

**How to Estimate the Cost of a Rammed Aggregate Pier Foundation System**

**CPE Candidate No. 0110004**

**December 2010**

Section 1: Introduction

- A. Main CSI Division
- B. CSI Subdivision
- C. Brief Description of Subject Matter
- D. Typical Process

Section 2: Types and Methods of Measurements

- A. Units of Measure

Section 3: Project Specific Factors to Consider

- A. Effect of Large Quantities vs. Small Quantities
- B. Impact of Soil Conditions
- C. Availability of Materials
- D. Seasonal Effect on Production

Section 4: Overview of Labor, Material, Equipment, and Indirect Cost

- A. Overview of Labor
- B. Overview of Materials
- C. Overview of Indirect Costs

Section 5: Special Risk Considerations

Section 6: Ratio and Analysis

Section 7: Other Pertinent Information

Section 8: Sample Plan View and Typical Details

Section 9: Sample Estimate

Section 10: Copy of Approval Letter from ASPE Certification Board

Section 11: References

## **Section 1: Introduction**

Due to the continued construction of new buildings and associated global infrastructure, the need to develop sites containing poor soil conditions is ever increasing. For decades two main types of ground improvement methods were utilized to overcome poor soil conditions. These methods included (1) deep foundations and (2) overexcavating / replacement of unsuitable soils.

Frustrated by the limitations and costs associated with the aforementioned methods, a group of geotechnical engineers developed a more practical method for soil reinforcement known as the aggregate pier. The purpose of this paper is to illustrate to a construction estimator how to estimate the costs associated with an aggregate pier foundation system.

### **A. Main CSI (Construction Specifications Institute 2010 Master Format) Division**

Division 31 66 00 Special Foundations

### **B. Main CSI (Construction Specifications Institute 2010 Master Format) Subdivision**

Subdivision 31 66 13.13 Rammed Aggregate Piles

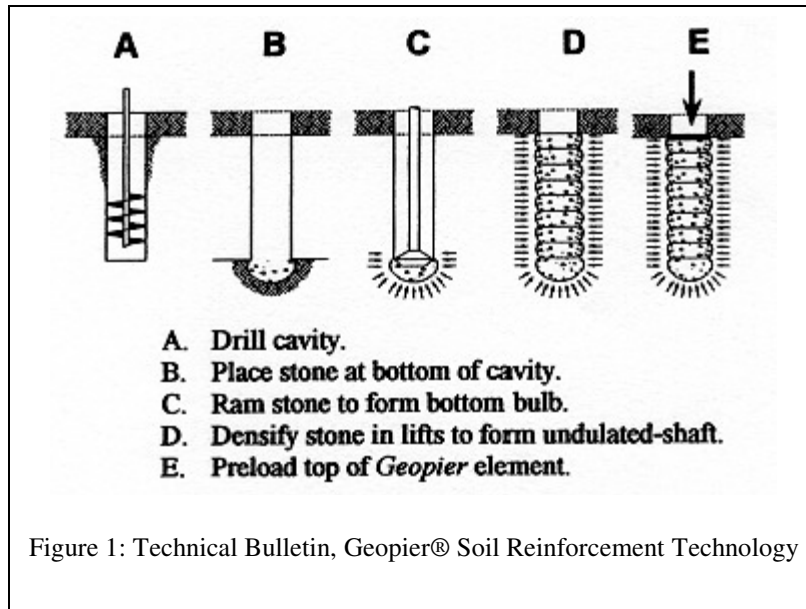
### **C. Brief Description**

In the past, sites comprised of soils which contain inadequate bearing capacities for new structures are typically remediated with deep foundations such as drilled piers or cast piles. The purpose of these deep foundation systems is to transfer the structural load from the unsuitable soils to the competent soils to reduce potential settling, as well as providing adequate bearing capacity for the footings. These types of deep foundation systems can be costly to install. Consequently, constructing buildings that require deep foundation systems can become cost prohibitive when the foundation system is disproportionate to the cost of the entire structure. For this reason, aggregate pier systems were developed as an economical alternative to the traditional ground improvement methods.

Aggregate pier systems effectively control settlement of structures by reinforcing the existing soils below the structure, and thus improving the bearing capacities and allowable bearing pressures necessary for typical shallow footing design practices. Essentially, by using a rammed aggregate pier system to increase the existing soils' bearing capacity the structural engineer can design a shallow footing system that would typically be used for a site with preferred soil conditions.

#### **D. Typical Process**

Aggregate pier systems are fairly simple in nature to install. They are installed by drilling 24- or 30-inch diameter holes and compacting lifts of clean aggregate within the holes to form a dense aggregate pier. Typically these pier holes extend vertically from 7 to 20 feet below the bottom of footing elevations; however, field conditions will determine the final depth of the aggregate pier due to the fact that they are unique to each specific soil condition. Each lift of clean aggregate is brought up in lifts of approximately 12 inches in thickness. Temporary casings may be used when the soils are not stable. Compacting takes place after each lift with a beveled tamper that densifies the aggregate vertically while also forcing the aggregate laterally into the sidewalls of the pier. The combination of this vertical and lateral compaction process stiffens and stabilizes the entire surrounding soil mass. The result of stiffening the soils is increasing the soils' bearing capacity allowing for a more economical footing design.



## **Section 2: Types and Methods of Measurements**

### **A. Units of Measure**

Several types of measurements are used when estimating an aggregate pier system. The units of measure that will be used include linear feet (LF), cubic yard (CY), tons (T), and hours (HR).

Each individual process involved in the installation of an aggregate pier element is measured utilizing a specific unit of measure. For example, the drilling of the pier hole is commonly measured in linear feet. However, the removal of the spoils generated by the pier drilling process is measured in cubic yards.

## **Section 3: Project Specific Factors to Consider**

### **A. Small versus Large Quantities**

As is consistent with the estimating of most construction processes, small versus large quantities can greatly affect unit costs. The relationship between cost and quantity is typically referred to

as economy of scale. Economy of scale is a well-known concept that refers to reductions in unit costs as the level of production increases. One of the reasons that this economy of scale principle is applicable to most construction processes is because the fixed costs are shared over an increased number of outputs. This is particularly true when estimating an aggregate pier foundation system. Mobilization of specialized heavy equipment is a fixed cost that does not have a direct relationship to the number of aggregate piers that will be completed for each project. Therefore, as expected, the greater number of aggregate piers a specific project contains, a lower cost per aggregate pier can typically be expected.

#### **B. The Impact of Soil Conditions**

Aggregate piers are most commonly introduced into a construction project by the recommendation of the geotechnical engineer. Upon completion of the soil borings and after consultations between the geotechnical and structural engineers, a direction for which ground improvement method is decided upon. It is important that the estimator thoroughly read and understand the contents of the soils report.

In recent years, aggregate piers have grown to become the most commonly used ground improvement method in the United States. Due to the fact that aggregate piers are considered a shallow foundation system, typically only the upper zone of the soils report is taken into consideration for both design and estimating purposes. Casing of piers and dewatering are the two leading factors to consider when evaluating a soils report. One example of this consideration is the use of aggregate piers in areas like Tampa, Florida. This region has primarily sandy soils coupled with a shallow water table. This type of soil condition will have a direct

impact on cost because of the likely need to case the aggregate piers. Due to the unpredictability of subsurface conditions, casing and dewatering are typically estimated as unit prices and are commonly excluded from the aggregate pier contractors' base bid. The unit prices established for casing and dewatering are only applied if these conditions are encountered.

### **C. Availability of Materials**

Clean, well-graded aggregate conforming to specific ASTM standards is the predominate material that is procured for an aggregate pier project. A Class-7 aggregate base is preferred in most regions of the country. In some instances where groundwater is encountered, No. 57 stone is sometimes used. The availability of this material will directly impact the overall system's cost and should be a major consideration when compiling an estimate.

### **D. Seasonal Effect on Production**

Weather and climate will have a direct impact on the process of installing aggregate piers. Productivity often decreases if the weather conditions are harsh or the temperature is at one extreme or the other. During the aggregate compaction process moisture contents must be maintained within a specified range. This is often referred to as the optimum moisture content. During wet weather seasons special care must be given to prevent the saturation of aggregate materials which could result in moisture contents that do not meet the specified requirements. It is important for the estimator to be aware of seasonal weather patterns for the specific region in order to understand this potential impact.

## **Section 4: Overview of Labor, Material, Equipment, and Indirect Cost**

## **A. Overview of Labor**

The labor required for the installation of aggregate piers is directly related to the number of pieces of equipment required. Based upon the equipment needed for this process, four operators will be required for the duration of the aggregate pier installation. For this example the cost of the four operators will be estimated on an hourly basis.

Labor rates are generally determined by individual companies or established through union organizations. Estimators should also be aware of and understand prevailing wage rates and be familiar with these requirements. It is common for projects funded with state or federal funding to have prevailing wage rates. The estimated labor should also include the costs associated with taxes, insurance, and fringe benefits.

Labor estimates for aggregate piers are typically established in one of two ways. Method (1) is accomplished by applying labor as a unit cost for a specific task. These unit costs are generally established through the use of the company's cost history records and is based upon previous job experiences. A simple example of this method is as follows:

*“Based upon job experience, labor will cost \$300 to install one aggregate pier; therefore, the total labor cost to install 100 aggregate piers can be estimated at \$30,000.”*

Due to constant changes in personnel and outside factors, it is imperative that an estimator have access to detailed records and up-to-date unit costs if this method is to be utilized for estimating



labor. In addition, project specific factors must be considered and applied to the historical unit labor costs.

Method (2) consists of estimating overall crew hours. This involves utilizing the known cost of a specific group of employees required to complete the task, and applying them to an estimated duration. A simple example of this method is as follows:

*“A crew of four employees necessary for this project will cost \$150 per hour. A four man crew will take 200 crew hours to install 100 aggregate piers. Therefore the total labor costs for this project can be estimated at \$30,000.”* (\$150 per hour multiplied by 200 hours)

Many seasoned estimators will estimate a project based upon detailed take-off and apply unit costs as described in Method (1). After they have performed this estimating function, the estimator will double check their estimate by employing the simplified use of Method (2).

## **B. Overview of Materials**

Material costs are established by performing quantity surveys which can be utilized to generate a materials list. The estimator should also consider industry standards or known waste factors, and incorporate them accordingly. After the materials list is created unit costs can be applied to each of the items identified during the quantity survey. The most common way to establish material unit costs is through material suppliers. In some instances databases are used to help establish these costs. It is important for the estimator to develop working relationships with the material suppliers and have a firm understanding on how specific items are quoted. In addition to the cost

of the raw materials, the estimator should research the cost associated with shipping or hauling the materials to the project.

When estimating aggregate piers two main materials are quantified. These are one (1), the spoils generated from the drilling process, and two (2), the aggregate required to construct the pier.

When estimating the spoils generated from the drilling process it is important to include the swell factor for this excavated material. A cubic yard of earth measured in its natural position (bank measure) will be more dense and compacted than a cubic yard of dirt that has been disturbed (loose measure). When earth is excavated it increases in volume because of an increase in voids. The change in volume of earth from its natural to loose state is known as swell. Swell factors are directly related to the specific type of material encountered. Below is a table which lists the swell factors for different bulk materials typically used in earthwork and foundation construction.

Typical Swell and Load Factors for Materials		
<u>Material</u>	<u>Swell %</u>	<u>Load Factors</u>
Clay	40	0.72 or 28%
Clay & Gravel	40	0.72 or 28%
SB2	40	0.85 or 15%
Coal	35	0.74 or 26%
Earth, Loam	25	0.80 or 20%
Gravel	12	0.89 or 11%
Gypsum	74	0.57 or 43%
Hardpan	50	0.67 or 33%
Limestone	67	0.60 or 40%
Sand	12	0.89 or 11%
Sandstone	54	0.65 or 35%
Shale	65	0.60 or 40%
Slate	65	0.60 or 40%

Figure 2: Standard Handbook for Civil Engineers

For the purpose of this estimate we will assume that we will be encountering clay, which has a swell factor of 40%, through the majority of our drilled operations. Therefore, to quantify the amount of spoils that will be required to be removed from one pier hole that is 24 inches in diameter and 10 feet in depth, the following equation will be used:

$$1' \text{ (radius of pier)} \times 3.14 \text{ (pi)} \times 10' \text{ (depth of pier)} \times 40\% \text{ (swell factor)} / 27 \text{ (cubic feet to cubic yards)} = 1.63\text{CY of spoils removal}$$

When estimating the aggregate required for installation of a pier, the same principles of volume can apply. However, instead of using a swell factor, the estimator must use a compaction or load factor. Through the process of ramming and tamping the aggregate in the pier cavity the aggregate becomes denser and more compact. Refer to *Figure 2* which lists the common compaction factors for different bulk materials typically used in earthwork and foundation construction. For the purpose of this estimate we will be using SB-2 aggregate for the installation of the aggregate piers. Therefore to quantify the amount of SB-2 required for one pier that is 24 inches in diameter and 10 feet in depth, the following equation will be used:

$$1' \text{ (radius of pier)} \times 3.14 \text{ (pi)} \times 10' \text{ (depth of pier)} \times 15\% \text{ (compaction factor)} / 27 \text{ (cubic feet to cubic yards)} = 1.34 \text{ CY of SB-2}$$

### **C. Overview of Equipment**

A commercial drill rig is used to drill the pier holes. A track-hoe fitted with a specialized tamper/hammer is required for compaction of the aggregate within the pier. A skid steer or

bobcat is used to remove spoils, as well as provide aggregate to the pier. In addition to the equipment stationed onsite a tri-axle dump truck will be used to haul aggregate to the site, as well, as hauling away pier spoils. It is important to identify if the equipment utilized will be rented or come from the company-owned fleet. In addition to the raw cost of the rented equipment, fuel and maintenance costs should be considered.

#### **D. Overview of Indirect Costs**

In addition to the direct costs to the project, indirect costs must be accounted for when preparing an estimate. Indirect costs can consist of but are not limited to office supervision, mobilizations, insurance, bonds, small tools, safety materials, temporary utilities, etc. These costs can be applied to the estimate in a lump sum or based upon percentages.

#### **Section 5: Special Risk Considerations**

The primary risk associated with the installation of aggregate piers is the subsurface soil conditions. It is important for an estimator to help mitigate the risks associated with poor soil conditions by utilizing a thorough scope of work letter. A strongly written proposal letter and scope of work attachment will let the prime contractor, developer, or engineers know the potential obstacles that could be encountered based upon your previous experiences. Unit prices established in an estimator's proposal letter will also allow the aforementioned members of the construction team to account for potential costs. It is also advisable, when possible, for the estimator to familiarize him or herself with the existing site conditions before completing their estimate. This will allow the estimator to take into account special conditions that may need to be included in the estimate. For example, sometimes it is necessary to build temporary roads in

order for an aggregate pier contractor to mobilize heavy equipment. Underground utilities will also need to be accounted for before drilling operations commence. Putting forth the effort to identify these items during the estimating process helps avoid costly delays due to insufficient planning.

### **Section 6: Ratio and Analysis**

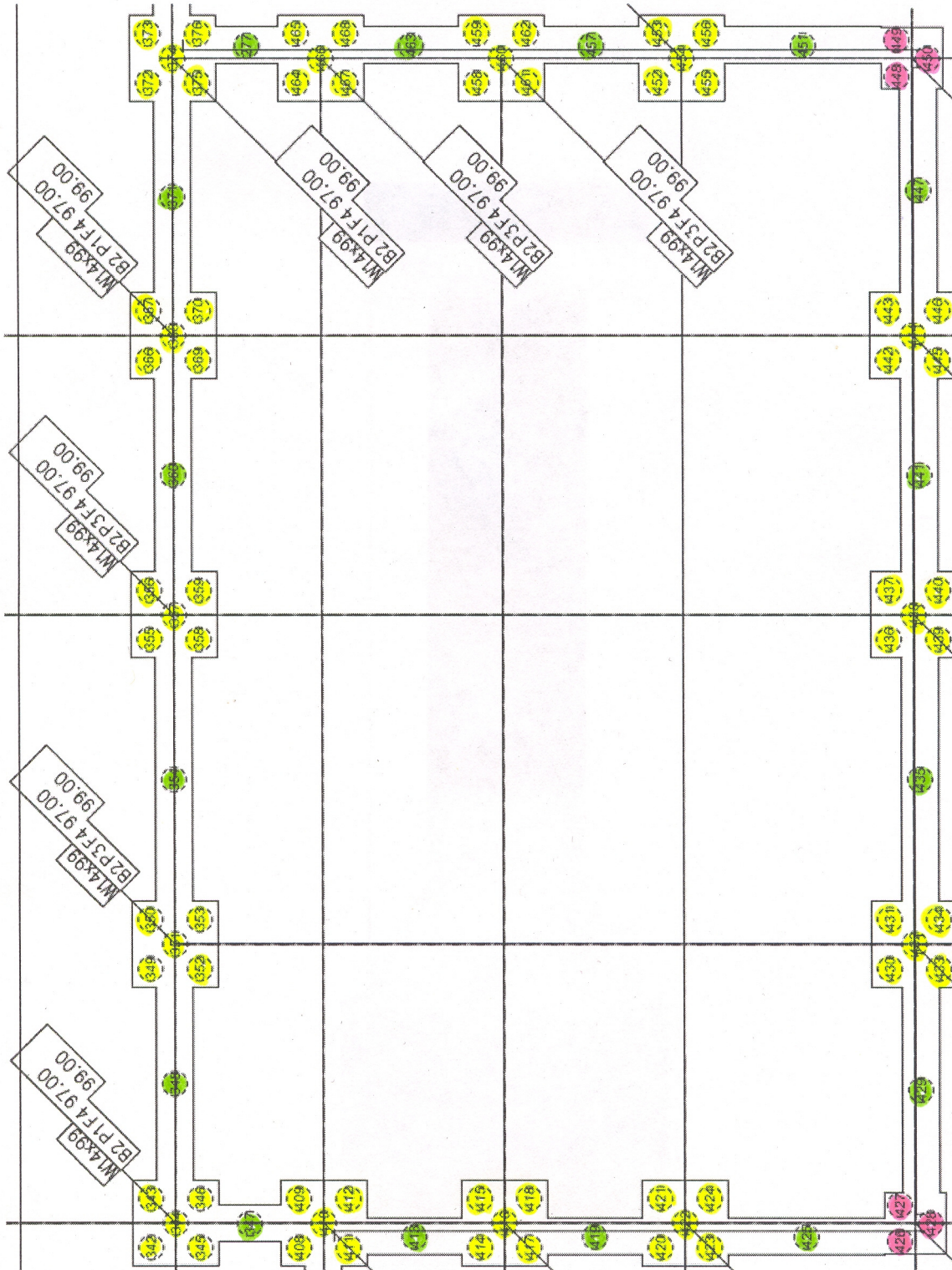
Once a detailed estimate has been completed, it is important to have a coworker double check the estimate. This process of having a coworker look through the quantity take-off and summarization sheets can oftentimes identify deficiencies in the estimate or items that may need to be adjusted. Another method that is often utilized is comparing the current estimate to previous job cost reports to make sure labor, material, and equipment costs are in line with previous projects. A company's ability to effectively track job cost and in turn utilize this information for preparing future estimates tends to be far more precise with their preparation of estimates.

### **Section 7: Miscellaneous Pertinent Information**

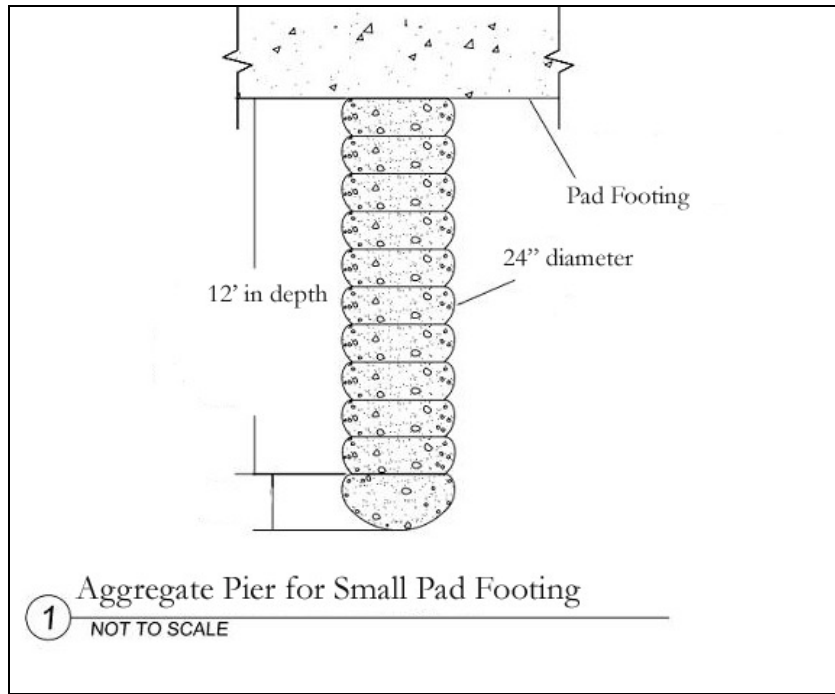
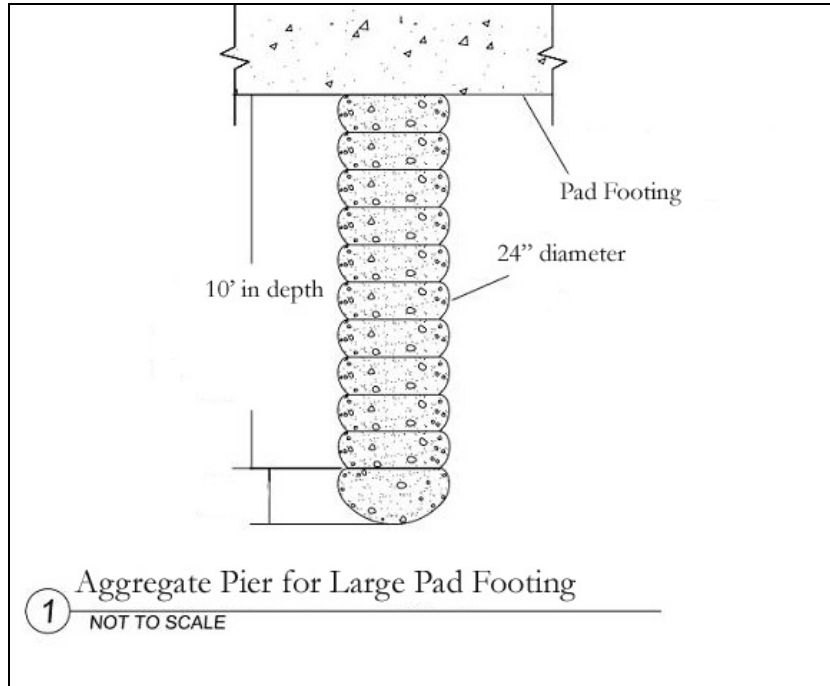
The estimator should identify the responsibilities associated with testing and verification for the installation of the aggregate pier system. Oftentimes the project specifications require a full-time, onsite geotechnical testing firm to oversee the installation of this type of foundation system. The costs associated with this testing process are typically the burden of the owner or prime contractor. Should the contract documents require the aggregate pier installer to pay for this testing the estimator will need to contact a geotechnical testing firm to obtain pricing. A

thorough scope of work attached to the estimator's proposal letter will help identify who is responsible for the testing and verification for this specific task.

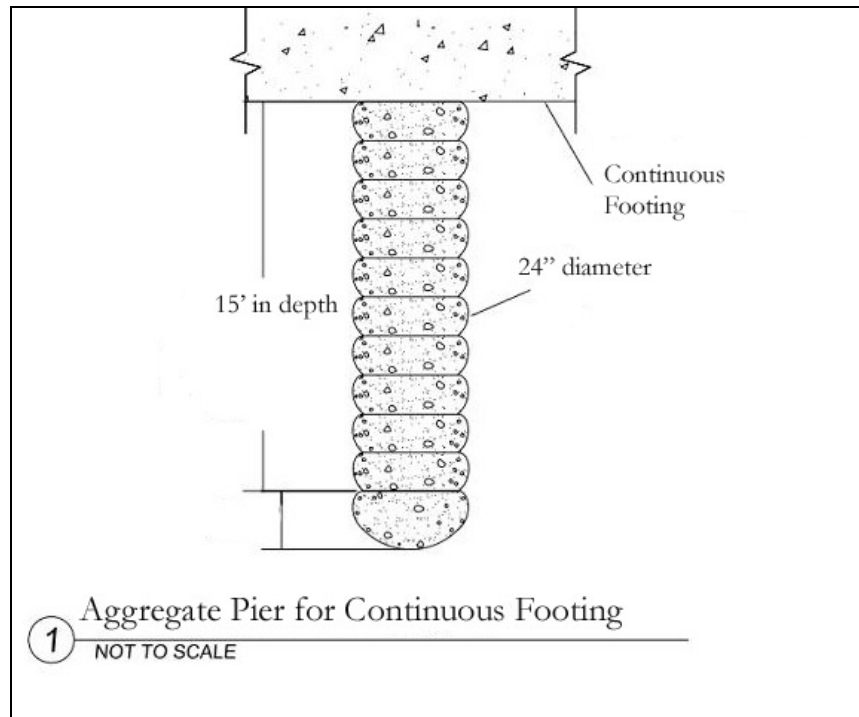
**Section 8: Sample Plan View and Typical Details**



*Figure 3: Sample Aggregate Pier Layout*







*Figure 4: Aggregate Pier Details*

### **Section 9: Sample Estimate**

On *Figure 3* we see a typical aggregate pier foundation system layout. You will notice that there are three different aggregate pier designations:

- Large Pad Footing, group of five piers (yellow)
- Small Pad Footing, group of three piers (pink)
- Continuous Footing, single pier (green)

The quantity survey is demonstrated as follows:

Aggregate Pier Quantity Survey for Figure 3				
Pier Location	Designation	Number of Groupings	Number of Piers in Group	Total Number of Piers
Large Footing	Yellow	14	5	70
Small Footing	Pink	2	3	6
Continuous Footing	Green	16	1	16
			<b>Total # of Piers =</b>	<b>92</b>

After performing the basic pier quantity survey, the units can be applied to the materials.

Aggregate Pier Spoils Removal Costs for Figure 3						
Pier Location	Total Number of Piers	Radius of Pier (FT)	Length of Pier (LF)	Pi	Swell Factor for Clay	Total Spoils (rounded)
Large Footing	70	1	10	3.14	40%	114
Small Footing	6	1	12	3.14	40%	12
Continuous Footing	16	1	15	3.14	40%	39
				<b>Total Spoils =</b>		<b>165 CY</b>

Aggregate Pier Aggregate (SB2) Costs for Figure 3						
Pier Location	Total Number of Piers	Radius of Pier (FT)	Length of Pier (LF)	Pi	Load Factor for SB2	Total SB2 (rounded)
Large Footing	70	1	10	3.14	15%	94
Small Footing	6	1	12	3.14	15%	10
Continuous Footing	16	1	15	3.14	15%	32
				<b>Total SB2 =</b>		<b>136 CY</b>

For the purposes of estimating labor and equipment, job cost history will be utilized, which tells the estimator that a crew of four employees can install ten (10) piers during each ten (10) hour working day.

Aggregate Pier Estimate for Figure 3					
Cost Item	Quantity	Unit of Measure	Days	Unit Cost Inc. Burden	Total Cost
<i>Labor</i>					
Operator - Drill Rig	10	HRS	10	\$37.50	\$3,750.00
Operator - Tamper	10	HRS	10	\$37.50	\$3,750.00
Operator - Skid Steer	10	HRS	10	\$35.00	\$3,500.00
Operator - Dump Truck	10	HRS	10	\$25.00	\$2,500.00
<i>Material</i>					
Disposal Fee for Spoils	165	CY	n/a	\$13.00	\$2,145.00
SB2 Aggregate	136	CY	n/a	\$17.50	\$2,380.00
<i>Equipment</i>					
Drill Rig	10	HRS	10	\$115.00	\$11,500.00
Track Hoe w/ Tamper	10	HRS	10	\$125.00	\$12,500.00
Skid Steer	10	HRS	10	\$85.00	\$8,500.00
Dump Truck	10	HRS	10	\$65.00	\$6,500.00
<i>Other Costs</i>					
Mobilization	1	EACH	n/a	n/a	\$2,500.00
Demobilization	1	EACH	n/a	n/a	\$2,500.00
<b>Subtotal</b>					<b>\$62,025.00</b>
10% Overhead					\$6,202.50
2% Bond					\$1,240.50
15% Profit					\$9,303.75
<b>Total Estimate</b>					<b>\$78,771.75</b>

**Section 10: Copy of Approval Letter from ASPE Certification Board**



**American Society of  
Professional Estimators**

**CERTIFICATION**

**Mailing & Administrative Office:**

2525 Perimeter Place Drive, Ste. 103 • Nashville, TN 37214 • 615-316-9200 • Fax 615-316-9800 •

August 10, 2010

Please sign this acceptance form and return to the Society Business Office within 15 days of the date of this letter. If you have any questions, please contact your Chapter Certification Chair or you may contact me at 615-316-9200 or by email - tanya@aspenational.org

Candidate Number: 0110004

Chapter Number: 33

Region: SE

**Summary Certification Cycle/Topic Acceptance Form**

Workshop Completed by: **September 30, 2010** Selected workshop format: **Chapter Level**

Technical Paper Topic: HTETCO a Rammed Aggregate Pier Foundation System

Technical Paper Due Date: **December 15, 2010.**

Late papers are subject to penalty of score as stated in the "Technical Paper" booklet included with this letter

Testing: **Schedule test dates during the month of March, 2011.**

Provide the Society Business Office with proctor information and schedule test dates 15 business days prior to testing.

Certification Discipline: 1.4 General Construction

Contact Email Address:

---

***I agree to the selected topic and will prepare my technical paper according to the format stated for the ASPE Certification Program.***

***I will meet the deadlines for the completion of the workshop, submittal of my technical paper, and testing. If I do not meet these deadlines, I understand that this certification cycle will terminate and I will need to submit a new application.***

***I have read the above information and by signing below agree to meet the requirements of the ASPE Certification Program and adhere to the guidelines of the program.***

**Signature:**

**Date:**

***Please retain a copy of this form for your records. Return this form to the Society Business Office  
Fax: 615-316-9800 or email tanya@aspenational.org***

## **Section 11: References**

- "Settlement of Shallow Foundations Constructed Over Reinforced Soil"; Geopier Technical Bulletin; 2004
- "Geopier Shear Reinforcement for Global Stability"; Geopier Technical Bulletin; 2002
- "Ground Improvement Technical Summaries"; Volume II; 1999
- "Foundation Analysis and Design"; McGraw Hill; 1988
- "Reinforcing Soft Cohesive Soils with Stone Columns"; Ground Engineering; 1974
- "Construction Vibrations"; ASCE Journal of Geotechnical Engineering; 1981
- "Settlement of Structures Supported on Marginal Inadequate Soils Stiffened with Aggregate Piers"; Geotechnical Specialty Publication Volume No. 40; 1994