Experience and Challenges of Geopier® Construction on the Gulf Coast

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ABSTRACT:
Over the past decade, *Geopier* Rammed Aggregate Piers™ have become increasingly popular as an economic method for reinforcing soils for the support of structures. The system involves drilling 30-inch diameter holes to depths of up to 30 feet below grade, constructing a bottom bulb, and ramming thin lifts of aggregate using a specially designed high-energy beveled tamper to form vertical inclusions of aggregate. The construction method results in Rammed Aggregate Pier elements that exhibit high stiffness and high shear strength, designed to control foundation settlements, increase bearing capacity, and increase shearing resistance.

Recently, Geopier Rammed Aggregate Piers have been used along the Gulf Coast to support shallow spread footings for commercial and residential buildings, above-ground large diameter fuel storage tanks, and highway retaining walls. This paper describes Geopier design and construction considerations for three projects in the Gulf Coast region. The projects include support for large-diameter above-ground fuel storage tanks in Pasadena, Texas with design emphasis on settlement and edge stabilization; foundation support for a large condominium and parking garage project in downtown Houston, Texas; and the provision of foundation bearing capacity improvements below highway MSE walls constructed for a new toll road in Harris County, Texas. For each of the projects, both the design considerations and construction hurdles are discussed.

The construction of two new 150-foot diameter, 52-foot tall tanks at the Kinder Morgan Liquids Terminal Facility in Pasadena presented problems related to future performance of the tanks. Project engineers predicted that the bearing pressures of over 3,000 psf would cause significant settlement in the 20-foot thick variable clay fill layer encountered at the site. In addition, concern that low shearing resistance of the existing soils may cause edge instability and subsequently mushrooming of the tank shell around the perimeter of the tank. Geopier Rammed Aggregate Piers were installed at spacings of 6.5 feet on-center to reinforce the clay fill, support the high bearing pressures of the tank, control settlement, and increase the factors of safety against edge instability. The installation involved hurdles including stringent safety requirements, construction within a containment levee, restricted site access, and the presence of underground piping and obstructions.

Problems with settlement and edge instability on an existing 150-foot diameter, 50-foot tall tank at the Kinder Morgan Liquids Terminal Facility led project engineers to a

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solution incorporating Geopier Rammed Aggregate Piers installed around the perimeter of the tank to reinforce the variable clay fill and reduce the potential for future edge instability and settlement as a result of lateral and vertical deformation by confining the soils beneath the tank. Design issues included the development of a solution that would increase the shear resistance around the perimeter of the tank, while allowing the tank to remain in service. Construction challenges included installation of piers with limited access and in close proximity to the existing tanks along with poor weather conditions.

Construction of a new four-story residential structure and wrap-around parking garage in Houston on highly variable soil conditions consisting of native stiff clays to highly variable soft to medium-stiff clay and clayey sand fill presented many challenges including the question of how to support the foundations. With competition from 24-inch driven concrete piles and 18 to 24-inch augercast piles, the column loads of up to 660 kips and strip loads of up to 23 kips per foot were supported on Geopier Rammed Aggregate Piers extending between 14 and 20 feet below footing bottoms. Design issues faces on this project included the prediction of estimated total and differential settlements on a site consisting of both variable fill and stiff native clay. Construction challenges included installing the piers in the variable fill soils.

The construction of new Mechanically Stabilized Earth (MSE) walls imposes high bearing pressures on soils and may lead to global instability, bearing capacity failures, or excessive settlement. The design of walls along the Westpark Tollway in Harris County indicated that problems with bearing capacity, global stability, and settlement may be realized for wall heights in excess of 12 feet. In order to achieve allowable bearing pressures of 6,000 psf with a factor of safety of 2, global stability factors of safety of 1.3, and settlement control of less than 2 inches, Geopier elements were installed beneath wall heights ranging from 12 feet to 32 feet tall at spacings on the order of 7 to 11 feet on-center. The installation of almost 400 Rammed Aggregate Piers in 2 weeks allowed for the project to remain on schedule even though the installation was hindered by construction within a busy intersection and the presence of underground obstructions.

This paper is of particular significance because it presents design details and local applications for a new and innovative foundation system that saves both time and money.