Searching for a Standard of Care for Engineered Shoring Plans

Engineering services within the excavation and construction industry, often broadly termed construction engineering, are unique and different from permanent works civil engineering. This article takes a closer look at construction engineering services specific to excavation shoring systems. What is the contractor looking for and expecting from an engineered shoring plan? What is the standard of care or what would a reasonably prudent professional engineer in that line of work be expected to produce for the entity ordering the work?

Unique aspects of shoring engineering

Shoring engineering is different from permanent work[1] in several ways:

- The structural design of shoring is based on the action of the soil and reaction of the shoring elements called the soil structure interaction. Geotechnical investigations are focused on the long term, 50 to 100 and more, years response of the soil to the structure and is focused on vertical support and settlement issues. Shoring system design involves short term aspects of the soil, will it stand up long enough to shore, can it be dewatered, short term horizontal loading is more important than vertical soil capacity.
- Shoring systems are most often temporary. They can be designed, constructed, and removed in as little as a few days. Permanent structures almost always take several months to years from inception to finished product.
- The review process is entirely different. Permanent structures are subject to building codes that regulate all aspects of the design and are submitted for review for conformance to these standards. Shoring systems and construction mechanisms are born out of necessity. Being temporary and removed after their use is completed the design of these systems is based on anything that works, can it be safely constructed and will it resist the intended loads. Strength of materials and design codes for timber, steel, and aluminum are usually the only ruling codes. Review is often as simple as a check by an associate engineer or the project owner's construction management team.
- The trigger for an engineer stamped design of these systems is most often OSHA construction safety orders. In excavation work it is OSHA Subpart P-Excavations
- Permanent work is developed in an engineering atmosphere where concept and need come from public agency licensed engineers, codes are developed by engineers, and construction is overseen and managed by engineers. Temporary work is initiated and constructed by the contractor. He may or may not have licensed engineers on his staff.

[1] Within the shoring industry a term that is often used to separate temporary work from final in place work is "production work". Production work is what is being constructed and left in place while temporary work is removed. In bridge building the temporary work is called "falsework"; however, that term is not commonly used in excavation shoring work.

The distinctive nature of construction and specifically shoring design engineering can make it difficult to define what the end product should look like and what is being asked for. With a building or a road, it is fairly obvious what engineering services are needed and standard of care should be applied.

Why does a contractor order an engineered shoring plan?

There are basically 4 basic triggers that cause a contractor to spend money on an engineered shoring plan:

1. **The project contract requires site specific engineering**

   Here the project specifications will set the standards to be adhered to and what the submittal should contain. Design standards are listed such as conformance to AISC, Aluminum Association, etc. The plan is usually reviewed by the construction management team for conformity to the specifications.

2. **OSHA Construction Safety Orders require it.**

   For open cut excavations anything over 20 ft deep requires an engineered shoring plan. Shoring systems that are not built-in place or tabulated by a manufacturer such as brace and sheeting, or shoring used outside the tabulated information require an engineer's stamp.

3. **The contractor is not sure about the type of shoring he needs and believes that it will be of value to employ the services of an experienced shoring design engineer.**

   Both added safety and cost effectiveness result from the engineered shoring design process.

4. **Risk management**.

   The contractor relies on the shoring designer's history, experience, and technical knowledge. He does not have this expertise in house or he would like to have someone outside his company also at risk. The contractor's insurance company sometimes requires it.

For any or all of these reasons it is important to define the expectations and what the contractor is paying for. The contractor should know what he is looking for and the engineer should be able to clearly state what he is providing.

When and Why to Use a Site Specific Plan

Site specific plans are required when there is no tabulated data available for the shoring system that the contractor wants to use. These cases are usually where;

- Tabulated data shoring systems like hydraulic shores and shoring shields are being used in situations that are not described or allowed by the data. The site specific plan is not used to get around the tab data but simply to use the equipment in ways that are not envisioned by the data. For example shoring shields with end plates are not allowed by tab data but it is still perfectly safe to do it as long as the loads are calculated and do not exceed the allowable strength of a shield or the plates.

  Another example is where single vertical lines of hydraulic shores are used in conjunction with shields at utility crossings.

- With tabulated data the soils must always first be identified by the competent person in accordance with OSHA Appendix A. The OSHA soil types and loadings are very conservative compared to engineered soils analysis so there is a lot to be gained in depth and shore spacing using engineering calculations.

- Shoring systems like sheet pile and wale typically are a combination of steel shapes and are not designed and marketed as a shoring system. There is tabulated design data for the components but it still requires an engineer to design the system.

- Manufactured systems like slide-rail and hydraulic brace are complicated and are best done by an engineer or at least someone that has experience with the data and engineering technical knowledge.
- Sometimes the contractor uses engineered plans for risk management. Just to make sure his guys are getting it right and have someone outside to share the responsibility if they get it wrong. In some cases the engineer just determines the soil types so that it is not all the responsibility of his competent person. The essential difference between Option 4 and Options 1 and 2 is that an engineer is responsible for the shoring design, not the contractor. The contractor is still responsible for installing it safely and in accordance with the plan.
- Another difference between site specific plans and tabulated data is that the plan looks at the specific location. It takes into consideration existing structures and buried facilities that affect the shoring system and looks at temporary surcharge loads. The site-specific plan should clearly designate the location of all buried utilities and if they are close or interfere with the shoring system there should be notes that require their exact location prior to or during the shoring installation. Critical facilities like high pressure gas and buried electrical lines should be clear on the plan. Problems that would delay the work in the field should be rooted out and solved at this stage of planning. This is part of what the contractor is paying for when he orders an engineered plan, **the engineer's eyes on everything that affects the safety and efficiency of his**

shoring operation. The contractor and the reviewing engineer should not let one of these plans go through unless this information is there.

- Tabulated data utilizes general soil types from strong to weak to determine allowable depth for the shoring equipment. It is used by the contractor's competent person to construct the shoring system. This categorization and lack of engineering expertise results in extremely conservative shoring designs. Site-specific shoring designs result in more accuracy, safety, and cost effectiveness in the shoring system.

Aside from the contractor the site-specific plan is used by other different entities for different reasons

The OSHA Perspective

OSHA looks at the site-specific plan for several different reasons.

- The plan gives them assurance that difficult soils and difficult shoring applications are safely planned and shored.
- It assures that a jobsite hazard analysis and solution has been performed.
- The plan tells the OSHA inspector how to inspect and determine if it is properly constructed.
- Option 4-Design by an engineer is OSHA's way of promoting and allowing innovation to function within the safety standard. There is no limit to what can be done in shoring as long as it is properly engineered and installed.

The Project Design Side Engineer

The project design side engineer is looking at the plan with an eye toward fulfilling his overview and due diligence to safety on the project obligation. It is a requirement that the project owner and his engineering firm establish (and consequently pay for) clear requirements for safety on the project. If there is to be excavation work on the project there must be a contract requirement that any contractor or subcontractor meets all OSHA safety requirements. The design side engineer must review and approve site specific plan submittals. The standard of care for doing this should be limited to making sure that the basic requirements are covered and not to taking responsibility for the accuracy of the calculations or drawings, this can vary depending on the circumstance.

Regarding engineered shoring plan review the standard of care for this is not well defined; however, it should be pertinent to the temporary work issues raised here.

Public agencies have developed their own review standards. These standards can be excessive, time consuming, and costly to the public. The city of Los Angeles has established shoring equipment design and material verification requirements that seem to be extremely excessive. Different manufacturers of shoring equipment hesitate to give out their design calculations and material acquisition standards because it is viewed as their "secret sauce". OSHA only askes for tabulated data and PSF ratings and

does not go into the design and manufacturing process. OSHA and Interstate commerce regulations enforce the fact that the manufacturer only needs to have one engineer and a stamp from the state that he/she works from, not stamps from every state in the USA.

It should also be noted that the shoring design engineer is the expert in his field of work and that it is not a requirement that the reviewing engineer have this level of experience.

It is not the objective of this paper to determine standard of care for shoring plan review.

From the bottom up, review typically goes something like this:

- In any excavation plan review, there should be verification that the contractor, when workers in the excavation, has a competent person and is providing worker protection from cave-in.

- For tabulated data applications the submittal reviewing engineer should look at:

  - ✓ The appropriateness of the proposed equipment for the soil types and applications.
  - ✓ Can it be installed with regard to safety and the soil conditions?
  - ✓ Is the proposed shoring strong enough to withstand soil and surcharge loads?
  - ✓ Will it stabilize the trench to protect existing facilities?
  - ✓ Will it meet settlement and deflection requirements?
  - ✓ Can the production work be performed, (stable bottom, working room to construct)?

- For the project engineer in the field, provided there is an experienced contractor and competent person working with the shoring system, a complete calculation or walk through of the data application should not be necessary. The accuracy and completeness of the shoring system is the responsibility of the contractor and varies according to the application. The contractor's means and methods should not be tampered with. Violations of the tabulated data should be noted in writing and referred to the contractor. This is where the rubber meets the road. If you go too far you start to become partly responsible. From a legal stand point it is better to be able to say I brought it up them than to have to say I told them how it had to be.

- Site specific plans should be reviewed to make sure elements such as:

  - ✓ Clear plan and detail, notes[2].
  - ✓ Inclusion of existing facilities.
  - ✓ Installation and removal instructions if not obvious.

[2] The notes on an engineered plan are as important as the lines and numbers, they should be read carefully and understood by both the contractor and the reviewing engineer

- ✓ Calculations should rely on soils report or site specific inspection where soils are not available.
- ✓ Confirmation of soil assumption and conformance to AS DUG conditions should be required to be obtained in the field as the excavation proceeds.
- ✓ Calculations should be clear and inclusive of tabulated information on the elements being used.
- ✓ The soils report and borings should be referenced.
- ✓ Standard engineering theories and material design codes should be apparent.
- ✓ Look at soil loading assumptions and diagrams.
- ✓ Make sure that the calculations are present and appropriate; however a line by line check review of all calculations is problematic as they lead to partial ownership of the problems.

- In cases where there are very difficult soils or water conditions site specific plans should always be required by the contract. If standard shoring solutions are not available they should be eliminated in the contract and acceptable solutions listed. In very complicated situations a preliminary shoring design should be developed with the project design. If standard shoring solutions are not readily available to the contractor and it is not pointed out in the specifications there is fertile ground for the contractor to come back with impossible to construct claims.

What the Plan Should Look Like

The content of the site specific shoring plan varies with the situation and there are no hard and fast rules about what should be included. In my opinion a plan that simply shows a shoring system with soil calculations that verify that it is strong enough is not a site specific shoring plan. Engineering is more than just drawings and calculations; it involves investigation and situational awareness. Sometimes these plans are reviewed and used extensively throughout the process and sometimes simply stuck in a file just in case it is needed. In my experience working with contractors and developing shoring plans since 1990, whenever there has been litigation whether it is by OSHA, the contractor vs the project owner, or the family vs every entity involved, the site specific plan has always been an important element in the case. As they say, if it is worth doing it is worth doing right. When a contractor orders a site specific plan he should expect all of the elements discussed above to be considered in the plan. For the safety of your workers and the protection of your company you should find a good experienced engineer that you trust and work with him whenever it is relevant to the shoring work you are doing. Site specific engineering is not really expensive in relationship to the cost of the shoring system being used. Typically one of these plans takes 1 to 3 days of an engineer's time to develop. Deep excavations and complicated soils and circumstances will increase the time spent. The fee covers time and risk to the engineer but is not looked at or billed the same as permanent project design side engineering.

Design options

There are two ways to develop a shoring system

1. Use tabulated data
2. Design by a registered engoneer

OSHA 1926 Subpart P Excavations States:

1926.652(a)(1)Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with paragraph (b)[3] or **(c)** of this section …

1926.652(c)-Design of support systems, shield systems, and other protective systems. Designs of support systems shield systems, and other protective systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (c)(1); or, in the alternative, paragraph (c)(2); or, in the alternative, paragraph (c)(3); or, in the alternative, paragraph (c)(4) as follows:

1. **Use of Tabulated Data**

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1926.652(c)(2)-Option (2)-Designs Using Manufacturer's Tabulated Data.
1926.652(c)(2)(i) Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer.

This option is is performed by the contractor and his competent person..

For this option the contractor need to have at the jobsite:

- The shoring system system manufacturers tabulated data
- A sketch, soil identification conclusion (OSHA Type A,B, orC), and step by step procedure for for determining allowable depths and spacing of elements of the system.
  The contractor is the one responsible for determining that the installed system will support the intended soil, surcharge, and all other influencing issues such as dewatering, bottom heave, support of existing facilities above and below ground, and anything that impacts the support system

2. **Design by a registered engineer**

1926.652(c)(4) Option (4)-Design by a registered professional engineer.

[3] This (b) applies to open cut excavations. The (c) here applies to shored systems.

1926.652(c)(4)(i)-Support systems, shield systems, and other protective systems not utilizing Option 1, Option 2 or Option 3, above, shall be approved by a registered professional engineer.

1926.652(c)(4)(ii) Designs shall be in written form and shall include the following:

1926.652(c)(4)(ii)(A)-A plan indicating the sizes, types, and configurations of the materials to be used in the protective system; and

1926.652(c)(4)(ii)(B) The identity of the registered professional engineer approving the design.

Note that OSHA is only requiring a plan and a stamp. What they are looking for is;

- A way to inspect and confirm that the system is constructed properly
- A stamp that certifies that an engineer has looked at all of the conditions that affect the design of the system.

If the contractor takes the **Option 4-Design by a registered engineer** route he is expecting that "all of the conditions that affect the design of the system" have been taken into account. This engineering work is subject to **engineering standards of care**. The engineering standards of care are far more involved than what OSHA is requiring the contractor to produce at the jobsite: however the engineering aspect still applies to the design of the shoring system. The engineer is seen as the adult in the room and the last look at the excavation before it is dug and the shoring system is put into the ground.

With design by a registered engineer the contractor should be getting;

A drawing that clearly shows the shoring system and surrounding existing conditions that affect the the shoring system. The contractor should be able to safely install and remove the shoring with this plan.

An assurance that the system will work and meet all of his or hers liability issues-

- worker safety
- Structural integrety
- servicability
- protection of existing facilities
- he does not have to rely on his inexperienced workers to get it right
- risk management on results of a failed shoring system
- assurance that he can install his production work
- shoring deflection and settlement issues
- a close look at all burried facilities that may be affected by the excavation work

- another responsible party at the table should a lawsuit develop

This is important to a smart contractor and he will gladly pay for it.

Not the same thing

A drawing simply showing the shoring equipment that is being provided **with a stamp on it** is not the same thing. It satisfies the plan and stamp part of the OSHA requirement but not the underlying professional engineering process.

It is acceptable for an engineer to provide engineering work on certain parts of an engineered project, for example the roof trusses on a house may be designed by one engineer while the wind and siesmic resistance system may be designed by another; however, there should be a note on the plan that indicates what the plan is limited to, for example :

This plan provides a drawing of the shoring system that is to be used and certifies that it is adequate to resist the soil and surcharge loading at the location when the equipment is set back in accordance with the setback table and dewatering is to level indicated on the plan.

No other excavation influencing conditions have been considered in the design.

There is one particular exclusion with an engineered site shoring plan, Dewatering is genearlly excluded due to the fact that dewatering is a different engineering discipline than structural design. This dewatering exclusion should be noted on the plan. The structural shoring designer sets the dewater level required and the dewatering engineer develops a plan to achieve that water level.

Standard of Care

When an egineer declares to his client, usually a contractor, that he will provide a shoring plan in accordance with **OSHA Subpart P 1926.652(c)(4) Option (4)-Design by a registered professional engineer,** the promise is the complete engineering package that considers at all of the unique aspects of temporary shoring work some of which are outlined and discussed in this article.
The American Society of Engineers defines Standard of Care this way:

Standard of Care: A **Professional Engineer is negligent** if he/she fails to use the skill and care that a reasonably careful professional engineer would have used in similar circumstances

The contractor would not necessarily be able to list what he is getting with this shoring plan; he just assumes that he is getting what OSHA has required him to provide. If there is

anything less in the package it should be clearly stated in the plan. If this is the case the cost should be decreased accordingly. You should get what you pay for. Part of the standard of care is to clearly define to the contractor what is excluded from the standard package.

The cost of site-specific shoring plans will vary due to many factors:

- The deeper the excavation the more it will cost
- Different geographical regions will see different costs due to population, soil types, history of excavation litigation, density of engineering competition, etc
- Due to the level of review requirements in the LA Basin the cost can be as much as triple the cost on the East Coast

The point here is that cost and value comparison should be based on commonalities not just a lump sum.

Conclusion

The two driving forces in development of a shoring plan are risk to employees and development of the most cost-effective method of constructing underground structures. Safety is the primary driver. OSHA option 4 design by an RCE consists of more than a plan and a stamp, the RCE requirement means you need to get the engineering process with it. Unless exclusions are stated, a plan in accordance with OSHA requirements contains engineering in accordance ASCE Standards. This is what the contractor should expect to receive, the experience and knowledge that comes with a registered engineer, all that applies to the safety and efficiency of the shoring system and a clear understanding of what may be left out of the package so that the contractor can take care of it in another way.

This article is independent commentary by the author and is not part of or been reviewed by NAXSA.

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