

Case Study

Saudi Arabia

Ethylene Plant : 2008

Foundation Failure : Subsidence

Ground Conditions : Previous foundations consisting of Vibro Stone Columns
Natural Stone combined with waste steel slag.

Options : Auguring and conventional piling proved unsuccessful.
SEA-Tech Drill Bar System Chosen by Contractor.

Contractor : Roger Bullivant Saudi Arabia Ltd.

Introduction to SEA-Tech Drill Bar System :

SEA-Tech Drill Bar is a roll-formed threaded hollow tube that is sectional and is connected together with couplers. It has a cutting head at the leading end that has two functions.

1. Firstly it is the drill string that operates in rotation percussion mode whilst concrete grout is continually pressure delivered through the cutting head—It acts as a tremmie.
2. Secondly when the SEA-Tech Drill Bar is installed to the required depth it forms the reinforcement all within one efficient operation, therefore the following installation steps become redundant with significant on site savings:
 - a.No removal of the drill/auger string required.
 - b.No need for the installation and removal of drill casing.
 - c.No insertion of an anchor rod or reinforcement cage.
 - d.No removals of large amounts of drill spoil.

The cutting heads and Drill bar diameters can be selected from 5 basic sizes to suit the ground conditions and the load capacity required. Loads from 2 to 150 tons can be achieved.

The unique method of pressure concrete grouting with this system means that there is an excellent bond with the ground to the pile grout and the pile grout to the Drill Bar. SEA-Tech Drill Bar is not restricted by ground conditions; it can be used in rock, hard shale, and in dense or soft sands and in ground containing obstructions.

Installed SEA-Tech Drill Bar can by design take the load on skin friction, or where required it can take load by being drilled into rock forming a rock socket and can be used to take loads in tension or compression.

With SEA-Tech Drill Bar running full depth there are no problems with continuity of reinforcement and it guarantees the working loads are transferred throughout the length of the pile or anchor.

SEA-Tech Drill Bar system can use several flushing techniques such as Air, Water, Grout or Concrete. In some ground conditions it is possible to use a combination of these flushing techniques for the construction of any one pile or anchor.

Special precautions are taken with contaminated ground and the removal of disposal of contaminated spoil. SEA-Tech Drill Bar can be used in groups, to accommodate very high loads.

The client Shaw Stone & Webster had noticed excessive settlements in some recently constructed structures at area 2100 of the Ethylene Plant. The structures affected were pipe rack foundations, a surge basin, and cable trenches in the vicinity of a newly constructed drainage sump.

A ground investigation carried out before construction showed the site was made up of medium to very dense sand and silts with SPT ranging from 20 at 2.0m depths and up to 100 at 10m depths. Before construction of the pipe rack foundations the ground had been improved using vibro stone columns. The columns had been constructed using a mixture of natural crushed stone and crushed slag from a nearby steel works.



View of Area 2100 looking down from East to West on the South Side of the Pipe Rack

Initial investigation showed that the pipe rack bases had settled up to 800mm and there were voids underneath the cable trench and surge basin. It was believed that the de-watering operations had washed out some of the subsurface soils causing the voids under the cable trench and surge basin thus resulting in the collapse of some of the stone columns, leading to the settlement of the pipe rack foundations.

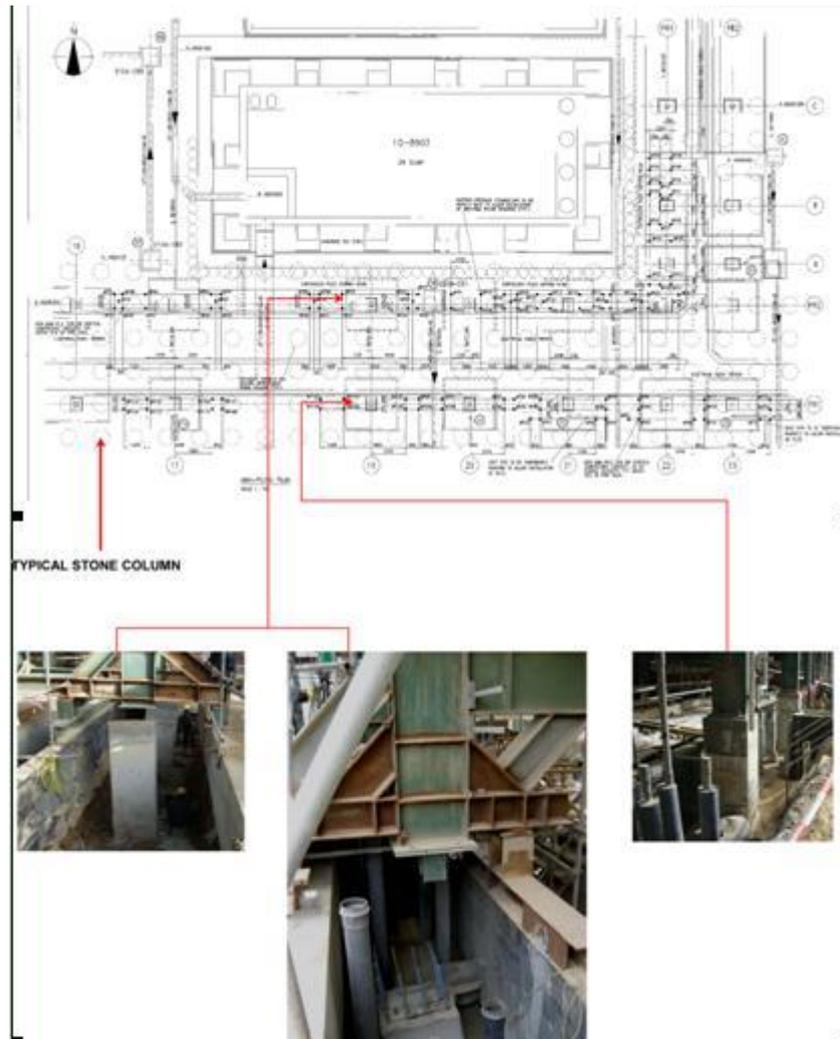
In order to determine the extent of the affected area the contractor carried out further site investigation at 35 positions, taking SPT readings every 250mm down to depths of 6.0m. Readings as low as 3 and 4 were recorded at depths of 2.0m and 3.0m confirming the soil strengths had been greatly reduced by the

effects of dewatering operations.

As a result of these tests the contractor proposed pressure grouting to fill the voids beneath the cable trench and surge basin, mini piles to support the effected pipe rack foundations and soil mixed grout columns to strengthen the soils under the surge basin. The contractor worked together with SSW to develop a design that lead to the installation of one hundred and nine min-piles to the pipe rack foundations,. A further fifty-three mini-piles were required with soil mixed grout columns to the surge basin together with pressure grouting works. The SEA-Tech piles used for this installation ranged from 200kN to 300kN and were installed to a factor of safety of 2.5 to depths up to 15.0m.

THE PROBLEM

Settlement to Pipe Rack support bases.



EQUIPMENT & DRILLING TECHNIQUES

Klemm 701 Drill Rig.

The rig was fitted with a drifter, this was chosen in the event that a stone column was encountered during the drilling process.

The contractor had 2 options available for cutting heads firstly the SEA-Tech cross bit, this cutting head would prevail in the dense sand environment, the other head was a SEA-Tech button head bit, this bit would and proved to be more efficient when encountering the steel slag in the stone columns, normally this type of bit is used for drilling through rocks/stones etc.

The rig itself is in two sections, the drilling unit and the power pack, because access differed on this site we were able to split the two sections and connect them back up by using 30mtr extension hoses.

The photographs show the rig working as a single unit with the Power Pack isolated in another location and Rig & Power connected as a single unit.



Because of the depth of the foundations for the pipe racks it was decided that the contractor would build a drilling platform using scaffold, wood planks and plywood sheets. All this was carefully designed so as to take the loads of the Rig that weighed a total of 5 Tons, when split the Rig was 3.5Tons and the Power Pack Unit 1.5Tons. This allowed for continuity of production, once the SEA-Tech piles had been constructed, the scaffold would be dismantled and used again for areas in front of the rig.



Access from ground level to the drilling platform was provided by ramps. These ramps were constructed strong enough to allow the rig to track up and down them. We did have the availability of heavy duty cranes on site, however because the overhead lines had been made live during our operation, it was decided that this was going to be the safest method of getting to the drilling platform.

GROUT EQUIPMENT

A Putzmeister P.11 Pump was used on this project to supply the pile grout directly to the Rig. Pressures from this pump are achieved through resistance and pressures up to 15 bar can be attained. A pressure gauge was installed inline on the drill rig itself allowing the rig operator to control grout pressures, as he deemed necessary.





DRIFTER HEAD

Grout is delivered from the pump via a grout intake hose to a flushing bottle situated directly below the drifter head on the drill rig. From the flushing bottle the grout is pressured down the center of the SEA-Tech drill bar to the cutting head.

FLUSHING BOTTLE

GROUT INTAKE HOSE

SEA-Tech DRILL BAR

Once groups of piles had been constructed and cured, they were systematically cut down to required depth. Plastic casing had been used for different reasons, for example on Grid Line PR1 17-23 (shown below) the plastic casing was used as a temporary support of the upper fill of 1mtr depth from G/L.



200mm diameter SEA-Tech Drill Bar piles, cured and ready for cropping

200mm diameter SEA-Tech Drill Bar Piles, cropped



On Grid Line PR2 17-23 (shown below) the plastic casing was used as a temporary support of the upper fill of 1mtr depth and extended up to the temporary drilling platform level some 3m+ above.



150mm diameter plastic casing positioned ready for the SEA-Tech 115mm diameter drill bar pile construction.

SEA-Tech 115mm diameter drill bar piles constructed, cured and ready for the cropping procedure.



Reinforcement being placed for PR1-21. Bars drilled through the existing plinth transfer the load to the new piled foundation.

Foundation to PR1-22&23 in the back-ground and to the right is ready for casting

The new foundation is cast over the SEA-Tech drill bar piles and is cured ready for backfill to be placed.

PILE TESTING



Because two different size piles were used on the project, two Pile tests were undertaken. A local independent consultant oversaw the tests.

The tests undertaken were as follows:

- SEA-Tech 115mm Diameter (Drillbar 40mm Diameter)
- SEA-Tech 200mm Diameter (Drillbar 90mm Diameter)

