Use of site-won soils for reinforced soil slopes and walls

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GEOANZ #1 ADVANCES IN GEOSYNTHETICS
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An increasing challenge in building RSS

Selected fills are **expensive** to quarry and to transport to site

Increasing **scarcity** of granular fills

Raising **environmental concerns**

Excavated soils are expensive to be **disposed**

Structural fill requirements for RS – BS8006-1

Table 2 **Summary references to the relevant component of the main materials within reinforced soil walls, abutments and slopes**

	Walls and abutments	*Steep slopes (≤ 70, > 45°)*	*Shallow slopes (≤ 45°)*	*Foundations*	*Comments*
Fill materials					
Class or type	*Selected granular fills (Classes 6I/J), Selected cohesive fills (Classes 7B/C/D) and Chalk (see Note 3)*	*Selected granular fills (Classes 6I/J), Selected cohesive fills (Classes 7B/C/D), General granular fill (Class 1), General cohesive fill (Class 2)(see Note 4) and Chalk (see Note 3)*	*Selected granular fills (Classes 6I/J), Selected cohesive fills (Classes 7B/C/D), General granular fill (Class 1), General cohesive fill (Class 2), and Chalk (see Note 3)*	*A1 Selected granular fills as specified in SHW A1*	*Fill classes as SHW Table 6/1. Class 7B not permitted for steel reinforcing elements. Specific drainage measures may be required with cohesive fills. See also* ***3.1.3.2*** *and* ***3.1.3.3****.*
Permitted constituents	*SHW Table 6/1*	*SHW Table 6/1*	*SHW Table 6/1*	*SHW Table 6/1*	
Grading	*SHW Table 6/1*	*SHW Table 6/1*	*SHW Table 6/1*	*SHW Table 6/1*	*Grading not applicable to chalk*
Shear strength (φ) test	*BS 8006-1* ***4.2.1***	*BS 8006-1* ***4.2.1***	*BS 8006-1* ***4.2.1***	*BS 8006-1* ***4.2.1***	*SHW, cl 636*
Friction (μ) test	*BS 8006-1* ***4.3.3***	*BS 8006-1* ***4.3.3***	*BS 8006-1* ***4.3.3***	*BS 8006-1* ***4.3.3***	*SHW, cl 639*
Compaction	*SHW Table 6/1 and Table 6/4*	*SHW Table 6/1 and Table 6/4*	*SHW Table 6/1 and Table 6/4*	*SHW Table 6/1 and Table 6/4*	

UK Highway Series 600 Earthworks specification

Table 8 **Classification of earthworks materials in the UK by the Highways Agency**

Type	Class	Description	Typical use
General granular fill	1A	Well graded granular material	General fill
	1B	Uniformly graded granular material	
	1C	Coarse granular material	
General cohesive fill	2A	Wet cohesive material	General fill
	2B	Dry cohesive material	
	2C	Stony cohesive material	
	2D	Silty cohesive material	
	2E	Reclaimed pfa cohesive material	
General chalk fill	3	Chalk	General fill
Landscape fill	4	Various	Fill for landscape
Topsoil fill	5A	Topsoil or turf existing on site	Topsoiling
	5B	Imported topsoil	

Site-won fills

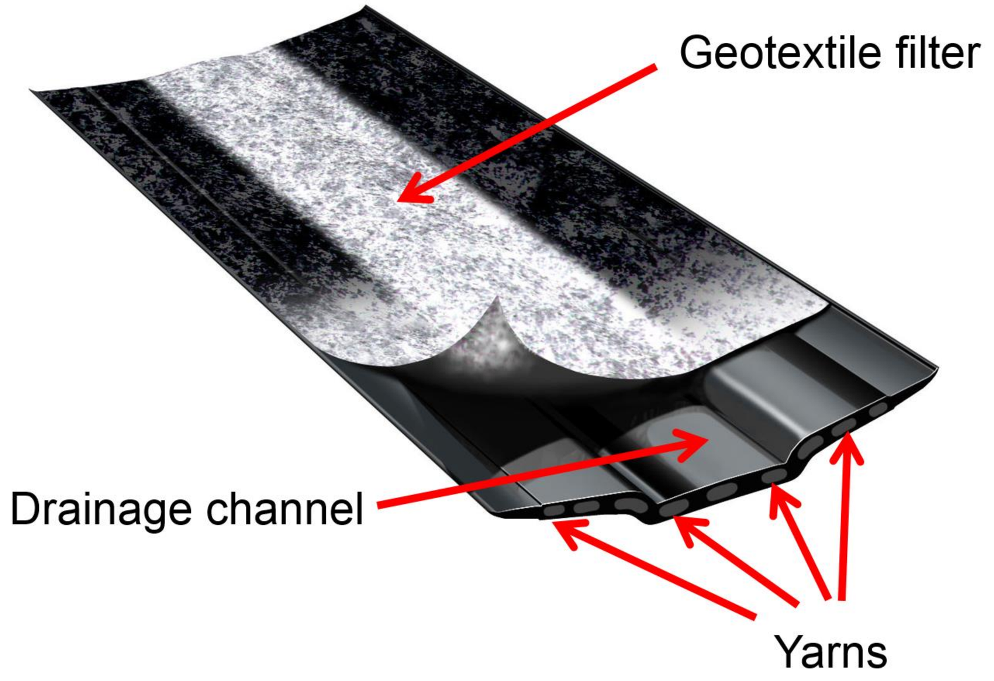
Advantages

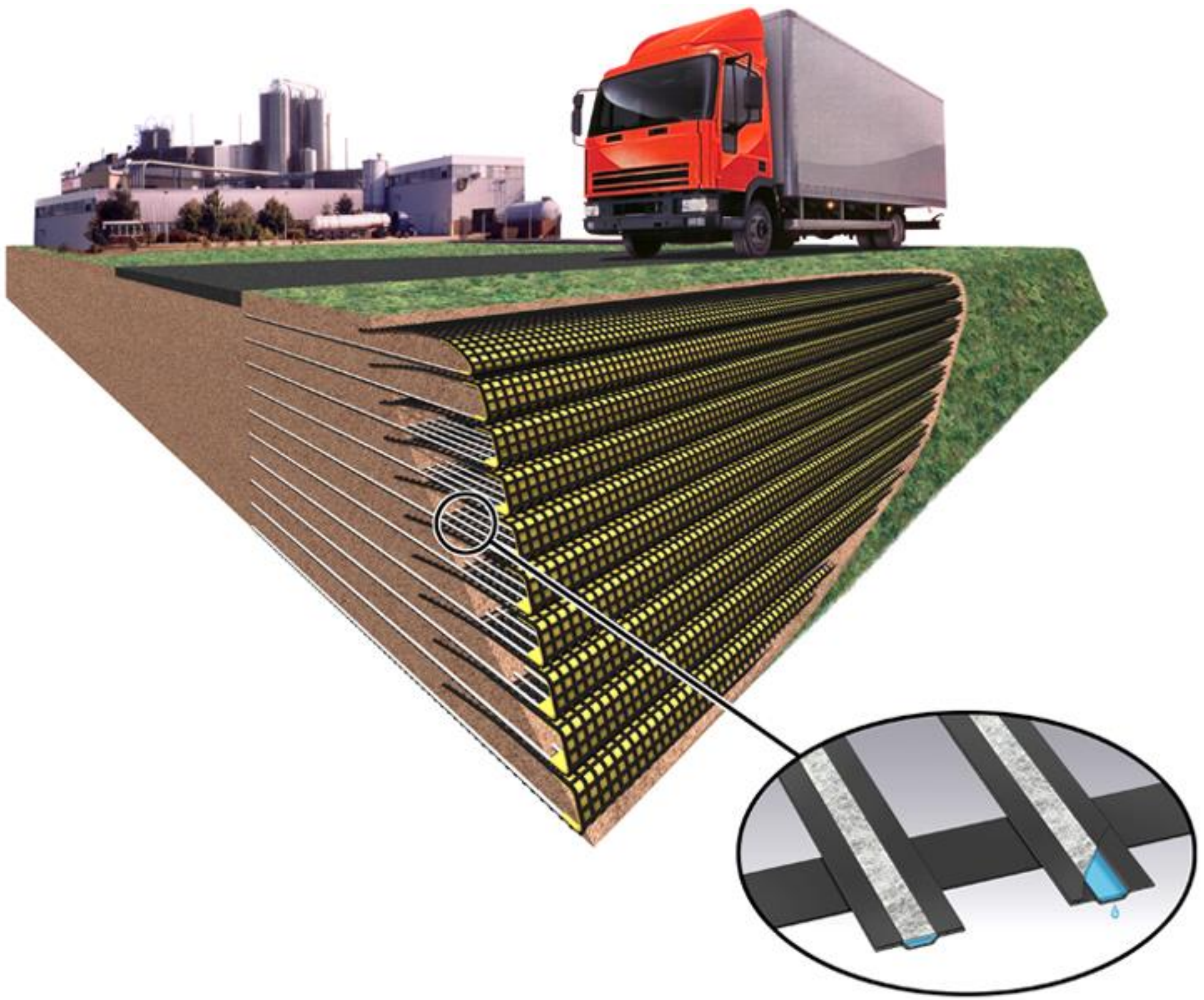
- Economical advantages
- Reduced environmental impact
- Reduced haulage
- Availability

Challenges

- Constructability
- Stability
- Durability

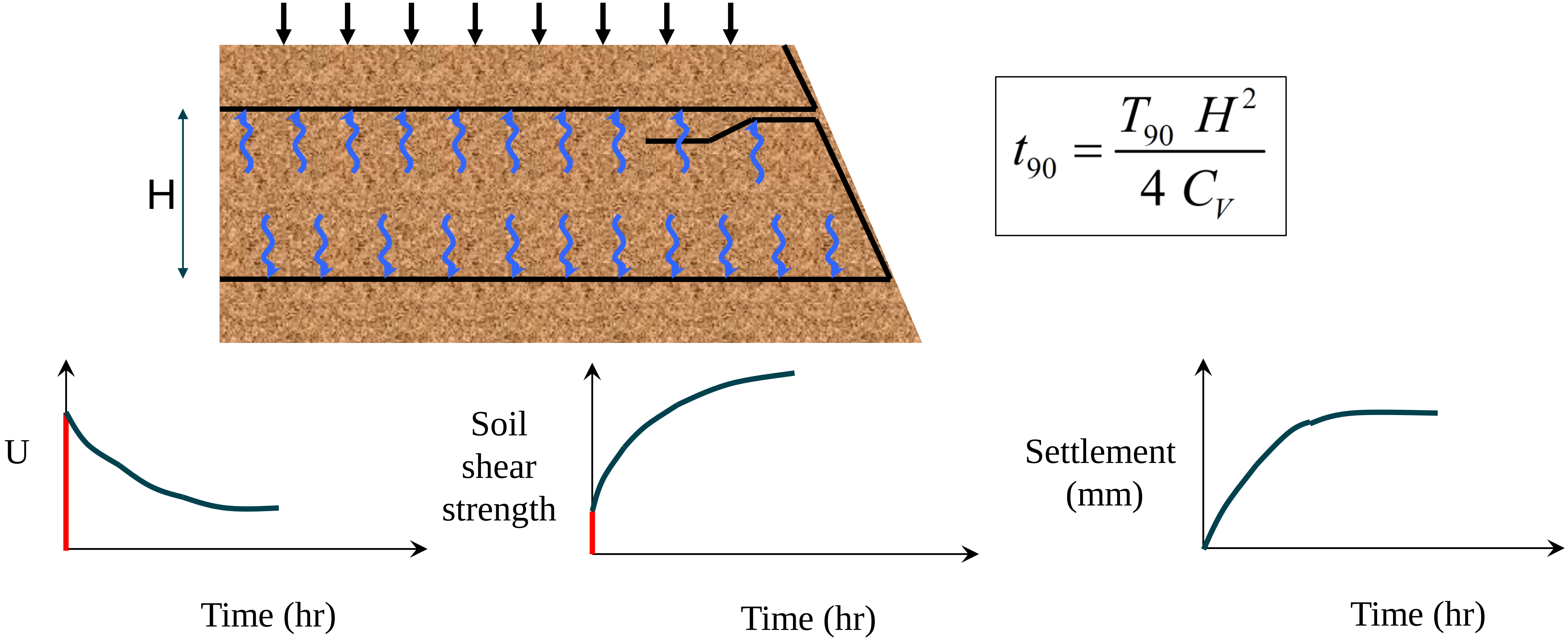
Draining geogrid





Draining geogrids

Slope Construction and Excess pore water pressure profile dissipation



$$t_{90} = \frac{T_{90}\ H^2}{4\ C_V}$$

Draining geogrids

- Increase the **rate of consolidation** of a fill material by **dissipating excess pore water pressures** created during compaction while reinforcing the structural fill
- Increase effective soil shear strength during construction
- **Improved bond strength** between soil and reinforcement
- Better control being achieved over settlements and deflections
- No need to treat the marginal fill with lime or cement to increase its properties
- **Increase productivity** (construction time & compaction)

Draining Geogrids used with wide range of soils

	ϕ (deg)	Cv (m2/NM)	mv (m2/year)	PI (%)	γ at OMC (kN/m3)	OMC (%)	%<63 μm
Bell Green, London	24	12	0.2	-	16.4-20.1	-	5-18
North Gawber, Yorkshire	25	8	0.2	21	13.3-17.4	13-35	4-82
Island Rd, Berkshire	25	2.5-16	0.2-0.4	19-32	18.8	-	-
Millbrook, London	26	7	0.2	40-58	16.3-16.9	20.5-22.4	42-56
Palmerston Park, Devon	28	57-73	0.1	10-15	22	-	9-44
Banbury Bund, Oxfordshire	24	5-40	0.3-0.5	-	16.2	22.3	-
Jenkins Lane, London	24	12	0.5	27	14.6-17.7	15-20	0-87
NBAR, Bexhill on Sea	25.5	12	0.5	23	17.4	-	-
Queensway, Hastings	26	-	-	20	19	-	-

Design considerations

1. Permeability of the soil

It governs the time required to dissipate the excess pore water pressure.

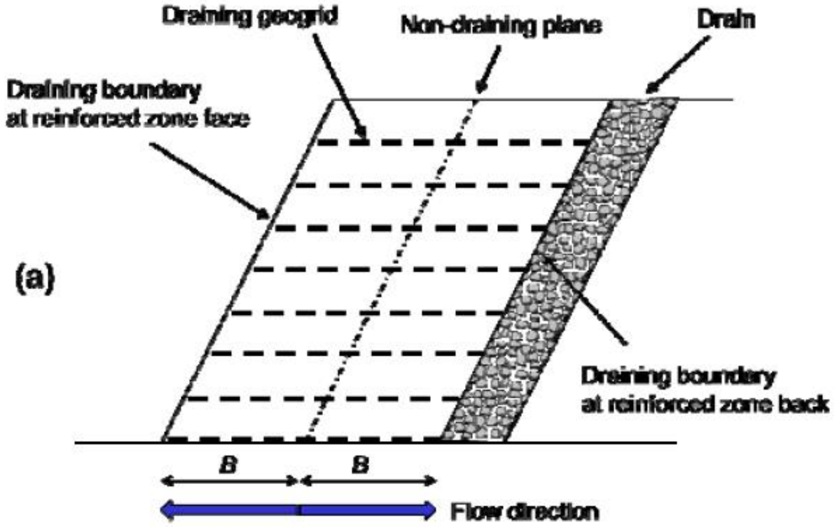
2. Length of the drainage path

i.e the distance the water needs to travel to reach the drainage.

3. Capacity of the drainage system

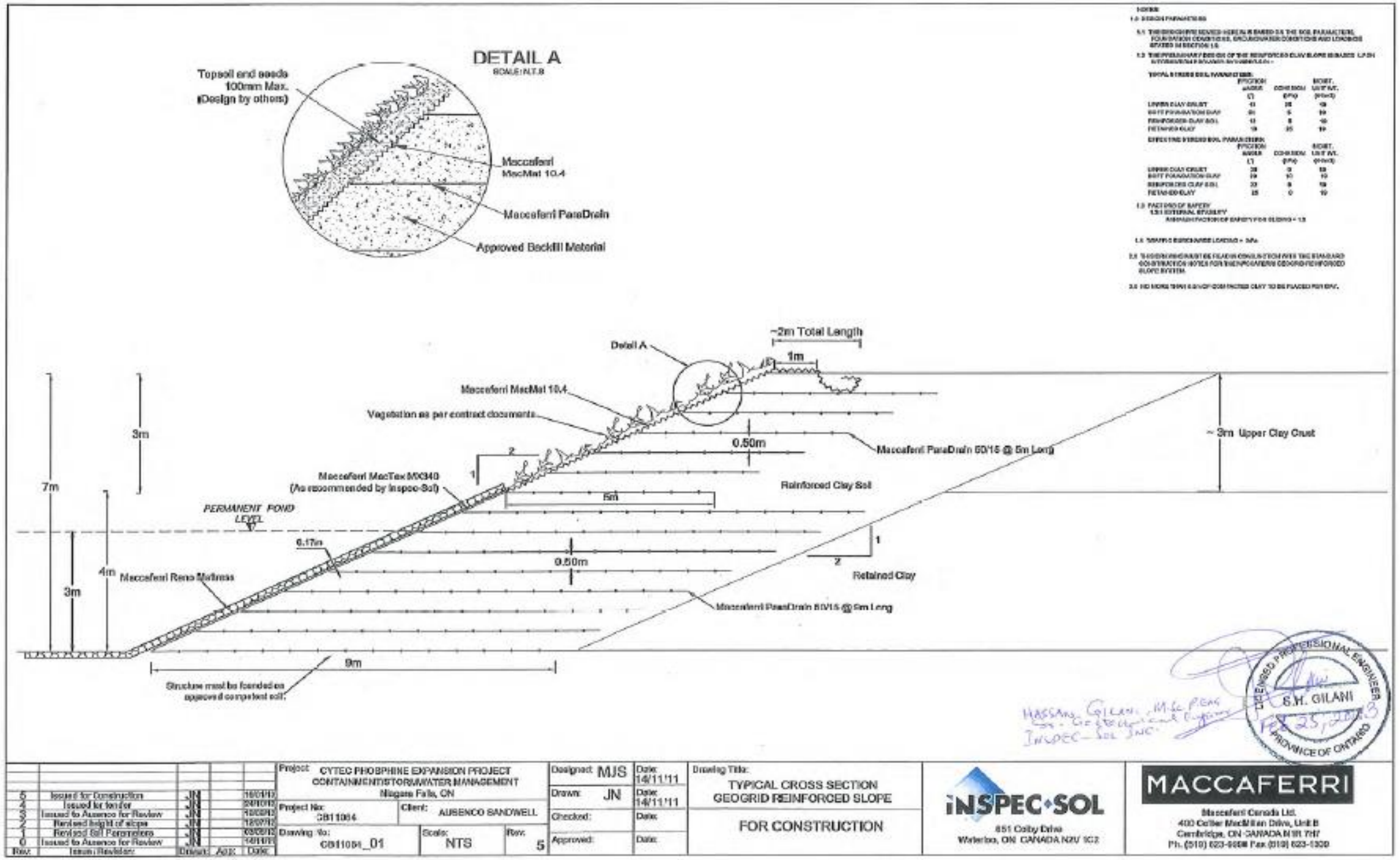
i.e. the transmissivity of the geogrid θ_L to drain the water away

$$k = \gamma_w C_V m_v$$



$$\theta_{req} = \frac{10 B^2 k}{H \sqrt{T_o}} = \frac{5 B^2 k}{\sqrt{C_V t_o}} \quad \text{if } 1 \times 10^{-6} \leq T_o \leq 1$$

$$\theta_{req} = \frac{10 B^2 k}{H T_o} = \frac{5 B^2 k H}{2 C_V t_o} \quad \text{if } T_o \geq 1$$



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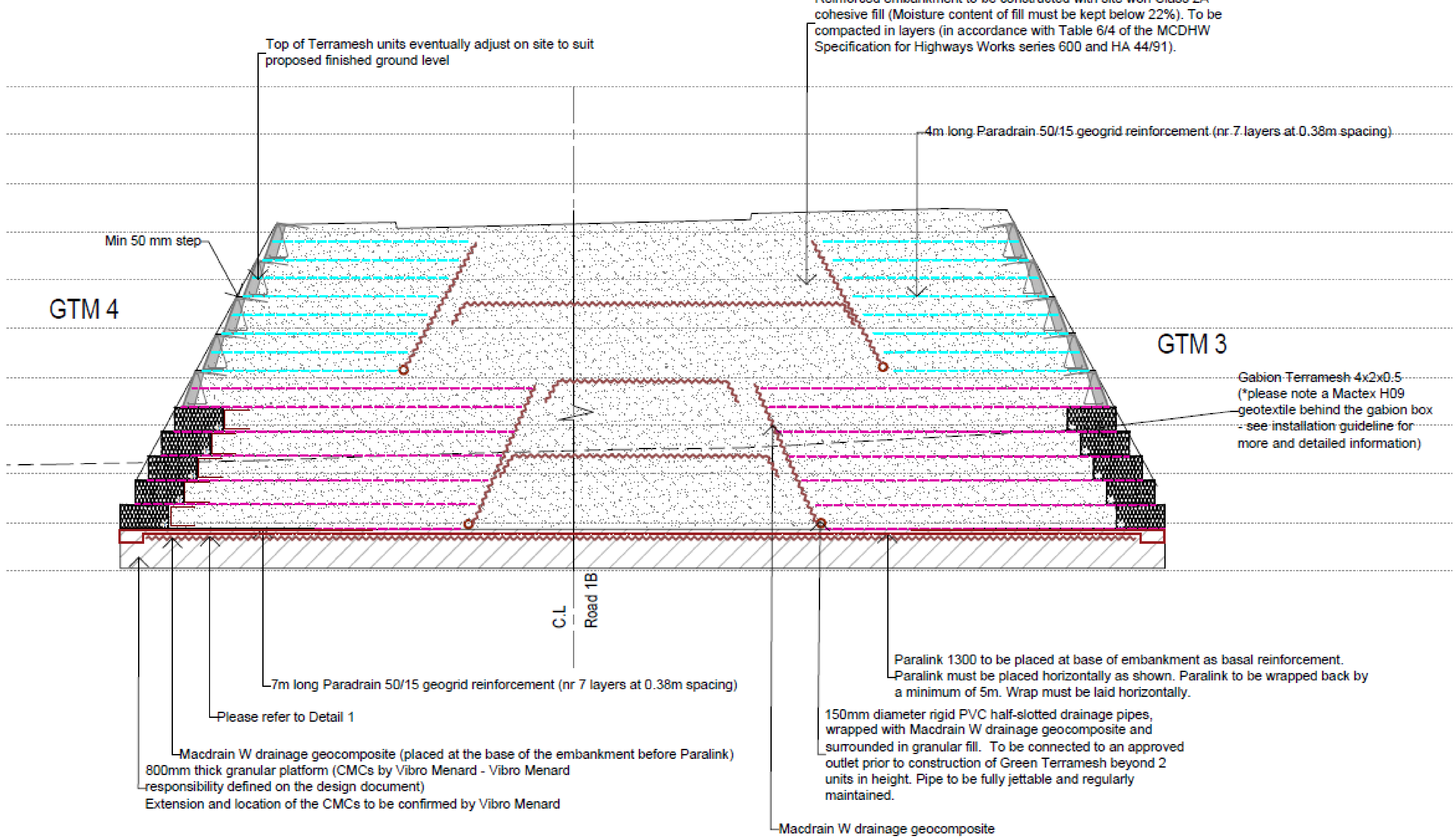
UK, Bexhill On Sea – Highway Embankment


cohesive fill (Moisture content of fill must be kept below 22%). To be compacted in layers (in accordance with Table 6/4 of the MCDHW Specification for Highways Works series 600 and HA 44/91).
Top of Terramesh units eventually adjust on site to suit proposed finished ground level
4m long Paradrain 50/15 geogrid reinforcement (nr 7 layers at 0.38m spacing)
Min 50 mm step
GTM 4
GTM 3
Gabion Terramesh 4x2x0.5 (*please note a Mactex H09 geotextile behind the gabion box - see installation guideline for more and detailed information)
C.L
Road 1B
Paralink 1300 to be placed at base of embankment as basal reinforcement. Paralink must be placed horizontally as shown. Paralink to be wrapped back by a minimum of 5m. Wrap must be laid horizontally.
7m long Paradrain 50/15 geogrid reinforcement (nr 7 layers at 0.38m spacing)
Please refer to Detail 1
150mm diameter rigid PVC half-slotted drainage pipes, wrapped with Macdrain W drainage geocomposite and surrounded in granular fill. To be connected to an approved outlet prior to construction of Green Terramesh beyond 2 units in height. Pipe to be fully jettable and regularly maintained.
Macdrain W drainage geocomposite (placed at the base of the embankment before Paralink)
800mm thick granular platform (CMCs by Vibro Menard - Vibro Menard responsibility defined on the design document)
Extension and location of the CMCs to be confirmed by Vibro Menard
Macdrain W drainage geocomposite

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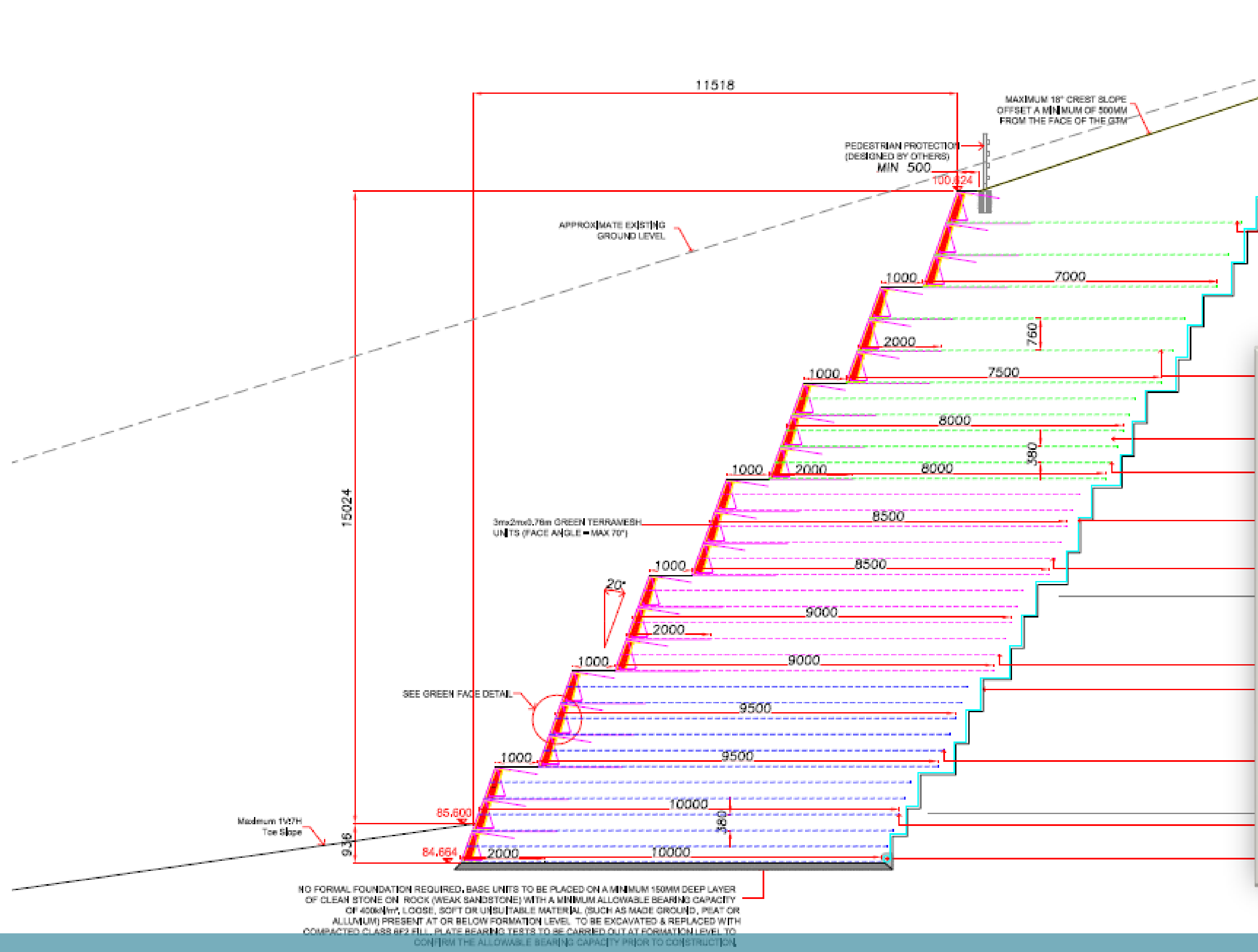
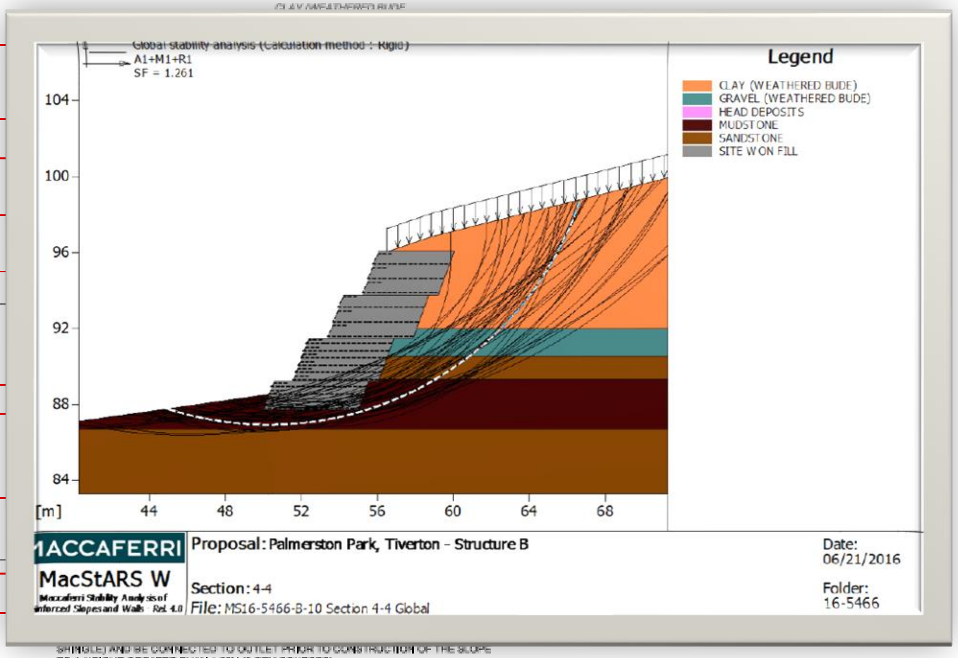
UK, Bexhill On Sea Phase 1, 2016 – Highway Embankment





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Conclusions

- **Granular fills** are the preferred choice for building reinforced soil slopes
- **Cohesive fills** can be used provided that adequate reinforcement, drainage, and construction practices are used
- Draining geogrids have been used for **more than 2 decades**
- **Draining geogrids** can be used to speed up dissipation of **excess pore pressure** during construction stage
- **Design methods** are available in literature and consider:
    - Strength and consolidation properties of the fill
    - Length of the drainage path
    - Discharge capacity of the draining geogrids

THANK YOU