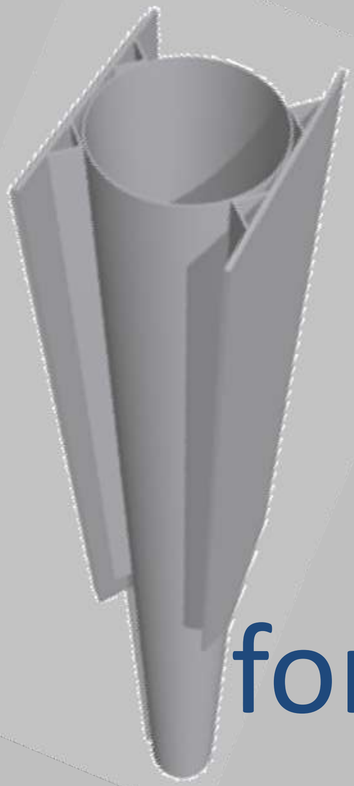
17th Annual Design and Installation of Cost-Efficient Piles Conference

Charleston Marriott, Charleston, South Carolina
Wednesday, September 21 and Thursday, September 22, 2016

Innovative Solution for

Marine Fenders
Foundations
&
Seawall Structures

Kevin Lathan, PE & **V. Larry Tsimmerman, PE**
Construction e Link, Inc. & Omega Trestle, LLC



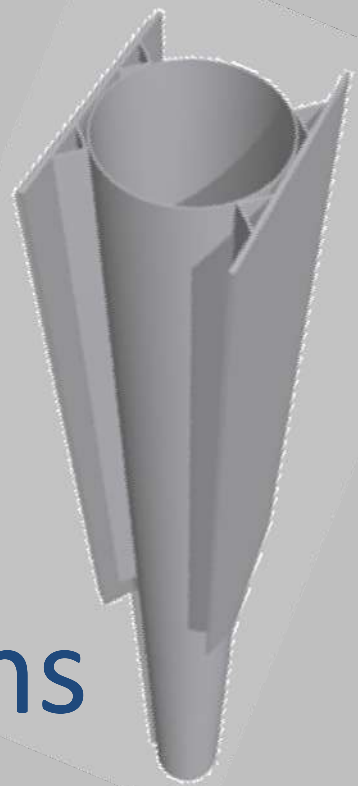
FLANGED PIPE PILE

(FPP)

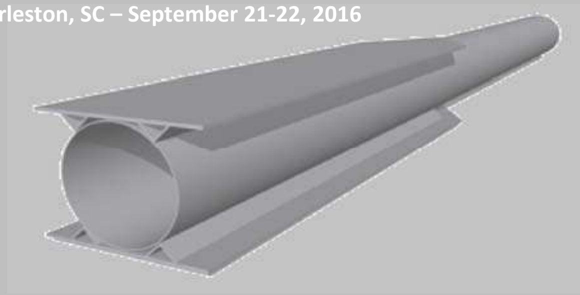
a NEW TOOL

for your driven pile solutions

Toolbox.

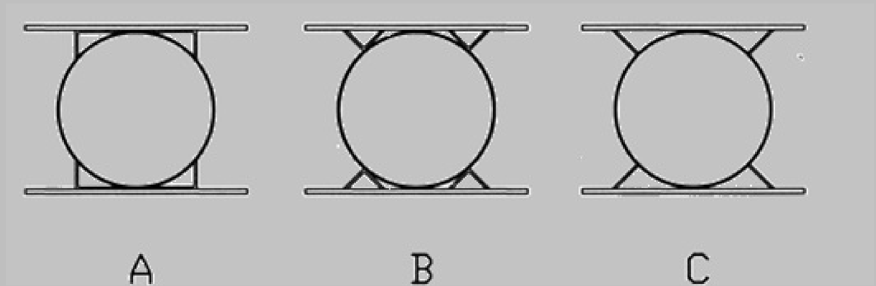


New structural section
The OMEGA Section



Omega Beam when horizontal & **Flanged Pipe Pile (FPP)** when driven

FPP section is built up from fundamental shapes **Pipe - Plates - Angles**



Advantages:

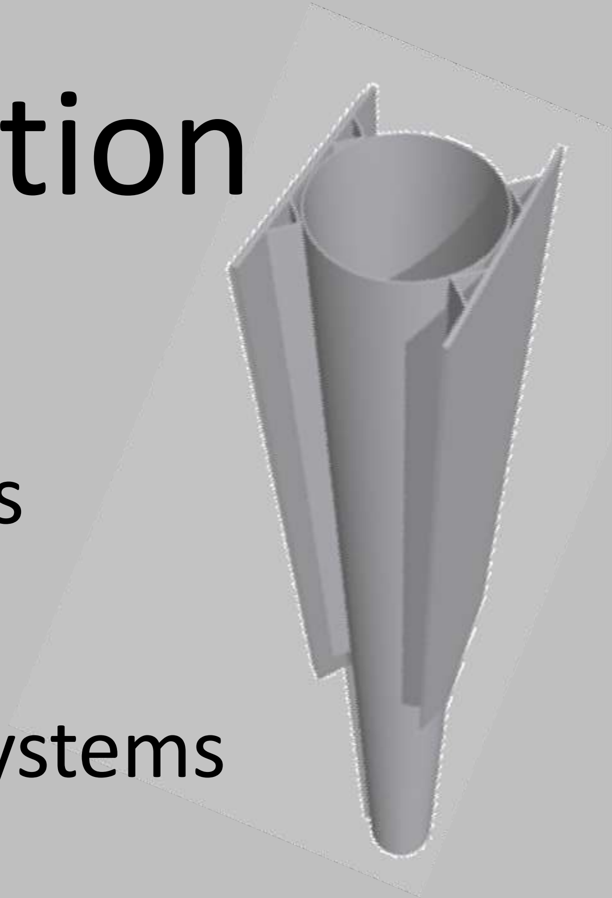
Available
Scalable to any size
Economical
Fabricate anywhere
High STRONG to SECONDARY axis ratio of about 2:1
Greater bending strength & smaller footprint than pipe of equal weight
Significant increase in torsional, and asymmetrical loading capacity

FPP as driven pile solution

For: LOAD CASES

Lateral loads - piers, wharfs and fenders

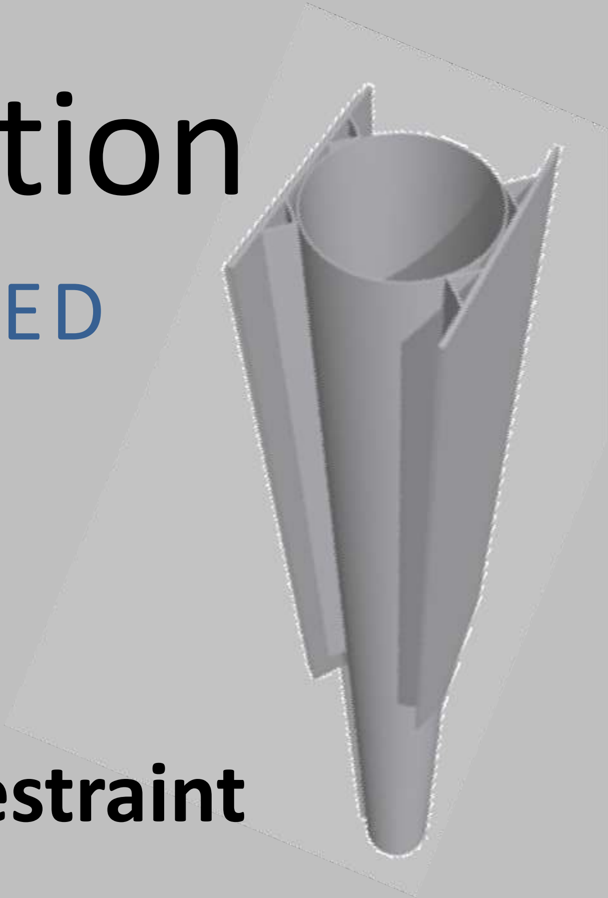
Earth Retention- connected & lagged systems



FPP as driven pile solution

When: GEOMETRICALLY CONSTRAINED

- **Anchoring piles into ROCK strata**
- **Minimized footprint desired**
- **No space for battered pile lateral restraint**



First, a little background on the Omega Project

Omega Project Background

TESTING

MANUFACTURING

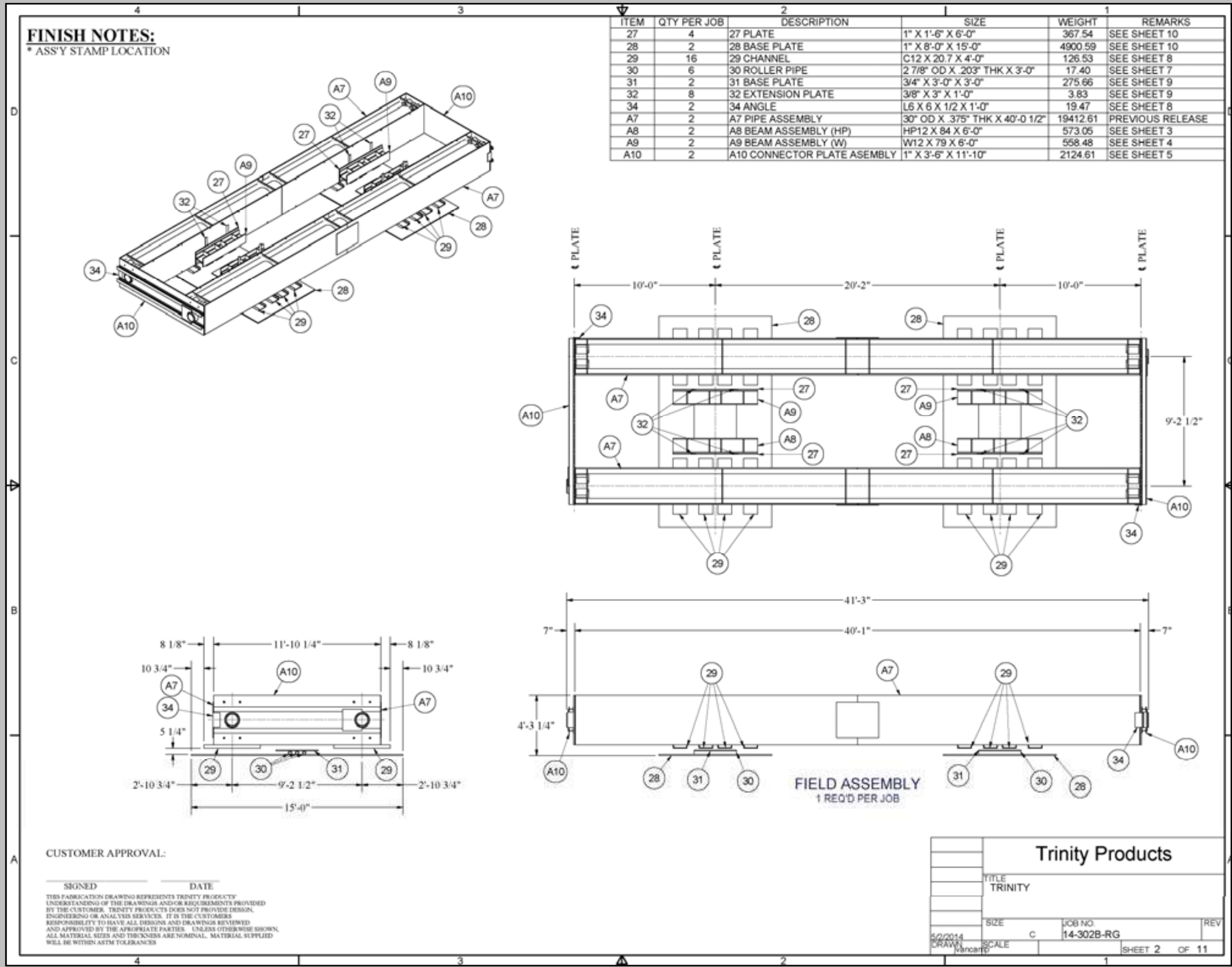
FIELD DEPLOYMENT

TESTING

TEST 1

Maximum Bending Moment

Maximum Shear & Full shear end connection test



ITEM	QTY PER JOB	DESCRIPTION	SIZE	WEIGHT	REMARKS
27	4	27 PLATE	1" X 1'-6" X 6'-0"	367.54	SEE SHEET 10
28	2	28 BASE PLATE	1" X 8'-0" X 15'-0"	4900.59	SEE SHEET 10
29	16	29 CHANNEL	C12 X 20.7 X 4'-0"	126.53	SEE SHEET 8
30	6	30 ROLLER PIPE	2 7/8" OD X .203" THK X 3'-0"	17.40	SEE SHEET 7
31	2	31 BASE PLATE	3/4" X 3'-0" X 3'-0"	275.66	SEE SHEET 9
32	8	32 EXTENSION PLATE	3/8" X 3" X 1'-0"	3.83	SEE SHEET 9
34	2	34 ANGLE	L6 X 6 X 1/2 X 1'-0"	19.47	SEE SHEET 8
A7	2	A7 PIPE ASSEMBLY	30" OD X .375" THK X 40'-0 1/2"	19412.61	PREVIOUS RELEASE
A8	2	A8 BEAM ASSEMBLY (HP)	HP12 X 84 X 6'-0"	573.05	SEE SHEET 3
A9	2	A9 BEAM ASSEMBLY (W)	W12 X 79 X 6'-0"	558.48	SEE SHEET 4
A10	2	A10 CONNECTOR PLATE ASEMBLY	1" X 3'-6" X 11'-10"	2124.61	SEE SHEET 5

TESTING

Proof Load

600 Tons

Two (2) 800 Ton Jacks Certified and Calibrated

Application of jack forces and instrumentation was in general accordance with ASTM 1143/D 1143M-07 and adapted for this horizontal application.

TESTING

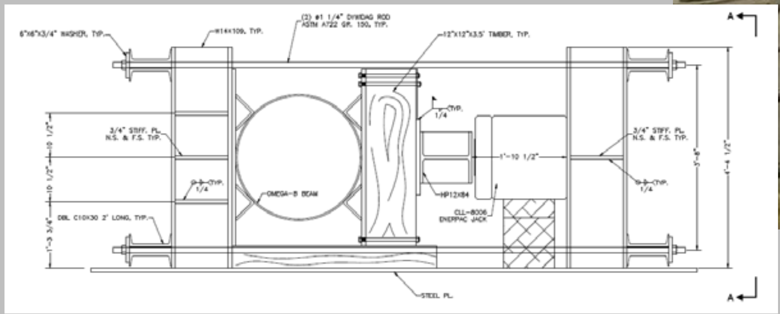
Proof Load 275 Tons

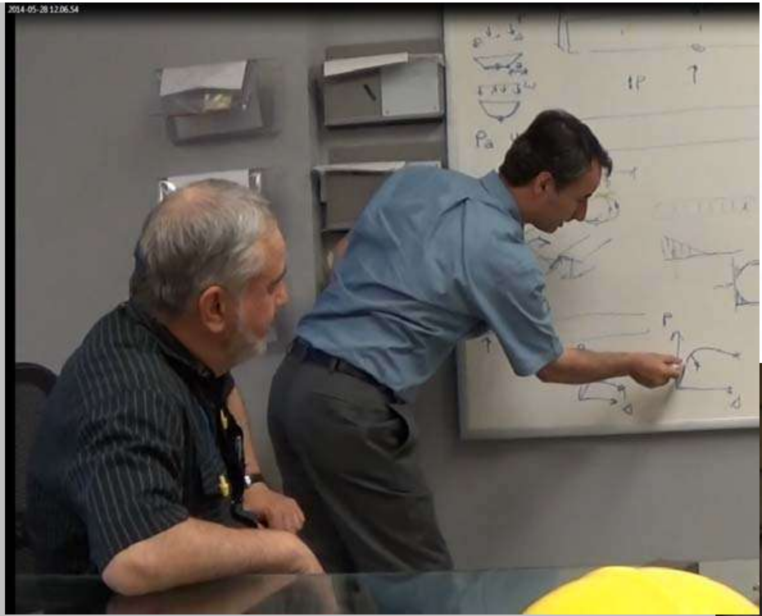
TEST 2

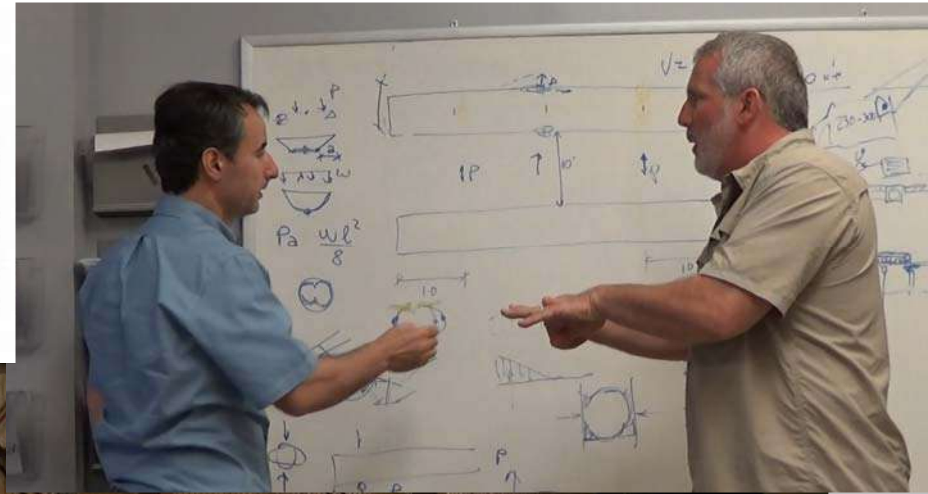
Compression Test

Localized

“Crush Test”







Special thanks to:

The Ohio State University &
Dr. Halil Sezen, P.E.
Professor of Civil Engineering

Dr. Sezen provided his valuable assistance with the static load tests on the Omega Beams in St. Charles MO in May & June 2014.

We look forward to continuing our knowledge sharing relationship with The Ohio State University and Dr. Sezen.

MANUFACTURING

Nearly 3,000 LF of beams moved into production in late 2014

MANUFACTURING

MANUFACTURING

FIELD DEPLOYMENT –

Pre-assembly & Barge Transport

1,200 LF of Trestle = 30 Spans at 40 ft. for a 300 Ton Manitowoc 2250 Crane – Baltimore, MD

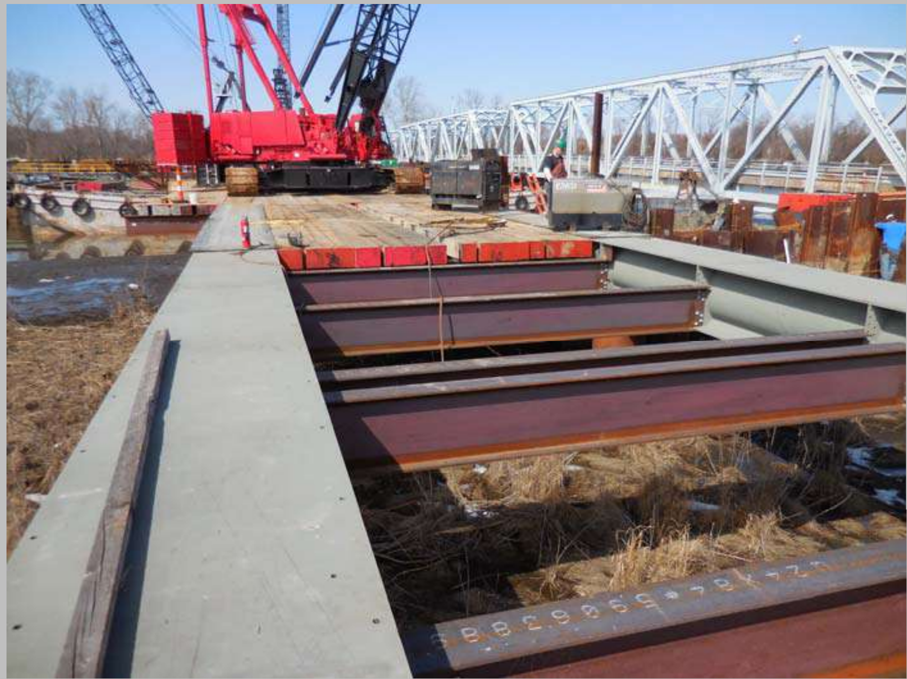
Frame style trestle in 40 ft. sections

Span by span loaded to barge

Barge loading 70% complete

FIELD DEPLOYMENT

Span by span installation, MD, Eastern Shore



FIELD DEPLOYMENT

Span by span installation, MD, Eastern Shore

FIELD DEPLOYMENT

Span by span installation & production pile starts

Omega Trestle in Service

Omega Trestle in Service
of pier foundations

Omega Trestle in Service
in girder erection

Another application: as High Capacity Pier

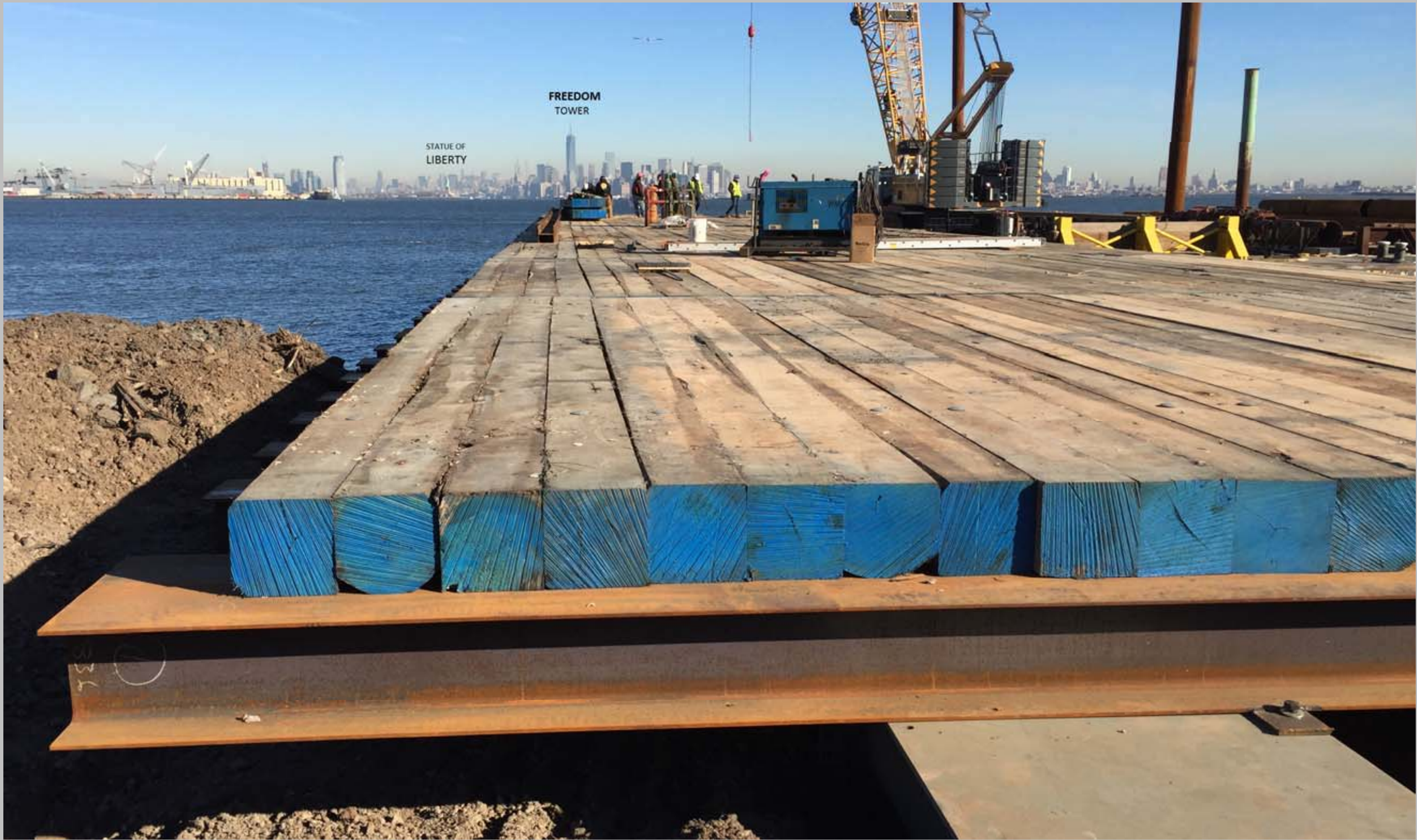
NEW YORK WHEEL
LOAD TRANSFER PIER
1150 Ton Design Capacity

E Elevated Omega Style - High Capacity Pier

E Elevated Omega Style - High Capacity Pier

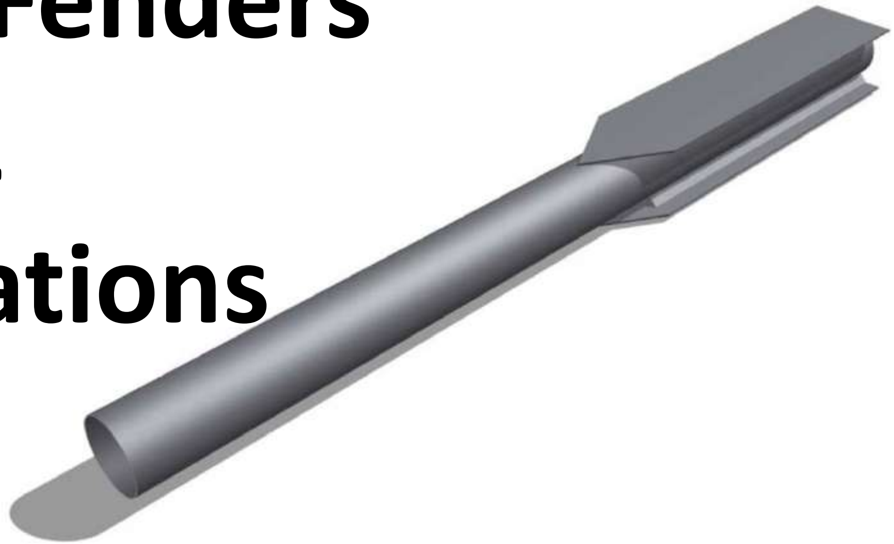
some details

NY WHEEL - High Capacity Pier



Benefits of Flanged Pipe Pile **FPP**

Marine Fenders & Foundations

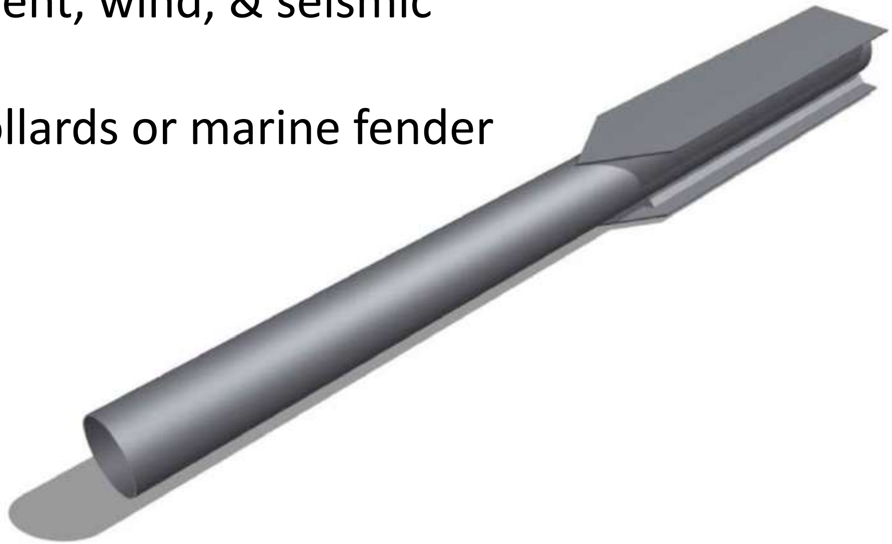


FPP as part of driven pile toolbox for :

Lateral loads cases

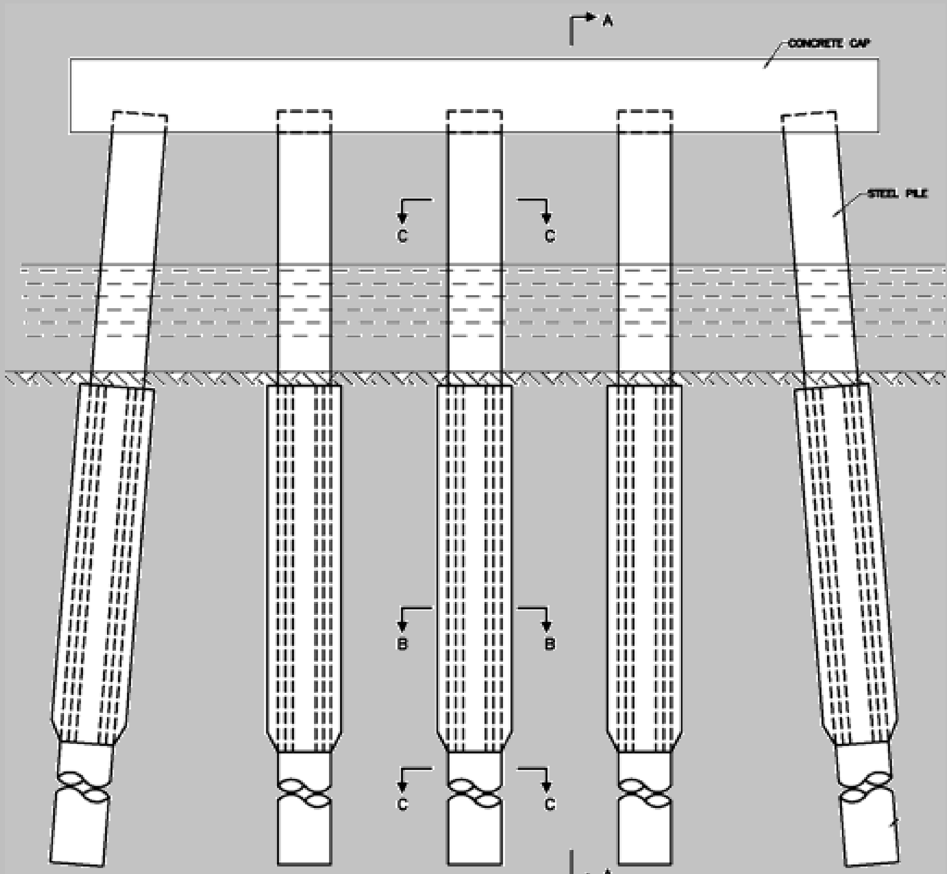
I. Cyclical such as Current, wind, & seismic

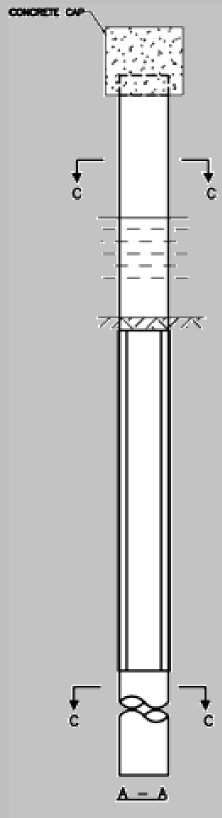
II. Impact- collision bollards or marine fender

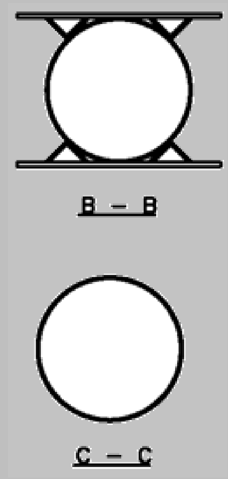


Pier Example 1:

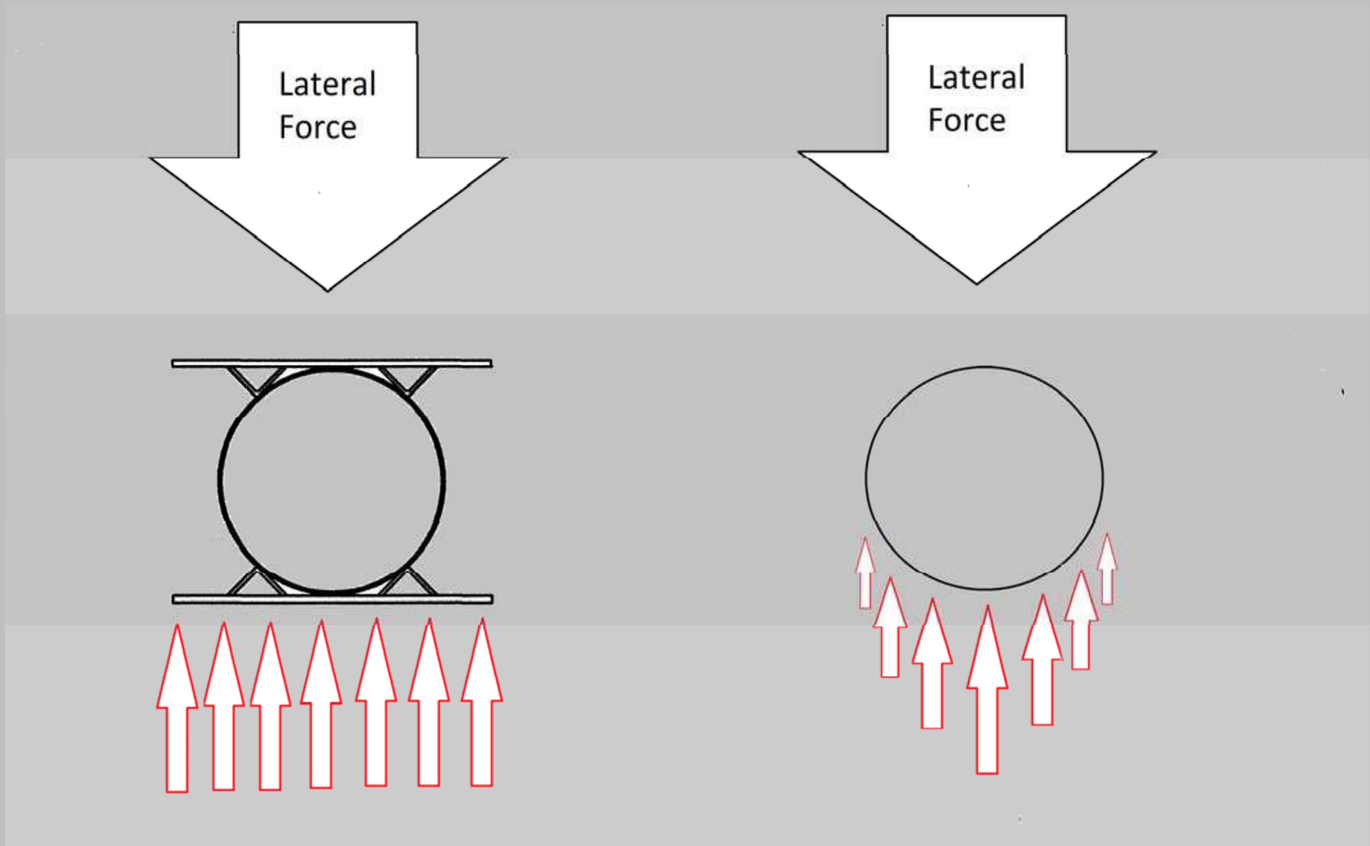
Improve performance in poor soils by increasing bending capacity, surface area and radius of gyration





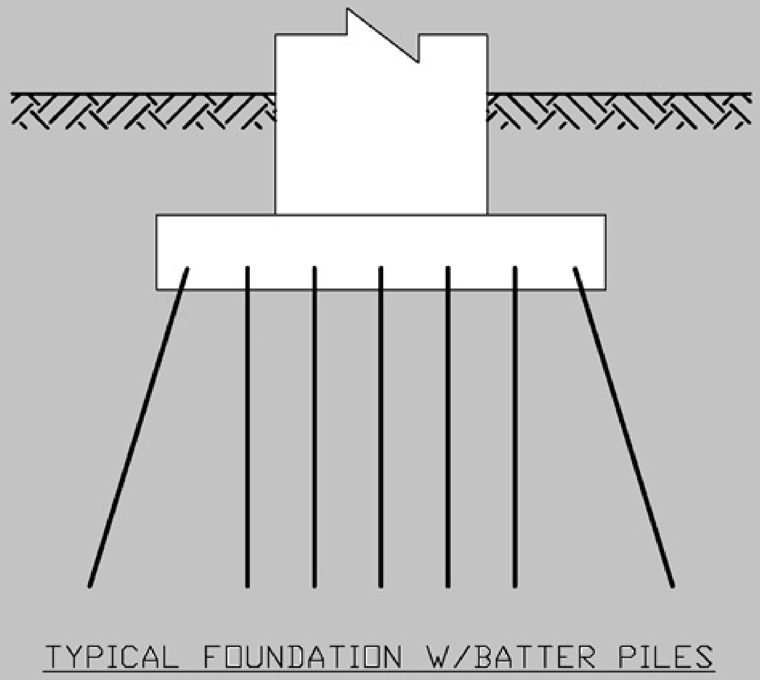


Improved lateral geotechnical engagement

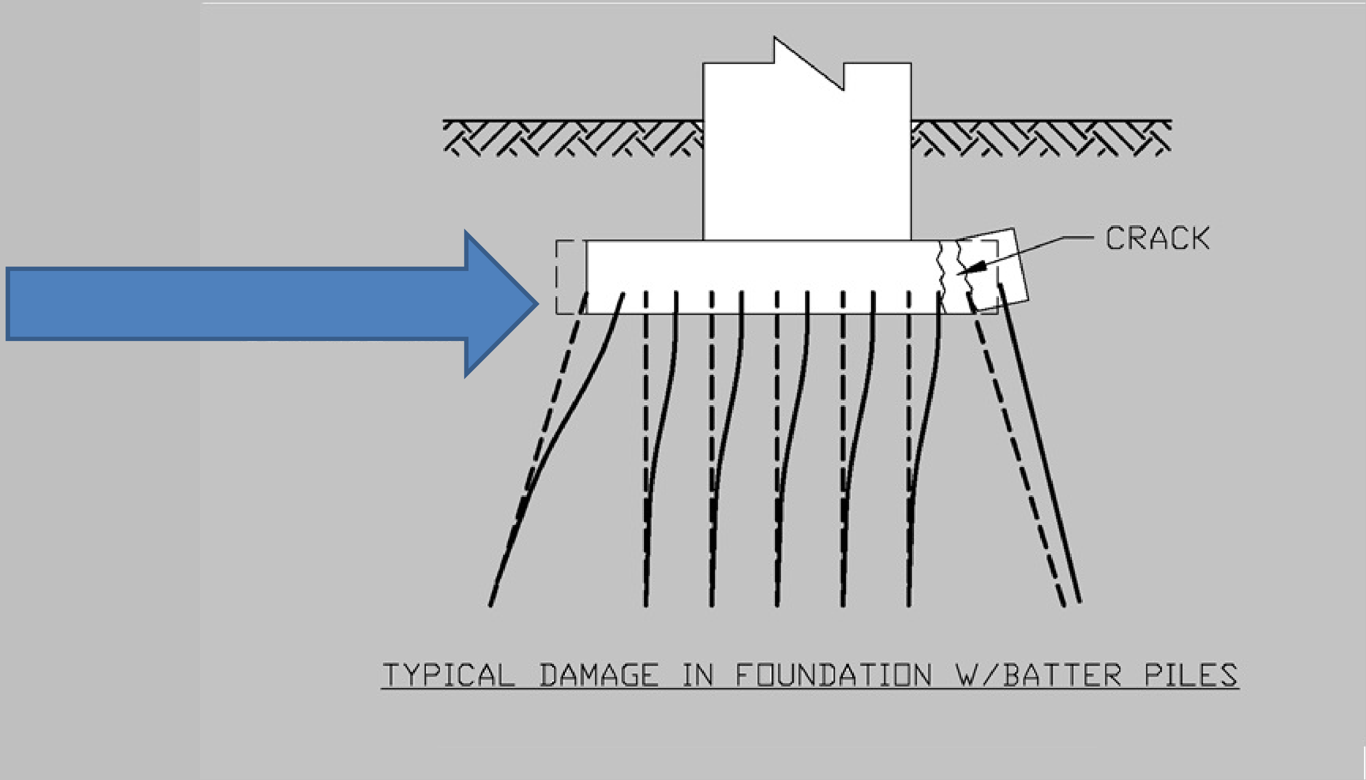


Geotechnical reactive forces shown in above schematics are approximated to highlight benefits of FPP geometry

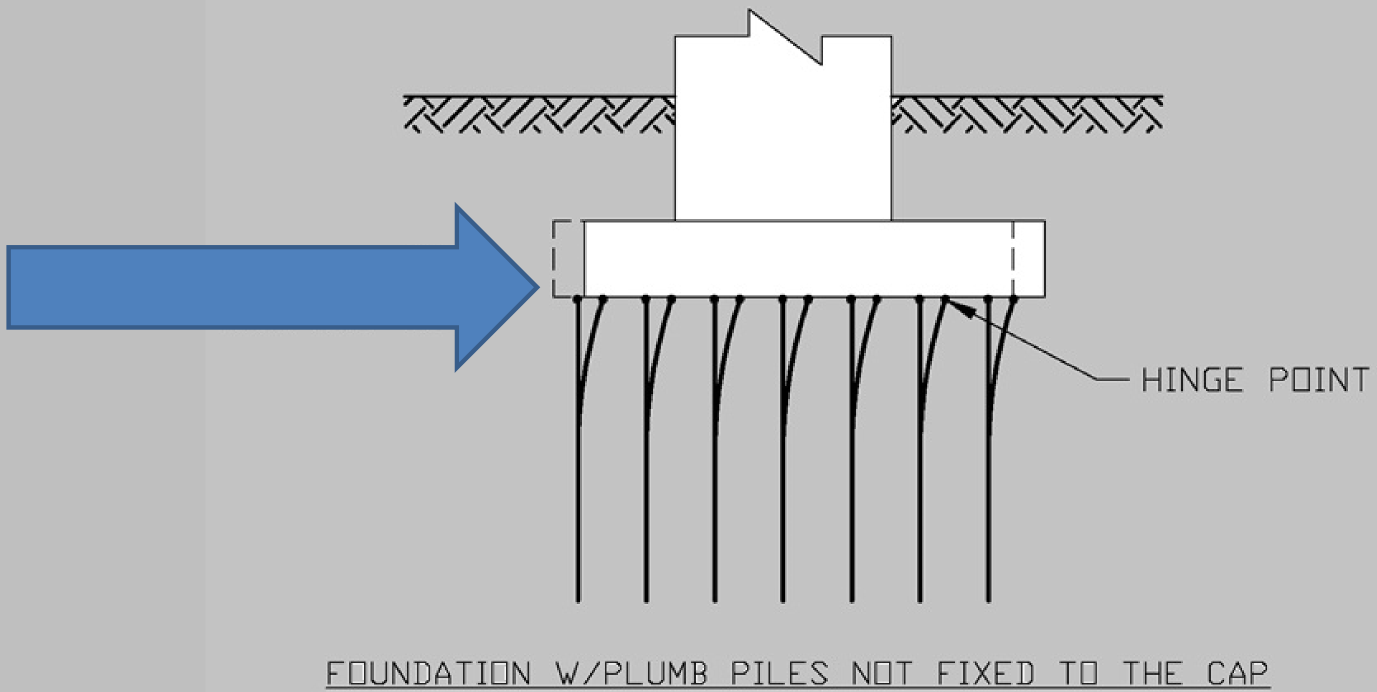
Pier Example 2: Typical bridge pier with batter piles used for lateral load resistance

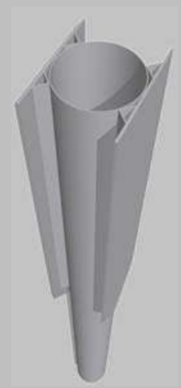


Batter pile foundations are effective, but can cause substantial damage when subjected to seismic, wind or impact loading due to lateral stiffness



Plumb pile foundations are not as stiff as the foundations with batter piles. Such foundations absorb energy better during lateral loading events.

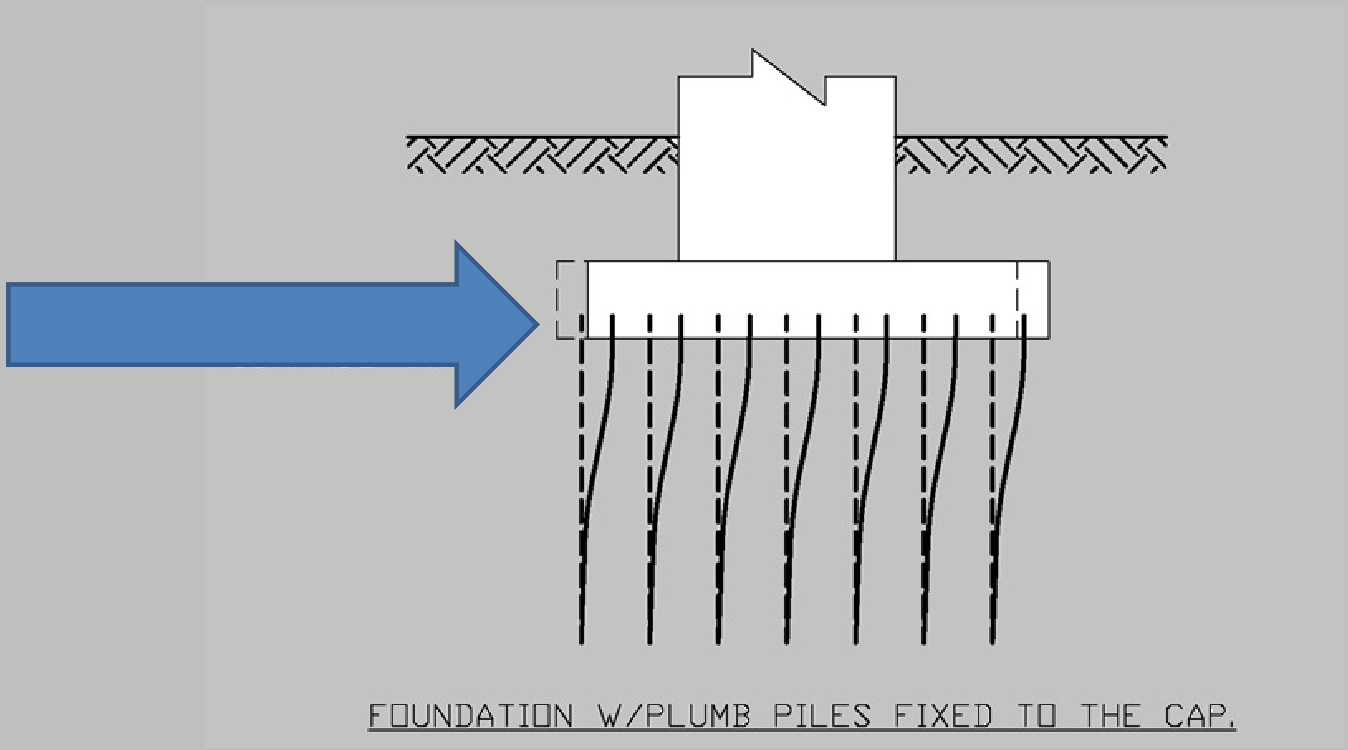


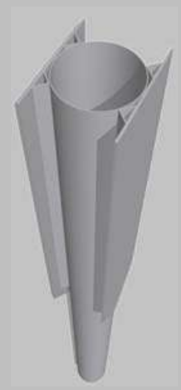


FPP

is an effective pile option here !

Plumb pile foundation
with fixed connection to the pile cap.





FPP

is an
effective pile
option here !

When we select a **steel pile for a foundation**, our options are;

1. Pipe - optimized to resist compression and torsion.

Sy/Sx= 1

-often less economical when it comes to bending because it has extra material around neutral axis area.

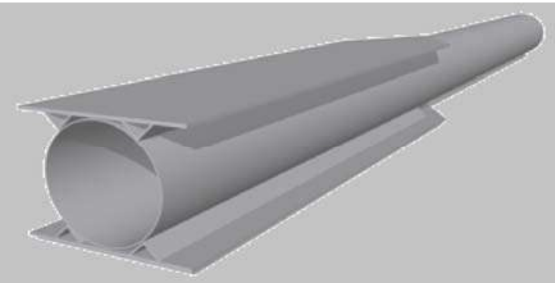
2. H-pile - limited in size when hot rolled.

- much weaker in one direction than the other.

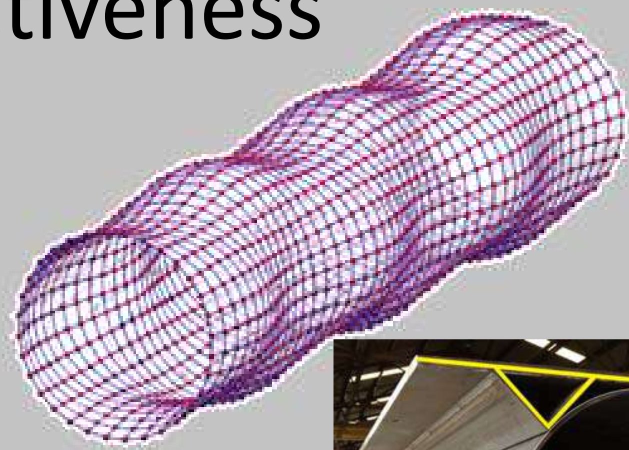
Sy/Sx=0.30 +/-

3. FPP a new piling option to consider …

The FPP



Fundamentals of effectiveness



60-70 % Stronger than H-pile in weak direction.

Unique section at

Sy/Sx = 0.50 +/-

Greater crushing strength than pipe alone !

- **Angles and plates reinforce pipe section.**
- **Pipe compression and bending capacity is improved significantly**
- **Addition of flanges can improve performance of any pipe section**
- **Very stable section due to use of pipe as “web”**
- **Scalable ability to use the flanges only where needed in the vertical column**

FPP as part of driven pile toolbox for :

Geometric constraints

I. When more compact section is preferred

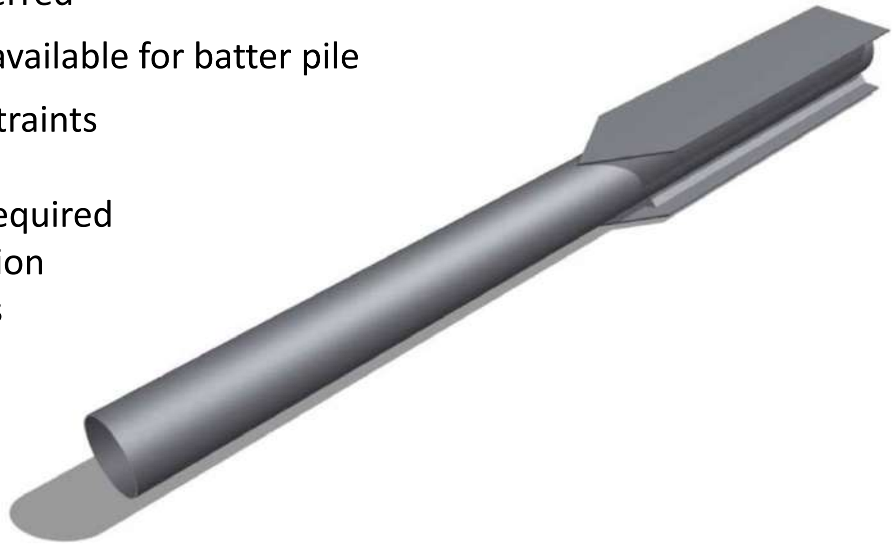
a. fender system where no room available for batter pile

b. wharf retrofit with permit constraints

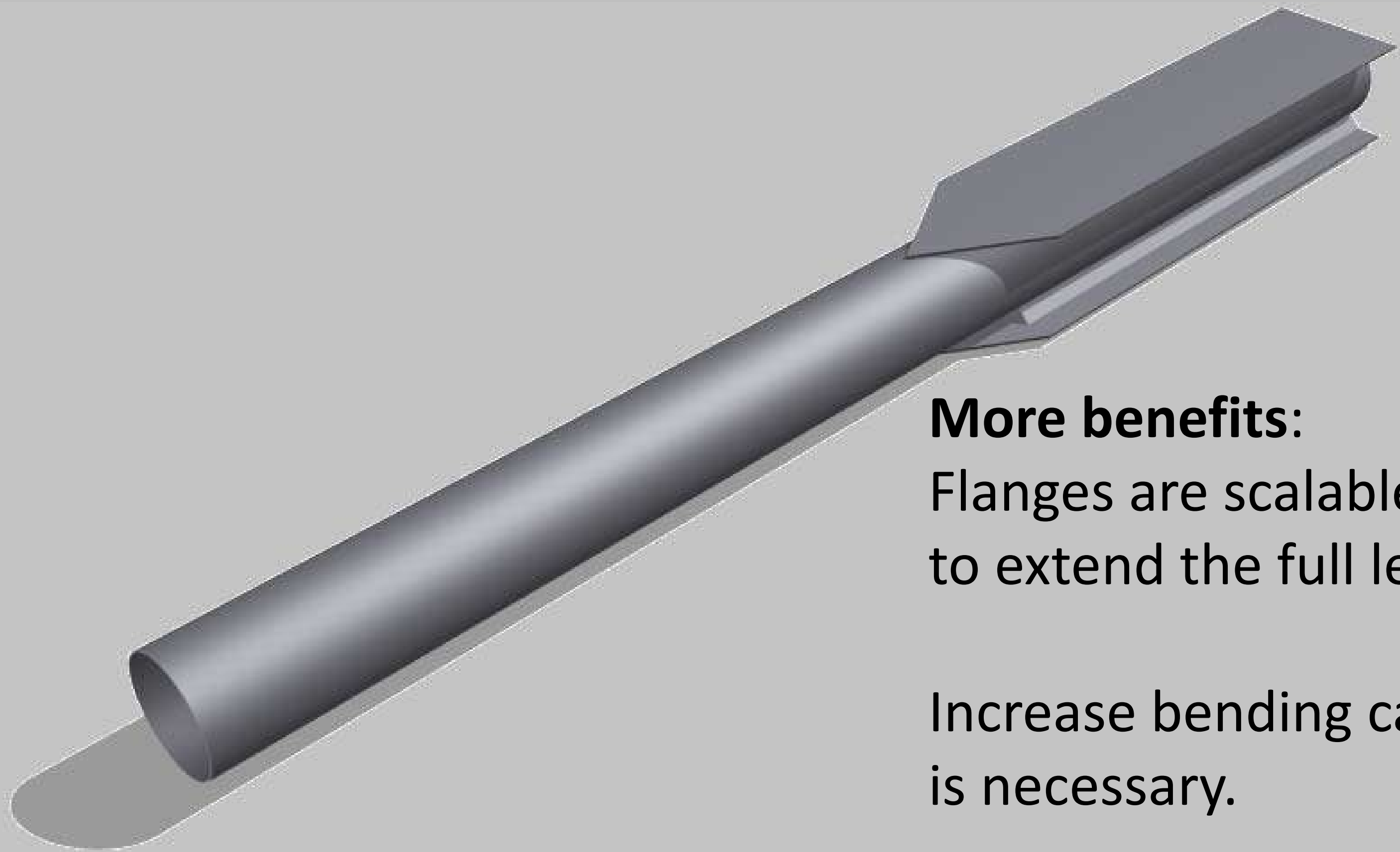
II. When anchoring into rock strata is required

pipe better than W or H section

FPP is has additional benefits



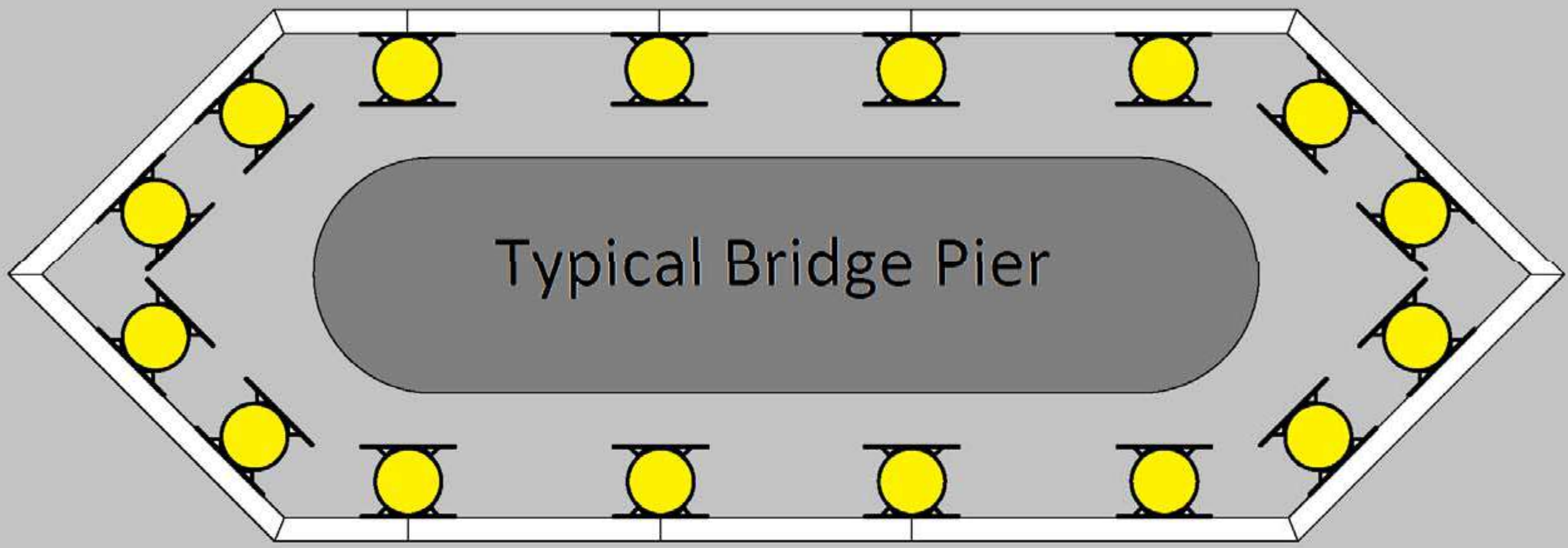
Flanged Pipe Pile (FPP)

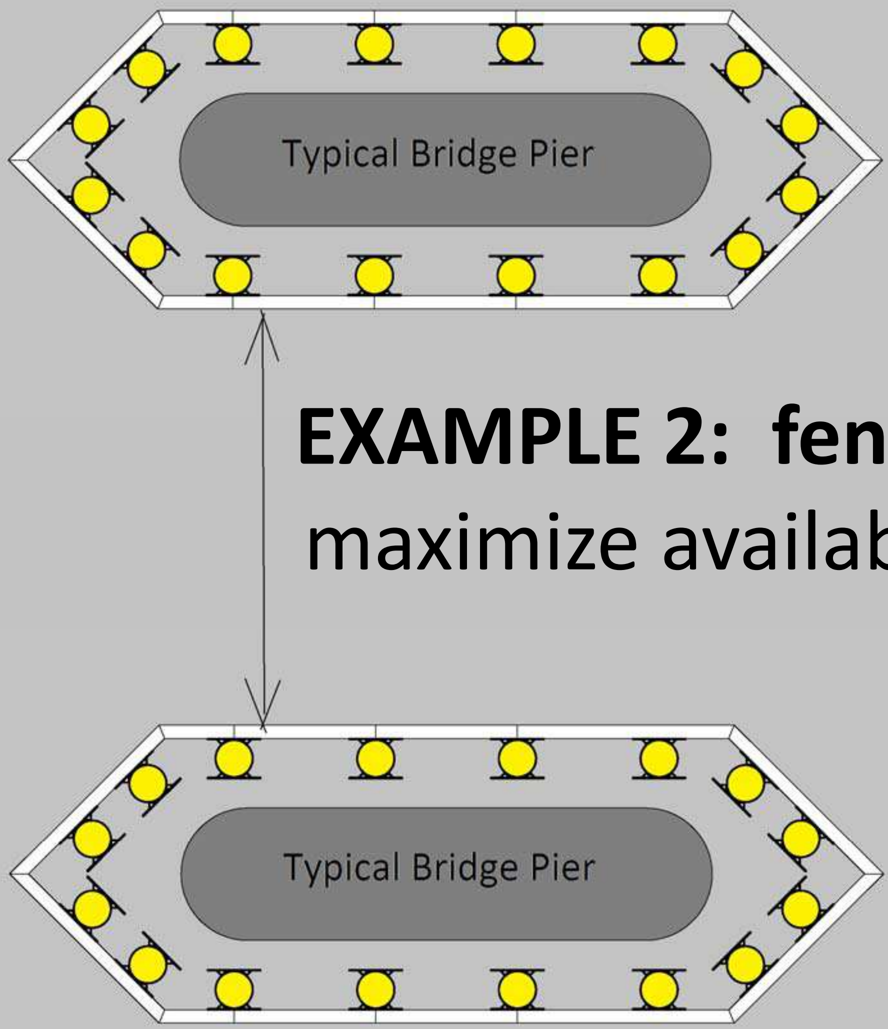


More benefits:
Flanges are scalable and DO NOT have to extend the full length of pile.

Increase bending capacity only where it is necessary.

compact section for lateral load resistance
EXAMPLE: fender
where batter piles are not possible





EXAMPLE 2: fender system

maximize available space

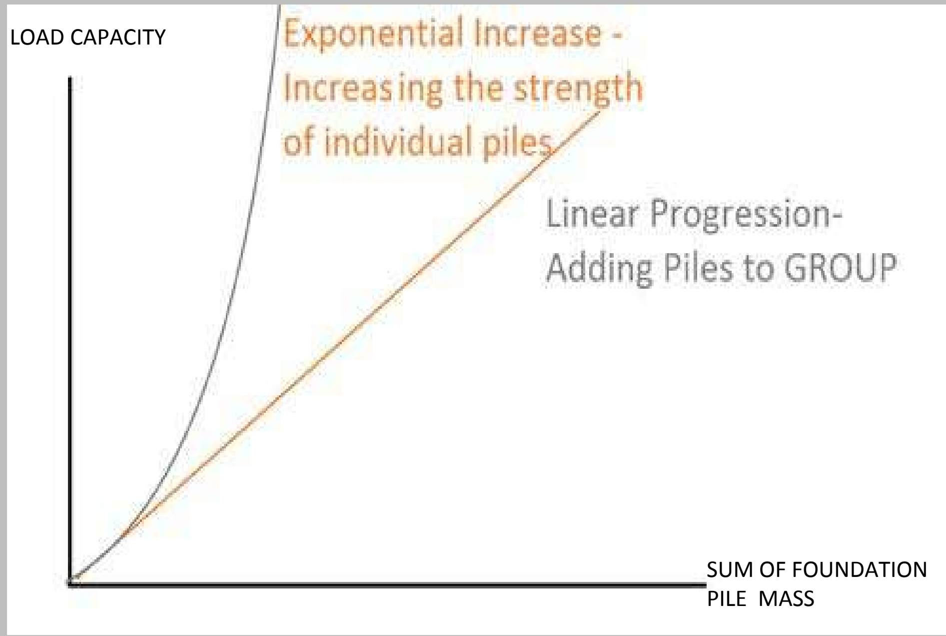
Individual Piles vs. Pile Group

GIVEN*: Piles act as individual piles in granular soils if their spacing is greater than 7 times the pile diameter;*

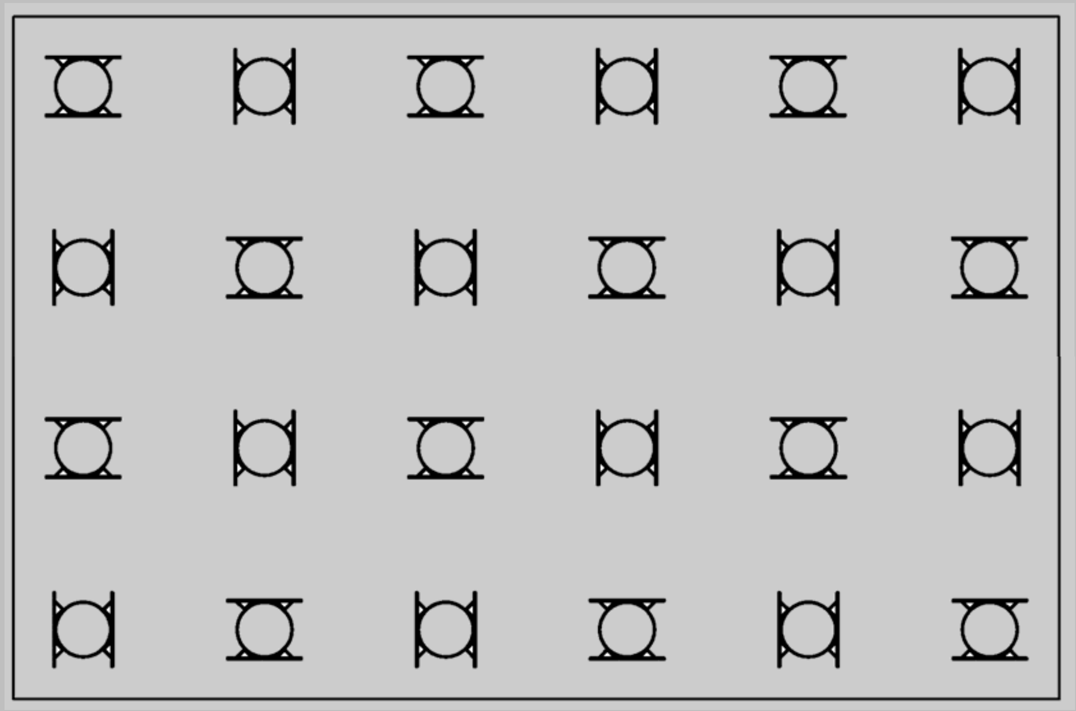
GIVEN*: Bearing capacity of pile groups is generally less than the sum of individual piles.*

THEN*, in order to increase capacity of the foundation you need to increase strength of piles without significant increase of their dimensions.*

SOLUTION*: Consider utilizing a FLANGED PIPE PILE (FPP) This is what it does !*



Because of smaller dimensions more FPP's can fit within the same foundation footprint than pipe piles.



Greater Sy/Sx ratio allows to achieve greater resistance to horizontal loads than that of H-pile foundations.

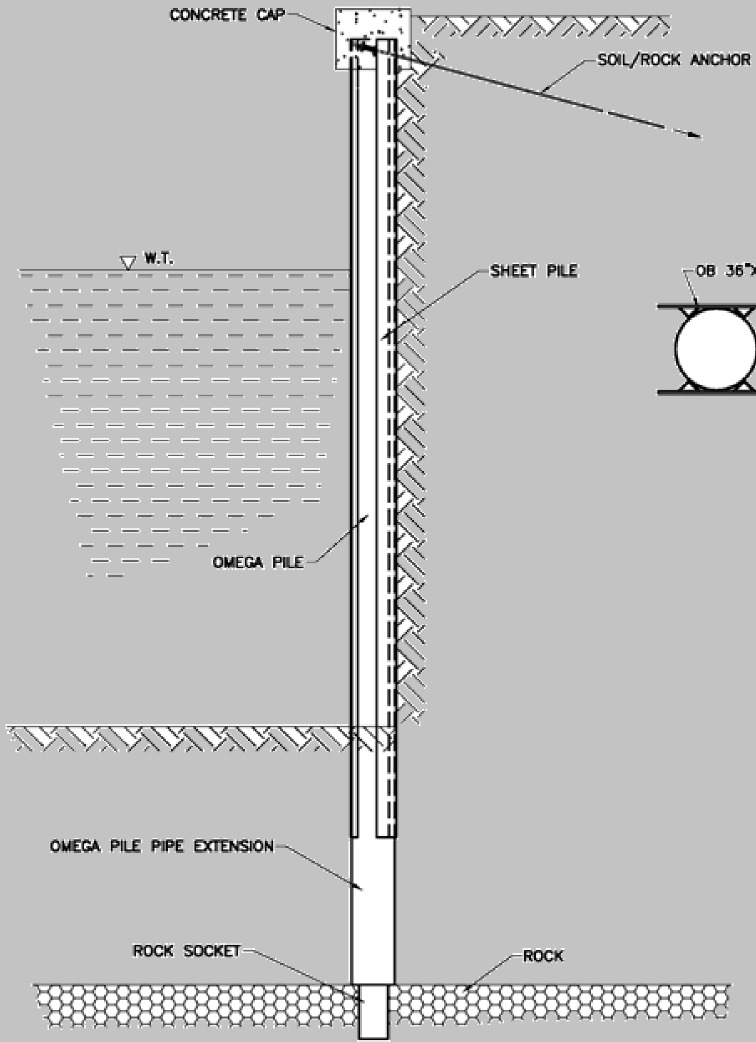
Hollow tubular core provides opportunity to break up obstructions and to anchor piles to rock.

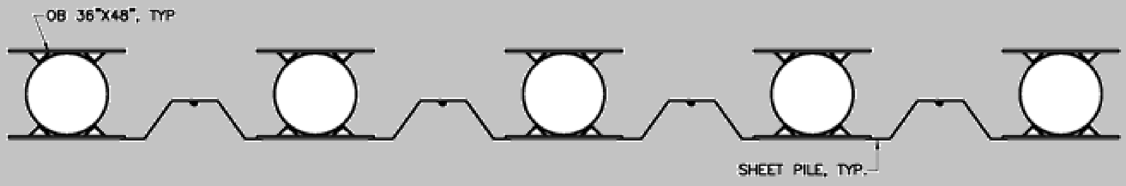
Benefits of Flanged Pipe Pile **FPP**

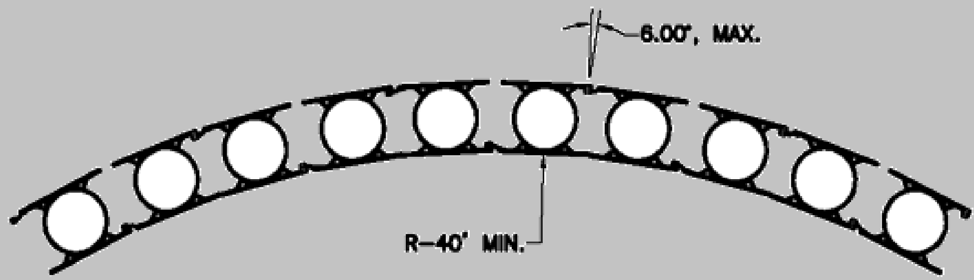
Seawalls & connected systems

Another application: **Connected Systems**.

smaller foot print = less environmental impact





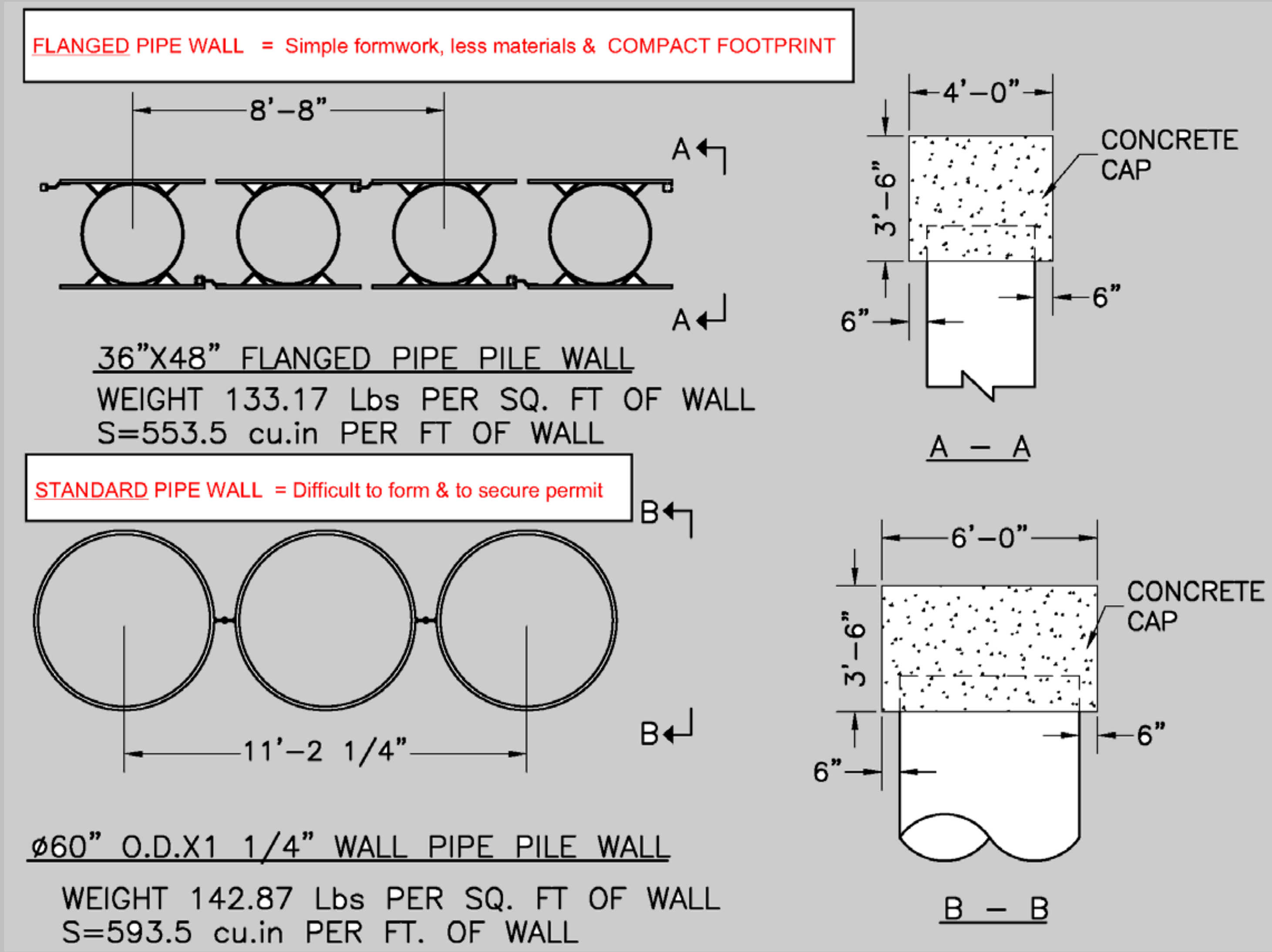


PIPE Wall

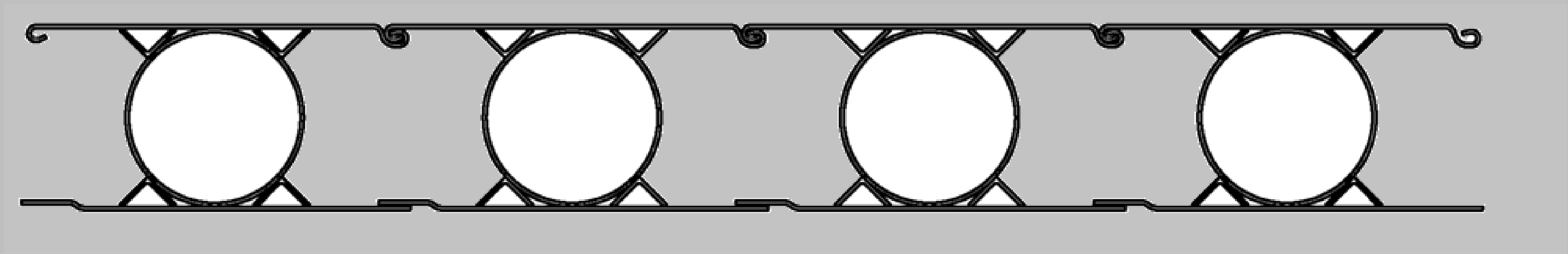
or

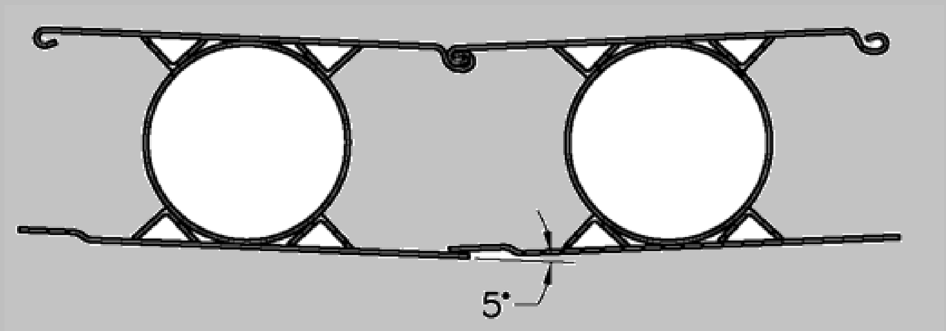
Combi-Wall

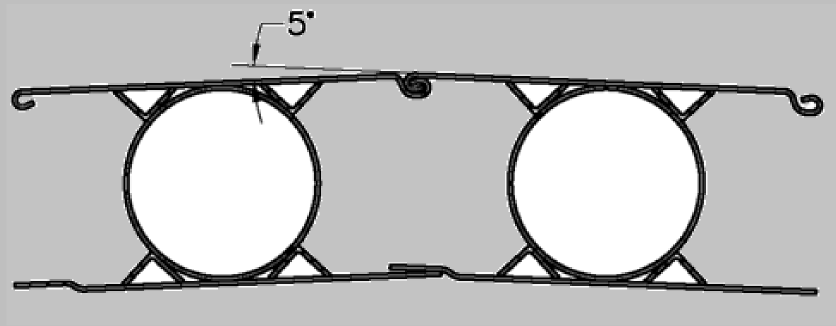
Footprint comparison



Cold rolled connected FPP

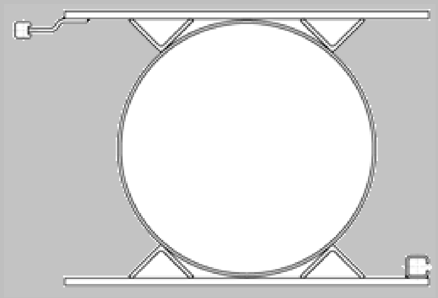


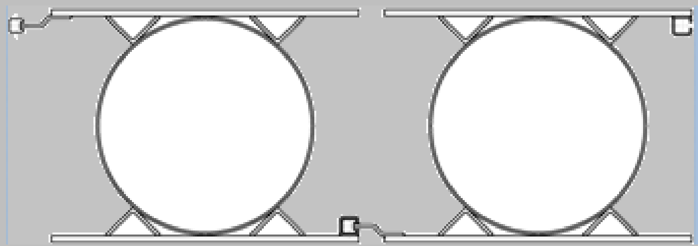


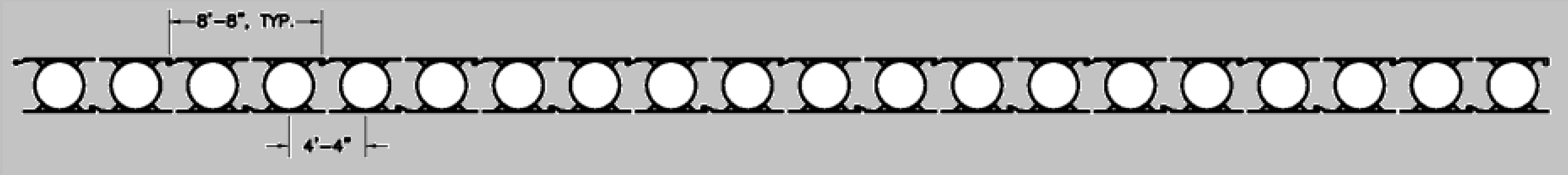


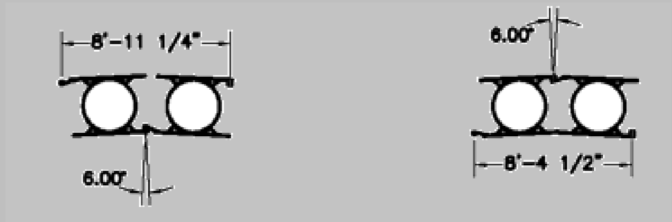
Connected systems

Smaller footprint = less environmental impact







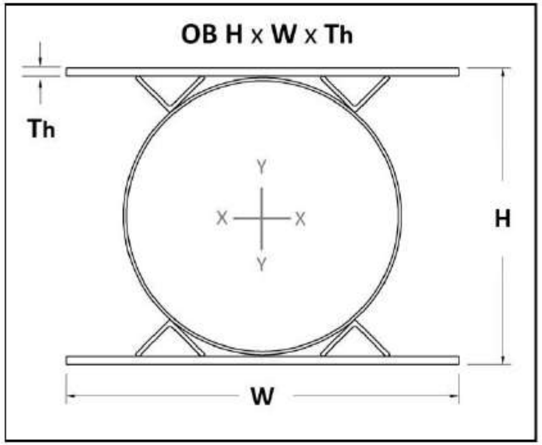


FPP Sections Guide

Standard Nomenclature

In Inches

Flanged Pipe Pile Nominal HEIGHT x Nominal Flange WIDTH x Thickness



EXAMPLE: **FPP 36** x **48** x **1** at 40 ft.

This is a Flanged Pipe Pile where **the flanges** are;

forty (40) foot long

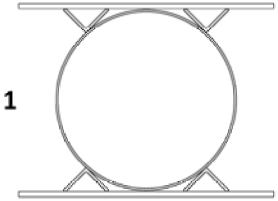
36" height or section depth

48" wide and 1" thick

Standard FPP Section Properties

THEORECTICAL SECTION PROPERTIES

FPP 44 x 60 x 1

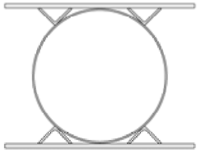


FPP 44 x 60 x 1

Weight: 759.4 lbs/lf
Area Steel: 223.63 in.^{2}

Moment of Inertia	Section Modulus
I_x = 82240 in.^{4}	S_x = 3738 in.^{3}
I_y = 58708 in.^{4}	S_y = 1957 in.^{3}

FPP 36 x 48 x 1

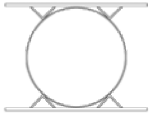


FPP 36 x 48 x 1

Weight: 540.0 lbs/lf
Area Steel: 158.69 in.^{2}

Moment of Inertia	Section Modulus
I_x = 40315 in.^{4}	S_x = 2240 in.^{3}
I_y = 26985 in.^{4}	S_y = 1124 in.^{3}

FPP 32 x 42 x 7/8

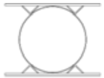


FPP 32 x 42 x 7/8

Weight: 447.1 lbs/lf
Area Steel: 131.50 in.^{2}

Moment of Inertia	Section Modulus
I_x = 25362 in.^{4}	S_x = 1598 in.^{3}
I_y = 17270 in.^{4}	S_y = 822 in.^{3}

FPP 26 x 32 x 5/8



FPP 26 x 32 x 5/8

Weight: 279.4 lbs/lf
Area Steel: 82.27 in.^{2}

Moment of Inertia	Section Modulus
I_x = 9566 in.^{4}	S_x = 750 in.^{3}
I_y = 6347 in.^{4}	S_y = 397 in.^{3}

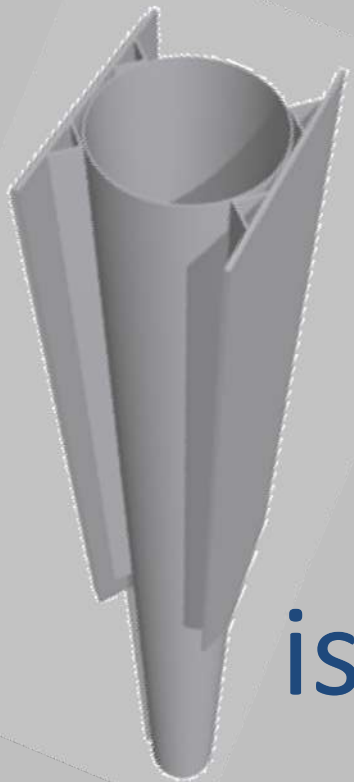
FPP 17 x 20 x 5/8

FPP 17 x 20 x 5/8

Weight: 181.7 lbs/lf
Area Steel: 53.30 in.^{2}

Moment of Inertia	Section Modulus
I_x = 2747 in.^{4}	S_x = 318 in.^{3}
I_y = 1750 in.^{4}	S_y = 175 in.^{3}

NOTE: FPP Sections can be customized to suit any specific application



Summary-

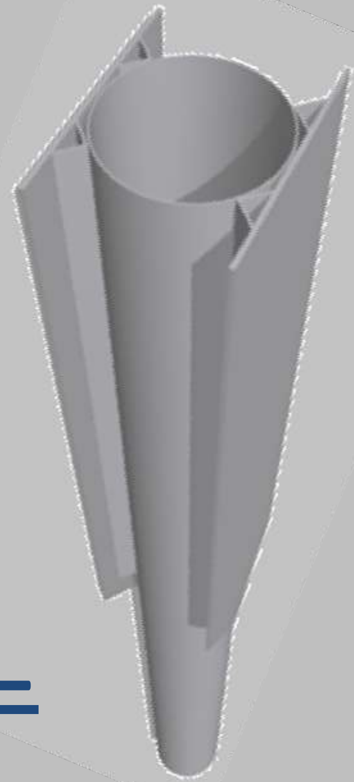
PLEASE REMEMBER

FLANGED PIPE PILE

(FPP)

is an effective NEW TOOL

for your pile driving Toolbox.



PILE DRIVING CONTRACTORS ASSOCIATION

17th Annual Design and Installation of Cost-Efficient Piles Conference

Thank You !

Any questions?

Charleston Marriott, Charleston, South Carolina
Wednesday, September 21 and Thursday, September 22, 2016