# AASHTOWare Bridge Design Training - (BrD 6.4) - Drilled Shaft

## **Topics Covered**

- Drilled Shaft Definition
- Drilled Shaft Reinforcement
- Drilled Shaft Analysis Control

🗟 Bridge Explorer (24 Virtis/	Opis brid	dges	retrieved for the current folder, al	l rows retrieve	ed)											×
All Bridges		BID	Bridge Id	Bridge Name	District	County	Facility	Location	Route	Feat. Intersected	Mi. Post (mi)	Owner	Maintainer	Area	Length (ft)	Built
Deleted Bridges		1	TrainingBridge1	Training Brid	11	01	SR 005	Pittsburg	0051	SR 6060	17.00	1	1	-2	161.00	999
Deleted Bridges		2	TrainingBridge2	Training Brid	-1	-1	N/A	N/A	-1	N/A	0.00	-1		-1	0.00	996
		3	TrainingBridge3	Training Brid	11	01	I-79	Pittsburg	0079	Ohio River	125.00	1	1	-1	455.00	999
-		4	PCITrainingBridge1	PCI TrainingB					-1		0.00			-1	0.00	0
		5	PCITrainingBridge2	PCITrainingBr					-1		0.00			-1	0.00	0
		6	PCITrainingBridge3	PCI TrainingB					-1		0.00			-1	0.00	0
		7	PCITrainingBridge4	PCITrainingBr					-1		0.00			-1	0.00	0
		8	PCITrainingBridge5	PCI TrainingB					-1		0.00			-1	0.00	0
		9	PCITrainingBridge6	PCITrainingBr					-1		0.00			-1	0.00	0
		10	Example7	Example 7 PS					-1		0.00			-1	0.00	0
		11	RCTrainingBridge1	RC Training B					-1		0.00			-1	0.00	0
		12	TimberTrainingBridge1	Timber Tr. Bri					-1		0.00			-1	0.00	0
		13	FSys GFS TrainingBridge1	FloorSystem	06	15	NJ-Tur	NJCity	-1		0.00			-1	0.00	002
		14	FSys FS TrainingBridge2	FloorSystem	11	333	1-95	NYC	-1		0.00	1	2	-1	0.00	998
		15	FSys GF TrainingBridge3	FloorSystem	07	06	1-95	ATL	-1		0.00	2		-1	0.00	998
		16	FLine GFS TrainingBridge1	FloorLine GF	01	01	1-75	JAX	-1		0.00	1	1	-1	0.00	001
		17	FLine FS TrainingBridge2	FloorLine FS	02	02	I-75	GNV	-1		0.00	1	1	-1	0.00	000
		18	FLine GF TrainingBridge3	FloorLine GF	01	01	1-95	NY	15		2200.00	2	-1	-1	0.00	999
		19	TrussTrainingExample	Truss Trainin					5		0.00				0.00	930
		20	LRFD Substructure Example 1	LRFD Substr							0.00				0.00	0
		21	LRFD Substructure Example 2	LRFD Substr			SR 403	ERIE CO	4034	FOUR MILE	8.12				095.80	002
		22	LRFD Substructure Example 3	LRFD Substr							0.00				0.00	0
		23	LRFD Substructure Example 4	LRFD Substr					-1		0.00				240.00	004
		24	Visual Reference 1	Visual Refer	01	12	I-76	WAITSFI	1-76	MAD RIVER	1199.25	1	1	-1	168.00	938

### Fig 1. Bridge Explorer

From the Bridge Explorer (Fig 1) select LRFD Substructure Example 1(BID20) and double click (or right click and select open) to open it.

Once Bridge Workspace tree shows up expand "PIERS" under "BRIDGE ALTERNATIVES"- "2 Span Bridge (E)(C)" by clicking on "+". Then expand "pier 1" and select "3 – column pier (E)(C)" under "PIER ALTERNATIVES".

Expand "3 – column pier (E)(C)" by clicking on "+" and select "Column1" under COLUMNS. Select "FOUNDATION ALTERNATIVES" and expand it. Now the Bridge Workspace tree will be as shown in Fig 2.



Fig 2. Bridge Workspace Tree – Foundation Alternatives

Double click on "FOUNDATION ALTERNATIVES" to open New Foundation Alternative Wizard window (Fig 3).

Fig 3. New Foundation Alternative Wizard Window

Select Single Drilled Shaft alternative and click on "Next" button. Enter the data on next window as shown in (Fig 4).

New Foundation Alternative Wizard	-	x
Type: Name:	Drilled-Shaft Foundation 4' Drilled Shaft	
Description:		
Units:	US Customary 53.75 ft	
Bottom of shaft elevation:	30.00 ft	
Shaft diameter: Shaft material:	4.00 ft Class A (US)	
Rock socket		
Bottom of socket elevation:	ft	
Socket diameter:	Class A (US)	
Socket material:		
	< Back Finish Cancel Help	

Fig 4. New Foundation Alternative Wizard Window

Click on "Finish" button to save and close the window. Once "Finish" button has been clicked Foundation Properties window (Fig 5) will pop up. On Foundation Properties window go to Soil tab enter Water Elevation as 40 ft. Click on "New" button to add a new row for Soil Profile. Add two new rows and enter the data as shown in Fig. 6. Click on "OK" button to save and close the window.

🕰 Foundation Properties - Pier 1 - 3-column pier - Column1	- • •
Name: 4" Drilled Shaft Foundation type: Drilled-Shaft Foundation	
Description Soil User p-y Curves User t-z Curves User q-w Curves	
Description:	
Shaft material: Class A (US)   Rock socket  Socket material: Class A (US)  The socket	
Socket materia: Udoss A (US)	
Steel Casing	
Casing runs entire length of shaft (excluding rock socket)	
Casing material: ASTM A572 - 1" max, Fy = Top of casing elevation:	
Corroded casing thickness: in Bottom of casing elevation: ft	
	Cancel

# Fig 5. Foundation Properties Window

If the 'Consider axial loading' box is checked, the analysis will consider the axial loading (t-z, q-w curves) of the shaft in addition to the lateral loading (p-y curves). If the box is not checked, the analysis will only consider the lateral loading (p-y curves) of the shaft.

Enter the following data to describe the soil profile.

Finished groundline elevation: 54.50 ft Finished groundline slope: Degrees Water elevation: 40.00 ft Nominal end bearing: Ksf ioil Profile Loading Type © Static © Cyclic Number of cycles: Layer Curve Type User Defined Name Top Bottom Elevation (ft) (kcf) Ckcf) Strain50 Phi (kcf) k F Nominal Unit Side Resistance (ft) (kcf) (kcf) (kcf) (kcf) (kcf) (kcf) (kcf) (kcf) (kcf) (ksf) (kcf) (ksf)	Finished groundline elevation: 54.50 ft Finished groundline slope: Degrees Water elevation: 40.00 ft Nominal end bearing: Ksf Nominal end bearing: Ksf Loading Type © Static © Cyclic Number of cycles: Layer Curve Type User Defined Name Elevation (th) Elevation (kcf) Density (kcf) (ksf) Strain50 Phil (kcf) A F Nominal (kcf) (kcf) (kcf) (ksf) (kcf) (ksf) (kcf) (ksf)	inished g oil Profile Loadin () S	groundline ele Water ele ng Type	vation: 54.50 vation: 40.00	ft ft	Finished gro Nomina	oundline slope:		legrees					
Loading Type       © Cyclic       Number of cycles:         Layer       Curve Type       User Defined Name       Top Elevation (ft)       Bottom (ker)       Soil Density (ker)       Saturated Density (ker)       C (ksf)       Strain50       Phi (Degrees)       k (kcf)       A       F       Nominal Unit Side Resistance         1       Sand       54.500       40.000       0.100       30.00       69.120       itemation         2       Sand       40.000       10.000       0.600       35.00       69.120       itemation	Loading Type	oil Profile Loadin () S	ng Type				ar onto beaninty.	k	sf					
Layer         Curve rype         Uses defined name (ft)         Levalue (ft)         Densy (kcf)         Uses defined name (kcf)         Stransu (kcf)         Stransu (kcf)         Stransu (kcf)         M         P         Resistance (ksf)           1         Sand          54.500         40.000         0.100          30.00         69.120          (ksf)           2         Sand          40.000         10.000         0.600         35.00         69.120	Layer         Curve type         Ose beined value         Levalue         Clevalue		Static 🔘	Cyclic Number of c	ycles:	Bottom	Soil	Saturated	с	Steele F	Phi	k		Nominal Unit Side
		1 S	Sand v		(ft) 54.500	(ft) 40.000	(kcf) 0.100	(kcf)	(ksf)	StrainSU	(Degrees) 30.00 35.00	(kcf) 69.120 69.120	~ '	Resistance (ksf)
		2 S	Sand 💌		40.000	10.000		0.600			35.00	69.120		
												New	Duplic	ate Delete

#### Fig 6. Foundation Properties Window – Soil Tab

The Nominal end bearing and nominal unit side resistance data are only required if you have chosen to consider the axial loading in the shaft analysis.

Soil resistance curves (p-y, t-z, q-w curves) will be developed based on the data entered here in accordance with procedures specified in the FHWA report "Handbook on Design of Piles and Drilled Shafts Under Lateral Load" and AASHTO LRFD 10.8.2.2.2.

The user also has the ability to enter user defined soil curves.

Graphical plots of computed and user entered soil curves will be available in the software.



Fig 7. Bridge Workspace Tree – 4' Drilled Shaft

After Drilled Shaft has been defined, a 4' Drilled Shaft has been added to the Bridge Workspace tree as shown in Fig. 7. Expand 4' Drilled Shaft by clicking on "+". Under "4' Drilled Shaft" select and double click on "Geometry" to open Drilled Shaft Geometry window (Fig 8).



Fig 8. Drilled Shaft Geometry Window

Click on "OK" button to save and close the window.

Select and double click on Reinforcement Definitions to open Reinforcement Definition window (Fig 9). On this window click on "Generate Pattern" button to open Generate Pattern Wizard (Fig 10).

Control Contro	r 1 - 3-o	olumn pie	r - Column1			8
_+Y	Name :	lle bars				
T +X Sta Ahead	Bar	Bar Size	Material	X (in)	Y (in)	
Generate Pattern			New	Duplicate	Delete	,
			ОК	Apply	Cance	:

Fig 9. Drilled Shaft Reinforcement Definition Window

Generate Pattern Wizard		10.00		×
Pattern name:	15#10bars	Bundle Type Single	Bar size:	10 •
Drilled shaft segment:	Shaft 🔻	<ul> <li>2 Parallel</li> <li>2 Perpendicular</li> </ul>	Material:	Epoxied Grade 60 🔹
Segment cross section:	Round	🔘 3 Bar	Clear cover:	3.5000 in
Top/Bottom:	Тор 👻		Number of bars:	15
Overall trans width:	48.0000 in			
Overall long width:	48.0000 in			Apply Cancel

Fig 10. Generate Pattern Wizard

On Generate Pattern Wizard window enter data as shown in Fig 10 and click on "Apply" button. Once "Apply" button is clicked reinforcement will be populated on Reinforcement Definition window (Fig 11).

🕰 Drilled Shaft Reinforcement Def - Pier 1 - 3-column pier - Column1								
,+Y	Name :	: 15#1 dle bars	ЮБа	ars				
T	Bar	Bar S	ize	Material		X (in)	Y (in)	
/ +X	1	10	٠	Epoxied Grade 60	-	19.865	0.000	
	2	10	-	Epoxied Grade 60	-	18.148	-8.080	
$  \langle \langle \cdot \rangle \rangle = i - j$	3	10	-	Epoxied Grade 60	-	13.292	-14.763	
	4	10	-	Epoxied Grade 60	-	6.139	-18.893	
	5	10	•	Epoxied Grade 60	-	-2.076	-19.756	
	6	10	•	Epoxied Grade 60	-	-9.932	-17.204	
	7	10	-	Epoxied Grade 60	-	-16.071	-11.676	
T four thread	8	10	-	Epoxied Grade 60	-	-19.431	-4.130	
ISta Anead	9	10	-	Epoxied Grade 60	-	-19.431	4.130	
L L	10	10	-	Epoxied Grade 60	-	-16.071	11.676	
	11	10	-	Epoxied Grade 60	-	-9.932	17.204	
	12	10	-	Epoxied Grade 60	-	-2.076	19.756	
	13	10	-	Epoxied Grade 60	-	6.139	18.893	
	14	10	-	Epoxied Grade 60	-	13.292	14.763	
	15	10	Ŧ	Epoxied Grade 60	-	18.148	8.080	
				New		Duplicate	Delete	•
Generate Pattern				ОК		Apply	Cance	-

Fig 11. Reinforcement Definition Window

Now click on "OK" button to save and close the Drilled Shaft Reinforcement Definition Window.



Fig 12. Bridge Workspace Tree - Reinforcement Definition

Now we can see 15#10bars reinforcement definition has been add to the Bridge Workspace tree. To apply this reinforcement definition to drilled shaft, double click on "Reinforcement" to open Drilled Shaft Reinforcement window.

•	A Drilled Shaft Reinforcement - Pier 1 - 3-column pier - Column1											
	Flex	ural	Shear									
	s	Set	Start Distance (ft)	Straight Length (ft)	End Distance (ft)	Pattern		Hook at Start	Hook at End	Developed at Start	Developed at End	
		1	0.167	23.417	23.584	15#10bars	-					
	,								N	ew	Duplicate	Delete
										OK	Apply	Cancel

Fig 13. Drilled Shaft Reinforcement Definition Window – Flexure Tab

Enter data on Drilled Shaft Reinforcement Definition Window – Flexure Tab as shown in Fig 13. Now go to Shear tab and enter data as shown in Fig. 14. Click on "OK" button to save and close the window.

<b>A</b>	Drilled Sha	aft Reinfo	orcement - Pier 1	L - 3-column	pier - Colum	n1	
	Flexural S	hear					
	Shear R Ties	einforcem ()	ent Type Spirals 🔘 S	Spirals designe	d as ties		
	Bar Size	Pitch (in)	Material	Start Distance (ft)	Length (ft)	End Distance (ft)	
	4 💌	3.00	Grade 60 💌	0.167	23.417	23.584	
						Ne	w Duplicate Delete
							OK Apply Cancel

Fig 14. Drilled Shaft Reinforcement Definition Window - Shear Tab

Select and double click on Analysis Control in the Bridge Workspace tree to open Drilled Shaft Analysis Control window. On this window on FE Control tab enter the data as shown in Fig 15.

Uonsider shaft non-linear (cracked) stiffness	Target FE element length: 2.00 ft	
FE Analysis Control	Additional Points of Interest	
Maximum number of iterations: 20	Default nodes are located at column/shaft interface,	
Convergence tolerance: 0.001 in	shaft/rock socket interface, bottom of shaft/rock socket, and groudline elevation.	
Excessive shaft head deflection: 30.000 in	Elevation (ft)	
Output		
Produce output at:		
At user-defined points		
FE Nodes		
Every node		
Every other node		
Every third node		
Every fourth node	New Duplicate Delete	
Every fifth node		

Fig 15. Drilled Shaft Analysis Control Window - FE Control tab

Convergence tolerance: when the maximum change in deflection at any node for successive iterations is less than this value, iteration stops.

Excessive shaft head deflection: the value of deflection at the top of the shaft that is considered grossly excessive and stops the analysis.

🕰 Drilled Shaft Analysis Control	
FE Control Ultimate Moment	
Produce ultimate moment capacity output at: For axial	oads:
Elevation (ft) 45.00	oad ) 0
New Duplicate Delete New	Duplicate Delete
	OK Apply Cancel

Fig 16. Drilled Shaft Analysis Control Window - Ultimate Moment tab

Go to the Ultimate Moment tab and enter data as shown in Fig. 16. To add a new row to Elevation and Axial Load column click on "New" button under corresponding columns. Click on "OK" button to save and close the window.

This tab allows the user to specify locations where the ultimate moment capacity output is desired. At a location and for a specified axial load, the following ultimate moment capacity output will be generated:

- 1. Report containing moment capacity, EI, curvature, maximum strain, neutral axis location
- 2. Results graphs showing moment vs. curvature, EI vs. moment

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