500 KL TANK (LITTON MILLS)
Jet Grouting Works
Amang Rodriguez Avenue, Rosario, Pasig City

Description: A 30m dia. 500 KL Fuel Storage Tank of Litton Mills was experiencing settlement and was tilting on one side.

Ocular observations revealed the presence of cracks on the concrete pad suggesting distress due to settlement.

Subsurface Conditions: The results of the subsurface soil exploration conducted at the site indicate the presence of relatively very poor soil to -5.0m below existing Natural Ground Line (NGL). These are very soft brown lean clay (CL) with sand to brownish gray to gray very loose to loose silty sand (SM).

Design Details: Two Underpinning Procedures were considered to at least guard against tilting or toppling of the Tank, namely: Micro Piling and Jet Grouting.

The client finally chose Jet Grouting, which proved to be the more cost effective option as it does not require a complex connection detail that micro piling needs in order to effectively underpinned the Tank.

16 Jet Grouted Piles were installed around the circumference of the 30m dia. Tank, (4) of which were treated with expansive in order to somewhat negate the differential settlement.

Client: Pilipinas Shell Petroleum Corp. (PSPC)
Owner: Litton Mills
Reference: Mr. Greg Sarmiento - Pilipinas Shell Petroleum Corp
GLOBE TELECOM (MSC1 BUILDING)
Jet Grouting Works
Vito Cruz Extension cor. Balagtas Street, Makati City

Description: The 4 Storey Globe Telecom Office Building was experiencing distress as evidenced by the visible cracks on beams and CHB walls due to additional loads (cell site batteries and telecommunications switching equipment) which are being stored but were not considered in the design.

Subsurface Conditions: Underneath the 150mm thick concrete slab up to -3.0m is a fill of dark brown, non-plastic medium dense silty sand. The natural deposit immediately under the fill consist of light gray to brown non-plastic to low plasticity silty clay up to -7.0m. Sand at about depths of -7.0 to -11.0m and silty clay up to the depth of -13m. Although the SPT values are fairly high there are pockets of loose silt at -12m.

Bedrock was encountered at depth -16.5m.

Design Details: The choice for the underpinning/retrofitting was narrowed down to Micro Piling and Jet Grouting, but due to space constraints especially the limitation of the Headroom and problems associated with connection effectiveness to the existing footings, the Client opted for Jet Grouting. The design called for the Installation of 108 JSP positions to effectively carry the additional loads.

Owner/Client : Globe Telecom
Consultant : DCCD Engineering Company
Reference : Mr. Emilio Daniel Tible - DCCD
SOUTH OF MARKET (SOMA)
Slope Protection Works by Soilnailing
Fort Bonifacio Global City, Taguig, Metro Manila

Description: The Project consists of providing slope protection for the excavation works for the Proposed 38 Storey Structure having four (4) level basement within the Fort Bonifacio Global City, Taguig Metro Manila.

Subsurface Conditions: The soil exploration showed superficial deposits of detrital soils consisting of silty sand (SM) at least 1.5m thick and highly weathered rock layers. Along other areas, the sedimentary rock (siltstone formation) is mantling the surface. The underlying formation is predominantly siltstone with intervening sandstone layers.

Design Details: Temporary support for excavation was necessary to ensure safety and prevent collapses.

The design consist of shotcreting an area of 1,422 sq.m. along the perimeter of the excavation extending 6.0m from the Natural Ground Line (NGL) including installation of about 356 pcs of 25mm dia. x 12.0 m length of soil nail.

Owner/Client : Meridien East Realty & Development Corp.
Reference : Arch. Roland Rodas, VP - Operations
Description: The 18 x 35 x 1.2m thick Mat Foundation for the Proposed J.T.A. Boiler Building for the Binalbagan Isabela Sugar Company Inc. needs to be supported due to the very poor soil of the proposed location. Driving of Precast Piles was halted due to the heavy vibrations encountered which could adjacent boiler building threaten the adjacent Boiler Building through settlements of loose sands during driving.

Subsurface Conditions: Based on the vertical soil profile drawn from each borehole, the make up of the sub-surface soil of the proposed Boiler, consist of about 6.0meters soft/loose clayey (CL) and silty sands (SM), underlain by about 9 meters very soft elastic silts (MH) and clayey sands (SC), resting on medium to very dense silty sands (SM) and rock flour (ML) up to the end of borehole. Water table was observed at 18 ft. (5.5m) from the ground.

Design Details: The original foundation-support proposed were 400 x 400 concrete driven piles. However, with only 4.0m of driving the concrete pile, it was discontinued due to the vibration/disturbance it was causing the adjacent structures particularly the existing Boiler Building.

It was then that Jet Grouting was considered as a cost effective alternative without the attendant vibrations. A total of 61 JSP position were successfully installed for a period of 30 days.

Client : BISCOM Inc.
Consultant : John Thompsom & Associates
Reference : Engr. Emma Dael - Plant Manager, Biscom Inc.
SOHO CENTRAL
Slope Protection Works by Soilnailing
Edsa Central, Shaw Boulevard, Mandaluyong City

Description: The Project consists of providing slope protection for the excavation works for the Proposed 40 Storey Structure having four (4) level basement located at Soho Central, Shaw Boulevard, Mandaluyong City.

Subsurface Conditions: The soil exploration showed superficial deposits of residual soils consisting of silty clay (CH) and silty sand (SM) at least 1.5m thick. Along other areas, the sedimentary rock (siltstone formation) is mantling the surface. The underlying formations generally consist of siltstone and sandstone layers.

Design Details: Temporary support for excavation are necessary to ensure safety and prevent collapses.

The design consist of shotcreting an area of 1,186 sq.m. along the perimeter of the excavation extending 5.0m from the natural ground line (NGL), including installation of about 354 pcs of 28mm dia x 6.0 length of soil nail.

Owner/Client: Meridien Development Group Inc.
Reference: Arch. Roland Rodas, VP - Operations
Description: A pier supporting 60 m long span Precast Concrete Box Girder for a light rail transit crossing a river experienced significant settlements immediately upon placement of the Girders (Dead Load). The pier is supported on six (6) 1500 mm diameter bored piles designed to be socketed into the bedrock at least 2.0 m based on design requirements. The structure started to settle during the erection of the superstructure, with an initial settlement of 36mm for a dead load of 700 metric tons to a maximum settlement of 45.7mm for a load of 1600 metric tons at the time construction was halted. The pier was designed to carry a maximum total load of 2100 metric tons.

Subsurface Conditions: The check boreholes BHs 1 & 2 revealed that the overburden soils are relatively poor to very poor below 7 meters and consist of clays and silts down to about 15.0 meters and slightly sloping. The upper layers are essentially sands, which have been precompacted by traffic and various construction activities in the vicinity.

Underlying this thin overburden sandy layer is a soft to very soft layer of clays and silts which needed to be bypassed by the Bored Piles to transfer the foundation loads to more competent rock.

The Borings through the installed Bored Piles revealed that the tip of the Bored Piles were not socketed nor even resting on the bedrock as specified. A clear gap of about 200mm between the tip and the bedrock is filled with soft clay and possibly drilling mud.

The RQD values below the soil bedrock interface showed relatively fair values of 19% and 16% respectively. Average Bedrock Unconfined Compressive Strengths are about 20.0 kg/cm² near the Bored Pile Tip characteristic of soft volcanic sedimentary rock known as the Guadalupe Tuff Formation (GTF).
**Design Details:** The confirmatory borings BH 1 & 2 verified that the Bored Pile Tips were resting on very soft soils or on highly weathered bedrock and were not adequately socketed as required by the design.

Several remediation measures were discussed and these were narrowed down to two feasible technologies: Micropiling and Jet Grouting.

The Micropiling was finally ruled out due to large lateral forces involved, which would have required extensive use of reticulated Micropiles and extensive drilling through the heavily reinforced 1500 mm pile cap. The installation alone would unavoidably cause cutting of numerous rebars in the critical areas of the pile cap. In addition, Micropile connection integrity was put to question.

The Jet Grouting solution was finally selected because it offered a far better assurance of stability during seismic loadings and also reduced damage in the pile cap rebar.

The solution consisted of installing 44 Jet Grouted Curtain Wall in secant pile arrangement around the footprint of the pile cap, including two cluster of 3 JSP in the interior. These were intended to fully take up the load on the bored piles during service loading effectively relieving the bored piles of any loads.

In addition, each of the Jet Grouted Piles were reinforced at the center by 25 mmø rebars, which were inserted by redrilling the Jet Grouted Pile after it has sufficiently cured, and extending this 2.0 meters beyond the Soil/Bedrock interface into competent Bedrock. The drilled hole and dowel bars were subsequently regouted effectively doweling each JSP into the Bedrock.

Also, the Project Consultants required that the existing Bored Piles be redrilled at the center to allow for the insertion of Grouting pipes in order to grout the pile tip. Jetting was done to wash away the remaining soft clay on the now hanging bored pile and jet grouting with rich grout was done. This would ensure that once the “Soilcrete” had cured, the Bored pile tips would be resting on solidified ground.

This added measure partially restored the load carrying capacity of the bored piles allowing it to contribute to the overall load capacity rather than just hang as “deadweight” from the pile cap.

The Jet Grouting remediation turned out to be effective in arresting the settlement with minimal disturbance to traffic and the surrounding houses and commercial establishments. It also ensured the lateral stability of the substructure due to earthquake loading, which was a primary concern.

The innovative remediation process instituted successfully arrested the settlements and restored the Pier to full serviceability.
General Contractor : Hanjin Itochu-Joint Venture
Consultant : MMLRT Consultants
Owner : Republic of the Philippines - Light Rail Transit Authority
Reference : Mr. Tae Hee Lee, Hanjin Heavy Industries & Const. Co., Ltd.
**SHELL PASACAO INSTALLATION TANK FARM**

**Slope Protection Works**

*Shell Pasacao Refinery, Camarines Sur*

**Description:** The Peripheral Bundwall of the Tank Farm at the Pasacao Depot is a riprapped Slope embankment about 4.5m high from the finish grade of the Depot office.

Ocular inspection shows cracks on the lateral surfaces of the existing riprapped embankment which would indicate ground movement and may collapsed if not remediated.

**Subsurface Conditions:** The result of the recently completed Subsurface Soil Exploration revealed a layer of very poor overburden fat clay (CH) immediately underlain by limestone and shale bedrock.

The poor overburden clays consisting of 5.0 meter thick very soft to medium stiff layers with N values ranging from 10 bpf to 23 bpf extending to within 10m from NGL.

The underlying limestone and shale bedrock possess Rock quality Designation (RQD) values generally ranging from 21% to 91% with an average of 61%. Unconfined Compression Test results from extracted core samples indicate rock qu values ranging from 696 Kpa to 2,000 Kpa with an average rock qu value of 1350 Kpa.

**Design Details:** The remedial measure consists of the installation of 32mm dia. x 1,902 lm of soilnail and the shotcreting of the existing marginal slopes of the Tank Farm or an area of about 431 sq.m. in order to stabilized the area of the Tank Farm Slope.

*Client:* Pilipinas Shell Petroleum Corp.

*Reference:* Mr. Chino Manalo
Description: The project consists of providing slope protection for the excavation works along the proposed Kapitunan underground sub station.

Subsurface Conditions: The Soil exploration showed superficial deposit of residual soils consisting of silty sand and conglomeratic siltstone (fractured) at least 1.5m soil thick. The underlying formation is generally moderate to highly weathered rock layers.

Design Details: The design called for the installation of about 7,730.5 lm of varying diameter soilnail on both faces of the excavation along the route of the underground tunnel and shotcreting the face of the excavation at varying depth from the Natural Ground Level (NGL) or about 6,690.497 sq.m.

General Contractor: Hanjin Itochu-Joint Venture
Consultant: MMLRT Consultants
Owner: Republic of the Philippines - Light Rail Transit Authority
Reference: Mr. Tae Hee Lee, Hanjin Heavy Industries & Const. Co., Ltd.
Description: Available records show that the town of Paete was founded in 1580 by the Rev. Jose de Plascencia, as Spanish missionary. The significant dates on the Paete church are as follows:

- 1646 - construction of the stone church and convent
- Before 1777 - stone church was ruined
- 1717 - construction of a stronger church by Rev. Francisco dela Torre
- 1880 - earthquake destroyed the church
- 1884 - church was re-built by Rev. Pedro Galiano, O.F.M.
- August 20, 1937 - earthquake destroyed the church
- 1939 - church was re-built

The Church has since been declared a historical landmark and its continued preservation is a concern of the National Historical Institute. In view of its history of destruction during earthquakes the NHI requested a soil investigation project to assess the need to strengthen or improve the foundation as part of an overall effort to enhance the chances of survival of the structure during major earthquakes.

Subsurface Conditions: Based on the borings and laboratory test results soil profiles were drawn along two sections, A-A and B-B, presented in Figures 5a and 5b. It is immediately evident from these profiles that the subsurface consists broadly of three stratigraphic units designated and described as follows:

Layer A: Fill – consisting of mixtures of clay, silt, and coarse particles ranging from sand to cobbles; fragments of red bricks and lime are also present; its thickness varies from about 1.5 to 2.0m but it is almost uniformly 2.0m thick along section A-A; in place, its density varies from loose to very dense.
Layer B: Silt and clay sediments with gravel and sand; soft to very stiff consistency; its thickness is about 3.0m along section A-A but along section B-B it varies from 1.5m to 3.0m.

Layer C: Deposits of gravel, cobbles and boulders with sand and clay prevail in this layer; owing to the location of the site relative to the steep mountain range in Paete such deposits are expected; core recoveries indicate basaltic lava which is occasionally vesicular in structure.

Groundwater is at 1.5m depth and is higher than the stream level at the creek nearby. Fairly strong recharge was noted during the excavation of the test pits for which reason deeper excavation was not attempted.

**Design Details:** The solution chosen for the Foundation Retrofitting Works is Jumbo Special Piling (J.S.P.) 24 positions 800 to 1,000mm diameter x 6.0m were successfully installed to stabilize the facade of the Paete Church and thus reduce the chances of foundation related failures.

**Owner** : Republic of the Philippines - National Historical Institute

**Reference** : Mr. Serafin D. Quiazon - Chairman & Executive Director III