

GROUND INVESTIGATION GUIDELINES

04.6 - SOFT GROUND TUNNELLING

What do we need to know?

- Finalise tunnel alignment
- Selection of most appropriate tunnelling method
- Assess the rates of advance
- Design the permanent lining
- Assess the affects on buildings, utilities, other tunnels etc
- Design of temporary works including shafts



Notes: (1) This GIG focuses on soft ground tunnelling. For tunnels comprising rock reference should may be made to GIG 4.4.
(2) Investigation of contaminated soils is not covered under this GIG.

Notes: (1) As much appropriate information as possible should be obtained and assessed.
(2) The geological model should be reviewed and the databases added to as more information is received.



Information Required

Proposed Tunnel Alignment & Access Shaft Locations

Geological Model + Potential Geotechnical Hazards + Hydrogeological Profile

Existing building structures sensitive to settlement
Existing Utilities
Existing Tunnels
Existing Mineworkings
Existing buried structures (Eg. old sea walls, piles)

Source

Scheme Plans

Field Mapping

API

Site Reconnaissance

Desk study of Geological Maps Existing GI & Geophysics Records

Site Reconnaissance

Desk study of utility records, topographic survey plans, as built records

Appropriate G.I. Methods - Field

What is Required?

Develop Geological Model

- Bedrock level
- Rock & soil types
- Layer thickness
- Weathering profile
- Overburden thickness
- Fault zones

Investigation of Potential Geological Hazards

e.g. Corestones, fault zones, old seawalls, cavities

Develop Hydrogeological Profile

- Perched water table
- Piezometric levels

Recover material for laboratory testing

G.I. Methods

Drillholes with regular sampling & SPT tests. Supplemented by CPT and/or geophysical methods (seismic/radar/resistivity/gravity) as appropriate.

Additional 'targeted' vertical, inclined and even horizontal drillholes.
Also probing (e.g. for seawalls).

Install and monitor piezometers (vibrating wire, pneumatic or Casagrande) and standpipes.

Sampling in boreholes:
In clays - pistons or undisturbed samples

In sands - SPT liners
In decomposed rock and Fill - Mazier samples
In bedrock - rotary coring

What is Required?

'N' value for soil classifications, correlation with other parameters & use directly in empirical analysis (granular soils)

Undrained shear strength, C_u (soft clays)

σ_h , OCR, G , m_v , σ -E (soils/weak rocks)

In Situ Test Results

σ_h , G , OCR, m_v (soils/weak rocks)

F_s , q_c , for soil classification, correlation with other parameters and in empirical analysis (soils)

Permeability

Presence of gas & type of gas

Rock discontinuity orientations & detailed discontinuity log

G.I. Methods

SPT Test

In situ vane shear test

Pressuremeter

Dilatometer

Static cone penetration testing

Variable & constant head tests (soil) packer tests (rock)

Test borehole with a gas meter

Borehole televiewer / impression packer

Notes : (1) Based on US National Committee on Tunnelling Technology study for better results increase scope of SI to
• 1.5 linear metre of borehole per route metre tunnel alignment
• 3% of cost of tunnelling civil works for ground investigation

Appropriate G.I. Methods - Field Instrumentation

What is Required?

Baseline monitoring of building structure defects and subsequent change

Monitoring of ground settlement

G.I. Methods

Crack gauges & meters

Settlement markers (surface settlement), extensometers (sub- surface layer settlement)

Notes:(1) For piezometers/standpipes refer to 'GI Methods – Field' (Above)

Appropriate G.I. Methods - Field Mapping & Logging

What is Required?

TCR, SCR, RQD, Fracture Index, discontinuity description

Identification of cohesive and none cohesive soils and their description

G.I. Methods

Logging of rock samples

Additional Engineering Geological Mapping where good rock exposure

Splitting and Logging of soil samples

Appropriate G.I. Methods - Laboratory Testing - Soils

What is Required?	G.I. Methods
Soil classification (Atterberg Limits, W , γ)	Index tests
Parameter for settlement analysis (C_e , C_v , e_o , m_v) and permeability	Oedometer Test/Rowe cell
Soil strength (C_u , C' , ϕ') & also stiffness	Triaxial tests

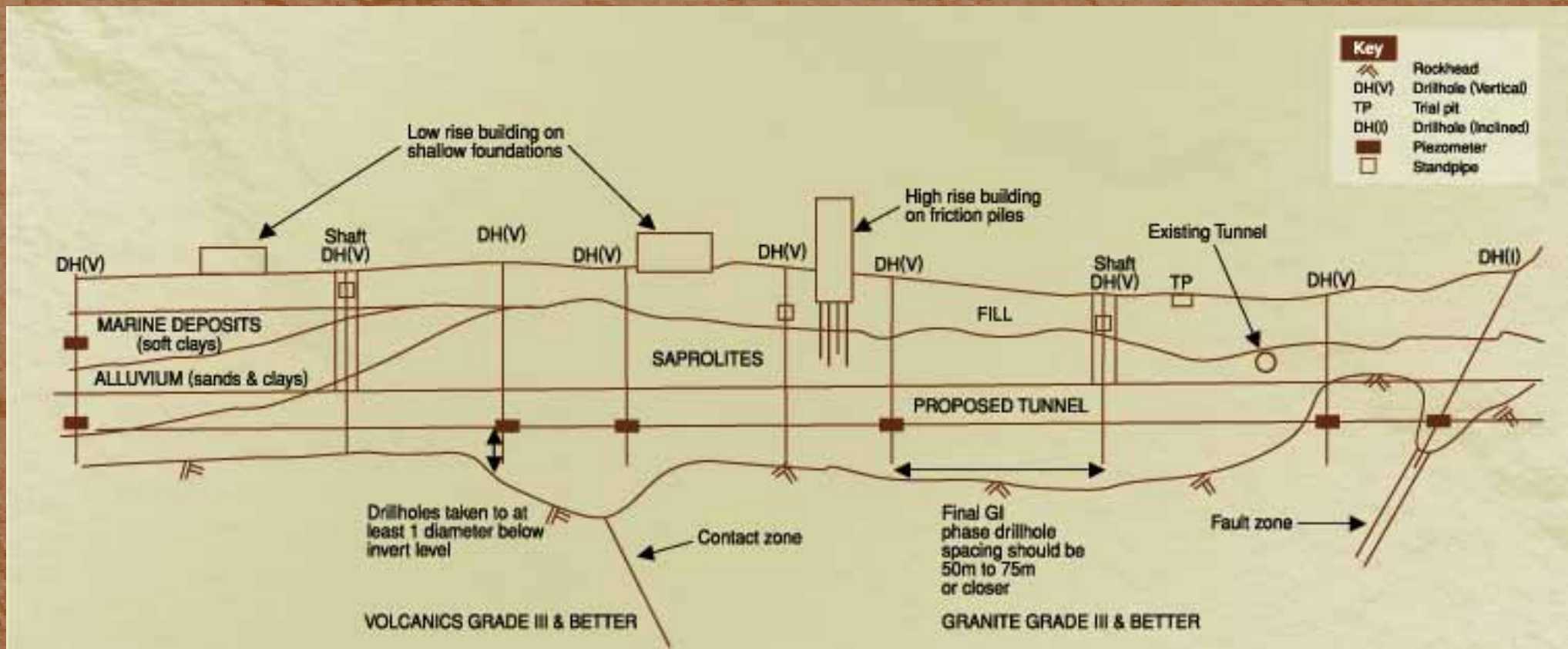
Appropriate G.I. Methods - Laboratory Testing - Rocks

What is Required?	G.I. Methods
Rock classification (w , γ)	Index tests
Strength (UCS)	Unconfined compressive strength
Strength (Point Load Index)	Point load test
Assessment of abrasiveness to TBM cutter	Petrographic analysis Abrasive tests (Cerchar Abrasivity, Paddle Test)

Appropriate G.I. Methods - Laboratory Testing - Water

What is Required?	G.I. Methods
Aggressiveness of ground water to concrete	Tests for SO_4 & pH

Schematic G.I. Layout for a Soft Rock Tunnel (Section)



Note : (1) Movement monitoring required for all affected structures. (2) For clarity instrumentation not shown (with the exception of piezometers)