AASHTOWare BrDR 7.5.0 Substructure Tutorial Pier Drilled Shaft Example







# BrDR Substructure Training

# Pier Drilled Shaft Example

This example modifies one of the spread footings in the **BID20** example to be a drilled shaft foundation. BrDR substructure has the ability to perform a soil-structure interaction analysis. An example describing the analysis can be found in tutorial "3 Drilled Shaft" in 2012 User Group – Training.

If the user does not want to use the BrDR soil-structure interaction analysis, this example describes how to analyze a pier with drilled shafts considering a user-defined point of fixity. The user can enter a point of fixity found from an outside source, such as LPile or COM624, as the base of the drilled shaft in BrDR. BrDR can then perform a finite element analysis and spec check of the pier considering that point of fixity.

Double click on **BID20 LRFD Substructure Example 1** from the **Bridge Explorer** (or click and select **Open**) to open the bridge as shown below.

Br	AASHTOWar	e Bri	dge Design and Rating	? – 🗆 🗙
BRIDGE EXPLORER BRIDGE	FOLDER R	ATE	TOOLS VIEW	
New Open Batch ~ Fin	d Copy Paste	Co To	Py Remove Delete From	
Bridge	М	anag	e	
🗝 🙀 Favorites Folder		BID	Bridge ID	Bridge Na
Recent Bridges		1	TrainingBridge1	Training Bridge 1(LRFD)
🖃 📂 All Bridges		2	TrainingBridge2	Training Bridge 2(LRFD)
Implates     Deleted Bridger		3	TrainingBridge3	Training Bridge 3(LRFD)
Deleted bridges		4	PCITrainingBridge1	PCI TrainingBridge1(LFR)
		5	PCITrainingBridge2	PCITrainingBridge2(LRFD)
		6	PCITrainingBridge3	PCI TrainingBridge3(LFR)
		7	PCITrainingBridge4	PCITrainingBridge4(LRFD)
		8	PCITrainingBridge5	PCI TrainingBridge5(LFR)
		9	PCITrainingBridge6	PCITrainingBridge6(LRFD)
		10	Example7	Example 7 PS (LFR)
		11	RCTrainingBridge1	RC Training Bridge1(LFR)
		12	TimberTrainingBridge1	Timber Tr. Bridge1 (ASR)
		13	FSys GFS TrainingBridge1	FloorSystem GFS Training Brid
		14	FSys FS TrainingBridge2	FloorSystem FS Training Bridg
		15	FSys GF TrainingBridge3	FloorSystem GF Training Bride
		16	FLine GFS TrainingBridge1	FloorLine GFS Training Bridge
		17	FLine FS TrainingBridge2	FloorLine FS Training Bridge (
		18	FLine GF TrainingBridge3	FloorLine GF Training Bridge
	_	19	TrussTrainingExample	Truss Training Example
	E E	20	LRFD Substructure Example 1	LRFD Substructure Example 1
		21	LRFD Substructure Example 2	LRFD Substructure Example 2
		22	LRFD Substructure Example 3	LRFD Substructure Example 3
		23	LRFD Substructure Example 4	LRFD Substructure Example 4
		24	Visual Reference 1	Visual Reference 1
		25	Culvert Example 1	Culvert Example 1
			Total Bridge Count:	34

Expand the Bridge Workspace tree as shown below.



#### 3D Schematic - Pier

Select **3-column pier** and click on the **3D Schematic** button on the **SUBSTRUCTURE DESIGN** ribbon (or right click and select **3D Schematic**) as shown below.



The 3D schematic of the pier is shown below. The 3-column pier example is a multi-frame pier on spread footings.

Schematic	– 🗆 ×
3D Schematic	$\sim \times$
tur 🐙 🙀 🎘 🚳 🚳 Linear 🗸 🗸	÷
Superstructure Reference Line GC GC GC GC GC GC GC GC GC GC GC GC GC	

This tutorial discusses modeling the foundation for Column 1 as a drilled shaft instead of a spread footing.

# **Column Properties**

Expand the **COLUMNS** folder under the pier alternative - **3-column pier** and double click on **Column 1** to open the **Column Properties** window as shown below.



ame:       Column1         Description       Additional loads             Image: Second Se							
Description       Additional loads         Existing       Current       Foundation alternative name       Description         >       -       Foundation Alt 1       -	me:	Column1					
Existing Current Foundation alternative name Description  Foundation Alt 1  Exposure factor: 1	Desc	cription	Additiona	al loads			
Exposure factor: 1	>	Existing	Current	Foundation alternative name Foundation Alt 1	Description		
Exposure factor: 1							
Exposure factor: 1							
Exposure factor: 1							
Exposure factor 1							
Exposure factor: 1							
Exposure factor: 1							
Exposure factor: 1							
	Exp	osure facto	or: 1				

Uncheck the checkboxes for the **Existing** and **Current** foundations as shown below.

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

## **Column Components**

Double click on the **Components** node in the **Bridge Workspace** tree to open the **Column Components** window and increase the number of segments to 2 as shown below.

Segment    Segment	~	Round	~	None	Class A (US) 🗸	1	
seyment	~	Bound					
		Tround I	~	None	Class A (US) 🗸	2	
					-		

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

## Column Geometry

Double click on the **Geometry** node in the **Bridge Workspace** tree to open the **Column Geometry** window and enter the bottom elevation of Segment 2 as 40.00. For **Segment 2** enter the D1 = 4.0 as shown below.



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

## Column Reinforcement - Generate Pattern Wizard

Create a reinforcement definition for the drilled shaft segment using the **Pattern Wizard** as shown below. Be sure to select the column segment 2 as shown so the reinforcement bar coordinates will be generated correctly for the 4' wide drilled shaft segment.

From the **Bridge Workspace** tree, double click on the **Reinforcement Definitions** folder to open the **Column Reinforcement** window and add a new reinforcement. The following window appears.

🗅 Column Reinforcement - 🛛 - Pie	r 2 - 3-colum	in pier					_		>
	Name:								
	Bund	lle bars							
++Y	Bar	Bar size	Material	X (in)	Y (in)				
Sta Ahead									
						New	Dualianta	D.L.	
Generate pattern						New	Duplicate	Delet	2

#### Click on Generate pattern to open the Generate Pattern Wizard. Enter data as shown below.

🕰 Generate Pattern W	izard							×
Pattern name:	Drilled S	haft Bars	Bundle type	Bar size:	10 🗸			
Column segment:	2	~	O Single	Material:	Epoxied Gra	de 60	~	
Segment cross section:		Round	2 Parallel	Clear cover:	2.5	in		
Top / bottom:	Тор		3 Bar	Number of bars:	12			
Overall trans. width:	48	in						
Overall long. width:	48	in						
							ОК	Cancel

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

The reinforcement data generated using the result will show up in the Column Reinforcement window as shown	
below. Make sure to uncheck <b>Bundle bars</b> checkbox for this example.	

1	Name:	Drilled	l Shaft E	Bars				
	Bu	ndle bai	s					
	Ba	r	Bar size	Material	X (in)	Y (in)		
	1	10	$\sim$	Epoxied Grade 60 $\lor$	20.865	0		
×	2	10	$\sim$	Epoxied Grade 60 $$	18.06962	-10.4325		
	3	10	$\sim$	Epoxied Grade 60 $\lor$	10.4325	-18.06962		
	4	10	$\sim$	Epoxied Grade 60 $\lor$	0	-20.865		
	5	10	$\sim$	Epoxied Grade 60 $\lor$	-10.4325	-18.06962		
	6	10	$\sim$	Epoxied Grade 60 $\lor$	-18.06962	-10.4325		
	7	10	$\sim$	Epoxied Grade 60 🗸 🗸	-20.865	0		
	8	10	$\sim$	Epoxied Grade 60 $$	-18.06962	10.4325		
	9	10	$\sim$	Epoxied Grade 60 $\lor$	-10.4325	18.06962		
	> 10	) 10	$\sim$	Epoxied Grade 60 $\lor$	0	20.865		
	1	10	$\sim$	Epoxied Grade 60 🗸 🗸	10.4325	18.06962		
	12	2 10	$\sim$	Epoxied Grade 60 $\lor$	18.06962	10.4325		
					10.00502	10/4525		
					(	New	Duplicate	Delete
						OK	Arrel	Cancel

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

## Column Reinforcement

Double click on the **Reinforcement** node in the **Bridge Workspace** tree to open the **Column Reinforcement** window. Assign the column reinforcement as shown below.

-enu	ıral	Shear										
	Set	Start distance (ft)	Straight length (ft)	End distance (ft)	Pattern	Hook start	t Hook at end	Developed at start	Developed at end	Follows profile		
	1	0	13.75	13.75	Drilled Shaft Bars			<ul> <li>Image: A set of the set of the</li></ul>				
	2	9.75	10	19.75	8 #10 bars	/ 🗌						
>	3	13.75	17.58	31.33	8 #10 bars	/ 🗌			$\sim$		1	

The first row describes the rebar in the drilled shaft segment. Mark these bars as **Developed at start** which assumes that the actual length of the drilled shaft segment below the point of fixity at elevation 40.0 ft provides enough length for these bars to be fully developed.

The second row describes the lap bars extending from the column into the drilled shaft.

The third row describes the column reinforcement. Mark these bars as **Developed at end** since it can be assumed that the bars extend far enough into the cap to be developed.

Navigate to the **Shear** tab of this window and enter the shear reinforcement as shown below. The overlap of spirals at the column-drilled shaft connection is a detailing requirement that can be ignored in this example.

			it - Columni - Pie	er 2 - 3-0	column pier						_	
exura	al Sh	ear										
She	ear reinfr	orcemer	at type									
C	) Ties	O Sp	pirals Spira	ls desig	ned as ties							
		-										
	Bar size	Pitch (in)	Material		Start distance (ft)	Length (ft)	End distance (ft)					
> 4	4 ~	3	Grade 60	$\sim$	0	32.08	32.08					

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

#### 3D Schematic - Pier

Select **3-column pier** and click on the **3D Schematic** button on the **SUBSTRUCTURE DESIGN** ribbon (or right click and select **3D Schematic**) to open the pier schematic.



A specification check will now be performed on the pier.

# Specification Checks - Pier

With **3-column pier** selected in the **Bridge Workspace** tree, click on the **Specification Check** button from the **Analysis** group of the **SUBSTRUCTURE DESIGN** ribbon.



The **Bridge Validation** window appears as shown below. Click on the Continue spec check button to perform the specification checks.

<b>A</b>	Bridge Validation	×
]	Total Number of Messages: 16 Number of Information Messages: 14 Number of Warning Messages: 2 Number of Error Messages: 0	
]	Pier Alternative: 3-column pier 3-column pier (Frame Pier Alternative) Column1 (Column) Warning: Existing foundation alternative not defined for foundation. Warning: Current foundation alternative) No errors or warnings. Column2 (Column) Existing foundation alternative: Copy of Foundation Alt 1 Current foundation alternative: Copy of Foundation Alt 1 Copy of Foundation alternative: Copy of Foundation Alt 1 Copy of Foundation alt 1 (Foundation Alternative) No errors or warnings. Column3 (Column) Existing foundation alternative: Copy of Foundation Alt 1 Corrent foundation alternative: Copy of Foundation Alt 1 Corrent foundation alternative: Copy of Foundation Alt 1 Corrent foundation alternative: Copy of Foundation Alt 1 Current foundation alternative: Copy of Foundation Alt 1 Current foundation alternative: Copy of Foundation Alt 1 Copy of Foundation alternative: Copy of Foundation Alt 1 Copy of Foundation alternative: Copy of Foundation Alt 1 Copy of Foundation Alt 1 (Foundation Alt 1) No errors or warnings.	
	Continue spec check Cancel spec check	

The Substructure analysis progress window opens showing the analysis log. Once the analysis the complete, click

the **OK** button to close this window.

A Substructure analysis progress	×
<ul> <li>Location - 13.3219 (ft)</li> <li>Location - 13.7500 (ft)</li> <li>Location - 13.2450 (ft)</li> <li>Location - 13.248 (ft)</li> <li>Location - 31.3300 (ft)</li> <li>Component 3 of 6 - Columna</li> <li>Location - 17.5800 (ft)</li> <li>Location - 59read Footing</li> <li>Location - 59read Footing</li> <li>Location - Footing Longitudinal Moment Section</li> <li>Location - Footing Longitudinal Moment Section</li> <li>Location - Footing Longitudinal Shear Section</li> <li>Location - Footing Longitudinal Moment Section</li> <li>Location - Footing Longitudinal Shear Section</li> <li>Location - Footing Longitudinal Moment Section</li> <li>Location - Footing Transverse Moment Section</li> <li>Location - Footing Transverse Mean Section</li> <li>Location - Column Punching Shear Section</li> <li>Location - Column Punching Shear Section</li> <li>Location - Column Punching Shear Section</li> <li>Location - Footing Transverse Mean Section</li> <li>Location - Footing Transverse Mean Section</li> <li>Location - Footing Transverse Shear Section</li> <li>Location - Footing Transverse Mean Section</li> <li>Location - Footing Transverse Mean Section</li> <li>Location - Soutian - Column Punching Shear Section</li> <li>Location -</li></ul>	
3	Print OK

Specification check results can be reviewed by clicking the Specification Check Detail button from the Results group

of the SUBSTRUCTURE DESIGN ribbon. The window shown below will open.



	Articles								
9	Generate	All articles	$\sim$						
Properties		Format Bullet list	~						
pecification filter		Report							
🔺 🚞 Pier Component			Specification	n reference	Limit State	Flex. Sense	Pass/Fail		
🕨 🚞 Cap			5.10.8 Shrinkage and Temperature Reinforcement			N/A	Passed		
🔺 🚞 Column1		5.4.2.5	Poisson's Ratio		N/A	General Com	р.		
<ul> <li>0.00 ft.</li> <li>9.29 ft.</li> <li>13.32 ft.</li> <li>13.75 ft.</li> <li>15.29 ft.</li> </ul>		<ul> <li>5.4.2.6 Modulus of Rupture</li> <li>5.7.2.2 Rectangular Stress Distribution</li> <li>5.7.4.2 Limits for Reinforcement</li> <li>5.7.4.5 Biaxial Flexure</li> <li>5.8.2.1 Torsion</li> </ul>			N/A	N/A General Con	р.		
					N/A	N/A General Comp			
					N/A	Passed			
					N/A	Passed			
					N/A	Passed			
18.21 ft. 31.33 ft.			<ul> <li>5.8.2.5 Minimum Transverse Reinforcement</li> <li>5.8.2.7 Maximum Spacing of Transverse Reinforcement</li> </ul>			N/A	Passed		
						N/A	Passed		
Column2		✓ 5.8.3.3	Nominal Shear Resistance		N/A	Passed			
Column3     Column1:Foundation Alt 1			5.8.3.4	Procedures for Determining Shear Resistance		N/A	General Com	р.	
Column2 Column3 Column3	Copy of Foun Copy of Foun	dation Alt 1 dation Alt 1							

Specification checks are performed at the following locations in Column 1.

The focus is primarily on the following points:

- 1. The 0.00 ft location is the base of the column in BrDR which is the point of fixity for the drilled shaft segment.
- 2. The 13.75 ft location is the interface of the column and drilled shaft segment.

The remaining points are the locations where the reinforcement achieves full development.

The specification check at the point of fixity is shown below.

