Capability Statement: Railway Infrastructure

Providing efficient and reliable geotechnical solutions for the most challenging projects

LONDON – DUBLIN – EDINBURGH – BELFAST
GAVIN AND DOHERTY GEOSOLUTIONS (GDG)

GDG is a specialist geotechnical and civil engineering consultancy, providing innovative geotechnical solutions to a broad range of engineering problems. GDG is a UK and Irish based company that provides engineering services to the international market, including concept design, detailed design, in-situ monitoring and general geotechnical advice. With offices located in London, Edinburgh, Dublin and Belfast, we are well placed to service the demands of our diverse range of clients.

GDG has developed from a strong background in applied geotechnical and civil engineering research. Through application of these skills, we offer progressive and reliable designs across a range of industry problems. GDG provides a unique engineering service that combines the state of the art research with industry and leads to the most efficient geotechnical designs.

We are actively involved in a diverse range of international projects ranging from major civil infrastructure projects, road and railway schemes, harbours/marinas, development of offshore oil/gas fields, onshore and offshore windfarms, and commercial structures. Our clients include railway operators, large civil contractors, project developers and engineering consulting firms. We also undertake high level railway infrastructure research for the European Union.
Overview

The design team at GDG has experience across a variety of infrastructure engineering designs. GDG has developed skills in road and railway network design, including preliminary design, detailed design, remediation works and post – construction monitoring.

Our infrastructure expertise extends to geotechnical asset management, life-cycle performance calculations, and network wide risk modelling. GDG can assist with the development of new infrastructure, modification of existing assets or adaptation of maintenance strategies.

Services

- Slope Asset Management
- Risk Modelling of Earthworks
- Embankment & Cutting Stability Analysis
- Road and Rail Network Design
- Slope Stability Design and Analysis
- Access Shafts and Tunnel design
- Ground movement analysis for existing tunnels
- Design of Remedial Works for Slope Failures
- Monitoring of Slopes and Embankments
- Site-Investigation Design and Supervision
- Geological and Soil Strata Mapping
- Shallow and Pile Foundation Design
- Retaining Wall Designs
- Instrumentation Scheme Designs, In-situ monitoring and Reporting
- Earthwork Assessments & Cut and Fill Operations

\[ c' = 8 \text{ kPa} \]
\[ \phi' = 36^\circ \]

1-in-10 year GW

Calculated FOS

1.53 1.41 1.34
GDG has an expert team of geotechnical engineers and engineering geologists who specialise in the design of civil infrastructure.

From the project outset, we provide specialist advice to scope and manage the site investigation campaign including design, procurement, management, site supervision, laboratory testing schedules and ultimately technical auditing of the factual report. We tailor specific investigative methods based on the early site appraisal work to target the testing to match the proposed construction and anticipated ground conditions.

**Design Tools & Capabilities**

- GIS based ground modelling including developing 2D and 3D ground stratigraphy profiles using ArcGIS software
- Prepare Geotechnical Interpretive Reports
- Prepare Geotechnical Design Reports
- Geohazard Mapping
- Material Suitability Assessment for Earthworks Operations
- Optimisation of Cut-Fill Volumes
- Civil 3D cross sections for Earthworks Alignment
- Borrow pit assessments
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Slope Stability Analysis

Most European railway networks are between 100 and 150 years old and have been constructed using techniques that were common at the time. As a result, the cutting and embankments that exist across the network do not always conform to today's modern design standards. GDG has extensive experience of undertaking stability analysis for existing slopes that incorporate a wide range of materials and construction techniques. These slopes are also negatively impacted by changing weather conditions and climatic influences which we have incorporated into our analysis of both short term and long term slope risk.

Recent slope stability projects have included:
- 100m high rock cliff analysis in eastern Ireland
- Peat stability assessments in England, Scotland and Wales
- 20m high soil cutting for a railway line in Kerry, Ireland
- 15m high ash rail embankment in Wexford

Design Tools & Capabilities

- Slope inspections
- Cutting Analysis
- Embankment/Cutting Analysis
- Rock Slope Assessment & Geological Rock Mapping
- Limit Equilibrium Design of Slopes
- Finite Element Design of Slopes
- Predictions of Long-Term Slope Stability
- Remediation Design of Slopes
- Reliability based design and Probabilistic based design of slope networks (rail and road infrastructure)
- Design of slope maintenance strategies
- Design of slope drainage systems
Recognising the ageing nature of the railway network and the varied nature of the cutting and embankment assets, GDG has developed expertise in a wide variety of remediation solutions to deal with slope slips and ground movements. GDG has extensive experience in root cause analysis to determine the triggering mechanisms for mass landslides or local ground slipages. By identifying the root cause, we can design efficient and robust remedial solutions, which include softer approaches such as monitoring to harder engineered systems such as retaining walls, barriers, rock netting, etc.

Remedial Design Options

- Regrading slopes
- Rock Combing
- Slope face drainage
- Interceptor drainage engineering
- RC Retaining Wall Design
- Gabion wall design
- Shotcreting
- Rock Netting
- Barrier / Catch systems
- Soil Nailing
- Geogrid design and facing membranes
- Screwpiles / micropiles / ground anchors
- Monitoring
- Softer solutions (including vegetation recommendations)
- Rock revetments /buttress systems
Foundation Inspections

As a specialist foundation design consultancy, we have developed our own in-house procedures for undertaking inspections of existing bridge foundations, piers and abutments. GDG has also developed expertise in the analysis of scour susceptibility and the design of optimum remedial works, such as underpinning, etc.

GDG has developed excellent relationships with a number of partner organizations, which allows us to provide a full suite of inspection and exploratory services including geophysical interrogation, underwater dive surveys, etc. Following the on-site inspection process, the resulting data is integrated into a structural/civil model which then allows remedial solutions to be developed.

Retaining Walls & Piled Structures

Since 2011, GDG has undertaken a wide variety of retaining wall and pile design projects which have involved both permanent and temporary structures for the construction of major infrastructure schemes. In total, GDG has completed over 100 projects involving structures of this nature across the UK and Ireland, where we have provided tender designs, detailed designs, construction drawings and on-site supervisory roles. GDG has worked closely with leading Universities such as Queens University Belfast to develop optimisation software to ensure the most efficient design of retaining structures while still working with the Eurocode requirements. Some typical examples of the types of structures we design are provided below:

- RC Gravity walls
- RC embedded walls
- Contiguous piled walls
- Secant piled walls
- Sheet piled walls
- Cofferdams
- Anchored / Tied walls
- Kingpost walls
Ground Movement Analysis & Soil-Structure Interaction

Using a range of different modelling software, GDG have the expertise to provide accurate predictions of ground movements and the impacts on adjacent structures. Typical ground movement predictions may consider the impact of new basement works on adjacent railway bridges/embankments or on the tunnel network below the site.

The image above highlights the stress contours for a new basement construction in central London which generated significant ground heave. The image below shows the impact of this heave on the lining of the Northern Line tunnel wall which is located at depth below the proposed excavation.

The image below shows a high-rise development project in Gothenburg, Sweden where the site was bounded on two sides by strategic railway tracks supported by piled bridges.

Due to the extensive soft ground deposits, which reached depths greater than 50 meters, there were significant concerns that the piling for the new structures would cause the existing railways to displace laterally. Using Finite Element techniques GDG explicitly modelled the installation of every new pile to predict the ground movement effecting the in-situ piles. The analysis showed the ground displacement contours to be within acceptable limits, allowing the project to proceed on time and in-budget.

Soil-Structure Interaction

- Tunnel Movements
- Tunnel Lining Forces
- Wall movement predictions
- Foundation Settlements
- Earthworks settlement
- Excavation heave analysis
- Shaft movement predictions
Network Risk Modelling & Asset Management

Over the past five years, GDG has invested heavily in internal Research and Development, as well as leading major international Research projects involving both academic and university partners from across the world. These projects have allowed us to work side-by-side with Network owners/operators, where we have developed network wide risk modelling software.

Our capabilities include geotechnical asset management and reliability based design of complex infrastructure systems, which has been successfully applied to the Irish Rail network where we have developed a risk tool to analyse all 4000 slopes.
Technical Advisory & Training
As technical specialists in the areas of geotechnical design and civil engineering, we provide direct advice and support to utility companies, route managers and overall network owners/operators. Our technical advice can include support for new capital projects, developing new design tools and in establishing maintenance procedures for existing earthwork assets. We also provide a research and development service where clients are interested in exploring new ideas, design philosophies or implementing new technology. Our technical advisory services include Category 3 checking where there is another designer already in place and on-site support where construction is underway.

With our extensive background knowledge of railway infrastructure, GDG is also ideally placed to provide training and support to railway owners. This is a role that GDG has undertaken with Irish Rail where we train all the track/slope asset inspectors to ensure a uniform and non-subjective inspection regime is completed across the network.

GDG Vision
As a specialist SME, we pride ourselves on offering technically efficient and robust design solutions to the international market. Through a first-principals approach we always consider novel and innovative solutions which provide value to the client, allowing projects to be completed on time and in budget. At all times, we focus on the quality of project delivery by ensuring we are both responsive and flexible regardless of the size or complexity of the project.