



Desktop guide to aggregate pier ground improvement



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Whether it's a new building, a storage tank, a retaining wall or some other structure, a stable foundation is at the core of every successful construction project. But most construction sites fail to start on a firm footing. Often, some sort of ground improvement or deep foundation is necessary to get a project out of the ground and moving forward.

In this white paper, we explain the nuances of ground improvement, particularly aggregate piers, and why those nuances should always be primary considerations for any construction project in soft soils.

If you have any questions as you read this guide, please don't hesitate to contact us at 866-421-2460. Ground improvement is something we take seriously, and we want to help you any way we can.



Ground improvement 101

[Ground improvement](#) is typically defined as using mechanical means to improve the ground's ability to support a structure. Although there are several different ground improvement techniques, this white paper focuses primarily on what are referred to as [aggregate piers](#).

Stretching back more than a decade, aggregate piers have become a popular construction technique in the U.S. But they're still a relatively new option to consider. So engineers, contractors and owners often don't have a full understanding of how their project can be designed, bid and built to best use aggregate pier ground improvement.

There are three primary options that geotechnical engineers consider when making recommendations for building on native and fill soils that are soft or loose:

1. Removing the soil and replacing it with engineered fill
2. Using deep foundations, such as [drilled shafts](#), [auger cast piles](#) or [micropiles](#)
3. Using ground improvement, such as aggregate piers, to improve the bearing pressure to support shallow foundations

Ground improvement is often the most economical and efficient of the three options, assuming the soil conditions and structural loads are suited for it.

A deep dive into aggregate pier ground improvement

Before ground improvement methods like aggregate piers became prevalent, shallow foundations could only be used if marginal soils were removed and replaced with engineered fill. If the structural loads were still too high to warrant the use of shallow footings, the only option for the building site was to use deep foundations — a much more costly method. Today, aggregate piers provide a way to construct shallow foundations in marginal soils, which is often more cost-effective than removing and replacing fill or using deep foundations.

Aggregate piers may also be referred to as vibro stone columns, vibropiers® or geopiers®. Rammed Aggregate Piers® are a proprietary system developed by the Geopier® company. They're made up of 20-to-36-inch diameter columns of highly compacted stone, constructed in groups within a footing. The stone replaces or displaces the existing soft soil, resulting in a footing area with both stone columns and existing soils. That combination can produce bearing pressures up to three or four times the bearing pressures of the in situ (previously present on-site) soils. The high modulus columns also help significantly reduce the anticipated settlement of the loaded area.

There are two primary types of aggregate piers: Rammed Aggregate Piers® and vibrated aggregate piers (or vibro stone columns). The primary difference between the two is the way they're constructed. Rammed Aggregate Piers® are constructed by pre-drilling a hole, putting aggregate into lifts, and then tamping or ramming the lifts down into the hole. The process is repeated until the pre-drilled hole is filled with highly compacted aggregate.

Vibrated aggregate piers use large vibratory probes that vibrate at a high frequency to compact granular material. The probes can be inserted in a pre-drilled hole, or using some unique rigs, crowded into the ground to laterally displace the soft soil and create an open column. The stone can then be poured into the hole and compacted in lifts with the vibratory probes. At Subsurface Constructors, we use several such rigs to install stone columns without pre-drilling. As a result, we are able to minimize or even eliminate the generation of spoils. Because this technique eliminates a substantial part of the ground improvement process, vibrated piers that are installed without pre-drilling are often the most cost-effective approach. Of course, in some soil types, it's necessary to pre-drill. This is usually the case with extremely hard soils and some fill soils.

When the stone for aggregate piers is dumped from the ground surface, the process is called “top-feed installation,” especially when referring to vibro installation methods. The top-feed technique is used when the soils are relatively stable, and a pre-drilled or probed hole will stay open during the stone placement and compaction process. But when the existing soils are unstable, such as in silty or granular soils, a bottom-feed installation technique can be used. In this case, the stone is tremied to the bottom of the hole through the compaction device, and the tool is not removed from the hole until the aggregate pier is complete.

Rammed Aggregate Piers® typically require a graded stone to reach maximum compaction, while vibrated piers use clean stone — stone that is all roughly the same size. Both rammed and vibrated piers can provide bearing pressures in the range of 4,000 pounds per square foot (psf) to 6,000 psf or higher, depending on the soil makeup. The main concerns owners have regarding different types of aggregate piers are one, that they provide the structure with the necessary support, and two, choosing the least expensive option.

Feasibility and cost discussion of aggregate piers

Before the development of aggregate piers, if a shallow foundation could not be supported by the in situ soil, builders had to use deep foundations, such as drilled shafts or driven piles. Deep foundations consist of piers or piles made from timber, steel, reinforced concrete or pre-stressed concrete. These piers or piles are often reinforced with rebar and can either be driven into the ground or drilled. Implementing deep foundations is typically more expensive than using aggregate piers or removing and replacing the marginal soils. If it's determined that deep foundation work is necessary for a specific building project, the costs associated with deep foundations can actually prevent that building project from being constructed.

Aggregate piers are often the most economical option for constructing in soft soils because of the materials used (stone is cheaper than concrete), the speed of construction (specialty contractors can often install 40 to 60 aggregate piers per day) and the treatment depth. The average depth of an aggregate pier is in the 15-to-20-foot range. Although most companies have the equipment to treat down to 30 feet, and in some cases much deeper, ground improvement becomes much more expensive at greater depths.

Since starting our ground improvement division in 2005, Subsurface Constructors has also designed and built custom vibro equipment that allows for more flexibility and efficiency in the mobilization and installation processes. By building our own equipment and parts, we are able to increase our capacity to do work in most areas of the country. At Subsurface Constructors, we pride ourselves on being innovators in construction process improvements and the implementation of emerging technologies.

It's important to note that aggregate piers can only sustain a certain load, depending on the soil type. In some cases, such as high-rise buildings and other heavily-loaded structures, deep foundation work may be the only option. Few ground improvement contractors perform both aggregate pier work and deep foundation work. A company with knowledge and experience in the design and construction of both can provide engineering support in the early stages of a project to help determine the most feasible and economical foundation solution.



What geotechnical engineers should know about ground improvement

The geotechnical engineer's recommendation is typically the start of the ground improvement process, and most geotechs have significant experience with different types of ground improvement. The geotechnical engineer's borings logs and report recommendations help identify the best way to support a new structure.

An experienced geotechnical specialty contractor can help the geotechnical engineer determine the most feasible and cost-effective type of ground improvement to use or help geotechs determine if deep foundations are the most cost-effective option. A contractor who designs and installs both ground improvement and deep foundations is best suited for this task.

When the geotechnical report is written, there's often only limited structural information available, such as column loads. As a result, geotechs are often unable to provide specific information regarding the achievable bearing pressures using aggregate piers. Usually, the specialty contractor with the winning bid designs the aggregate piers, not the geotechnical consultant. But geotechs should be able to provide a reasonable range of bearing pressures (i.e. 4,000psf to 6,000psf) that are typical for aggregate piers and state that range in their report. A ground improvement contractor should also weigh in at this point and help determine this bearing pressure range by using available boring information, general column loading and some assumed footing sizes.

When recommending aggregate piers, the specific language in a geotechnical report can greatly impact how a project is specified and bid. Before vibrated pier technology became an economical type of aggregate pier in the U.S., Rammed Aggregate Piers® were by far the most-used option. Geotechnical reports and construction specifications often referred specifically to Rammed

Aggregate Piers® — a proprietary product that only licensed installers can implement. There's typically only one licensed installer per geographical territory, significantly limiting the bid activity for this type of work. When this is the case, owners don't receive nearly the value they should when aggregate piers are the chosen foundation type.

In order to get the best bid on the project, it's important to use the correct language in the geotechnical report and the construction specifications. Using the phrases “aggregate piers” and “vibro stone columns” opens the bidding process up to any company that installs aggregate piers of any kind. While they're both fully suitable for most ground improvement jobs today, there's enough of a difference between the two installation techniques that the language of the specifications can exclude one of the processes from being an acceptable foundation type on a project. To prevent this from happening, many engineers and specifiers have made it commonplace to use the phrase “aggregate piers” in reports. Then, they further define aggregate piers as either a rammed or vibrated pier.

Specialty ground improvement contractors and geotechnical organizations, such as the [Deep Foundations Institute \(DFI\)](#) and the [ASCE Geo-Institute](#), have guidance documents and actual specifications examples you can modify for your project. It's always a good idea to contact more than one specialty contractor when developing your project specifications.

What structural engineers should know about ground improvement

Structural engineers probably play the biggest role in a project that will ultimately require the use of ground improvement, and aggregate piers in particular. A structural engineer must use the geotechnical report to decide which type of foundation to design, understanding that if the structure can be designed with shallow foundations, the overall construction costs will be less than if deep foundations are used. This decision is less straightforward when the soil conditions are poor and structural engineers are trying to optimize footing size given the recommended bearing pressure. In these marginal soils, aggregate piers provide a significantly greater bearing pressure than just the existing soils, allowing the structure to be supported by shallow foundations.

An experienced ground improvement contractor can work with structural engineers to make sure aggregate piers can provide the required bearing pressure for the optimal footing size. In many cases, the ground improvement contractor can also start to put some reasonable cost estimates together based off of the information provided by structural engineers. With specialty expertise, ground improvement contractors can help determine whether ground improvement or deep foundations are the most economical option.

For a structural engineer, it's important to acknowledge consistent and comprehensive specifications for ground improvement as a key part of the construction process. Well-written specifications actually reduce the costs of a construction project. They should be inclusive to every company who should be able to bid on the project, allowing for a wider selection of bids but also assuring that only experienced and reputable specialty contractors are approved to bid the work. Carelessly written specs can exclude qualified specialty contractors from the bidding process, and that can significantly raise the price of the project. In the case of aggregate piers, the design is

often provided by the specialty contractor, introducing even more risk to their work. To ensure you're working with an experienced specialty contractor, select one who has licensed, professional engineers on staff and a long list of completed projects under their belt.

In order to hire the best company for the job, specifications must allow maximum flexibility in potential technologies and explicitly define performance requirements. Discussing the project with the geotechnical engineer, the owner and a specialty ground improvement contractor allows you to identify this terminology before specifications and requirements are finalized and the bidding process begins.

When writing the specifications, it's important to consider the following:

Terminology

Subtle phrases in the text that seem general could represent a proprietary technique. Make sure to consult more than one ground improvement contractor when writing specifications so you can use general terminology and ensure you don't exclude any reputable companies from bidding.

Relationships and responsibilities

During the ground improvement process, boundaries of responsibility between the involved parties can sometimes become blurred. Avoid this whenever possible. Well-written specifications establish where the boundaries are and who is responsible for what. That ensures accountability, and accountability is what makes a job site successful.

Operation constraints

Communicating the constraints of each project site and its environment is essential for enabling contractors to provide realistic proposals. Include all agreements, covenants and any other situations that can restrict a contractor.

Performance requirements

Performance requirements are extremely important and should be taken seriously. Specifications should address the following:

- Settlement
- Bearing pressure
- Seismic considerations
- Slope stabilization
- Groundwater control application
- Confirmation/testing

The means and methods of confirmation are also an important part of the project, and specifications should identify them. The specification should also indicate who is responsible for the confirmation and testing procedures.

If you're concerned about writing specifications without being exclusionary, simply reach out to consult ground improvement contractors during the creation of your specs. Expertly written specs will yield more and better results during bidding.



What general contractors should know about ground improvement

General contractors need a good price on bid day from a company that's well respected in the ground improvement industry. Knowing and understanding the process of ground improvement helps general contractors during all phases of a project — from concept to construction. If you're negotiating your work on a project, then a basic understanding of ground improvement, specifically aggregate piers, may allow you to provide value-added solutions that the owner or engineer has not considered. If you're competitively bidding a project that requires aggregate piers, the same basic understanding can help you sort through the aggregate pier bids and know what questions to ask of your bidders. You'll also be able to tell if the bids are accurate and can then feel confident when it comes time to choose a ground improvement company.

So what are some of the important aspects of aggregate pier construction that general contractors should know when pursuing or bidding projects? The list below addresses several.

1. Have a basic understanding of the different types of installation techniques and the equipment that would be used on-site. Know the difference between rammed and vibrated piers. Learn if this is a top-feed or bottom-feed project. See how many pieces of equipment the process requires. These elements are project-specific and are ultimately determined by the specialty contractor, but knowing them will help you in planning and managing the project.

2. Learn how much spoil is generated during the aggregate pier construction and who is responsible for removing spoils. Some aggregate pier contractors have unique rigs that allow them to install the piers without having to pre-drill — if soil conditions allow. When possible, this technique could save a considerable amount of money by reducing or eliminating spoils on a project. Ask your specialty contractors how they plan to create the aggregate pier hole. If spoils are anticipated, make sure to plan accordingly for spoil removal.
3. Learn whether or not your specialty contractor plans to pre-drill the aggregate piers. Some contractors may approach the project assuming that they could install the aggregate piers without having to pre-drill, resulting in a lower price on bid day. However, if they ultimately decide they need to pre-drill once on-site, they may come back to you and ask for more money. Address this question when reviewing the bids and get comfortable with the approach that the specialty contractor plans to take, assessing their track record for sticking to their plan.
4. Understand the need that some installers have for temporary casing. Some installers of aggregate piers are not well-equipped to install aggregate piers in unstable soils, and therefore have to use temporary casing to keep the hole open during installation. General Contractors need to know that this expense can sometimes be “buried” in a bid. General Contractors should educate themselves on the application of temporary casing, know whether it’s included or excluded in the installer’s bid, and understand what it will cost if it has to be implemented on a project.
5. Develop a level of comfort with your specialty contractor for aggregate pier design and installation. A good geotechnical contractor communicates openly with general contractors and other project team members, so everyone looks good to the owner and the seeds for a successful project are planted.

When reviewing bids for aggregate pier work, general contractors will naturally consider price but should also consider reputation. It's usually instinct to go with the lowest price, but if the lowest bidder doesn't have a solid reputation, it's worth considering other companies. Look over the bid proposals closely and ask questions if you have any. Ground improvement is an extremely important part of any construction process, and you need to work with a partner you trust.

Subsurface Constructors: your full-service geotechnical contractor

Successful ground improvement is rooted in collaboration and communication at all steps in the process. Here at Subsurface Constructors, we're committed to making ground improvement as affordable and easy as possible. At Subsurface, we:

- Are among the nation's leading, full-service foundation contractors
- Work with engineers and contractors every step of the way
- Have a long history of technical competence and practical experience
- Believe that a safe job site is a productive job site
- Work with you to find the most practical and cost-effective means for your foundation, shoring and ground improvement projects

From drilled shafts and driven pile to auger cast pile and vibro stone columns, Subsurface has evolved through a century from a traditional foundation contractor to a full-service geotechnical contractor.

If you have questions or concerns or would simply like an expert in the field to review your project specifications, please [contact us](#). We'll make sure you start your project on a solid foundation.

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