AASHTOWare BrDR 7.5.0 Substructure Tutorial Pier3 - Modify Footing Example







## BrDR Substructure Tutorial

### Pier 3 – Modify Footing Example

This example modifies one of the spread footings in the BID20 example provided with the sample database to be a drilled shaft foundation. The BrDR substructure unit can perform a soil-structure interaction analysis. An example describing the analysis can be found in 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. A point of fixity found from an outside source, such as LPile or COM624 can be entered as the base of the drilled shaft in BrDR. BrDR can then perform a finite element analysis and specification check of the pier considering that point of fixity.

From the **Bridge Explorer**, using the Import button, import the Pier 3 xml provided with the **Pier3 Frame Pier** tutorial. The partially expanded **Bridge Workspace** tree is shown below.



### Column Properties – Pier1 – 3 Column Frame

Double click on Column1 node in the Bridge Workspace (BWS) tree as shown below.



Uncheck the checkboxes Existing and Current in this window as shown below.

<b>A</b> (	Colu	mn Prope	rties -Pier1	- 3 Column Frame				-		×
Nam	ne:	Column1								
	)esc	ription	Additiona	al loads						
		Existing	Current	Foundation alternative name	Description					
ſ	>			12x12 Footing						
	Expo	osure facto	or: 1							
						OK	Ap	ply	Cance	el

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

### Foundation Alternative

Double click on **FOUNDATION ALTERNATIVES** node and the **New Foundation Alternatives Wizard** opens. Select the **Single Drilled Shaft** option and click **Next**.



New Foundation	Alternative Wizard						×
	Туре:	Drilled-Shaf	t Foun	dation			
	Name:	Drilled Shaft					
	Description:						
	Units:	US Customar	у	$\sim$			
	Top of shaft elevation:	53.75	ft				
	Bottom of shaft elevation:	40	ft				
	Shaft diameter:	4	ft				
	Shaft material:	Class A (US)	$\sim$				
	Rock socket:						
	Bottom of socket elevation:		ft				
	Socket diameter:		ft				
	Socket material:	Class A (US)					
		< Ba	ck	Fir	iish	Cancel	Help

Enter the following description of the foundation and click **Finsh**.

The Foundation Properties window opens. Click **OK** to add this foundation alternative and close the window.

Foundation Prop	perties-Pier1-3	Column Fra	me-Column1				-		×
lame: Drilled Sh	aft		Founda	ation type:	Drilled-Shaft Foundation				
Description	Soil User p	-y curves	User t-z curves	User q-w	/ curves				
Description:				Ur	its: US Customary V	·			
Shaft material:	Class A (US)		~		Consider axial loading				
	Rocket so	cket							
Socket material:	Class A (US)								
Steel casing									
Include	steel casing				Casing runs entire length of shat	ft (excluding rocket socket)			
Casing mate	rial:	ASTM A57	'2 - 1" max, Fy = 60	k ∨ T	op of casing elevation:	ft			
Corroded ca	sing thickness:		in	E	lottom of casing elevation:	ft			
						OK	Apply	Canc	el

### Drilled Shaft Geometry

Expand the **Drilled Shaft** foundation alternative. Double click on **Geometry** to open the **Drilled Shaft Geometry** window to view the geometry data. The drilled shaft point of fixity is at 40'.



### **Reinforcement Definitions**

Double click on **Reinforcement Definitions** node to open the **Drilled Shaft Reinforcement Def** window and click on the **Generate pattern** button to open the **Generate Pattern Wizard** window as shown below.

BRIDGE WORKSPACE     WORKSPACE     TOOLS     VEW     DESIGN/RATE     DESIGN/RATE     DESIGN/RATE     DESIGN/RATE       Profinition// Generate     Load     Analyze     Specification     Profinition	Bridge Workspace - LRFD Substructure Example 1 AN	ALYSIS SUBSTRUCTURE REPORTS	5	? – 🗆 ×
Image:	BRIDGE WORKSPACE WORKSPACE TOOLS VIEW DESI	GN/RATE DESIGN REPORTIN	IG	
Analysis       Beaults         Workspace       Image: Components         Bridge       Components         Bridge       Components         Bridge       Components         Bridge       Supress/Structuruses         Bridge       Bridge         Bridge       Components         Bridge       Bridge         Bridge       Supress/Structuruses         Bridge       Column Frame (B) (C)         Bridge       Secondary         Bridge       Column Frame (B) (C)         Bridge       Column Frame (B) (C)         Bridge       Column Frame (B) (C)         Bridge       Secondary         Bridge       Column Frame (B) (C)         Bridge       Column Frame (B	Preliminary Generate Load Load Analyze Specification Model Combinations Palette Substructure Check	Tabular Specification Results Check Detail Outputs Graph	Soil Schematic	
Workspace         Bridge       Components         Outled Shaft Reinforcement Definitions         PIER ALTERNATIVES         PIER TOWNDATION ALTERNATIVES         PIER ALTERNATIVES         PIER ALTERNATIVES         PIER ALTERNATIVES         PIER ALTERNATIVES	Analysis	Results		
Birdge Components   A Continuous span steel bindge   A Continuous span steel bindge   Bar	(	A Drilled Shaft Reinforcement Def - P	ier1 - 3 Column Frame - Column1	– – ×
Bundle bars Bundle bars Bundl	Workspace Bridge Components		Name:	
Bar Bar Material X V (in) (in) (in) (in) (in) (in) (in) (in)	Continuous span steel bridge     A Training Alt	±V	Bundle bars	
Image: Second state pattern         Image: Second state pattern <th>SUPERSTRUCTURES      Ht Stiffness Analysis</th> <th><b>A</b></th> <th>Bar Material X size (in)</th> <th>Y (in)</th>	SUPERSTRUCTURES      Ht Stiffness Analysis	<b>A</b>	Bar Material X size (in)	Y (in)
		J Sta Ahead		New Duplicate Delete OK Apply Cancel

### Enter the data shown below and click **OK**.

🕰 Generate Pattern Wi	zard							×
Pattern name:	Drilled Shaf	t Bars	Bundle type	Bar size:	10 🗸			
Drilled shaft segment:	Shaft	~	O Single	Material:	Grade 60		~	
Segment cross section:	Rou	ind	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

	Name:	Drille	d Shaft	Bars						
	Bu	ndle ba	ars							
	B	ar	Bar size	Material		X (in)	Y (in)			
1		10	~	Grade 60	~	20.865	0			A
··+×	2	2 10	~	Grade 60	~	18.06962	-10.4325			
1	3	3 10	~	Grade 60	~	10.4325	-18.06962			
/	1	4 10	~	Grade 60	~	0	-20.865			
	-	5 10	$\sim$	Grade 60	~	-10.4325	-18.06962			
	(	5 10	~	Grade 60	~	-18.06962	-10.4325			
	-	7 10	~	Grade 60	~	-20.865	0			
	\$	3 10	~	Grade 60	~	-18.06962	10.4325			
	9	9 10	~	Grade 60	~	-10.4325	18.06962			
	1	0 10	~	Grade 60	~	0	20.865			
	1	1 10	~	Grade 60	~	10.4325	18.06962			
	> 1	2 10	~	Grade 60	~	18.06962	10.4325			
							New	Duplicate	Delete	
							OK	Apply	Cancel	

Uncheck the **Bundle bars** checkbox and click **OK** to save the reinforcement definitions and close the window.

### Reinforcement

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

Shear										
Set	Start distance (ft)	Straight length (ft)	End distance (ft)	Pattern	Hook at start	Hook at end	Developed at start	Developed at end		
1	0	13.75	13.75	Drilled Shaft Bars 🗸			<ul> <li>Image: A set of the set of the</li></ul>			
							New	Dupl	cate	Delete
							New	Dupl	cate	Delete
	Set 1	Set distance (ft) 1 0	Setdistance (ft)length (ft)1013.75	Setdistance (ft)length (ft)distance (ft)1013.7513.75	Setdistance (ft)length (ft)distance (ft)Pattern1013.7513.75Drilled Shaft Bars	Set     distance (ft)     length (ft)     distance (ft)     Pattern     Hook at start       1     0     13.75     13.75     Drilled Shaft Bars	Set     distance (ft)     length (ft)     distance (ft)     Pattern     Hote at start     Hote at end       1     0     13.75     13.75     Drilled Shaft Bars     Image: Comparison of the start     Image: Comparison of the star	Set     distance (ft)     length (ft)     distance (ft)     Pattern     Hook at start     Hook at end     Developed at start       1     0     13.75     13.75     Drilled Shaft Bars     Image: Comparison of the start     Image: Comparison of the start	Set     distance (ft)     length (ft)     distance (ft)     Pattern     Hook at start     Developed end     Developed at start       1     0     13.75     13.75     Drilled Shaft Bars     Image: Comparison of the start     Image: Comparison of the start	Set     distance (ft)     length (ft)     distance (ft)     Pattern     Hook at start     Hook at end     Developed at start     Developed at end       1     0     13.75     13.75     Drilled Shaft Bars     Image: Comparison of the start     Image: Comp

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

exu	ral Sh	ear	inent - Fierr -	3 Column Fram	ie - Colum	nn I	— U
- s	hear reinf	orcemer O Sp	nt type	pirals designed	as ties		
	Bar size	Pitch (in)	Material	Start distance (ft)	Length (ft)	End distance (ft)	
>	4 ~	3	Grade 60	~ 0	32.08	32.08	

Navigate to the Shear tab of this window and enter the shear reinforcement in the drilled shaft as shown below.

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

The overlap of spirals at the column-drilled shaft connection is a detailing requirement that can be ignored in this BrDR description.

#### Schematic – Pier Alternative

While selecting the pier alternative **3 Column Frame**, click on the **Schematic** button from the **SUBSTRUCTURE DESIGN** ribbon (or right click and select **Schematic**) to view the schematic of this pier alternative as shown below.





## Specification Check

The pier needs to be analyzed first to perform a specification check. The program is configured to perform a specification check after revising geometry or reinforcement without the need to perform finite element analysis each time a change is made. This capability allows a quick refinement of the reinforcement and geometry. However, in this case a significant change has been made to pier by extending the length of Column1 to include a drilled shaft. If the specification check is performed without redoing the FE analysis, it will result in an error that the existing FE model does not match the pier structure.

Therefore, in this case, the pier will be analyzed first. Select the **3 Column Frame** and click on the **Analyze Substructure** button from the **Analysis** group of the **SUBSTRUCTURE DESIGN** ribbon as shown below.



## Schematic – Pier Alternative

The FE model generated by the program is shown below.



### Specification Check

Select the **3** Column Frame and click on the Specification Check button from the Analysis group of the SUBSTRUCTURE DESIGN ribbon as shown below.



To view the specification check results, click on the **Specification Check Detail** button from the **Results** group of the **SUBSTRUCTURE DESIGN** ribbon. The specification checks performed in the following locations in **Column 1** are shown below.

Bridge Workspace - LRFD Substructure	Example 1 AN	ALYSIS SUBSTRUCTU	RE REPORTS	?	-	o x	
BRIDGE WORKSPACE TO	DLS VIEW DESI	GN/RATE DESIGN	REPORTIN	G			
Preliminary Generate Load Load Model Combinations Palette Su	Analyze Specification bstructure Check	Tabular Specification Results Check Detail	Engine Results Dutputs Graph	Soil Schem	Datic		
Analysis		Res	ults				
Specification Checks for 2 Column Frame	10 of 669						×
- specification checks for 5 Column Plane -	10 01 005						^
Articles							
All articles							
Properties Generate Format	~						
Specification filter Report							
🔺 🚞 Pier Component	Specification refere	ence		Limit State	Flex. Sense	Pass/Fail	
🕨 🚞 Cap	5.4.2.5 Poisson	's Ratio			N/A	General C	omp.
Column1	B 5.4.2.6 Modulu	is of Rupture			N/A	General C	omp.
Column2	🗎 5.7.2.2 Rectan	gular Stress Distribution			N/A	General C	omp.
Column3	× 5.7.4.2 Limits f	or Reinforcement			N/A	Failed	
Column1:Drilled Shaft	✓ 5.7.4.5 Biaxial	Flexure			N/A	Passed	
0.00 ft.	✓ 5.8.2.1 Torsion				N/A	Passed	
10.77 ft.	✓ 5.8.2.5 Minimu	im Transverse Reinforcem	ent		N/A	Passed	
🔄 15.75 π.	✓ 5.8.2.7 Maxim	um Spacing of Transverse	Reinforcement		N/A	Passed	
Column2:12x12 Footing	🗙 5.8.3.3 Nomina	al Shear Resistance			N/A	Failed	
Column3:12x12 Footing	5.8.3.4 Proced	ures for Determining She	ar Resistance		N/A	General C	omp.

The 0.00 ft location is the base of the column in this example which is the point of fixity for the drilled shaft segment. The 13.75 ft location is the interface of the column and drilled shaft segment.

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

📲 Spec Ch	heck Detail f	or 5.7.4.5 Biaxial Fle	exure													-	n ×
5 Concr 5.7 Mat 5.7.4 C 5.7.4.4 5.7.4.5 (AASHTO	ete Struc erial Pro Compressio Axial Re Biaxial D LRFD Bri	ctures operties on Members esistance Flexure idge Design Sp	ecifica	tions, Fift	h Edition -	2010,	with 2010 i	nterims)									
Pier Dr	illed Sha	aft Section - 3	At Loca	tion = 13.7	500 (ft) - E	Bottom											
Cross S	Section Pr	roperties for	circula	r column													
f'c Diamete Area Axial P Flexura	= er = Phi = al Phi =	4.00(ksi) 48.00(in) 1809.19(in^2) 0.75 0.90															
Flexura	l Reinfor	rcement															
Rebar	As (in^2)	X (in)	Y (in)	Rebar	As (in^2)	X (in)	Y (in)	Rebar	As (in^2)	X (in)	Y (in)						
Steel C	asing Mod	deled as Flexu	ral Rei	nforcement													
Pabar	λ	v		Debar	۸e	v	~	Pehar	7.9	v	v						
Repar	(in^2)	(in)	(in)	Rebar	(in^2)	(in)	(in)	Rebai	(in^2)	(in)	(in)						
Limit S	State	Load		Pukin	Mux kip-ft		Muy kip-ft	Mur kip-ft	Alpha	Phi	Phi * Pn kip	Phi * Mnr kip-ft	Mnr/Mur	de	dv in	h	
STR-I STR-I		37 38		1026.09	-40.54		-5.34	40.89 41.23	187.50 187.32	0.75	1026.16	1389.84 1395.85	33.99 33.86	24.00	34.56	48.00	
STR-I		37		1026.09	-40.54		-5.34	40.89	187.50	0.75	1026.16	1389.84	33.99	24.00	34.56	48.00	
STR-1 STR-I		30		747.38	5.44		-4.63	7.15	319.61 319.27	0.75	600.72 747.41	933.69	99.00	24.00	34.56	48.00	
STR-I		93		878.81	5.44		2.03	5.81	20.46	0.75	878.73	1248.22	99.00	24.00	34.56	48.00	
STR-I		61		403.39	5.44		-0.93	5.52	350.29	0.75	403.38	669.83	99.00	24.00	34.56	48.00	
STR-I		109		663.08	-50.76		1.77	50.79	178.01	0.75	663.10	1009.88	19.88	24.00	34.56	48.00	
STR-I STR-T		53		809.70	-64.63		2.29	64.67 51.43	177.97	0.75	809.70	1176.04	18.19	24.00	34.56	48.00	
STR-I		54		816.49	-65.31		2.38	65.35	177.91	0.75	816.46	1183.28	18.11	24.00	34.56	48.00	
STR-I		110		669.87	-51.39		1.82	51.43	177.98	0.75	669.83	1017.90	19.79	24.00	34.56	48.00	
STR-I STR-I		98 42		769.02 915.59	-97.92		5.31	47.71	173.61	0.75	768.98 915.62	1285.24	23.72	24.00	34.56	48.00	
STR-I		100		765.62	-47.16		5.25	47.45	173.64	0.75	765.59	1127.90	23.77	24.00	34.56	48.00	
STR-I		44		912.20	-58.56		6.53	58.93	173.63	0.75	912.19	1281.84	21.75	24.00	34.56	48.00	
STR-1 STR-T		100		765.62	-47.16		5.25	47.45	173.64	0.75	765.59	933.69	23.77	24.00	34.56	48.00	
STR-I		40		1029.48	-40.72		-5.30	41.06	187.41	0.75	1029.49	1392.84	33.92	24.00	34.56	48.00	
STR-I		86		600.71	5.44		-4.63	7.15	319.61	0.75	600.72	933.69	99.00	24.00	34.56	48.00	
STR-I		37		1026.09	-40.54		-5.34	40.89	187.50	0.75	1026.16	1389.84	33.99	24.00	34.56	48.00	
STR-I STR-I		30		747.38	5.44		-4.63	7.18	319.61	0.75	747.41	1107.61	99.00	24.00	34.56	48.00	
STR-I		93		878.81	5.44		2.03	5.81	20.46	0.75	878.73	1248.22	99.00	24.00	34.56	48.00	
STR-I		93		878.81	5.44		2.03	5.81	20.46	0.75	878.73	1248.22	99.00	24.00	34.56	48.00	
A11 28	load case	54 es evaluated p	assed (	816.49 Capacity ra	-65.31 tio >= 1.0)		2.38	65.35	177.91	0.75	816.46	1183.28	18.11	24.00	34.50	48.00	
																	ОК