

Moll's Gap- Soil Nail Remediation of a Collapsed Retaining Wall Co. Kerry, Ireland

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ATKINS

N71 'Ring of Kerry' National Road

Popular tourist route through the scenic Kerry mountains

25km south of Killarney
9km north of Kenmare

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Introduction

N71 'Ring of Kerry' National Road, close to Moll's Gap

- Retaining wall collapse September 2016
- Atkins/TII/KCC site visit
 - northbound lane closure
 - daily monitoring by KCC
- Atkins appointed October 2016
 - ground investigation
 - develop outline remedial options
 - detailed design of preferred option
 - AA Screening Report



The Site

Collapsed drystone wall

- 6m to 8m retained height
- Constructed circa 1820s
- Road widened by cutting into rock outcrop ~10 years ago
- Possible causes of failure:
 - Age/degradation
 - Blocked drainage
 - Infiltration from surface drainage
 - Heavy loads due to modern use





The Site: 3D Terrestrial LiDAR



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Extract from Navisworks software image generated from 3D topographical survey undertaken by Murphy's Surveys

The Brief:

- Eurocode Compliant Design
- 120 year design life
- Optioneering stage for early contractor selection
- Road to re-open before tourist season

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Challenges/Restrictions

- Access:
 - Remote location
 - Steep slopes
 - Working at height
- Weather:
 - Mountain location
 - High winds
 - Winter cold weather working
- Structure/Road:
 - Loose and unstable, safe working paramount
 - Unknown construction
- Complex ground conditions:
 - Variable folded, fractured and sloping bedrock
 - Unknown backfill



Ground Investigation

Phase 1

- Rock face logging
 - Understand variable rock discontinuities
- Rotary cored boreholes
 - Samples of backfill and superficial deposits
 - Rock core samples for logging and testing



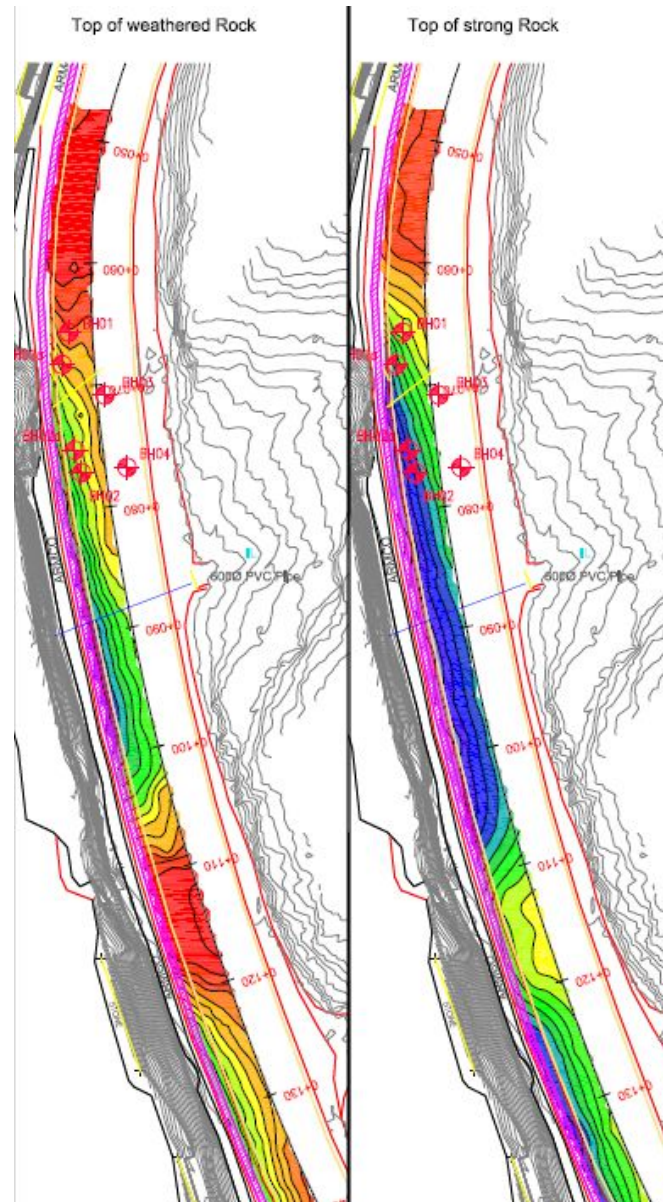
Phase 2

- Geophysics
 - GPR
 - Seismic refraction



Ground Conditions

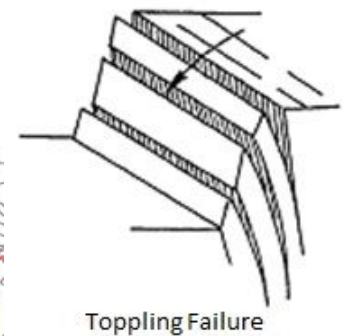
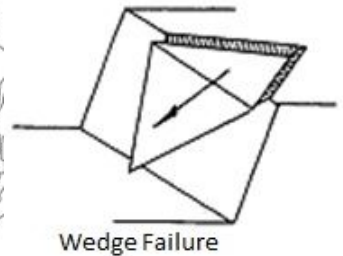
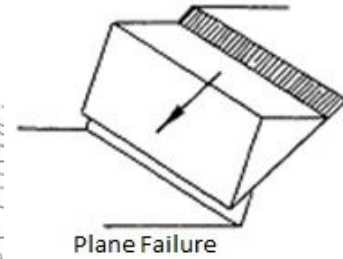
- Backfill
 - Mixed granular material, clay and **soft peat** over rock
- Highly variable craggy rockhead
- Bedrock
 - Devonian Glenfesk Chloritic Sandstone
 - Inclined bedding, folded, faulted and variable orientation
 - Rock strength varies from moderately weak to strong



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Modified from Hoek and Bray, 1981



Dip angle across site varies due to folding

Variable discontinuity spacing and rock strength

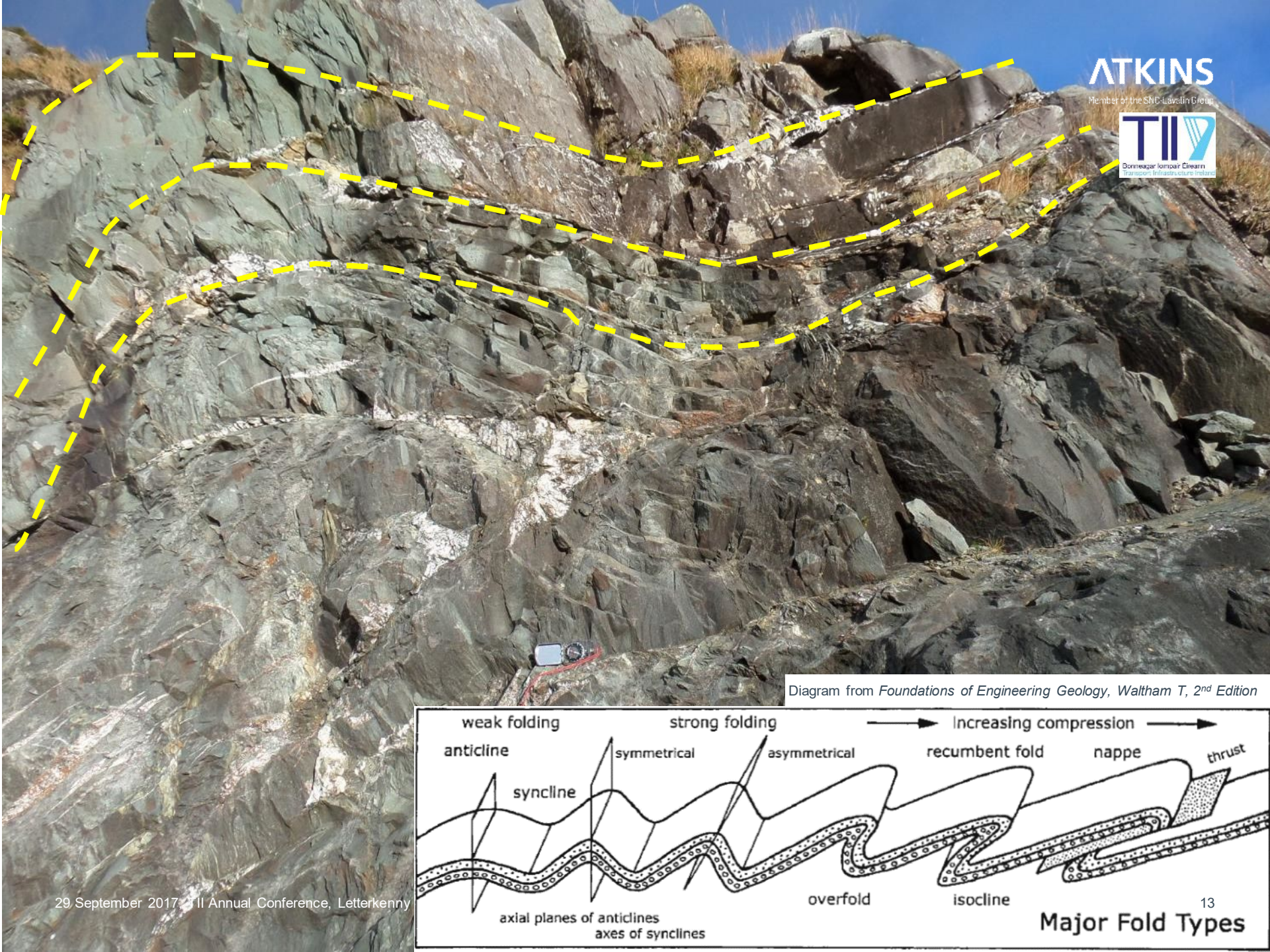
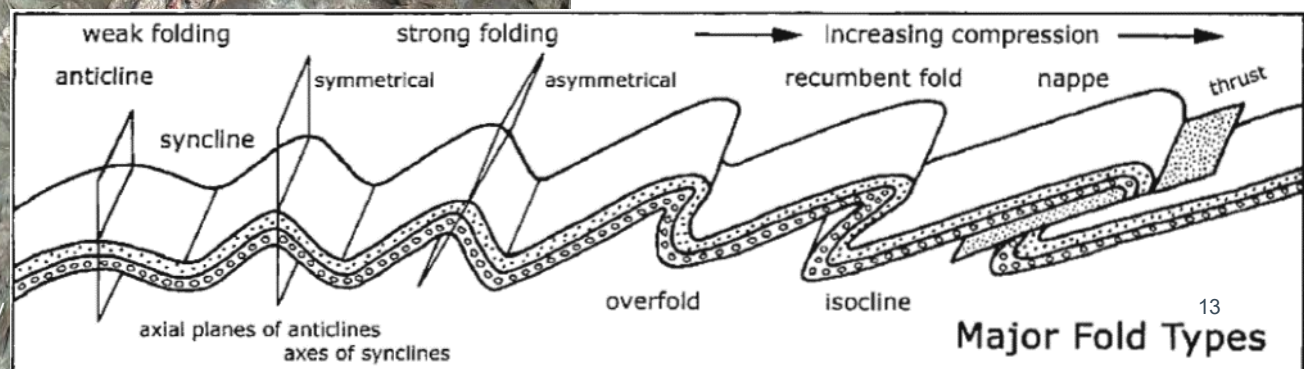
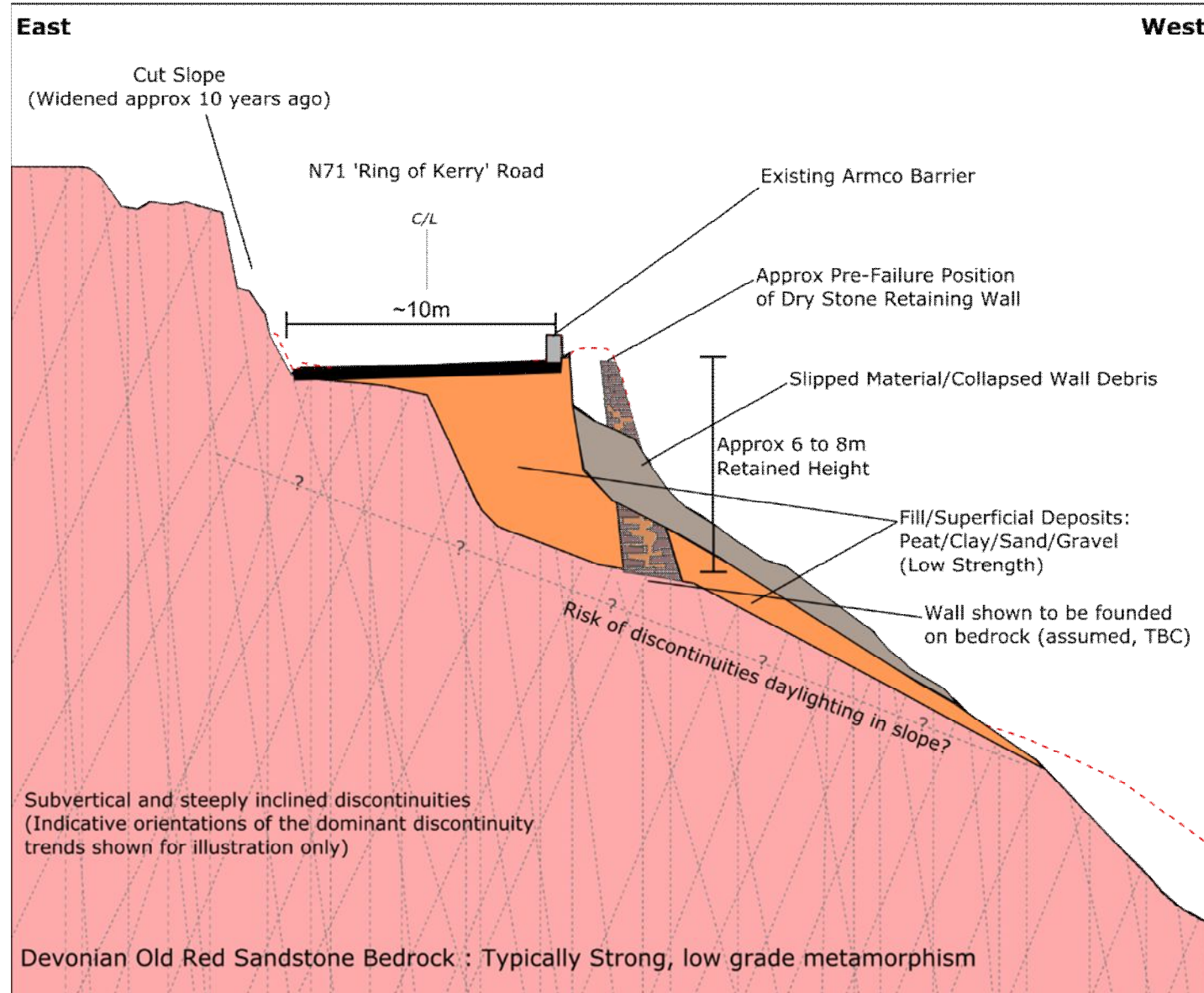


Diagram from *Foundations of Engineering Geology*, Waltham T, 2nd Edition





N71 Retaining Wall Failure (Molls Gap): Remedial Options (Concept Stage)



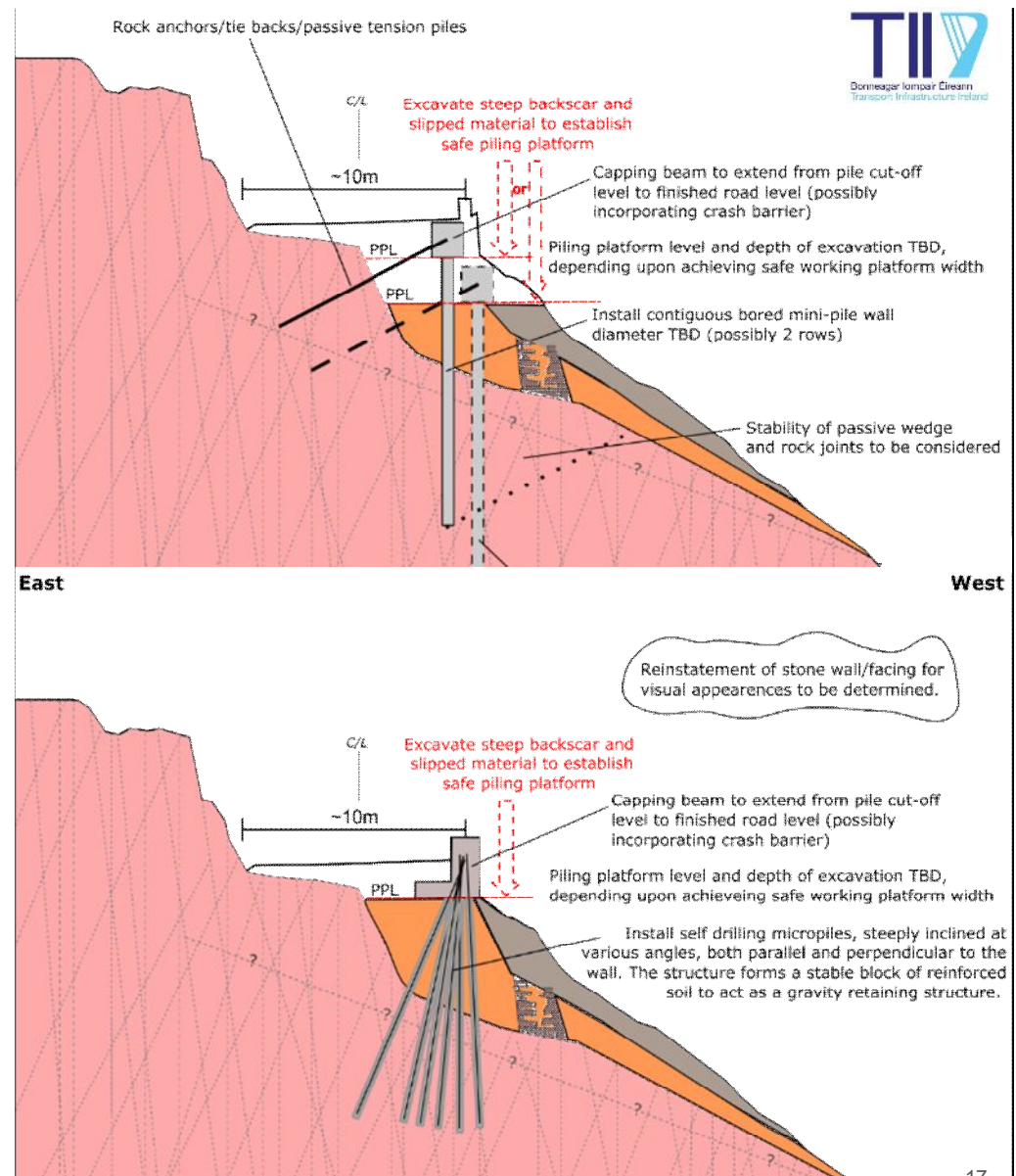
Optioneering

- **Mass concrete buttress**
 - Discounted due to unsafe working, spoil removal, construction of formwork
- Contiguous bored pile wall/reticulated micropiles
 - Discounted due to rig of vibration and heavy plant adjacent to unstable slope and wall.
- Dig and replace/rebuild
 - Discounted for H&S risks of excavating under unstable slope/wall, volume of excavation and materials, difficult access, difficult to tie-in with adjacent wall
- Soil nails with facing system
 - Preferred option due to reduced H&S risk from 'top-down' construction, less material, ability to tie in to adjacent wall



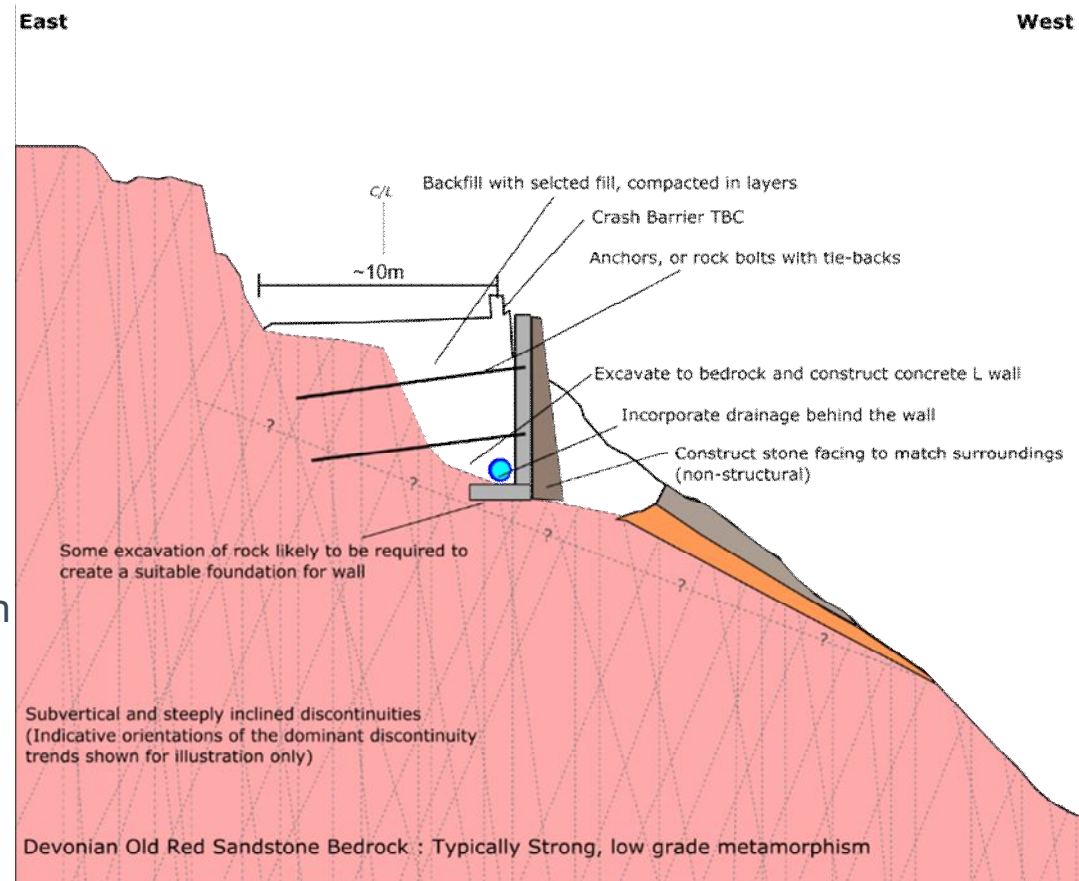
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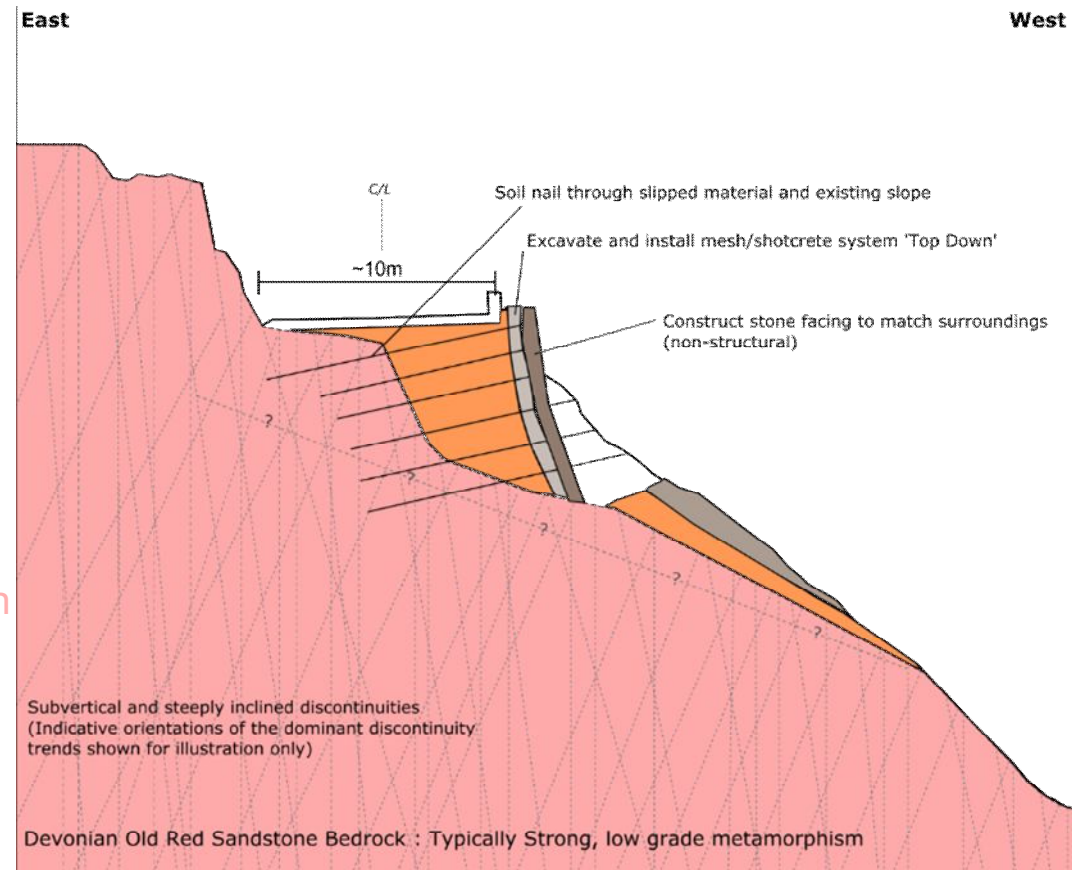
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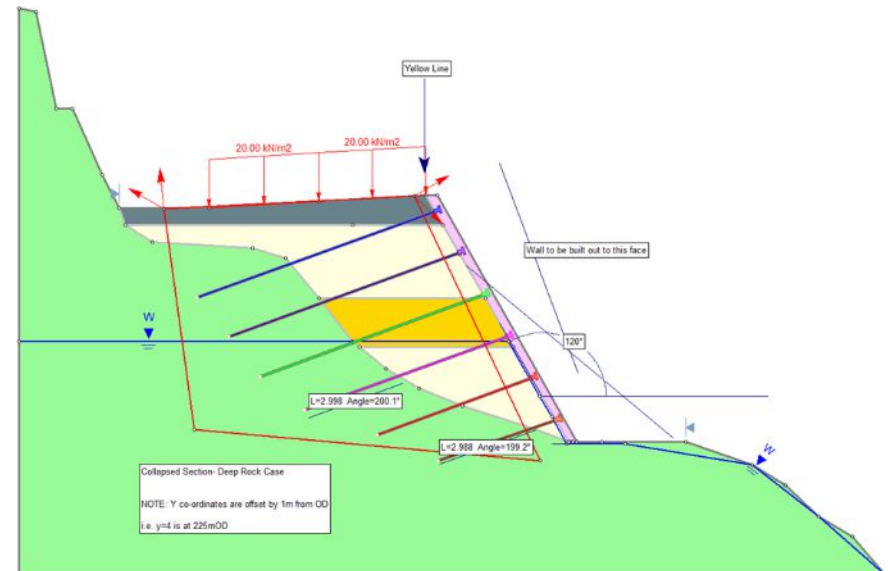
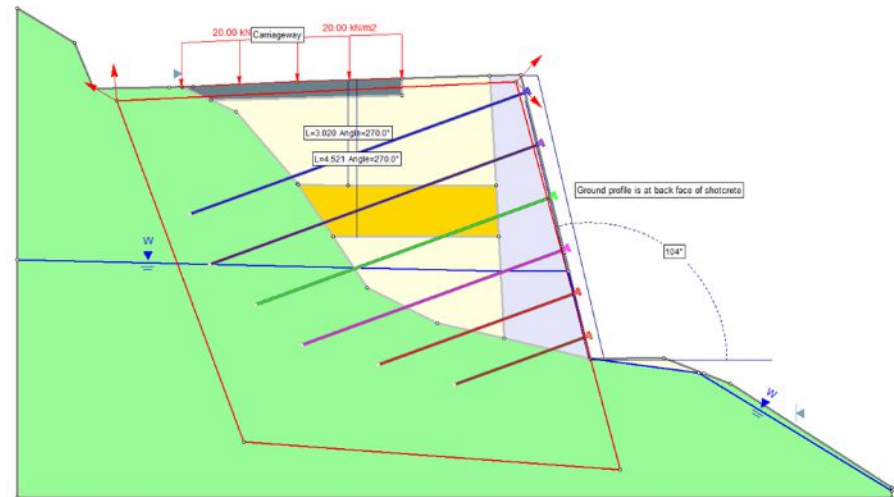
Design Requirements

- Soil nail slope stabilisation with rigid shotcrete facing:
 - Eurocode 7 geotechnical compliant
 - Eurocode 3 structural steel compliant
 - Eurocode 2 structural concrete
 - Soil nails designed to BS 8006-2:2011 (EC compliant)
- BD2 TAR for approval by TII
- 120 year design life
- Improve drainage:
 - Behind wall
 - Road surface drainage
- Replace crash barrier to meet current standards
- S&H: DRAs and Contractor's RA

Geotechnical Design: Slope stability

Over 200 separate analysis scenarios:

- 3 design cross sections (collapsed section and 2 adjacent unstable walls)
 - Drained/undrained conditions
 - Circular/non-circular failure mechanism
 - Rock mass strength (Hoek-Brown)
 - Backfill ground conditions and variability
 - Nail spacing and length optimisation
- Sensitivity
 - Variable rockhead
 - Variable water pressures
- Temporary works
 - stability for staged dig (top-down construction)
 - plant loading pressures
- Construction support



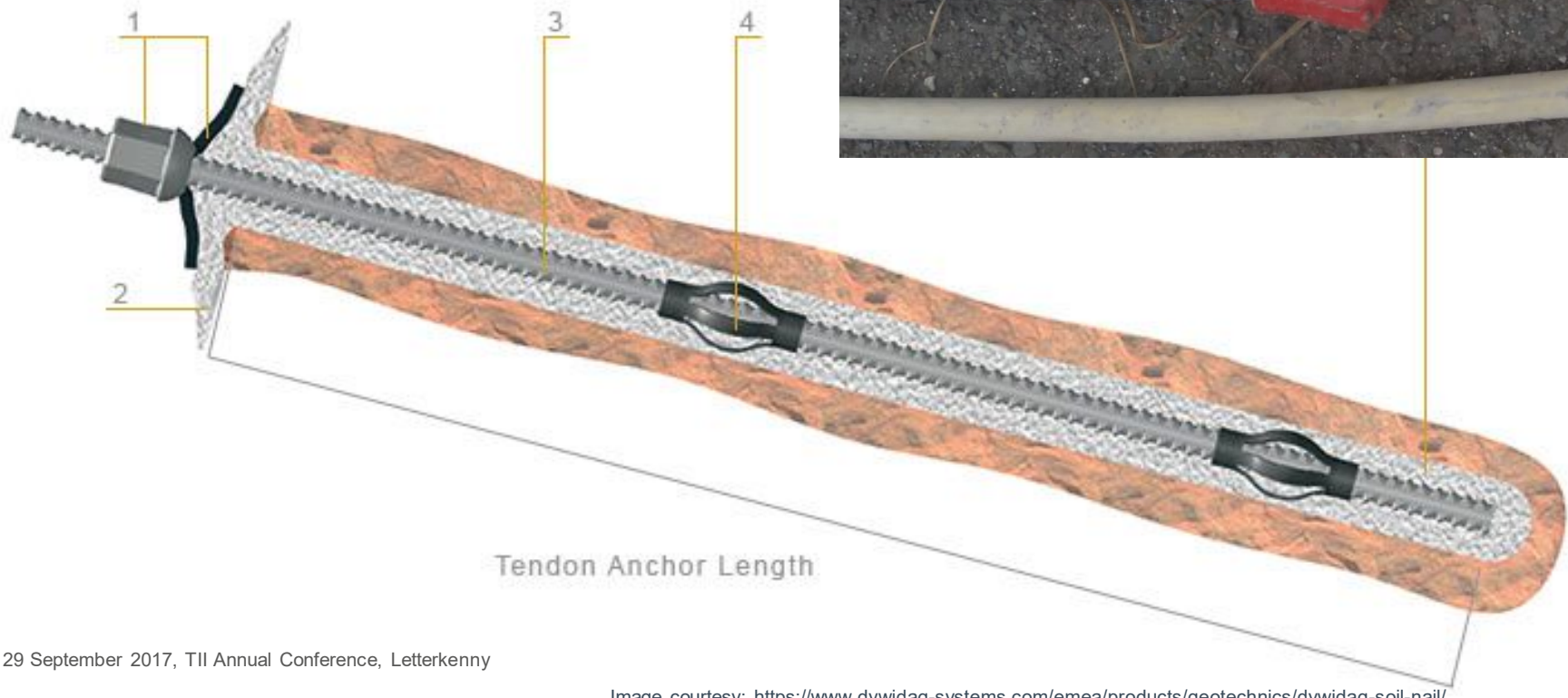
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Geotechnical Design: Soil Nails

- Dywidag R38 (550)
 - Self drilling soil nails
 - 76mm diameter sacrificial carbide button bit (rock bit)



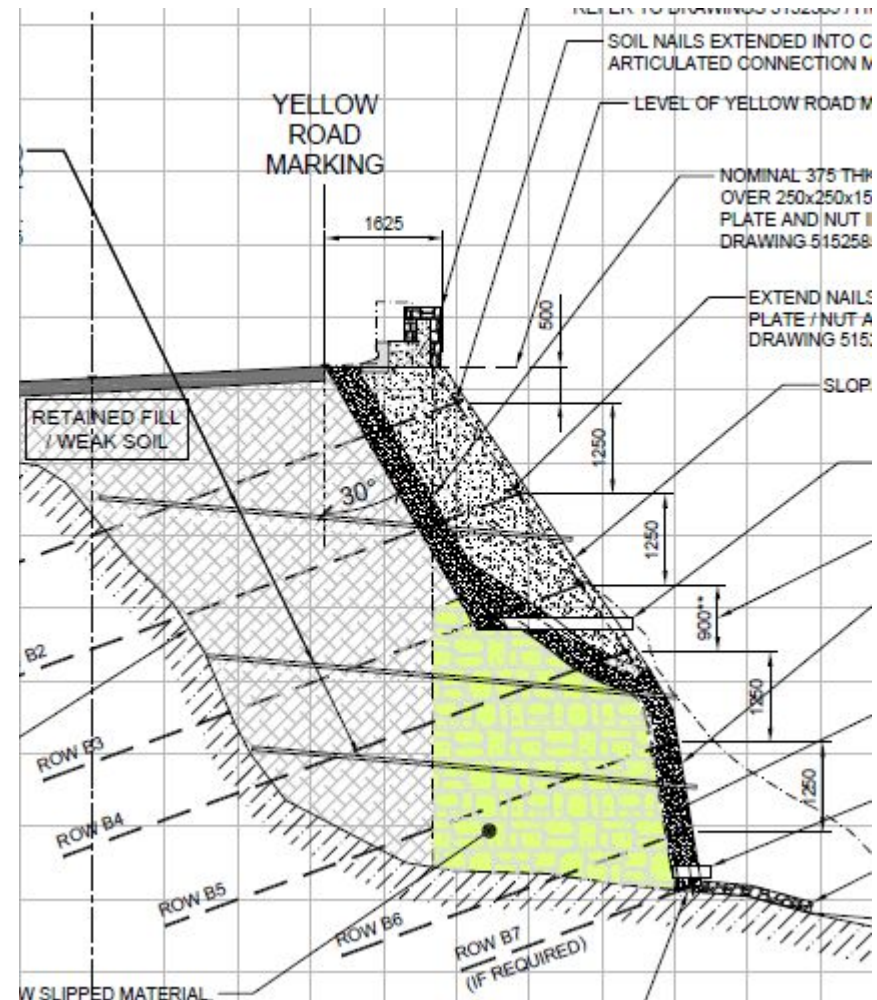
Geotechnical Design: Soil Nails

- Pull-out resistance
 - Bond strength in rock and soil
 - Verified by preliminary pull-out tests and production nail tests
- Corrosion/aggressivity
 - Aggressive soil (peat); corrosion allowance
 - Grout sulphate resistance
 - 30N/mm² DC3 cementitious grout, full surround
- Block pull-out and sliding block check



Structural/Civil Design

- Shotcrete Facing
 - 2 layers A393 mesh
 - 40N/mm² strength shotcrete, DC2
 - Designed to Eurocodes with reference to CIRIA 637 in permanent and temporary condition
 - Punching check around header plates
 - Bending capacity between nail heads
- Vehicle Restraint (trief kerb)
 - Bearing capacity
 - Lateral impact load
 - L-shaped wall with stone masonry facing



Construction

- Contractor- Lemac Ltd (Cork)
 - Development of solution through ECI
- Site Supervision and Technical Support- Atkins
 - Cork: Project Management & Structural/Highways Design
 - Dublin: Geotechnical Site Supervision
 - UK: Geotechnical Design Support

Construction- Enabling Works

- Remove unstable remains of collapsed wall
- Gunite face of adjacent walls for stability and to seal cracks
- Grouting of adjacent drystone walls
 - Improve overall wall stability
 - Stabilise stone blocks to allow drilling to progress without bore collapse
 - Prevent grout loss from soil nails to ensure encapsulation
- Temporary weep holes
 - Prevent build-up of excess water pressure behind grouted wall



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Construction- Soil Nailing

- Nail and plate adjacent walls to enable safe access to collapsed section
- Staged dig (top-down)
- Install nails
- Drainage
 - Back of wall wick drains
 - Sub-horizontal drains
- Fix reinforcement mesh and header plates
- Shotcrete
- Shotcrete cure time- repeat



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Soil Nailing:

- Locate remains of drystone wall
- Grout wall to stabilise
- Install soil nails
- Connect drainage

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Soil Nailing:

- Lower levels at maximum reach
- Probing and hand digging required to locate base of wall and rockhead

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Soil Nailing:

- Install vertical nails to support weight of thick shotcrete founded on soft ground

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Construction- Highways Engineering

- Trief Kerb N1 Containment appropriate for 85km/h design speed (trialled on Ring of Kerry in 2013)
- Barrier faced with stone sympathetic to surroundings
- Channel drain to divert surface drainage to safe outfall location
- Erosion protection below sub-horizontal drains



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**Road reopened 13 April
2017 in time for the
Easter Holidays**

Thank You

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