Design and Construction of Auger Cast Piles

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CONTENTS

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Example of Foundations Failure

Example of Foundations Failure

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Example of Foundations Failure

Auger Cast Pile Types

- Auger Cast Pile (ACP)
- Continuous Flight Auger (CFA) Piles
- Augered-Cast-in-Place (ACIP)
- Auger Pressure Grout
- Screw Piles
- Drilled Displacement (DD) Piles

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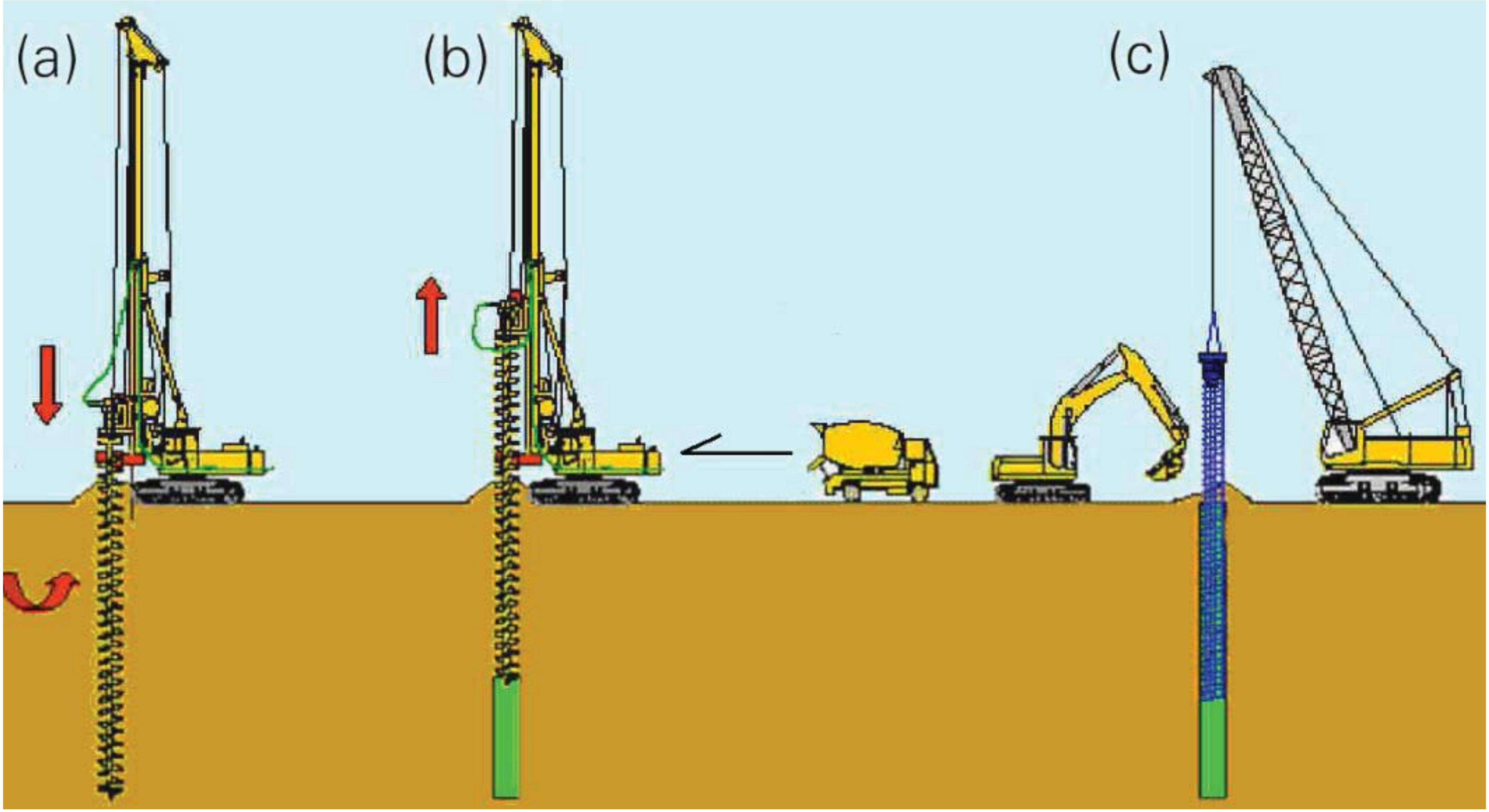
Auger Cast Pile Types

Auger cast piles are a type of drilled foundation in which the pile is drilled to the final depth in one continuous process using a continuous flight auger.

Auger Cast Pile Types



A) During drilling the flights of the auger are filled with soil, providing lateral support and maintaining the stability of the hole. **B)** At the same time the auger is withdrawn from the hole, concrete or a sand/cement grout is placed by pumping the concrete/grout mix through the hollow center of the auger pipe to the base of the auger that provides continuous support of the hole. **C)** Then Steel-reinforcement is placed into the hole.

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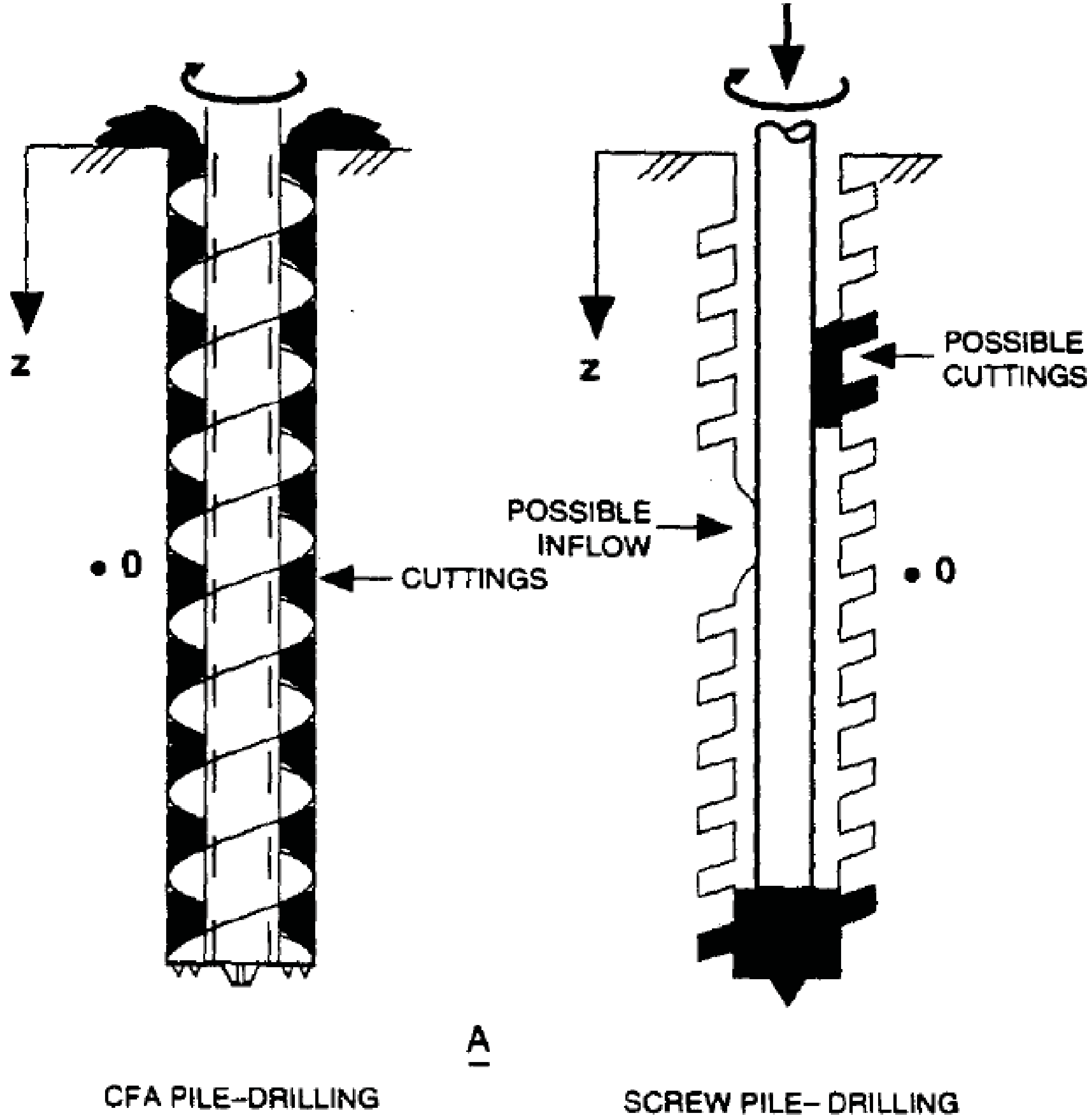
Auger Cast Pile Types

Drilled Displacement (DD) Piles

Auger Cast Pile Types



Auger Cast Pile Types

- Auger cast piles are typically installed with diameters ranging from 12 to 36 in. and lengths of up to 100 ft. In Europe with more recent powerful rigs, diameters could go up to 60 in.
- The reinforcement is in the upper portion of the pile for ease of installation and low bending stresses are transferred below these depths. In some cases, full-length reinforcement is used, as is most common with drilled shaft foundations.
- Auger cast piles can be constructed as single piles like for soundwall or light pole foundations
- For bridges or other large structural foundations, auger cast piles are most commonly installed as part of a pile group in a manner similar to that of driven pile foundations

Auger Cast Piles

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Auger Cast Pile Types

Drilled Shaft vs. CFA Foundation

- Use of casing or slurry to temporarily support the hole is avoided.
- Drilling the hole in one continuous process is faster than drilling a shaft excavation.
- Because of torque requirement the diameter and length of CFA piles are generally less than drilled shafts.
- Continuous auger for installation also limits CFA piles to soil or very weak rock profiles.

Auger Cast Piles

Auger Cast Pile Types

Drilled Shaft vs. CFA Foundation

Auger Cast Pile Types

Driven Piles vs. CFA Foundation

- Noise and vibration due to pile driving are minimized.
- CFA piles eliminate splices and cutoffs.
- Soil heave due to driving can be eliminated when non-displacement CFA piles are used.
- A disadvantage of CFA piles compared to driven piles is that the available QA methods to verify the structural integrity and pile bearing capacity for CFA piles are less reliable than those for driven piles.
- CFA piles generate soil spoils that require collection and disposal especially if it is contaminated.


Auger Cast Piles

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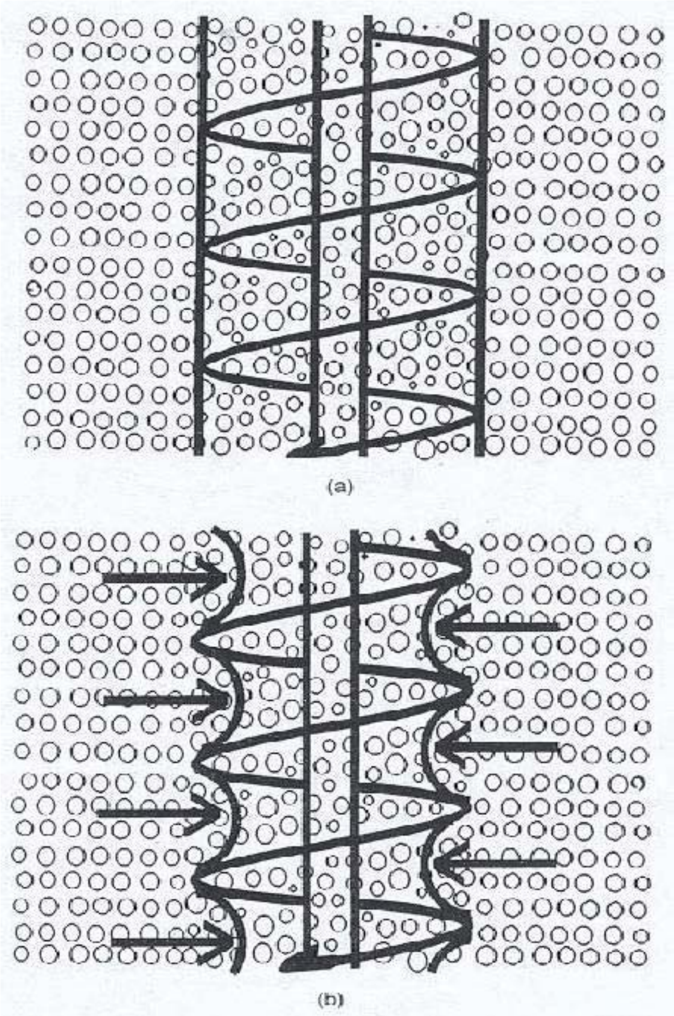
Construction Sequence - Drilling

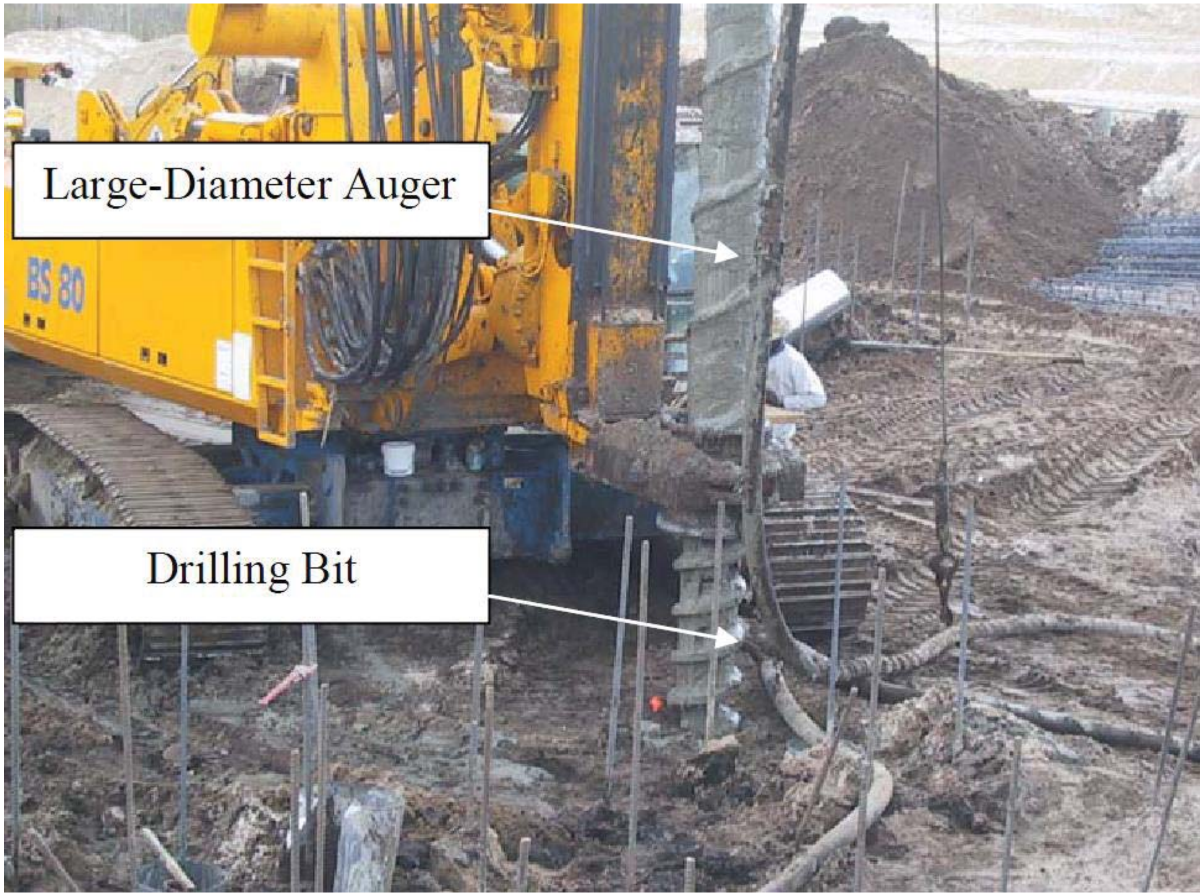


Balanced auger rotation and penetration rates

The auger having an excessively slow penetration rate and an insufficient base feed to keep the auger flights full

Effect of Over- Excavation using CFA Piles

Construction Sequence - Drilling



When a soil profile being drilled has mixed soil conditions (e.g., weak and strong layers), difficulties may arise. If the rig cannot penetrate the strong soil stratum at the proper rate, the augers can "mine" the overlying weak soil to the surface and cause subsidence.

One solution to properly balance soil removal and penetration rate is to use Drilled Displacement (DD) piles.

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Construction Sequence - Grouting

Grout Delivered to Pump

When the drilling stage is complete and the auger has penetrated to the required depth, the grouting stage must begin immediately. Grout or concrete is pumped under pressure through a hose to the top of the rig and delivered to the base of the auger via the hollow center of the auger stem.

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Construction Sequence - Grouting

Hole at Base of Auger for Concrete

Construction Sequence – Grouting Sequence

- Upon achieving the design pile tip elevation, the auger is lifted a short distance typically 6 to 12 in. and grout is pumped under pressure to expel the plug at the base of the internal pipe and commence the flow. The auger is then screwed back down to the original pile tip elevation to establish a small head of grout or concrete on the auger and to achieve a good bearing contact at the pile tip.
- The grout is pumped continuously under pressure typically up to 150 to 300 psi measured at the top of the auger while the auger is lifted smoothly in one continuous operation.
- Simultaneously, as the auger is lifted, the soil is removed from the flights at the ground surface so that soil cuttings are not lifted high into the air (potential safety hazard).
- After the auger has cleared the ground surface and the grouting/concrete procedure is completed, any remaining soil cuttings are removed from the area at the top of the pile and the top of the pile is cleared of debris and contamination.
- The reinforcement cage is lowered into the fluid grout/concrete to the required depth and tied off at the ground surface to maintain the proper reinforcement elevation.

Construction Sequence

Construction Sequence

Grout at Surface after Auger Withdrawal

Sometime the top of the pile can be difficult to find among the surface disturbance. Attention to detail in the final preparation of the surface is critical to ensure that structural integrity is maintained.

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Construction Sequence

Finishing Pile and Reinforcement Placement

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Construction Sequence - Grout vs. Concrete

Grout

- Majority of work is using a sand/cement grout mixture because of the fluidity and ease of installation of reinforcement. The typical range of compressive strength of grout (4,000 to 5,000 psi).
- In the grout mix, fly ash and slag are often substituted for a portion of the cement for 24% to 30% to produce mixes with higher workability and pumpability, reduced bleeding, and reduced shrinkage.
- Grout is so fluid that the workability is typically measured using a flow cone.

Concrete

- For concrete a pea-gravel size aggregate with around 42% sand used in the mix. Concrete is cited as being less costly than grout, less prone to overrun volume, and is considered to be more stable in the hole when constructing piles through soft ground. Concrete slump for CFA construction is similar to that of wet-hole drilled shaft construction, with target slump values in the 8 in. ± 1 in. range.

Applications For Transportation Projects

- Bridge Piers and Abutments.
- Soundwalls.
- Earth Retaining Structures.
- Pile-Supported Embankments.

Advantages And Limitations of CFA Piles

- Speed of installation of CFA piles and lower cost over other pile types.
- Increased requirements to minimize noise and vibrations from pile installation in heavily populated areas.
- A reluctance by many owners to utilize CFA piles because of concerns about quality control and structural integrity.
- Demand on bridges for uplift and lateral load capacity, scour considerations, and/or seismic considerations, require pile diameters and possibly lengths

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Advantages And Limitations of CFA Piles

Favorable Geotechnical Conditions

- Medium to very stiff clay soils.
- Cemented sands or weak limestone.
- Medium dense to dense silty sands and well-graded sands.
- Rock overlain by stiff or cemented deposits.

Unfavorable Geotechnical Conditions

- Very soft soils.
- Loose sands under groundwater.
- Geologic formations containing voids.
- Hard soil or rock overlain by soft soil or loose, granular soil.

Applications For Transportation Projects

When to Select and Use the CFA Piles

- Favorable geotechnical conditions available.
- Projects where speed of installation is important.
- Batter Piles Required.
- Projects where large numbers of piles are required.
- Low headroom conditions.

Applications For Transportation Projects

Bridge Piers and Abutments

Types of bridge most suited for the use of CFA

- Interchange structures (where scour is not a major issue).
- Approach structures.
- Or those involving bridge widening.

Applications For Transportation Projects

Bridge Piers and Abutments
Crosby, Texas

Applications For Transportation Projects

Bridge Piers and Abutments
Crosby, Texas

- Twelve production piles were instrumented and monitored during construction and load testing using trucks. The results from the pile instrumentation suggest that the piles supported the fully loaded bridge entirely by mobilizing side friction alone and with very small around 0.1 in. movements.

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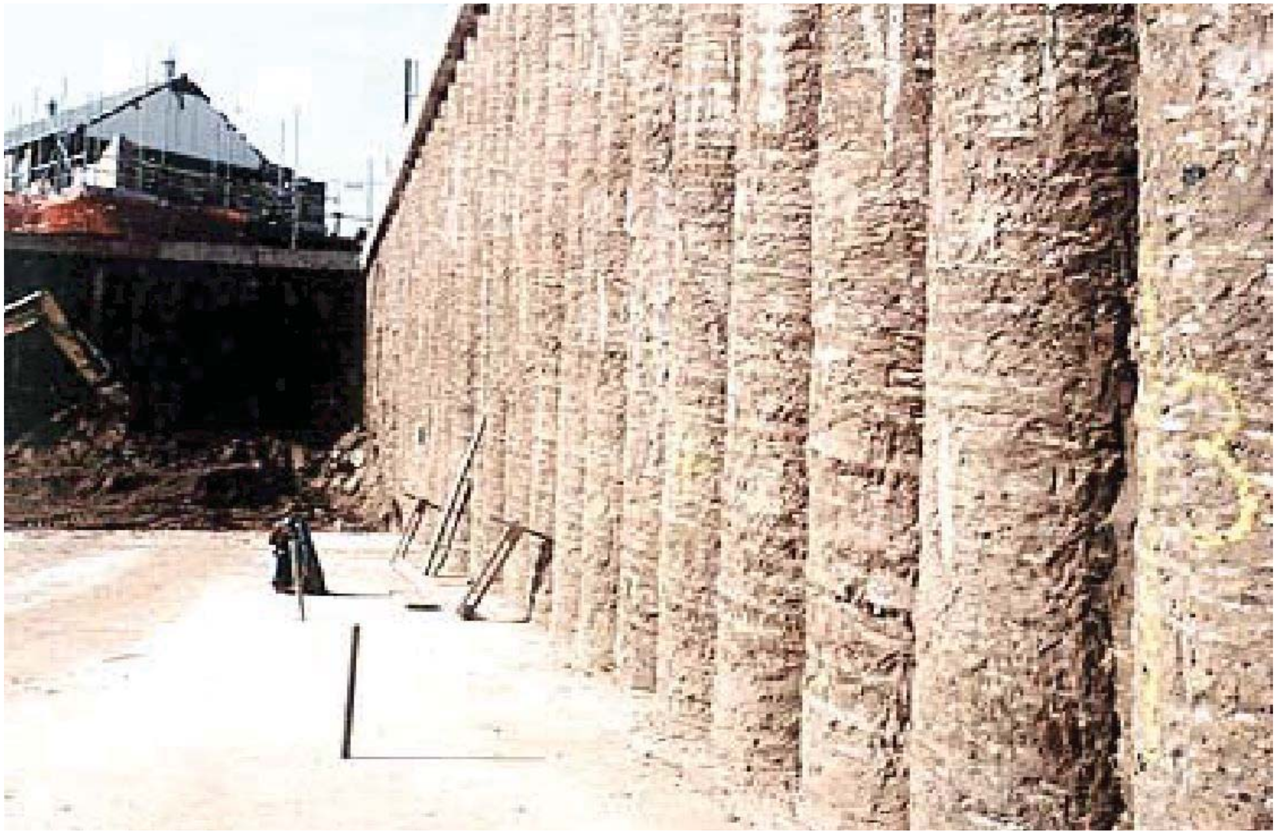
Applications For Transportation Projects

Low Headroom Conditions

Applications For Transportation Projects

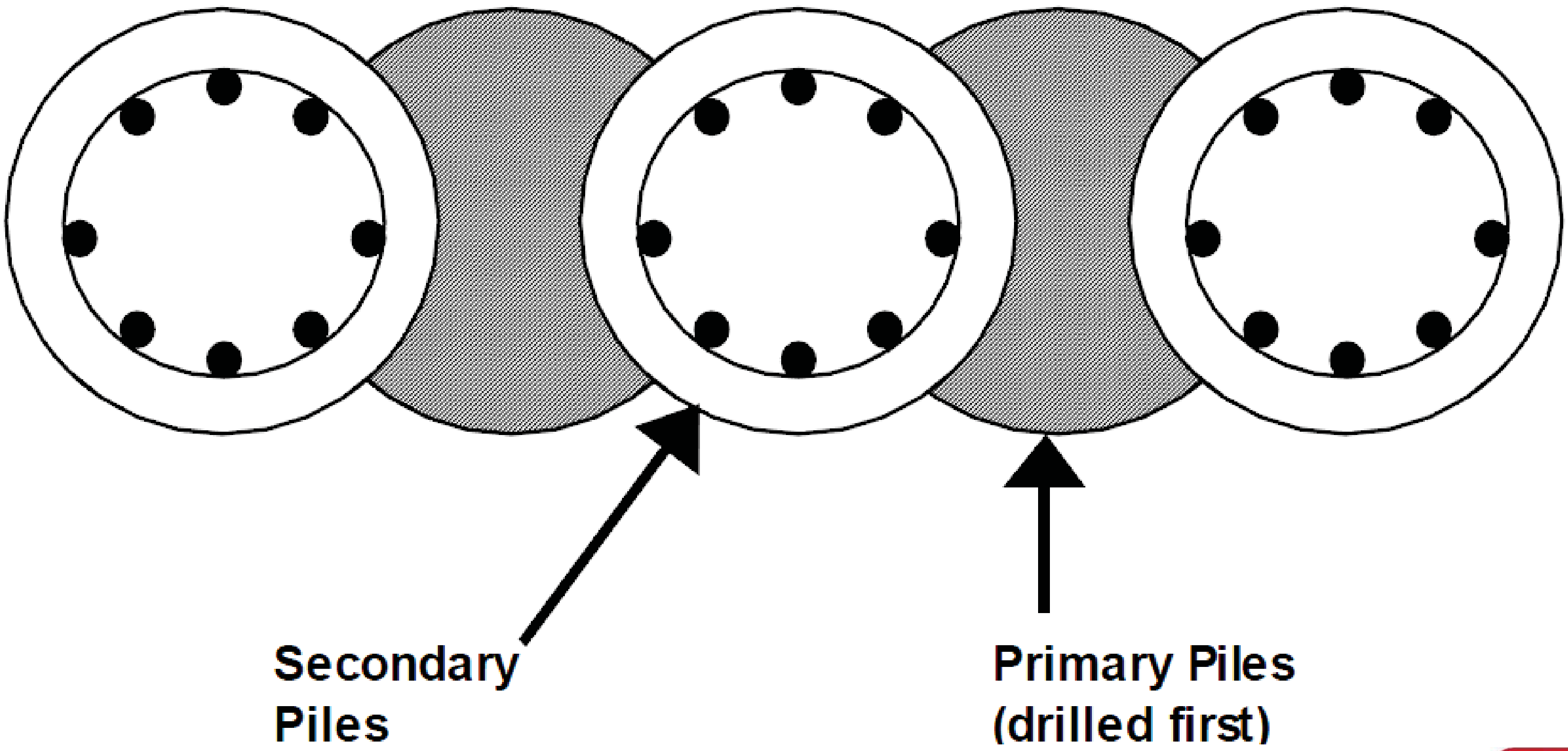
Secant or Tangent Pile Walls

- CFA piles can be a viable alternative to drilled shafts or slurry walls.
- A structural steel section may be used for pile reinforcement rather than a reinforcing cage.
- Needs heavy drilling equipment.



Applications For Transportation Projects

Secant or Tangent Pile Walls



Applications For Transportation Projects

Drilling CFA Piles for Secant

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Applications For Transportation Projects

Secant or Tangent Pile Walls
New Haven, Connecticut

Applications For Transportation Projects

Secant or Tangent Pile Walls
New Haven, Connecticut

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Applications For Transportation Projects

Soundwalls in Favorable Soil

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Applications For Transportation Projects

Pilecaps on CFA Piles for a Pile-Supported Embankment

The use of CFA piles for a pile-supported embankment may represent a cost-effective alternative to ground modification

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Applications For Transportation Projects

Pilecaps on CFA Piles for a Pile-Supported Embankment

- Foundation strata consist of weak and compressible subsoils, which would take a long time to consolidate.
- Accelerating construction.
- fill supporting a transportation facility that is particularly sensitive to settlements (such as a high-speed rail).
- Accelerated construction is required for projects where additional cost due to traffic shifts, geotechnical instrumentation, and related time delays present an unacceptable situation to project owners

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Construction Cost

($20 to $28 per linear foot

Many Variables Affect Pile Costs

- Costs relating to performance and integrity testing are likely to be higher on transportation projects.
- Length, diameter, reinforcement, and grout strength.
- Size of the project.
- Mobilization cost

Construction Equipment

Crane-Attached CFA System

Hydraulic CFA System

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Construction Equipment

Augers for Different Soil Conditions: Auger for CFA Piles in Sandy Soil (Top) and Augers for DD Piles (Bottom)

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Construction Equipment

Auger for Use in Clay, with Auger Cleaner Attachment

Construction Equipment

Cutter Heads for Hard Material (left) and Soil (right)

Construction Equipment

Double Rotary CFA Piles

Construction Equipment

Trucks Discharging into Pump

Close up View of Grout Pump

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Construction Equipment

In-Line Flowmeter

Construction Equipment

Sensor for Concrete Pressure at Auger Tip

Reinforcement

Machine-Welded Reinforcement Cage on Project Site

Reinforcement

Use of Steel Pipe to Reinforce a CFA Pile for a Wall

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Reinforcement

Installation of Reinforcement Cage into Battered CFA Pile

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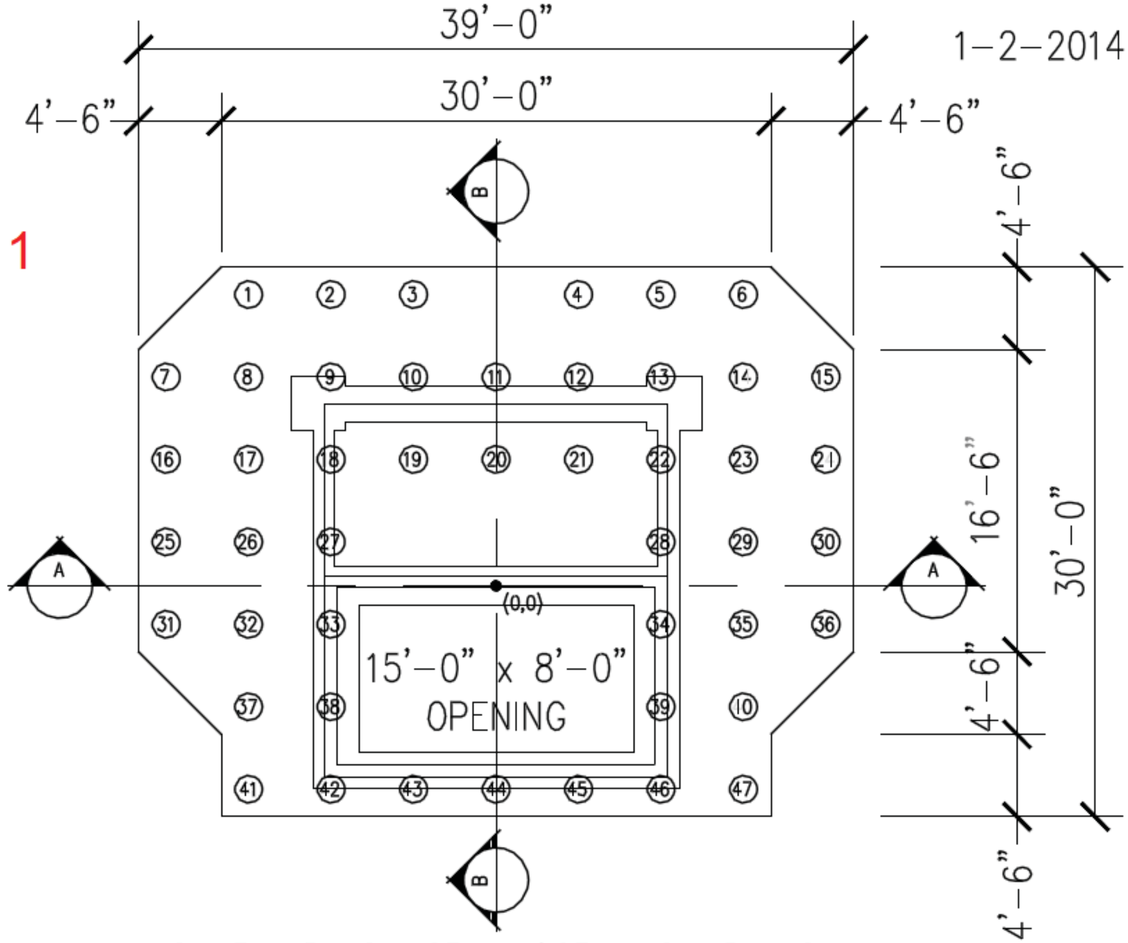
Static Axial Capacity and Group Effects, Case History

Case 1



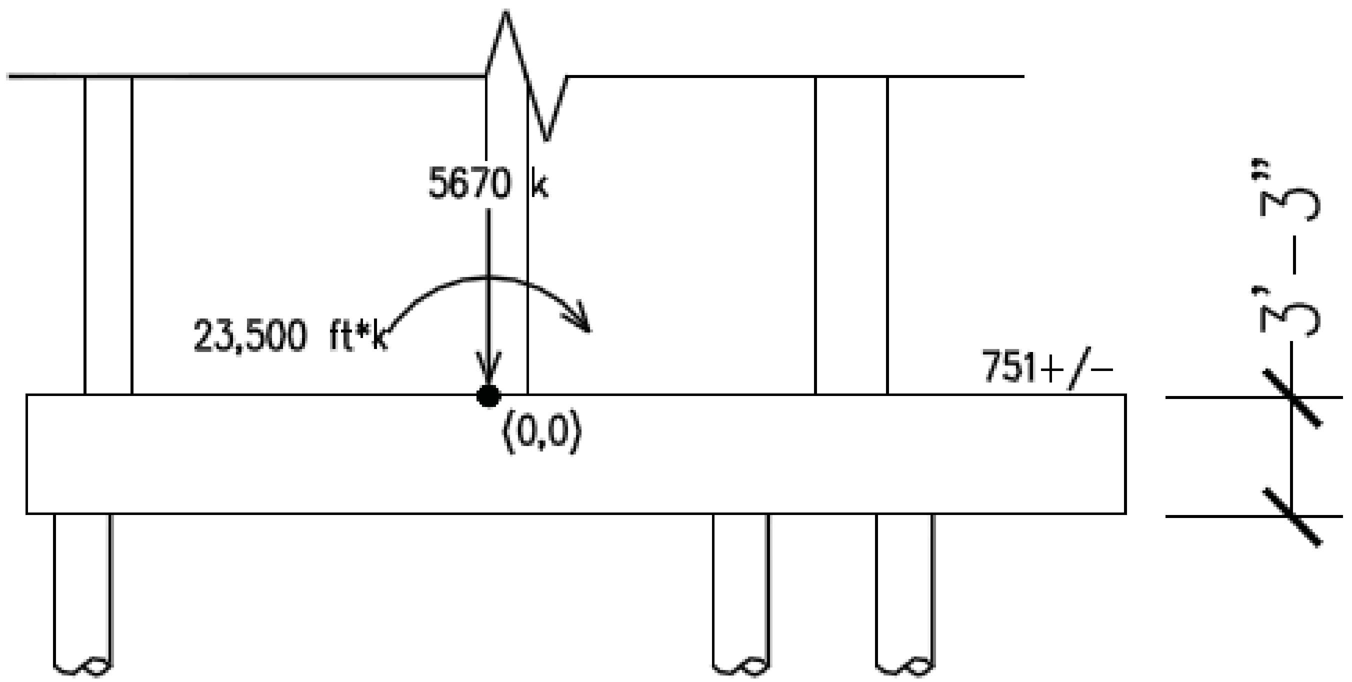
ASH BUILDING NORTH CORE FOUNDATION

18"ø PILE SPACING = 4'–6" O.C.

3'–3" THICK PILE CAP

12 Floors Building in Downtown Fort Wayne, Indiana

Static Axial Capacity and Group Effects, Case History



SECTION B: DL + LL

ASH BUILDING NORTH CORE FOUNDATION
18"ø PILE SPACING = 4'-6" O.C.
3'-3" THICK PILE CAP

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Static Axial Capacity and Group Effects, Case History

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Static Axial Capacity and Group Effects, Case History

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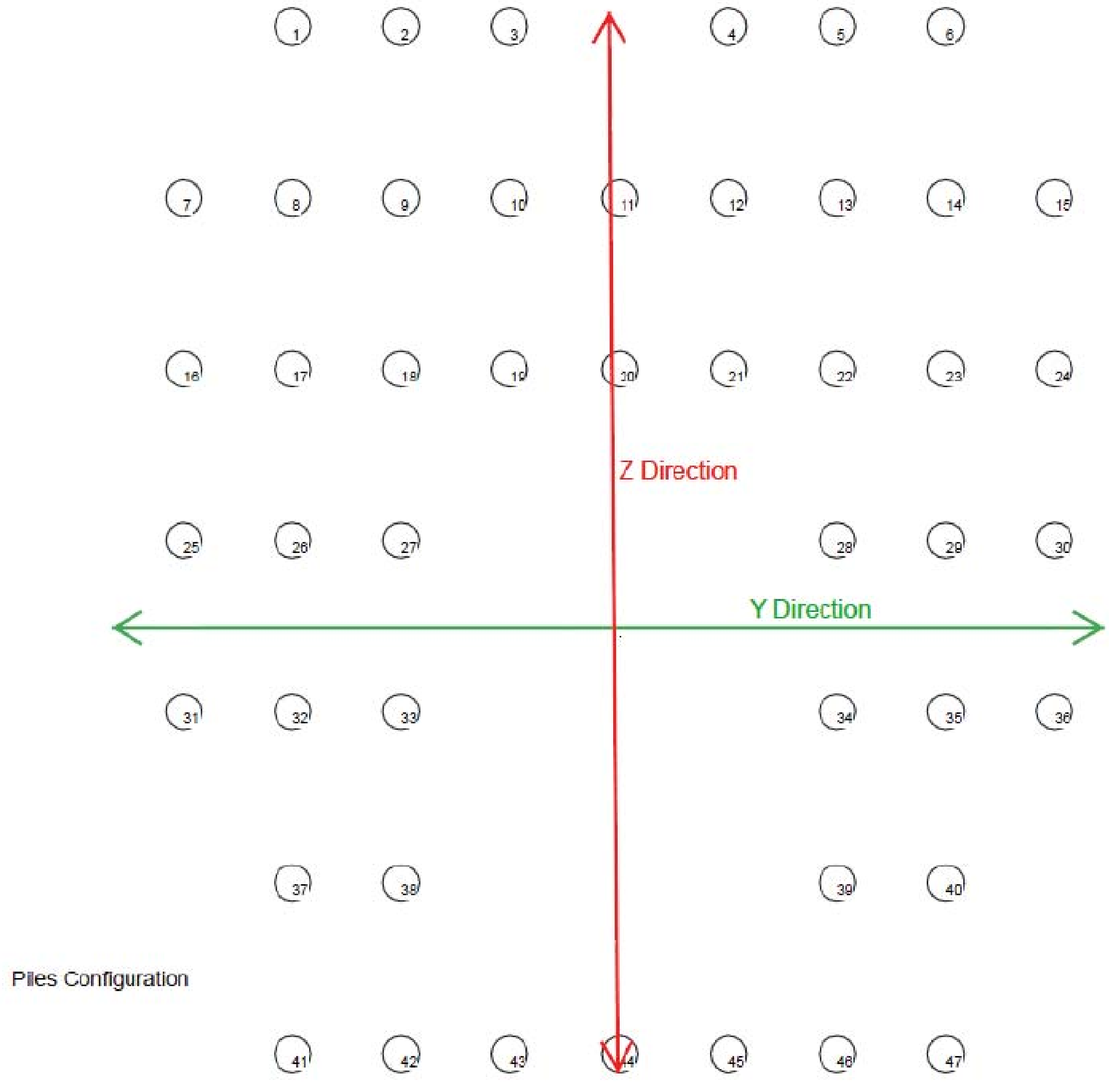

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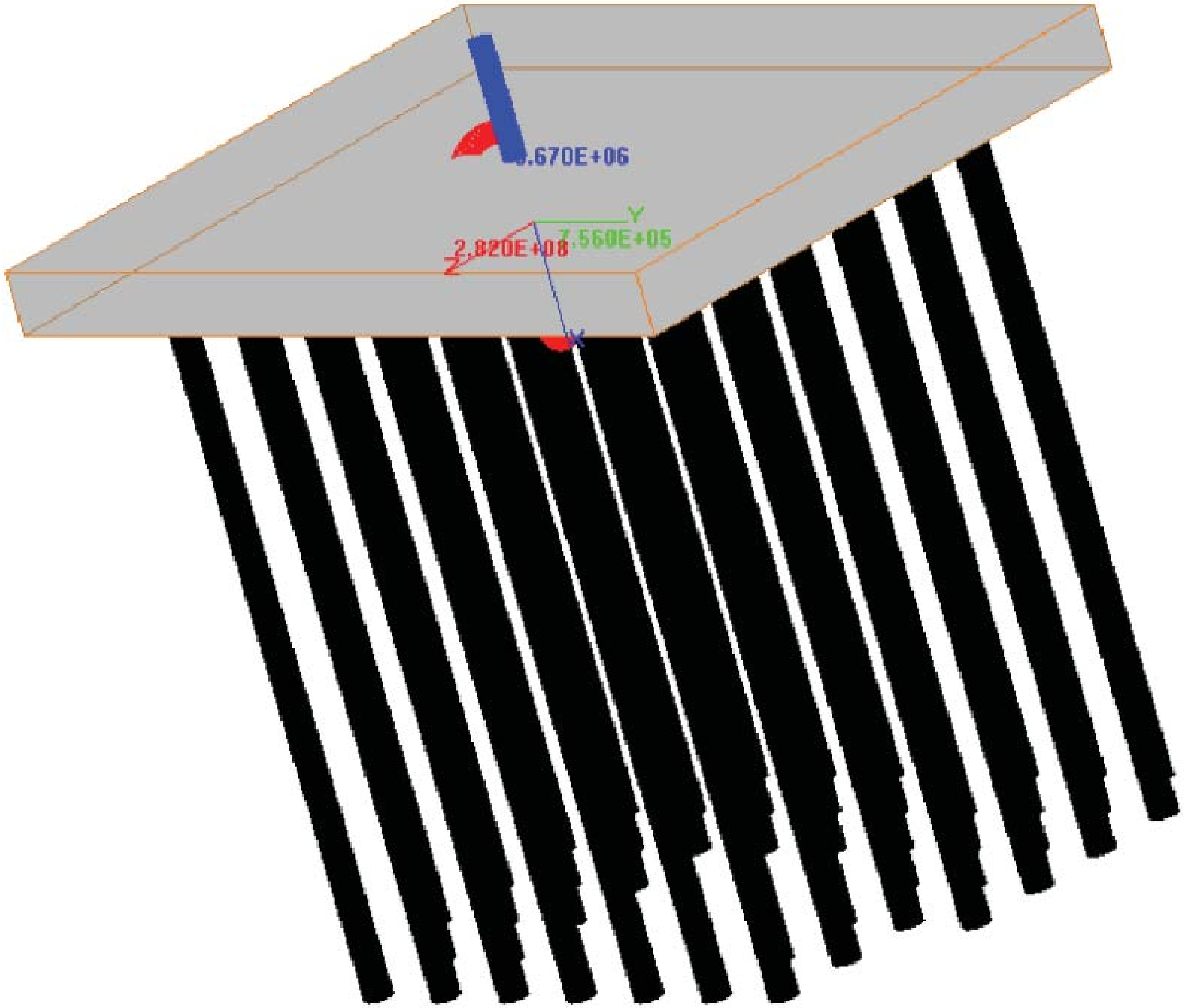

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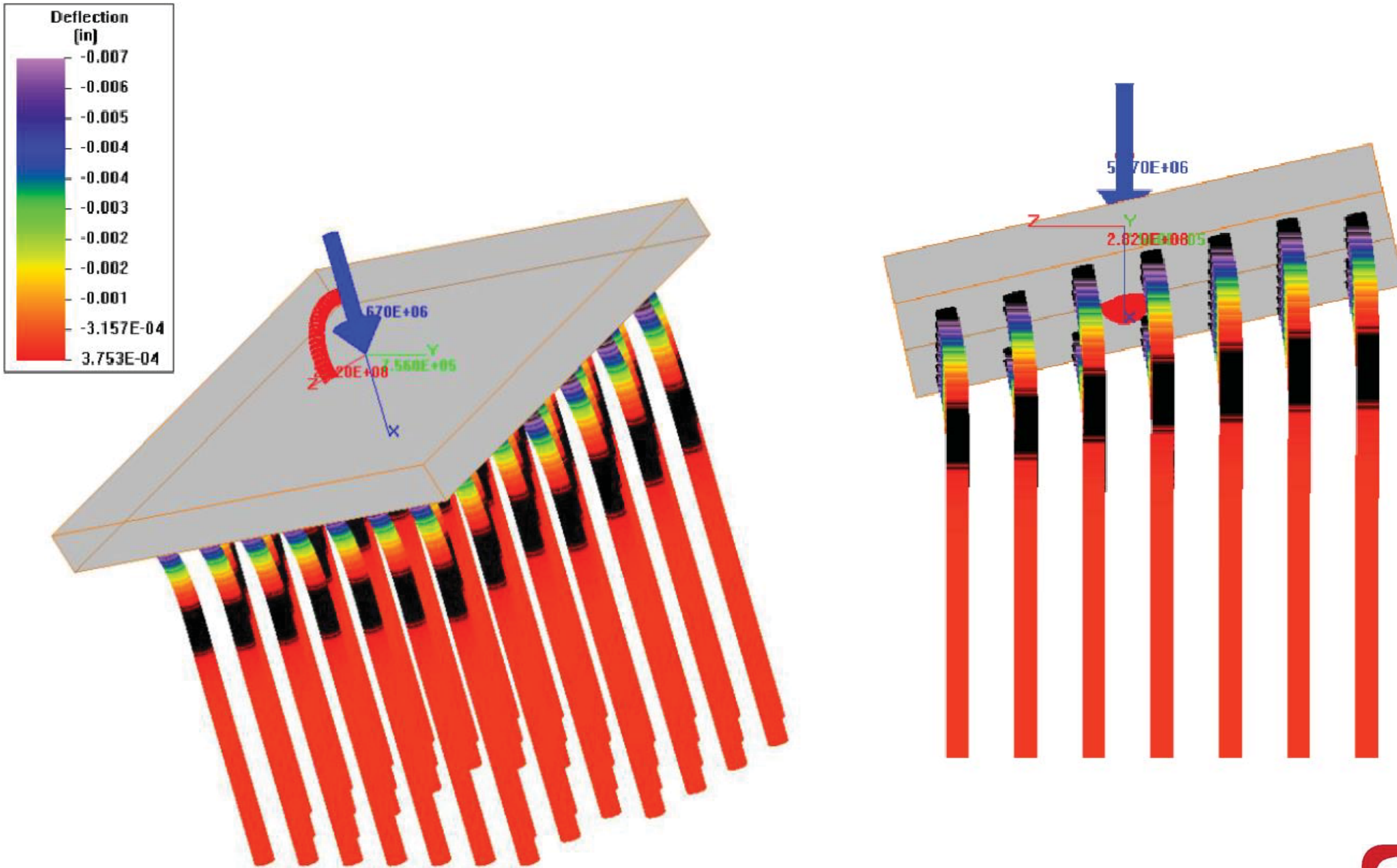

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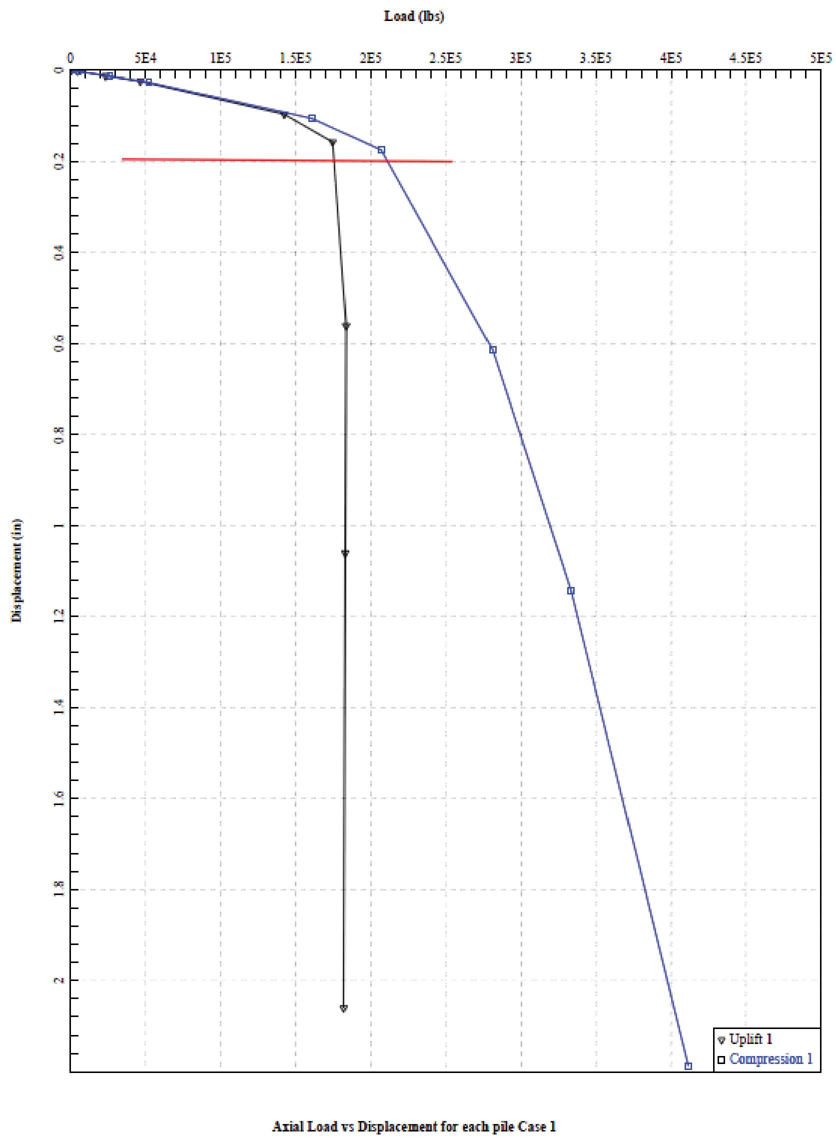

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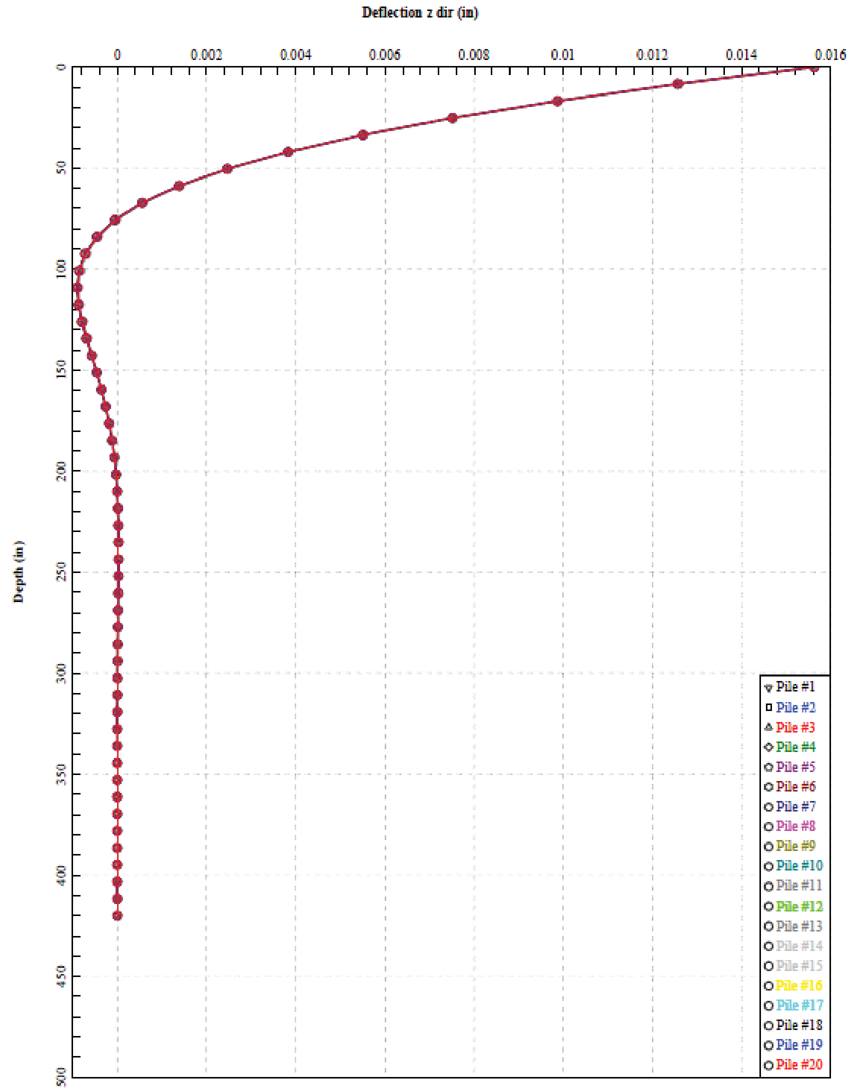
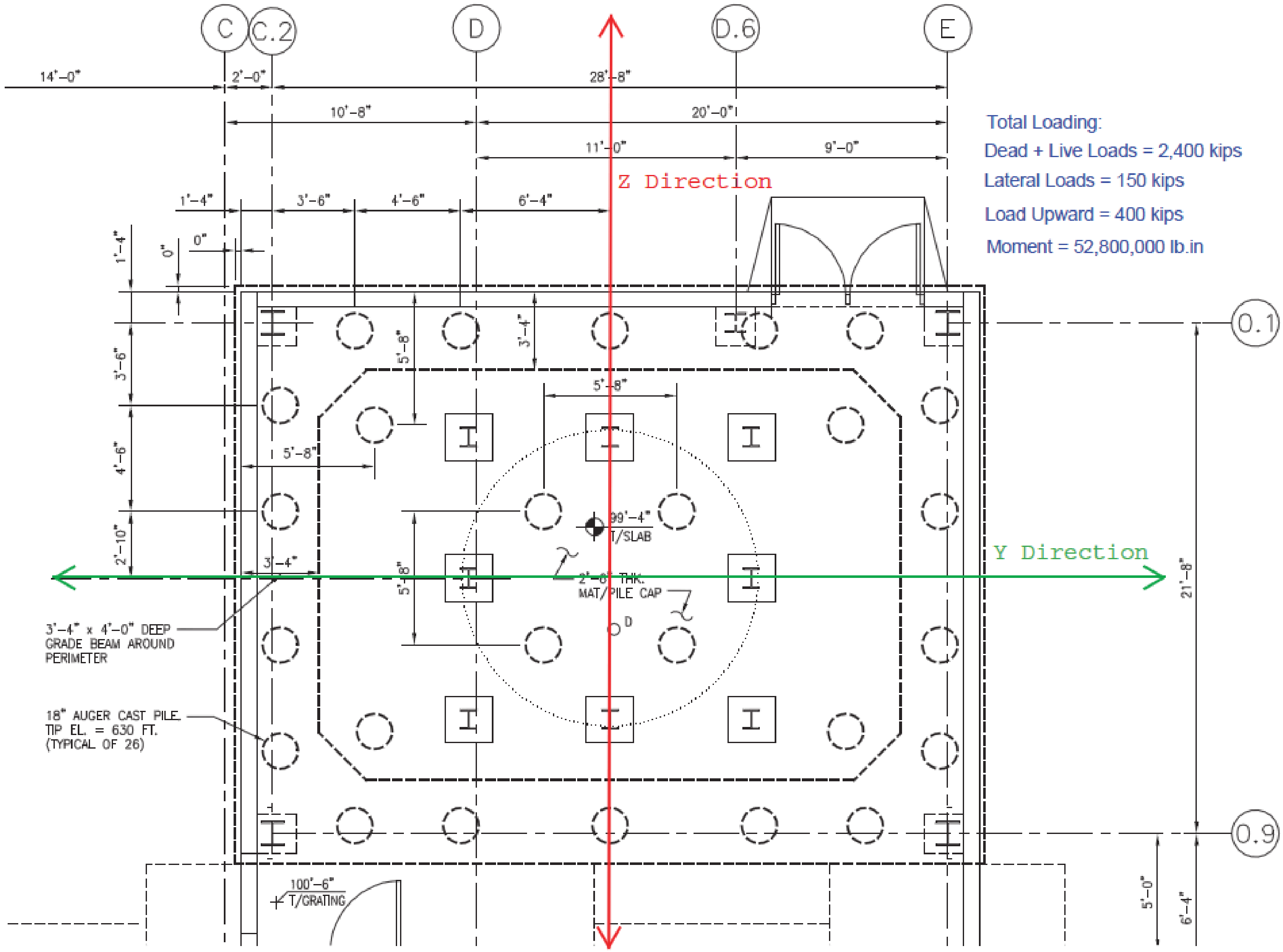


Deflection Z Direction vs Depth All piles Case 1

12 Floors Building in Downtown Fort Wayne, Indiana

Static Axial Capacity and Group Effects, Case History



Total Loading:

Dead + Live Loads = 2,400 kips

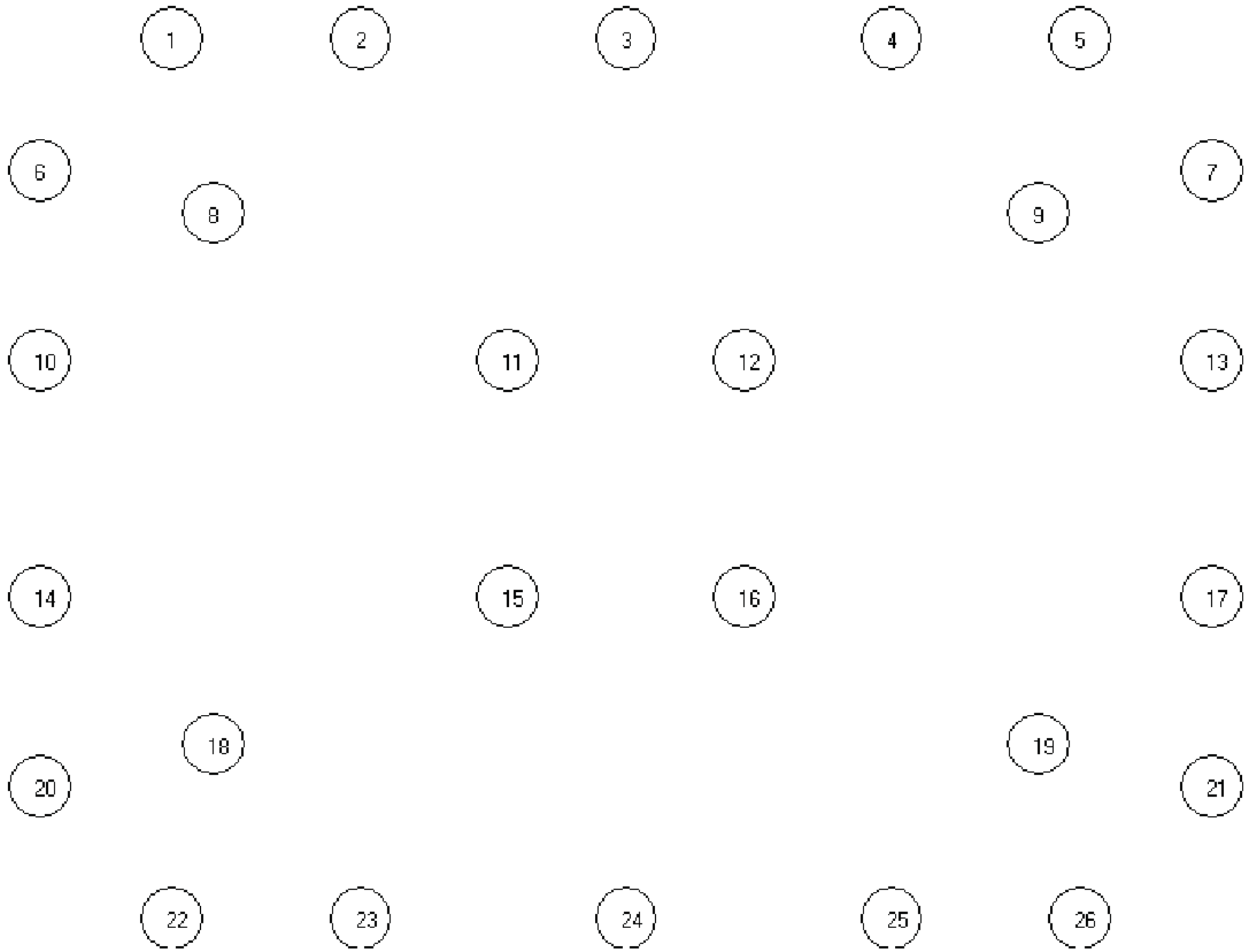
Lateral Loads = 150 kips

Load Upward = 400 kips

Moment = 52,800,000 lb.in

14 Floors Tower in Downtown Indianapolis, Indiana

Static Axial Capacity and Group Effects, Case History



14 Floors Tower in Downtown Indianapolis, Indiana

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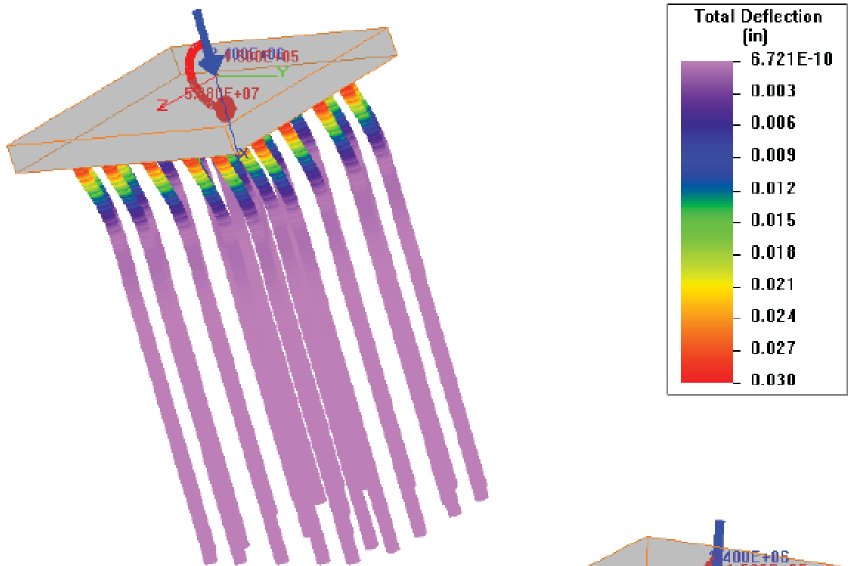
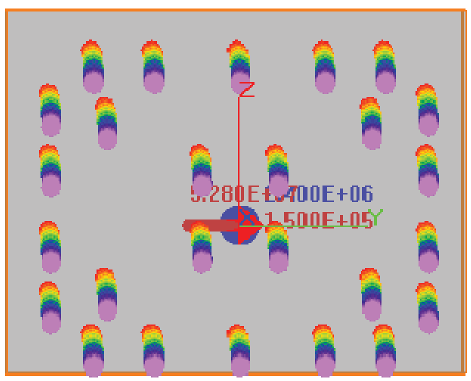
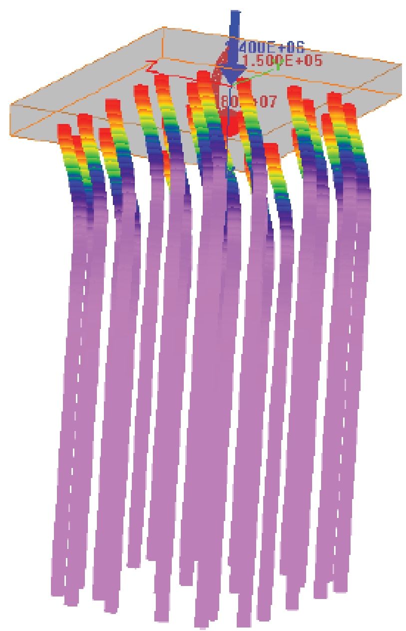
Static Axial Capacity and Group Effects, Case History





Deflection Viewing Bottom of the Cap



14 Floors Tower in Downtown Indianapolis, Indiana

Quality Control (QC) / Quality Assurance (QA)

Monitoring and Control of the Drilling Phase

The operator and inspector should observe and record the depth of the auger, the speed of the auger, the rate at which the auger penetrates into the ground, and the torque with which the auger is rotated.

Operator with Cab Mounted Display Used to Control Drilling

Quality Control (QC) / Quality Assurance (QA)

Monitoring and Control of the Grouting/Concreting Phase

Control of the grouting / concreting phase of construction may be the most important aspect of QA/QC for CFA piles.

In-line Flowmeter

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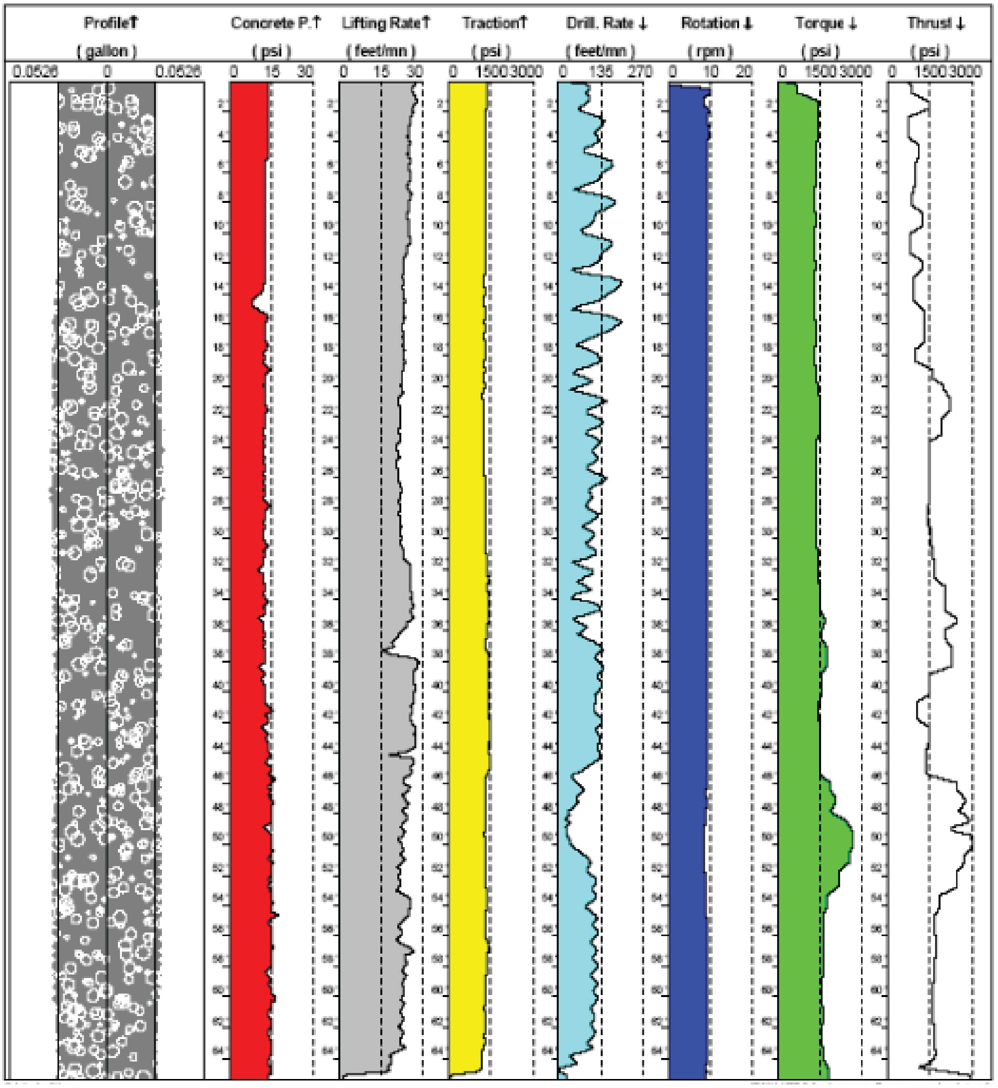
Quality Control (QC) / Quality Assurance (QA)

Monitoring and Control of the Grouting/Concreting Phase

Display Panel for Observation by Inspector

Quality Control (QC) / Quality Assurance (QA)



Example Data Sheet from Project

Quality Control (QC) / Quality Assurance (QA)

Cubes for Grout Testing

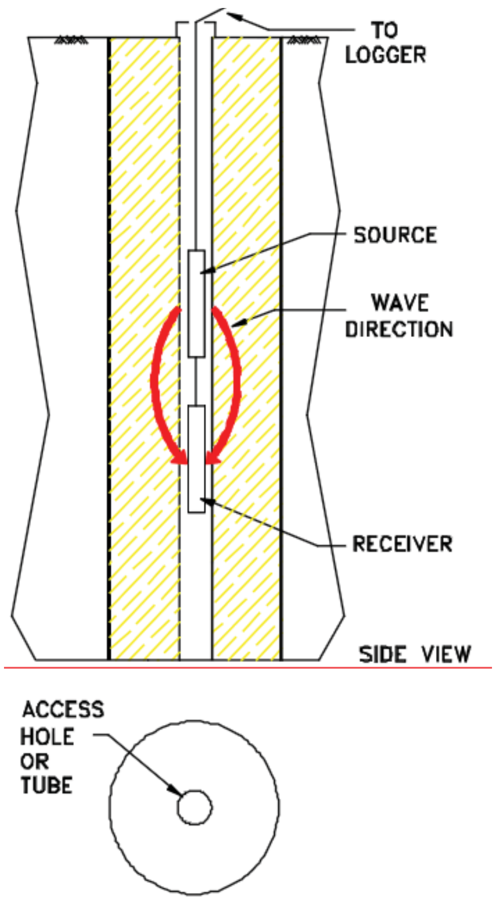
Quality Control (QC) / Quality Assurance (QA)

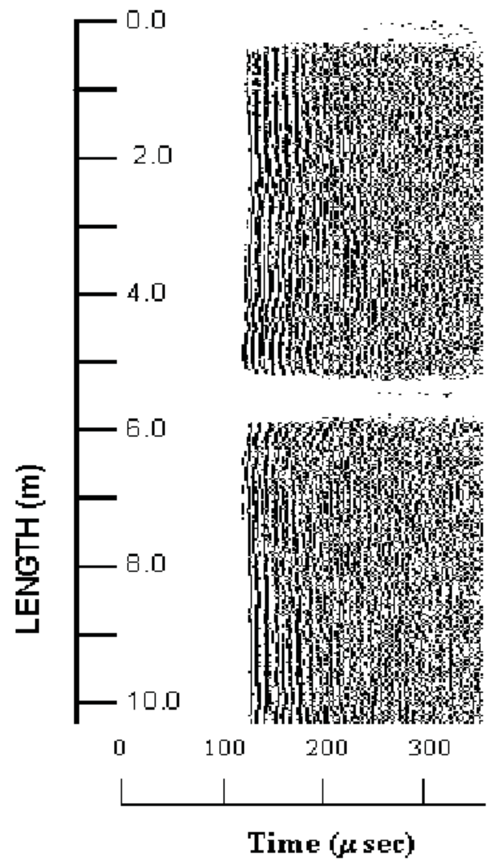
Use of Integrity Testing

Integrity Testing by Surface Methods -Sonic Echo Testing

Quality Control (QC) / Quality Assurance (QA)

Use of Integrity Testing





Integrity Testing using Downhole Techniques
Downhole Single-Hole Sonic Logging (SSL) Concept

Quality Control (QC) / Quality Assurance (QA)

Load Testing

Static Load Test Setup on CFA Piles

Quality Control (QC) / Quality Assurance (QA)

Load Testing

Proof Testing of Production Piles with Statnamic

Questions ?

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