Rammed aggregate pier ground improvement

Structural and geotechnical perspectives on two projects

By Rimas M. Veitas, P.E., SECB

Rammed aggregate pier (RAP) systems have been used in New England for nearly a decade by engineers and contractors needing to solve unique geotechnical and structural foundation support challenges. System construction involves compaction of thin lifts of high-quality aggregate or recycled concrete — green alternatives — using a patented ramming process to form high-density aggregate piers. The vertical ramming actively increases the lateral stress and improves the stiffness of the soil surrounding the pier. The piers are used to provide increased bearing pressure and settlement control for foundations and floor slabs.

The following project summaries provide examples of effective RAP ground improvement, from both a structural and geotechnical perspective.

Orange Hall, Salem State College

The geotechnical conditions encountered at the site of the new five-story, steel-framed Orange Hall consisted of up to 9 feet of fill soils, underlain by as much as 3 feet of peat and organics followed by marine clay.

To deliver acceptable performance under maximum loads of 760 kips, the design team considered a variety of options, including massive excavation and replacement, pile foundations, and a RAP solution. The team's review found that the RAP option was less costly, reduced risk of exposing contaminated fill, and minimized vibration concerns to an immediately adjacent laboratory. In addition, Orange Hall was to be located adjacent to an existing Salem State College dorm building, which was supported successfully on a RAP system from Geopier in 2003.

The RAP solution provided foundation support for axial column loads up to 760 kips, which were designed for bearing pressures up to 7,000 pounds per square foot (psf). Additionally, the moment frames were designed with fixed bases, which developed moments in the spread footings. The RAP elements were arranged beneath the shallow foundations so that the induced moments were resisted by the RAP elements in conjunction with the vertical gravity loads. In addition to foundations, the unreinforced slab-on-grade was supported on an approximate 10-foot by 12-foot grid of RAP elements. Control joint spacing was coordinated with the locations of RAP elements in the design. All piers were installed to penetrate completely the poor fill and organic soils to terminate in the marine clay.

The nearby laboratory building, located within 30 feet of the new construction, housed a tenant with vibration-sensitive equipment. A vibration monitoring system was implemented during construction to monitor RAP installation. The monitoring indicated that the high-frequency ramming during RAP installation produced only minimal vibrations and did not disrupt the sensitive equipment operation.

The use of RAP technology allowed the foundations to be designed on high-capacity conventional spread footings, eliminated the possibility of a structural slab and associated shop drawings, reduced the potential for contaminated fill disposal, accelerated the construction schedule, and eliminated vibration issues to an adjacent tenant.

The site of the new five-story, steel-framed Orange Hall consisted of up to 9 feet of fill soils, underlain by as much as 3 feet of peat and organics followed by marine clay; but successful foundations were easily designed using a RAP system.

Dimella Shaffer

Preferred freezer warehouse

The site of an 84,000-square-foot refrigerated freezer addition in Chelsea, Mass., was underlain by up to 14 feet of contaminated urban fill and several generations of old foundations. The fill was underlain by up to 7 feet of organic silt and peat in approximately half of the site. The fill and organics were underlain by stiff clay or medium dense sand and dense glacial till.

The geotechnical challenges on the site involved providing a support solu-

tion that addressed the contaminated fill, buried foundations, and compressible organic layer. The structural challenge was to economically support a freezer rack system with imposed equivalent uniform pressures of 1,200 psf.

Exploratory test pits confirmed that buried foundations were extensive at the site. Although a pile and structural slab system was evaluated, corrosion protection for the piles combined with the cost of a structural slab proved to be cost prohibitive. An alternative solution involved RAP elements for support of a slab-on-grade.

Prior to pier installation, the site was excavated to 10 feet below grade to remove the existing foundations, which were then crushed, mixed with the existing contaminated fill, and placed back into the excavation in compacted lifts to avoid the expense of fill removal. The piers were then installed to reinforce the fill and organic soils.

RAPs were installed to reinforce the fill and organic soils so that the team could economically support a freezer rack system with imposed equivalent uniform pressures of 1,200 psf on a warehouse project in Massachusetts.

Once the racking system location was finalized, the RAP elements were designed to be directly below the rack legs to support a maximum load of 35 kips. Layout of the piers to provide support at the heavy rack load locations allowed the use of a 6-inch-thick conventional slab-on-grade which could also support the fork lift and pallet loading of up to 350 psf. Piers were spaced on a 9-foot grid pattern to support slab pressures of up to 350 psf in the non-high bay rack areas. The presence of new structural fill at the site placed over the piers also allowed for more uniform support of the floor slabs. ▼

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