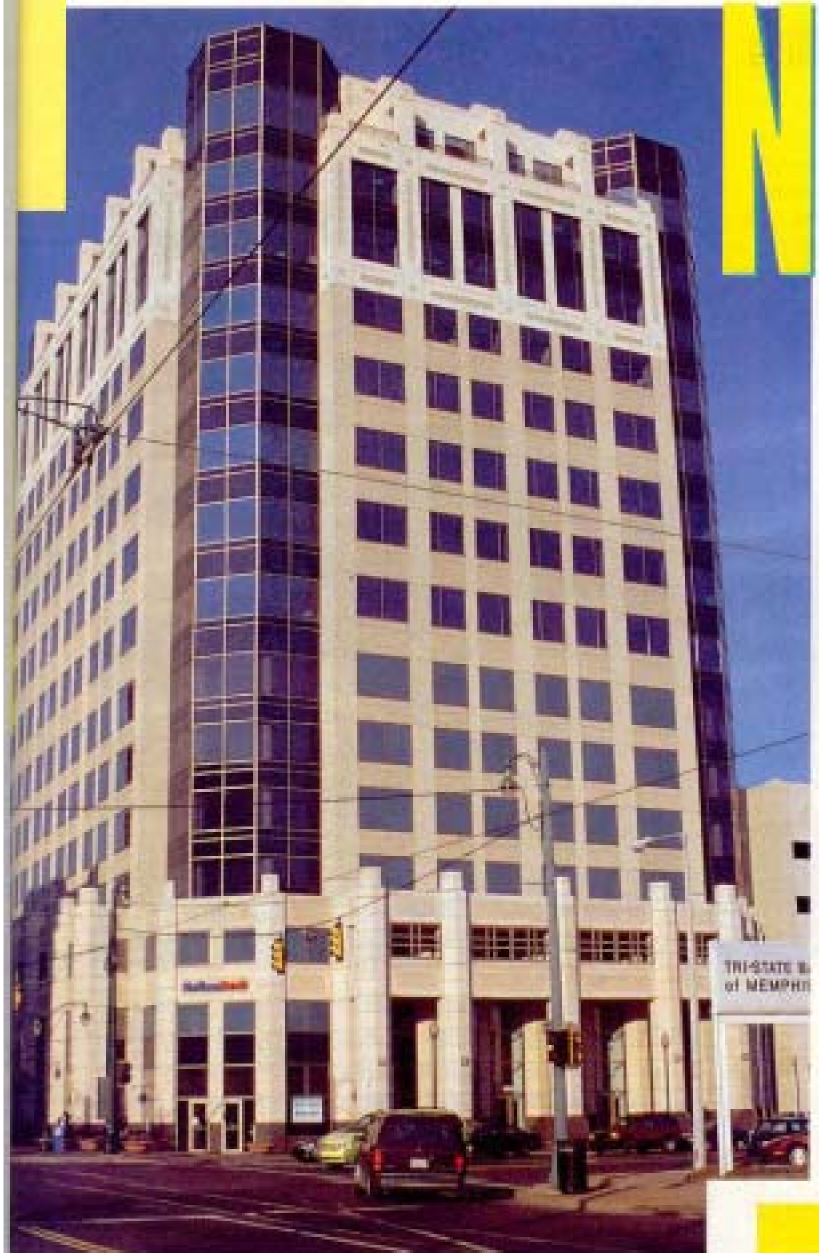

No more piles

American company Geopier Inc. claims to have developed an alternative foundation system for soft soil sites which may eliminate the use of deep piles, caissons and over excavation and replacement filling.

A recently introduced intermediate foundation support method, best described as a combined soil enhancement and structural element system is claimed to improve significantly on standard foundation technologies by cutting costs and reducing the amount of over excavation on site.

Short aggregate piers, developed by the Geopier Foundation Company Inc. in the US, can be used as an alternative to traditional foundation methods such as cast-in place drilled shafts or driven piles which may be up to 30m deep or massive overexcavation which can require depths of up to 10m. The company claims that with its system, drilled excavations for the "Rammed Aggregate Piers" are usually less than 5m deep.

A Geopier intermediate foundation element is a dense aggregate pier constructed in a pre-excavated cavity with patented equipment that imposes significant lateral pre-stress into the undisturbed soils surrounding the element. The combination of constructing the piers in pre-excavated cavities and lateral stress build-up that results from the patented ramming equipment, are claimed to be the key elements that set the Geopier system apart from other aggregate pier or stone column systems.

Pier cavities are typically excavated by conventional drilling techniques, using either truck-mounted auguring equipment or "dangle drill" equipment mounted on an excavator or crane. The cavities for the elements in this system typically range from 450mm to 900mm in diameter, and the elements themselves are constructed in lifts of approximately 300mm thickness. Each lift is rammed vertically and laterally using the special tamping device, and within 15 seconds of this operation, it is claimed that a lift can receive over two times the compactive energy that is put into the maximum density laboratory test (ASTM 1557).

Geopier elements - vs - stone columns

	Stone columns	Geopier
Primary use	Support for extremely flexible structures (embankments, tanks, wood frame buildings)	Support for rigid semi-rigid, and structures (all types of buildings, embankments etc).
Typical length	4.5m to 15m	2.0m to 4.5m
Typical L/D ratio Length/diameter	6 to 20	2.5 to 6
Typical allowable footing bearing pressure for foundation design	25-250kPa	200-500kPa
Typical spacing (on centres)	4 times diameter	1.5 - 2 times dia.
Lift thickness during construction	1.5m to 3m	300mm
Verification testing	Typically not done	* Full scale pier load test * Dynamic penetration testing during construction

Typical design parameters

	Stone columns	Geopier
Stiffnes ratio Pier to matrix soil	2.5 to 5	8 to 45
Density	1.92Mg/m3 to	8.74 to 9.42 Kg/m³
Void ratio	0.4 - 0.7	0.07 - 0.23
Phi	35 to 40 degrees	45 to 55 degrees

With the use of a casing, Geopier elements can be constructed below ground water in all soils ranging from peat to loose clean sands to soft clays. The aggregates used for pier construction are typically high quality crushed rock of the type often used for highway base course construction. Lower quality material can be used as long as the compacted characteristics are relatively uniform and are defined by field testing. For liquefaction migration, free-draining aggregate can be used allowing the system to operate also as a drain to relieve excess water pore pressures.

The company claims that since the elements are constructed in pre-excavated cavities, there is essentially no re-moulding of the surrounding soils, as can occur with techniques that involve complete soil displacement. This means that the surrounding soils cannot experience long-term strength loss due to the construction methods, but rather gain a significant increase in stiffness as each 300mm lift is rammed.

By constructing the elements in clusters, spaced from approximately 1.5 to 3 times the diameter apart, the Geopier reinforced soil mass experiences significant permanent prestressing, which greatly improves its strength and consolidation characteristics .

The system is suitable for any application where a significant increase in stiffness and/or shear strength of a soil mass will improve engineering performance. This includes: spread footings - increase in bearing capacity and reduction of settlement; floor slabs/mats - improve sub-grade uniformity and reduce settlement; slopes - increase in factor of safety for stability; increase in lateral load resistance and in uplift anchor resistance.

Case in point

The Ice House in New Jersey, USA comprised a two-storey reinforced concrete building containing four full size hockey rinks under one roof. The site conditions were solid waste landfill.

The geotechnical investigation for the project including four borings within the proposed building area, and indicated that conventional spread footings were feasible for the perimeter walls, although special foundation treatment was recommended for heavily loaded columns. One of the boring logs made casual mention of "a little glass debris". The Geopier system was selected to provide foundation support for the heavily loaded columns.

Due to the structural loading, a field modulus test was scheduled on a test foundation element.

When the test drilling started, it became apparent that the site subsurface conditions varied substantially from what was indicated in the geotechnical borings and that the site was actually an old solid waste land fill. Additional drilling around the site revealed the soil profile to be 125mm thick sandy soil mantle underlain by about 4.2m of continuous solid waste which included substantial amounts of glass, metal, concrete debris, wire, car tyres and other parts of old vehicles. Groundwater occurred near the top of the landfill debris. Beneath the landfill was a native clay soil formation.

Once the actual site subsurface conditions were defined, the field modulus test was completed on one Geopier element, and the original foundation design was revised to accommodate the known site conditions. The revised design included installation of 750mm diameter elements beneath all foundations. All piers penetrated

through the landfill debris and terminated in the underlying native clay formation.

Field observations over a two-year period since the building was constructed had revealed that foundation settlement has been controlled to less than 25mm.

This example project is atypical in the fact that poor materials were penetrated by the Geopier elements. In 90% of all Rammed Aggregate Pier jobs in poor soils, piers remain within the poor soil layer and do not need to penetrate the poor soil zone to extend to a better soil layer. The exceptions are in peat soils and solid waste landfills.

ENQ: 174