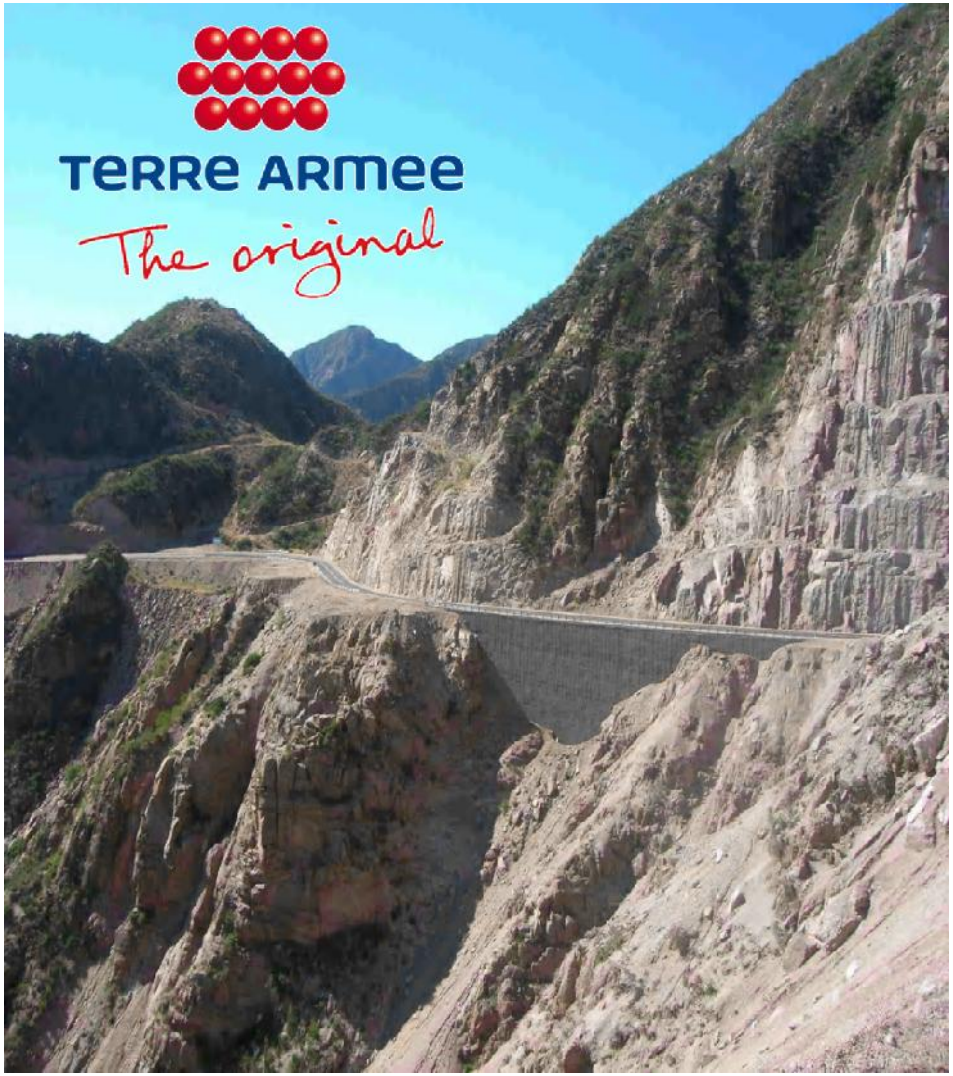


Slope Engineering and Geo-Hazard Solutions

Somnath Biswas

The safe way is the only way

A SUBSIDIARY OF SOLETANCHE FREYSSINET

Challenges and Difficulties in dealing with slope stabilization problems ….

- **Most highway and road development projects in "manageable" terrains – engineering and construction challenge limited to some major bridges and tunnel works.**

- **Several NHIDCL entrusted projects in mountainous terrains, difficult access and workability conditions.**

- **Conventional resources have been applied in the last several decades in road building – and more so in maintenance and attempting to make the infrastructure asset 'all weather'**
  - Prolonged time of construction – maintenance basic and repetitive !
  - Safety is always a concern
  - Conventional solutions produce 'conventional' results

So where are we today…

- **Limited geotechnical expertise, experience and project references**
  - sample size is small….(unlike common highway and railway projects).

- **Input - Data Accuracy ..**
  - Geotechnical, geological, geomorphological, geophysical data
  - Accurate survey and topological mapping
  - Details on river morphology, bathymetry …
  - Phreatic lines and ground water positions …(historic and seasonal)

Consequently …and likely

Output – Basis of Design and Engineering Detailing at DPR stage

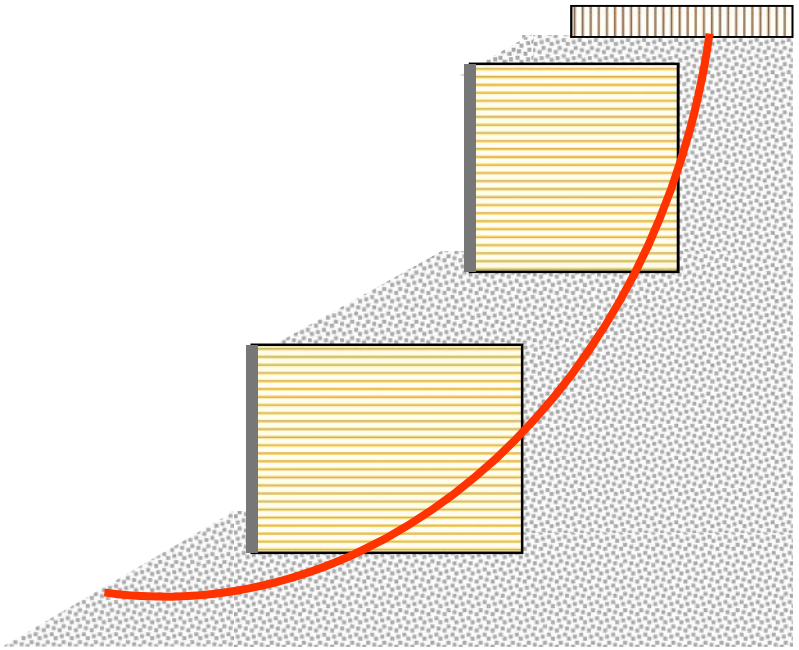
  - on "best" assumptions and "good" experience ??
- Likely variance of DPR stage project budget versus 'bid price' for EPC contracts
- Long term approach to asset performance may be missing – DLP limited to 4 years

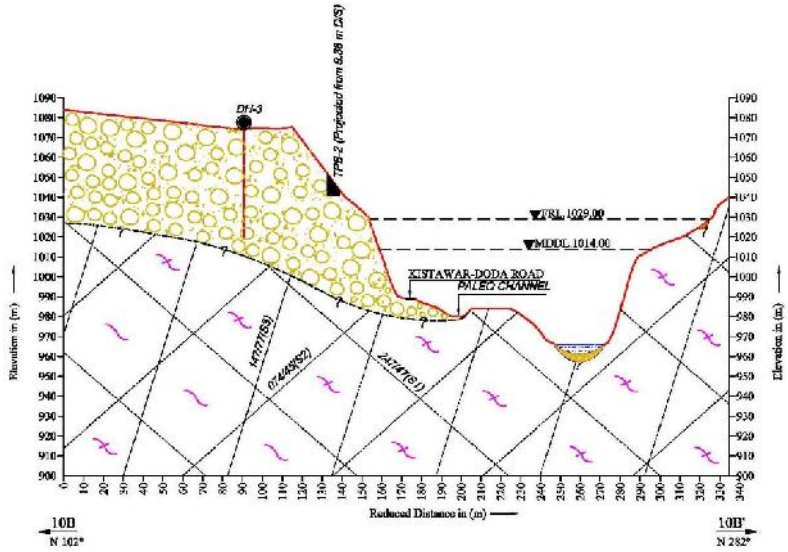
Basics once resolved…what are the core aspects in attending to Slope Stability Problems ?

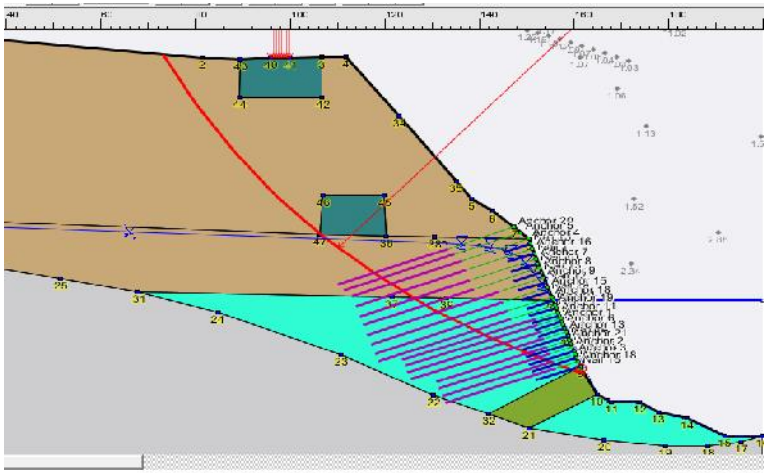
- ***Scientific Temper ?*** **Industry attractiveness ….**
  - Engineering
    - Basic Principles approach
  - Methods
    - geotechnical engineering, hydraulic engineering
    - slope stabilization techniques, rock fall techniques
  - Integrating
    - knowledge of materials – earth, rock, timber, natural fabrics, fluids, plastics, steel, alloy…
    - Integrating industrial products (like geosynthetics, steel bars, nets…) with techniques, technology and scientific know-how

Engineered approach – Slope stability

- **Detail soil and geological Investigation**
  - Macro level
  - Micro level – Validation
- **Geotechnical approach – Construction stage analysis**

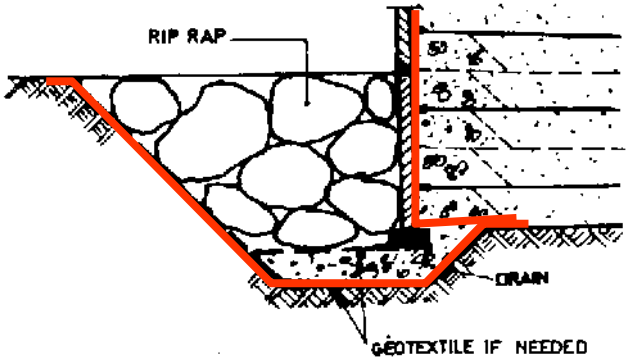


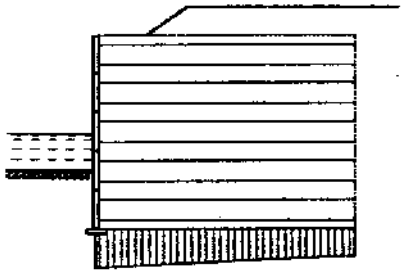


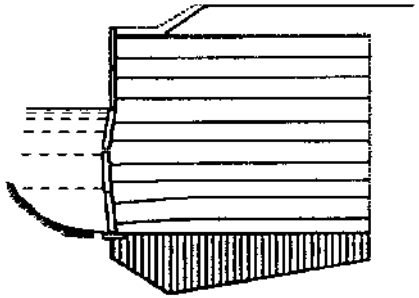


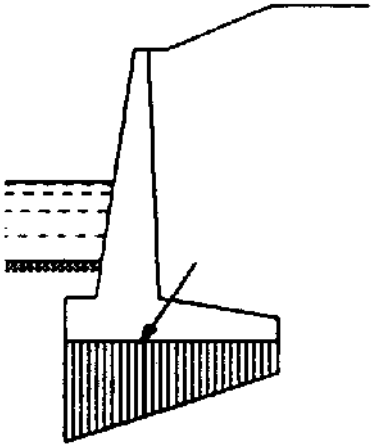
Influence of induced water in civil works

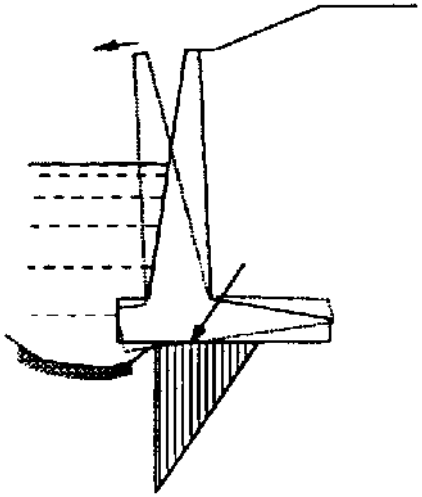
- Drainage (Internal and External)
- River Training works (Toe Erosion and Under scour)





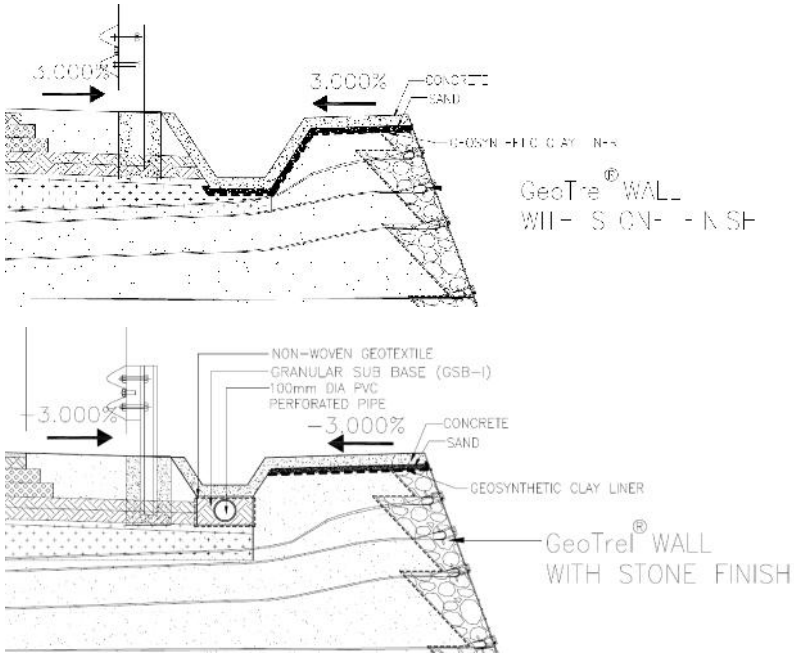






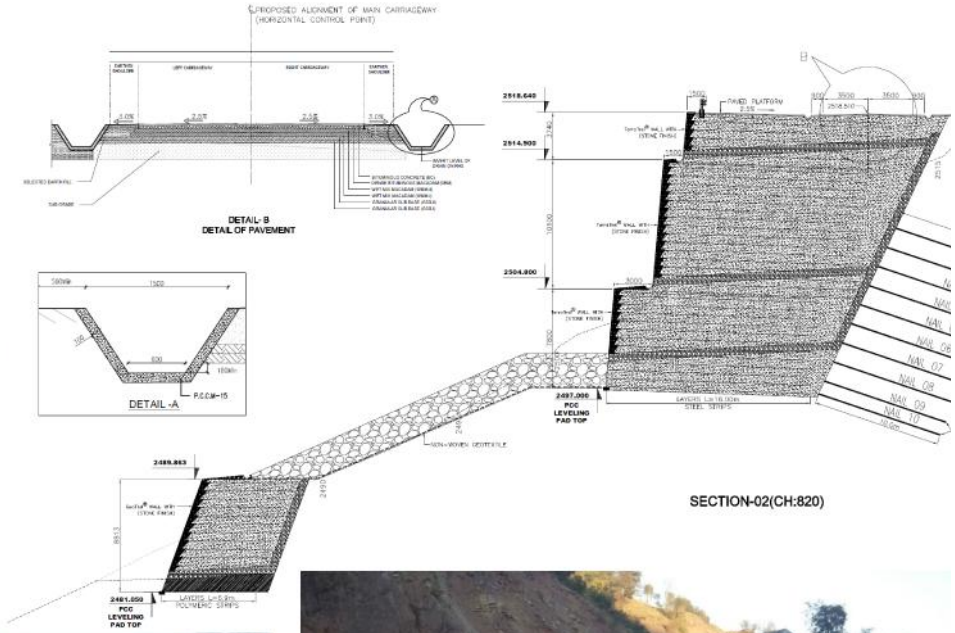
Drainage System

- **Surface Drainage**
  - Engineered surface drainage system | storm channel reduces water seepage
  - 85 – 90% water discharge by surface run-off
  - Only 10 to 15% seepage water

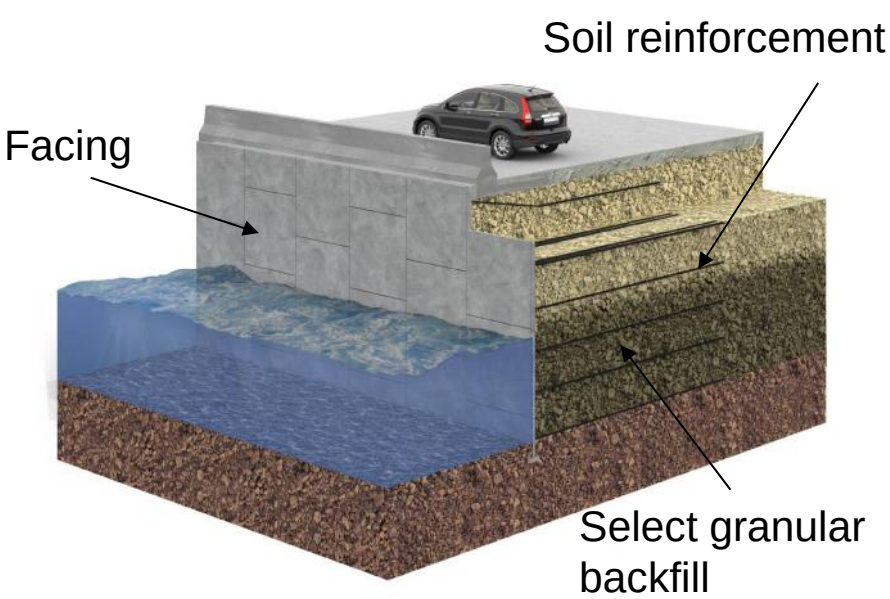


Drainage System

- **Sub-surface Drainage**
  - For dissipation of pore water pressure
  - Improves slope stability

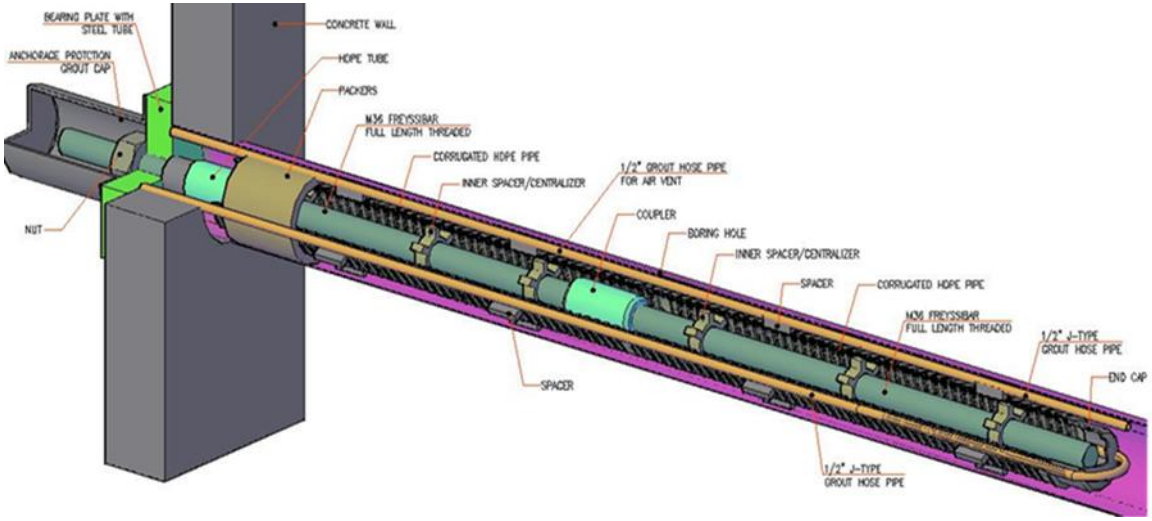


River bank, toe and bed protection - TechRevetment

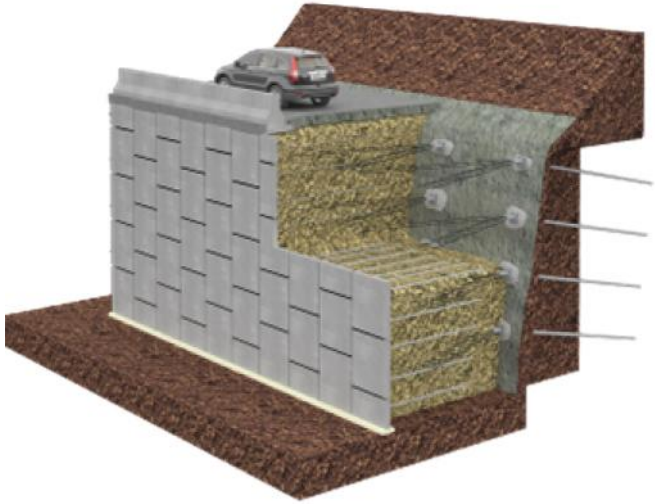


In-situ slope stabilization methods

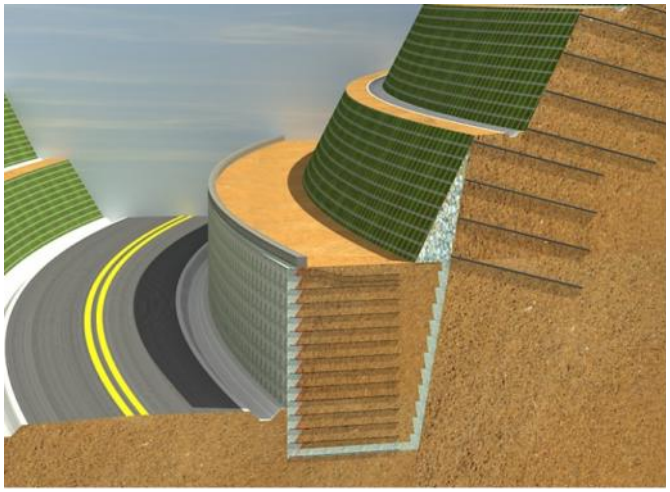
- **Ground Anchors (FreyssiAnchor) – soil and rock mass integration**
- **Soil Nails (TerraNail) – grouted – hollow / solid geotechnical bars nails**
- **Earth Anchors (TerraAnchor) – driven pre-stressed anchors**

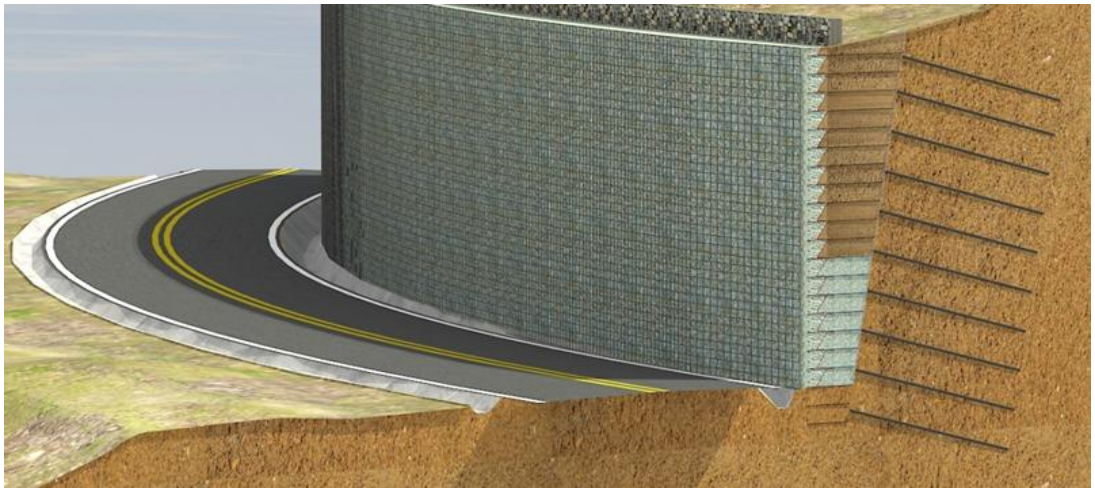


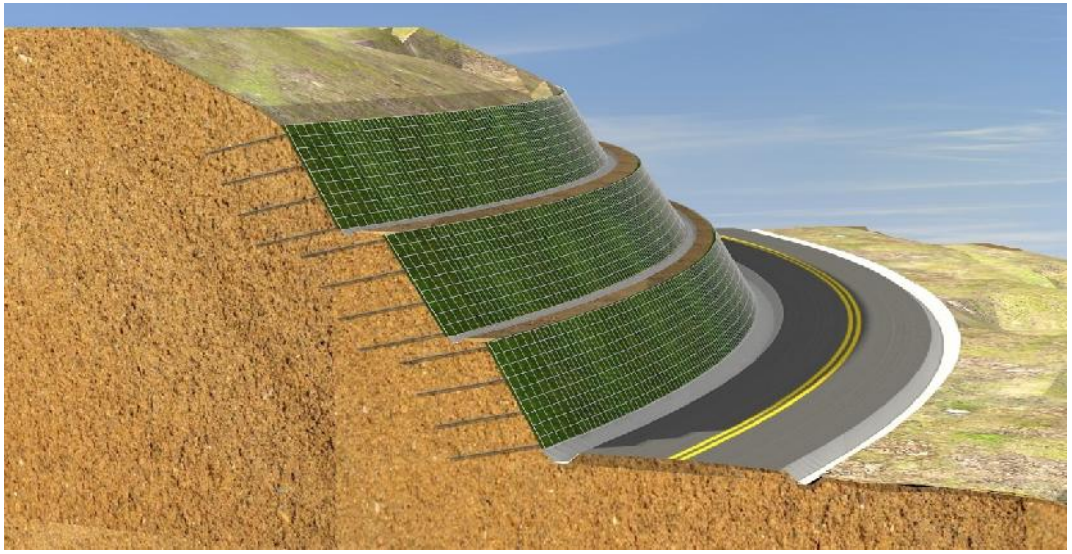
Combining Reinforced Earth with TerraNail

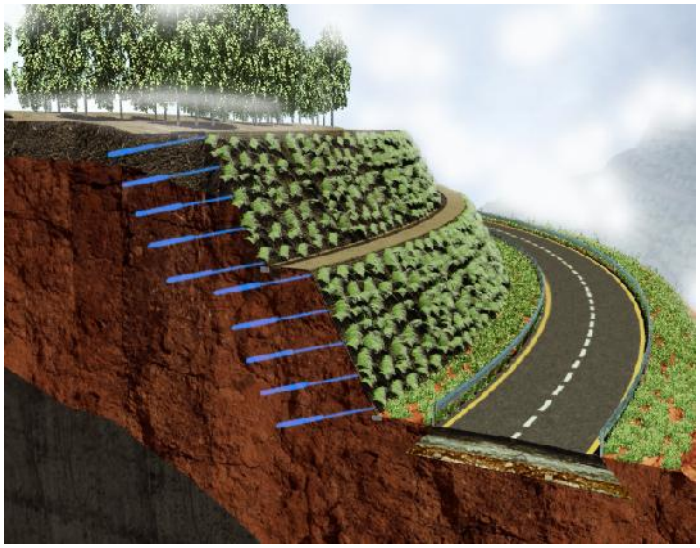


Examples



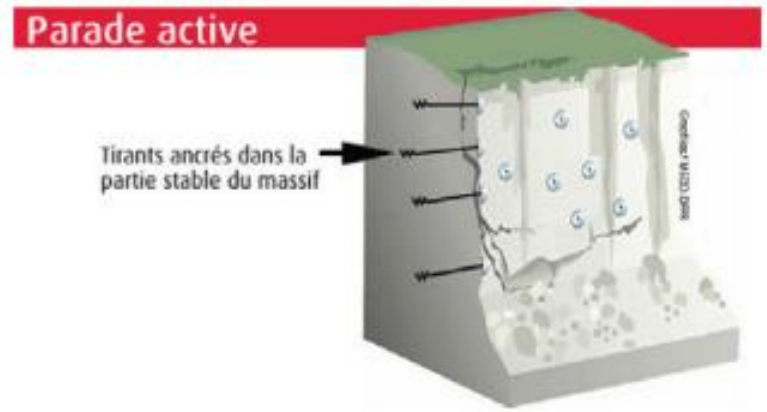






Various Rockfall Protection systems

- ✓ **Active mitigation**: is carried out in the initiation zone and **prevents the rockfall event from ever occurring.**
  - Rock blasting
  - Cable lashing
  - Rock bolting
  - Slope retention systems
  - Slope protection
  - Shotcrete
  - ….



- ✓ **Passive mitigation**: where only the **effects/consequences of the rockfall event are mitigated** and are generally employed in the deposition or run-out zones
  - Drape nets (mesh and cable)
  - Catchment fences
  - Barrier fences
  - Diversion dams **(Reinforced Earth)**
  - Rock sheds **(TechSpan and TechBox)**
  - Protection bunds **(Reinforced Earth)**

Passive Rockfall Protection systems

- **GeoTrel™ / TerraTrel® walls as shock absorbing structures**
  - Excellent energy dissipation
  - Tailor made designs
  - New developments under way

- **TechSpan® and TechBox™ rock sheds**
  - Tailor made designs
  - Benefits of precast solutions
  - Speed of construction
  - Limited traffic interruption

GeoTrel™ protective bund testing (France)

Mexico – rockfall protection

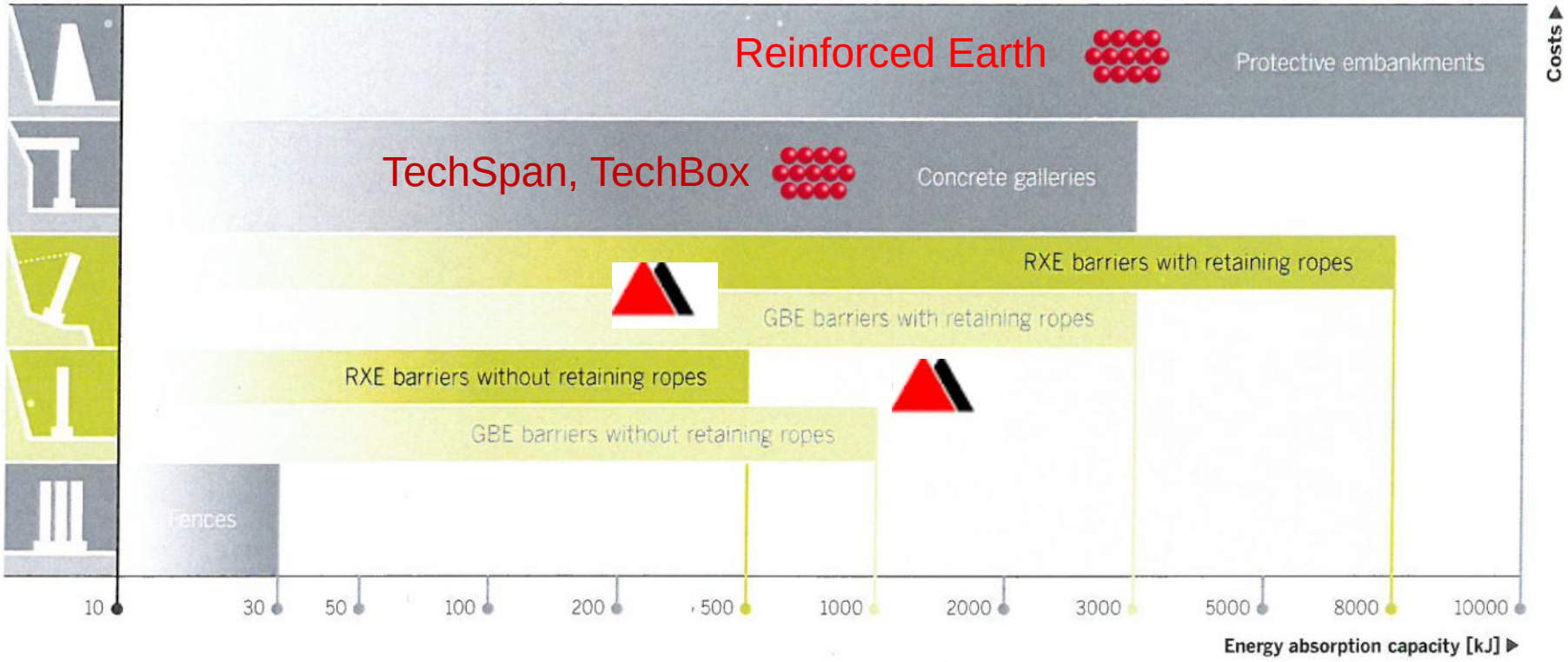
South Korea - tunnel extension

Spain – TechBox™ rock shed

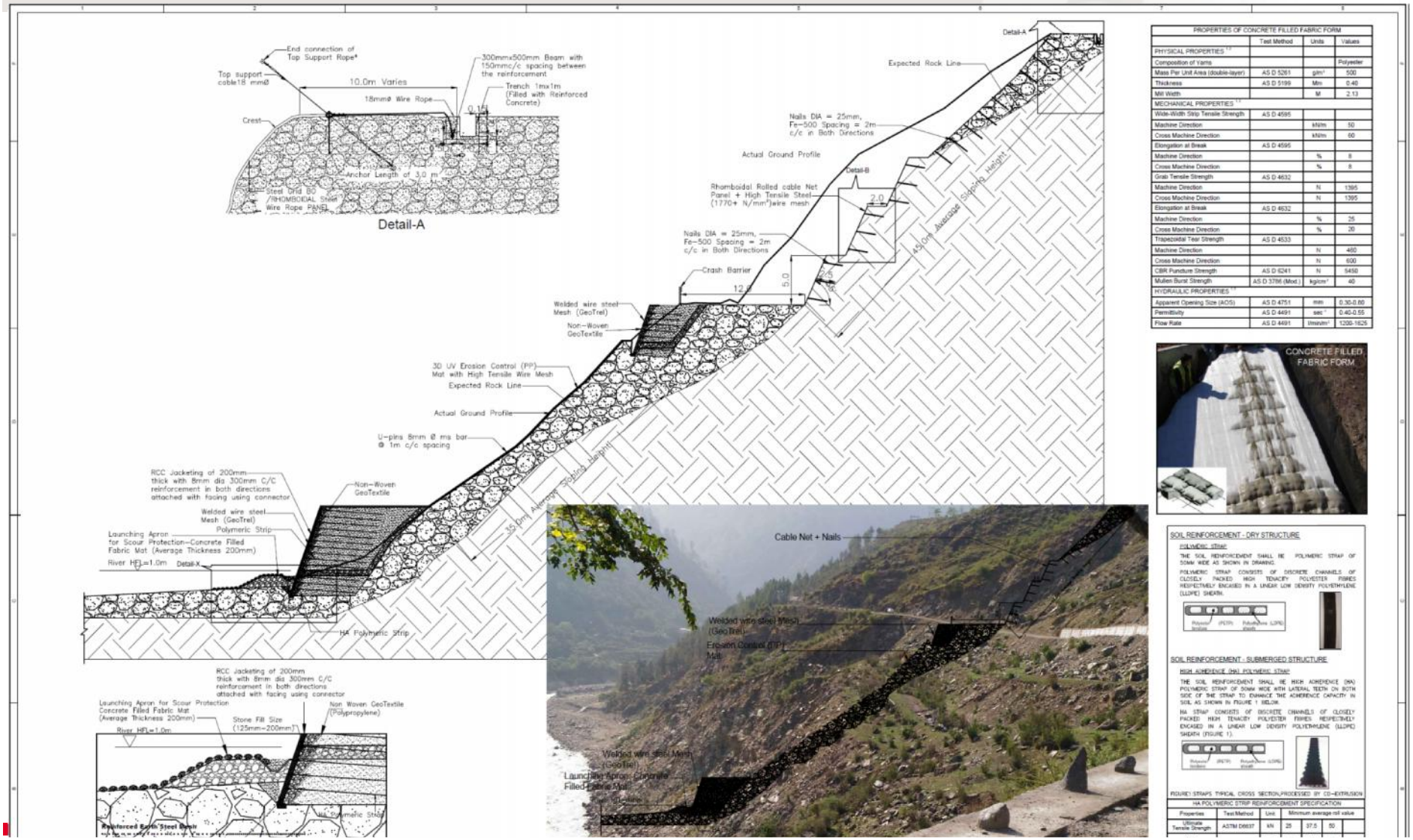
Passive solutions for rockfall protection

<< Complementarity Solutions >>

Comparison of rockfall protection systems



Integrating Engineering Solutions



PROPERTIES OF CONCRETE FILLED FABRIC FORM			
	Test Method	Units	Values
PHYSICAL PROPERTIES [1]			
Composition of Yarns			Polyester
Mass Per Unit Area (double-layer)	AS D 5261	g/m²	500
Thickness	AS D 5199	Mm	0.46
Mill Width		M	2.13
MECHANICAL PROPERTIES [1]			
Wide-Width Strip Tensile Strength	AS D 4595		
Machine Direction		kN/m	50
Cross Machine Direction		kN/m	60
Elongation at Break	AS D 4595		
Machine Direction		%	8
Cross Machine Direction		%	8
Grab Tensile Strength	AS D 4632		
Machine Direction		N	1395
Cross Machine Direction		N	1395
Elongation at Break	AS D 4632		
Machine Direction		%	25
Cross Machine Direction		%	20
Trapezoidal Tear Strength	AS D 4533		
Machine Direction		N	460
Cross Machine Direction		N	600
CBR Puncture Strength	AS D 6241	N	5450
Mullen Burst Strength	AS D 3786 (Mod.)	kg/cm²	40
HYDRAULIC PROPERTIES [1]			
Apparent Opening Size (AOS)	AS D 4751	mm	0.30-0.80
Permittivity	AS D 4491	sec	0.40-0.55
Flow Rate	AS D 4491	l/min/m²	1200-1625

Focus – Technology, Techniques and Construction Methods