Ground Improvement for Building Support

What is it and Who is Responsible?

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Many types of ground improvement (GI) are used in modern geotechnical construction. For the purpose of this article, GI refers to a rigid or semi-rigid cylindrical inclusion (GI element) installed through otherwise unsuitable bearing soils into underlying suitable strata to enable the use of spread footing foundations for building support. Due to favorable economics compared to viable foundation alternatives, use of GI is accelerating in the United States.

Commonly, GI elements are formed of crushed stone, grouted crushed stone, grout or concrete. They are typically designed and installed by specialty subcontractors using a variety of analysis and design approaches, installation methods and equipment. Historically, GI has been used to limit footing settlements to tolerable levels by transforming the unsuitable strata into a stiffer "composite" media consisting of low-capacity GI elements and the "improved" soil. GI was not typically relied upon to increase bearing capacity significantly or provide the factor of safety against this mode of failure. Recently, in addition to settlement control, GI elements are now also being used in situations where they must provide most if not all of the margin of safety against a bearing failure.

As applications of GI are being pushed to new limits, the need for deep understanding of installation conditions, behavior and adequate quality assurance becomes more critical. The adequacy of GI in bearing capacity applications cannot be assumed simply because of its successful legacy for settlement control. In such challenging applications, the Engineer(s)-of-Record (EOR) and project team must ensure that the GI provides comparable bearing capacity, settlement control, resiliency during earthquake and other loading conditions, quality assurance and overall performance as other "conventional" foundation systems. Experience is proving that this is easier said than done.

Due to the nature of GI elements and commonly used installation methods, quality assurance is more difficult than for other types of foundation systems. Each step of the process – including the decision to use GI, specifications, GI type selection and design, reviews, element/system testing and on-site monitoring – is vital to success. Adding further complication is the fact that there is confusion in the industry over what various element types are called or consist of, as they are sometimes referred to generically even though the elements and their installation methods can differ significantly. Some are proprietary, making it difficult to know important details.

The already fuzzy lines of responsibility for GI among the Geotechnical Engineer, Structural Engineer, Architect – especially if the Structural Engineer is retained through the Architect – General Contractor and specialty GI subcontractor become further blurred. Adding to the complexity is the fact that most current building codes in the U.S. do not address use of GI; the authors are only aware of one where GI is mentioned: the Massachusetts State Building Code, and its use only requires notification to the Building Official. Typically, design – including element type, installation method, configuration, depth and capacity – of a GI system is performed by a registered Professional Engineer retained by the subcontractor using building loading information provided by the Structural Engineer and information on site subsurface conditions provided by the Owner's Geotechnical Engineer. The project may have a GI specification as part of the construction contract documents, prepared by the Owner's Geotechnical Engineer. Sometimes, structural redesign of the footings may also result.

Each team member has contractual and (potentially) legal obligations in a design/construction project. When GI is used, the Owner's Geotechnical Engineer may or may not have recommended its use; GI is sometimes proposed by an Owner or contractor as a value engineering alternative. Details of the GI design are provided by the subcontractor's designer through a P.E.-stamped submittal. The submittal is typically reviewed by the Geotechnical and Structural Engineers. The use of GI, the subcontractor's GI design and reviews by the Owner's Engineers impact and intertwine with the Engineer-of-Record (EOR) responsibility for the building foundations in potentially complex ways, which can depend on applicable codes, project specifications, contracts and actions by the involved parties.

Often, the Structural Engineer and Owner rely upon the Geotechnical Engineer to be sure that "everything is okay," despite the fact that the Structural Engineer is the EOR for the structural aspects of the building including the foundations. By submitting a stamped design for GI, the specialty subcontractor's designer takes primary responsibility for foundation performance, often contractually through the General Contractor. Because of his/her unique understanding and role in the project, the Geotechnical Engineer also has a professional responsibility in the process, including advising the Client and the project team of the special issues and potential risks involved.

The very important technical issues and responsibilities associated with the use of GI on building foundation projects are too complex to be addressed in detail in this short article. The key point is that use of GI presents special challenges that are the result of their inherent complexities, and that are becoming more acute each day due to the very rapid evolution of the systems, their application, and the contractors installing them. It is important for project teams to understand the roles and responsibilities of each team member in the process. In addition to the potential benefits, project-specific challenges and risks must also be identified, and provisions must be put in place to mitigate them.▪

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