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WHITE PAPER

WORKING WITH CONTROLLED MODULUS COLUMN (CMC)® RIGID INCLUSIONS

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INTRODUCTION In the evolving landscape of ground improvement solutions, working with new and innovative technologies presents distinct challenges to project teams. When implementing these technologies, it is important to develop a clear vision of process and scope division between the many moving parts of the design and construction entities. While Controlled Modulus Column (CMC)® rigid inclusions are not a new technology, many engineers and contractors have yet to encounter this technique on their projects. It is common to find project teams in a position where they have recognized CMC rigid inclusions as the most appropriate technical and economic solution, yet from a design and planning standpoint, they may not be sure how to best implement the technique. This can render the division of scope within the project team clouded and risky. Industry guidance is often necessary to ensure that engineers and contractors understand how to schedule the engineering and construction of the CMC rigid inclusion system and plan for appropriate site preparation to avoid potential construction conflicts. General contractors should understand how to accommodate the site support required by Menard as the CMC rigid inclusion specialty design build subcontractor, and recognize some of the special construction considerations that are distinctive of the CMC rigid inclusion technology.

BACKGROUND As with many foundation support systems, allowing appropriate time for development of the solution can make or break the success of the use of the technique on the project. From the time that CMC rigid inclusions are identified as the appropriate foundation support solution, the Menard design data and development of engineering properties for use in design. Menard will often collaborate with the local geotechnical engineers and lean on their local experience when developing geotechnical design parameters. Once the engineering properties are established, the FEM models can often take days, or even weeks to build and produce successful results.

Unlike conventional piling systems that are sometimes designed by the project's structural or geotechnical engineer, CMC rigid inclusions are designed by Menard and often use complex finite element modeling (FEM) techniques. These modeling methodologies require significant analysis of the geotechnical

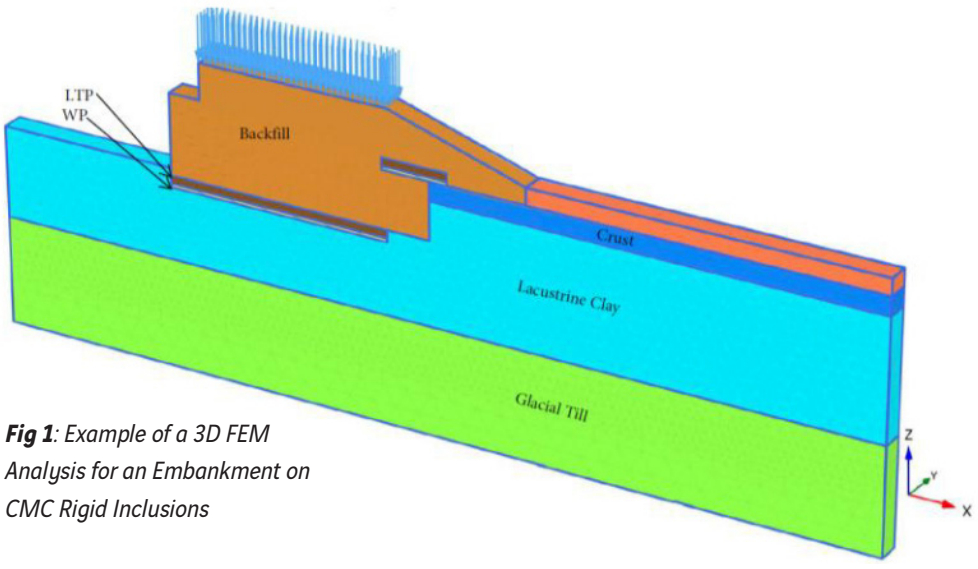

***Fig 1**: Example of a 3D FEM Analysis for an Embankment on CMC Rigid Inclusions*

It goes without saying that small, straight-forward projects with simple and/or uniform soil strata and basic loading conditions can be designed in short duration (3 to 4 weeks), while large and complex projects with challenging/variable soil conditions and numerous load cases can often require months to develop. It is important that engineers and contractors allow for appropriate time on the front end of the project schedule, not only for development of the CMC rigid inclusion design calculations and models, but also for review on behalf of the owners' engineering representative. Healthy back and forth discussions between Menard and the project team during the design phase ensures that the project is designed without gaps or miscues. This process should not be rushed, as the interface between the geotechnical engineers, structural engineers, and Menard requires an open and collaborative dialogue. It is often possible that Menard can run the design concurrently with project startup/mobilization preparation activities to ensure maximum schedule efficiency from the time of Notice to Proceed. A total of six to eight weeks is normally required for Menard to design, allocate rigs and crews, mobilize and start the project.

Site Preparation

Menard dœs not typically perform earthwork operations, rather they work closely alongside the owner's earthwork contractor to deliver the final product. Menard and the earthwork contractor should be integrated early in the project development to ensure adequate time to collaborate on the site specific requirements necessary for successful implementation of the CMC rigid inclusion system. Once the project is designed and Menard is ready to work, it will be expected that the earthwork contractor has cleared and grubbed the site, removed all obstructions and interferences above and below grade (powerlines, utilities, etc.), prepared a level and stable working platform, and has provided adequate access for Menard's equipment and material suppliers. This ensures maximum efficiency of the CMC rigid inclusion installation process and reduces the likelihood of delays and change orders down the road.

Most projects are arranged having the concrete foundation contractors providing survey and layout of the CMC rigid inclusion locations. This ensures a seamless transition between the location of the structural/architectural features and the CMC rigid inclusion system positioning. The CMC rigid inclusions are usually left below grade and red-lined as-builts are used in lieu of surveyed as-builts.

Once the CMC rigid inclusion system is installed, an LTP (Load Transfer Platform) is often required. While the LTP is designed and prescribed by Menard, the construction of the LTP is performed by the earthwork contractor. The inspection of LTP construction is usually performed by the owner's geotechnical engineer. This presents a situation with several responsible parties and the delineation of scopes can often be blurred without proper communication in the development phases of the project.

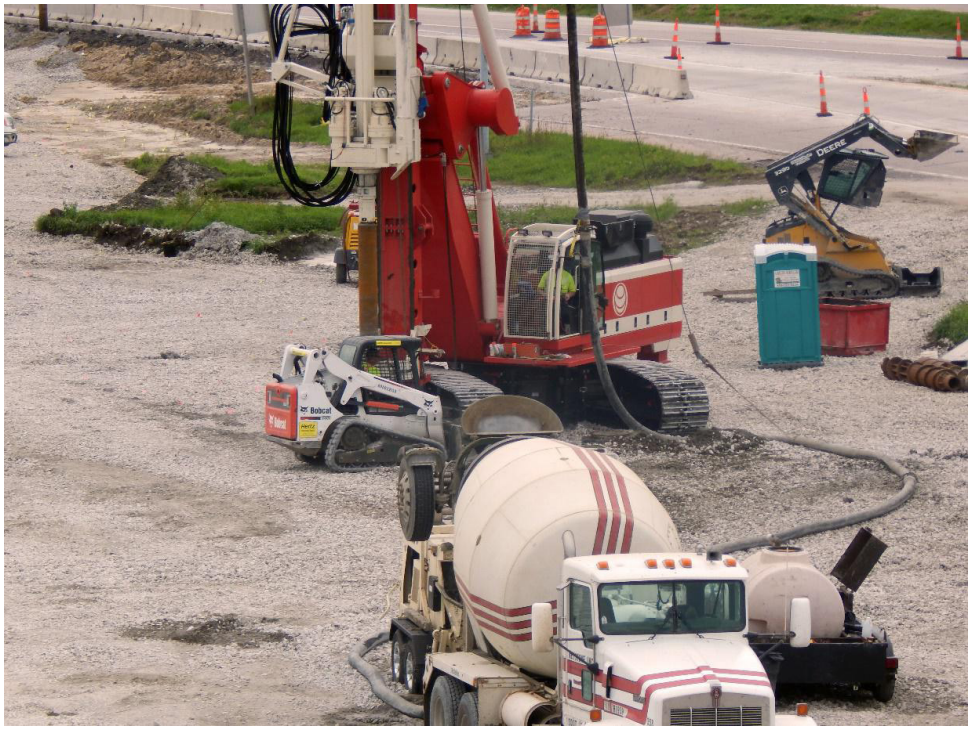

***Fig 2**: CMC Rigid Inclusion Cutoff Procedures*

In addition to the site preparation, Menard often requires several support items to be provided by other team members. Adequate area should be allocated to Menard for staging of the equipment, laydown and maintenance of equipment, and placement of site office for Menard's project management team. Menard will require a source of water for daily cleanout, access to power for job trailers, and typical site amenities such as portable sanitation units. Adequate access, wheel wash, and clean out facilities must be provided for the grout supplier who is delivering grout to the site in ready mix trucks. For projects were grout is batched on site, sufficient plant and material storage areas are required.

The CMC rigid inclusion process, much like piling or other deep foundation systems, utilizes large specialty drill rigs, along with pumps, skidsteers, loaders, forklifts, and manlifts. The site should be cleared of any surficial or above-grade features that hinder the operation of these types of equipment. Slopes, muddy work benches, powerlines, and close proximity of other construction operations will impede Menard's operation and present potential unsafe site conditions. It is important that the site contractor provide a work site that dœs not restrict the CMC rigid inclusion operations and allows for a safe work environment.

Although the CMC rigid inclusion system utilizes large robust drilling machines, below grade features can often obstruct the proper installation of CMC rigid inclusions. Boulders, steel, timbers, and remnant foundations will inhibit installation. A thorough geotechnical investigation can help to identify potentially obstructive features, which helps Menard to plan for such scenarios and work with the project team to develop structural or operational solutions prior to arriving on site.

Since geotechnical borings will never catch all potential obstructions, field-engineered solutions are often required. These solutions can include offsetting

***Fig 3**: Typical CMC Rigid inclusion Set-up*

the CMC rigid inclusions to either side of the obstruction, removal of the obstruction (if shallow), or even pre-drilling depending on the nature of the obstruction. Owners should expect that obstructions can be encountered, and when they are, a collaborative team approach is required in order to quickly and effectively handle the issue using either operational or design-based solutions. Either approach will require a strong relationship and coordination between the structural engineer, earthwork contractor, and Menard.

In order to accommodate various structural conditions, the CMC rigid inclusion system may be modified or adapted to manage such circumstances. Footings and walls are often constructed at depths well below the working grade for CMC rigid inclusion installation. This requires low-cut CMC rigid inclusions such that the top elevation after installation corresponds to the bottom elevation of the LTP for the deeper foundations. CMC rigid inclusions that require shallow cutoffs (i.e. 1-3' below the working surface) can easily be trimmed by field personnel using hand tools. Cutoffs beyond 3-foot-deep require augering by equipment such as skidsteers or Continuous Flight Auger (CFA) drilling rigs. As the depth of the cutoff increases, accuracy of the final top elevation requires increased care and specialized equipment and may be subject to variations. This may make it necessary for the site/foundation contractor to provide "trimming" of the CMC rigid inclusion elements at depth, or locally thickened LTPs below foundations. This is particularly true in cases where the future top of CMC rigid inclusion elevation is exists below the water table.

Another special circumstance exists when footings require structural connections to accommodate uplift or lateral forces. In these cases, CMC rigid inclusions may be reinforced and should be treated in the field similar to piling, where site contractors should expect to have to work around steel protruding from the ground during footing construction. The site contractor will also be responsible for chipping the grout away from the rigid inclusion to expose the reinforcement.

CONCLUSION The CMC rigid inclusion technology boasts numerous technical and economic advantages over conventional deep foundations and other forms of ground improvement. Nonetheless, well organized planning and collaborative development within the project team is required for the system to be implemented successfully. A trusted CMC rigid inclusion design builder, such as Menard USA, should be retained for the work, allowing the project team to benefit from their experience and expertise.

GOING FORWARD: Do you have a project that you think would be a good candidate for a CMC rigid inclusions?

Get in touch with Menard today at **412-620-6000** or visit us at **www.menardusa.com** today to find your local Menard representative and to sign up for our newsletter, The Column.

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