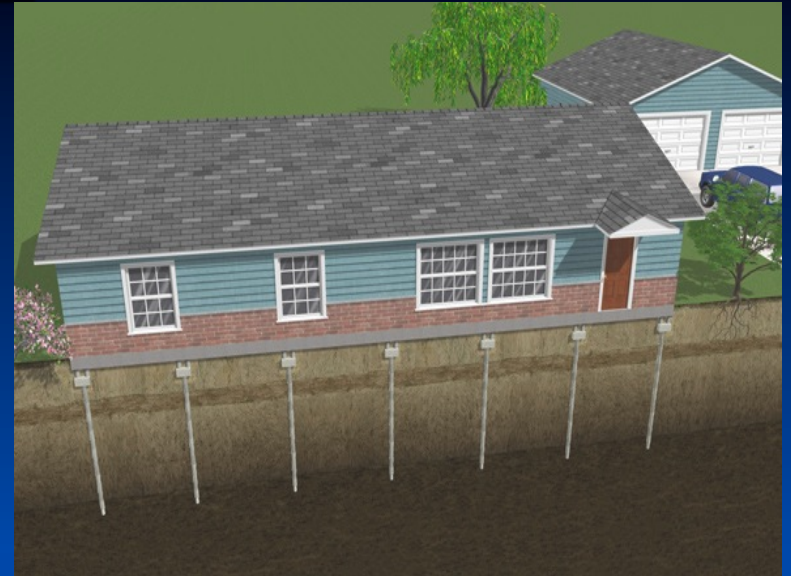

**Design, Manufacture, and
Installation Guidelines
of
Precast Concrete Segmented
Piles
for
Foundation Underpinning**



by
The Structural Committee
of
The Foundation Performance
Association
Houston, Texas



ACKNOWLEDGMENTS

- Subcommittee Chair – Karl Breckon
- Subcommittee Members - Ron Kelm, Michael Skoller, Dan Jaggers, Nicole Wylie, Stephen Newberry, Gerard Duhon, JR Hernandez, Jim Dutton, Steve Schilder
- Rev A issued Jan 24, 2001
- Rev 0 issued July 17, 2005
- Rev 1 Issued March 2014

INTENDED USE

- Repair contractors, structural engineers, geotechnical engineers, forensic engineers and consultants, homeowners, and others interested in the lifting of foundations for residences and other low-rise buildings using pre-cast concrete segmented piles

TABLE OF CONTENTS

1.0 INTRODUCTION

2.0 GENERAL DESIGN CONSIDERATIONS

3.0 FOUNDATION UNDERPINNING REPAIR GUIDELINES

- 3.1 DEFINITIONS
- 3.2 REFERENCES AND STANDARDS
- 3.3 DESIGN REQUIREMENTS
- 3.4 SUBMITTALS
- 3.5 QUALITY ASSURANCE / QUALITY CONTROL
- 3.6 DELIVERY, STORAGE, AND HANDLING
- 3.7 WARRANTY
- 3.8 PRODUCTS
- 3.9 INSTALLATION

INTRODUCTION

- Guidance and information for projects that use precast concrete segmented piles for underpinning the foundations of existing residential and other low-rise structures.
- Most applications involve lifting or stabilizing existing foundations.
- Most of the available segmented pile systems utilize cylindrical concrete segments, but rectangular and other shapes may be used.

INTRODUCTION

- Piles consist of precast concrete segments installed one by one on top of one another pressed into the ground by hydraulically jacking.



- The weight of the structure is used to create the reactive force that allows the pile segments to be driven into the soil.

INTRODUCTION

- Categorized as driven displacement piles
- Load transfer occurs to the foundation soils primarily through skin friction.

INTRODUCTION

- System is mainly utilized in soils where the driving resistance is such to allow the weight of the structure to be used to develop the driving force necessary to obtain sufficient pile penetration.
- High-pressure water injection technique, called jetting, or other methods, such as pre-drilling, may be used to break up the soil and allow additional pile penetration.



INTRODUCTION

- Interconnection may consist of steel bar, threaded rod, or cable that is inserted into a hole preformed through the center of each of the concrete segments along their longitudinal axis.
- An alternative method of interconnection may be to bond the segment ends using epoxy or other adhesive.

INTRODUCTION

The committee found that the IBC permits the use of such technology as follows:

- Under IBC (2012) Section 104.11 Alternative materials, design and methods of construction and equipment, states “The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved.
- The IBC (2012) Commentary Section 104.11 states, “The code is not intended to inhibit innovative ideas or technological advances. The building official is responsible for determining if a requested alternative provides the equivalent level of protection of public health, safety and welfare as required by the code.”

INTRODUCTION

- Under Chapter 18, Soils and Foundations, in Section 1810.1.4 Special types of deep foundations, IBC (2012) states, “The use of types of deep foundation elements not specifically mentioned herein is permitted, subject to the approval of the building official, upon the submission of acceptable test data, calculations and other information relating to the structural properties and load capacity of such elements.” Because Precast Concrete Segmented Piles have not been specifically mentioned by IBC, this deep foundation system is allowed by IBC provided the building official approves the submission, if applicable.
- Considering the information contained in the references above, it is the opinion of the committee that the use of Precast Concrete Segmented Piles for repair of foundations by underpinning are in compliance with the IBC.

GENERAL DESIGN CONSIDERATIONS

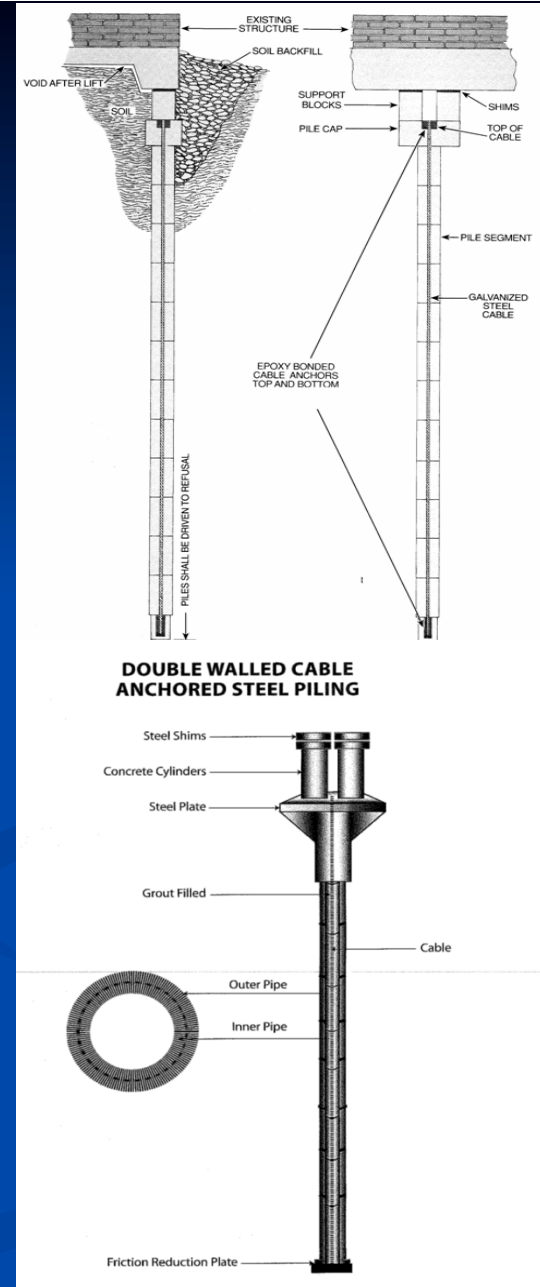
- Precast concrete segmental piles are not able to resist significant bending moments due to lateral loads.
- Interconnection may help to avoid detrimental vertical misalignment of the pile while being driven.
- Interconnected concrete segmental pile is more likely to resist the uplift forces due to swelling of expansive soils transmitted via friction along the shaft.

GENERAL DESIGN CONSIDERATIONS

- Precast concrete segmental piles will not provide resistance against foundation uplift.
- The final depth of each pile will vary from pile to pile.
- If a void exists under the slab subsequent to the lifting process, treatment of the void should be determined on an individual basis.
- Geotechnical investigation and structural analysis would be of value for the design of the foundation repair.

DEFINITIONS

- Segment
- Pile
- Pile Head
- Foundation Underpinning
- Shim
- Non-Interconnected
- Interconnected
- End Elevation Adjustment
- Foundation Stabilization
- Refusal

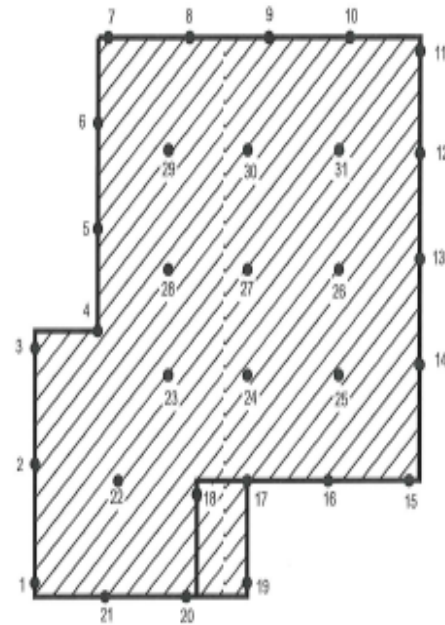


REFERENCES & STANDARDS

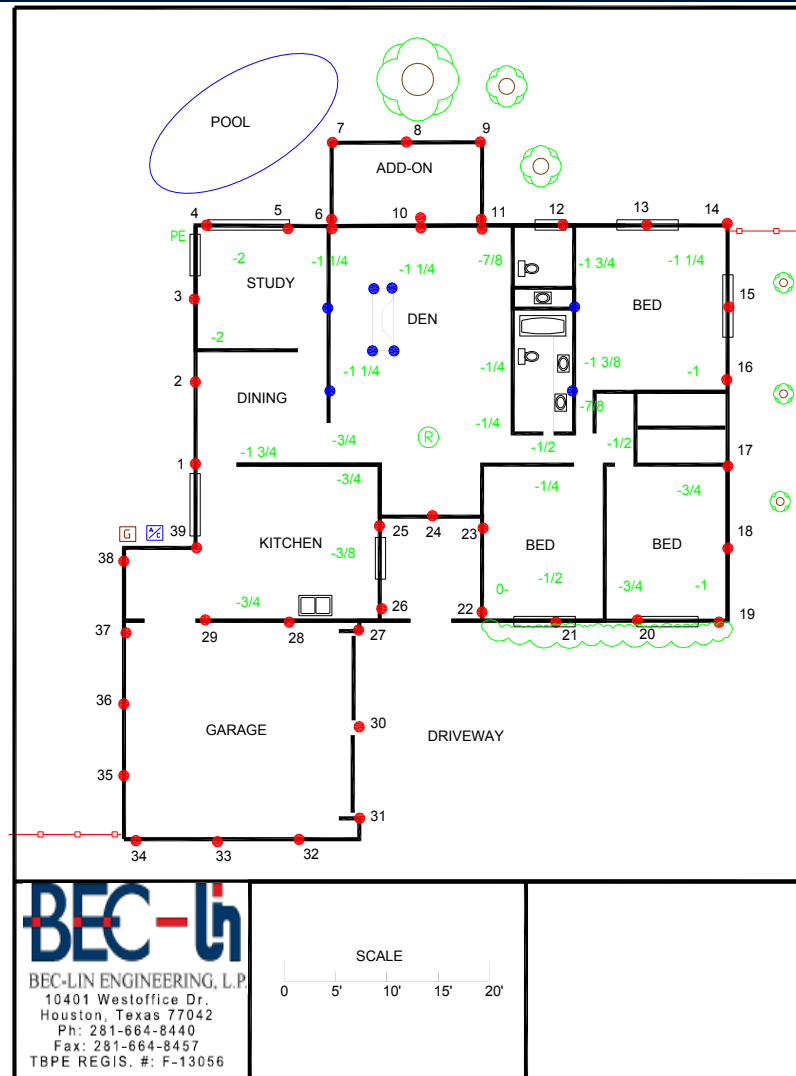
- ASTM A29/A29M Steel Bars, Carbon and Alloy, Hot-Wrought and Cold Finished.
- ASTM A36/A36M Carbon Structural Steel.
- ASTM A153 Zinc Coating (Hot Dip) on Iron and Steel Hardware.
- ASTM A416 Steel Strand, Uncoated Seven-Wire for Pre-stressed Concrete.
- ASTM A615 Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
- ASTM A706 Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
- ASTM A767 Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
- ASTM A775 Epoxy-Coated Reinforcing Steel Bars.
- ASTM A992 Structural Steel.
- ASTM C33 Concrete Aggregates.
- ASTM C39 Test Method for Compressive Strength of Cylindrical Concrete Specimens.
- ASTM C150 Portland Cement.
- ASTM C494 Chemical Admixtures for Concrete.
- IBC 2006, 2009, 2012, International Building Code, ICC International Code Council, Inc.

DESIGN REQUIREMENTS

- Exterior Pilings
- Interior Pilings
- Corners
- Fireplaces
- Porches
- Wing Walls
- Additions
- Garages
- Additional Support



DESIGN REQUIREMENTS



SUBMITTALS

- Product Data
- Pile Location Drawings
- Qualification Data
- Professional Engineering Analysis
- Pile-Driving Equipment
- Foundation Lifting Equipment
- Pile-Driving Records
- Prequalification Test Reports
- Safety Program
- Initial Elevation Survey
- Final Elevation Survey
- Material Test Reports or Material Certificates

QUALITY ASSURANCE / QUALITY CONTROL

- Contractor Qualifications
- Professional Engineer Qualifications
- Pre-installation Meeting
- Precast Concrete Segment Manufacturing Tolerances
 - Cylinder Diameter
 - Cylinder Length
 - Segment Ends Concentricity
 - Hole Location (if applicable)
 - Hole Diameter (if applicable)
 - End-Bearing Surface Flatness
 - End-Bearing Surface Cant
- Quality-Control Testing
- Defective Work
- Verification of Equipment Performance

PRODUCTS

- Minimum Compressive Strength - 5,000 psi
- Reinforcement – per applicable ASTM Standards
- Pile Heads - same strength and properties as segments.
- Interconnection Steel Reinforcement Corrosion Protection – epoxy grout, epoxy paint, or galvanized
- Accessories - match the load capacity of the precast concrete segments

INSTALLATION

- Work Plan / Locate Utilities
- Plumbing Leak Test
- Groundwater & Surface Water Control
- Existing Drilled Piers
- Stockpile Segments
- Concrete Segment Size
- Driving Records / Hydraulic Pressure / Pile Depth
- Axial Alignment
- Lubrication
- Load Sharing / Refusal / Pile Depth
- Water Jetting / Pre-Drilling
- Foundation Lift
- Final Elevation Survey
- Restore Landscaping and remove excess material

Threading Interconnecting Pilings over cable during driving process



Driving concrete
segmental piles using
a hydraulic ram



Pile system ready for
lifting



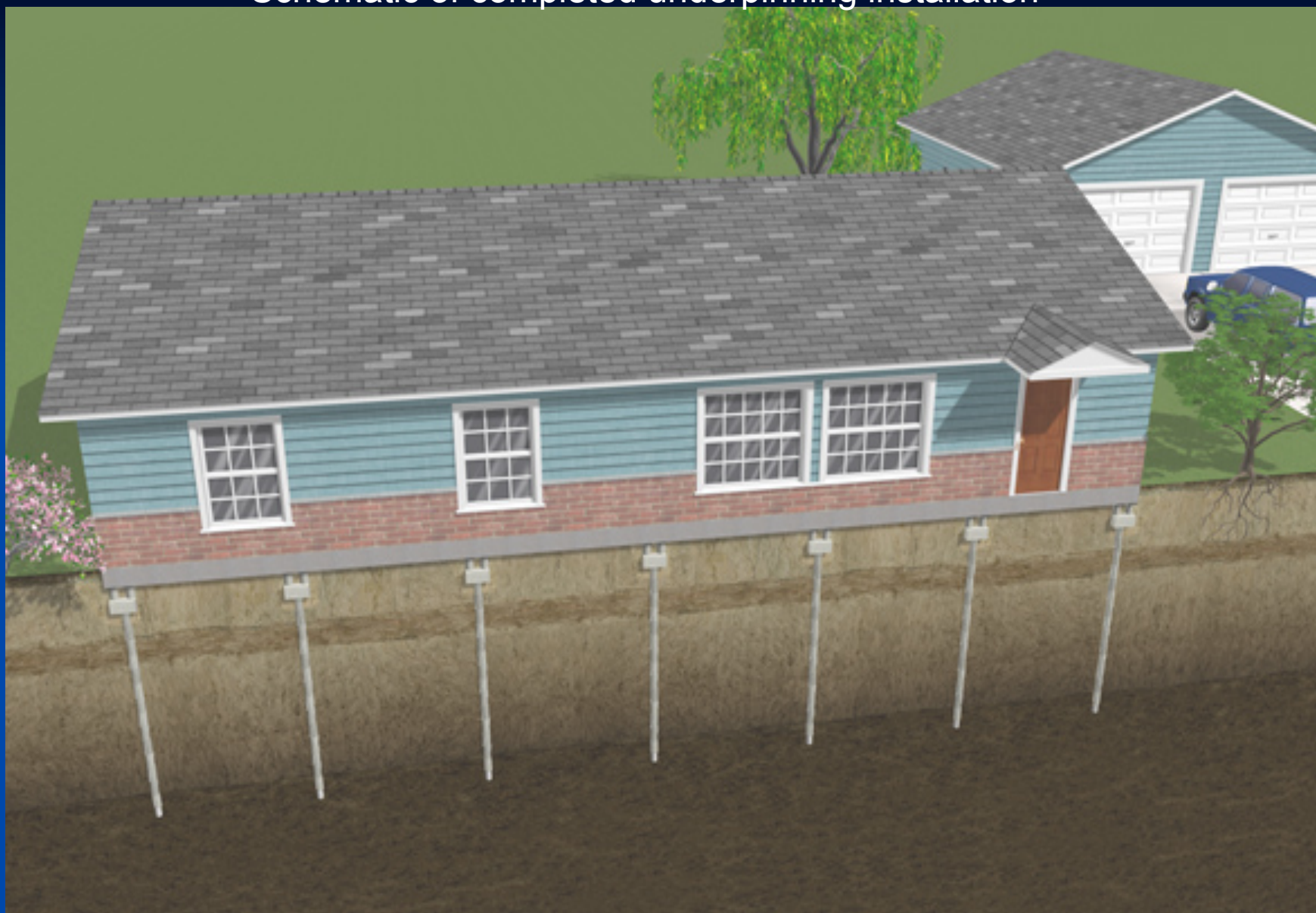
Lifting structure
using hydraulic
jacks



Completed pile
showing pile
cap, support
blocks and
shims



Schematic of completed underpinning installation



SUMMARY

- Structural Committee's paper no. FPA-SC-08-1, has been peer-reviewed by the FPA and is published on the FPA website at:
http://www.foundationperformance.org/committee_papers.cfm
- The major topics addressed in this paper are the design, manufacturing, and installation guidelines of pre-cast concrete segmented piles for foundation underpinning of existing residential and other low-rise structures. The document addresses both interconnected and non-interconnected systems, provides general design considerations when using pre-cast concrete segmented piles, and offers suggested manufacturing, quality assurance, and installation guidelines.
- Those benefiting from this paper are repair contractors, structural engineers, geotechnical engineers, forensic engineers and consultants, homeowners, and others interested in the lifting of foundations for residences and other low-rise buildings using pre-cast segmented piles.