Welcome to GDG’s Newsletter

Special Edition: Design & Build Projects

by Paul Doherty, Managing Director

As a flexible and dynamic consultancy, GDG is ideally suited to working on Design & Build projects where we work closely with our contracting clients to deliver optimum design solutions that are practical and easy to build.

Over the last 12 months, D&B projects have been a significant growth area for GDG where we are seeing strong return business across a wide range of infrastructure and heavy civil engineering schemes.

A significant aspect of D&B projects is often the transfer of ground risk on to the contractor and an important aspect of our role is to effectively manage this risk while simultaneously identifying opportunities for value engineering.

This edition of the GDG newsletter includes a number of articles on D&B projects that interface with the ground including deep access shafts, slope stabilization, subsurface tanks for water treatment works and retaining walls.

"WE AIM TO DELIVER OPTIMUM DESIGN SOLUTIONS THAT ARE PRACTICAL AND EASY TO BUILD"

The team at GDG particularly enjoys the interaction with the contractor's engineers, which allows us to merge our collective expertise and develop innovative solutions. D&B is a true partnership approach that can deliver the most cost effective solutions to the end client.
Temporary Works Designs

by John O’Donovan, Head of Structures

GDG specialises in the design of temporary works for all aspects of civil engineering construction. Temporary works design becomes increasingly complex in urban environments where ground movements have to be tightly controlled, there is potential conflict between temporary works and permanent works in constrained sites and temporary works may be incorporated into the permanent works design. In addition, the function of a temporary works design may change over time as the construction conditions evolve during the construction programme.

Design Approaches

The temporary works design is generally the responsibility of the contractor and GDG has developed excellent relationships with a number of contractors to deliver efficient solutions.

We utilise a number of techniques to complete temporary works design. These include empirical methods, hand calculations, pseudo-finite element solutions and full finite element models.

We also work with suppliers to develop efficient solutions for temporary works problems, including geosynthetic solutions for working platform designs, slope reinforcement and slope stabilization measures.

Figure 1: Typical slope analysis safety map from GDG’s analysis.

Figure 2: Reuse of old sheet piles for a temporary retaining wall.

EMPIRICAL METHODS ARE BASED ON THE RESULTS OF PREVIOUSLY COMPLETED TEMPORARY WORKS CONSTRUCTION THAT HAVE BEEN INSTRUMENTED AND MONITORED OVER TIME.

HAND CALCULATIONS GENERALLY ADOPT CONSERVATIVE APPROACHES THAT SIMPLIFY REALITY SO THAT A SAFE DESIGN CAN BE QUICKLY COMPLETED.
Temporary Works Designs continued

by John O’Donovan, Head of Structures

In addition, developing a better understanding of geogrids has allowed us to optimise design of working platforms on very soft soils (that have strength less than the typically recommended as a minimum in the BRE guidance). Working platform design is generally completed using a combination of hand calculations and empirical methods.

A FULL FINITE ELEMENT PACKAGE CAN MODEL MULTIPLE STRUCTURES IN COMBINATION WITH A GROUND MODEL.

PSEUDO-FINITE ELEMENT PACKAGES AND LIMIT STATE PACKAGES HAVE BEEN TAILORED TO SPECIFIC DESIGN SCENARIOS SUCH AS A RETAINING WALL DESIGN OR A SLOPE STABILITY ASSESSMENT. THESE PACKAGES GENERALLY PROVIDE EFFICIENT SOLUTIONS TO INDIVIDUAL SCENARIOS BUT ARE UNABLE TO PROVIDE SOLUTIONS TO COMPLEX DESIGN SCENARIOS

Temporary Slope Stability

Infrastructure projects typically utilise a number of temporary slopes or berms during construction. The design of these slopes is typically completed by GDG utilising limit state analysis.

A suite of analysis packages can be used to both identify the critical slip surface and calculated a factor of safety against collapse. Imposed surcharges on the top of the slope can be input in the software along with groundwater profiles to best approximate conditions during construction. >>

Figure 3: Voids and existing buildings creating restraints in both temporary and long-term condition for contiguous piled walls.
Limit state analysis is often the most appropriate for slope stability design scenarios as typically movement is not a consideration for the slopes. GDG designs reinforcement for slopes to improve factors of safety. For slopes that are currently being constructed geogrids and drains can be used to increase the factor of safety. For slopes that are created through excavation the factors of safety can be increased using driven or bored anchors and nails combined with a mesh. Bulk bags and gabions may also be used to increase the factor of safety by applying increased restoring force at the pile toe.

GDG has completed numerous slope stability assessments on earthworks projects such as those associated with a new waste to energy facility in the UK. The facility was a large industrial complex.

**Embedded Pile Walls**

As specialist pile designers, GDG will often act as designer for embedded pile walls to support temporary excavations. There are a number of available piling solutions and the decision depends on stratigraphy, hydrogeology, retained height, permissible ground movement, etc. King post walls, contiguous pile walls, secant pile walls, diaphragm walls and sheet pile walls represent some of the more popular temporary retaining solutions available. It may be possible to support cohesive soils and dry granular soils using king post and contiguous pile walls with the soil arching between the pile supports.>>

**Figure 4: Typical example of an embedded pile wall.**
Secant piling and sheet piling are cost-effective where water cut-off is required. Temporary works are typically used to support structures and infrastructure adjacent to construction works. GDG typically designs these supports for situations where not only must the structures in question be supported but must be supported to within a given movement criterion.

We have designed and analysed numerous supporting systems for basements in urban environments where they are located close to neighbouring buildings. The movements and strains that develop in these neighbouring buildings can be analysed in a number of ways.

Empirical relationships are useful in areas such as London where there is a large degree of available monitoring data to correlate movements against excavation depths.

Monitoring data is widely available for projects in London, and Dublin to a lesser degree, and for projects involving a bored pile wall or diaphragm wall. The recently updated CIRIA C760 presents available monitoring data so that trendlines are obtained for ground movement due to excavation in front of a retaining wall.

Future Developments

The development of cheaper wireless sensors will make it easier to monitor temporary works during construction in the future. This would provide further opportunities to improve temporary works design making them more predictable, safer and cheaper. Increased use of monitoring enables the use of observational method approaches. In addition to project specific benefits there is an advantage to the increased availability of monitoring records to calibrate soil models and improve empirical design approaches. The perceived drawbacks of monitoring which include expense, cabling and delay to construction works are increasingly being reduced through innovation in monitoring techniques. GDG is highly active in Research and Development and we would be delighted to use the knowledge from our research projects to optimize designs using limit state predictions and monitoring.
Inverurie WWTP Stormwater Shaft

by Steve Sumner, Principal Engineer

GDG was recently appointed by Coffey Group to provide design input to a shaft construction at Inverurie Wastewater Treatment Plant (WWTP) in Scotland. Scottish Water has awarded the asset management programme (AMP) to Efficient Service Delivery (ESD), which is a consortium of designers and contractors. The plant is being upgraded to utilise the Nereda Process, which uses granular activated sludge to facilitate faster settlement times for sediment particles, thereby reducing treatment time and increasing volume capacity.

Overview

The shaft interior is partitioned with an overflow weir and the primary compartment will provide stormwater storage prior to pumping to the Nereda Process tanks, however during peak flows, stormwater will overflow the partition weir and fill a second chamber for pumping out.

The site also has a history of flooding, and flood levels were recorded up to 2m above ground level, so floatation was a significant concern.

Furthermore, the tank was required to be built within the footprint of one of the existing and redundant primary sediment tanks to overcome land constraints.
Inverurie WWTP Stormwater Shaft continued

by Steve Sumner, Principal Engineer

Geosolutions

One of our first tasks was to identify the contractors’ preferred method of construction. The contractor preferred to retain the perimeter of the existing PST tank by breaking through the middle of the tank base to install the shaft, since the tank walls would retain the adjoining ground supporting the other tanks. We also suggested that by tying the outer residual PST structure to the new shaft, the combined mass could be used to resist floatation.

Figure 3: View showing excavation during underpin phase

We also suggested reducing the thickness of the base down to 1m depth. Although this reduced the mass available to resist floatation, it also reduced the depth of hard dig and the overall depth of the shaft construction. We suggested that any deficit in floatation resistance could be made up using ground anchors to tie the base to the underlying bedrock.>>
The initial plan for construction of the shaft was to excavate a steep slope within the rock and build the shaft back up using what is known as the chimney method. However, once excavation commenced it became apparent that the rock was significantly fractured. To minimise risks from loose rockfalls during excavation, we amended the construction sequence to allow the upper sections to be built using the chimney method, while the lower segments would be installed using the underpin method, which minimised the depth of rock exposed at any time for segment installation. This reduced the anticipated backfill depth of mass concrete to the rear of the shaft segments, with a corresponding loss of mass to resist floatation forces, so we had to revisit the floatation analysis.

Another significant aspect of D&B is that the contractor is usually working to tight timescales, and the lead time for procurement of materials and components can have a bearing on meeting programme dates, and as part of our service we revised the design for Coffey so that they could use an alternative precast segment which was readily available from stock.

**Figure 5: Concrete Infill between the existing PST tank and the new inner shaft**
Foynes Port

by William Brown, Belfast Leader

Shannon Foynes Port Company is currently seeking planning approval to reclaim land between their two main marine assets, their West Quay and East Jetty in Foynes Port. The new lands will help provide additional berthing capacity whilst improving set-down facilities for bulks and other cargoes entering Foynes Port. In order to inform the preliminary design and EIS, the Client’s Engineer commissioned new site investigations at the proposed reclamation site. The investigations were also extended to another adjacent site at the Durnish lands where a separate development is being considered by the Port.

Abco Marine brought together a team with them acting as Principal Contractor and barge operators, GDG as on-site Geotechnical Engineers and Ground Investigations Ireland as their drilling team in order to carry out the proposed works. As well as providing an on-site presence, providing technical direction and soil logging, GDG also coordinated laboratory testing and prepared both the factual and interpretative reports required by the contract. Site works commenced in March 2017 and ended in June, with 33nr boreholes being drilled on site up to depths of 45m. The project was primarily led from the GDG Belfast office with some support from the Dublin office. We generated the AGS 4.0.4 format files which provides the digital information for inclusion in BIM models. There is enormous potential visualisation, integration and management of risk by utilising a digital environment. GDG is streamlining these tools into our workflow process.
GDG helping Design and Build teams to win work and deliver solutions
by Paul Quigley, Principal Engineer

Our geotechnical skills base is a natural fit with Design and Build teams seeking reliable solutions that de-risk earthworks, foundation and stability challenges. We work closely with contractors to understand their objectives and priorities and deliver value-driven solutions while satisfying the Employer’s Requirements. Our excellent relationships with many of Ireland’s leading contractors is testament to the value of our services.

Our experience ranges across roads, rail, port infrastructure, industrial facilities and tunnels. We use our experiences with differing foundation solutions from across our business sectors to deliver optimised solutions. Some examples of some of our recent work is outlined below.

GDG’s RANGE OF EXPERIENCE

- Embankment Stability Analysis
- Road and Rail Network Design
- Slope Stability Design and Analysis
- Design of Access Shafts and Tunnels for Sewerage Infrastructure
- Reliability Determination for Slope Assets
- Reinforced soil slopes, walls, embankments on soft soils and bridging voids over karst and mining voids
- In-situ Monitoring of Slopes and Embankments
- Site-Investigation Design and Supervision
- Pile Foundation Design
- Instrumentation Scheme Designs, In-situ monitoring and Reporting
- Earthwork Assessments for Cut and Fill Operations
- Provision of sophisticated ground models and Eurocode 7 compliant GIRs and GDRs

A737 Dalry Bypass

We have teamed up with Fehily Timoney and Company and Farrans Roadbridge JV to deliver the A737 Dalry Bypass near Glasgow. The scheme is approximately 4km long and is packed with geotechnical challenges. The route crosses the River Garnock on a 400m long viaduct which is supported on piles. >>

Figure 1: A737 Dalry Bypass
We reviewed the specimen foundation solution and devised an alternative CFA piled foundation to support the bridge. Farrans Roadbridge JV has undertaken full scale instrumented pile tests with test loads up to 11.4 MN. The results have been very useful in determining the portion of the pile capacity carried by shaft resistance and base capacity. We also optimised the earthworks ground model to provide detailed information on reusability, groundwater management and slope stability measures. We also developed solutions for managing soft ground areas and transitioning onto the existing pavement.

Ports and Harbours

Ports are a vital component of maintaining efficient trading links with our trading partners. Many Irish and UK ports and harbours are investing in upgrading their infrastructure to accommodate larger vessels and improve the efficiency of moving freight in and out of the port.

Ports and harbour are a natural fit for geotechnical engineers as the retaining walls and hardstanding areas are usually located in areas with complicated ground conditions and onerous foundation loadings.

GDG has recently completed the Crossberth Quay, working on behalf of Roadbridge L & M Keating JV to design Dublin’s deepest quay.

The recently completed project will provide new berthing facilities for modern cruise liners, breathing new life and improved visitor experiences for crew and tourists. The quay comprising of a combi wall anchored by deadman anchors.

We recently teamed up with ABCO Marine and Ground Investigations Ireland to undertake a ground investigation and geotechnical interpretative report for Foynes Port Company.
GDG helping Design and Build teams to win work and deliver solutions continued
by Paul Quigley, Principal Engineer

>> Foynes has Ireland’s deepest water draft and is developing their quayside infrastructure to increase capacity. GDG worked alongside ABCO Marine and GII to log boreholes, compile digital data using the AGS 4.0 format and produce a geotechnical Interpretative report for Foynes Port Company and their consulting engineer, RPS.

Foundations

As clients seek more space for their buildings there has been an increased focus on optimisation of basement solutions. We are working with a number of contractors on developing basements for a variety of end uses.

We were working with J Murphy and Son on the design of a pumping station shaft for the Birmingham Resilience Project.

Another live project is in Dublin’s Docklands, where we’re developing foundation solutions for a refurbishment of an old warehouse with one of Ireland’s leading contractors.

We have been engaged at early design stage to assist with the temporary works and permanent retaining wall options for a highly constrained site.

Figure 4: Core logging onsite at Foynes Port

Figure 5: Plaxis 3D model of Birmingham Resilience Project
GDG helping Design and Build teams to win work and deliver solutions continued

by Paul Quigley, Principal Engineer

We have developed designs for deep circular shafts using Plaxis 3D to create a piling layout and capping beam arrangement which is more efficient than a comparable solution derived from 2D analyses.
GDG recently carried out a site inspection for the Water Treatment Works upgrade at Assynt, Inverness Scotland. Coffey engaged GDG as temporary works designers for the project.

The project required the excavation into an existing slope with the aim of providing a level platform for the construction of the 70m long by 25m wide water treatment tank.

Space was at a premium on the project due to the tight boundaries.

We were requested to design an economic stable cut slope, face protection and drainage system to facilitate the construction of the new water treatment tank.

Following close communications with our client, GDG and Coffey devised a strategy to avoid using expensive ground retention systems such as sheet piling or soil nailing.

The solution involved detailed modelling of the ground and water conditions for the site by our specialist geotechnical team, followed with slope stability evaluation.

The ultimate solution involved the steepening of the cut face within the bedrock which allowed for a shallower slope angle within the overburden.

The design also included a slope membrane and drainage system to prevent both slope erosion and surface water permeation into the slope.

Site engineers were in close communication with GDG during the excavation works, as part of an observational approach to verify the ground conditions employed within the design.

At an early stage in the rock exposure, GDG carried out a site visit to confirm the quality of the bedrock and the suitability of the approach.