ACEI Design Excellence Awards 2018
Nomination Form

Category (1) Bridges
Category (2) Other Civil Projects
Category (3) Innovation Project (all disciplines)
Category (4) Overseas Project (all disciplines)

Company Details

Contact Name: **Paul Doherty**

Firm: **Gavin and Doherty Geosolutions Ltd. (GDG)**

Address: **A2 Nutgrove Office Park, Rathfarnham, Dublin**

Tel: **01-2071000** **Email:** **pdoherty@gdgeo.com**

Categories/Groups:

Project Category: M & E ☐ **Innovation** X **Overseas** ☐

Project Group:
Small project (under €2.5m) X **Medium project** (€2.5m - €10m) ☐ **Large project** (over €10m) ☐

Note – The foundations were undertaken as a single contract with an estimated construction value of €1.8 million and as such we have classified this project as Small.

Project Information:

Name of Project: **Gamlestads Torg, Gothenburg**

Location: **Gothenburg, Sweden**

Commencement date: 2015 **Completion Date: 2017**

Client: **Sigma Civil AB**

Contact: Nicholas Lusack (Head of Geotechnical Department)

Email: nicholas.lusack@sigma.se Tel: +46 761 04 06 39

Design Team:

Architect Civils Project – N/A

Contact Email: N/A Tel: N/A

Contractor Serneke Construction Ltd (Contact: Fredrik Jonsson)

Contact Email: *Fredrik.Jonsson@serneke.se* Tel: +46 31712 97 52

Authorisation to contact above: Yes X **No** ☐

Project Details:

(1) Provide a brief outline of the project (Max 200 words):

GDG was commissioned by Sigma Civil to conduct an extensive study, analysing the effects of pile driving in extremely soft clay for a development in Gamlestad, Gothenburg. The proposed development comprised 3 buildings up to 18 stories in addition to basement levels, built on a highly constrained site. This heavily loaded structure is the largest building in the area and dwarfs any surrounding structures. The development acts as a transport hub interlinking trains, trams and buses connecting the eastern parts of Gothenburg. The site is bounded by;

- the Gamlestad bridge (supported on piles) to the west
- the River Säveån and the Partihallen viaduct to the South
- neighbouring works by Trafikkontoret which included new tram tracks on elevated piers.

A planning requirement prior to construction commencement was to undertake a comprehensive ground movement analysis to confirm the impact of the foundation installation on highly sensitive adjacent infrastructure. This task required a highly innovative engineering approach.

Figure 1 Architectural rendering of the proposed development

GDG's primary geotechnical challenge was to accurately predict lateral soil displacement due to driving 300No. 300mm reinforced concrete piles driven to 40m below ground in extremely challenging soft soil conditions. This was the highest risk item on the project.

Figure 2 Aerial photo of the triangular shaped piling site bounded by railway bridge, river and tram lines

(2) Provide a statement regarding why this project might be considered award winning: (Max 300 words):

- Ground conditions on-site represented one of the most challenging soils that exist worldwide, with extremely soft clay extending to more than 40m depth, necessitating extensive piling works. The strength of these Swedish clays is similar to soft peat strengths experienced in Irish bogs.

- The foundation comprised 300 precast concrete piles. The installation of this number of piles in soft clay would cause the site expansion laterally, stressing existing foundations of adjacent structures. Authorisation to start construction could not be secured until a ground movement prediction was carried out and the risks fully quantified. Other consultants approached by the client were unable to solve this issue. GDG provided solid engineering insight into predicting ground movements to ensure adjacent infrastructure would not be affected. As a result of our precise analysis, the project was authorised to proceed.

- GDG succeeded to accurately model the construction sequence and pile installation to quantify the level of interaction between new piles and existing construction. The analysis also helped us advise certain mitigation measures during piling.
- The predicted movements matched on-site measured displacements within 0.5mm accuracy, an accuracy rate quite rare in engineering practice.
- A pile-driving sequence was developed to minimise ground movements due to pile-driving.
- An article about this work was published in Plaxis Bulletin (Issue41), as ground-breaking research conducted for a commercial project that uniquely applied Finite Element Methods to predict intensive pile-driving-induced movements.
- Our project was the Keynote Lecture in Swedish Foundation Day 2016. Our method of predicting pile-driving-induced movements has since become a reference and a success story for similar Swedish projects. Our novel approach is now known as the Gold Standard for movement predictions in soft clay in Sweden.

The project was completed on time and on budget, without any detrimental effects on adjacent infrastructure.

(3) Provide further details of the project such as: design elements / procedures; complexities involved; innovation aspects; site management and supervision; health & safety issues; project cost controls and any other relevant information (Max 500 words):

Some of the complexities involved in this project are explained below.

Ground Conditions

The ground conditions comprised approximately 40m of extremely soft clay overlying bedrock. The extensive deposit of very soft material, with clay strengths less than 15kPa represented a significant design challenge.

Extensive Piling Works

The structure comprised various buildings with different heights. As a result, the foundation design included 300 number of 40m long precast concrete piles scattered across the triangular-shaped site, with different size, spacing and no specific arrangement. This also applied a major challenge to every analysis associated with the foundation.

Problem Definition

The piled site was bound by the Gamlestad bridge (supported on piles) to the west and River Säveån to the south. Neighbouring works by Trafikkontoret included new double tram tracks on two of three sides of the property. The Partihallen viaduct is also located to the south as well as several buildings in close proximity to the piling site. All tram lines around the property were designed as elevated bridge structures or piled deck structures and the dual train line consists of a station on a piled bridge structure. Hence, there were substantial risks concerning ground interactions between the different piled structures and the new development. One of the planning requirements was to undertake a detailed ground movement analysis to confirm the impact of the foundation installation on highly sensitive adjacent infrastructure. This task required a detailed innovative engineering approach.

Methodology

GDG was commissioned as geotechnical specialists to predict the explained interaction between new piles and existing substructures. Numerical analysis was undertaken using PLAXIS3D Finite Element (FE) package. The pile driving was simulated by applying Volumetric Expansion (VE) on bulks of soft soil material.

Considering the complexity of the problem and the highly non-linear nature of the calculations, it was deemed necessary to validate the approach using a simplified geometry. The numerical model was validated using a single pile expansion and comparing the numerical results to published data from available literature, which had previously succeeded to predict ground movements caused by pile installation using an analytical Shallow Strain Path Method (SSPM).

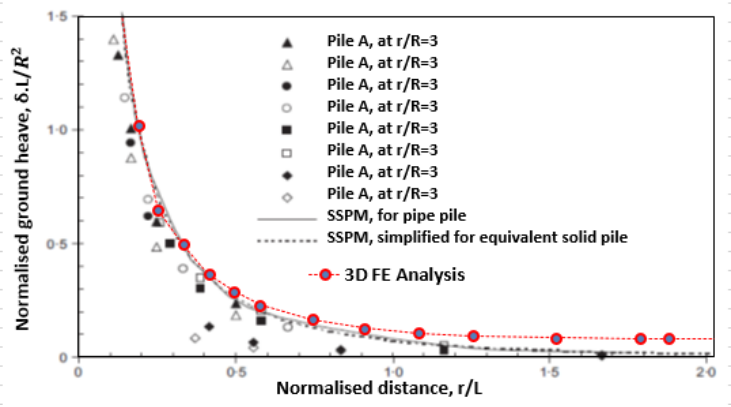


Figure 3 Validation Exercise

Following validation, the numerical model was expanded to take into account multiple pile installations according to the pile layout. In order to make the FE works feasible, a super-pile approach was defined where VE was applied on bulks of soil that included several number of piles. The existing foundations of the adjacent bridge structures were also modelled as piled rafts surrounding the new piling location.

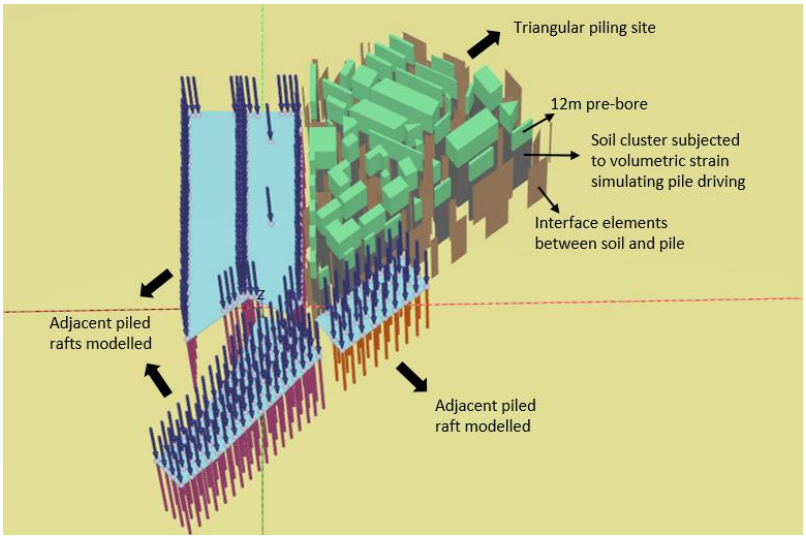


Figure 4 Numerical model in Plaxis

Results and Construction Phase

During piling operations, inclinometers were installed to monitor soil displacements. All structures were surveyed in three directions. It was concluded that the FE analysis gave a very accurate result (within 0.5mm accuracy). As a result of our in-depth accurate engineering practice, the project was successfully completed with no negative impact on the surrounding structures.

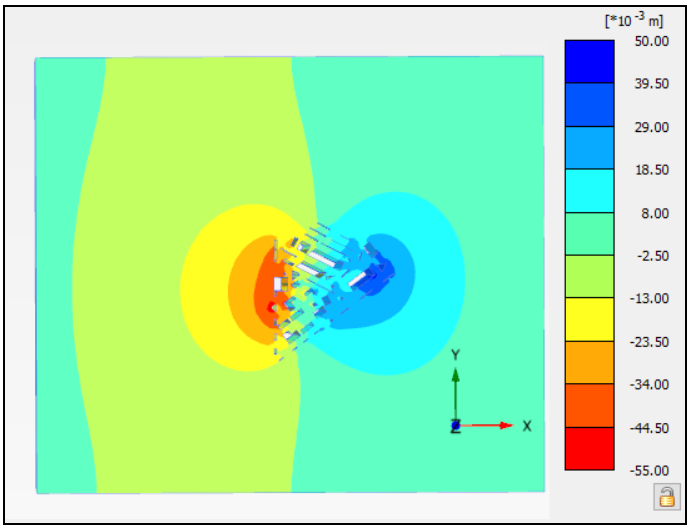


Figure 5 Displacement Contours

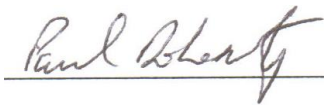
Figure 6 Construction phase

Entries should highlight where possible the particular influence or benefit the project engineering design has on society and the wider environment.

Please confirm by electronic or written signature that:

(a) The supplied text may be used in any marketing material issued in connection with the awards.

(b) Agreement has been received from the client and other stakeholders that the project can be inspected by the adjudicator and provide contact details as requested above for the relevant person to be contacted in this regard.

Signed: 

Firm: Gavin & Doherty Geosolutions Ltd.

Entry details:

Note: Applicants are encouraged to review the Awards Regulations and Procedures before submitting nominations.

Send the completed entry form and supporting photos / images altogether in **one PDF document** (one pdf document per project nomination) by email to: info@acei.ie with a subject line:
ACEI Design Awards 2018.

Note: Closing date for receipt of nomination forms: **17:00, Friday 12th January 2018**

Enquiries: ACEI office info@acei.ie 01 6425588