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Settling Soil Issues:

Use of Dynamic Soil Compaction on the upswing in non-traditional areas

Common knowledge says that before you can construct a building or renovate an existing facility, you must consider what is below it: Structures built on soil that contains excess air or water may eventually become unstable due to settlement. While some minor settlement may be deemed acceptable by a qualified Geotechnical and/or Structural Engineer, too much of either true or differential settlement on the slab and foundations in the post-construction phase can jeopardize the function of a structure. Structural cracks, uneven floor slabs and "steps" at joints disrupt foot traffic and product transport in buildings and facilities.

So what do you do when your soil is not right for the job and you know that, left untreated, settlement and/or bearing capacity issues may occur? Hixson dealt with this scenario recently when a client was asked to "accept" a site that had been prepared for other uses. A large amount of on-site fill dirt had been placed on the site to bring the soil up to the building pad level; however, the fill material was placed loosely and improperly compacted. This resulted in soil which, according to the geotechnical report, would have ultimately caused both settlement and soil bearing capacity issues. While bearing capacity could have been addressed with other solutions, using shallow footings for this project without undertaking any soil remediation was simply not a reasonable option since anticipated building settlement was unacceptably high.

Traditional Soil Remediation Options

For this client, two options for addressing the anticipated settlement issues for the structure were considered as a matter of course:

- **Deep Foundation Systems**. Deep foundation systems, such as piles or piers embedded deep within the ground, are often used in cases where the soil condition is weak and building loads are high because negligible building settlement occurs with this solution. In this case, however:
  - The piles would have needed to be 60 ft. deep to overcome the soil conditions and prevent future settlement.
  - The structure did not have significant load to warrant the capacity of a deep foundation system.
  - The cost to install/build the solution would have been approximately $1 million.
  - Additional piles would be required should the client wish to expand the facility in the future.
- **Soil Removal and Replacement**. This option involves removal and reconditioning of the existing fill, then replacing the fill in multiple lifts compacted to a prescribed density. This method can be labor and time sensitive for projects with an aggressive construction schedule, and minor settlement is expected after the original settlement that occurs during backfill operations. Another issue in this particular case was cost: With 5 to 25 ft. depth of fill required across the site, this option

A crane prepares to drop a weight onto the soil.

The weight impacts the soil.

Holes created after compaction.

would have cost between $300,000 and $400,000 to remediate both the current project site as well as adjacent areas for potential future expansion.

A Third Option: Dynamic Soil Compaction

Of the options available, dynamic soil compaction was one that, while often overlooked in the Midwest, was found to be most appealing. This method, widely used in areas such as the Eastern Seaboard and the West Coast, is also used in Midwest locations that have granular soils. However, it is not typically used with clay soils, which are common in the part of the Midwest where this project is located, because of the tendency of clay to expand and contract.

With dynamic soil compaction, a crane drops a weight from a specified height at regular intervals across the project site. The mass of the weight, as well as the height of the drop, are calculated to create the desired level of compaction. Compaction is created throughoutthe area, and thus soil density is improved, decreasing settlement potential and increasing bearing capacity.

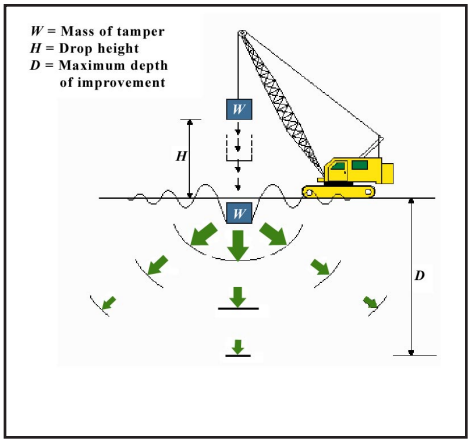

Figure A: As the weight is dropped into the soil, vibrations are created. While these vibrations dissipate with distance and usually have little effect on neighboring facilities, they can be calculated if required.

It is important to note that compaction can be effective to depths of 20-25 ft. Should soil deeper than 25 ft. require compaction, the process would need to be modified to reach those depths. One way, of course, would be to remove the top layer(s) of soil, perform the compaction, return the soil and then compact again. However, in this project, an alternative method was used to remediate a small portion of the entire site that needed deeper compaction. Holes were drilled to approximately a 15 ft. depth and then drops similar to the surface drops described above were made with a weight that fit the profile of the drilled hole. This method consolidated the deeper soil without requiring the soil layers above it to be removed, saving additional expense and time.

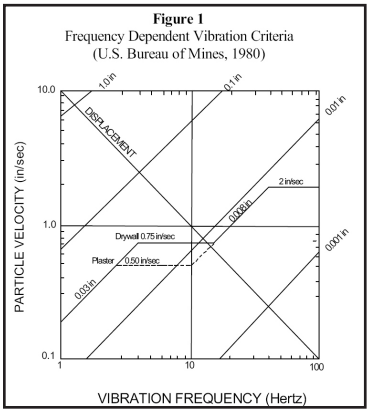

Figure B: This information, from the U.S. Bureau of Mines, outlines the particle velocities in various frequency ranges and identifies that damage to neighboring facilities can be prevented by keeping velocities below 0.5 inches/second. Note that drywall has the potential to crack at a velocity exceeding .75 in/sec.

There are Benefits with Dynamic Soil Compaction...

When looking at dynamic soil compaction as an option, cost and schedule are the greatest savings opportunities. For this particular project, dynamic compaction was completed in just three weeks over the entire site, giving the client the option to expand their facility on the site without having to treat the soil again before future expansion. Cost was also a big factor: dynamic soil compaction cost approximately $200,000 - $250,000, a significant savings from the other available options.

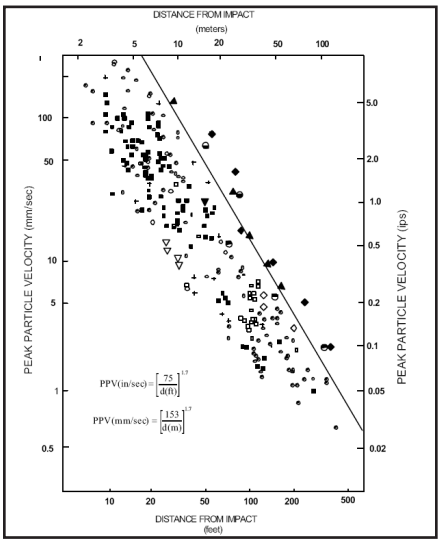

Figure C: Researcher Paul Mayne, presenting at the ASCE Soil Dynamics Committee Convention in 1985, showed the relationship of particle velocity to distance from the source.

...But Risks as Well.

No benefit comes without risk. Because dynamic soil

compaction is an atypical method in many parts of the country, projects that use this method will need to have due diligence performed on the specialty contractors being considered for the work: Contractors who are unfamiliar with the proper operating procedures for the particular soil type for the project pose a higher degree of risk.

Another risk is the effect that the "perceived" degree of vibration from the dynamic compaction process can have on neighboring structures. The process has little potential to cause drywall to crack and create other foundation issues for neighboring facilities – in reality, and under most conditions, such effects should be minimal or non-existent. Should complaints from neighbors occur, the vibration from the frequent pounding can be measured. (See Figures A, B, and C).

Finally, be prepared for some surprises. For this particular project, the drops created craters much deeper than anticipated. On reasonably compacted soil, the depth after five drops of the weight in one spot should be less than one foot. As seen in the photos included with this article, the craters created for this project varied in depth from 2.5 ft. to 5 ft. Despite the fact that the new facility had nominal building loads, it would not have been functional given this huge degree of consolidation. Extra gravel and recycled concrete were required to fill the craters that were located across the site. (Fortunately, such material is relatively inexpensive).

Is Dynamic Soil Compaction Right for your Project?

For your next building project, having a qualified Engineer provide a Geotechnical report is an important first step to understanding what issues may be lurking underground. Should soil remediation be required, your Engineer can then help you determine whether or not dynamic soil compaction is a viable method for your project.

Advocacy: Hixson is a "No-Bias" Company

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