

Substructure Design Examples for the 400 kip Vehicle Collision Load

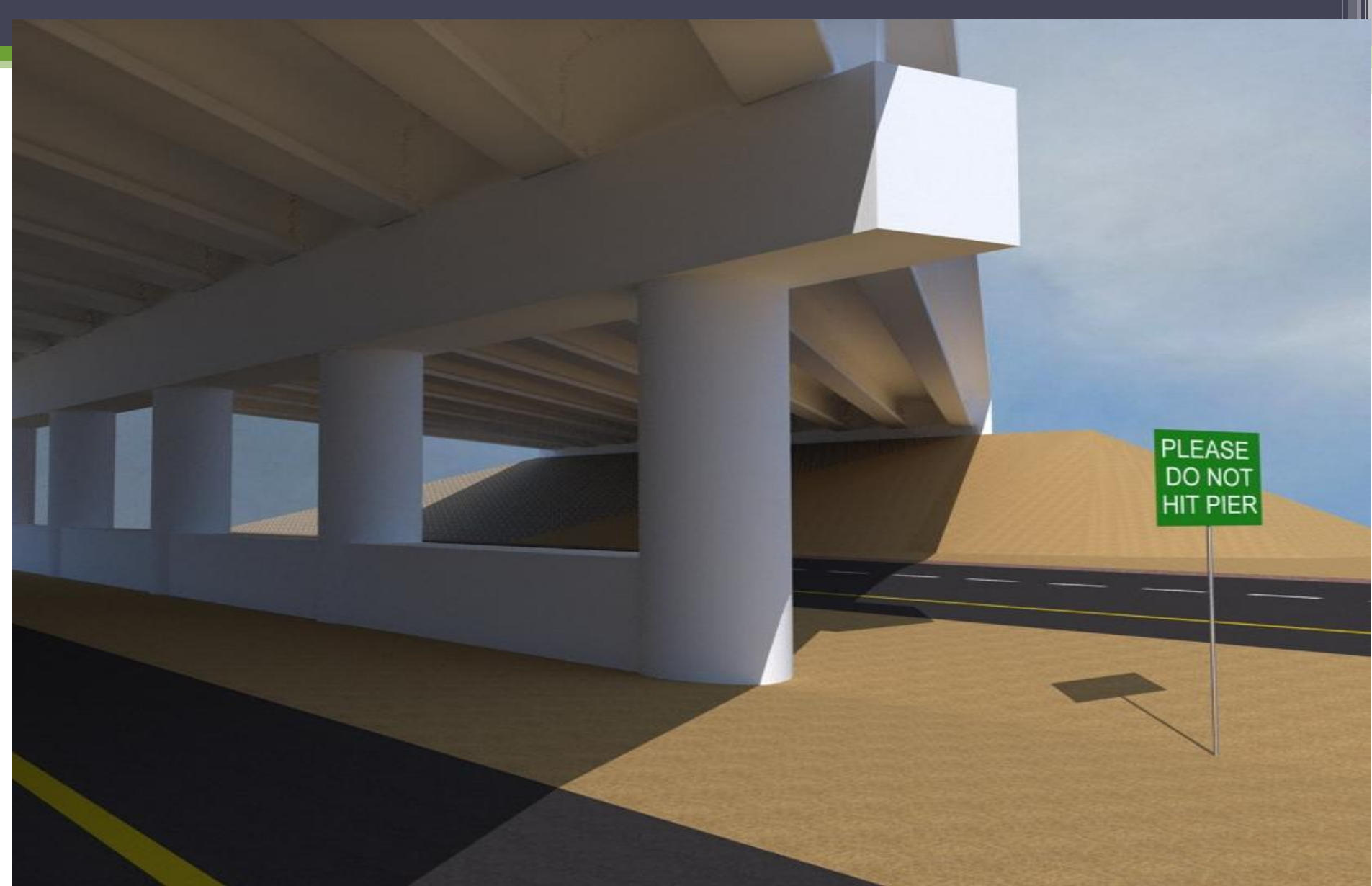
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Agenda

- AASHTO LRFD Bridge Design Specification Article 3.6.5 – Vehicular Collision Force: CT
- TL-5 Barrier
- Example #1 – Two Span Bridge with T-Pier (Hammerhead)
- Example #2 – Four Span Bridge with Multi-column Piers







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3.6.5—Vehicular Collision Force: *CT*

3.6.5.1—Protection of Structures

Unless the Owner determines that site conditions indicate otherwise, abutments and piers located within a distance of 30.0 ft to the edge of roadway, or within a distance of 50.0 ft to the centerline of railway track shall be investigated for collision. Collision shall be addressed by either providing structural resistance or by redirecting or absorbing the collision load. The provisions of Article 2.3.2.2.1 shall apply as appropriate.

Where the design choice is to provide structural resistance, the pier or abutment shall be designed for an equivalent static force of 400 kip, which is assumed to act in any direction in a horizontal plane, at a distance of 4.0 ft above ground.

C3.6.5.1

Where an Owner chooses to make an assessment of site conditions for the purpose of implementing this provision, input from highway or safety engineers and structural engineers should be part of that assessment.

The equivalent static force of 400 kip is based on the information from full-scale crash tests of barriers for redirecting 80.0-kip tractor trailers and from analysis of other truck collisions. The 400-kip train collision load is based on recent, physically unverified, analytical work (Hirsch, 1989). For individual column shafts, the 400-kip load should be considered a point load. For wall piers, the load may be considered to be a point load or may be



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Where the design choice is to redirect or absorb the collision load, protection shall consist of one of the following:

- An embankment;
- A structurally independent, crashworthy ground-mounted 54.0-in. high barrier, located within 10.0 ft from the component being protected; or
- A 42.0-in. high barrier located at more than 10.0 ft from the component being protected.

Such barrier shall be structurally and geometrically capable of surviving the crash test for Test Level 5, as specified in Section 13.

distributed over an area deemed suitable for the size of the structure and the anticipated impacting vehicle, but not greater than 5.0 ft wide by 2.0 ft high. These dimensions were determined by considering the size of a truck frame.

For the purpose of this Article, a barrier may be considered structurally independent if it does not transmit loads to the bridge.

Full-scale crash tests have shown that some vehicles have a greater tendency to lean over or partially cross over a 42.0-in. high barrier than a 54.0-in. high barrier. This behavior would allow a significant collision of the vehicle with the component being protected if the component is located within a few ft of the barrier. If the component is more than about 10.0 ft behind the barrier, the difference between the two barrier heights is no longer important.



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- 400 kip load
- All structures within 30-feet of traveled way that are not protected by a TL-5 Rail
- Load Combination Extreme Event II



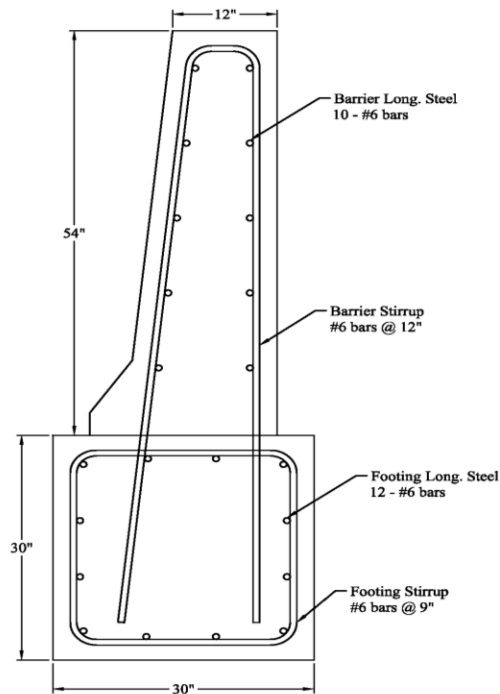
Pier Protection



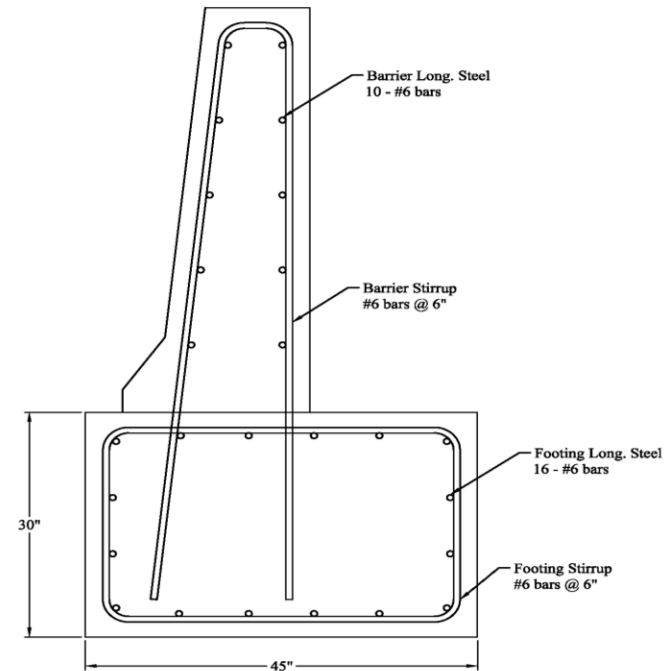
Pier Protection



54" Tall, F-Shape, TL-5 Barrier (Sample)



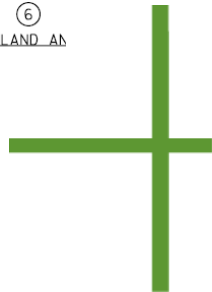
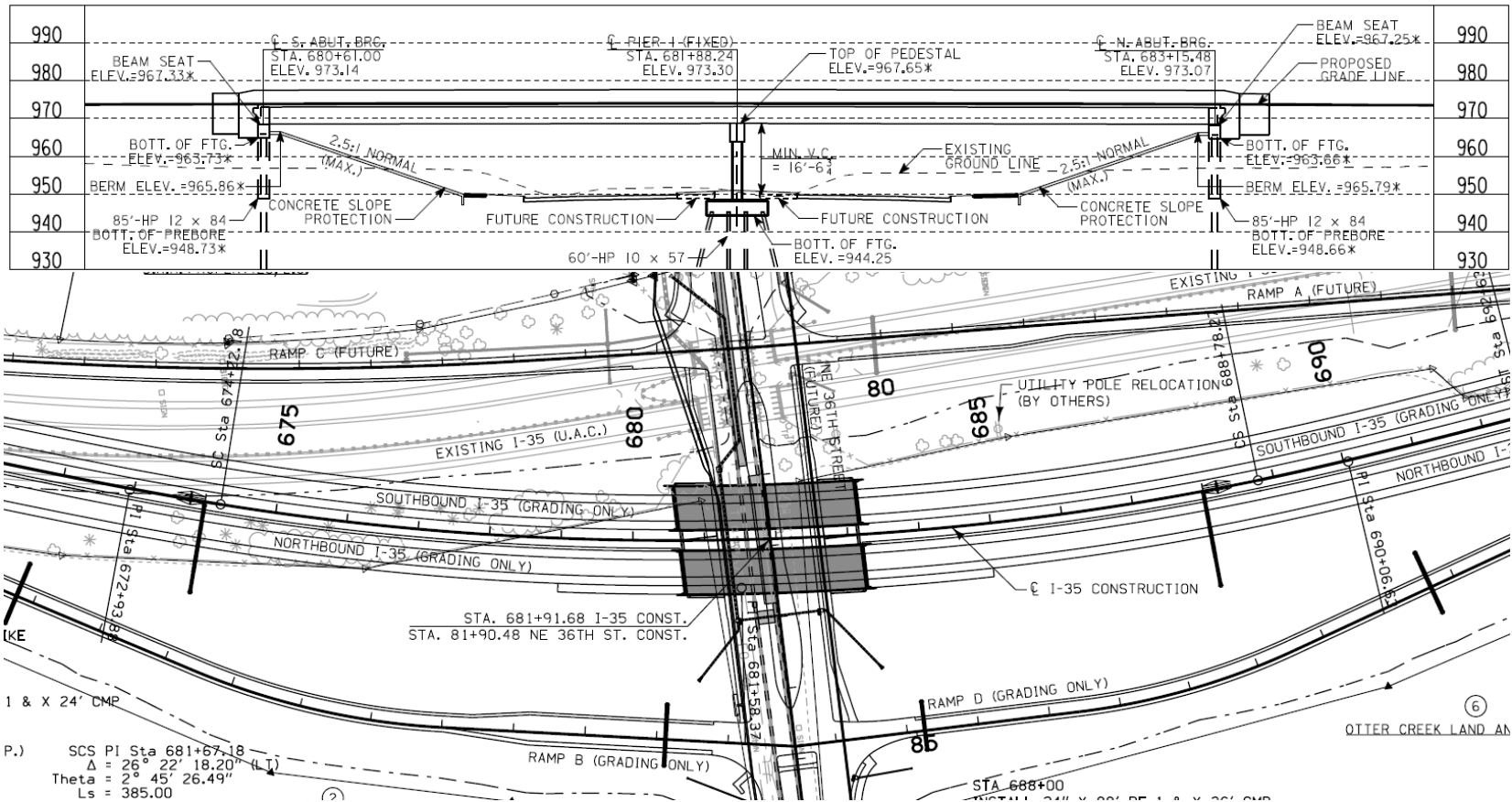
Interior Section



End Section - 15 ft. Minimum Length



Example #1 – T-Pier



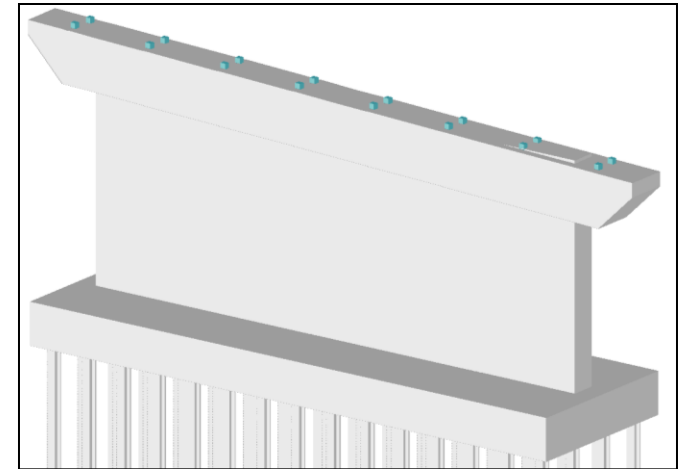
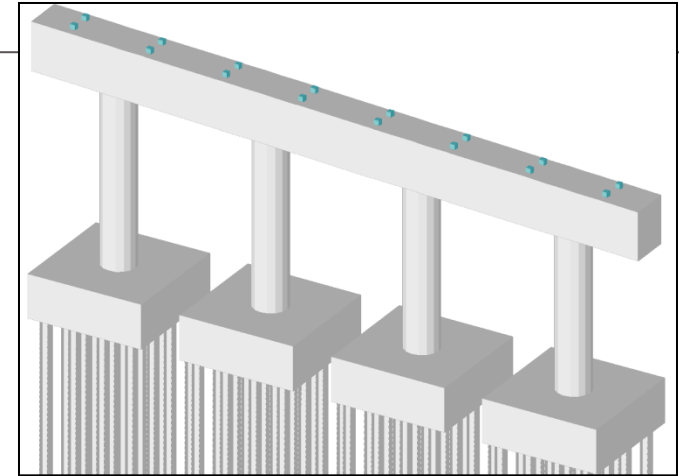
Example #1 – T-Pier

- Original Plan for Multi-column Pier



Example #1 – T-Pier

- Design Loads (Multi- Column)
 - Standard Loading (without CT)
 - CT force in Plane with Pier
 - CT force Transverse to Pier
- Design Load (T-Pier)
 - CT force Transverse to Pier



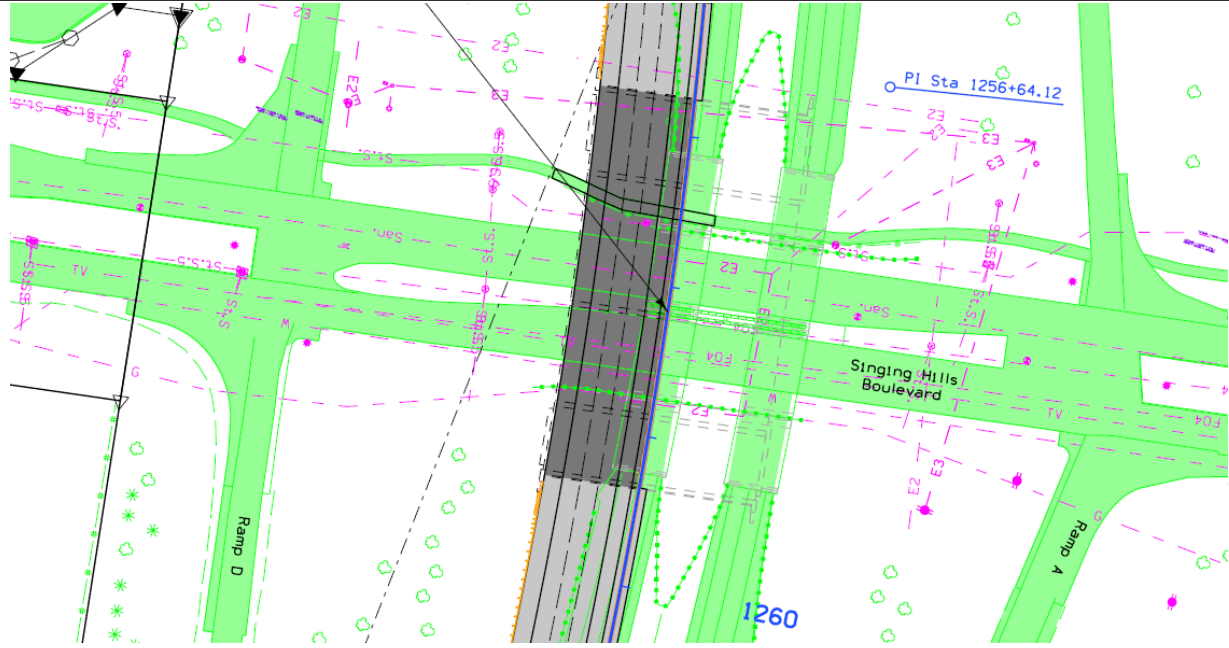
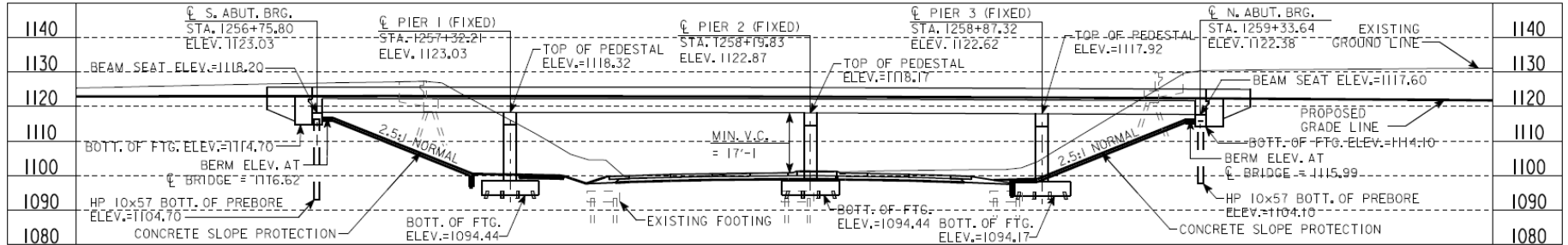
Example #1 – T-Pier



Example #1 – Results

Condition	Column	Footing
Multi-Column (without CT)	42" Dia. Column 21 - #9 Verticals (1.5%) (Strength I)	4 - 9' X 15' 13 Piles (52 Total) (Strength I & V)
Multi-Column (CT in plane with Pier)	42" Dia. Column 29 - #11 Verticals (3.3%) (Extreme Event II)	4 - 12' X 12' 16 Piles Fails (Need continuous footing) (Ext. Event II)
Multi-Column (CT Transverse to Pier)	42" Dia. Column 29 - #11 Verticals (3.3%) (Extreme Event II)	4 - 12' X 15' 16 Piles (64 Total) (Extreme Event II)
T-Pier (CT Transverse to Pier)	51'-6" x 2'-6" Wall 148 - #9 Vert. (~1.0%) (Strength I)	55'-6" X 16'-6" 60 Piles (Strength I)

Example #2 – Multi-Column



Example #2 – Multi-Column



Example #2 – Multi-Column



Example #2 – Multi-Column

Condition	Column	Footing
Without CT	42" Square Column 32 - #8 Verticals (1.4%) (Strength I)	64' X 12' 51 Piles (Strength I)
With CT	42" Square Column 32 - #10 Verticals (2.3%) (Extreme Event II)	64' X 12' 51 Piles (Strength I)



Questions?

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