
EXAMPLE 13 - VEHICLE COLLISION ON A PIER

GENERAL INFORMATION

Example 13 illustrates pier design to provide structural resistance to withstand the vehicular collision using LEAP Bridge Substructure software. The only load case investigated in this example is Extreme Event II. Other load cases are not discussed for this example but should be investigated in the complete pier design.

References and Software Used:

AASHTO LRFD 8th edition

CDOT Bridge Structural Worksheets

LEAP Bridge Concrete CONNECT Edition, Version 16.02.00.01, Substructure Module

LEAP Bridge Concrete Model Description:

The pier under design is a middle support of a two-span, 60-ft.-wide (out to out) bridge. Pier cap is 60 ft. long, 4.5 ft. wide, and 4 ft. deep, supported on three 20 ft. tall columns, spaced at 22 ft. The superstructure consists of six BT54 girders spaced at 10.5 ft. with an 8 in. deck. Columns are round, 4 ft. in diameter, supported on drilled shafts, 4.5 ft. in diameter. Refer to Figure 1 for details.

The following were also assumed in modeling the pier in the LEAP Bridge Substructure program:

- The end of the column is fixed at the top of the drilled shaft
- The drilled shaft point of fixity is located at 3x drilled shaft diameter = 13.5 ft.
- Total drilled shaft length is 5x drilled shaft diameter = 23 ft.

The Designer should use the project geotechnical information and a suitable design tool to determine the drilled shaft point of fixity and required drilled shaft total length and enter it in the LEAP Bridge Substructure program.

Material properties used (refer to BDM Section 5.3):

Pier cap concrete strength	$f'_c =$	4500.00	psi
Column concrete strength	$f'_c =$	4500.00	psi
Drilled shaft concrete strength	$f'_c =$	4000.00	psi
Concrete density	$\gamma_c =$	150.00	pcf
Steel yield strength	$f_y =$	60.00	ksi

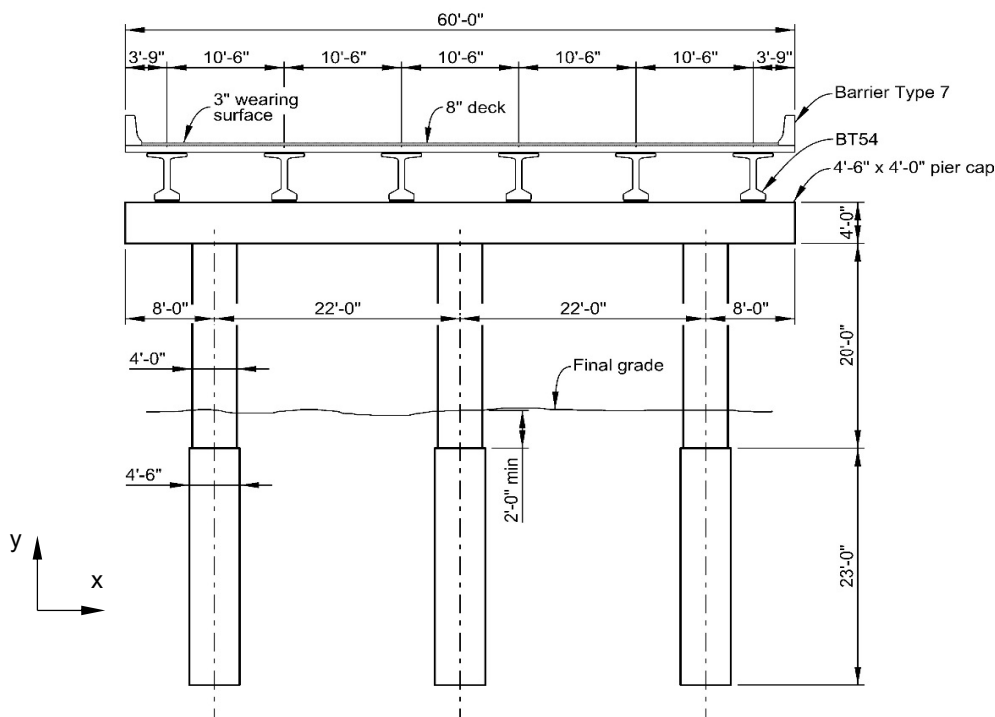


Figure 1 - Design Section

Applied Loads:

In this example, the only loads included in the analysis are collision loads and dead loads, due to the improbable coincidence of other loads (BDM Section 3.5.2). Designer may choose to include live loads, but in most cases shear from vehicle impact will control the design.

DC - dead load of structural components and nonstructural attachments

DW - dead load of wearing surfaces and utilities

CT - vehicular collision force

If the LEAP Bridge Superstructure model is available, DC and DW loads may be imported to pier model. Otherwise, they can be autogenerated as shown below.

- DC:
1. Slab and girder dead loads - autogenerated from superstructure input, $\gamma = 150$ pcf
 2. Barrier dead loads - total load per foot = 486 plf (see Structural Worksheets B-606-7B)

- DW:
1. Wearing surface total load per foot = $36.67 \text{ psf} * (57 \text{ ft clear roadway width}) = 2090.19 \text{ plf}$ (refer to BDM Section 3.4.2)

CT: Equivalent static load = 600 kip, applied in a direction of 0 to 15 degrees, 5 ft. above the ground (AASHTO 3.6.5.1)

In the case of a multi-column pier, the Designer must investigate the collision force CT acting on each column separately and select the one with the maximum shear force. The Designer should then check the shear capacity of the column. The Designer is responsible for determining the most conservative load cases taking into account both directions of travel under the bridge and the geometry of the bridge.

Note: The critical design section for a column is at the point of impact. The Designer should add additional check points near the impact from the 'Structure Model' menu to get information needed for design.

Column length in LEAP Bridge Substructure model (includes drilled shaft length to fixity)

$$L = 1/2 \times 4 \text{ ft. cap depth} + 20 \text{ ft.} + 13.5 \text{ ft.} = 35.50 \text{ ft.}$$

Point of application of CT from drilled shaft point of fixity

$$y_1 = 5 \text{ ft.} + 2 \text{ ft. drilled shaft cover} + 13.5 \text{ ft.} = 20.50 \text{ ft.}$$

Case Number	Case Name	Col. No.	ϕ	Magnitude		Location y_1 / L
				X	Z	
Case No. 1	CT1	1	0	600.00	0.00	0.58
Case No. 2	CT2	1	15	579.56	155.29	0.58
Case No. 3	CT3	2	15	579.56	155.29	0.58
Case No. 4	CT4	3	15	579.56	155.29	0.58

Summary of CT Load Cases

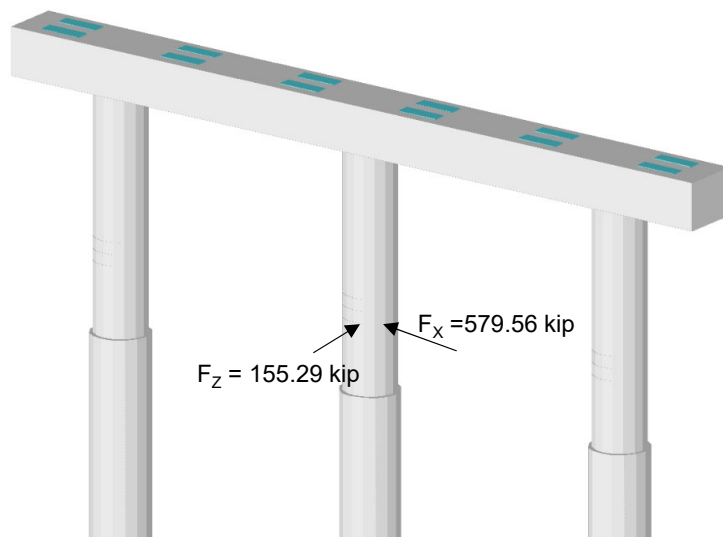


Figure 2 - CT Load Application

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Analysis of the columns is performed using the P-delta method. See below for the following outputs from LEAP Bridge Substructure:

- Summary of load combinations used in the design
- Controlling column design results
- Detailed shear design calculation for controlling column

Summary of Design:

Column reinforcement -	main rebar	22 #10 bars, equally spaced
	shear reinforcement	#4 ties @ 6"

Design of a drilled shaft in the Extreme Event collision case is similar to the design of a drilled shaft in the Strength cases and will not be shown for this example. The Designer must account for the collision load in the drilled shaft design by applying Extreme Event loads from the bottom of the column to the top of the caisson. It is recommended that the Designer use a suitable design tool to analyze shaft-soil interaction to determine stability and strength requirements.