LESSONS LEARNED:

GEOTECHNICAL ENGINEERING

OBSERVATIONS AND LESSONS FROM THE SCHOOL OF EXPERIENCE

DEEP DYNAMIC COMPACTION

Deep Dynamic Compaction (DDC) is a relatively new (about 35 years, if that can be considered new) type of ground improvement. When they coined the phrase "Necessity is the mother of invention" who would have thought it would have come to this? DDC is one of a number of procedures or methods used for ground improvement. Other common deep methods of ground improvement (several of which have been addressed in previous issues of ***Lessons Learned***) include lime stabilization, the use of geotextiles, soil cement stabilization, compaction grouting, and chemical grouting.

What is Deep Dynamic Compaction? DDC is the application of high energy to loose soil or fill deposits. At its very essence, DDC consists of repeatedly dropping a large (generally 4 to 12 feet in diameter), heavy (typically 5 to 15 ton) steel and/or concrete weight, also known as a tamper, from heights of up to 100 feet. As you might imagine, DDC does grab quite a bit of attention during implementation. If there are existing structures near the site, a preconstruction condition survey of the structures prior to DDC operations is prudent along with vibration monitoring of selected structures during DDC operations.

Where would I consider using Deep Dynamic Compaction? DDC is an economical method of improving the engineering properties (mainly stiffness and density) of large deposits of very loose soil or fill deposits by densification. DDC was developed in response to the two primary axioms of real estate: 1) Location, location, location, and; 2) All the good sites are taken. DDC is one procedure that can aid in making use of land that may not be economically viable using conventional construction methods. The project site may be one that is an ideal location, but the poor soil properties are such that no development has occurred to date because the costs are just too high. Another example (and one that is becoming more prevalent in the major urban areas) is a project site that contains appreciable amounts of non-engineered fill (read: just about anything) resulting either from dumping activities, demolition of prior structures, or extensive filling, including landfills. In many cases, without the use of DDC these projects would just not get done.

How does Deep Dynamic Compaction Work? The concept of DDC usually enters the picture during site development and preliminary design. Depending on the known circumstances of the project site, the design team may already know that site soils are poor, or the geotechnical exploration may have already revealed poor soils. If the soils are appropriate, DDC may be a viable solution. For DDC to be effective there are generally three requirements that must be met. The first is the soils should be essentially granular (sand, gravel, coarse fill materials such as brickbat, concrete etc.). Cohesive (clayey) soils or organic soils such as peat generally do **not** respond well to DDC. Second, the ground water table should be at least 10 feet below the existing ground surface, and preferably deeper. If the ground water is too close to the ground surface, excessive pore water pressures will develop (miniature geysers), effectively undoing any benefit imparted to the subsurface soils. Third, the project must be isolated enough so that the DDC will not damage nearby structures and/or utilities.

Based on the existing soil conditions and the project design criteria, the geotechnical engineer determines the amount of energy necessary to achieve the desired final soil properties. The geotechnical engineer then develops the DDC program, which will determine the appropriate size of the tamper (generally 5 to 15 tons), the drop height (from 15 to 100 feet, but typically 50 to 80 feet), the number of drops per pass, the grid pattern for each pass, and finally the number of passes necessary to impart the total necessary energy to effect the desired improvement. Once the primary passes are completed, a secondary, "ironing" pass will be necessary. In the ironing pass, the spoils generated by the impacts are bulldozed into the craters (the depth of the craters vary, but are generally 3 to 8 feet deep) and a grid pattern with a lower drop height and fewer drops per pass is used to densify the near surface soils. Fine grading is then required to provide a relatively uniform final profile upon which to construct the project.

During the DDC operations, the geotechnical engineer must be on site to observe the work, monitor apparent effectiveness, measure the depth of the craters and generally monitor the operation. DDC is not an exact science and most projects will require adjustments in the program to achieve the desired results. After each phase of the project is completed, soil borings are required to determine the actual improvement achieved. Depending on the soils and DDC program, improvement of soil properties to depths of as much as 25 feet can be achieved. The results of the borings serve not only to confirm the effectiveness of the program, but also to help make subsequent phases more efficient. Common modifications to the DDC program during the operations are increasing or decreasing the number of drops or the number of passes, changes to the tamper dimensions and/or weight, and changes to the drop height to achieve the desired result. However, when the members of the design and construction team work together, this evolutionary process works quite well.

Some interesting side effects of DDC are that the final ground surface is generally 1 to 2 feet lower than that when the project began. Another potential benefit of DDC on environmentally-sensitive sites is that the process reduces the amount of surface spoils that could require special handling and expensive off site disposal. This procedure has been used successfully on rubble fills to allow for the use of shallow foundations to support the project structures, a situation where deep foundations would have been the only alternative, which not only cost more, but can add another site development problem by creating potentially-impaired spoils that would require special handling and disposal.

What does Deep Dynamic Compaction Cost? Depending on the size and geographic location of the project, costs typically range from $1.50 to $2.75/SF.

We hope this ***Lessons Learned*** will be beneficial to you in the planning of your next project with marginal soils.

Respectfully,

ECS Corporate Services, LLC