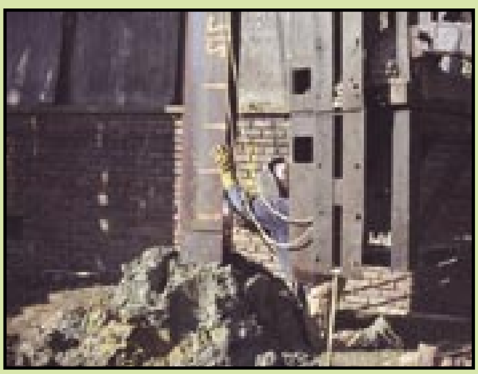
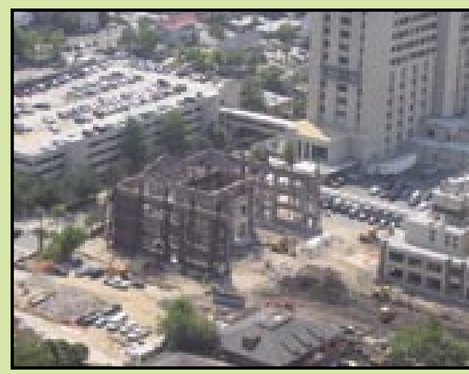
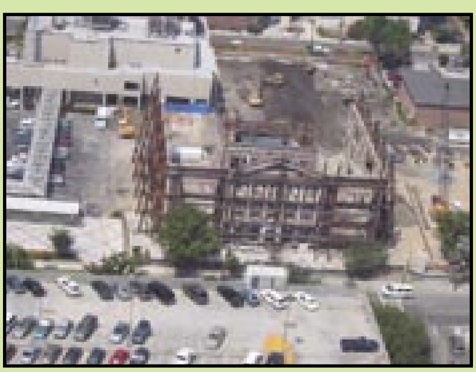
PILEDRIVER

The Official Publication of The Pile Driving Contractors Association | Q2 2005 vol. 2, no. 3

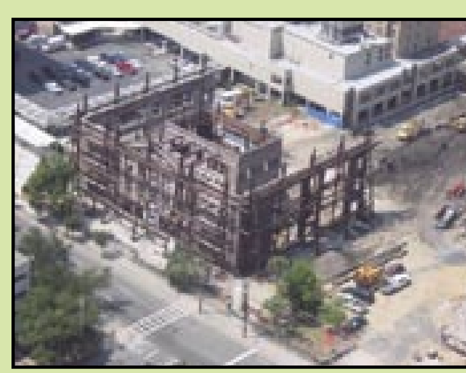






PROJECT SPOTLIGHT:

Charleston High School Renovation Project



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Project Spotlight: Charleston High School Renovation Project

PDCA: Driving the Length of the Field

By Randy Dietel, PDCA President

All presidents or heads of organizations like to have bragging rights, especially during their tenure. In this *President's Message* I have two:

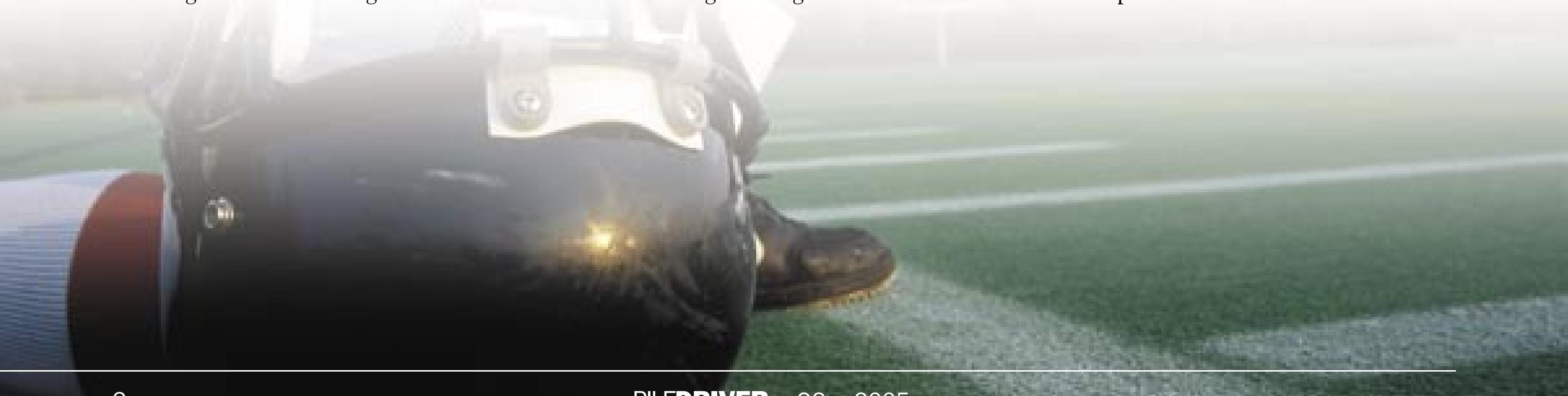
The first is in reference to our Third Professors' Piling Institute, held again on the beautiful campus of Utah State University in Logan. I have attended all three and this one was the best yet. Not only were the 24 college professors who attended this year's Institute very complimentary about the week-long course work, they were also excited and appreciative of the field activities.

This has got to be the best "bang for our buck" program PDCA does. For it is here, a grass-roots program, where we offer university professors printed course material to use in their classrooms as well as hands-on experience. The majority of these professors have had very little field experience with driven piles. Here, on the university campus, they got to witness the set-up of the equipment and driving of piles, and actually participate in running and monitoring both vertical and lateral load tests. They also got to witness and have hands-on experience taking soil core samples for analysis. If picture taking is any indication of their interest, then we hit a home run.

The second bragging point I would like to make is certainly not to my account, but to PDCA, and more particularly to the South Carolina Chapter of PDCA. It is my understanding through Harry Robbins and John King, that they have won another victory for driven piles over the original choice of another foundation system. Harry is vice president of PDCA this year and current president of the South Carolina chapter, based in Charleston. John King is vice president of the South Carolina chapter for 2005.

The Citadel football stadium was originally designed to be on stone columns with spread footings. When Harry and John found out about the project, they immediately asked for and obtained a copy of the soils report. By working in tandem, they were successful in getting an audience with the head of engineering at the Citadel. They discussed multiple projects in the local area, which were on driven piles and the practicality of them over other types. Next, they spoke to the State Engineer's office, and they agreed that a driven pile cost comparison should be done. The structural engineer on the project also had to agree and he proceeded to do a redesign using prestressed concrete piles. Harry provided a sample specification for their review and the rest is history. The structure is going in on driven piles!

So, my final salvo in this text is that this local chapter has been a real asset to our national organization. They have proven to be successful in all aspects. My pitch to each of you as members of PDCA is to think about the opportunities that your company could enjoy if you were part of a local chapter of PDCA. Several areas of the country are very appropriate for developing a local chapter. The South Carolina Chapter of PDCA has once again proven that by working together, local pile driving companies can improve their share of the deep foundation market. ▼



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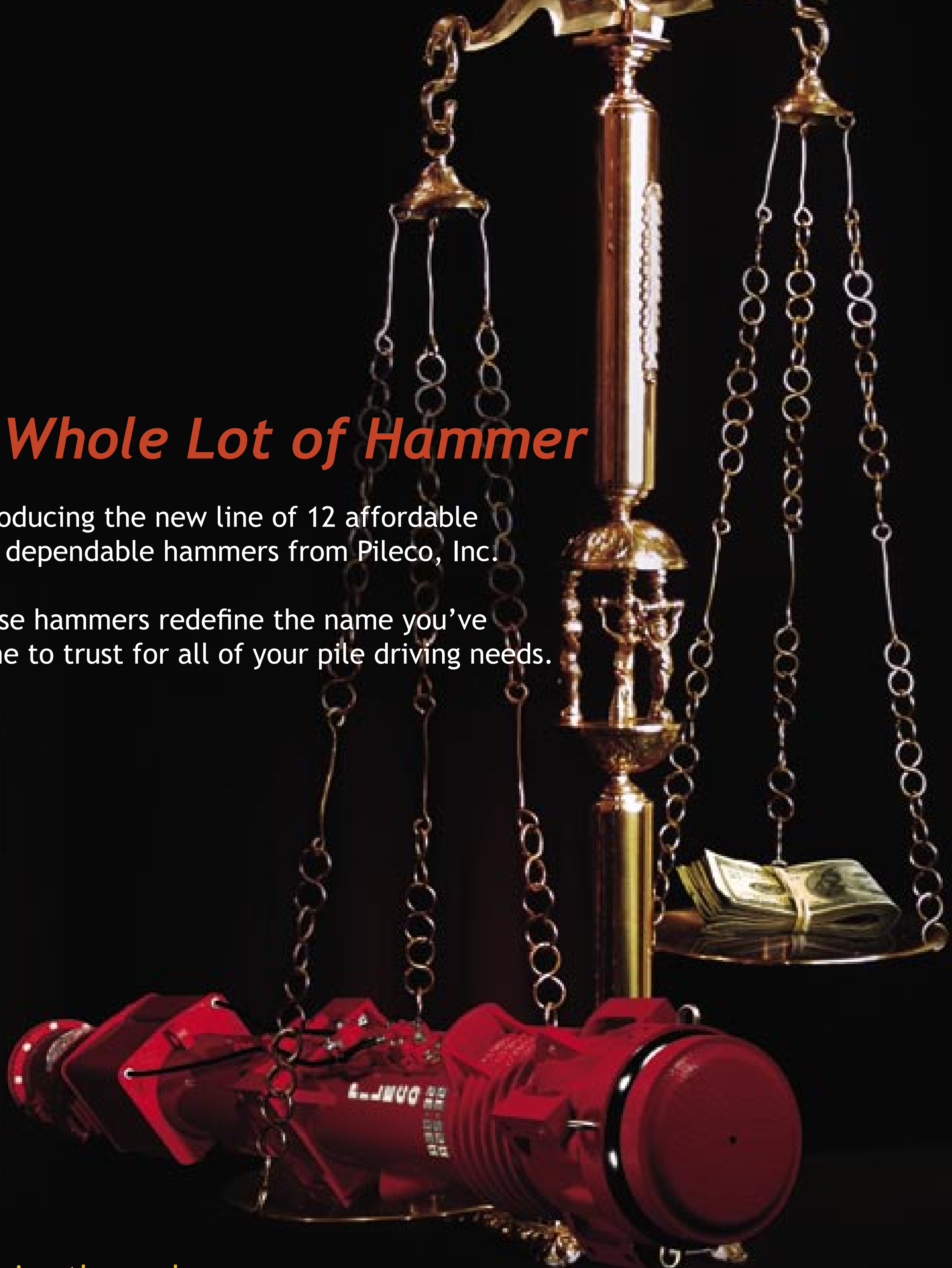

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2005 Professors Institute **Best One Yet!**

By Tanya Goble, PDCA Executive Director

PDCA conducted its Third Professors Piling Institute June 19-24 at Utah State University in Logan to glowing evaluations from the 25 professors in attendance.

PDCA believes that professor education is one of the most important and effective activities that the association does. The Professors Institute is an intensive week-long program that covers all aspects of driven pile installation, design, and quality control. It is truly a unique program that blends practical, real work construction knowledge with academics. The objective is to ensure that engineering educators are presenting material in the classroom that will result in constructible and economic driven pile foundations. The attendees also receive comprehensive teaching materials and course outlines. Key topics in this year's Institute included:

- Driven pile design process including ASD and LRFD methods
- Geotechnical response of driven piles (static analysis, set up, relaxation, group response)
- Pile types and pile driving equipment
- Subsurface investigations for driven pile foundations
- Wave mechanics, wave equations
- Lateral behavior of pile groups
- Computer workshops with GRLWEAP, DRIVEN and FB-PIER
- CAPWAP workshop
- Cost components and economics
- Field demonstrations of pile driving, dynamic measurements and static load testing

Since 2002, PDCA has delivered this program to approximately 75 professors representing more than 60 universities (see page 6) from around the country. We estimate that on average, each professor teaches foundation engineering courses to approximately 40 students every year. This adds up to 3,000 engineering students getting much better training on designing constructible and economic driven pile foundations every year!

The PDCA has many to thank for helping us put together and deliver this outstanding program.

The Professors Institute would not be possible without financial support from the PDCA membership. A list of this year's sponsors is provided on page 8. These sponsors will also be featured in the 2005 PDCA Membership Directory. PDCA expresses its sincere thanks to these companies for their ongoing support of our programs.

PDCA sends a big thank you to Build, Inc., that once again generously contributed their equipment and manpower in difficult site conditions to help us provide an actual pile driving demonstration along with static load test and dynamic pile monitoring demonstrations. We also want to recognize Pile Dynamics, GRL Engineers, Campbell Scientific, and Jay Appedaile Drilling for their wonderful contributions as well. The field demonstrations are consistently mentioned by the attending professors as the highlight of the Professors Institute.

The Professors Institute instructors are well-known in industry and academia and PDCA is grateful for the time and energy they devote to the success of the program. This year's instructors included:

- J. Brian Anderson (University of North Carolina)
- Loren Anderson (Utah State University)
- Jim Bay (Utah State University)
- Steve Dapp (Dan Brown & Associates)
- George Goble (Goble Consulting LLC)
- Pat Hannigan (GRL Engineers)
- Van Komurka (Wagner Komurka Geotechnical)

PDCA Professors Institute 2002-2005 Participating Universities

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California State University, Sacramento
Case Western Reserve University
Clemson University
Colorado School of Mines
Colorado State University
Cornell University
Drexel University
Florida Institute of Technology
Florida Atlantic University
Ilinois Institute of Technology
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University of North Florida
University of Puerto Rico
University of Rhode Island
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University of Southern California
University of Texas, El Paso
University of Texas, Arlington
University of Texas, Austin
University of Toledo
University of Wisconsin, Milwaukee
University of Wisconsin, Platteville
Utah State University
Washington State University

2002-2005

- Garland Likins (Pile Dynamics)
- Kyle Rollins (BYU)
- Joe Caliendo (Utah State University)

PDCA also wants to thank Utah State University, Loren Anderson, Jim Bay, and especially Joe Caliendo for their tremendous efforts in pulling together another highly successful Institute! The Institute would not be possible without their commitment and access to the beautiful facilities that the university has to offer.

The Professors Institute has helped PDCA established excellent relationships with many university programs around the country. We encourage PDCA members to build upon these relationships by reaching out to their local universities. Many professors would love it if you offered to speak at their class or conducted a field demonstration for their students and you will find the door open to you. The competition is doing these things today. Please call PDCA headquarters if you would like contact information or an introduction.

PDCA and Utah State plan to continue to offer the Professors Institute in the future and hope to offer the next one as soon as 2007. Thanks once again to all who contributed to making this year's Institute a big success! ▼

PDCA wishes to recognize the sponsors of the 2005 Professors Institute, without whom this important program would not be possible.

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THE PILE DRIVING CONTRACTORS ASSOCIATION PRESENTS:

September 15-16, 2005 | Boston, Massachusetts

We have seen dramatic developments in piles and pile driving equipment in the past 30 years. Quality control devices have improved the reliability of driven piles so that lower factors of safety can be justified. Higher strength pile materials are available at little or no cost increase. We have a better understanding of pile behavior, and the result is a product vastly superior and more cost-effective than alternative piling methods.

This seminar is intended for geotechnical engineers, structural engineers, contractors, and college professors interested in taking advantage of opportunities in driven pile design and installation to reduce the cost of their deep foundation designs.

General Information

The 1-1/2 day seminar will present the technical basis for understanding, analyzing, and controlling pile driving. Educational material on the process of designing and installing driven piles is provided. Examples of design applications of high design loads will be presented and the potential for the use of high design loads and lower factors of safety in the PDCA Code will be discussed. Choosing design and installation methods that minimize the overall cost of the foundation system are a key focus of the conference. You will receive practical knowledge and tools that you can immediately put to use to save time and money on your next project.

ATTENDEES WILL RECEIVE A CERTIFICATE VERIFYING 1.1 CEUS OR 11 PDHS.

Registration & Fees

Fees are $275 if payment is received by Friday, Sept. 9, 2005 and $300 after that date. The registration fee includes: the official Book of Proceedings, session handouts, copies of the PDCA Code Books, "Recommended Design Specifications for Driven Bearing Piles, Third Edition," and the brand new "Recommended Installation Specifications for Driven Bearing Piles, First Edition," along with coffee beaks, lunch, and evening reception on Thursday.

Tabletop exhibits are also available. The fees are $550 if payment is received by Friday, Sept. 9 and $600 after that date. The fee includes conference registration for one person.

Schedule

Thursday, Sept.15, 8:30 a.m. – 5:00 p.m.
Friday, Sept. 16, 8:00 a.m. – 12:00 noon

Location

The conference will be held at the Sheraton Framingham Hotel
1657 Worcester Road
Framingham, Massachusetts, 01701

Reservations can be made by calling (508) 879-7200. The deadline for the guaranteed conference room rate of $129 is Aug. 24, 2005. Ask for the PDCA conference room block. After date, the room rate is available on a space-available basis only.

Program Schedule

More details are available at www.piledrivers.org

Thursday, Sept. 15, 2005 Grand Ballroom North

8:00 – 8:30 a.m.
Registration & Coffee in Exhibit Area

8:30 – 8:35 a.m.
Welcome and Introduction to the Seminar – *Randy Dietel, PDCA President*

8:35 – 9:30 a.m.
"Driven Pile Design Process," – *George Goble, Consulting Engineer*
The design process for driven piles will be reviewed and compared with other deep foundations. Both ASD and LRFD design methods will be discussed.

9:30 – 10:30 a.m.
"Comparing Static Axial Capacity between Drilled and Driving Piles," – *Dan Brown, Auburn University*
This presentation will provide an overview of the differences in static capacity between drilled and driven piles. The effects of installation, time dependency, displacements required to mobilize capacity and field verification of capacity during construction will be discussed. Select case histories will be examined and soil conditions in which each foundation type may be used will be identified.

10:30 – 11:00 a.m. Break

11:00 – 12:00 p.m.
Wave Equations and Dynamic Pile Testing, Garland Likins, Pile Dynamics, Inc.
Background information on wave equation analysis and practical applications will be discussed, along with dynamic testing and analysis of driven piles.
Noon – 1:00 p.m. Lunch

1:00 – 1:45 p.m.
"Wantagh Parkway Bascule Bridge to Jones Beach, Long Island," - *Stephen Borg, New York Department of Transportation*
The bascule leaf pier caps were constructed using large diameter pipe piles and the approach spans are supported by pre-stressed concrete cylinder piles. PDA testing was used during the driving of the pipe piles and cylinder piles and velocity measurements were taken on the hammer ram. Capacity verification of the piles was done using the PDA measurements before and after soil clean-out and CSL testing was used to evaluate concrete quality.

DESIGN OF COST-EFFICIENT DRIVEN PILES CONFERENCE

Thursday, Sept. 15, 2005 *continues*

1:45 – 2:30 p.m.
"Incorporating Setup into the Design and Installation of Driven Piles," – *V. Komurka*
Accounting for set-up in pile design can result in the use of smaller hammers, smaller pile sections, shorter piles, higher capacities, and therefore more-economical installations than otherwise possible. A methodology and case history are presented which utilize dynamic monitoring during initial driving and restrike testing to characterize unit set-up distribution as a function of depth, allowing for development of depth-variable penetration resistance criteria.

2:30 – 3:00 p.m. Break

3:00 – 3:45 p.m.
"Support Cost Components of Driven Pile Foundations,"– *Van Komurka, Wagner Komurka Geotechnical Engineers*
Foundation support cost, expressed in terms of cost per allowable load, is a normalized way to evaluate cost-effectiveness of foundation alternatives. The individual cost components of a driven pile foundation are presented along with methodologies to maximize the cost-effectiveness of the overall foundation system.

3:45 – 4:30 p.m.
"How Driven Piles Saved $7M: A Case History of a Power Plant," *William Camp, S&ME*
An existing power plant was built on drilled shafts. A major expansion designed under a new building code required much larger seismic demand. A flexible foundation design based on driven piles instead of drilled shafts saved $7M.

4:30 – 5:00 p.m.
Pile Design & Installation Codes – PDCA Technical Committee
To address the many problems that contractors see with pile installation specifications for private sector work, PDCA has developed its own set of recommended specifications. Attendees receive a free copy of this new spec which will be presented and discussed.

5:00 – 6:00 p.m. Networking Reception

Friday, Sept. 16, 2005

8:00 – 8:45 a.m.
"High Capacity Piles," *Peter Osborn, FHWA*
High capacity piles continue to gain interest with the transportation community in support of national initiatives such as accelerated construction. The benefits of high capacity piles are discussed and recent highway projects that have used high capacity piles are reviewed. Load testing data and cost comparisons will be presented.

8:45 – 9:30 a.m.
"Pile Driving Vibrations"
Ed Hajduk, Wright Padgett Christopher, Inc.
Methods of measuring & monitoring vibrations during pile driving are discussed and best practices are described using real world case studies. Comparative data is presented and conclusions are drawn on where vibrations may be critical.

9:30 – 10:00 a.m. Break

10:00 – 10:45 a.m.
"A Lesson Learned from Two Bulkhead Failures,"
Richard Hartman, Hartman Engineering
Investigation of two separate sheet pile bulkhead failures indicates that a common design procedure should be modified. The two investigations will be described. Conclusions will be explained and simple preventive measures presented.

10:45 – 11:45 a.m.
"The Use of FB-Pier for the Analysis of Pile Groups,"
J. Brian Anderson, University of North Carolina
FB-Pier is a computer program that analyzes a pile group, cap, and pier for a general set of loads, including loads that induce both axial and lateral loads on the pile. This program is a very powerful tool for foundation design making it possible to perform analysis and re-design quickly and efficiently. Examples will be shown.

The Pile Driving Contractors Association
“A Driven Pile is a Tested Pile”

MEMBERSHIP BENEFITS

General Membership Information

We are the premier association for pile-driving contractors

The PDCA was founded in 1996 to promote use of driven-pile solutions in all cases where they are effective. We strive to build and maintain working relationships among end users, manufacturers, government agencies, educational institutions, engineers and others involved in the design, installation and quality control of the driven pile.

We are dedicated to advancing the driven pile

As the only organization solely dedicated to pile-driving contractors, we know that you understand the superiority of the driven pile in most applications. We are the only association addressing the intrusion of non-driven solutions that take away business from the driven-pile contractor. The PDCA understands that to survive in today’s competitive marketplace, a pile-driving contractor must strive to stay abreast of the latest trends and technologies in the industry. That is why we maintain close ties with the world’s leading suppliers to the industry. It’s why we provide a broad range of educational programs for university professors, practicing engineers and contractors. And, it’s why more and more contractors, engineers and suppliers are realizing that the PDCA significantly increases their value in the marketplace.

We are a direct link to decision makers

Major manufacturers take an active role supporting the PDCA. At our conferences, we bring together the world’s leading design manufacturers and technical application experts to assist you in advancing the driven pile as a superior product.

The PDCA works closely with the technical community to format design codes and installation practices. We offer seminars throughout the country for engineers and educators on the capabilities and advantages of the driven pile. We also work with agencies, such as the Federal Highway Administration and state DOTs, which develop specifications for highway building and other infrastructure project that use driven piles.

We offer timely, valuable services

The PDCA improves your company’s bottom line, as well as your stature in the construction industry, through a variety of programs and services:

Job Referrals

We are the only organization that provides contractor referrals to end users of driven piles. You tell us where you will drive piles and we will refer you to end-users. We also provide referrals to our supplier and technical members.

Peer-to-Peer Opportunities

With more than 100 contractor members, networking opportunities abound at the PDCA. Whether at our Winter Roundtable, our regional seminars or by just picking up the phone, you’ll develop long-lasting professional relationships and friendships in the industry.

Annual Membership Directory

As a member, you'll receive PDCA's annual membership directory of our contractor, supplier and technical members. Your company is listed along with the piling solutions you employ and states in which you work. This directory is provided throughout the year to construction users on a complimentary basis.

Educational Conferences and Meetings

The PDCA offers cutting-edge education for contractors, engineers, geotechs and anyone else interested in the driven pile and its applications at two major conferences annually. Members receive discounts on exhibit and registration fees.

- The Winter Roundtable, held each February since 1997, is a nationally recognized conference that brings together leading technical experts, suppliers to the piling industry and contractors. This conference focuses on the key issues faced by pile-driving contractors and features discussions and presentations as well as an extensive exhibit area.

- The Design and Installation of Cost-Efficient Driven Piles Conference (DICEP), held each September since 2000, is a nationally recognized two-day conference that brings together geotechnical and design engineers, college professors and contractors to discuss the latest trends in understanding, analyzing and controlling piling costs.

Industry Development

The PDCA continually strives to expand market share for the driven pile. The PDCA sponsors the College Professors Piling Institute, held at Utah State University in Logan, Utah. Up to 25 professors, from major engineering schools, are invited to participate in an intensive, week-long program that presents them with the latest concepts in driven-pile design, installation and quality control. Some of the leading faculty in the deep foundation field has attended the institute to date. The program supplies the educators with the tools and knowledge to be able to teach their students about the advantages of the driven pile. It promises to have a long-term impact on market share for the driven pile.

Publications and Reference Materials

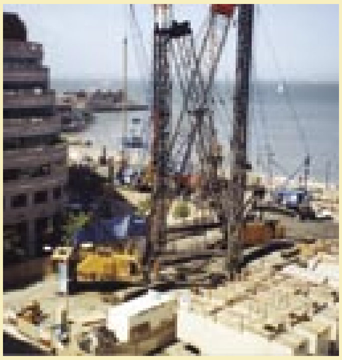
As a PDCA member, you will receive our quarterly publication, "*Piledriver*," which presents articles on issues and trends of interest to our industry. As a member, you'll receive discounts on advertising in the magazine.

All PDCA members receive a complimentary copy of the PDCA's codebook, "*Recommended Design Specifications for Driven Bearing Piles*," now in its third edition. This book covers all required guidelines for driven piles and includes a suggested bid and payment schedule.

The PDCA also sells "*The Pile Design Manual*," an FHWA manual on the design and construction of driven piles. Order forms are available on the PDCA Web site.

"Through its programs and services, PDCA has presented our company with numerous opportunities to continue our business success. It is certainly a cornerstone for growth in a very competitive business."

D.R. Jordan, President and CEO, Jordan Pile Driving, Inc.



Connect Worldwide at www.piledrivers.org

The PDCA's newly redesigned Web site at www.piledrivers.org lets you research the latest trends in the industry and find direct links to manufacturers, suppliers, engineers and others. PDCA members receive a free listing in our member search area, which is being used by an increasing number of end users to find pile driving contractors and services. Our forums area makes it easy for you to connect with others to discuss issues and problems.

Leadership Opportunities

Membership in the PDCA provides opportunities for recognition and leadership. Positions are available on the PDCA board of directors and various committees that impact the industry. The PDCA recognizes noteworthy contributions to the industry with our "Driven Pile Project of the Year" award, giving opportunities for high profile recognition.

Membership is available to you

There is strength in numbers and we, at the PDCA, need to count your company when telling government agencies, engineers and suppliers that we are interesting in keeping your business viable and in growing market share for the driven pile. We need your ideas and efforts in working together toward a common goal: the use of driven-pile solutions. You can contribute your expertise and assist the Association in developing:

- A greater focus on safety
- The quality of driven pile products
- The formatting of codes and specifications for the driven pile
- Support for a program to help educate students in the use of driven piles

Join today. Be part of a growing and vibrant organization the will play a key role in the future of deep foundations. Support your industry by completing the membership application in this issue. You will immediately begin to enjoy benefits of membership. ▼

PDCA MEMBERSHIP APPLICATION

PDCA PILE DRIVING CONTRACTORS ASSOCIATION

Step 1: Select Membership Type

I wish to apply for the following membership status (check one):

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❑ **(Annual Gross Sales <$1 Mil./year: $350/year)**

A Contractor Member is defined as a specialty subcontractor or general contractor who commonly installs driven piles for foundations and earth retention systems. Includes one primary membership. Secondary memberships are $75 each.

❑ **Associate ($700/year)**

Associate Members of the Association shall consist of firms or corporations engaged in the manufacture and/or supply of equipment, materials, testing or other services to the pile driving industry. Secondary memberships are $75 each.

❑ **Technical Affiliate ($95/year)**

Technical Affiliate Members of the Association shall consist of individuals who are involved with the design and installation of driven piles or in teaching the art and science of pile design and installation. They may be employed engineers, architects, government agencies, or universities. Employees of contractors are not eligible to become Technical Affiliate Members. Note: Technical Affiliate Membership category is for individuals only. For a company listing in the directory and on the Web site, you must join as an Associate Member.

❑ **Retired Industry Member ($50/year)**

A Retired Member shall be defined as any individual who has reached retirement age as defined by U.S. law, who has left active employment and who wishes to remain a member.

I am retiring as a: ❑ Contractor ❑ Associate ❑ Technical Affiliate

Step 2: Demographic Information

Company Name ______________________ Phone ______________________

Your Name ______________________ Fax ______________________

Address ______________________ Email ______________________

City/State/Zip ______________________ Home Page ______________________

Step 3. Method of Payment

Attached is my payment of $__________ for annual dues.

❑ I understand that dues are due annually on December 31 and, that if I joined PDCA after March 31, I may be entitled to a prorated dues amount for the subsequent year only.

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Name as it appears on card: ______________________ Signature: ______________________

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Applications Systems

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- ❑ Coatings & Chemicals
- ❑ Structural Steel
- ❑ Synthetic Material Piles
- ❑ Other________________________
- ❑ Steel Pipe Piles
- ❑ Steel Sheet Piles
- ❑ Vinyl Sheet Piles
- ❑ Other Structural Materials
- ❑ Timber Piles/Treated Lumber & Timbers
- ❑ Concrete Piles
- ❑ Composite Piles
- ❑ H-Piles

Equipment

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- ❑ Cranes
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- ❑ Testing
- ❑ Trucking
- ❑ Vibration Monitoring ________________________
- ❑ Other __________________

General

❑ Rental ❑ Sales ❑ Other __________________ ❑ Other __________________

C. Technical Affiliate Only (check all that apply)

- ❑ Analysis
- ❑ Geotechnical
- ❑ Surveying
- ❑ Civil & Design
- ❑ Materials Testing
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Step 4. Geographic Areas Where Contracting, Products and Services Available

(All applicants check all that apply)

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❑ AL	❑ DE	❑ IN	❑ MI	❑ ND	❑ OK	❑ TX	❑ WY
❑ AR	❑ FL	❑ KS	❑ MN	❑ NH	❑ OR	❑ UT	❑ Canada
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Step 5. Sponsorship: Who told you about PDCA?

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Name as it appears on card: _______________________ Signature: ___________________________

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PDCA Member

Don Foster Sees Endless Possibilities for L.B. Foster

PDCA wishes to recognize and thank Don Foster and L.B. Foster Company for their sponsorship of the 2005 PDCA Professors Piling Institute.

By Amber N. Billman, Piledriver Editor

After retiring from a rewarding 24-year career with United States Steel Corporation, Don Foster could not pass up the opportunity to work for L.B. Foster.

Don Foster is the managing corporate officer of L.B. Foster Company's piling, fabricated bridge products, and precise custom bridge fabricating divisions. Don joined L.B. Foster in 2004 after a successful 24-year career with United States Steel Corporation. He retired from his position as President of U.S. Steel International to become L.B. Foster's Executive Vice President of Construction Products. During his short tenure, Don has already expanded the group's market share with the introduction of innovative new piling and construction products.

For more than 100 years, L.B. Foster has delivered the construction products necessary to build and maintain the nation's infrastructure. The company was founded in 1902 by 20-year-old Lee B. Foster who financed his company with a $2,500 loan from his father. Today, L.B. Foster remains a quality manufacturer, fabricator, and distributor of products for the transportation, construction, utility, and energy industries. The company markets its products worldwide to industries requiring rail and accessories; sheet, pipe, and H-piling; bridge decking and highway products; earth retention systems and soundwalls; precast concrete buildings and threaded pipe and coated pipe. The company tries to stay abreast of technology issues in several ways; through their customers, through their international supplier network, and through the various trade associations to which they belong.

Don Foster understands the importance of these associations, particularly PDCA. "PDCA provides us a number of useful seminars and professional opportunities to learn and advance our knowledge in the areas of foundations, pile driving, and equipment productivity," he says. "Towards this end, in our own operations, Foster strives for continuous improvement in such critical areas such as customer satisfaction, lean manufacturing techniques, and employee training and development." Don Foster has also relied on the benefits of PDCA membership to help guide him toward successful product and market decisions. "Our customers, our extensive international supplier network, and our membership in trade associations, such as PDCA, keep us abreast of important piling and construction industry technology issues," Don noted.

L.B. Foster Company strives to bring innovative, creative, and cost effective foundation solutions to owners, engineers, and contractors by relying on strategic alliances to expand its product and service offerings. Don has furthered L.B. Foster's key partnerships with Chaparral Steel, TKB Hoesch, Piene Piling, PND Engineering Consultants, Hartman Engineering, and Pile Pro Extruded Connectors. Foster also maintains important working relationships with Northwest Pipe, ACIPCO, Maverick Tube, Stupp Corporation, Copperweld Corporation and SCCI of Florida.

Don graduated from Indiana University in 1978 and pursued a Masters in Management from Benedictine University in Illinois in addition to attending the Executive program at the University of Michigan. In addition to his educational background, Don brought the many skills he learned in his extensive career prior to L.B. Foster to the company. "The opportunity at L.B. Foster was hard to pass up. The company is on the verge of some very exciting developments. There is a new strategic direction and a great team spirit. When you have quality people, the possibilities are endless," he says.

Don has been married to his wife, Eileen for 25 years, and they have three children: Doug, Sara, and Brad. "Besides being committed to my marriage and my children, we try to serve at our church, Orchard Hill Church in Wexford, Pa. I also serve on the board of the Light of Life Mission and the Pine Richland Opportunity Fund," he adds.

L.B. Foster Projects

L.B. Foster Company provided Chaparral-manufactured flat sheet piling for the construction of an Open Cell dock facility at the Port that required 300 tons of PS 31 and 150 tons of PS 27.5 flat web steel sheet piles. The project was originally designed to use Z sheet piling to rehabilitate an existing old dock and bulkhead structure. General contractor, American Construction Company, and the Port's agencies discovered that the fill behind the existing structure was contaminated. After determining the high costs associated with removal of this type of structure, the Foster team and PND's Todd Nottingham suggested an alternative Open Cell piling system to encapsulate the old dock and bulkhead, isolating the hazardous material and producing a substantial cost savings to the customer.

L.B. Foster also recently supplied 400 tons of sheet piling for the Kuparuk River Bridge Project in Alaska where unique design and construction challenges included extreme environmental conditions, vehicle weights approaching 4 million pounds, impact loading from thick river ice, and discontinuous permafrost soil conditions. Another current Northwestern project required the delivery of 600 tons of pipe piling to Ruskin Construction, Ltd. for use on the new Kodiak Pier 2 for the City of Kodiak, Alaska. ▼

THE VIBRATORY PILE INSTALLATION TECHNIQUE

By Kenneth Viking, Ramboll Sverige AB
Email: kenneth.viking@ramboll.se, Web: www.ramboll.se

Part III

Soil Behavior in the Vicinity of a Vibro-Driven Pile

The purpose of using vibrators to drive piles in cohesionless soils is to put the soil volume closest to the pile into a state were it loses its inner shear strength. Several authors have (incorrectly) implied that the shear strength reduction is "primarily" related to the soil mechanism termed liquefaction. However, it should be noted that the shear strength reduction is also present during artificial conditions, such as in laboratory tests using air-dried sand [1], [11], [12], and [13]. From these tests it can be concluded that soil liquefaction is not the "primary" explanation of the shear strength reduction.

Reduction of Soil Shear Strength

As a vibro-driven pile undergoes a pure axial-vibratory motion having an amplitude of $0.1<S_p<0.9$ [in.] and an acceleration amplitude of $8<a<20$ g, it interacts with the neighboring soil volume. This dynamic interaction introduces inertia forces $F_I = \gamma z(a/g)$ to the soil in the vicinity of the pile. The inertia forces creates a dynamic motion of the individual soil grains (see Fig. 7b) and when the peak acceleration in the soil exceeds ~1.0 g (approximately gravity) the grains start to experience short phases/moments of "free fall."

In other words, as the acceleration amplitude within the soil volume exceeds a site-specific threshold value, which corresponds to the initial overburden pressure $\sigma_v = \gamma z$, the confining stress drops to nearly zero during parts of each steady-state loading cycle. This implies that the inner shear strength reduction is instead "primarily" related to short-time drops of the inter-granular contact N and shear T forces between the grains, as illustrated by Fig. 7.

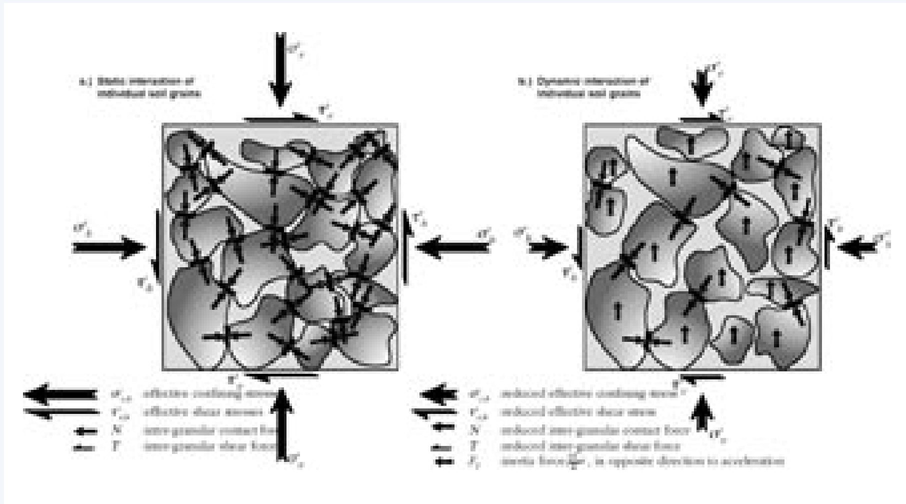

Fig. 7. Graphic explanation of the soil shear strength reduction when vibro-driving in cohesionless soils: a.) undisturbed state, b.) dynamic state [16].

Even if the acceleration-induced motion of the individual grains appears to be the "primary" mechanism behind the shear strength reduction, it is of course evident that the induced excess pore-pressure during field related conditions is undoubtedly of great assistance in reducing the soil resistance. Test results by [14] and [15] show that the induced "large" cyclic shear strains γ_c»10^{-1}, together with volume changes Δe within the soil volume close to the pile, induce equally cyclic excess pore-pressure changes Δu. However, the developed excess pore pressure in the vicinity of the pile does not necessarily have to achieve a state of liquefaction. Instead, it seams more realistic that the induced excess pore-pressure puts the soil volume close to the pile in a state best described by the soil mechanism termed "cyclic mobility."

Dynamic Soil Resistance of Vibro-Driven Piles

The Soil Resistance during Vibratory Driving (SRVD) consists of the sum of: the dynamic forces at the pile toe R_t and along the shaft R_s, together with interlock-friction R_c when driving sheet piles (see Fig. 5).

Fig. 8a illustrates the constitutive relationship between toe resistance and displacement (R_t–u) of a vibro-driven pile, somewhat simplified but greatly similar to the few published field measurements of the actual (R_t–u) relationship. Field measurements of the (R_t–u) curve do not, in reality, display a linear relationship, but instead they display a concave, upward, strain-harden, loading and unloading curve, without tendency to reach the typical plateau of equivalent impact curves, e.g., Smith soil model of an impact driven pile toe.

Fig. 8b illustrates the constitutive relationship between shaft resistance and displacement (R_s–u). The illustrated

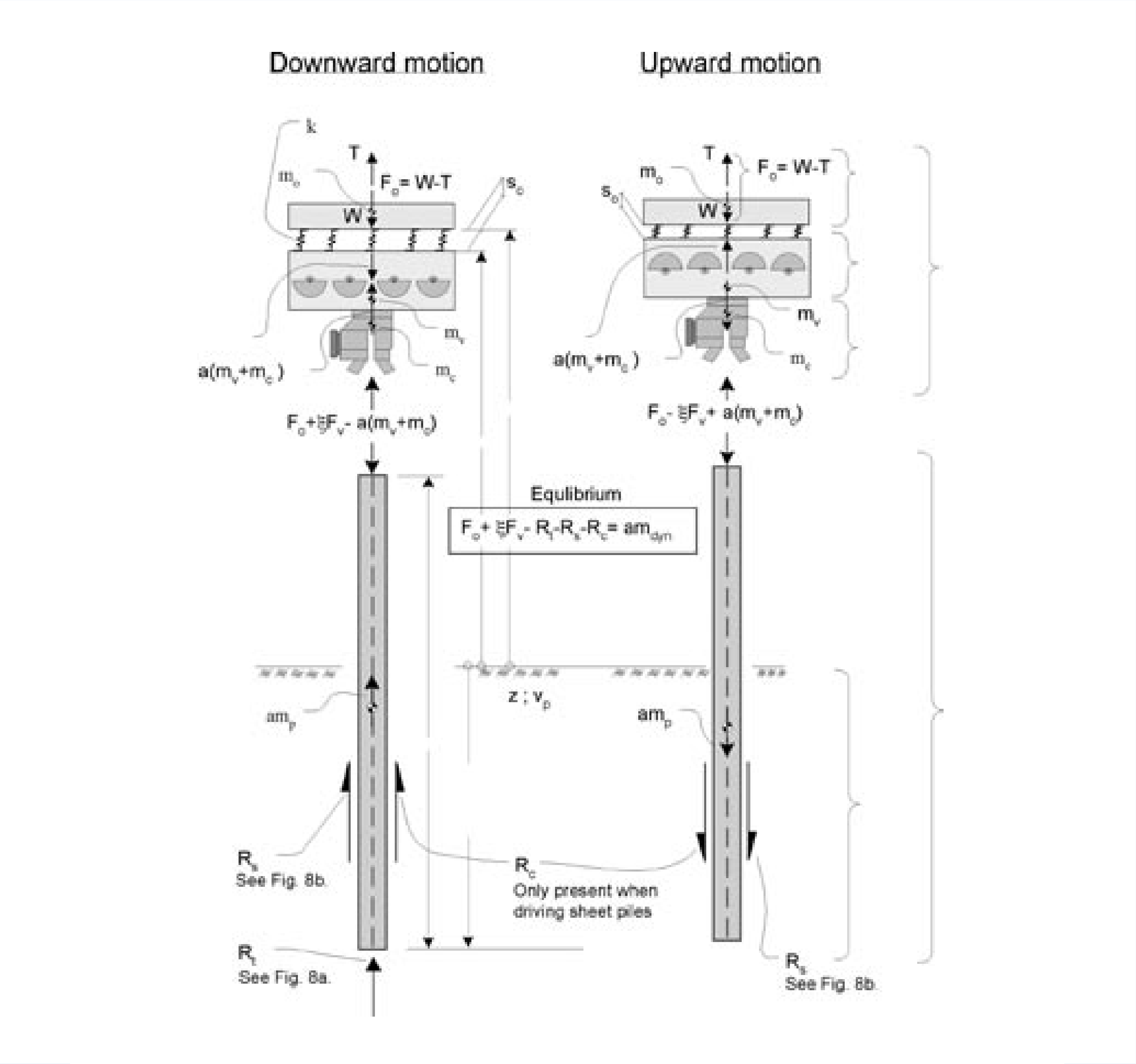

Fig. 5. Forces at play when driving piles (free-hanging vibro equipment), after [16].

curve describes a general pattern (with a great deal of simplifications) that varies symmetrically between its positive loading and negative unloading value, $\pm R_{s,max}$. Note the higher unloading stiffness k_u compared with the loading stiffness k_l, which is explained by hysteresis of the induced cyclic shear strains, which are largely irreversible.

It is well known amongst practitioners that the magnitude of the dynamic interlock-friction force R_c quite frequently overshadows the sum of both dynamic toe and shaft resistance. However, intuitively, the direction and variation of the interlock-friction force R_c should be correlated with the pattern of the shaft resistance (R_s–u) curve.

Theoretical Prediction of SRVD

From an engineering point, being able to estimate the magnitude of the SRVD (read R_t and R_s) versus depth z is the key for a reasonable prediction of the penetration speed v_p. Vibrodrivability, in a broad sense, is defined by the shape of the (v_p–z) curve as a result of the dynamic equilibrium of the vibro/pile/soil system, schematically illustrated by Fig. 5.

The difficulty in predicting the magnitude of encountered SRVD boils down to the lack of appropriate soil investigation methods that duplicate the conditions in the vicinity of a vibro-driven pile. Current standard investigation methods devised to characterize the magnitude of SRVD include: i.) probing tests (CPT and SPT), ii.) sampling tests and iii.) laboratory tests (tri-axial, resonant column, and direct shear tests). All these have been developed to produce input for static design issues, and are obviously not suitable to quantify the magnitude of SRVD. However, promising techniques do exist. One of the more recent techniques can be found in [15].

Countries such as Belgium, the Netherlands, Germany, France and Sweden, to name a few, are places where the majority of steel sheet piles are installed with vibratory drivers/extractors, several prediction methods have emerged regarding the choice of minimum required vibro-driving force to drive a specific sheet pile to designated design depth in a specific soil profile. The more notable techniques, all mentioned in [16], are based on results of CPT, where the quasi-static cone q_c and sleeve friction f_s have been empirically reduced to levels resembling the dynamic soil resistance in the vicinity of a vibro-driven pile. The author applies the following methods, depending on whether it's an on- or offshore-related job.

Onshore Jobs

The SRVD is estimated according to the Vibdrive model that was initially developed by [18], and has undergone refinements by [19] and [20]. The SRVD estimate is rather simple; it's based on the soil driving unit resistance at toe q_d and along shaft τ_d that are correlated with pile geometry. Estimated $R_{t,max}$ and $\pm R_{s,max}$ are then modeled as constants both with respect to time and displacement (see Fig. 8). However simple or not, the model does incorporate the two main soil related factors, i.e., i.) the cyclic motion of grains due to vibratory accelerations, and ii.) induced pore-pressure build up. Furthermore, the model is based on the assumption that the vibro-unit and pile behave as a rigid body, and therefore allows for application of Newton's second law of motion to the moving masses. The theoretical driving force amplitude is calculated according to Fig. 3b, using rated values of f_d, M_e, and an assigned value of $\xi<1.0$. The penetration speed v_p is obtained by integrating the net down-ward and up-ward acceleration over a complete cycle ($T=1/f_d$).

Offshore Jobs

The procedure to estimate SRVD

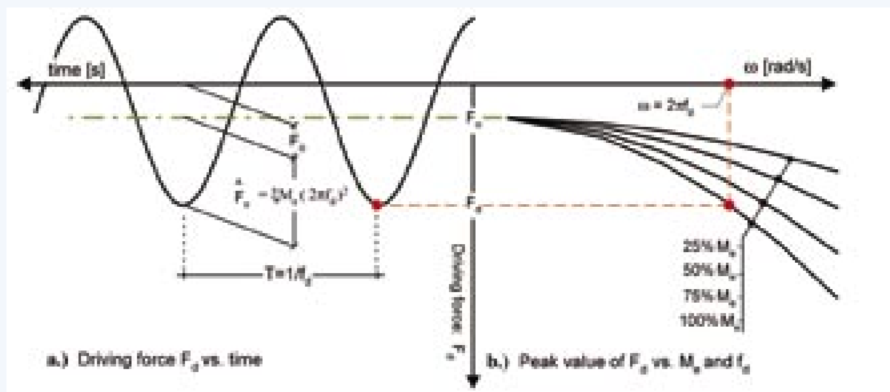

Fig. 3. Driving force as function of changed frequency and eccentric moment.

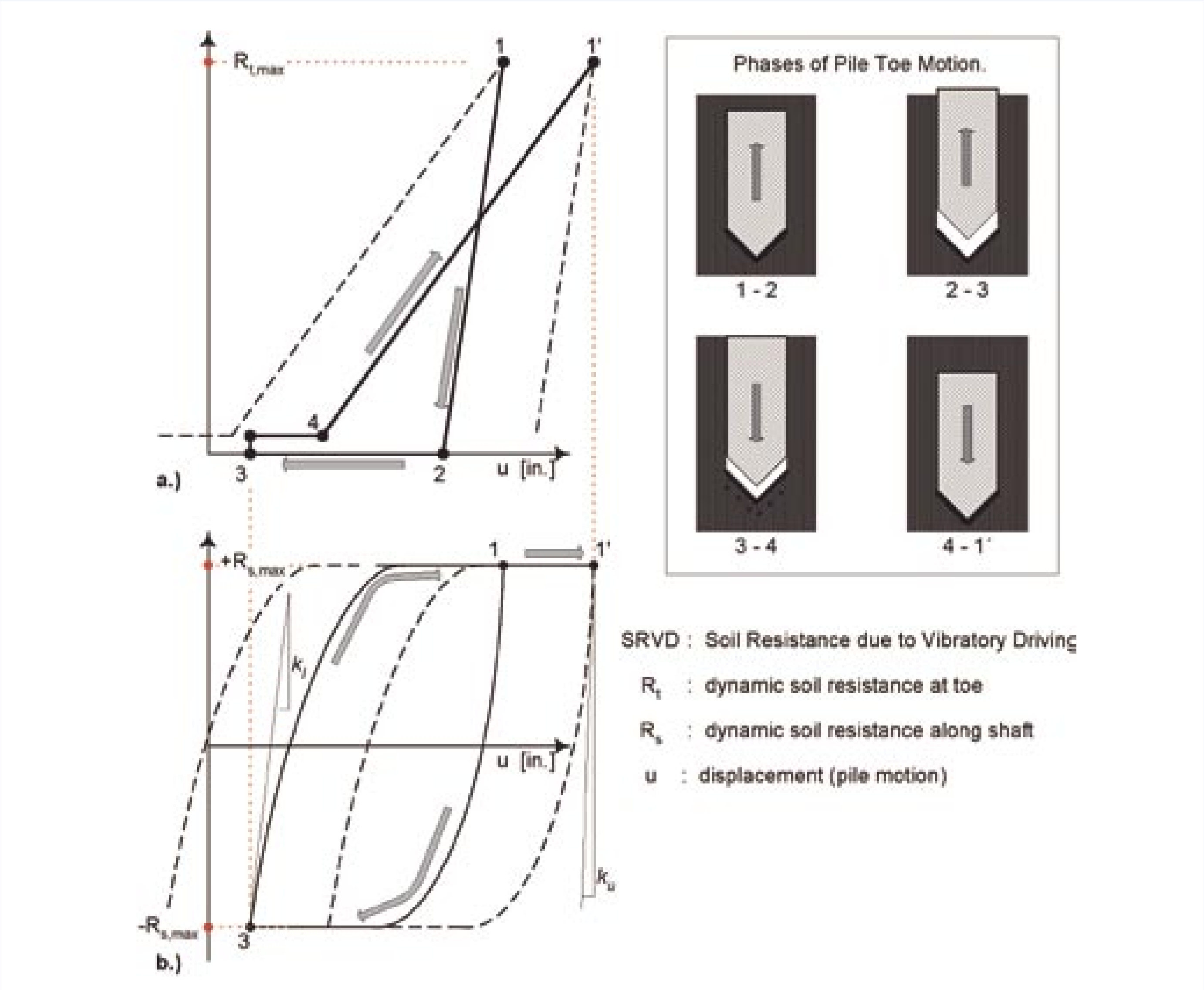

Fig. 8. SRVD versus displacement for: a.) toe resistance, b.) shaft resistance, after [4].

is a bit more elaborate compared with above description for onshore-related jobs. Estimation of $R_{t,max}$ and $\pm R_{s,max}$ are instead calculated according to [21], which is an empirical model, based on decades of measurements of mobilized SRD for impact driven pipe piles in marine deposits. The theoretical driving force amplitude is calculated in the same manner, with the difference that the system efficiency is assigned a value of $\xi \ll 1.0$. The penetration speed is calculated according to the same procedure as described above.

It might be argued that the above-mentioned methods of predicting the SRVD are a bit crude, and that it's more appropriate to apply a time-dependent, non-linear method to analyze vibratory installation of piles. However, the main weakness of these methods is the accuracy of the constitutive components of the proposed use of non-linear soil models (e.g., Fig. 8b). The dynamic soil-related mechanism in the vicinity of a vibrating pile must therefore be thoroughly understood and accurately simulated in order to produce reasonable results, and these conditions have not yet been met. However, with the popular but simple elasto-plastic Smith model for soil response of impact driven piles in mind, it will probably take some time before anything sensible will emerge.

Theoretical Prediction of Capacity

At present, there is a complete lack of elegant monitoring systems (like the PDA analyzer™) for verifying capacity of vibratory installed piles.

Furthermore, there is also a great hesitancy within the engineering community to allow foundation piles to be installed with vibratory driving equipment, even when it's been verified (dynamic and/or static load tests) that the conditions are indeed favorable. But more importantly, if an in-situ monitoring technique such as the PDA-based technique would emerge, it would indeed be invaluable for further development of a cost effective pile installation technique. ▼

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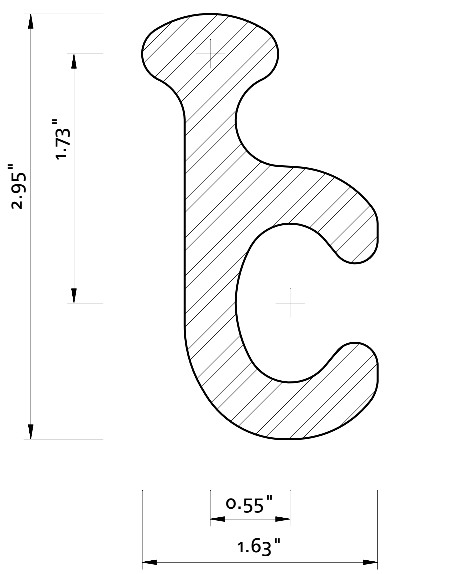
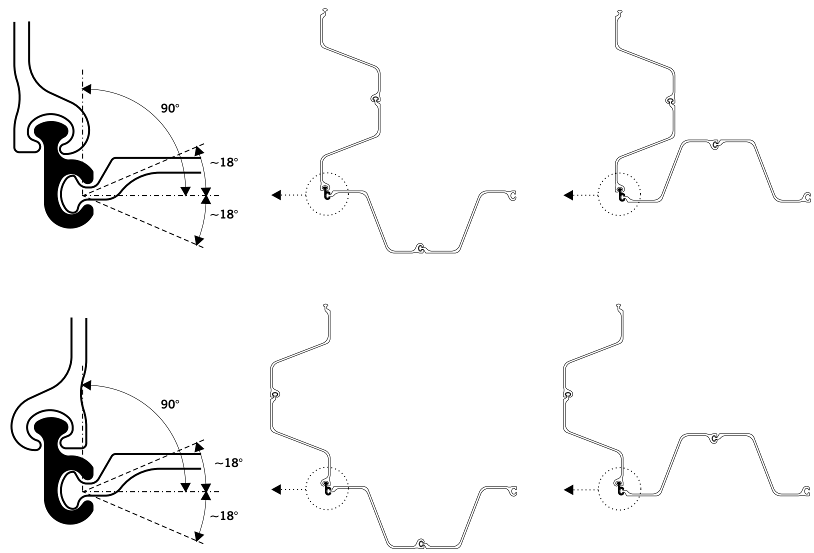


Weight: 7.3 lbs/ft (10.9 kg/m)

Steel grade: Astm A572 Grade 50 (S 355 GP)

Proper Interlocking Examples

Each interlock has a typical degree swing of 20° (+/- 5°) so that the probable swivel range is 40° (+/- 10°) when interlocking two PZ sheets via the connector.



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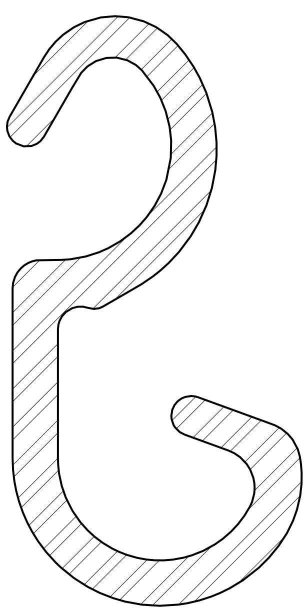
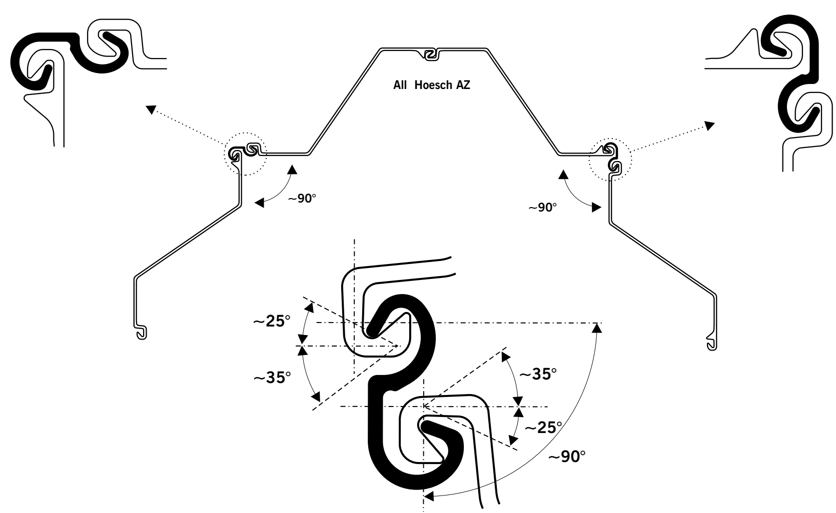


Weight: 8.9 lbs/ft (13.2 kg/m)

Steel grade: Astm A572 Grade 50 (S 355 GP)



Installation Guidelines:

1. Thread the connector into the interlock while the sheet pile is out of the ground.

2. Adjust the connector to the appropriate position.

3. Tack or spot-weld the connector in place (typically a 10" weld attaching the connector to the sheet pile at the top is sufficient.)

4. Drive/extract the sheet (with the connector attached) as you would normally.

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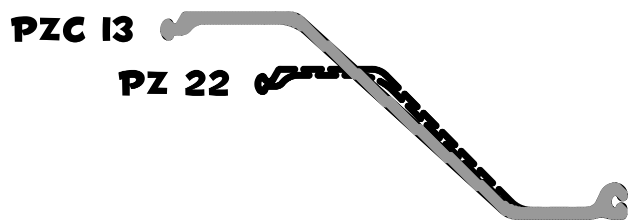
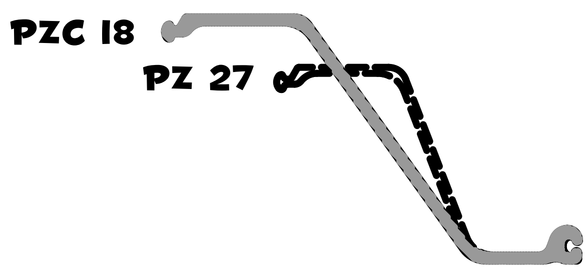


SHEET PILING	Nominal Width, in.	Weight in Pounds		Moment of Inertia, in.^{4}		Section Modulus, in.^{3}	
		Per lin. ft of bar	Per sq ft of wall	Single Section	Per lin. ft of wall	Single Section	Per lin. ft of wall
PZC 13	27.88	50.4	21.7	353.0	152.0	56.2	24.2
PZ 22	22.0	40.3	22.0	151.0	82.4	32.5	17.7



SHEET PILING	Nominal Width, in.	Weight in Pounds		Moment of Inertia, in.^{4}		Section Modulus, in.^{3}	
		Per lin. ft of bar	Per sq ft of wall	Single Section	Per lin. ft of wall	Single Section	Per lin. ft of wall
PZC 18	25	50.4	24.2	532.2	255.5	69.8	33.5
PZ 27	18	40.5	27.5	282.0	188.0	45.3	30.2

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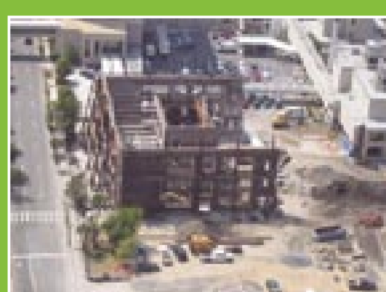
CHAPARRAL STEEL

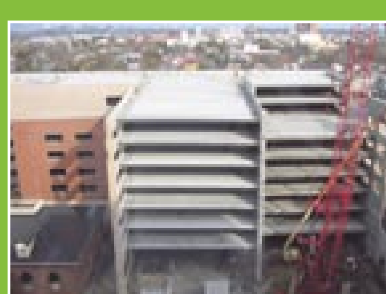
PROJECT OF THE YEAR

PDCA 2004 Under $1,000,000

Abandoned since the 1980s, the old Charleston High School building was given a second chance as it became part of the Medical University of South Carolina.

By Amber N. Billman, Piledriver Editor





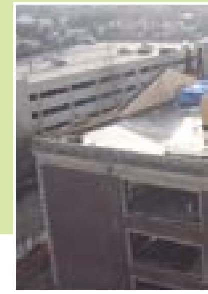
Charleston, South Carolina is a town that celebrates its rich heritage and history. This made the renovation of the old Charleston High School (built in the 1920s) a challenging one. Located adjacent to the main campus of the Medical University of South Carolina (MUSC), the building seemed a natural location for the expansion of the University. However, there was a challenge to preserve the existing brick façade and incorporate it into the new development of a parking garage and additional office building.

The project was selected as the PDCA 2004 Project of the Year (Under $1,000,000) for the particular challenge faced by the renovation team. PDCA members WPC Inc. and Palmetto Pile Driving, Inc. were part of this team, and faced these challenges head-on.

Unique Pile Driving Used in the Project

Driven piles for this project were necessary for the renovation and new construction, as well as the existing brick façade support frame of the Charleston High School building. The project was challenging because it involved pile installation within 3 feet of a braced, un-reinforced brick masonry frame, which is a distinct application for driven piles. "Although the brick façade was braced, the masonry was un-reinforced and old (80 + years old), which made it susceptible to vibrations. In addition, the working area was limited in and around the existing brick façade, posing additional challenges," says Ed Hajduk, PE, Geotechnical Engineer for WPC Inc. It is also important to mention that the pile driving was located in the heart of Charleston, SC near a working hospital, which necessitated extensive monitoring. Because of the 20+ years of neglect the building suffered, it did not meet the current seismic standards of the SC building code (i.e. IBC 2000). Therefore, the existing structure minus the façade had to be demolished and replaced. Limited construction space, concerns of soil subsidence caused during drilled shaft construction, and quick testing capability of driven piles via dynamic testing led to the selection of driven piles.

Although not new, the combined pile design and installation monitoring program showcased how teamwork from the geotechnical engineer (WPC), owner (MUSC), general contractor (Mashburn Construction), and pile driving subcontractor (Palmetto Pile



Driving) can utilize driven pile foundations as the economical solution for the unique situation of installing a foundation system around a space restricted, vibration sensitive site. J. Harry Robbins, Jr. is president of Palmetto Pile Driving, Inc., and he especially understood the need to get the job done right: “Early on the design team was considering the use of alternatives to driven piles, due to vibration concerns. We knew that driven piles would work, and I wanted very much to be able to prove it. If driven piles on the highly visible project caused vibration problems, it would potentially have had a long-reaching, negative impact on driven piles in Charleston,” he says.

The use of driven steel H piles provided a cost-efficient foundation solution in this setting. Since steel H piles are low displacement, they (combined with pre-augering) produced a minimal amount of vibrations that did not affect the sensitive un-reinforced brick façade. In addition, the ability to easily splice steel H piles allowed long (100+) foot pile to be installed in a restrictive space. The ability to splice piles also allowed for a smaller pile storage area on site, which also assisted the project by allowing other activities to be conducted concurrently with the pile driving. Additionally, the use of driven piles had a beneficial impact on the schedule when compared to other foundation options because of these concurrent activities.

Equipment Used

An International Construction Equipment (I.C.E.) Model 75 hammer was used to install the production and test piles. A 12-inch diameter auger was used to pre-auger the pile locations to a maximum depth of 40 feet below the ground surface.

The piles were primarily steel HP12 x 53, with lengths ranging from 90 to 105 ft. Also, 12 in OD x 0.219 (wall thickness) steel open-ended pipe (OEP) by 45 feet long were used to support the un-reinforced brick façade.

“Hammer, auger and leads were manufactured by I.C.E. Our crane was a Link-Belt 138H-II crawler crane. Piles were manufactured by Nucor Steel and supplied by Skyline Steel. Forsberg Engineering did the surveying layout of the piles. WPC engineering did the quality control,” Robbins says.

Working Conditions

The site conditions for the project were restrictive, given that the site was surrounded by existing buildings. “One of these buildings was a working MUSC hospital that maintained regular patient visits and surgeries during the pile driving operations. In addition, an existing interior structure from the old Charleston High School was kept, making access on the interior of the existing brick façade limited as well.

Although not new, the combined pile design and installation monitoring program showcased how teamwork from the geotechnical engineer (WPC), owner (MUSC), general contractor (Mashburn Construction), and pile driving subcontractor (Palmetto Pile Driving) can utilize driven pile foundations as the economical solution for installing a foundation system around a space restricted, vibration sensitive site.

Other Project Concerns

Safety

The primary safety issue regarding the pile driving on this project (in addition to standard pile driving safety issues) was the effects of vibrations on the existing brick façade and the concern for subsequent collapse. By monitoring pile vibrations and existing cracks, the team was able to determine the vibrations generated by pile driving did not affect the brick façade.

Environmental

Due to the location of the site near existing historical residential homes and existing MUSC facilities, vibrations were a concern at these locations as well. This concern was addressed by performing a pre-condition survey of the surrounding area and conducting vibration and existing crack monitoring on selected adjacent structures during pile driving.

Noise

Given that the project was in a dense urban environment with residents and workers directly adjacent to the site, noise was a concern. However, the method of pile installation selected to limit vibrations (i.e. pre-augering through the

"…We knew that driven piles would work, and I wanted very much to be able to prove it…" J. Harry Robbins, Jr., President,Palmetto Pile Driving, Inc.

upper soils and use of a low hammer stroke) reduced noise generated during pile driving.

About WPC

"WPC's geotechnical capabilities, knowledge, and experience allowed us to recommend driven piles as the ideal foundation solution for the project in terms of cost and installation. Our construction services capabilities, knowledge, and experience allowed us to refine our pile design, thereby reducing pile lengths and project cost. In addition, by conducting extensive monitoring in the form of pre-condition surveys and pile/vibration/crack monitoring, we were able to verify that the driven piles did not cause damage to the existing old Charleston High School structures that were to be incorporated into the new development or the adjacent structures," Hajduk says.

Quality Control

Quality control for the pile installation consisted of: A pre-condition survey of the existing brick façade and surrounding buildings; a test pile program consisting of dynamic monitoring during pile installation and hammer restrikes, as well as vibration monitoring; pile inspection during installation consisting of monitoring pile blow counts and other information such as hammer stroke; vibration and existing crack monitoring during pile installation; and finally, a review of all available pile data at the end of the project by a registered engineer.

Hajduk attributes teamwork and recognition of the unique attributes of the project as factors to its success. "Teamwork is a successful factor to almost every successful project," Hajduk adds. ▼

Project Breakdown

- Work began on the project to renovate and build a parking garage and office building on to the old Charleston High School Building in the Spring of 2004.
- Pile driving was completed Aug. 2, 2004.
- **Owner:** Medical University of South Carolina (MUSC)
- **Architect:** JHS Architecture
- **Structural Engineer:** Mabry Engineering
- **Geotechnical Engineer:** WPC Inc.
- **General Contractor:** Mashburn Construction Company, Inc.
- **Sub-Contractors/Supplier:** Palmetto Pile Driving, Inc. and WPC, Inc.

OPEN-END
DIESEL HAMMERS

The Open-End Diesel hammer is a single cylinder, two-cycle internal combustion hammer that operates on diesel fuel. The piston serves as the pile driving ram. The combustion energy in the diesel fuel generates the stroke of the ram and, for all except the easiest driving conditions; the impact of the ram drives the pile. Diesel hammers have compression ratios in the same range as typical diesel engines so the temperatures in the pre-compressed gasses are high enough to induce combustion.

The principal components of the diesel hammer are shown in Figure 4. A cycle of the operation can be described beginning with the ram at the top of the stroke in Figure 4a. It falls freely under the action of gravity to the exhaust ports as shown in Figure 4b. To this point, the ram velocity could be calculated from the simple laws for freely falling bodies. Of course, there will be some reduction in velocity due to friction between the ram and the cylinder. When the ram passes the exhaust ports it blocks further gases from escaping and begins compressing the gas in the combustion chamber (Figure 4c). During this stage, the ram starts to decelerate and finally will lose velocity due to the action of the pre-compression pressures under the ram. As it descends, the falling ram activates the fuel pump and causes a metered amount of fuel to be introduced into the combustion chamber. The method of activation of the fuel pump varies with the brand of the hammer. A cam mechanism is commonly used. Other systems use an air piston which senses the pressure in the combustion chamber. Some hammers are of the impact atomization type where fuel enters in liquid form to be atomized when the nose of the piston strikes the anvil while others are of the pressure injection type where fuel is injected by diesel injectors in atomized form.

At or near the time of impact, the fuel and the heated compressed air mixture in the combustion chamber begins to burn; the gas pressure in the combustion chamber increases dramatically when the fuel burns. It is the impact that does most of the pile driving, but in very easy driving the pile is also pushed down into the ground by the force of the compressed gas in the combustion chamber acting down on the anvil.

After impact, the ram begins to move back up in the chamber. The upward motion is generated by both the rebound of the pile and the gas pressure. In very easy driving conditions, some pile penetration is generated by the gas pressure directly, reducing the gas pressure available for raising the ram. Thus, the stroke of the Open-End Diesel hammer is dependent on driving resistance, fuel charge, pile movement, and pile stiffness.

Under the action of the gas pressure, the ram is accelerated upward until it reaches the port where the excess gas pressure is exhausted to the atmosphere (Figure 4e). Since the ram has a velocity at that point, it "coasts" on up to the top of the stroke decelerating under the action of gravity. During this part of the stroke, fresh air is drawn into the combustion chamber scavenging the burned gases (Figure 4f). When the ram reaches the top of the stroke, the cycle is repeated.

To start the Open-End Diesel, the ram is lifted mechanically (see Figure 4a) for its initial fall. Released by a mechanical trip, the piston falls through the cycle described above.

In very easy driving, the stroke of the ram may be so small that scavenging is inadequate and the hammer will not run. In such cases, the ram must be lifted repeatedly by the crane until the pile is driven to the point where it has sufficient resistance to provide enough stroke to make the hammer run.

The diesel fuel for the operation of the open-end diesel hammer is carried in a tank on the hammer and fed to the combustion chamber by a pump system, also mounted on the hammer. Some hammers have a throttle with fixed steps that make possible the injection of various metered amounts of fuel into the combustion chamber. Others have continuously variable throttles. Some are adjustable by an operator on the ground while others can only be changed at the hammer. Varying the throttle setting varies the fuel input, which varies the stroke and energy, allowing for greater controllability.

Open-End Diesel hammers are either air or water-cooled. The water-cooled machines have a water reservoir in the hammer while the air-cooled type has cooling fins on the outside of the combustion chamber.

Open-End Diesel hammers require adequate lubrication for efficient operation. Most modern hammers have an automatic oil pump for piston lubrication and grease fittings for high temperature grease to lubricate the anvil. The purpose of the lubricant is to keep the piston rings working freely and

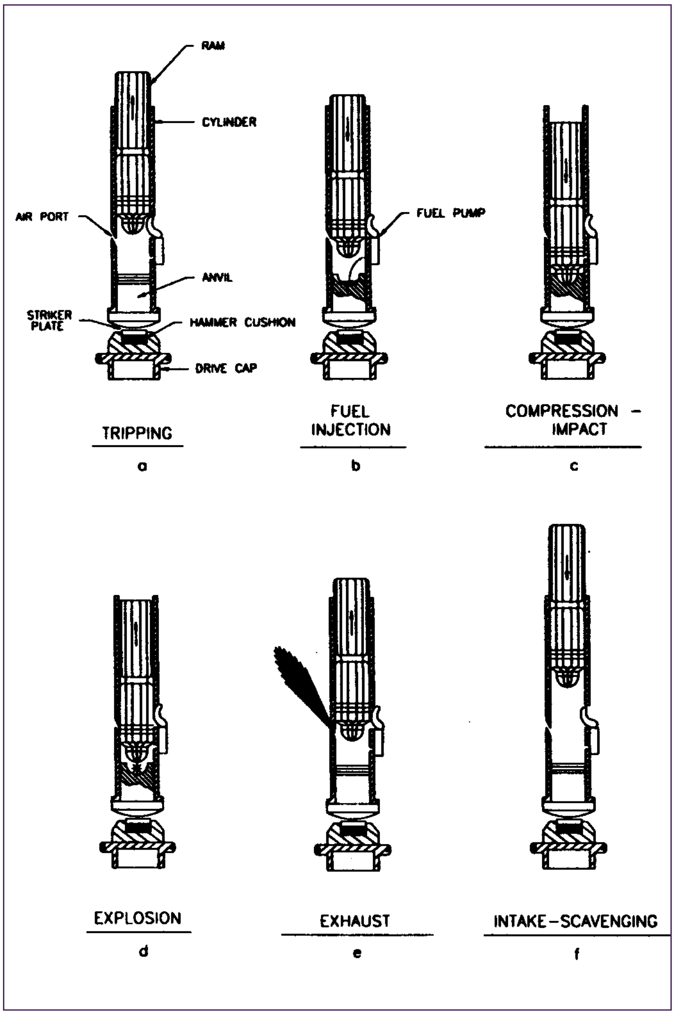


Fig. 4

to reduce wear on the anvil, ram, and hammer cylinder. The pile driving crew should periodically stop operations to add lubricating oil and/or to grease the hammer.

Diesel hammers usually employ a hammer cushion between the anvil of the hammer and the drive cap. The function of the cushion is to soften the impact and protect both the hammer and the driving system. Some manufacturers eliminate the hammer cushion through use of rebound absorption systems to protect the hammer without utilizing a cushion between the hammer and the drive cap.

There is no standardized method for rating diesel hammers as is the case for air/steam hammers. Some manufacturers use a thermodynamic analysis to arrive at a rating while others simply multiply the maximum stroke by the ram weight. Other methods are also used. Since the ram stroke varies with the driving resistance, the fuel charge, friction, and the axial stiffness of the pile, stroke cannot be easily predicted or completely controlled. A set of driving conditions will produce a particular stroke. While the stroke can be reduced by throttling the hammer back, it cannot be increased beyond that achieved with a full throttle.

Open-End Diesel Hammer Operational Conformance Checklist

1. Obtain the manufacturer's current specifications for the type and model of hammer being used.

2. Check that the cushion material being used between the anvil and the drive cap is in good condition and in conformance with the hammer manufacturer's recommendations.

3. Stroke can be determined by timing the speed of operation of the hammer. The stroke can be calculated from the formula

$$H = \frac{450g}{b^2} - 0.3 \qquad (1a)$$

where H is the stroke in feet, b is the speed of hammer operation in blows per minute, and g is the acceleration of gravity, 32.2 feet per second per second.

This formula may be simplified to the form

$$H = \frac{14500}{b^2} - 0.3 \qquad (1b)$$

for English units, or

$$H = \frac{4400}{b^2} - 0.9 \qquad (1c)$$

for SI units.

Table I Stroke versus Hammer Operating Speed

BPM	Stroke ft	Stroke m	BPM	Stroke ft	Stroke m	BPM	Stroke ft	Stroke m
34	12.2	3.73	**43**	7.5	2.3	**52**	5.1	1.54
35	11.5	3.51	**44**	7.2	2.19	**53**	4.9	1.48
36	11.0	3.32	**45**	6.9	2.09	**54**	4.7	1.42
37	10.3	3.13	**46**	6.5	2.00	**55**	4.5	1.37
38	9.7	2.97	**47**	6.3	1.91	**56**	4.3	1.32
39	9.2	2.81	**48**	6.0	1.83	**57**	4.2	1.27
40	8.8	2.67	**49**	5.7	1.75	**58**	4.0	1.22
41	8.3	2.54	**50**	5.5	1.68	**59**	3.9	1.18
42	7.9	2.41	**51**	5.3	1.61	**60**	3.7	1.14

For convenience, the stroke is given in Table I for various hammer speeds from the above formulas.

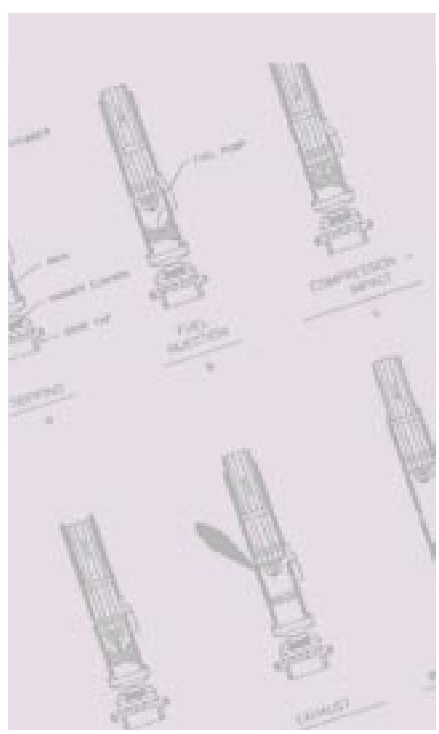
There is an electronic device that is sometimes available on site to determine the stroke directly from the time between blows detected by sound of the operating hammer. Increased ring friction as with a new or rebuilt hammer and operation on a batter require correction of the above formulas. Correction can be by direct observation of ram stroke and is encouraged.

4. Obtain the driving criteria from the engineer. If a Wave Equation analysis has been used the driving criteria will include stroke in addition to blow count. Observe the driving of a test pile and note the ram stroke or speed of operation when the required blow count is reached. Determine if these conditions satisfy the job requirement.

5. Check the manufacturer's recommendations. Observe the hammer operation for a short time to see that the specified piston stroke is consistently reached as a minimum and that the stroke is relatively constant (within six inches from the specified minimum). The stroke can be verified by measuring the operating speed of the hammer in blows per minute and computing the approximate stroke from the formula in Item 3 or obtain it from Table I.

6. When observing the hammer on production piles, expect that the stroke of the ram will usually be less than was observed at final driving on the test pile. When the pile is penetrating easily, a shortened stroke will be most apparent and occurs because some of the gas pressure energy of the hammer is performing work directly on the pile. Less energy is left to propel the ram upward, and the upward stroke of the ram decreases. In this circumstance, there is nothing that the contractor's personnel can do to produce full stroke of the ram. As the pile "takes up" (increased blow count) the stroke of the ram will increase until the pile reaches the required stop criteria. At this time the required stroke should again be observed.

7. During the course of observing the hammer stroke throughout the work day, be alert for any unusual change in the ram stroke. In periods of sustained driv-



ing at high blow counts, (20 blows per inch or 25 millimeters and above), and/or in conditions of high pile rebound, diesel hammers can overheat, producing premature combustion of the fuel. This condition is commonly called preignition. Hammers operating in conditions requiring many blows per pile may develop these problems after several hours of operation. (Note that most manufacturers void their equipment warranties for hammers worked consistently in excess of 10 blows per inch or 25 millimeters). Preignition could also be caused by improper fuel (highly volatile fuel with a low flash point). Preignition decreases the impact velocity and in extreme cases, prevents impact. The observable result will be an increase in the stroke of the hammer as compared to that observed on other piles earlier in the day. Pile penetration at the specified blow count will also decrease. A hint of this impending problem can be a darkening of the hammer exhaust gases, with even flame sometimes flashing at the exhaust ports. The sound of the blow will sometimes become duller, losing the sharp crack common with a properly running hammer. The hammer should be stopped and allowed to cool before proceeding with further driving operations. A restrike test with a cold hammer can be used to detect preignition. It will be indicated if the blow count is less than with a hot hammer.

Hammer Trouble Shooting

1. Sluggish hammer operation and shorter strokes can result from inadequate piston lubrication, low grade fuel, and worm parts (check manufacturer's recommendations). Note: Worn compression rings can be diagnosed at hammer test by aborting the fuel flow and tripping the piston to fall onto a dry anvil block. Proper compression will be noted by the piston's rapidly decaying bounce on the entrapped compressed air (see manufacturer's recommendations for minimum decay time).

2. Erratic hammer operation and variable stroking can result from foreign material or water in the fuel lines, fuel filter or pump (check manufacturer's recommendations), plugged or closed fuel tank breather, and in the case of fuel injection hammers, fouled fuel injectors.

3. A decrease in the average and maximum strokes over the day for a water-cooled diesel hammer may be the result of the boiling off of the water in the water jacket (check for cooling water in water jacket).

4. Increase in blow count for a typical driving record during the day could be an indication of preignition.

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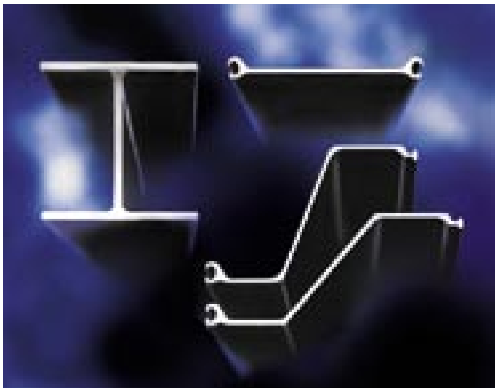

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Section Designation	AREA		WIDTH		HEIGHT		WEIGHT (MASS) PER SINGLE		WEIGHT (MASS) PER WALL		MOMENT OF INERTIA		SECTION MODULUS Per Single		SECTION MODULUS Per Wall		SURFACE AREA Total Area		SURFACE AREA Nominal Area*	
	in^2	cm^2	in	mm	in	mm	lb/ft	kg/m^2	lb/ft^2	kg/m^2	in^4	cm^4	in^3	cm^3	in^3/ft	cm^3/m	ft^2/ft	m^2/m	ft^2/n	m^2/m
PZ22	11.9	76.6	22.0	559	9.0	228.6	40.3	60.1	22.0	107	151	6301	32.5	532	17.7	952	4.92	1.50	4.48	1.37
PZ27	12.1	78.2	18.0	457	12.0	304.8	40.5	61.3	27.5	134	282	11734	45.3	742	30.2	1622	4.93	1.50	4.48	1.37
PS27.5	13.4	86.6	19.7	500	—	—	45.1	67.9	27.8	136	5.02	209	3.19	52.2	1.94	104	4.58	1.40	3.88	1.18
PS31	15.2	98.2	19.7	500	—	—	50.9	77.0	31.5	154	5.51	229	3.35	55.0	2.04	110	4.58	1.40	3.87	1.18

*Note: Nominal coating area excludes socket interior and ball of interlock.

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The Pile Driver's Legal Corner

The Law on Defective Specifications and its Relevance to Driven Pile Projects

By Mark J. Rice, Esq. – Attorney to Pile Driving Companies

What is the proper course when the owner's design does not work?

Some old case law can help answer this tempest. All pile driving contractors face at least once in a lifetime, an owner's specifications that will not work due to defective design, or erroneous soils information relied on and used to bid from by contractor and owner's engineer. This can result in contentiousness, claims, threats of termination, and the like. How is it best for pile driving contractors to deal with such design impossibility risks, early and effectively? Here are some case studies, and some practical tips.

The Key Case Studies that Frame this Area of Construction Law

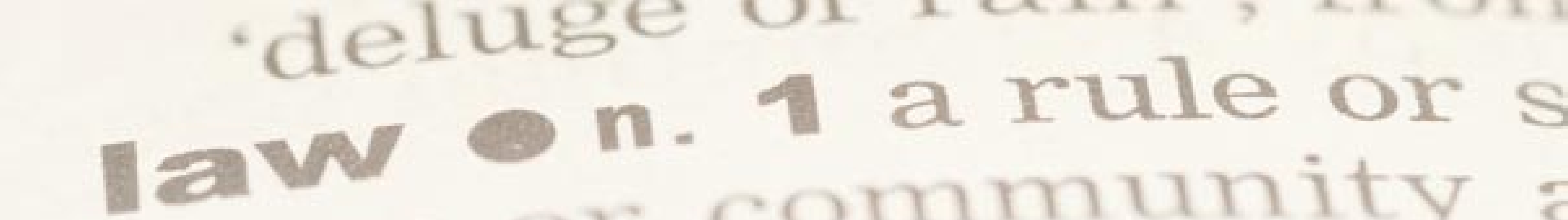
While there are not that many "impossibility" cases in published court decisions, a fair number of those cases involve underground construction and differing soil conditions. This is perhaps why pile drivers "bet the company" when they bid. Here are seven cases that all pile drivers should consider having in their back pocket when going "toe to toe" with an owner or A/E over whether performance conditions are not as promised.

The Spearin Case and Spearin Doctrine

The famous construction law case that coined the *Spearin Doctrine*[1], involved specifications that failed to take into account underground sewer works that overflowed, preventing completion of a dry dock contracted by the Navy. That case is famous for first articulating directly the bidding concept of the owner's "implied warranty of accuracy and completeness of plans and specifications." That implied warranty is the touchstone for most differing site condition and defective specification claims. As stated in *Spearin,*

"…if the contractor is bound to build according to plans and specifications prepared by the owner, the contractor will not be responsible for the consequences of defects in the plans and specifications."

The *Spearin doctrine* is generally considered a "claim" or extra compensation case, but in fact, it was the first clearly articulated "design impossibility" case. In *Spearin*, after 15 months of unsuccessful effort, the contractor walked off the project and the Navy sued for the cost of completing performance by other means. Spearin was the defendant, and convinced the U.S. Supreme Court that Spearin was



excused from further performance by the undisclosed defects in the plans, making them unbuildable.

Christie v. U.S.

The Supreme Court relied on an earlier sheet piling case, *Christie v. U.S.*[2], where the dam contractor on the Warrior River in Alabama was awarded extra costs for more difficult pile driving, when the soil conditions changed from those indicated in the borings (the Resident engineer was told of sunken logs encountered during the drilling of the borings, and said they did not need to be referenced in the logs, and later were struck during piling). The *Christie* case introduced the concept that a "positive representation" in soil borings could be the basis of an additional compensation claim, where actual conditions encountered were materially different and caused increased costs:

"It makes no difference to the legal aspects of the case that the omissions from the records of the results of the borings did not have sinister purpose. There were representations made which were relied upon by claimants, and properly relied upon by them, as they were positive."

It makes sense to tie the "old law" into today's new projects and driven piling near infrastructures. That old law, simply stated, puts the onus on the owner to submit accurate data and buildable plans. Many states, such as California, actually adopt this law by statute as a public policy, so design risks are owner risks (except in design build projects). See Public Contract Code section 1104:

"No local public entity, charter city, or charter county shall require a bidder to assume responsibility for the completeness and accuracy of architectural or engineering plans and specifications on public works projects, except on clearly designated design build projects. Nothing in this section shall be construed to prohibit a local public entity, charter city, or charter county from requiring a bidder to review architectural or engineering plans and specifications prior to submission of a bid, and report any errors and omissions noted by the contractor to the architect or owner. The review by the contractor shall be confined to the contractor's capacity as a contractor, and not as a licensed design professional."

Paul N. Howard Co.

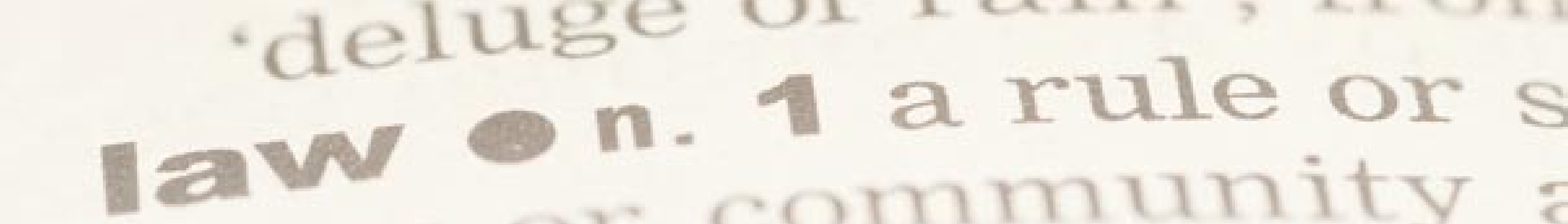
A more recent sheet pile case, *Paul N. Howard Co. v. Puerto Rico Aqueduct Sewer Authority*[3] held the contractor was excused when the sheet piling failed due to a differing site condition causing soil instability. This case used the insistence of the owner on exact performance as a basis for finding legal impossibility:

"The district court found that the instability of the highway embankment constituted a differing site condition justifying rescission of that part of the contract that required Howard to lay the pipeline along the highway embankment and rejected PRASA's contention that it was the design of Howard's sheet pile system that was responsible for Howard's difficulties. In coming to this conclusion the district court relied on expert testimony that the tendency of the highway embankment to slide was unusual and unpredictable, and that only by changing the course of the pipeline or leaving the sheet piling in place could lateral displacement of the pipeline be prevented…Under these circumstances we have no hesitation in affirming the district court's conclusion…Finally, we reject PRASA's contention that the district court improperly based its finding of impossibility on an "insignificant defect" – the 7" lateral deviation in the pipeline. Inasmuch as PRASA refused to accept the pipeline with that deviation, and inasmuch PRASA ordered Howard not to proceed unless it could prevent the embankment from sliding, we think the district court was justified in concluding that it was IMPOSSIBLE to lay the pipeline within the tolerances deemed acceptable to PRASA. Id, at *884*."

Blount Brothers v. U.S.

In *Blount Brothers Corp. v. U.S.* (Fed. Cir. 1989) 872 F2d 1003, at 1007 the Contractor was relieved of its obligation to meet the specifications for brown and tan aggregates by proving that no such aggregate gravel could be found after a reasonable search.

"Specifications having major safety defects are fully as much in breach of the implied warranty as defects in the feasibility, practicability, or commercial possibility of performance as specified...



We hold, therefore, that Blount Bros. has carried its burden of establishing legal impossibility by proving that the contract specifications as written were defective."

Hol-gar Mfg.

Impossibility can also be proven when the government yields or relaxes its specifications in response to legitimate claims of extremely difficulty in achieving compliance with specifications. See also *Hol-Gar Mfg. Corp. v. U.S.* (1966) 360 F2d 634, at 638, 175 Cl.Ct. at p. 524:

"That changes in the specifications were required is clear from the fact that after numerous negotiation sessions, during which time the plaintiff was attempting unsuccessfully to comply with the specifications, they were changed by the execution of Supplemental Agreement No. 8."

Foster Wheeler

Foster Wheeler Corp. v. U.S. (Cl. Ct. 1975) 513 F2d 588, at 594, citing the definition of Impossibility in Restatement of the Law, Contracts, section 454:

"Impossibility means not only impossibility but impracticability because of extreme and unreasonable difficulty, expense, injury, or loss."

In Foster, the specifications required "shock hard" boilers. In accepting the contractor's claim of design impossibility, the court found it compelling that the government accepted the contractor's design build design despite its non-compliance with the "shock hard" specification:

"The Government ultimately accepted plaintiff's boiler design; although it knew the boiler was not shock-hard... There can be no dispute that the Government retreated from its requirement that the AGC-19 boilers be shock-hard. In its letter of January 11, 1967, FWC described several areas which were overstressed and proposed modifications of design which, in some cases, admittedly violated accessibility and maintenance specifications, but which were considered necessary to satisfy shock specifications."

Most state court's jurisprudence in this area cites *Spearin* and *Foster* as the foundation of their "differing site condition" law. Also, the Federal Acquisition Regulations contain a specific "checklist" to determine if a Differing Site Condition is encountered. That checklist should be used as the outline for a claim or constructability analysis for your engineering team and experts.

OK – What to do on the job when the Specifications do not work or appear unsafe?

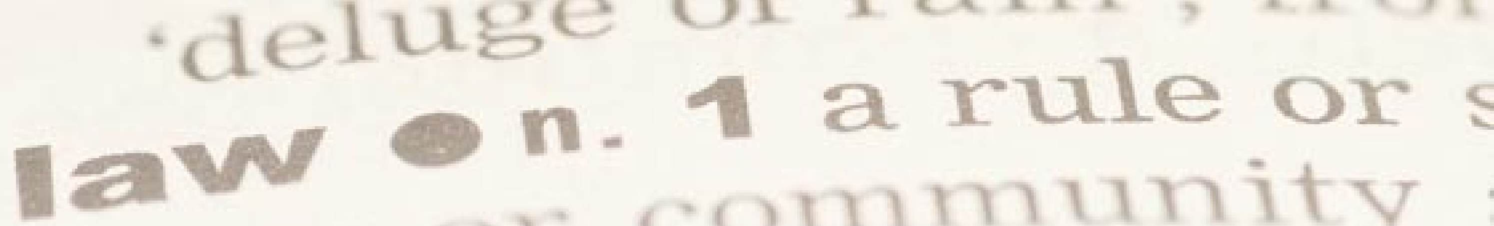
Some owners will partner quickly and treat a design impossibility issue as a constructability problem to be solved jointly. Others may be included to quote contract and subcontract boilerplate that they believe shifts the risk of the situation elsewhere, and leave the contractor little choice but to confront the situation with a potential claim posture. How to win over the owner, so the owner does not "shoot the messenger:"

Some Suggestions:

1. Bring in a soils engineer of your own to perform additional borings on site during production.

2. Consider using a "WEAP" analysis to test your means and methods (hammer size, pile size, length, soil etc.) against represented versus actual conditions.

3. Test and verify the soil strengths and structural calculations in the soils report – it has happened that math was wrong, or the



report writer misinterpreted a formula, leading to a factor of safety contrary to owner intent.

4. Secure the actual field drilling logs. Were there any slant drillings that were extrapolated? Any abandoned borings not disclosed? Interesting stuff found in this grab bag.

5. Use software modeling to show that your bid was reasonable and the inputs – soils – changed.

6. Take the initiative with the owner – ask for a meeting to exchange engineering views. Submit an expert's report early.

7. When the project has safety or damage risks, consider a shut down carefully. Seek owner indication in the pre-job conference that the owner will respect legitimate safety driven suspensions when related to the project design and will not claim delay. Ask, even if they say no.

8. Train field superintendents and foreman to keep good daily production records per pile, annotated factually, that can serve to measure true impact and save later claim costs.

Conclusion

Pile Driving is a challenging and innovative field, and has been for more than 100 years. It has been the "darling" of the U.S. Supreme Court, who rightly recognized by l915, that design risks belonged to the owner, and construction efficiency and cost would be better absorbed by paying for extra work, and recognizing impossibility when it exists. For the pile driver, this lesson remains a challenge on each new project. The concepts of these cases should help support the pile driver's cause, for a fair shake, when it follows the plans and the plans do not work.

Mark J. Rice is a California attorney who represents pile driving contractors, and is a member of the California ACG Legal Advisory Committee. Mr. Rice litigates differing site condition claims, defective specification claims, and property damage claims. ▼

References

US v. Spearin, 248 US 32, 39 S.Ct. 59 (1918)

2Christie v. US, 237 US 234, 35 US 565 (l915)

3 744 F. 880 (1984 1st Cir.)

PDCA New Member List

We would like to welcome the following new members. Please visit the PDCA website at www.piledrivers.org and click on Member Search for complete contact information on all members.

NEW CONTRACTOR MEMBERS

Ahrens Piledriving
Cheyenne, Wyoming
Contact: Mark Ahrens
Services provided: bulkheads, deep excavation, marine, pile driving

Clark Foundations, Inc.
Bethesda, Maryland
Contact: Mahmoud Hosseini
Services provided: pile driving

Foundation Materials
New Orleans, Louisiana
Contact: Paul Tassin
Services provided: pile driving, general contractor

Franks Casing Crew and Rental
Lafayette, Louisiana
Contact: Donnie Crain
Services provided: marine, pile driving, off-shore, pipe sales, equipment sales & rental

Herlihy Mid-Continent Co.
Romeoville, Illinois
Contact: Arthur Haggerty
Services provided: bridge building, docks & wharves, earth retention, general, highway & heavy civil, marine, pile driving

Kuhn Construction
Hokessin, Delware
Contact: M. Lawrence Kuhn
Services provided: docks & wharves, marine, pile driving

McDowell NW Piling, Inc.
Kent, Washington
Contact: Michael McDowell
Services provided: pile driving contractor, earth retention, general contracting

R.L Morrison and Sons
McClellanville, South Carolina
Contact: Michael Morrison
Services provided: pile driving

Saddlebrook Construction
Pickens, South Carolina
Contact: Don White
Services provided: pile driving contractor, bridge building, earth retention, general contracting, highway & heavy civil

Sea & Shore Contracting
Boston, Massachusets
Contact: Michael Lally
Services provided: bulkheads, deep dynamic compaction, deep excavation, docks & wharves, earth retention, general contracting, marine, pile driving

Signor Enterprises
Austin, Texas
Contact: Rusty Signor
Services provided: pile driving

Sun Marine Maintenance
Frankford, Delaware
Contact: Michael R. Jahnigen
Services provided: pile driving contractor, bulkheads, docks & wharves, marine

Waterfront Marine Construction
Virginia Beach, Virginia
Contact: Ken Sutton
Services provided: bridge building, bulkheads, general contracting, highway & heavy civil, marine, pile driving

Weeks Marine, Inc.
Cranford, New Jersey
Contact: Gary A. Platt
Services provided: pile driving

WH Engineering
Grand Junction, Colorado
Contact: Sandy Heley
Services provided: bridge building, earth retention, highway & heavy civil, pile driving

NEW ASSOCIATE MEMBERS

AB Chance / Hubbell Power Systems
Centralia, Missouri
Contact: Rich Zinser
Services provided: composite piles, helical steel piers, steel pipe piles, drill equipment, drive caps & inserts, leads & spotters, marine equipment

CDS Manufacturing
Quincy, Florida
Contact: Clayton Sembler
Services provided: concrete piles, trucking services

Instantel
Ottowa, Ontario
Contact: Rob Lee
Services provided: instrumentation for vibration monitoring

Kobelco Cranes
Houston, Texas
Contact: Jack Fendrick
Services provided: cranes

PilePro
New York, New York
Contact: Rob Wendt
Services provided: sheet piling accessories

Standard Concrete Products
Charleston, South Carolina
Contact: TBA
Services provided: concrete piles

TA Services, Inc.
Mansfield, Texas
Contact: Lilli Schaefer
Services provided: trucking

NEW TECHNICAL MEMBERS

Buster Blalock
Wahoo Enterprises
Folly Beach, South Carolina
Services provided: trucking

John Collins
Collins Company
Camans ISC, Washington
Services provided: pile driving equipment

Shawn "Tiny" J. Etier
GS2 Engineering & Environmental Consultants, Inc.
Charleston, South Carolina
Services provided: geotechnical engineering, pile driving monitoring, vibration monitoring.

PDCA New Member List

Robert Hollingsworth
Charleston, South Carolina
Services provided: dynamic pile testing, geotechnical engineering

Steve Kiser
MACTEC Engineering & Consulting, Inc.
Charlotte, North Carolina
Services provided: analysis, civil & design, geotechnical, materials testing, pile driving monitoring, vibration monitoring.

Ronald Lejman
GMU Geotechnical
Rancho Santa Margarita, California
Services provided: consulting, geotechnical, materials testing, vibration monitoring

Jim McNance
Carpenters Training Union
Pleasanton, California
Services provided: pile driving training

Randy Wirt
MACTEC Engineering & Consulting, Inc.
Richmond, Virginia
Services provided: geotechnical

PDCA Calendar of Events

September 15-16, 2005

Design of Cost-Efficient Driven Piles Conference
Sheraton Framingham Hotel
Boston, Massachusetts

March 2-4, 2006

10th Anniversary Winter Roundtable Conference
Hilton Palacio Del Rio Hotel
San Antonio, Texas

Other Industry Events

September 22-24, 2005

DFI 30th Annual Conference on Deep Foundations and Members Meeting
Fairmont Hotel
Chicago, Illinois

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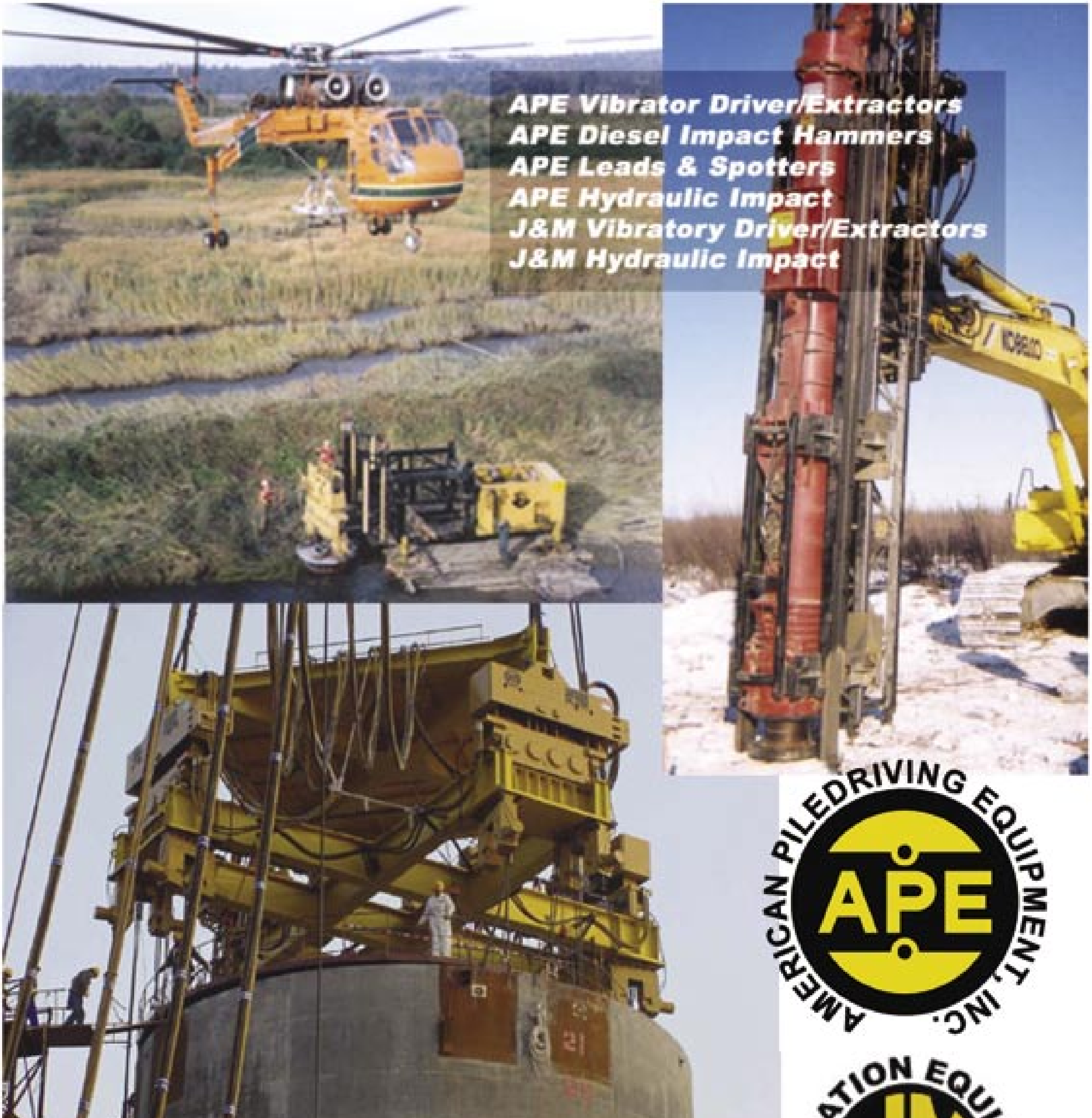
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