Climate Min Max Min Max Min Max (Degrees F) (Degrees F) (Degrees F) (Degrees F) (Degrees F) (Degrees F) Moderate 0 120 10 80 10 75 Cold -30 120 0 80 0 75	lem	perature ran	ges						temperatu	re and clima	te foi
Moderate 0 120 10 80 10 75 Cold -30 120 0 80 0 75 this tab defaults to the ASHTO specs.		Climate	Steel or a Min (Degrees F)	Max (Degrees F)	Con Min (Degrees F)	Crete Max (Degrees F)	Min (Degrees F)	Max (Degrees F)	the bridge	. All other d	ata or
Cold -30 120 0 80 0 75 AASHTO specs.	>	Moderate	0	120	10	80	10	75	this tab	defaults to	o the
AASHTO specs.		Cold	-30	120	0	80	0	75		defutitio to	<i>y</i> ui
										Apply	

Navigate to the **Stream** tab. This tab allows to enter data describing the stream flow for this bridge. The stream drag coefficient values default to those in AASHTO LRFD Table 3.7.3.2-1 and 3.7.3.1-1. This example does not consider stream flow.

	ad basis									Store unit as	
Gu	ıst speed 🔘 F	Fastest-mile	speed							🔘 us 🔵 si	
:l-qu	ust Wind-fast	test Tem	perature	Stream							
Stre	am pressure lon	igitudinal dra	ag coefficier	nt		Str	eam pressure lateral drag coefficient				
		Туре			CD		Angle between direction of flow and longitudinal axis of pier	CL			
\rightarrow	Sen	nicircular-no:	sed pier		0.7		(Degrees)				
	Debria	lodged again	nst the pion		1.4		0	0			
-	Wedged-nose	d pier with r	nose angle 0)0 de	0.8		5	0.5			
			angle .				10	0.7			
							20	0.9			
							30		-		
	name	Consider	(ft)	(ft/sec)	(ft)						
>	Low							-			
	Mean										
	Design Flood										
	Check Flood										

Click **OK** to apply the data and close the window.

Design Parameters

Double click on the **Design Parameters** node in the **BWS** tree. This window allows to specify how superstructure loads are distributed to the substructures.

🕰 Design Parameters	_		×
Load distribution:			
Longitudinal force distribution			
Longitudinal forces, except friction, carried only by fixed bearings			
O Longitudinal forces carried by both fixed and expansion bearings			
Simplified method of distribution			
Refined method of distribution considering relative stiffness			
User specify superstructure length for each load and each pier			
Load distribution Transverse forces carried by both fixed and expansion bearings			
Consider vertical reactions due to induced moment caused by tran	sverse fo	orces	
ОК Арр	ly	Cano	el

Check the consider vertical reactions checkbox if BrDR Substructure is to consider the vertical reactions on the superstructure due to the induced moment about the superstructure longitudinal axis caused by transverse forces acting on the superstructure as shown below. Refer to the BrDR help topic for this window for more information.



Pier3 - Frame Pier Example

To describe the pier, navigate to the **Training Alt** bridge alternative and follow steps as shown below.



Stiffness Analysis

Double click on the **Stiffness Analysis** node in the **BWS** tree. This window describes the bearing data at each substructure unit in the bridge alternative. This bearing data can be used by BrDR to compute the length of loaded superstructure applied to each substructure unit.

Unit type Substructure unit name Station (ft) Offset (ft) Current alternative (ft) Geometry defined > Abutment Abut1 0 0 0 Pier Pier1 130 0 0 0 Abutment Abut2 260 0 0 0 Abutment Abut2 260 0 0 0 Support line Support line 1 Abut1 Fixed ~ 6 Support Line 2 Pier1 Expansion ~ 6 Elastomeric ~ Support Line 3 Abut2 Expansion ~ 6 Elastomeric ~	ubst	tructure unit data	c						
Abutment Abut1 0 0 Pier Pier1 1130 0 0 Abutment Abut2 260 0 0 Abutment Abut2 260 0 0 Support line Substructure unit name Longitudinal movement types: Number of bearings Bearing type Support line 1 Abut1 Fixed ~ 6 Elastomeric ~ Support line 2 Pier1 Expansion ~ 6 Elastomeric ~ Support Line 3 Abut2 Expansion ~ 6 Elastomeric ~		Unit type	Substructure unit name	e Station (ft)	Offset (ft)	Current alternative	Geometry defined		
Pier Pier1 130 0 Abutment Abut2 260 0 Image: Comparison of the comparison of	>	Abutment	Abut1	0	0				1
Abutment Abut2 260 0 Abutment Abut2 260 0		Pier	Pier1	130	0 0				
Support line Substructure unit name Longitudinal movement type Number of bearings Bearing type Support Line 1 Abut1 Fixed × 6 Elastomeric × Support Line 2 Pier1 Expansion × 6 Elastomeric × Support Line 3 Abut2 Expansion × 6 Elastomeric ×		Abutment	Abut2	260	0 0				
Support Line 1 Abut1 Fixed 6 Elastomeric Support Line 2 Pier1 Expansion 6 Elastomeric Support Line 3 Abut2 Expansion 6 Elastomeric	earii	ng types:	Substructure	Longitudinal	Number				
Support Line 2 Pier1 Expansion ✓ 6 Elastomeric ✓ Support Line 3 Abut2 Expansion ✓ 6 Elastomeric ✓	earin	ng types: Support line	Substructure unit name	Longitudinal movement type	Number of bearings	Bearing type			
Support Line 3 Abut2 Expansion \checkmark 6 Elastomeric \checkmark	earin	ng types: Support line Support Line 1	Substructure unit name Abut1	Longitudinal movement type Fixed ~	Number of bearings 6	Bearing type Elastomeric V			
	earin	ng types: Support line Support Line 1 Support Line 2	Substructure unit name Abut1 Pier1	Longitudinal movement type Fixed × Expansion ×	Number of bearings 6 6	Bearing type Elastomeric ~ Elastomeric ~			
	earin >	ng types: Support line Support Line 1 Support Line 2 Support Line 3	Substructure unit name Abut1 Pier1 Abut2	Longitudinal movement type Fixed × Expansion × Expansion ×	Number of bearings 6 6 6 6 6	Bearing type Elastomeric \checkmark Elastomeric \checkmark Elastomeric \checkmark			

The **Bearing data (cont'd)** tab allows to enter the coefficient of friction for sliding bearings so BrDR can compute the friction forces on the pier. Since this bridge has elastomeric bearings, the coefficient of friction is not entered for the bearings.

Navigate to the Relative stiffness tab. Click the **Compute superstructure length to apply to each pier** button to have BrDR compute the loaded superstructure lengths to apply to this pier.

Bridge attenative name: Training Att Bearing data Bearing data (cont'd) Relative stiffness Iongitudinal forces distribution On ongitudinal forces carried by both fixed and expansion bearings Iongitudinal forces carried by both fixed and expansion bearings Simplified method of distribution considering relative stiffness Iongitudinal forces carried by both fixed and each pire Specify length unit Specify length unit Specify length percentage Compute superstructure length to apply to each pier. Substructure Superstructure length to apply to ounit (%) 2 Abutt 65 25 1 Substructure Striet Striet 2 Abutt 65 25 1 30 30 30 2 Abutt 65 25 1 130 50 4but2 65 25	🕰 Relative Stiffness Analysis - Training Alt				-		×
Bearing data Bearing data (cont') Relative stiffness Longitudinal force distribution Or carried only by fixed bearings Compute supprestructure length for each load and each pire Specify length unit Specify length unit Specify length to apply to each pier. Compute supprestructure length to apply to unit (ft) Superstructure length to apply to unit (ft) Abut1 65 25 Pier1 130 50 Abut2 65 25	Bridge alternative name: Training Alt						
Longitudinal force distribution Image: Display the service of	Bearing data Bearing data (cont'd) Relative stiffness						
 Conguitudinal forces carried by both fixed and expansion bearings Simplified method of distribution Refined method of distribution considering relative stiffness User specify superstructure length for each load and each pier Specify length unit Specify length percentage Compute superstructure length to apply to each pier. Substructure Superstructure length to apply to unit f(t) Superstructure length to apply to unit (f(t) Superstructure length to apply to unit (f(t) Superstructure length to apply to unit (f(t) Abut1 65 25 Pier1 130 50 Abut2 65 25	Longitudinal force distribution Longitudinal forces, except friction, carried only by fixed bearings						
Compute superstructure length for each load and each pier Specify length unit Specify length percentage Compute superstructure length to apply to unit pipy to unit (?%) Abut1 65 25 Pier1 130 50 Abut2 65 25	Longitudinal forces carried by both fixed and expansion bearings Simplified method of distribution						
User specify superstructure length for each load and each pier Specify length unit Specify length percentage Compute superstructure length to apply to each pier Substructure length to each pier Substructure length to apply to each pier Substructure length to each pier Substructure length to each pier Abut1 65 Abut2 65 Substructure length to each pier	 Refined method of distribution considering relative stiffness 						
Specify length unit Specify length percentage Compute superstructure length to apply to each pier Substructure length to int (ft) Abut1 65 Pier1 130 50 Abut2 65 25	User specify superstructure length for each load and each pier						
Compute superstructure length to apply to each pier Substructure length to apply to unit (ft) Superstructure length to apply to unit (%) > Abut1 65 25 Pier1 130 50 Abut2 65 25	Specify length unit						
> Abut1 65 25 Pier1 130 50 Abut2 65 25	Compute superstructure length to apply to each pier		Substructure unit name	Superstructure length to apply to unit (ft)	Superstructure length to apply to unit (%)		
Pier1 130 50 Abut2 65 25 OK Apply Cancel		>	Abut1	65	25		-
Abut2 65 25 OK Apply Cancel			Pier1	130	50		
OK Apply Cancel			Abut2	65	25		
OK Apply Cancel							
				ОК	Apply	Can	cel

Click the **OK** button to apply all the changes and close the window.

Pier

Double click on the **Pier1** node in the **BWS** tree and enter the following data.

Diaut					
Pieri					
Description Stream llow					
Pier skew angle			Description		
O Input skew angle	ikew angle: () Degrees	occupiton.		
Input bearing angle					
Finished groundline elevation:	54.5	ft 🗸	Superstructure defined in BrDR		
Soil density:	0.12	kcf			
- Superstructure lengitudinal di	inaction				
Consider as fixed	rection				
Consider as expansion					
Pier location relative to bridge	e alternative —				
Station: 130 ft	Offset	0 ft			
- Commuted size landing solution		Constation			
Computed pier location relation	ve to structure	Computed pier coordi	hates		
Station: 130 ft		X: 130			
Unset: 0 ft		Y: U	ττ.		
Existing Current Pier a	ternative name	Description			
					-
					v

Click **OK** to apply the data and close the window.

Pier Alternatives

Double click the **PIER ALTERNATIVES** node and the following **New Pier Alternative** will open. Select the **Frame Pier** and click **Next**.



Enter a name for the pier alternative and number of columns and click **Finish** to close the wizard and create the new pier alternative.

A New Pier Alternative		×
Type: Name:	RC Frame Pier 3 Column Frame	
Description: Units: Number of columns: Columns have combined footings:	US Customary V 3 🗘	Combined/independent footings cannot be changed once a selection is made here. A new pier alternative will need to be created to change the footing type.
	< Back Finish	Cancel

The **Pier Alternative** window will automatically open. No changes are required. BrDR provides an option to override the default design setting with user defined design setting in this window.

me: 3 Colur	mn Frame	Type:	RC Frame Pier	
Description	Stiffness Reports			
Description:		A	Units: US Customary \checkmark	
			 LRFD substructure design settings 	
		w.	Preliminary mode	
Columns -			Default design settings: Preliminary Design	Setting (U
Number e	f columnsi		Override default	
Number o	or columns:		Design settings:	
Columns ł	have combined footings: () Yes	O No	Find we do	
			Pofault decign settings - Final Davies Sattin	- (115)
			Override default	y (03)
			Design settings:	
			Advanced DLA	

Navigate to the **Stiffness** tab of this window. This tab computes information about the stiffness of the pier to assist in determining the type of structural analysis required. Since the pier geometry data is not entered yet, BrDR cannot compute the slenderness ratio and the **Compute slenderness ratio** button is disabled. Click the **OK** button to apply the data and close this window. Do **not** click the Cancel button as that will cause the creation of the new pier alternative to be canceled.

me:	3 Column Frame			Type: F	C Frame Pier					
Descr	iption Stiffnes	s Reports								
sle	Compute enderness ratio	Analysis n Method:	nethod First Order Elastic	~	Slenderness computed u geometry is	values canno intil the pier s entered.	ot be gross			
C P	vier longitudinal av	cis								
	Sidesway O Braced	Unbraced	Unbraced le	ength:	ft	Effective le	ngth factor, K:	0.65		
	Slenderness re	sults re								
	Gross area:	0	ft^2 Moment o	f inertia: () ft^	4 Radius of	gyration:	0	ft	
P	ier transverse axis									
	Braced	Unbraced	Unbraced le	ength:	ft	Effective le	ngth factor, K:	2		
	Slenderness re	sults								
	Up-to-dat	te								
	Gross area:	0	ft^2 Moment o	f inertia:) ft^	4 Radius of	gyration:	0	ft	
	KL/r:	0								

The partially expanded bridge workspace under **PIER ALTERNATIVE** is shown below.



Default Materials

Double click on the **Default Materials** node in the **BWS** tree. This window allows the user to select materials that will be used as default selections for the pier components.

Cap:	Class A (US)	\sim	O Spirals
Column/wall:	Class A (US)	~	Spirals designed as ties
Footing:	Class A (US)	~	Ties
Steel pile:	ASTM A572 - 1" max, Fy = 60 ksi	~	
Cap:	Grade 60	\sim	
Column/wall:	Grade 60	~	Steel nile shape W 44x262
Footing:	Grade 60	~	F

Pier Geometry

Double click on the **Geometry** node in the **BWS** tree. This window allows the user to define some basic pier geometry. It should be noted that the figure in this window is not drawn to scale. The location of the pier beneath the superstructure is set in this window by entering the distance from the superstructure reference line to the left end of the cap or wall. This is an important input since a bad value could result in girders not being supported by the pier. Enter the following data and click the **OK** button to apply the data and close the window.



Cap Properties

Double click on the Cap node in the BWS tree and enter the following data.

Сар	Properties	- Pier1 - 3 Col	lumn Frame				– 🗆 X	
Desc	ription	Additional lo	ads					
Сар	type: Be	am Shape Ca	p Cap top configuration	on: Sloped		Cap material:	Class A (US) 🗸 🗸	
 	Pedestals		Exposure factor: 1					
	Member	CL bearing station (ft)	Angle between CL member and CL support (Degrees)	Bearing seat elevation (ft)	Pedestal width (ft)	Pedestal length (ft)		
>	G1	130	90	76.5	2.5	2.5	۵	
	G2	130	90	76.68	2.5	2.5		
	G3	130	90	76.86	2.5	2.5	(\mathbb{P})	
	G4	130	90	76.86	2.5	2.5	Use CTRL-C t	o copy the value in a
_	G5	130	90	76.68	2.5	2.5	cell and then use	SHIFT-INSERT to
	G6	130	90	76.5	2.5	2.5		
							paste it into anothe	er cell.
						OK	Apply Cancel	

The loads from the superstructure will be applied at the bearing seat elevations specified on this tab.

The **Additional loads** tab allows to define additional, user defined loads on the cap. This example does not contain any additional loads on the cap. Click the **OK** button to apply the data and close the window.

Cap Components

Expand the **BWS** tree under the **Cap** label and double click on the **Components** node to open the **Cap Components** window. Select the following type of cap cantilever component for both the left and right cantilevers.

🕰 Cap Components - Pier1 - 3 Column Frame	- [⊐ ×
Cap left cantilever		
Straight Cantilever		
	OK Apply	Cancel
🕰 Cap Components - Pier1 - 3 Column Frame	- [X
Cap type 🔘 Beam 💿 Inverted Tee Beam		
Cap left cantilever Cap right cantilever		
Straight Cantilever		
	OK Apply	Cancel

Click **OK** to apply the changes and close the window.

Cap Geometry

🕰 Cap Geometry -	Pier1 - 3 Colum	nn Frame									-		×
61 Mar	Ahead Span		Super	rstructure ence Line		Ŧ							
CL Pier_						Cap Width							
I	Back Span		Plan Vie	~									
i 🕹	*												
	STA. AHEAD												
			Can Lengt										
Left Elevation	-					Right Elevi	H Right Elevation						
D2													
Å <mark>r→</mark> L	D3		Elevation V	iew	D3								
Cap width: 3.33	} ft					Dimension							
Cap length: 51	ft	Location	Cantilever type	Elevation (ft)		(ft)							
					D1	D2	D3						
		Left	Sloped	76	3	1.67	5.25						
		Right	Sloped	76	3	1.67	5.25						
													Ŧ
									OK	Appl	у	Cance	el

Double click on the **Geometry** node to open the **Cap Geometry** window and enter the following cap geometry data.

Click **OK** to apply the data and close the window.

Cap Reinforcement

Double click on the Reinforcement node to open the Cap Reinforcement window. Enter data as shown below.

p Rein	force	ment - Pier	1 - 3 Co	lumn Fram	e										-		
xural	Sł	lear															
Longi Bar si	tudin ize: 🕑	al skin	Bar s	pacing: 6		in Bar	material: Grade	e 60	~	St	irrup clear	cover: 2		in			
Prima	ry fle	xural														\mathbb{N}	
R	einfor	cement inp	ut met	hod	-											♥ The #3	bar is a
) Si	mplified		lvanced	✓ R	einforcemer	nt follows cap pr	ofile								deliberate mis	stake that
	Set	Meas from o	ure cap	Vertical distance (in)	Bar size	Number	Material		Start distance (ft)	Straight length (ft)	End distance (ft)	Hook at start	Hook at end	Developed at start	Developed at end	will be fixed l	ater in the
	1	Тор	\sim	3.26	10 ~	6	Grade 60	~	0.5	50	50.5					tutorial.	
	2	Тор	\sim	6.03	10 ~	6	Grade 60	~	0.5	50	50.5					_	
	3	Bottom	~	3.189	3 ~	5	Grade 60	×	0.5	50	50.5					-	
]]]						(New	Duplica	ste Del	lete	
														ОК	Apply	Cancel	

Click **OK** to apply the data and close the window.
Navigate to the **Shear** tab of this window. Enter the following data to describe the shear reinforcement for the left half of the pier cap.

Bar	size	Number of legs	Material		Measure from		Direct	tion	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)	
5	\sim	4	Grade 60 🗸	Left	Edge of Cap	\sim	Right	\sim	0.583	1	0	0	0.583	
5	\sim	4	Grade 60 🗸	Left	Edge of Cap	\sim	Right	\sim	0.583	10	5.5	4.5833333	5.1663333	
5	\sim	4	Grade 60 🗸	Left	Edge of Cap	\sim	Right	\sim	8.333	1	0	0	8.333	
5	\sim	4	Grade 60 🗸	Left	Edge of Cap	\sim	Right	\sim	8.333	12	5.5	5.5	13.833	
5	\sim	4	Grade 60 🗸	Left	Edge of Cap	\sim	Right	\sim	13.833	6	11	5.5	19.333	
5	\sim	4	Grade 60 🗸	Left	Edge of Cap	\sim	Right	\sim	19.333	10	5.5	4.5833333	23.9163333	

To enter the shear reinforcement for the right half of the cap, select each row entered above and then click the **Dup & Mirror** button. The following shows the completed shear reinforcement.

	Bar s	size	Number of legs	Material		Measure from		Directi	ion	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)	
	5	~	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	\sim	0.583	1	0	0	0.583	
1	5	~	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	\sim	0.583	10	5.5	4.5833333	5.1663333	
	5	~	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	\sim	8.333	1	0	0	8.333	
	5	~	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	\sim	8.333	12	5.5	5.5	13.833	
	5	\sim	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	\sim	13.833	6	11	5.5	19.333	
	5	\sim	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	~	19.333	10	5.5	4.5833333	23.9163333	
	5	~	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	\sim	50.417	1	0	0	50.417	
	5	~	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	\sim	45.3753333	10	5.5	4.5833333	49.9586666	
1	5	~	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	\sim	42.667	1	0	0	42.667	
	5	~	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	\sim	36.7086667	12	5.5	5.5	42.2086667	
1	5	~	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	\sim	30.7503333	6	11	5.5	36.2503333	
,	5	\sim	4	Grade 60	\sim	Left Edge of Cap	\sim	Right	\sim	26.6253333	10	5.5	4.5833333	31.2086666	



Column Properties

Expand the node for **Column1**. Double click on the **Column1** node to open the **Column Properties** window. Enter the **Exposure Factor** as shown below.



There is no additional data to enter on the column window so click **OK** to close this window.

Column Components

Double click on the **Components** node in the **BWS** tree for **Column1**. The **Column Components** window allows the user to specify the cross-section segments in the column. Segment cross-sections can vary linearly over their height. In this example, the cross-section is constant over its height.

¢	à C	olumn Compo	nents - Pier1 - 3 Co	lumn Frame - Co	lumn1			_		×
	Nun	nber of cross-s	ection segments fo	r column: 1 🔇						
		Segment	Material	Segment vary	Cross-section type			\prod	_	
	>	1	Class A (US) 🗸	None 🗸	Round ~			.	segmen	tl
									Segmen	t 2
							v			
						ОК	Арр	oly	Cance	el

BrDR assumes the column cross section type is round when a new column is created by the user. Since this pier has round columns, this assumption is correct. Click **OK** to close this window.

Column Geometry

Double click on the **Geometry** node in the BWS tree for **Column1**. Enter the following column geometry data.



Click **OK** to apply the data and close the window.

Reinforcement Definitions

Double click on the **Reinforcement Definitions** node and create a reinforcement definition for the column using the Pattern Wizard as shown below.

🕰 Column Reinforcement Pier	1 - 3 Column Frame	:				_	ΟX
	Name:						
	Bundle bars						
++Y	Bar Ba siz	ar Mate	erial	X (in)	Y (in)		
T Sta Ahead							
Generate pattern					New	Duplicate	Delete
					OK	Apply	Cancel

Enter the following details in the **Generate Pattern Wizard** window and click **OK** to close this window and create the reinforcement definition.

🕰 Generate Pattern W	izard							×
Pattern name:	8 #10 bars		Bundle type	Bar size:	10 🗸			
Column segment:	1	~	🔘 Single	Material:	Grade 60		~	
Segment cross section:	R	ound	2 Parallel	Clear cover:	2.5	in		
Top / bottom:	Тор		3 Bar	Number of bars:	8			
Overall trans. width:	36	in						
Overall long. width:	36	in						
							OK Can	cel

🕰 Column Reinforcement Pier1 -	3 Columi	n Frame				_	
1	Name: 8	8 #10 bars					
(Bund	le bars					
++Y	Bar	Bar size	Material	X (in)	Y (in)		
	1	10 ~	Grade 60 V	14.865	0		-
+X	2	10 ~	Grade 60 V	10.5111423	-10.5111423		
	3	10 ~	Grade 60 V	0	-14.865		
ll	4	10 ~	Grade 60 V	-10.5111423	-10.5111423		
Sta Ahead	5	10 ~	Grade 60 V	-14.865	0		
L L	6	10 ~	Grade 60 V	-10.5111423	10.5111423		
	7	10 ~	Grade 60 V	0	14.865		
	> 8	10 ~	Grade 60 V	10.5111423	10.5111423		
							-
Generate pattern					New	Duplicate	Delete
				(ОК	Apply	Cancel

Uncheck the **Bundle bars** checkbox and click **OK** to create the reinforcement definition and close the window.

Reinforcement

Double click on the **Reinforcement** node in the **BWS** tree for **Column1** and assign the column reinforcement as shown below.

Flexu	ural	Shear									
	Set	Start distance (ft)	Straight length (ft)	End distance (ft)	Pattern	Hook at start	Hook at end	Developed at start	Developed at end	Follows profile	
>	1	-2.5	20.08	17.58	8#10 ~				 Image: A start of the start of		1

lexu	iral S	hear									
- S	hear reint	forcemer	nt type								
	Ties	O Sp	pirals Spirals de	signed as ties							
	Bar size	Pitch (in)	Material	Start distance (ft)	Length (ft)	End distance (ft)					
0	4 ~	3	Grade 60	× -1	19.58	18.58					1
							New	Duplic	ate	Delete	

Navigate to the Shear tab of this window and enter data as shown below.

Click **OK** to apply the data and close the window.

Since this column reinforcement is going to extend down into the footing, a foundation alternative will be added and this section will be revisited to assign this pattern to the column. If this step is not performed, validation will show a message that the column rebar does not fit inside the footing.

FOUNDATION ALTERNATIVES

Double click on the **FOUNDATION ALTERNATIVES** node in the **BWS** tree and the **New Foundation Alternatives Wizard** will open. Select **Spread Footing** and click **Next**.



Enter the following description of the foundation and click **Finish** to open the **Foundation Properties** window as shown below.

A New Foundation	n Alternative Wizard				×		
	Type:	Spread Found	ation				
	Name:	12x12 Footing	1				
	Description:			A			
	Units:	US Customary	~	V			
	Footing width:	12	ft	Footing thickness: 3.75	ft		
	Footing length:	12	ft				
	Footing material:	Class A (US)	~				
Foundation Prop Name: 12x12 Foo Description A Description:	erties-Pier1-3 Column ting dditional Loads Sc	Frame-Column1 Fo	< Back F undation type: Spread Foundation Units: US Customary	inish Cancel Hel	lp		
Footing			Foundation seal				
Footing mate	rial: Class A (US)	~	Foundation seal	Material: CI	lass A (US) 🗸 🗸		
Exposure factor	1		Width:	ft			
			Length:	ft			
			Bottom elevation:	ft			
					QK Analy	Foundatincluded in model of the described	ations are not 1 the finite element the pier but can be in BrDR.
					OK Apply	Cancel	

12x12 Ecoting	Foundation type:	Spread Foundation		
	Foundation type:	Spread Foundation		
escription Additional Loads Soil				
Soil O Rock				
actored bearing resistance: 20 ksf				

Navigate to the Soil tab and enter the rock factored bearing resistance as shown below.

Click the **OK** button to apply the data and close the window. Do **not** click the Cancel button as that will cause the creation of the new foundation alternative to be canceled.

Foundation Geometry

Double click on the Geometry node in the BWS tree for the foundation alternative just added.



Enter the bottom of footing elevation and click the **OK** button.

Foundation Reinforcement

Double click on the **Reinforcement** node in the **BWS** tree for the foundation alternative just added. Enter data as shown below.

irection of topmost reba	ar:	Transve	rse 🗸	Top bar clear cover:	3	in	End cover:	3		in			
irection of bottommost	rebar:	Longitu	idinal 🗸	Bottom bar clear cove	er: 3	in	Material:	Grade	e 60	~	/		
Top longitudinal reinfo	orceme	nt			Top transverse	e rein	forcement						
Bar size:	5	\sim	Number:	13	Bar size:		5	\sim	Numbe	r: 13	}		
Fully developed	ainforce	ement			Fully dev	elope	ed						
Bar size:	9	~	Number:	17	Bar size:	0.201	9	~	Numbe	r: 17	7		
Fully developed					Fully dev	elope	ed						
								ov				C	-1

Click **OK** to apply the data and close the window.

Similarly define the properties for Column2 and Column3.

Column Components and Geometry – Column 2 and Column 3

Open the **Column Components** window for each column and select the column concrete material and cross section type. Then define the geometry in each **Column Geometry** window as shown below.

4	Nun	olumn Compo nber of cross-s	onents - Pier1 - 3 Co section segments fo	lumn Frame - Col	lumn2		_	
		Segment	Material	Segment vary	Cross-section type		ΠŤ	
	>	1	Class A (US) 🗸	None ~	Round ~	A		Segment 1 Segment 2
,	~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~_		putte		



Pier3 - Frame Pier Example





Pier3 - Frame Pier Example

Copy Footing

Now the footing can be copied from **Column1** to the other two columns. Click on the **12x12 Spread Footing** alternative and select the **Copy** button from the **Manage** group of the **WORKSPACE** ribbon or right click and select



Now select the **FOUNDATION ALTERNATIVE** node for **Column2** and click the **Paste** button from the **Manage** group of the **WORKSPACE** ribbon or right click and select **Paste**.



Repeat this process for Column3 as well.

Similarly copy the reinforcement details to Column 2 and Column 3.

The partially expanded Bridge Workspace (BWS) tree is shown below.



Pier Alternative – Stiffness

Now that the pier geometry is defined, reopen the **Pier Alternative** window by double clicking on the **3 Column Frame** node in the **BWS** tree, navigate to the **Stiffness** tab and evaluate the slenderness of the pier.

tiffnoss Ponanta						
anness reports						
Analysis r	nethod					
tio Method:	First Order Elastic	~				
linal axis						
/						
ced Unbraced	Unbraced length:	17.58 ft	Effective length factor,	K: 0.65		
ess results						
to-date						
ea: 21.20576	ft^2 Moment of inerti	a: 11.9282346' ft^	4 Radius of gyration:	0.75	ft	
15.236						
se axis / ced O Unbraced	Unbraced length:	22.25 ft	Effective length factor,	K: 2		
ess results						
to-date	AAD Married of a	17.71000041 514	(Dedive of eventi	15	P	
ea: 21.20576	π^2 Moment of inerti	a: 47.7129384: π^	4 Radius of gyration:	1.5	π	
29.66667						
	Analysis r Method:	Analysis method tio Method: First Order Elastic linal axis Unbraced (ced Unbraced uss results Unbraced length: to-date 15.236 se axis Unbraced (ced Unbraced ubbraced Unbraced length: to-date Unbraced ubbraced Unbraced length: to-date Unbraced uess results Unbraced length: to-date 15.236 se axis Unbraced (ced Unbraced uess results Unbraced to-date 12.20576 to-date 12.20576 <t< td=""><td>tio Method: First Order Elastic linal axis (ced Unbraced Unbraced length: 17.58 ft less results to-date ea: 21.20576 ft^2 Moment of inertia: 11.9282346 ft^4 I5.236 Unbraced length: 22.25 ft less results to-date rea: 21.20576 ft^2 Moment of inertia: 47.7129384; ft^4 29.66667</td><td>tio Method: First Order Elastic linal axis / ced Unbraced Unbraced length: 17.58 ft Effective length factor, less results to-date ea: 21.20576 ft^2 Moment of inertia: 11.9282346 ft^4 Radius of gyration: 15.236 se axis / ced Unbraced Unbraced length: 22.25 ft Effective length factor, ress results to-date ress results to-date rea: 21.20576 ft^2 Moment of inertia: 47.7129384; ft^4 Radius of gyration: 29.66667</td><td>Analysis method tio Method: First Order Elastic linal axis ced Unbraced Unbraced Unbraced length: 17.58 ft Effective length factor, K: 0.65 ess results to-date ea: 21.20576 ft^2 Moment of inertia: 11.9282346 ft^4 Radius of gyration: 0.75 15.236 0.01 ubraced Unbraced length: 22.25 se axis 0.01 ced Unbraced length: 22.25 ft Effective length factor, K: 2 ess results 1.00 1.5 to-date 1.20576 ft^2 Moment of inertia: ea: 21.20576 ft^2 Moment of inertia: 47.7129384; ft^4 ea: 21.20576 ft^2 Moment of inertia: 47.7129384; ft^4 Radius of gyration: 1.5 29.66667 0.00 0.00 0.00 0.00 0.00 0.00</td><td>tio Method: First Order Elastic Inal axis / ced Unbraced Unbraced length: 17.58 ft Effective length factor, K: 0.65 less results to-date ea: 21.20576 ft^2 Moment of inertia: 11.9282346 ft^4 Radius of gyration: 0.75 ft 15.236 se axis / ced Unbraced Unbraced length: 22.25 ft Effective length factor, K: 2 less results to-date ea: 21.20576 ft^2 Moment of inertia: 47.7129384; ft^4 Radius of gyration: 1.5 ft 29.66667</td></t<>	tio Method: First Order Elastic linal axis (ced Unbraced Unbraced length: 17.58 ft less results to-date ea: 21.20576 ft^2 Moment of inertia: 11.9282346 ft^4 I5.236 Unbraced length: 22.25 ft less results to-date rea: 21.20576 ft^2 Moment of inertia: 47.7129384; ft^4 29.66667	tio Method: First Order Elastic linal axis / ced Unbraced Unbraced length: 17.58 ft Effective length factor, less results to-date ea: 21.20576 ft^2 Moment of inertia: 11.9282346 ft^4 Radius of gyration: 15.236 se axis / ced Unbraced Unbraced length: 22.25 ft Effective length factor, ress results to-date ress results to-date rea: 21.20576 ft^2 Moment of inertia: 47.7129384; ft^4 Radius of gyration: 29.66667	Analysis method tio Method: First Order Elastic linal axis ced Unbraced Unbraced Unbraced length: 17.58 ft Effective length factor, K: 0.65 ess results to-date ea: 21.20576 ft^2 Moment of inertia: 11.9282346 ft^4 Radius of gyration: 0.75 15.236 0.01 ubraced Unbraced length: 22.25 se axis 0.01 ced Unbraced length: 22.25 ft Effective length factor, K: 2 ess results 1.00 1.5 to-date 1.20576 ft^2 Moment of inertia: ea: 21.20576 ft^2 Moment of inertia: 47.7129384; ft^4 ea: 21.20576 ft^2 Moment of inertia: 47.7129384; ft^4 Radius of gyration: 1.5 29.66667 0.00 0.00 0.00 0.00 0.00 0.00	tio Method: First Order Elastic Inal axis / ced Unbraced Unbraced length: 17.58 ft Effective length factor, K: 0.65 less results to-date ea: 21.20576 ft^2 Moment of inertia: 11.9282346 ft^4 Radius of gyration: 0.75 ft 15.236 se axis / ced Unbraced Unbraced length: 22.25 ft Effective length factor, K: 2 less results to-date ea: 21.20576 ft^2 Moment of inertia: 47.7129384; ft^4 Radius of gyration: 1.5 ft 29.66667

BrDR computes the KL/r ratios for the pier longitudinal and transverse axes based on the pier alternative geometry. The KL/r ratios can independently be evaluated in accordance with AASHTO LRFD Article 5.7.4.3 to determine if the first order elastic analysis performed by BrDR is satisfactory for this pier.

Pier 3D Schematic

With the pier alternative **3 Column Frame** selected, click on the **3D Schematic** button from the **SUBSTRUCTURE DESIGN** ribbon or right click and select **3D Schematic** as shown below.





This 3D schematic is a to-scale drawing of the pier alternative. This schematic view has a lot of useful features like rotating, scaling, and dimensioning.

Select the **Properties** button to open a window to select features to be displayed in the **3D Schematic**. The schematic shown below was created by selecting to display the gross geometry dimensions and elevations on the **View Properties: Dimensions** tab.





Validating a Pier Alternative

Another useful feature is to validate the pier alternative once the geometry is defined. The validation process alerts the user to any missing or incorrect data in the pier description. To validate, right click on the pier alternative and select **Validate** as shown below.

Bridge Workspace - LRFD Substructure Exar BRIDGE WORKSPACE WORKSPACE TOOLS	mple 1 VIEW	ANALYS DESIGN/F	RATE	STRUCTURE DESIGN	REPORTS REPORTING	?	-		×
Preliminary Generate Load Load Ana Model Combinations Palette Substra	lyze Speci ucture Cl	fication heck	bular Specif esults Check	fication Engine Detail Outp	ne Results Soil uts Graph Plot	3D Schema	atic		
Analysis				Results					
Workspace	\$ X	Schematic		Ŕ	× Report			5	× <
Bridge Components	🗣 Expan	d Branch ose Branch							
Components Diaphragm Definitions Diataral Bracing Definitions	Dpen			_					
MPF LRFD Multiple Presence Factors EC Environmental Conditions	🖺 Duplic 🗱	ate:							
Design Parameters Design Parameters Design Parameters	Image: Image	ate Model hematic							
Simple span structure (right support is Im Simple span structure (left support is	Load (Combination	ns						
English Continuous span English BRIDGE ALTERNATIVES	Analy:	ze ication Cheo	:k					5	? ×
A 2 span bridge (E) (C) A Continuous span steel bridge	Tabula	ar Results							
🖻 🦾 Training Alt	View 9	ue Summary Re	port						
++ Stiffness Analysis	Q View I	Detailed Rep	ort						
🖻 😁 PIERS	@ Gener	al Preferenc	es						
🖹 🔛 PIER ALTERNATIVES	Close	Bridge Work	kspace						
ter⊢ II 3 Column Frame (E) (C)									

This opens a window which contains warnings and errors if the pier alternative description is in error or missing data.

Report		- 🗆 ×
Validation - 3 Column Frame		~ ×
Total Number of Messag Number of Information I Number of Warning Mes Number of Error Messag	es: 17 Messages: 17 sages: 0 es: 0	
Pier Alternative: 3 Colum 3 Column Frame (Frame Column1 (Colu Existin Currer 12X12 Column2 (Colu Existin Currer 12X12 Column3 (Colu Existin Currer 12X12 No errors or wa	in Frame e Pier Alternative) mn) g foundation alternative: 12x12 Footing t foundation alternative: 12x12 Footing Footing (Foundation Alternative) No errors or warnings. mn) g foundation alternative: 12x12 Footing Footing (Foundation Alternative) No errors or warnings. mn) g foundation alternative: 12x12 Footing t foundation alternative: 12x12 Footing t foundation alternative: 12x12 Footing t foundation alternative: 12x12 Footing Footing (Foundation Alternative) No errors or warnings. mn) en footing (Foundation Alternative) No errors or warnings. rnings.	

BrDR allows the user to control if validation should be performed before any FE analysis or specification check is performed. Validation prior to the analysis or specification check may help identify missing data prior to the analysis. This can be turned off by unchecking the box on the Preferences: Analysis tab from Bridge Explorer as shown below.

		0.175	70.016	AASHTOWare Bridge Design and Rating	\bigcirc	
BRIDGE EXPLORER	JE FOLDER	KAIE	IOOLS VIEW			Database information
📄 📄 🍝 Import	66	Ì I	l 🖺 🎁 🗌		Preferences	Connected
New Open 隨 Batch 🗸	Find Copy P	aste Co	py Remove Delete		Database information	Build date
D. i.e.						BrM and BrDR chare this database
Bridge		ivianag	le		•	bitit and bibit share this database
		BID	Bridge ID	Bridge Name	💾 Import	Database connection and driver info
E 📁 All Bridges	-	3	TrainingBridge3	Training Bridge 3(LRFD)	Help	Server name localhost
🗄 📁 Sample Bridges		4	PCITrainingBridge1	PCI TrainingBridge1(LFR)		DataSource name localhost
🎾 Deleted Bridges		5	PCITrainingBridge2	PCITrainingBridge2(LRFD)	License	Database name AASHTOWareBr7
		6	PCITrainingBridge3	PCI TrainingBridge3(LFR)	🖾 Exit	DBMS name SQL Server Datab

Pier3 - Frame Pier Example

Bridge Explorer Bridge Workspace Confirmations Analysis Rep	ort Tool
Default analysis settings template	Cancel
	~
	Reset
Analysis output	
Analysis engines report folder	
✓ Use the current user's "My Documents" folder	Browse
C:\Users\SharanyaRao\Documents	
Analysis cache folder	
Use user defined file path	Browse
C:\Users\SharanyaRao\AppData\Local\Temp\ V \AASHTOWare	eCache-7.5.1.1
Number of line girder analyses to cache: 15	
Number of 3D FEM analysis to cache: 15	
	Clear cache
Issue warning at startup for network drive	
Analysis output viewer	
Use alternate viewer	Browse
Floorbeam analysis	
Automatically save the new computed stringer reactions	
Remove previous analysis results before beginning a new analysis	
Validate before substructure analysis	
Enable analysis option for line girder analysis	

Load Palette

Click on the **Load Palette** button from the **Analysis** group of the **SUBSTRUCTURE DESIGN** ribbon. Apply the following selections and click **OK** to close the window.

🕰 Load Palatt	te				- 0	×
Use	Input defined	Override	Use	Input defined	Override	
DC 🔽	\checkmark		EH Active	NA		
DW 🔽	\checkmark		EH At-Rest	NA		
ш 🔽	\checkmark					
PL	\times					
			TU 🔽	\checkmark		
BR	\times		TG	NA		
ст	NA		SH	\times		
WA 🔽	\checkmark		CR	NA		
ws 🔽	\checkmark		SE	NA		
WL 🔽	\checkmark		FR	\times		
			CV	NA		
Select all	Clear all	Open template	Save template	ОК	Cancel	

Topic 3 - Pier 2 – Frame Pier Example

This topic is the third of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, two independent prestress simple span superstructures are supported by a 3 column frame pier. These 2 superstructures are **not** made continuous for live load so the pier supports two independent superstructures. If the prestress spans were made continuous for live load, the pier would support 1 two-span continuous superstructure.

Note: Topics 1 and 2 in the series must be completed before entering this topic. It is assumed that users are familiar with the BrDR Superstructure module and as such this example does not go into detail describing BrDR Superstructure windows or bridge workspace navigation.

Superstructure Loads

This section discusses loads acting on the pier. The first thing to review is the following axis convention that is used for the superstructure and pier axes.



For the **3 Column Frame**, double click on the **Superstructure Loads** node as shown below.



The Superstructure load generation progress window appears as shown below.



BrDR computes some of the superstructure loads on the pier when the **Superstructure Loads** window is opened. This window lists details about how BrDR computes the loads and may contain warning and error messages. This window always appears after BrDR computes any loads. Click **OK** to close this window. This opens the Superstructure Loads window.

ck sp	an								Ahea	ad spar	n												
an n	o.:		1						Spar	n no.:		1											
pers	tructure	definitio	on: Simp	le span s	tructure (r	right suppo	rt is rolle	ed)	Sup	erstruct	ture definitio	n: Sir	nple spar	n struct	ure (left su	ipport is	rolled)	Pler	skew: U)	Degr	ees	
F	RL	L setting	s LL-re	eaction	LL distr	ibution bac	k LL	distribu	ution ah	read	LL distributi	ion bad	k ahead:	BR									
Com	puted r	eactions																					
	Result	up to d	ate																				
Res	ults tim	estamp:																					
					Back sp	an																	
				Cor	nputed i (kip	reactions)											6	$\overline{)}$					
		D	C load		G1	G2	G3	G4	G	5							l l	TI 🖁	ne us	ser r	nust	chec	k
>	Non-o	omposit	e (Stage 1)							8									_			
	Comp	osite (lo	ng term) (Stage 2)							*						0	verr	ide v	alue	s if u	ser-c	lefi
	-									•							10	ads	are to	o be	used	in t	he
				Cor	nputed r	reactions																	
		D	Al Inc. al		(kip)	62	<i>C</i> 1		-							fi	nite	elem	ent a	nalys	is.	
	New y		/V IOad	`	GI	G2	G3	G4	G	•													
-	Non-o	omposi	e (Stage 1) Stage 21																			
-	<	osite (io	ng term) (stage 2)				_		Þ	*												
Over	ride rea	ictions																					
	Use or	/eride va	lues																				
					Back s	pan																	
				Ov	erride re	eactions																	
		G1	G2	G3	G4	, G5		G6															
>	DC							-															
	DW																						
						J																	
											v.												
																							1
npute	DL rea	ctions	Comput	e LL reac	tions																		

The **Compute DL reactions** button will launch a batch superstructure analysis. **Superstructure load generation progress** window opens detailing the analysis progress. BrDR Substructure will then compute the friction forces if the pier contains sliding bearings.



The computed dead load reactions will be displayed in this window and the computed friction forces will be displayed on the **FR** tab. This bridge has elastomeric bearings, so the friction forces are not computed.

Since this pier supports two independent superstructures, this tab displays the dead load reactions for both the back and ahead span superstructures.

An option is available to the user to override the values computed by BrDR for the loads. Check the checkbox **Use override values** for these override values to be used in the pier finite element analysis.

rstructure	Loads-P	ier1-3 Column Fr	ame								
ck span							Ahead	span —			
an no.:		1					Span n			2	
erstructure	e definiti	on: 2 Continuou	is span				Supers	tructure	definition	: 2 Conti	nuo
FR I	LL setting	gs LL-reaction	LL-distri	ibutio	n BR						
omputed	reaction										
Result	lt up to d	ate									
Results tin	nestamp	Friday, March	01, 2024 13:1	12:29							
				Cont	tinuous span						
			C	omp	uted reaction (kip)	15					
	C	IC load	G1		G2	G	3	G4	G5	G6	
> Non-	composi	te (Stage 1)	155.383	1597	175.6565972	175.65	565972	175.6	175.6	155.3	
Comp	posite (lo	ing term) (Stage 2	27.365-	4514	27.3654514	27.36	554514	27.36	27.36	27.36	
Total			182.748	6111	203.0220486	203.02	20486	203.0	203.0	182.7	
			c	omp	uted reactior	ns					
					(kip)						
	D	W load	G1	G2	G3	G4	G5	G6			
> Non-	composi	te (Stage 1)							-		
Total	posite (ic	ing term) (stage 2	.)						-		
TOTAL											v
)verride re	actions										
Use o	overide v	alues									
				Cor	ntinuous span						
				Overr	ride reactions	s					
	61	62 63		GA	(kip)	65			66		
> DC	01	02 03		04		05			00		
DW										-	
npute DL rea	actions	Compute LL re	actions								

The friction loads would be displayed on the **FR** tab shown below if this bridge had sliding bearings. The **Override** button opens a window where the user can override values for the friction loads. Remember, these values will only be used in the pier finite element analysis if the **Use override values** box is checked on this window. The **Calcs** button will open a report detailing the calculations BrDR performed to compute the friction forces.

ack span	Ahead span			
ban no.: 1	Span no.: 2		Pier skew: 0 Degrees	
perstructure definition: 2 Continuous span	Superstructure definition: 2 Continu	uous span		
Adstro LRFD spec article 3.13 friction force Moment Consider moment				
Bearing radius: in				
.oads				
Display				
O Computed Override Use override values Override	de Calcs			
Superstructure does not exist and thus no force is computed.				
Superstructure longitudinal	force			
(kip)				
61 62 63 64 65 66		A		
,				
pute DL reactions				

Pier3 - Frame Pier Example

The LL settings tab allows the user to specify loading constraints for the transverse live load analysis.

pan no	an o.: tructure d	1 2 Continuous span		Ahead span Span no.: Superstructure definition	2 2 Continuous	s span		Pier skew: 0	Degrees		
Live I Trans Vehi Lane	R LL : loading ty User defi Automat sverse Loa cle increme	LL-reaction LL-dis per ined lanes Scan for contr ading - nent in lane: 2 nt 4	Introduction BR						The	settings on thi	s ta
Mov	re vehicle	right to left across travelway:				- 11 - 1 - 1			greatly	affect the	tin
Load	Load pattern	Description				Live load positi Load pattern: Number of vel	nicles: 1	× \$	required	d for a pier analy	sis.
	1 2 3	1 lane positive moment 1 lane centered 1 lane pushed to left				Vehicle	Distance from le edge of travelwa (ft)	ft ay			
	4	2 lanes positive moment 2 lanes centered				> 1	9.	62			
>	7	4 lanes									
			Ν	ew Duplicate	Delete					÷	

Each transverse live load position is a load case in the finite element analysis. The data entered on this tab can greatly affect the time required for analysis. If there is a wide travelway and small values for the vehicle increment and lane increment, the analysis will take a longer time than if having larger values for the vehicle and lane increment. Likewise, checking the box to move the vehicles from right to left across the travelway will double the number of live load cases in the pier finite element analysis. If user defined lanes are selected as live loading type, user can create their own load patterns at the bottom. If **Scan for controlling load positions** is not checked, the analysis will check all the live load positions defined.

The **Compute LL reactions** button will initiate a longitudinal live load analysis of the superstructure carried by the pier and compute the braking forces acting on the pier.

cit span				Ahead span			
an no :		1		Span po :	2		
		20.1		Spannon Sussesses definition		Pier skew: 0 Degrees	
perstructure	e definition:	2 Continuous span		Superstructure definition:	2 Continuous span		
FR LI	L settings	LL-reaction LL-distri	bution BR				
Computed n	reactions						
Result u	up to date						
Result times	stamp: Frid	ay, March 01, 2024 13:17:	52				
	W 1 1 1		Single lane				
	venicie	venicle type	(kip)				
н	IL-93 (US)	Axle Load	71.2923077		A		
H	IL-93 (US)	Truck Pair	125.3926154				
н	IL-93 (US)	Lane	103.792				
H	L-93 (US)	Tandem	49.8884615				
					Calcs		
pute DL read	ctions Cc	ompute LL reactions					
pute DL read	ctions) Cc	ompute LL reactions					

The vehicles used in the analysis are dependent on both the Design Mode selected on the BrDR Substructure Toolbar and the LRFD Substructure Design Settings chosen on the Pier Alternative: Description window.

This longitudinal live load analysis computes the single lane reaction for each vehicle. The **Calcs** button displays a report of the single lane reactions computed by BrDR.

The **LL-Distribution** tab allows the user to view the BrDR computed live load reactions distributed for a pier analysis or enter user defined distributed live load reactions.

к sp	pan				Ahead	span									
an n	10.:	1			Span n	10.:	2								
oers	structure defir	ition: 2 Continuous spa	n		Supers	tructure definition	2 Continue	ous span		Pier ski	w: 0	Degree	25		
F	FR LL sett	ings LL-reaction	L-distribution	BR											
			P/2	P/2											
	ribution metr	od	2'-0" 6'-1	0" 2'-0"											
2	Inibutary are	a	**i	. Ti											
	Lever rule		10'1a	ane											
	Rigid deck a	ction	w = (Read	ction · P)											
	da			10											
Load	as														
ſ	Display		()		and a										
	Comput	ed 🔵 Override 📃	Use override v	alues Ove	erride										
							Allahan a al mana	ويتعالم المحما والم							
						``	without dynam	nic load allowari	.e						
	Vahisla	Vahiela tuna	Single lane	Axle load	Uniform										
	venicie	venicie type	(kip)	(kip)	(kip/ft)										
>	HL-93 (US)	Truck + Lane	175.0843077	32	14.3084										
	111.02.010	Tenders - Leve													
	mL-95 (US)	Tandem + Lane	153.6804615	5 25	12.8680										
	HL-93 (US)	90%(Truck Pair + Lane)	153.6804615	i 25 3 28.8	12.8680										
	HL-93 (US)	90%(Truck Pair + Lane)	153.6804615 206.2661538	5 25 8 28.8	12.8680 17.7466										
	HL-93 (US)	90%(Truck Pair + Lane)	153.6804615 206.2661538	5 25 3 28.8	12.8680 17.7466										
	HL-93 (US)	90%(Truck Pair + Lane)	153.6804615 206.2661538	5 25 3 28.8	12.8680 17.7466										
	HL-93 (US)	90%(Truck Pair + Lane)	153.6804615 206.2661538	5 25 3 28.8	12.8680 17.7466		With dynami	c load allowance							~
	HL-93 (US)	90%(Truck Pair + Lane)	153.6804615 206.2661538	5 25 3 28.8 Single lane	12.8680 17.7466 Axle load	Uniform	With dynami	c load allowance							~
	HL-93 (US) HL-93 (US)	90%(Truck Pair + Lane) Vehicle type	153.6804615 206.2661538 Weighted DLA (%)	5 25 3 28.8 Single lane reaction	12.8680 17.7466 Axle load load P	Uniform load w	With dynami	c load allowance							~
	HL-93 (US) HL-93 (US)	Vehicle type	153.6804615 206.2661538 Weighted DLA (%)	5 25 8 28.8 Single lane reaction (kip)	12.8680 17.7466 Axle load load P (kip)	Uniform Ioad w (kip/ft)	With dynami	c load allowance							V
>	HL-93 (US) HL-93 (US) Vehicle HL-93 (US)	Vehicle type Truck + Lane Truck + Lane	Using the second	5 25 8 28.8 Single lane reaction (kip) 198.6107692	12.8680 17.7466 Axle load load P (kip) 36.29991	Uniform load w (kip/t) 16.2310	With dynami	c load allowance							v
>	HL-93 (US) HL-93 (US) Vehicle HL-93 (US) HL-93 (US)	Vehicle type Truck + Lane Truck + Lane	153.6804615 206.2661538 Weighted DLA (%) 13.43722 10.71261	5 25 8 28.8 Single lane reaction (kip) 198.6107692 170.1436538	12.8680 17.7466 Axle load load P (kip) 36.29991 27.6781531	Uniform load w (kip/ft) 16.2310 14.2465	With dynami	c load allowance							~
>	HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US)	Vehicle type Truck + Lane Truck + Lane Tandem + Lane 90%(Truck Pair + Lane)	Using the second	Single lane reaction (kip) 170.1436538 243.5077606	12.8680 17.7466 Axle load load P (kip) 36.29991 27.6781531 33.9998753	Uniform load w (kip/ft) 16.2310 14.2465 20.9507	With dynami	c load allowance							~
>	HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US)	Vehicle type Truck + Lane Truck + Lane Tandem + Lane 90%(Truck Pair + Lane)	153.6804615 206.2661538 Weighted DLA (%) 13.43722 10.71261 18.05512	5 25 3 28.8 Single lane reaction (kip) 198.6107692 170.1436538 243.5077606	12.8680 17.7466 Axle load load P (kip) 36.29991 27.6781531 33.9998753	Uniform Ioad w (kip/ft) 16.2310 14.2465 20.9507	With dynami	c load allowance							~
>	HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US)	Vehicle type Truck + Lane Truck + Lane Tandem + Lane 90%(Truck Pair + Lane)	153.6804615 206.2661538 Weighted DLA (%) 13.43722 10.71261 18.05512	Single lane reaction (kip) 198.6107692 170.1436538 243.5077606	12.8680 17.7466 Axle load load P (kip) 36.29991 27.6781531 33.9998753	Uniform load w (kip/t) 16.2310 14.2465 20.9507	With dynami	c load allowance							
>	HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US)	Vehicle type Truck + Lane Truck + Lane Tandem + Lane 90%(Truck Pair + Lane)	153.6804615 206.2661538 Ukeighted DLA (%) 13.43722 10.71261 18.05512	5 25 3 28.8 Single lane reaction (kip) 198.6107692 170.1436538 243.5077606	12.8680 17.7466 Axle load load P (kip) 36.29991 27.6781531 33.9998753	Uniform load w (kip/ft) 16.2310 14.2465 20.9507	With dynami	c load allowance							×
>	HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US)	Vehicle type Truck + Lane Truck + Lane Tandem + Lane 90%(Truck Pair + Lane)	153.6804615 206.2661538 Weighted DLA (%) 13.43722 10.71261 18.05512	5 25 3 28.8 Single lane reaction (kip) 198.6107692 170.1436538 243.5077606	12.8680 17.7466 Axle load load P (kip) 36.29991 27.6781531 33.9998753	Uniform load w (kip/tt) 16.2310 14.2465 20.9507	With dynami	c load allowance							•
>	HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US)	Vehicle type Truck + Lane Truck + Lane Tandem + Lane 90%(Truck Pair + Lane)	153.6804615 206.2661538 Weighted DLA (%) 13.43722 10.71261 18.05512	5 25 3 28.8 Single lane reaction (kip) 198.6107692 170.1436538 243.5077606	12.8680 17.7466 Axle load load P (kip) 36.29991 27.6781531 33.9998753	Uniform Ioad w (kip/tt) 16.2310 14.2465 20.9507	With dynami	c load allowance							×
>	HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US) HL-93 (US)	Vehicle type Truck + Lane Vehicle type Truck + Lane Tandem + Lane 90%(Truck Pair + Lane) © Compute LL reaction	153.6804615 206.2661538 Weighted DLA (%) 13.43722 10.71261 18.05512	5 25 3 28.8 Single lane reaction (kip) 198.6107692 170.1436538 243.5077606	12.8680 17.7466 Axle load load P (kip) 36.29991 27.6781531 33.9998753	Uniform load w (kip/ft) 16.2310 14.2465 20.9507	With dynami	c load allowance							

The Braking force tab BR is shown below.

erstruc	ture Load	s-Pier1-3 (Column Fr	ame				-		
k span							Ahead span			
an no.:		1					Span no.: 2 Pier skew 0 Degrees			
perstru	cture defir	nition: 2	Continuo	us span			Superstructure definition: 2 Continuous span			
FR	LL sett	inas L	L-reaction	LL-di	stribution	BR				
nout		-								
AASHT	TO LRFD sp	ec article	3.6.4 brak	ing force			BR 1			
Longitu	udinal load	d distribut	ion optior	Fixed 8	& Expansi	ion - Simplifie				
Back su	uperstruct	ure length		130	ft					
Numbe	er of lanes	in same d	irection:	3						
onde										
C Dis	play			NI			Quarrida			
C	Comput	ed 🔿 C	verride	Nu	m MP	F (kip)	Override			
				lan	es	(~)	Calcs			
U U	Jse overrid	e values				1 26				
- Bac	ck span									
				Supe	rstructur	re lonaitudi	al force			
						(kip)				
	Num. la	G1	G2	G3	G4	G5 (
>	1	3.6	3.6	3.6	3.6	3.6	3.6			
				Sup	erstructu	ure transvers	force			
						(kip)				
	Num. la	G1	G2	G3	G4	G5 (
Ľ	1	U	U	0	0	0				
				Vertical r	eaction	due to tran	verse force			
	N 1	61	62	C 2	C1	(kip)				
	1	0	02	0.0	04	0 0				
É		v		•			•			
oute D	L reaction:	s Com	pute LL re	actions						
							OK	Apply	Can	1

Click **OK** to apply the data and close the window.

Superstructure Environmental Loads

Double click on the **Superstructure Environmental Loads** node to open the **Superstructure Environmental Loads** window as shown below.

en no.: xerstruct super nput AASHTO fransvers	ture definition:	1 2 Cont														
super nput AASHTO fransvers	ture definition:	2 Cont				Span	no.:	2				Wind	load basis			
super nput AASHTO Transvers	MC		inuous span			Supe	rstructure definitio	on: 2 Co	ontinuous spa	an		\bigcirc	Gust speed 🤇	Fastest-m	ile speed	
nput AASHTO Transvers		1A/I														
nput AASHTO Iransvers	WS-OVEI	WL	10 311													
Transvers	D LRED Spec Ar	ticle 3.8 1	122 Loads fr	om Superstri	icture											
	rse load distrib	ution opt	tion: Fixed (& Expansion	Bearings	1	Friction velocity, V	/O:	8.2	mph						
Transver	rse superstruct	ure lengt	h: 130	ft		1	Friction length, ZC	D:	0.23	ft						
Superstr	perstructure design elevation: 80.1095833 ft					1	Base design wind	velocity,	VB: 100	mph						
Design h	sign height, Z: 25.6095833 ft						- V30:		100	mph						
Override	erride design height, Z															
oads for	or wind from let	t to right														
Displ	olay															
0	Computed	Overri	ide	Use over	ride values	Override	Calcs									
			Superstruc	ture longitu	udinal force	(kip)										
۱ ske (D	Wind ew angle Degrees)	G1	G2	G3	G4	G5	G6									
> 0	7.4	307639	7.4307639	7.4307639	7.4307639	7.4307639	7.4307639	î.								
15	6.5	390722	6.5390722	6.5390722	6.5390722	6.5390722	6.5390722									
30	6.0	932264	6.0932264	6.0932264	6.0932264	6.0932264	6.0932264									
45	1 0	2112012	N 0013013	N 0012012	N 0013013	N 00/120/12	N 00/120/12	*								
			Superstru	cture transv	verse force ((kip)					Vertical Rea	ction due to	transverse	(kip)		
ske (Dr	Wind ew angle Degrees)	G1	G2	G3	G4	G5	G6		Wind skew ang (Degrees	le G1	G2	G3	G4	G5	G6	
> 0		0	0	0	0	0	0	î	> 0	2.5544736	1.5326842	0.5108947	-0.51089	-1.53268	-2.55447	î
15	-0.8	9169	-0.89169	-0.89169	-0.89169	-0.89169	-0.89169		15	2.2479368	1.3487621	0.4495874	-0.44958	-1.34876	-2.24793	1
30	-1.7	8338	-1.78338	-1.78338	-1.78338	-1.78338	-1.78338		30	2.0946684	1.256801	0.4189337	-0.41893	-1.256801	-2.09466	1
15	-23	779.4	-2 37784	-2 2778/	-2 2778/	-2 2778/	-2 37784		/15	1 6850526	1.0115716	0 2271005	-0 33710	-101157	-1.68505	*
npute																

The top of the screen displays values computed by BrDR that are used to compute the wind on superstructure loads on the pier and in some cases BrDR allows the overriding of some of this data. The bottom of the screen displays loads on the superstructure members for wind blowing from left to right. BrDR allows users to specify which direction the wind should blow in the actual pier finite element analysis in the **Load Combination Settings** window. This will be discussed later in the tutorial.

The overturning wind on superstructure load window is shown below.

Superstructure Envi	onmental Loa	ds - Pier1 - 3 Colu	ımn Frame				-	
Back span				Ahead span			Pier skew: 0 Degrees	
Span no.:	1			Span no.:		2	Wind load basis	
Superstructure def	nition: 2 Con	tinuous span		Superstructu	ire definition:	2 Continuous span	Gust speed O Fastest-mile speed	
WS-super WS-c	ver WL	TU SH						
<_ Input								
AASHTO I RED S	c article 3.8.2	vertical wind pres	sure					
Transverse supe	structure leng	th: 130	ft					
Deck Width:		51.5	ft					
Vertical upward	wind procession	hoz	kef					
vertical upward	wind pressure.	0.02	KSI					
C Loads for wind f	om left to righ	it						
Display								
Compi		ride u	lear ann an talainn an talainn	Override	Calcs			
			se override values					
Overturnin	force: 133.9) kip						
		Verti	est reaction due t					
		veru 0	vertruning force	0				
			(kip)					
	G1	G2	G3	G4	G5			
> 4	9.6811626	38.7353642	27.7895658	16.8437675	5.8979691			
Compute								

The wind on live load tab is shown below.

ed.			Pler skew:					span	Ahead s					an	k sp
ed		ad basis	Wind loa				2	10.:	Span n				1	0.:	in r
	Fastest-mile s	st speed 🔘	Gu			Continuous span	on: 2 C	tructure definitior	Superst			nuous span	ion: 2 Contin	tructure definiti	ers
												U SH	WL T	er WS-over	sup
														.t	nnı
										es	ure on vehicl	3 Wind presu	c Article 3.8.1.	- HTO LRFD Spe	AAS
							^ ►	WL—		arinc	Expansion Be	on: Fixed &	tribution optic	sverse load dis	rar
						л	ft	n k			ft	130	ucture length	isverse superstr	rar
						Л	—["	1							
							_								
							L _								
													n left to right	is for wind from	.oa
														isplay	- 6
								Calcs	ride C	Over			Override	Computed	
										alues	lse override v	·] 🗆 '	Overnde		
									kip)	linal force (l	ure longitud	Superstruct	S		
								G6	G5	G4	G3	G2	G1	Wind skew angle (Degrees)	
							î	0	0	0	0	0	0	0	>
								-0.26	-0.26	-0.26	-0.26	-0.26	-0.26	15	
								-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	30	
														45	
								-0.69333	-0.69333	-0.69333	-0.69333	-0.69333	-0.69333	45	
	e (kip)	sverse force	due to tran	cal reaction	Verti		T	-0.69333	-0.69333	-0.69333 rse force (k	-0.69333	-0.69333 Superstruct	-0.69333	45	
	e (kip)	sverse force	due to tran	cal reaction	Verti	Wind	•	-0.69333	-0.69333	-0.69333 rse force (ki	-0.69333	-0.69333 Superstruct	-0.69333	Wind	
G6	e (kip) G5	sverse force G4	due to tran G3	cal reaction G2	Vertio G1	Wind skew angle	•	-0.69333 G6	-0.69333 ip) G5	-0.69333 rse force (k G4	-0.69333 ture transve G3	-0.69333 Superstruct G2	-0.69333	Wind skew angle	
G6	e (kip) G5	sverse force G4	due to tran G3	G2	G1	Wind skew angle (Degrees)	•	-0.69333	-0.69333 ip) G5	-0.69333 rse force (k G4	-0.69333 ture transve G3	-0.69333 Superstruct G2	-0.69333	Wind skew angle (Degrees)	
G6	e (kip) G5 -1.28421	G4 -0.42807	due to tran G3 0.4280716	G2 1.2842148	Vertic G1 2.1403581	Wind skew angle (Degrees)	•	-0.69333 G6 2.1666667	-0.69333 ip) G5 2.16666667	-0.69333 rse force (k G4 2.16666667	-0.69333 ture transve G3 2.16666667	-0.69333 Superstruct G2 2.16666667	-0.69333 G1 2.16666667	Wind skew angle (Degrees)	>
G6 14035 88351	e (kip) G5 -1.28421 -1.13010	G4 -0.42807 -0.376703	G3 0.4280716 0.376703	G2 1.2842148 1.1301091	Vertii G1 2.1403581 1.8835151	Wind skew angle (Degrees) > 0 15		-0.69333 G6 2.1666667 1.9066667	-0.69333 ip) G5 2.1666667 1.9066667	-0.69333 rse force (k G4 2.1666667 1.9066667	-0.69333 ture transve G3 2.1666667 1.9066667	-0.69333 Superstruct G2 2.16666667 1.9066667	-0.69333 G1 2.16666667 1.9066667	Wind skew angle (Degrees) 0 15	>
G6 .14035 .88351 .75509	e (kip) G5 -1.28421 [-1.13010 [-1.05305]	G4 -0.42807 -0.376703 -0.35101	G3 0.4280716 0.376703 0.3510187	G2 1.2842148 1.1301091 1.0530562	Vertii G1 2.1403581 1.8835151 1.7550936	Wind skew angle (Degrees) > 0 15 30	Ì	-0.69333 G6 2.1666667 1.9066667 1.7766667	-0.69333 ip) G5 2.1666667 1.9066667 1.7766667	-0.69333 rse force (k G4 2.16666667 1.9066667 1.7766667	-0.69333 ture transve G3 2.1666667 1.9066667 1.7766667	-0.69333 Superstruct G2 2.16666667 1.9066667 1.7766667	-0.69333 G1 2.1666667 1.9066667 1.7766667	Wind skew angle (Degrees) 0 15 30	>
								Calcs	ride C	alues Over	lse override v ure longituc	e u Guperstructu	n left to right Override	Is for wind from hisplay Computed Wind	.oa

The superstructure temperature load tab is shown below.

k span					Ahead span		Pier ske	ew: 0 Degrees	
	1				Span no :	2	145-	dired holic	
perstructure definition	· 2 Continuous s	nan			Spuir no.	2 2 Castinuar and	wind		
	2 continuous s	pan			superstructure definition:	2 Continuous span		Gust speed V Fastest-mile speed	
-super WS-over	WL TU S	н							
Input									
AASHTO LRFD spec	article 3.12.2 unifo	m temperatu	re						
		Applic	ation type						
Temperature rise:	100 F		orce						
Temperature fall:	20 F								
Computed based	on steel super.								
Loads									
Temperature rise	force:	kip							
Temperature rise	force:	kip kip							
Temperature rise Temperature fall f	force:	kip kip			Superstructur	ro longitudinal force			
Temperature rise Temperature fall f	force:	kip kip			Superstructur	re longitudinal force (kip)			
Temperature rise Temperature fall f	force: Grce: G2	kip kip G3	G4	G5	Superstructur G6	re longitudinal force (kip)			
Temperature rise Temperature fall f	force:	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			Î
Temperature rise Temperature fall f Rise Fall	force:	kip kip G3 0	G4	G5 0	Superstructur G6 0 0	re longitudinal force (kip)			Ĵ
Temperature rise Temperature fall f Rise Fall	iorce:	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			ţ
Temperature rise Temperature fall f Rise Fall	force:	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			Ĵ
Temperature rise Temperature fall f All G All Fall	force:	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			ţ
Temperature rise Temperature fall f Rise Fall	iorce: G2 0 0 0 0	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			Î,
Temperature rise Temperature fall f	iorce:	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			
Temperature rise Temperature fall f Rise Fall	iorce: G2 G2 O	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			
Temperature rise Temperature fall f Rise Fall	iorce: G2 G2 O	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			Ĵ.
Temperature rise Temperature fall f Rise Fall	iorce:	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			Ĵ
Temperature rise Temperature fall f Rise Fall	iorce:	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			Ĵ
Temperature rise Temperature fall f	iorce:	kip kip G3 0	64	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			
Temperature rise Temperature fall f Rise Fall	iorce: G2 G2 O	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 0	re longitudinal force (kip)			Ĵ
Temperature rise Temperature fall f	iorce: G2 G2 O	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 1	re longitudinal force (kip)			Ĵ.
Temperature rise	iorce:	kip kip G3 0	G4	G5 0	Superstructur G6 0 0 1	re longitudinal force (kip)			Ĵ.

BrDR does not compute the superstructure temperature load. These values must be entered.

The superstructure shrinkage tab is shown below.

						Ahead span		Pier skew: 0 Degrees	
an no.:		1				Span no.:	2	Wind load basis	
perstructu	ire definition:	2 Continue	ous span			Superstructure definition:	2 Continuous span	Gust speed C Eastest-mile speed	
			_						
-super	WS-over	WL TU	SH						
la aut									
	I PED spos arti	elo 2.12 ebri	nkana						
AASITIOT	ration type	cie 5.12 silii	пкаде						
	Force								
Loads									
Shrin	nkage force:		kip						
						Superstructur	e longitudinal force		
							(kip)		
	G1	G2	G3	G4	G5	G6			
>									<u> </u>
									~
									Ŧ
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BrDR does not compute the superstructure shrinkage load. These values must be entered.

Substructure Loads

Double click on the **Substructure Loads** node in the **BWS** tree to open the window shown below.

ck spar	n						Ahead spa	n				F	Pier skew: 0	Degrees			
an no.		1					Span no.:		2				Wind load basis				
perstri	ucture definition	2 Con	tinuous sp	an			Superstruc	ture definitio	n: 2 Continu	Jous span			Gust speed 🔾	Fastest-mile speed			
Sub																	
	Jioash																
nput AASH	TO LRED Spec A	rticle 3.8.	1.2.3 Force	s Applied D	irectly to the !	Substructure											
Passa	uind processor	0.04		kef Exi	ction valocity	VO.	0.2	mah									
lon o	f can elevation:	76		ti Fri	ction length 7	vo.	0.2	ft									
Botto	m of cap elevation	on: 71.3	3	ft Ba	se desian wind	l velocity. VI	3: 100	mph									
Groun	d elevation:	54.5		t V3	0:		100	mph									
oads	for wind from le	ft to righ	t														
Di	splay				Use override	valuer.	Override										
9	Computed (Overr	ide		Use overnde	values	Calcs										
		Design															
	Component	height 7 (ft)	PD (ksf)														
	Cap	2 (14)	0.	04													
	Column1		0.	04													
>	Column2		0.	04													
	Column3		0.	04													
																v	
		Wind ske	ew angle	Wind ske	w angle (deg)	Wind ske	w angle	Wind skew	angle (deg)	Wind sl	ew angle						
	- · ·	(de	:g)		15	(de	g)	4	45	(c	eg)						
	Component	Diona	PD tran	PD long.	PD tran.	PD long	PD tran	PD long.	PD tran.	PD long	PD tran						
		(ksf)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)						
>	Cap	0.04	0	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641					-	
	Column1	0.04	0	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641						
	Column2	0.04	0	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641						
	Column3	0.04	0	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641					v	
	nute																
Pier3 - Frame Pier Example

The substructure temperature and shrinkage tab is shown below.

k spa	n						Ahead spar	n				Pi	ier skew: 0	Degrees			
in no	a -	1					Span no.:		2				Wind load basis				
erst	ucture definition	2 Cont	inuous spi	an			Superstruc	ture definition	2 Continu	ious span			🔵 Gust speed 🔘 Faste	st-mile speed			
C																	
SUD	TO & SH																
nput	TO LEED Sees A	atiala 2.0	225	- Applied D	innethe to the C												
		a dele 5.6.		s Applied b	irectly to the c												
ase	wind pressure:	0.04		ost Frie	ction velocity,	VO:	8.2	mph									
opo	of cap elevation:	76	1	t Frie	ction length, Z	0:	0.23	π									
otto	m of cap elevati	on: 71.3	3 t	t Ba	se design wind	i velocity, VI	s: 100	mph									
irou	nd elevation:	54.5	1	t V3	0:		100	mph									
oad	for wind from le	eft to right	t														
	isplay						Override										
	Computed (Overri	de		Use override	values	Cales										
							ColCs										
	Component	Design height	PD														
		Z (ft)	(ksf)														
	Cap		0.0	04													
	Column1		0.0	04													
>	Column2		0.0	04													
	Columns		0.0	04													
																v	
		Wind ske (de	w angle a)	Wind skey	v angle (deg)	Wind ske (de	w angle a)	Wind skew	angle (deg)	Wind sl	(ew angle leg)						
	Component	0			15	3)	4	5		60						
		PD long. (ksf)	PD tran. (ksf)														
>	Cap	0.04	0	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641					-	
	Column1	0.04	0	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641						
	Column2	0.04	0	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641						
	Column3	0.04	0	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641						

Click **OK** to close the window.

Topic 4 - Pier 2 – Frame Pier Example

This topic is the fourth of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, two independent prestress simple span superstructures are supported by a 3 column frame pier. These 2 superstructures are **not** made continuous for live load so the pier supports two independent superstructures. If the prestress spans were made continuous for live load, the pier would support 1 two-span continuous superstructure.

Note: Topics 1, 2 and 3 must be completed in the series before entering this topic. It is assumed that users are familiar with the BrDR Superstructure module and as such this example does not go into detail describing BrDR Superstructure windows or bridge workspace navigation.

BrDR SUBSTRUCTURE DESIGN Ribbon

The following ribbon is available in BrDR Substructure when the pier alternative is selected in the Bridge Workspace tree.

REPORTS	?	- 0	×
REPORTING			
☆ 🌫	3D		
Results Soil s Graph Plot	3D Schematic		
+ +	+		
10 11	12		
	REPORTS REPORTING Results Soil s Graph Plot	REPORTS ? REPORTING REPORTING Results Soil s Graph Plot Schematic	REPORTS ? - REPORTING REPORTING Results Soil s Graph Plot 10 11 12

- Design Mode Specify the design mode as either Preliminary or Final. This determines which LRFD Substructure Design Settings are used in the pier analysis based on the design settings chosen on the Pier Alternative: Description tab.
- 2. **Generate Model** Opens the **Model Settings** window which allows the user to define parameters BrD/BrDR will use to generate the finite element model of the pier alternative.
- 3. Load Combinations Opens the Load Combination Settings window where the user specifies the load conditions to be considered when BrDR performs a pier analysis.
- 4. **Load Palette** Opens the **Load Palette** window where the user select the load types to be included in the finite element analysis of a pier alternative.
- 5. Analyze Substructure Initiates the finite element analysis of the pier alternative.
- 6. Specification Check Conduct LRFD specification check for the pier alternative.
- 7. **Tabular Results -** Opens the **Tabular Results** window where the user can create summary reports of analysis output data for the pier finite element analysis.
- 8. **Specification Check Detail -** It allows the user to review the LRFD specification checks based on the LRFD analysis results.
- 9. Engine Outputs Opens a window displaying all the result files generated for the analyzed member.
- 10. **Results Graph** Opens the **Results Graph** for the analyzed member.
- 11. Soil Plot Opens the Soil Plot window for the selected foundation alternative
- 12. **3D Schematic**. Open the pier alternative 3D schematic for viewing the pier alternative.

Pier3 - Frame Pier Example

Finite Element Model

This section covers the creation of the finite element model and the analysis f the pier.

Select the pier alternative – **3 Column Frame** in the bridge workspace tree and click on the **Generate Model** button from the Analysis group of the SUBSTRUCTURE DESIGN tab or right click and select Generate Model as shown below.

Bridge Workspace - LRFD Substructure	Example 1 ANA	ALYSIS SUBSTRUCTUR	REPORTS	? .	_	
BRIDGE WORKSPACE WORKSPACE TOO	LS VIEW DESIG	IN/RATE DESIGN	REPORTING			
Preliminary Generate Model Combinations Analysis	Analyze Specification Check	Tabular Specification En Results Check Detail Ou Result	Gine Results So tputs Graph Plc	il 3D Schematic		
Workspace	☆ × Scher	matic	\$ X	Report		× &
Bridge Components Image: Components Components Diaphragm Definitions Diaphragm Definitions Image: Components Diaphragm Definitions Image: Components Components Image: Components Continuous Components Image: Components Continuous span structure (right supported to the supp	Expand Branch Collapse Branch Open Copy Duplicate Delete Generate Model 1 1 Doublicate Second Combination Analyze Specification Cheel Validate View Summary Re View Detailed Rep General Preference Close Bridge World	ns :k port tort es (space	× &			

The **Model Settings** window will appear. This window allows the user to define the parameters BrDR will use to generate the finite element model of the pier.

Default parameters Points of i	nterest Member releases											
Default nodes are located at bea intersection of cap and column fa	m reaction points, cross-section cha aces, column/footing interfaces, and	inges, cap, I bottom c	/column cer of foundation	terline inter	sections,							
Cap elements		Pro	ovide mome	nt release b	etween tops of	columns an	d cap					
Number of equal elements in	a cap span: 2 🗘	Bott	om of Colun	n								
Column elements		ŚГГ		Longitudinal		Trar	nsverse					
Number of equal elements in	a column segment: 1 🗘		Column	Support type	Spring constant (kip-ip/rad)	Support type	Spring constant (kip-in/rad)					
Footing element type		>	Column1	Fixed 🗸	(kip in) day	Θ						
O None	O None			Fixed \checkmark		1 ¥.	1.4 1.1 1.1		• 1	_		
Beam grillage			Column3	Fixed $$		- ∀F	iit FI whil	e in this	windo	200		
O Plate			open to acc						ss the BrDR help			
- Column/wall moment of inerti	a					whic	h contains	a link to	the B	rI		
Use cracked moment of i	nertia					Subs	tructure 1	Model (Genera	ati		
Top of column/wall:	%					Licor	Monual	which (ontoi	na		
Bottom of column/wall:	%								Jointan	115		
						detai	led descrip	otion of I	iow B	rL		
and the second of the second o						gene	rates the F	E model				
enerate model												

Increase the number of elements in the cap as shown above. For components whose cross section properties vary over the length of the component, increasing the number of elements will result in a closer match between the finite element model properties and the actual pier properties as shown below.



The **Points of interest** tab allows the user to define additional nodes in the pier finite element model in addition to the default nodes generated by BrDR Substructure. Add a point of interest 5 feet from the bottom of Column1 as shown below.

Default parameters	Points of interest	Member releases	
Default nodes are lo	cated at beam reactio	on points, cross-section changes, cap/column interfaces, ump/section_interfaces_and bottom of foundations	
odel Settings - 3 Column Frame efault parameters Points of interest hefault nodes are located at beam reaction tersection of cap and column faces, colu Cap additional points of interest Distance from left end of cap (ft) New Duplicate Delet		Column additional points of interest	
Distance fr left end of (ft)	'om cap	Column Distance from bottom of column (ft)	
	A	> Column1 ~ 5	
		· · · · · · · · · · · · · · · · · · ·	
New D	uplicate Delet	te New Duplicate Delete	

The **Member releases** tab allows the user to define member releases in the finite element model of the pier alternative. Adding a member release on this window creates a node at that location with the corresponding releases. In this example, no member releases will be added.

🕰 Model Settings - 3 Column Frame	- 0	×
Default parameters Points of interest Member releases		
Cap Distance from Degree of (ft) freedom	Column Distance from bottom of column (ft) Degree of freedom New Duplicate Delete	
Generate model		These member releases are in the local member coordinate system.
	OK Apply Cance	

Click **Apply** to apply the data on this window. Then click the **Generate Model** button to generate the FE model. Then click **OK** to close the window.

Open the pier alternative **3D schematic** and view the FE model generated by BrDR. Select the **Properties** button on the 3D schematic ribbon.



Select the following settings to turn on display of the FE model in the schematic. Also select **Nodes** on the **Labels** tab to include the node numbers in the schematic.

Br View Properties	_		×	Br View Properties	– 🗆 X
General Labels Dimensions Scales				General Labels Dimensions	Scales
FE Model Vodes Point of interest Supports Member releases Rigid links Analysis results Select All Clear All	Solid Model Solid model Wire frame Finished groundline Water level Low			FE Model	Turn off display of the So Model to view the FE Mod The Wire Frame may also ne
	OK Apply	Cancel			turned off for viewing rou
					columns.



Click **OK** and the 3D schematic appears as follows.

Notice node 0 in Column1. This is the point of interest added 5' above the bottom of the column.

Pier Analysis

Loads

To select the loads to be included in the analysis, open the **Load Combination Settings** window from the right-click menu for the pier alternative or from the **SUBSTRUCTURE DESIGN** ribbon as shown below.

Bridge Workspace - LRFD Substructure Exa BRIDGE WORKSPACE WORKSPACE TOOLS	mple 1 VIEW I	ANALYSIS DESIGN/RATE	SUBSTRUCTURE	REPORTS	?	- 0 X
Preliminary Generate Model Combinations Analysis	lyze Specifica ucture Chec	ation :k Tabular Results	Specification Engi Check Detail Outp Results	ne Results So uts Graph Plo	il 3D ot Schematic	
,						
Workspace	× x	Schematic		$\Rightarrow \times$	Report	$x \approx x$
Bridge Components Image: Components Components Image: Components Components Image: Components Diaphragm Definitions Image: Components Diaphragmeters Image: Components Diaphragmeters	♀ Expand B ♀ Collapse ○ Collapse □ Copy □ Duplicate ♦ Delete ♦ Generate ↓ 3D Schen ✓ Load Com ✓ Load Com ✓ Analyze □ Specificat □ Validate ♀ View Sum ♀ Close Brid	ranch Branch Model natic nbinations tion Check esults mmary Report ailed Report Preferences dge Workspace		\$ X		

This window allows the user to specify the load conditions to be considered when BrDR performs the pier analysis. Make the following selections and click **OK**.

A Load Combination Settings - 3 C	Column Frame		— [⊐ ×	
LRFD substructure design settings:	Preliminary Design Setting (US)	LRFD factors: 2010	AASHTO LRFD Specifications		
Chosen limit states	Settings				
STRENGTH-I	Water levels	Wind direction	Additional combinations		
STRENGTH-II	Low Mean	Left to right Right to left	Check overall stability Check for deformation	s	
STRENGTH-III	Check flood				
STRENGTH-IV					
STRENGTH-V	Temperature change	Wind angles			
SERVICE-I	🗹 Fall	15 degrees			
SERVICE-II		30 degrees 45 degrees	\bigcirc		
SERVICE-III		60 degrees	It's ok to keep th	e water lev	vels turned on
SERVICE-IV	Consider simplified wind loading	Ор	even if the pier is n	ot subject	t to all of the
			water levels. The ignored if your pier	water le is not subj	vels will be ject to them.
			ignored if your pier	is not subj	ject to them.

Click **OK** to apply the data and close the window.

Load Palette

Another window that allows the user to specify the load types to be included in the pier analysis is the **Load Palette** window. This window can be accessed by selecting the name of the pier alternative in the bridge workspace tree and clicking on Load Palette in the **SUBSTRUCTURE DESIGN** ribbon.



🗛 Load Palat	te				- 🗆	×
Use	Input defined	Override	Use	Input defined	Override	If a load type is
DC 🔽	\checkmark		EH Active	NA		e ii a ioau type is
DW 🔽	~		EH At-Rest	NA		unchecked, the load
ш 🔽	\checkmark					combinations for the
PL	\times					limit states containing
			τυ 🔽	\checkmark		that load type will still
BR 🗹	\checkmark		TG	NA		be computed but that
ст	NA		SH	\times		
WA 🔽	\checkmark		CR	NA		load type will have
ws 🔽	\checkmark		SE	NA		zero loading.
WL 🔽	~		FR	\times		
			cv	NA		
Select all	Clear al	Open templat	te Save template	ОК	Canc	el

Click **OK** to apply the data and close the window.

The Load Palette can be very useful to evaluate individual load types on the pier and to minimize the time required for analysis.

If the "Use" checkbox is not checked for a load type, that load type will not be included in the pier analysis nor in the load combinations computed by BrDR. Results for limit states that contain that load type will still be computed but the loading for that load type will be missing.

It is ok to keep the **Use** box checked for load types that do not apply to the pier. They will be ignored if they do not apply to the defined pier.

Specification Checking

Now that the loads are selected, the pier is ready to be analyzed. Select the **Specification Check** button from the **SUBSTRUCTURE DESIGN** ribbon or from the right-click menu as shown below.



The Substructure analysis progress window will open as shown below. Click OK once the analysis completes.



Engine Outputs

With pier alternative selected in the bridge workspace tree, click on the **Engine Outputs** button from the ribbon as shown below. The following window will appear. This window contains a listing of the output files BrDR created when it computed the pier loads and when it performed the finite element analysis. Double click on any file to open it. Summary report of the specification checks can be viewed by opening the **Spec Check Results** file shown below.

- LRFD Substructure Example 1		
- Training Alt		
····Pier1		
🖻 3 Column Frame		
SuperDLReactions2		
·····SubDLReactions2		
FrictionReactions2		
SingleLaneReactions		
Live Load Patterns		
·····LLReactionsSummary		
WindOrCeReactions2		
WindOnSubReactions2		
WindOnliveReactions2		
WaterOnSubReactions2		
ShrinkageOfSuperBeactions2		
ShrinkageOfSubReactions2		
SettlementOfSubReactions2		
·····VehicleCollisionReactions2		
····VesselCollisionReactions2		
HorizEarthReactions2		
·····LL Scan Summary		
····Cap LRFD Reinf Dev Length Calcs Log File		
Column1 LRFD Reinf Dev Length Calcs Log File		
Column2 LRFD Reinf Dev Length Calcs Log File		
Column3 LRFD Reinf Dev Length Calcs Log File		
Column112x12 Footing LRFD Reinf Dev Length Calcs Log File		
Column212x12 Footing LRFD Reinf Dev Length Calcs Log File		
Course Charle Devide (Fidew Max 01, 2024 14:00:41)		
Spec Check Results (Friday Mar. 01, 2024 14:08:41)		
Parting Process Detail		
□ Colume212x12Eooting		
Bearing Pressure Detail		
Bearing Pressure Summary		
□ Column312x12Footing		
Bearing Pressure Detail		
Bearing Pressure Summary		
	Cance	al
	Cance	

This file contains a summary of the results of each specification check along with the design ratios for each spec article at each specification check location point. The design ratio is the ratio of the capacity to demand. A design ratio less than one indicates the demand is greater than the capacity and the spec article fails. A design ratio equal to 99.0 indicates the section is subject to zero demand.

The specification check detail can be viewed by clicking on the **Specification Check Detail** button from the ribbon as shown below.

Bridge Workspace - LRFD Substructure Example 1 BRIDGE WORKSPACE WORKSPACE TOOLS VIEW	AN/ DESIG	ALYSIS GN/RATE	SUBSTRUC	TURE	REPORTS	3	?	-	×
Preliminary Generate Load Load Analyze Sp Model Combinations Palette Substructure Analysis	ecification Check	Tabular Results	Specification Check Detail	Engin Outpu	e Results ts Graph	Soil Plot	3D Schema	tic	
Bridge Components Bridge Components Image: Components Disphragm Definitions Image: Disphragm Definitions Image: Disphragm Definitions Image: Display Definitions Image: Display Definitions <t< th=""><th>Anal</th><th>ysis</th><th></th><th></th><th>\$ ×</th><th>R</th><th>eport</th><th></th><th>\$ X</th></t<>	Anal	ysis			\$ ×	R	eport		\$ X

BrDR performs specification checks at each node in the finite element model along with locations where the reinforcement is developed and at a distance dv from the face of each column. Open the article for the flexural resistance at the center of the first interior span of the cap at 16.13'as shown below.

A Specification Checks for 3 Column Frame - 17 of 675				
Properties Specification filter	Articles All articles Generate Bullet list Report			
A 📋 Pier Componer	Specification reference	Limit State	Flex. Sense	Pass/Fail
🔺 🚞 Cap	✓ 5.10.8 Shrinkage and Temperature Reinforcement		N/A	Passed
🚞 0.00 ft.	5.4.2.5 Poisson's Ratio		N/A	General Comp.
🚞 1.50 ft.	5.4.2.6 Modulus of Rupture		N/A	General Comp.
🚞 1.56 ft.	5.5.4.2 Strength Limit State - Resistance Factors		N/A	General Comp.
🚞 2.51 ft.	5.7.2.2 Rectangular Stress Distribution		N/A	General Comp.
iii 2.63 ft.	✓ 5.7.3.2 Flexural Resistance (Reinforced Concrete)		N/A	Passed
🚞 3.00 ft.	X 5.7.3.3.2 Minimum Reinforcement		N/A	Failed
i 5.25 ft.	NA 5.7.3.4 Control of Cracking by Distribution of Reinforcement		N/A	Not Required
i 5.57 ft.	✓ 5.7.3.4(a) Longitudinal Skin Reinforcement		N/A	Passed
6.75 ft.	✓ 5.8.2.1 Torsion		N/A	Passed
7.93 ft.	✓ 5.8.2.5 Minimum Transverse Reinforcement	N/A	Passed	
■ 8.25 ft.	✓ 5.8.2.7 Maximum Spacing of Transverse Reinforcement	N/A	Passed	
8.29 π.	✓ 5.8.3.3 Nominal Shear Resistance		N/A	Passed
11.94 IL	5.8.3.4 Procedures for Determining Shear Resistance		N/A	General Comp.
16.13 ft	✓ 5.8.3.5 Longitudinal Reinforcement		N/A	Passed
0.13 ft	Cracked_Moment_of_Inertia Section Property Calculations		Positive Flexure	General Comp.
20.01 ft.	Cracked_Moment_of_Inertia Section Property Calculations	Negative Flexure	General Comp.	
i 24.00 ft.	v		-	

The following is noted for this window, other spec articles are similar:

- For each specification check location, both the left and right sides of the point are evaluated. The design ratio is printed out for the article. The design ratio is the ratio of capacity to demand. A design ratio less than one indicates the demand is greater than the capacity and the specification article fails. A design ratio equal to 99.0 indicates the section is subject to zero demand.
- 2. The user has control over which limit states are investigated. For this example, the Preliminary Design Mode is used and the default Preliminary Design Setting only contains the Strength-I limit state. For each limit state, the max and min force effect is checked. Thus each limit state shows two rows of data.
- 3. The LL load combination is shown in this column. If the location is not at a node in the FE model (e.g., the node is at a point where the rebar is fully developed), this column will list two load combinations separated by a comma. The first load combination is the combination considered at the left end and the second load combination is the combination considered at the right end of the FE element that contains this location. The resulting load displayed is a linear interpolation between the two displayed load cases.
- 4. The critical design ratio for positive moment at this point is 1.15 which is more than 1.0 so the specification check passes.

Spec Check Detail for 5.7.3.2 Flexural Resistance (Reinforced Concrete)	_		×
5 Concrete Structures 5.7 Material Properties 5.7.3 Flexural Members 5.7.3.2 Flexural Resistance (AASHTO LRFD Bridge Design Specifications, Fifth Edition - 2010, with 2010 interims)			Î
Pier Cap Section - At Location = 16.1250 (ft) - Left			
Cross Section Properties			1
Depth = 56.04(in) Width = 39.96(in)			
Area = 2239.36(in^2)			
Flexural Reinforcement			
As Dist. From Bottom			
7.62 52.78 7.62 50.01 0.55 3.19 5.00 5.82			
f' = 4.00 km			
1 0 - 1.00 Kul			1
Otherwise the Resistance is computed as per the Specification.			
- Override Mr=	NA		
Limit State Load Mu Phi Mn Phi Mn Phi * Mn Mr/Mu	Depth		
STR-I 5 1125.49 0.900 1435.02 1291.52 1.15 STR-I 10 800.28 0.900 1435.02 1291.52 1.61	4.23		111 111
Pier Cap Section - At Location = 16.1250 (ft) - Right			
Cross Section Properties			
Depth = 56.04(in) Width = 39.96(in)			
4			•
		OK	(

Footing Analysis

BrDR Substructure has the capability to analyze both individual and combined footings. Both spread and pile footings are supported. Specification checks at the critical locations in the footing are then performed. The footing analysis and specification check occurs when the specification check is performed on the pier. BrD determines the forces in the footing using the bottom of column forces from the finite element analysis along with the soil and footing loads. The following file containing the footing calculations is available after the specification check is performed.



Bearing P	ressure Detail -	Notepad					- 0	×
File Edit F	ormat View	Help						^
			Factored B	ottom of Colum	n Forces			. 1
LS STR-I	LC 6	Pu (kip) 785.98	MuLong (kip-ft) 287.88	MuTrans (kip-ft) -395.03	VuLong (kip) -49.24	VuTrans (kip) -12.43		
			Factored B	ottom of Footi	ng Forces			
LS STR-I	LC 6	Pu (kip) 903.25	MuLong (kip-ft) 334.47	MuTrans (kip-ft) -579.66	VuLong (kip) -49.24	VuTrans (kip) -12.43		
DC Factor EV Factor WA Factor	= 1.25 = 1.30 = 1.00							
Transvers Basic C	e eccentric	sures (P/A -	Long/Pu = +/- M/S)	-0.37(ft)				
Press1 (ksf) 3.10	Press2 (ksf) 5.42	Press3 (ksf) 9.45	Press4 (ksf) 7.12					
Bottom	Transverse	Steel						
Pressure Pressure Moment at Moment du Moment du Moment du Final bot	at ftg. edg at col. fac face of co e to footin e to soil c e to footin e to soil b tom transve	ge = 9.4 e = 8.9 blumn due to ng selfweig overburden = ng buoyancy buoyancy = erse moment	45(ksf) 54(ksf) o soil pressu ht = -7.67 = -1.28(ki = 0.00(k 0.00(kip- = 90.81(k	re = 99.75((kip-ft/ft) p-ft/ft) ip-ft/ft) ft/ft) ip-ft/ft)	kip-ft/ft)			
<								>
				Ln 1, C	ol 1	100% Windows (CRL	F) UTF-8	

Tabular Results

To view the tabular results, with pier alt 3 Column Frame selected, click on the Tabular Results button from the ribbon

or right click and select Tabular Results as shown below.

Bridge Workspace -	- LRFD Substruct	ture Example 1	ANALYSIS	SUBSTRUCTURE	REPORTS	? -	- 🗆 X
BRIDGE WORKSPACE W	VORKSPACE	TOOLS VIEW	DESIGN/RAT	E DESIGN	REPORTING		
Preliminary Generate Lu Model Comb	oad Load binations Palette	Analyze Spe Substructure	crification Check Resu	lar Specification En Its Check Detail Out	Second Se	3D Schematic	
Workspace			\$ * *	Schematic Analysis	× & × &	Report	× &

This window allows the user to create summary reports of analysis output data for the pier finite element analysis and save these report definitions for future use. Select **New** to create a new report definition. The first tab permits the selection of the FE model information to include in the report.

A Tabular Results - New Tabular Report -	- 🗆	×
New Open Save Save as	Generate	
Model Loads Reactions Displacements Forces Envelope Spec check results Options		
 Nodes Beams Section properties Materials Supports Member releases Load cases 		
Select all Clear all		
	Close	2

Switch to the **Loads** tab. This tab allows the user to select how the FE analysis output (reactions, displacements, element forces) is organized in the report. Selecting the Limit States filter permits the selection of limit states output to be included in the report. Selecting the Load Cases filter permits the users to select individual load cases output to be included in the report. Selecting the Load Combinations permits the user to pick individual load combinations output to be included in the report.

Select the **Load cases** filter and then select **Load case 1**. This results in a report that will contain the reactions, displacements, and forces for only this Load case 1.

New Open	Save Save a	s	Generate
odel Loads Reactions	s Displacements Force	s Envelope Spec check results Options	
Select Limit states	Load case	Name	
O Load cases	0 🔽 1	Superstructure DC	î
 Load combinations 	2	Substructure Self Weight - DC	
	3	LL1 T DV:1	
	4	LL2 T DV:1	
	5	Vehicle Braking - 1 Lane (Sta back direction)	
	6	Vehicle Braking - 2 Lanes (Sta back direction)	
	7	Vehicle Braking - 3 Lanes (Sta back direction)	
	8	Vehicle Braking - 1 Lane (Sta ahead direction)	
	9	Vehicle Braking - 2 Lanes (Sta ahead direction)	
	10	Vehicle Braking - 3 Lanes (Sta ahead direction)	
	11	Wind on Sub - 0.00 Degrees Left To Right	
	12	Wind on Super - 0.00 Degrees Left To Right	
	13	Wind on Super Overturning Left To Right	•
	Select all Clear all		

The **Reactions**, **Displacements**, **Forces**, **and Envelope** tabs lets the user specify if these actions should be included in the report. The actions will be included in the output for the loadings specified on the **Loads** tab. The **Spec check results** tabs allow the user to select the specicification check items to include in the report. The **Options** tab allows the user to specify formatting and output options for the report.

To save the settings on these tabs as a report definition that can be re-uses in the future, select the **Save As** button. This would save the settings on these tabs as a report definition file. It would not save the FE analysis output report for this pier. Select the **Generate** button to view the FE analysis output report for this pier. An xml file containing the data for this report is created and given the name **New Tabular Report.xml**. This file is overwritten each time the **Generate** button is clicked.

Method of solution

The method of solution can be accessed from the BrDR Help menu as shown below.

1. Click on the **BRIDGE WORKSPACE** ribbon.



- 2. Select AASHTO LRFD Substructure (BrD) from the Engine Help column.
- 3. Double click on Method of Solution from the Engine Help Configuration column.

\bigcirc	Bridge Workspace - LRFD Substructure Example 1	-	×
 Print Help 	Frequently Asked Questions Find questions that are frequently asked		
Close	Find more information on technical support		
	Engine Help Engine Help Configuration		
	AASHTO Culvert LRFR Method of Solution 3		
	AASHTO LFR Default Engine Help		
	AASHTO LRFD		
	AASHTO LRFD Substructure (BrD)		
	AASHTO LRFR		
	AASHTO Metal Culvert LFR		
	AASHTO Metal Culvert LRFR		
	ARA Timber ASP		
	Set As Main Engine Help		
	About		