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WHITE PAPER

**CONTROLLED MODULUS COLUMNS (CMC)[®] AND
LOW-MOBILITY GROUTING FOR STRUCTURE
SUPPORT**

CONTROLLED MODULUS COLUMNS (CMC)[®] AND LOW-MOBILITY GROUTING FOR STRUCTURE SUPPORT

INTRODUCTION As an alternative to traditional deep foundations, utilizing Controlled Modulus Column (CMC)[®] rigid inclusions and Low-Mobility Grouting (LMG) can be an effective approach for project sites with loose and/or compressible soils overlying karstic void-prone geology. Used in tandem, these techniques can address both deep and shallow settlement concerns, as well as mitigate the risk of a potential sinkhole formation, allowing engineers to design as if the structure were placed on competent ground.

BACKGROUND In regions where karst topography is known to exist, subsurface voids are often identified during the course of geotechnical investigation. Left untreated, such voids can lead to sinkhole formation and foundation failure. When soft or loose soils are present above the voids, a solution that treats both the upper and lower strata is required. Typically, this is accomplished with piles, caissons or other deep foundations, often combined with grouting of voids and cavities. While effective, the pile caps, grade beams and structural slabs associated with such a foundation add significant time and cost to a project. This is especially true for lightly to intermediately loaded structures, as costs associated with deep foundations may not have been considered during the planning stages of a project.

Menard, in conjunction with Nicholson Construction Company, has developed a solution to use both CMC rigid inclusions and LMG to treat the unsuitable upper and lower strata. In this combined approach, CMC rigid inclusions are used to limit settlement in the unsuitable compressible soils and are applicable across a wide range of soil types. CMC rigid inclusions offer different benefits depending on the soils through which they are installed:

- Organics and Compressible Clays:

High-capacity inclusions are possible in very weak soils. Additionally, techniques that use aggregate, such as stone columns or aggregate piers, do not work well in very soft soils.

- Silts and Sands: Installation technique does not require casing, keeping costs down. Provides beneficial load sharing between the in situ soil and CMC rigid inclusion elements.
- Urban Fills: CMC rigid inclusions can transfer load to competent, natural soils below, and a displacement installation technique can reduce or virtually eliminate the need for spoils disposal, which is especially helpful when working with contaminated soil.

Conversely, LMG targets voids or highly fractured formations to mitigate any sinkhole concerns and potential for excessive settlement. Some key advantages of LMG include:

- Utilizes a sand-cement mix rather than a neat cement mix to prevent pumping excessive grout volumes.
- Drilling technique allows for installation through difficult ground conditions (e.g., hard rock, rock ledges, fractured rock, etc.) unsuitable for other methods.

Figure 1 depicts the concept of the combined CMC rigid inclusion/LMG solution.

Successes

Grand Valley State University

L. William Seidman Center – Grand Rapids, Mich.

In western Michigan, gypsum deposits can be found ranging in thickness from 4 to 20 feet. These deposits are susceptible to karstic solution and development of cavities, and existing structures in the area have experienced excessive settlement and foundation failure brought on by void collapse/sinkholes. The site was in close proximity to the Grand River, which increased the likelihood of void formation. The karstic rock was overlain by undocumented fill material, resulting in a high risk of settlement. Menard and Nicholson Construction were able to mitigate the potential for foundation issues using a unique combined approach.

The four-story, 40,000-square-foot College of Business building included an academic center with courtyards and required support of all floor slabs, footings, and exterior planters. Compounding the issue was the presence of up to 25 feet of woodchips within the building area. The original design called for augercast piles or micropiles, but Menard and Nicholson were able to offer a joint solution to meet the performance requirements, while economizing the foundation design.

Menard installed CMC rigid inclusions through the variable fill and into the underlying dense sands. CMC rigid inclusions were installed to support not only the slab areas but also the load-

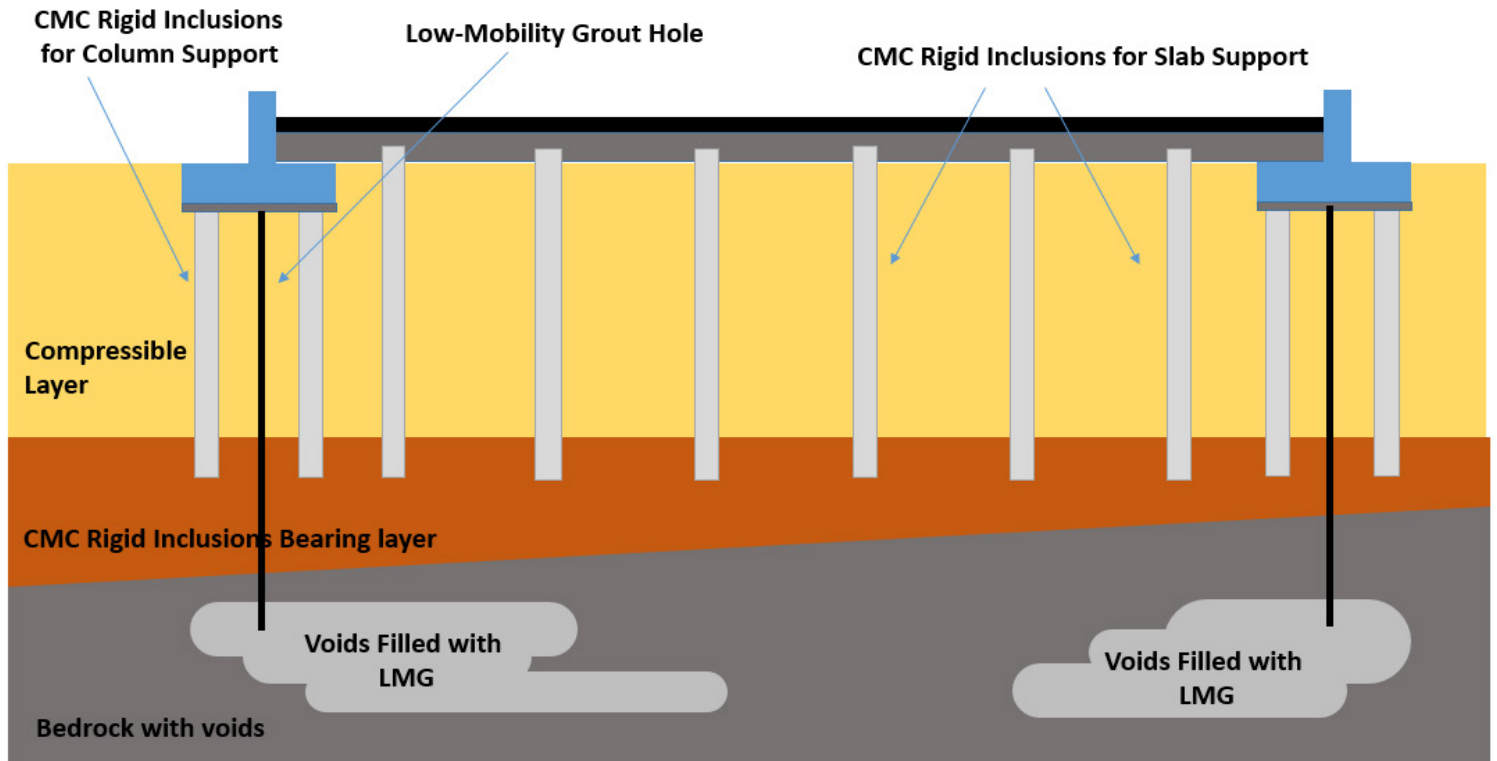


Fig 1: Load transfer mechanisms for CMC rigid inclusion in soft to stiff soil

bearing footings and walls. Nicholson Construction utilized LMG at select locations within the building footprint to treat the bedrock voids. The combined approach was more economical than deep foundations alone, and additional and substantial savings were also realized as pile caps, grade beams and structural slabs were eliminated.

*Consumer's Energy Employee Development Center
Grand Rapids, Mich.*

For a three-story, 12,000-square-foot training facility with conditions similar to those found at the Seidman Center, Rockford Construction approached Menard and Nicholson Construction for a ground improvement solution. Column footings were designed for 6,000 psf, wall footings for 3,500 psf and slabs for 150 psf. Now a proven technique in the area, Menard and Nicholson helped the project team tailor-fit the concept to the new structure throughout the design process. This early involvement afforded the Menard and Nicholson team the opportunity to help streamline the

structural design and provide the client the most economical approach.

Here again, Nicholson grouted voids in bedrock at all column footing locations and along continuous wall footings. Menard followed with CMC rigid inclusions through the sandy fill material and tipped each element into the dense, competent sands below, providing structure support at all footing locations and also within the slab area. Both Menard and Nicholson were able to overcome working in winter conditions and close proximity to an existing building, and a tight schedule to deliver a high-quality ground improvement solution.

*Frederic News Post
Frederick, Md. – A Stand-Alone CMC Rigid Inclusion Solution for Karstic Conditions*

A one-to-three-story, 100,000-square-foot newspaper printing facility was to be constructed in Frederick, Md., but site analysis showed poor soil conditions consisting of variable fill overlying very soft layers of compressible soil atop a

karstic limestone formation. Compaction grouting and piles were recommended for foundation support, but Menard offered an innovative design-build solution for CMC rigid inclusions to support the structure and cap grout the top of the limestone.

For this project, Menard performed cap grouting through the CMC tooling to treat the upper rock-soil interface, which contained fractured rock and soft soil pockets. CMCs were installed down to the top of the bedrock, where the cap grouting process commenced. Once the very soft soils at the soil-rock interface were mitigated, CMC columns were constructed up to the ground surface. In all, Menard installed over 30,000 linear feet of CMC rigid inclusions to depths up to 40 feet. The solution was designed to support very heavy floor loads (up to 800 psf) and column loads (up to 400 kips), while maintaining settlements to 1 inch total and ½ inch differential between columns.

CONCLUSION Ground improvement often offers economical solutions to deep foundations, even in complex geologic settings such as those present in karstic areas. Combining the strength of two different techniques to solve two different issues (void formation and settlement control), Menard USA has demonstrated that CMC rigid inclusions are a viable technical alternative to more conventional deep foundation solutions in sinkhole-prone karstic areas.

Allowing alternate, innovative solutions from the ground improvement industry rather than following convention is often in the best interest of the project team and offers the most value.

GOING FORWARD When typical pile solutions are recommended to support footings with high loads, consider CMC rigid inclusions support as an alternative. Menard is available to address any needs or questions.

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



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