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INFORMED INFRASTRUCTURE
The magazine for civil & structural engineers

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CONTECH® ENGINEERED SOLUTIONS

Vertical Foundations | Supporting America's Infrastructure

March 21, 2023

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Introduction

Robert Chapman
Director of Product & Analytics
Contech Engineered Solutions LLC

Bob Moore
Region Engineer
Contech Engineered Solutions LLC

Jerry Skoda
Director of Strategic Markets
Contech Engineered Solutions LLC

A.J. Margetis
Regional Sales Manager, Chicago
Contech Engineered Solutions LLC

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AGENDA

- **Introduction**
- History of Vertical Applications
- Wind Turbine Foundations
  - Historical Perspective on Deep Foundations
  - On-Site Manufacturing Solutions
- Foundation Solutions for Utility Poles, Pier Foundations, Crane Enclosures and More
- Conclusion

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THE CONTECH WAY

Contech provides innovative, cost-effective site solutions to engineers, contractors and developers on projects across North America. Our portfolio includes bridges, drainage, erosion control, retaining walls, sanitary sewer and stormwater management products.

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Who are we … the experts you need to solve your site solution problems

Contech is the leader in site solutions, helping engineers, contractors and owners with infrastructure and land development projects for over a century.

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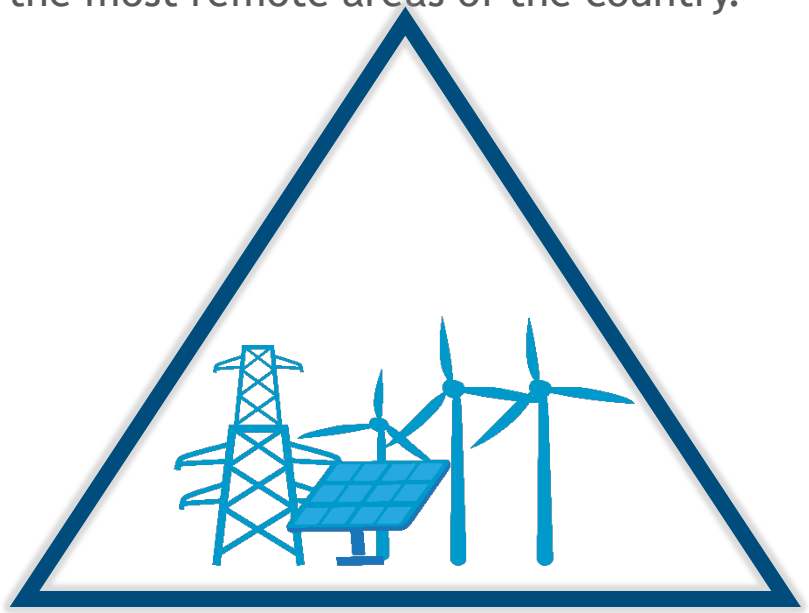
A Collaborative Effort with Project Partners

OWNER

We work as a collaborative partner across the board, providing education on solution development and can meet the most challenging of project lead-times in the most remote areas of the country.



ENGINEER

Our products have a proven track record, our expertise in the industry and understanding of environmental regulations, combined with strong engineering support, delivers ease and enhances design efficiency.

CONTRACTOR

Our logistical and installation support will help satisfy foundation requirements and ensure projects stay on schedule and on budget while giving piece of mind for structural integrity.

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The Green Product

- 99% of steel products can be recycled
- 75% more efficient production methods than years past
- 90% of energy used in processed, cleaned and returned to the environment

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Vertical Foundations in Infrastructure

- Contech has a decades-long history of successful vertical application projects including wind turbine foundations, utility poles, bridge pier foundations, crane enclosure, support for electrical transmission lines, petroleum cellars, and general concrete forms.

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Energy Market & Funding Opportunities | www.ContechES.com/iija

Infrastructure Investment and Jobs Act (IIJA) and Energy Market Funding

- Funding includes four major areas:
  - Delivering clean power / energy demonstrations
  - Funding for clean energy manufacturing and workforce development.

Wind Energy Technology Program

- Wind turbine vertical foundations capable of producing renewable energy are an opportunity for this program.

National Transmission Line Program supporting 53gw of Power

- MISO approved $10.3B for transmission line work through 2028

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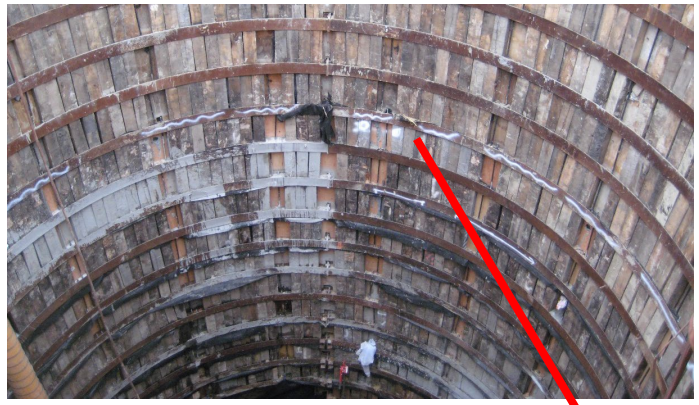
History of the Caisson

- **Caisson Historical Definition**: A chest or wagon for holding or conveying ammunition.
- **Caisson Engineering Definition**: Chamber or pipe made of steel, wood, or concrete used in the construction of foundations.
- First Steel Caissons for Foundations used in 1894.
- Chicago Stock Exchange building.
  - The EOR referred to them as shafts.
  - Over time Chicago construction workers referred to them as caissons.



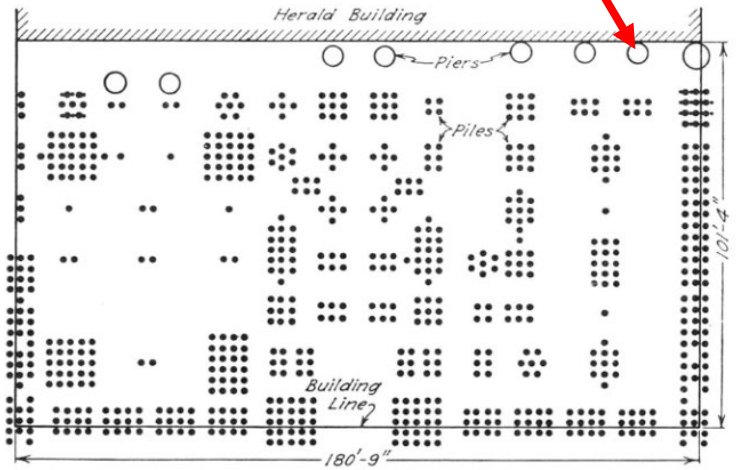


Fig. 30. Foundation Plan of Stock Exchange

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Construction Applications for Vertical Corrugated Steel Pipe

- Caissons for Utility Poles
- Electric Transmission Lines
- Bridge and Building Piers
- Wind Turbine Foundations
- Crane Enclosures
- Utility Sewer Shafts
- Petroleum Cellars
- Forms for Construction

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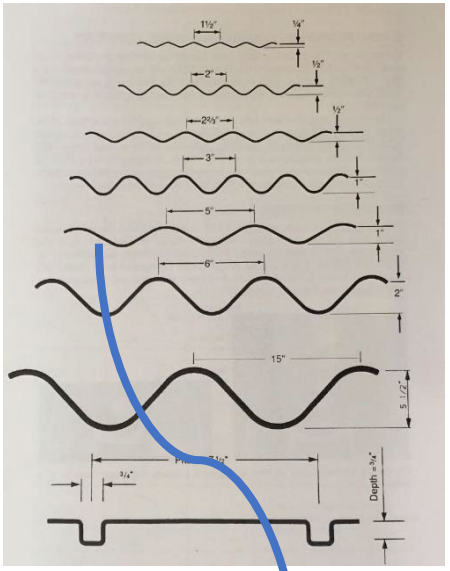
Why Corrugated Steel Pipe for Caissons/Vertical Construction?

- CSP is designed with a profile wall to provide more strength with less steel
- Efficient sinusoidal corrugation
- Many profiles - corrugation depths of ½”, 1”, 1 ¾”, 2”, and 5.5”



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Efficiently Engineered *Diameter Ranges*

Corrugation	Diameter
2 2/3” x ½”	12” – 84”
5”x 1” & 3” x 1”	48” – 144” (larger diameters available up to 198”*)
6” x 2” & 8” x 1 ¾”	60” – 312”
15” x 5 ½”	20’ diameter and larger

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SoFi Stadium - Inglewood, CA

- **Problem**: In order to construct such a massive stadium in a location known for its frequent seismic activity, special foundation design consideration was required.
- **Solution**: Contech manufactured large diameter, heavy gage HEL-COR® caissons to function as a casing/airgap between the structural concrete support columns and backfill, often referred to as “isolation casings.”
- 13,000 LF of 96” & 108” 12,000 LF of 30”, 42” & 54” of HEL-COR® CSP 3x1,10 GA Caissons

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Contech Wind Solutions

BRIDGE		• MULTI-PLATE® • Aluminum Structural Plate • Aluminum Box Culvert • SUPER-SPAN™ & SUPER-PLATE® • BridgeCor®	Span Range: 5' to 26' Span Range: 8-9' to 35' Span Range: 19' to 52' Span Range: 19' to 80'	These prefabricated solutions allow for fast and easy installation, accommodating both on-site and off-site issues. These products offers an economical solution with a long history of strength and durability.
		• CON/SPAN®	Span Range: 12' to 60'	These fully engineered, precast modular bridge systems can provide a natural bottom for environmental applications.
		Steadfast Bridge®	Span Range: 20' to 300'	These prefabricated vehicular truss bridges allow spanning of environmentally-sensitive areas. This facilitates more efficient permitting.

BUTLER RIDGE WIND FARM , WI

Contech Wind Solutions

PIPE		• Corrugated Metal Pipe (CMP)	Diameter Range: 12" to 196"	From coast to coast, engineers and contractors rely on CMP for culverts, storm sewers, small bridges and conduits. Our nationwide representatives can offer sales and service anywhere in the United States and more.
		• DuroMaxx®	Diameter Range: 30" to 120"	DuroMaxx steel reinforced polyethylene pipe is a revolutionary product capable of providing strength, long-term service and durability.
ADDED VALUE		• MOBILE PIPE™ (Modular mobile pipe mill)		The MOBILE PIPE creates the ability for on-site production for CMP projects, eliminating costly transportation expenses.

STATELINE WIND FARM, WA

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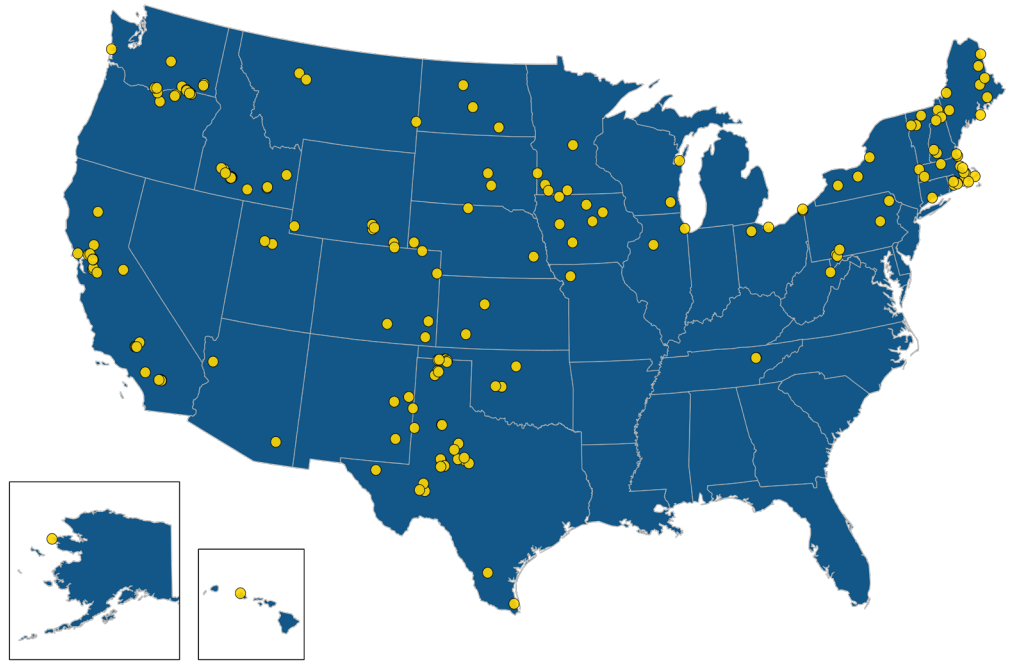
Historical Perspective

- Foundations in operation since 1994
- 7,000 + foundations installed providing >15 gigawatts of renewable energy
- Terracon purchased the P&H patents for the Pier and Anchor foundations in 2019
- Pier Foundations currently in operation in 5 countries outside the US – China , Mexico, Australia, Canada, Jamaica
- To-Date: Supporting the largest land-based WTG's - 4.5 MW



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Pier Foundations | GripTerra

Pier Foundations

Advantages

- Supports the largest turbines, 3 MW +
- Suitable for varying soil conditions
- Superior for seismically active zones, floodwater inundation, flood scour, frost depth, creeps and landslides
- Extended fatigue life characteristics due to post tensioning
- Speed of construction, less material, limited site disturbance
- Most efficient, cost-effective foundation solution in the industry

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Anchor Foundations | GripTerra

Anchor Foundations

Advantages

- Ability to support the largest available turbine systems- 3 MW +
- Anchor foundation systems excel in every soil type
- Reduced footprint and site disturbance
- Reduction and potential elimination of blasting requirements
- Increased stiffness and long-term reliability
- Maximizes material and resource efficiencies
- Superior for mountain and remote access sites
- 100+year design life achievable, re-certifiable (Repower)
- Anchors available – Rock and Soil (hollow stem , auger cast piles, helical, driven piles

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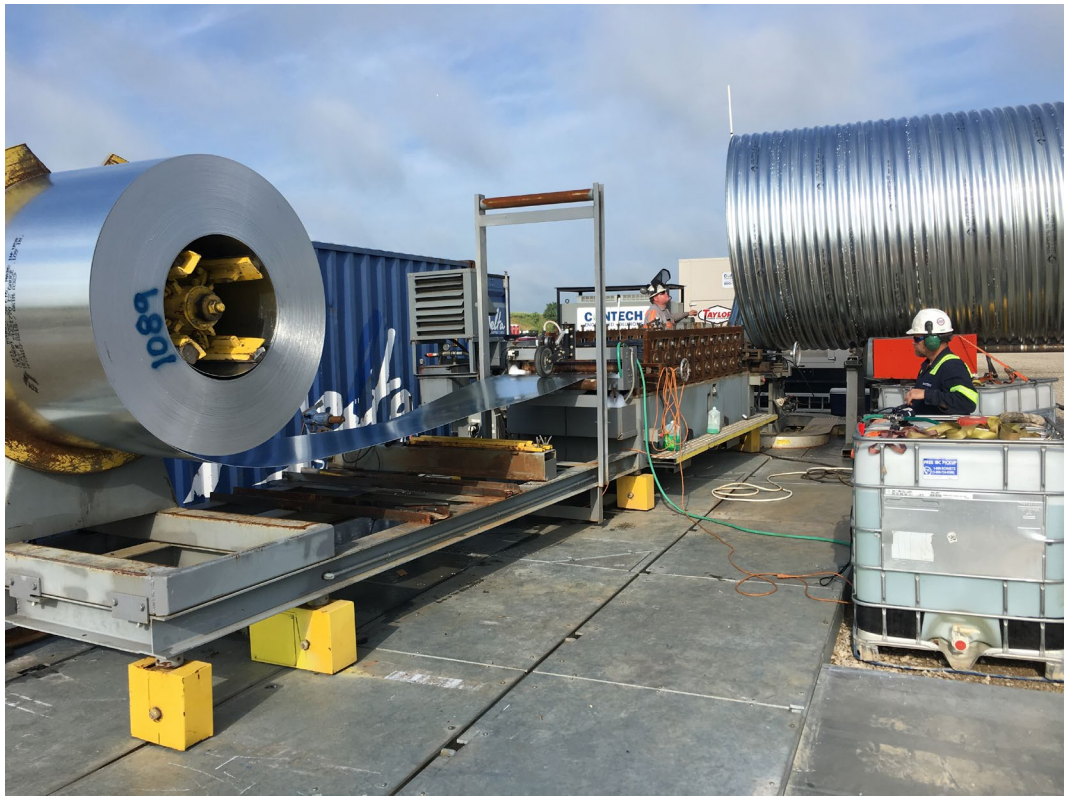
Electric Transmission Lines

- HEL-COR® CSP used as a permanent stay-in-place form.

Electric Transmission Lines

- Reynolds Topeka Transmission Line
- Summer/Fall 2016
- Owner: NIPSCO
- Contractor: CJ Drilling
- Manufacturing Location: On Site!
- MOBILE PIPE® Production Vehicle
- >700,000 lbs of 12 gage HEL-COR®



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HEL-COR® CSP for Bridge Piers

- CSP used as H Pile Encasement.

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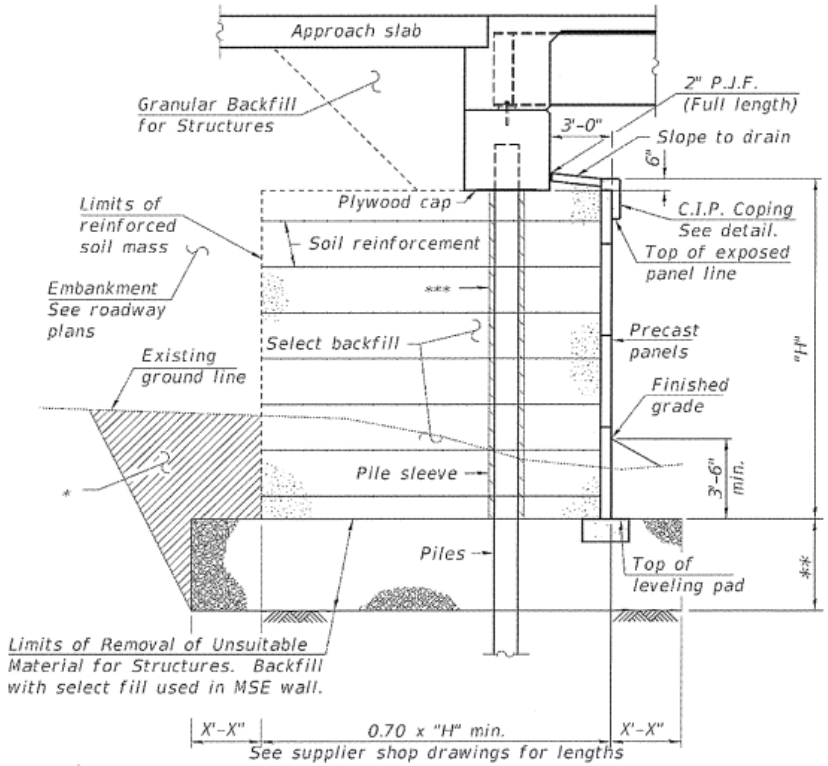
Vertical Foundation for Bridges

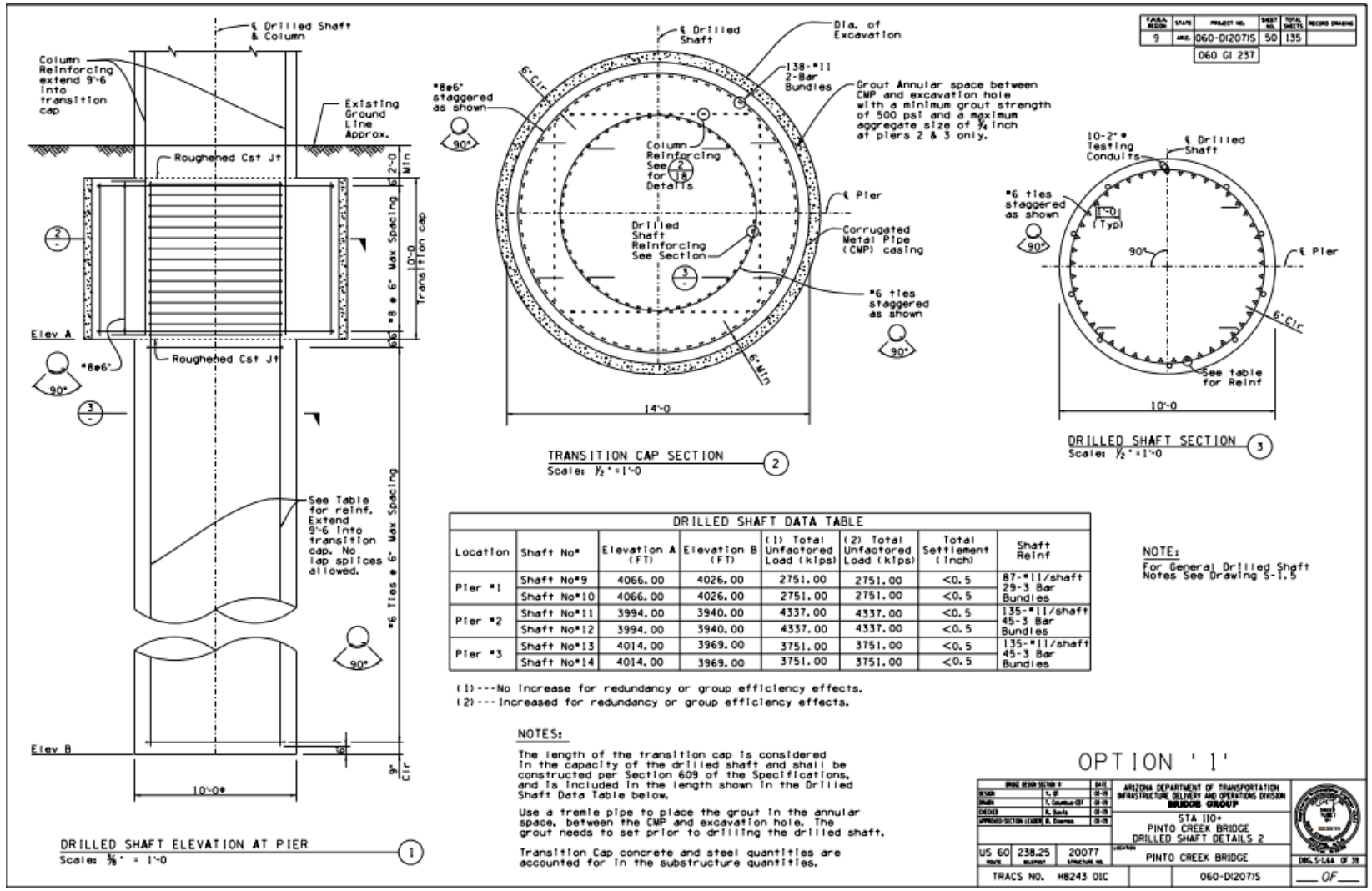


* Overexcavation beyond structure excavation and removal of unsuitable material. This area not measured for payment. Backfill overexcavation with same material used for select fill used in MSE wall.

** If required by structure geotechnical report.

*** Place Bentonite between pile sleeve and pile.

Vertical Foundation for Bridges



FAA/A REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	ARIZ.	060-D(207)S	50	135	
		060 GI 237			

DRILLED SHAFT DATA TABLE

Location	Shaft No*	Elevation A (FT)	Elevation B (FT)	(1) Total Unfactored Load (kips)	(2) Total Unfactored Load (kips)	Total Settlement (inch)	Shaft Reinf
Pier *1	Shaft No*9	4066.00	4026.00	2751.00	2751.00	<0.5	87-#11/shaft 29-3 Bar Bundles
	Shaft No*10	4066.00	4026.00	2751.00	2751.00	<0.5	
Pier *2	Shaft No*11	3994.00	3940.00	4337.00	4337.00	<0.5	135-#11/shaft 45-3 Bar Bundles
	Shaft No*12	3994.00	3940.00	4337.00	4337.00	<0.5	
Pier *3	Shaft No*13	4014.00	3969.00	3751.00	3751.00	<0.5	135-#11/shaft 45-3 Bar Bundles
	Shaft No*14	4014.00	3969.00	3751.00	3751.00	<0.5	

(1)---No increase for redundancy or group efficiency effects.
(2)---Increased for redundancy or group efficiency effects.

NOTE:
For General Drilled Shaft Notes See Drawing S-1.5

NOTES:

The length of the transition cap is considered in the capacity of the drilled shaft and shall be constructed per Section 609 of the Specifications, and is included in the length shown in the Drilled Shaft Data Table below.

Use a tremie pipe to place the grout in the annular space, between the CMP and excavation hole. The grout needs to set prior to drilling the drilled shaft.

Transition Cap concrete and steel quantities are accounted for in the substructure quantities.

OPTION '1'

DESIGN	L. GF		04-19
DRAWN	T. Columbus-CDT		04-19
CHECKED	K. Sparks		04-19
APPROVED-SECTION LEADER	B. Sherman		04-19

ARIZONA DEPARTMENT OF TRANSPORTATION
INFRASTRUCTURE DELIVERY AND OPERATIONS DIVISION
BRIDGE GROUP

STA 110+
PINTO CREEK BRIDGE
DRILLED SHAFT DETAILS 2

US 60	238.25	20077
ROUTE	MILEPOST	STRUCTURE NO.

LOCATION: PINTO CREEK BRIDGE

TRACS NO. H8243 01C | 060-D(207)S | DRG. S-1.64 OF 39 | ___ OF ___

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Largest HEL-COR® Caisson Ever!

- Arizona DOT Highway 303
- Keller – North America
- March 2016
- 186” (15.5’) Diameter CMP
- Plant: El Mirage, AZ

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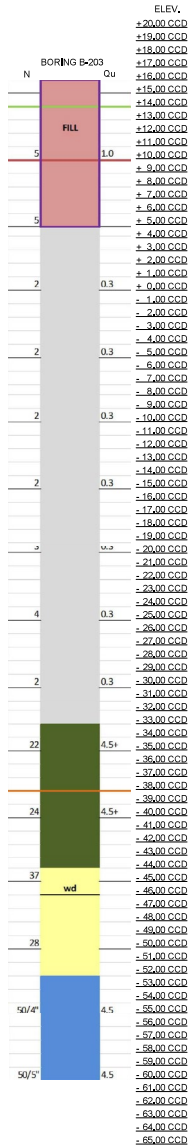
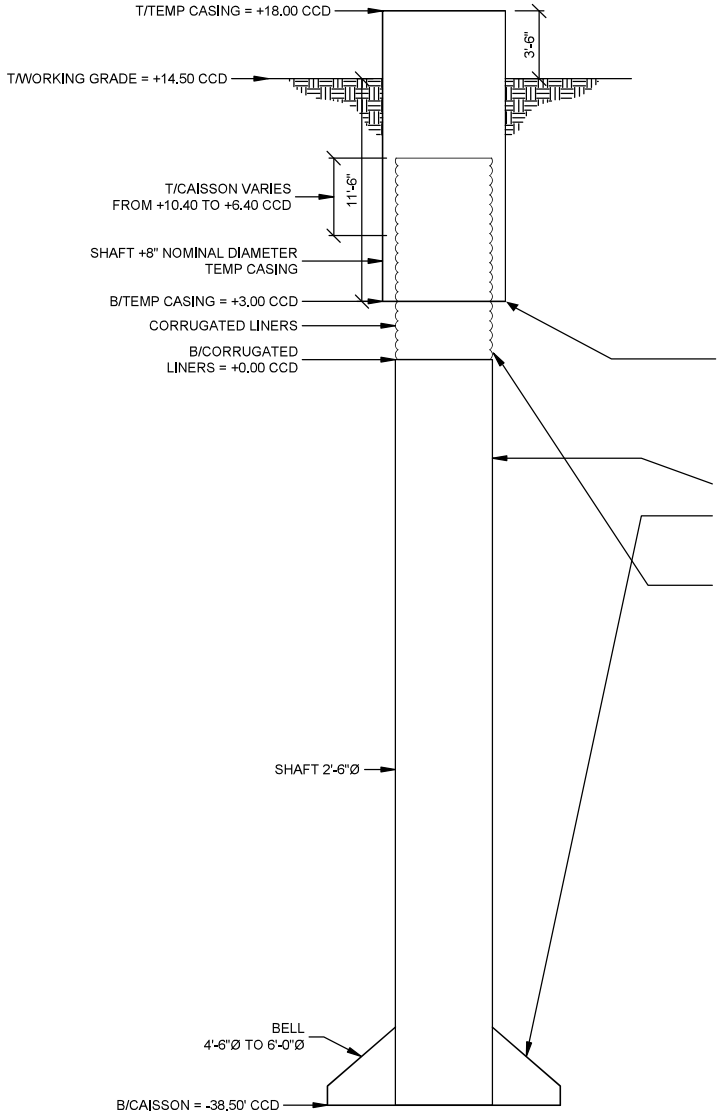
The Chicago Caisson Method





2’-6” DIAMETER SHAFTS WITH 4’-6” TO 6’-0” DIAMETER BELLS (48 CAISSONS):

1. Remove payment and any surface obstruction.
2. Locate center of shaft
3. Set and twist a shaft +8” nominal diameter temporary casing to +3.0 CCD. The casing will be above ground (3’-6”) and will serve as a safety rail.
4. Drill shafts to the bottom of a -38.5 CCD
5. Drill a 4’-6” to 6’-0” diameter bell at the bottom of the caisson. The bell angle should not be flatter than 60 degress from the horizontal.
6. Each caisson shall be inspected and approved by the soil engineer prior to placing the concrete, reinforcing steel, and corrugated liners. The top of the corrugated liners will be at the to of the caisson elevation, with the bottom of the corrugated liners extending 3’-0” below the bottom of the temporary casing to +0.0 CCD. The corrugated liners will be 7’-0” & 10’-6” long.
7. Set rebar cage.
8. Pour concrete into the shafte and corrugated liner to design elevation indiated in the drawings by free-fall method.
9. The next day, after the concrete has set up, grout will be poured in the annular space between the temporary casing and CMP liner, FA-5 screenings backfill will be placed from the top of caisson concrete to top of ground and the temporary casing will be pulled.

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Caissons for Building Foundations

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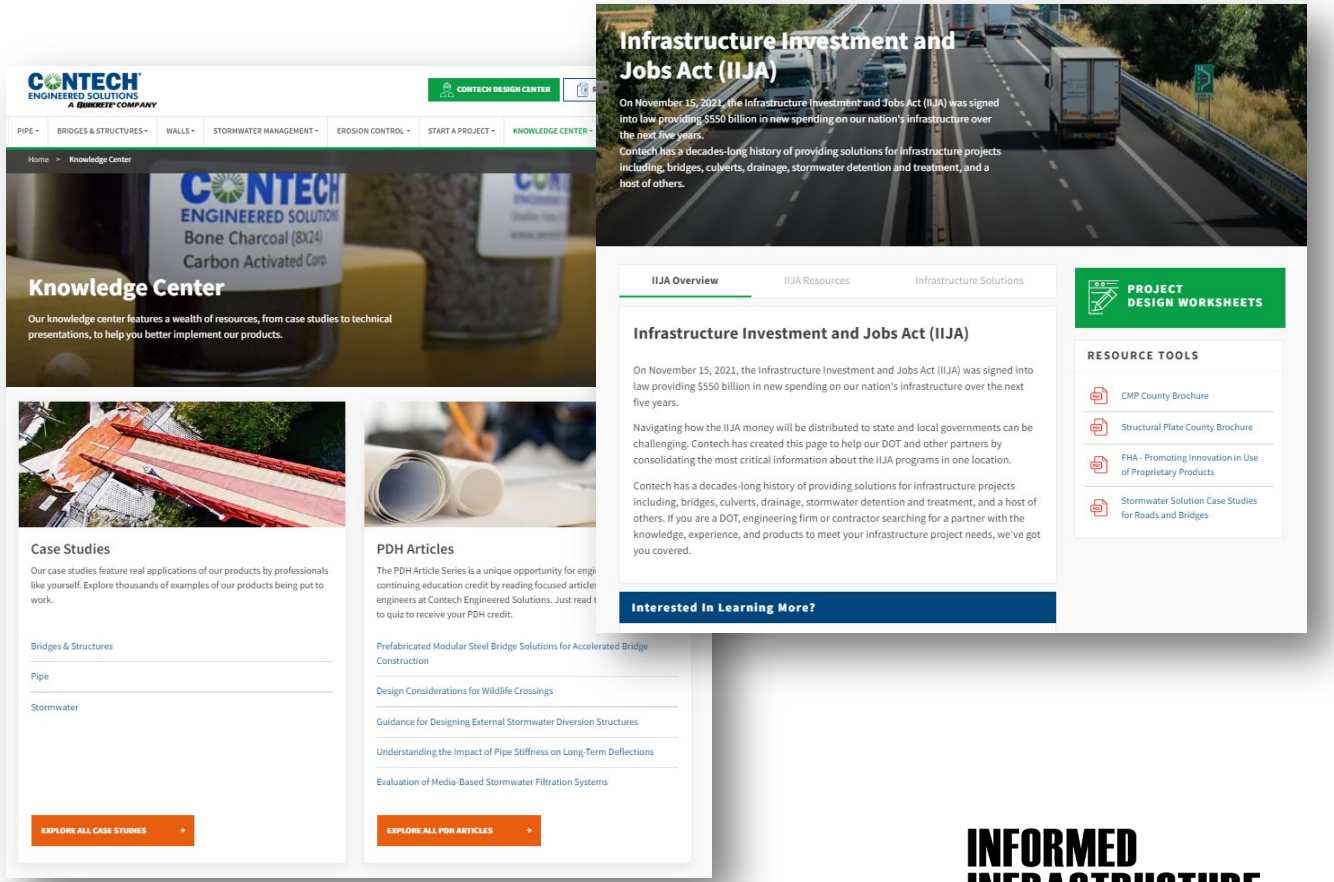
Resources

- IIJA Funding Opportunities | www.ContechES.com/iija
- www.ContechES.com
  - Contech Design Center
  - Product Design Worksheets
  - Technical Documents
  - PDH Articles
  - Case Studies & Blogs
  - Local Resources



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Questions and Answers with:

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