KEJADIAN TANAH RUNTUH DI LALUAN PERSEKUTUAN 148

SHARING KNOWLEDGE

ISI KANDUNGAN

- Latar Belakang
- Kronologi & Kaedah Pembaikan
- Analisa
- Pelajaran daripada kes

LATAR BELAKANG

- Merupakan Laluan Persekutuan yang baru dibina sebagai laluan alternatif untuk ke Bukit Fraser.
- Sebelum ini perlu melalui Gap. Kereta perlu bergilir untuk turun dan naik Bukit Fraser.
- Laluan ke Bukit Fraser melalui Laluan Persekutuan FT55 samada daripada Kuala Kubu Baru, Selangor atau Raub, Pahang .
- Siap dibuka dan diguna sekitar tahun 2007.

- Mula runtuh pada pertengahan Disember 2007. Runtuhan makin membesar dan serius sehingga akhirnya memutuskan jalan FT 148 dan jalan di bahagian bawah, FT55 menghala ke Raub.
- Sebelum kejadian, berlaku hujan yang lebat yang berterusan dan pergerakan tanah yang masih aktif.

KRONOLOGI & CADANGAN PEMBAIKAN

19 Jan 2008 – Hakisan dan Runtuhan

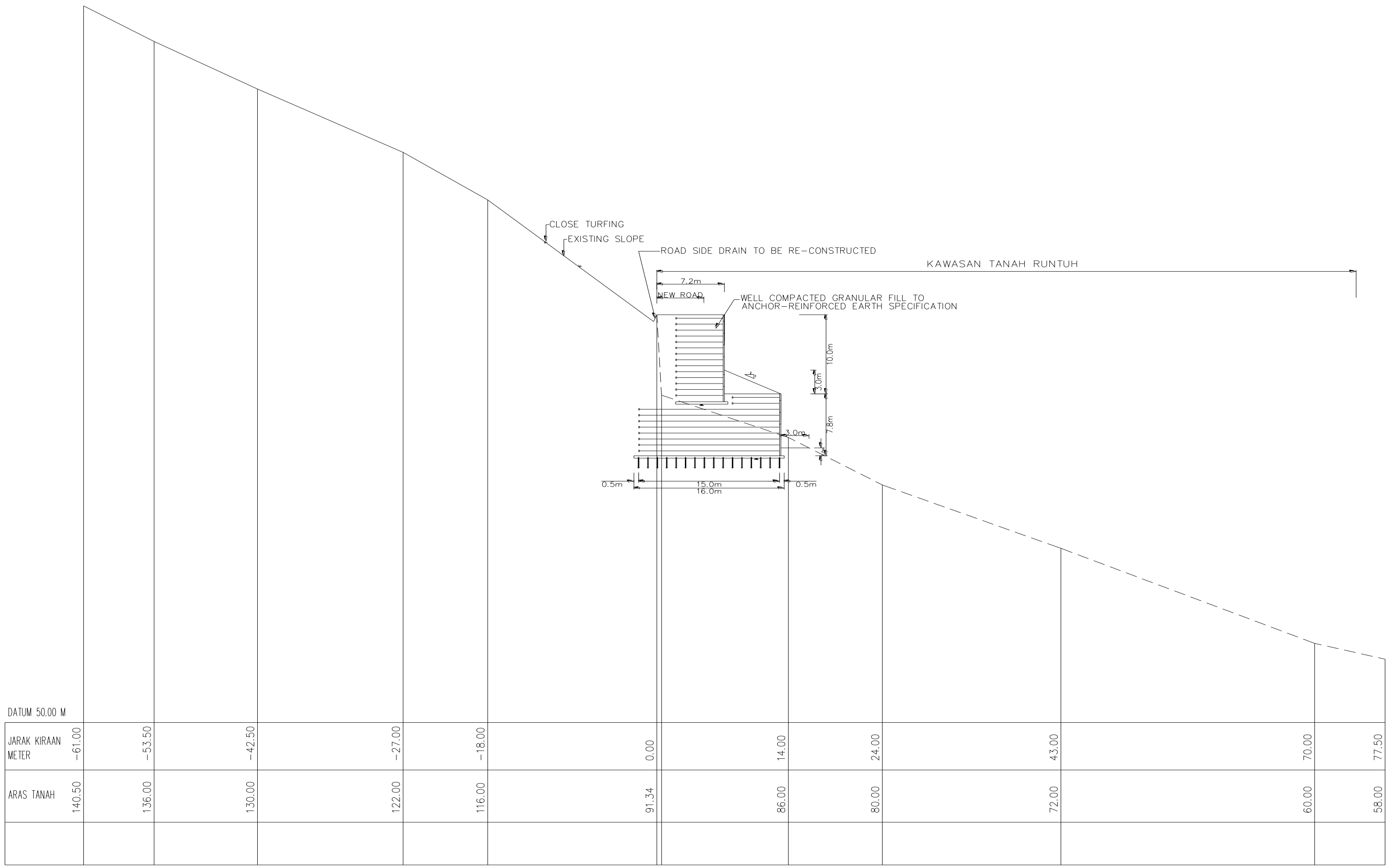
1 Feb 2008- Hakisan cerun tambakan semakin membesar sehingga ke sisi jalan

1 Feb 2008 – Longkang sedia ada ditemui tergantung pada Boulder

14 Feb 2008 – Cerun mulai gagal

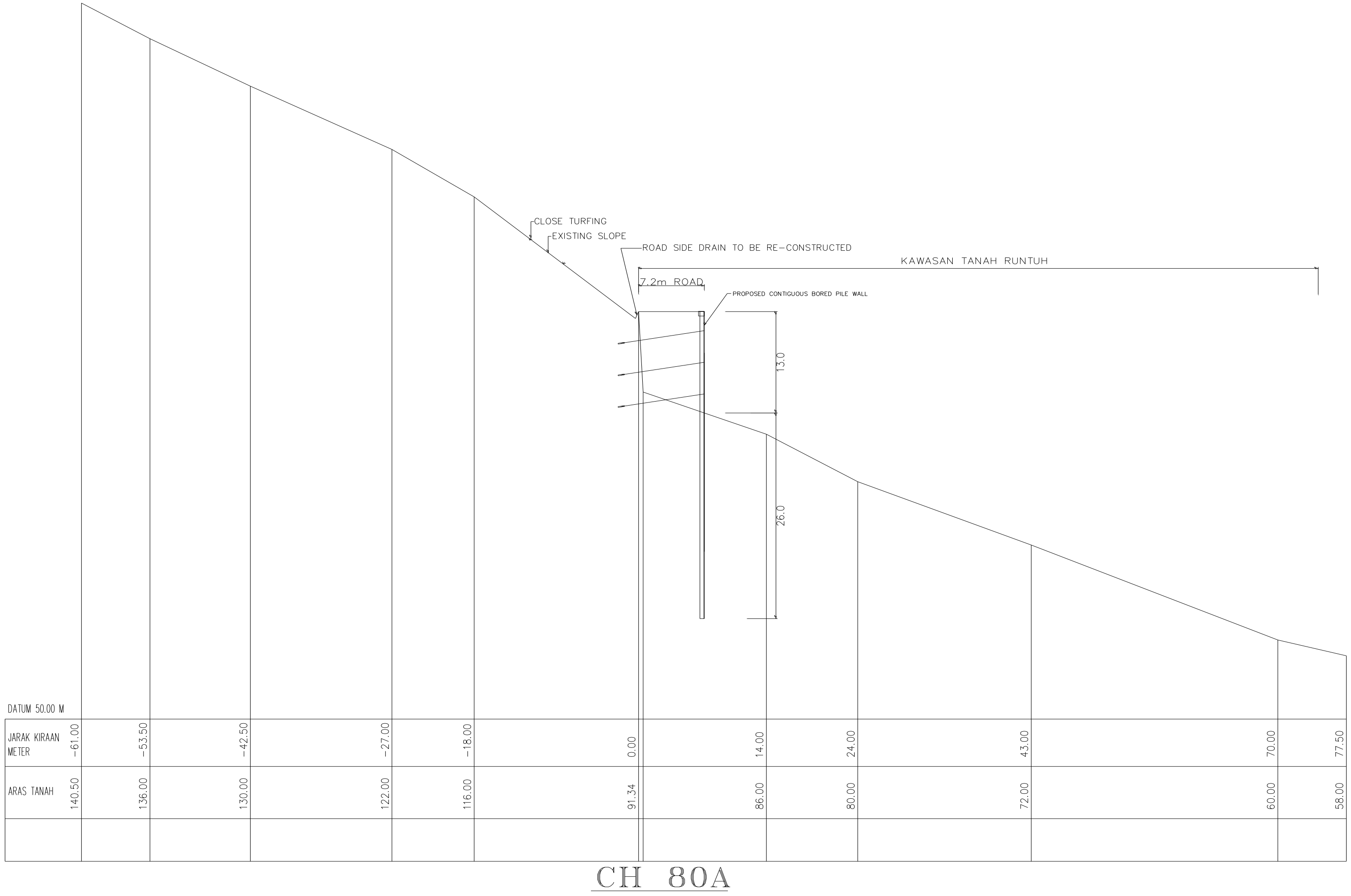
- Kaedah Perolehan adalah menggunakan AP55 iaitu kerja-kerja darurat oleh JKR Pahang.
- Tiga kaedah pembaikan yang dicadang:

- Option 1 – Reinforced Earth Wall
- Option 2 – Contiguous Bored Pile (CBP) Wall
- Option 3 – Road realignment with CBP Wall

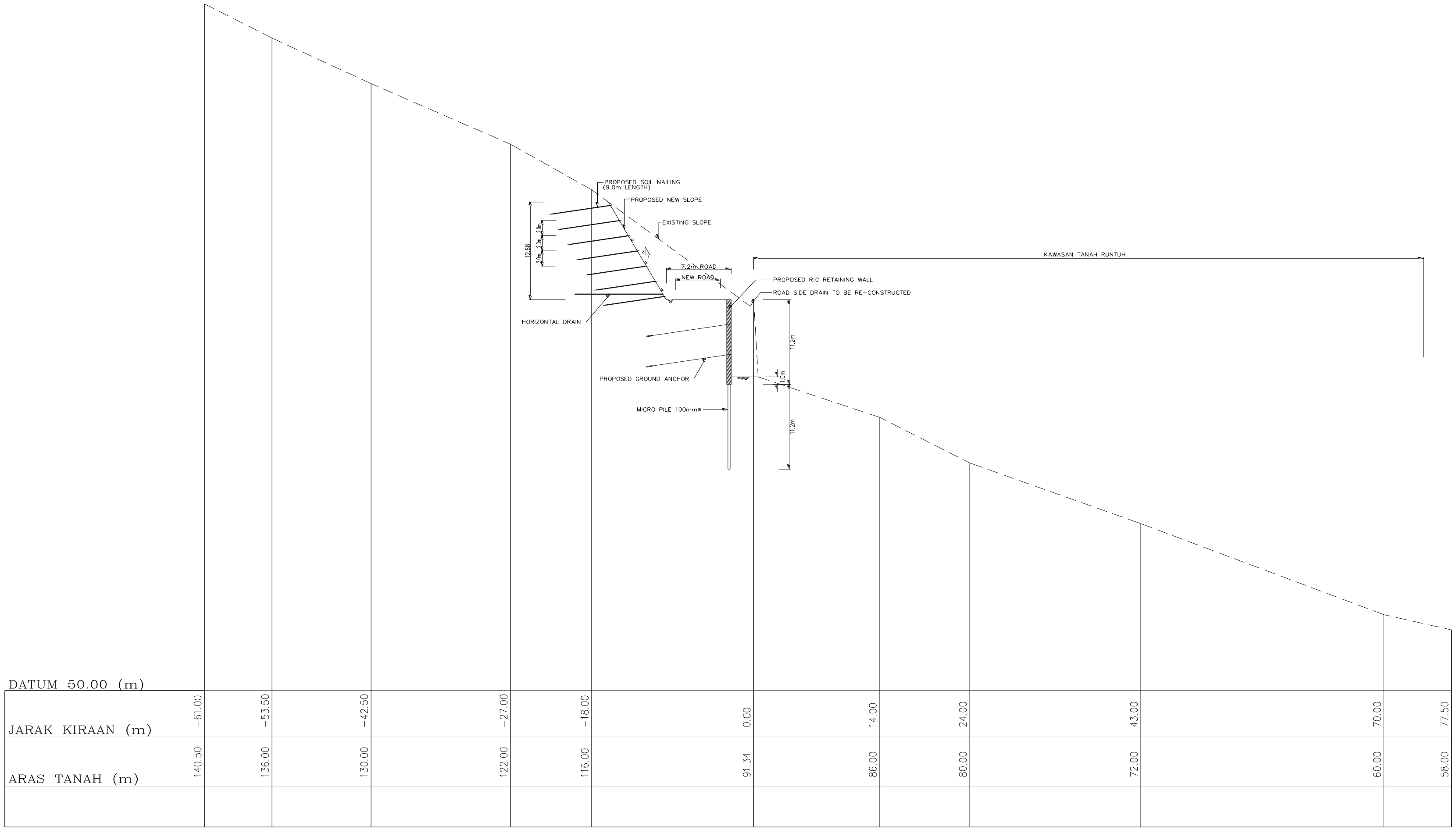


CH 80A

Option 1 – Reinforced Earth Wall



Option 2 – Contiguous Bored Pile (CBP) Wall



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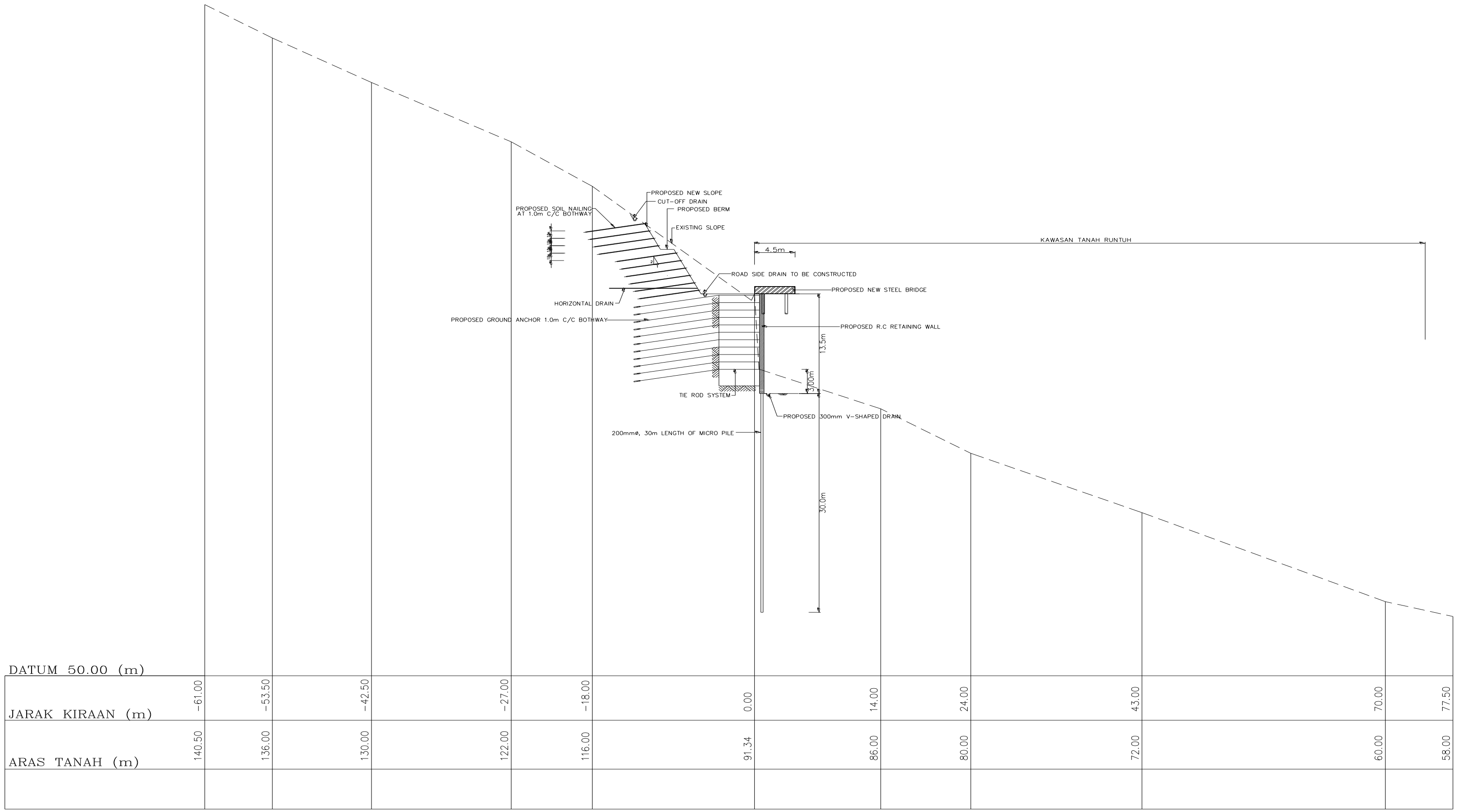
Option 3 – Road realignment with CBP Wall

3 Mac 2008- Sekitar 10m tinggi cerun potongan mula runtuh selepas berlaku hujan lebat

- 6 Mac 2008 – Mesyuarat Penyelarasan AP55 di JKR Pahang.
- Disebabkan oleh runtuhan cerun yang semakin membesar, maka kaedah pembaikan dicadangkan ditukar kepada :

  - Option 1 – New Bridge with Reinforced Concrete (RC) Anchored Wall
  - Option 2 – Road Realignment with Reinforced Concrete (RC) Anchored Wall

- Berdasarkan perbincangan, Option 2 telah dipilih.



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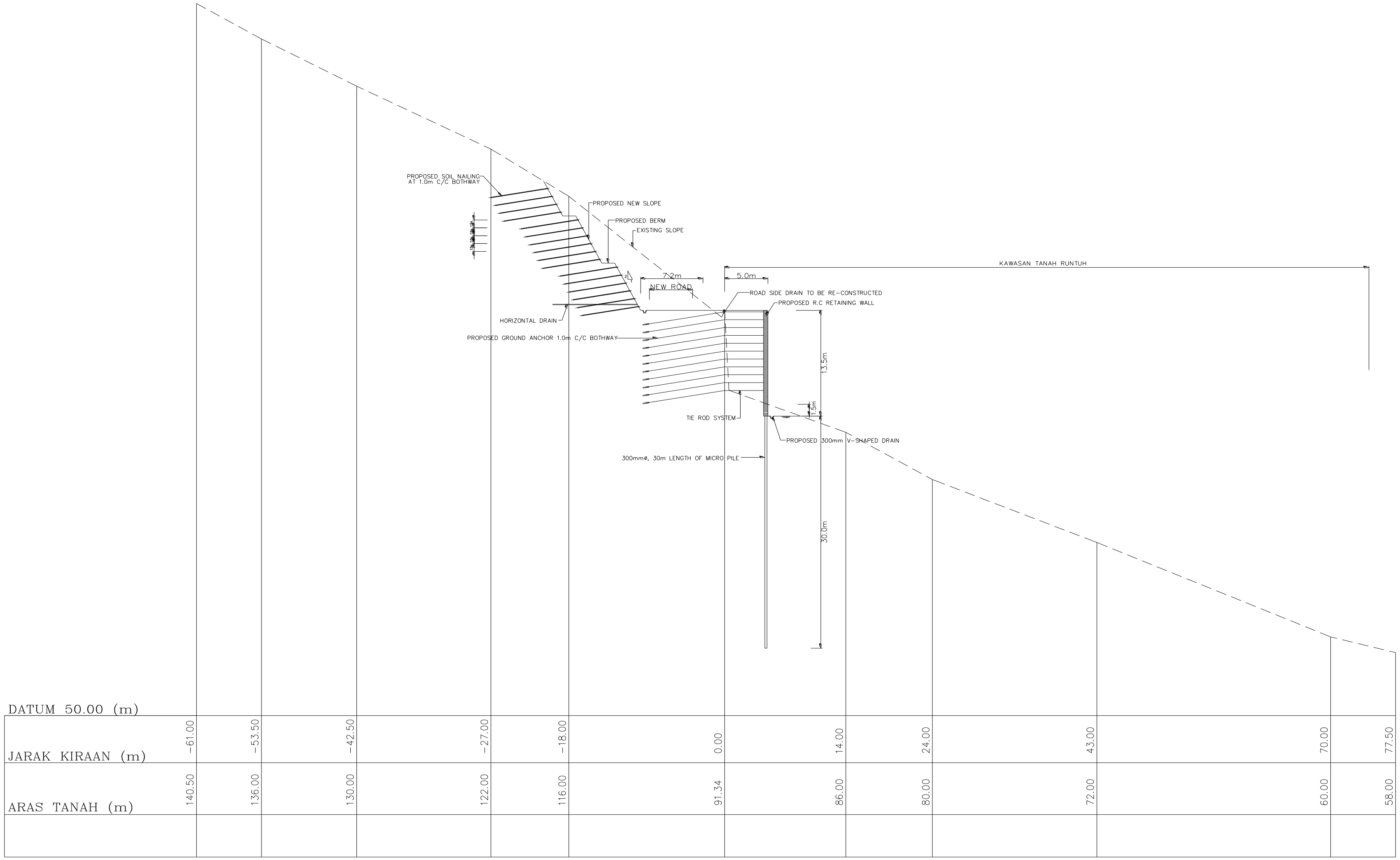
Option 1– New Bridge with Reinforced Concrete (RC) Anchored Wall



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Option 2– Road Realignment with Reinforced Concrete (RC) Anchored Wall

2 April 2008- Keadaan runtuhan yang semakin membesar.

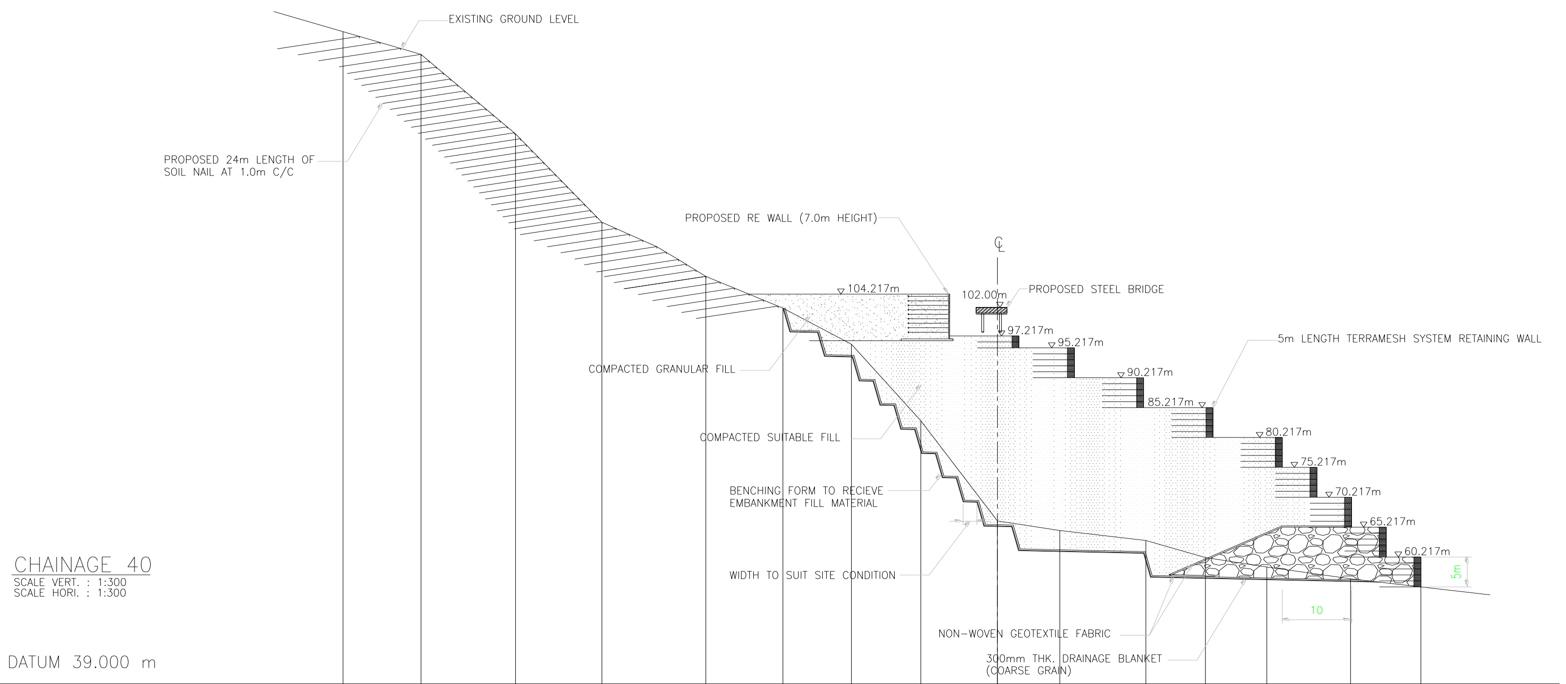
2 April 2008- Pandangan Down slope

14 April 2008- Ketinggian cerun potong yang gagal adalah sekitar 50m kepada puncak cerun.

- 14 April 2008 - Disebakan oleh keadaan semasa, JKR Pahang memutuskan untuk menggunakan Option 2 iaitu menggunakan Steel Bridge dan rawatan geoteknik di sekitar cerun.
- 23 April 2008 – Mesyuarat Penyelarasan di CKC.

<u>OPTION 1</u>

- Slope stabilisation consist of combination of soil nailing at the top slope and Reinforced Earth wall to stabilised the bottom slope
- Steel bridge supported by Micro pile



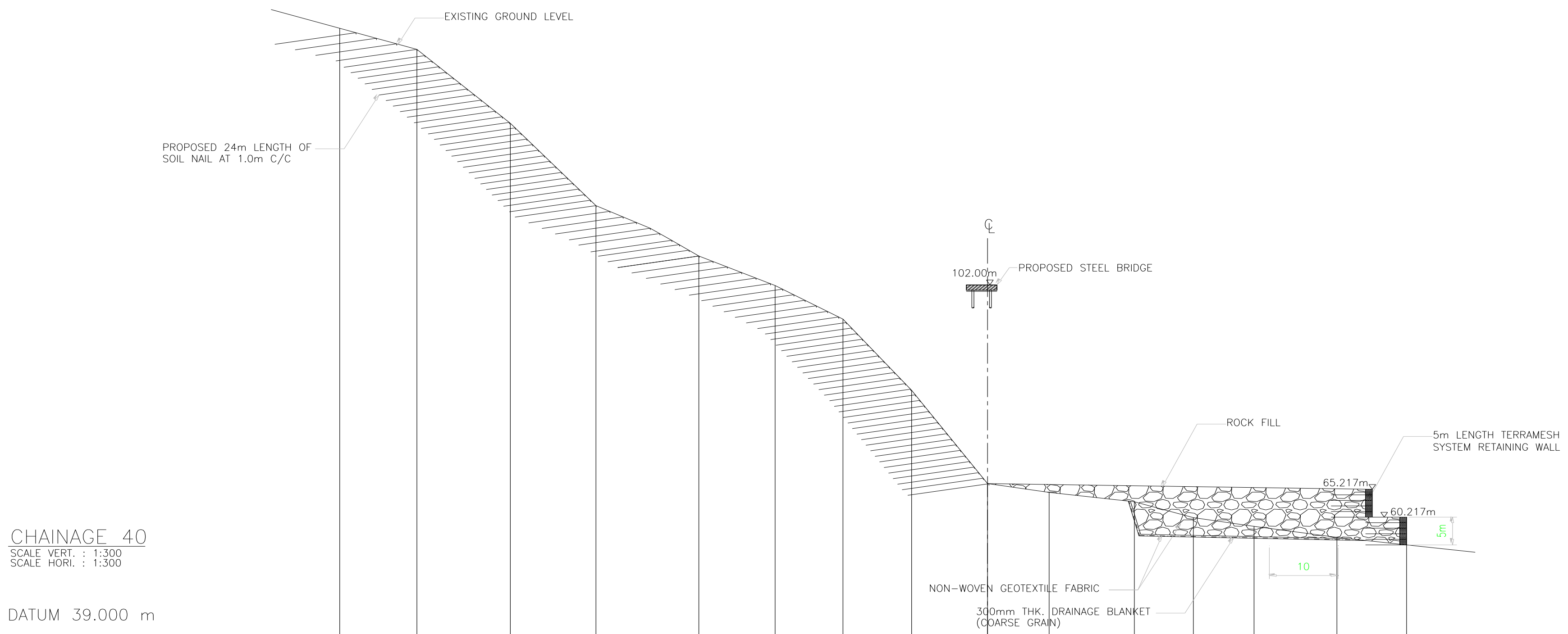
PROPOSED LEVEL (m)															
EXISTING GROUND LEVEL (m)	148.140	144.350	131.047	116.251	107.187 116.672	101.875	95.820	83.022	66.250	64.658	62.984	60.128	58.545	56.568	55.217
DISTANCE (m)	-94.428	-83.178	-69.549	-57.072	-42.080	-30.959	-21.067	-11.056	0.000	8.987	21.409	30.006	38.864	50.941	61.091

OPTION 1

OPTION 2

- Slope stabilisation consist of only soil nailing
- Flexible Barrier to retain debris and boulder
- Steel bridge supported by Micro pile

- Pilihan kedua ini telah dipilih untuk digunakan.



PROPOSED LEVEL (m)																
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OPTION 2

RETROGRESSIVE CIRCULAR FAILURE & DEBRIS FLOW – JULAI 2008

Upslope - FT 148

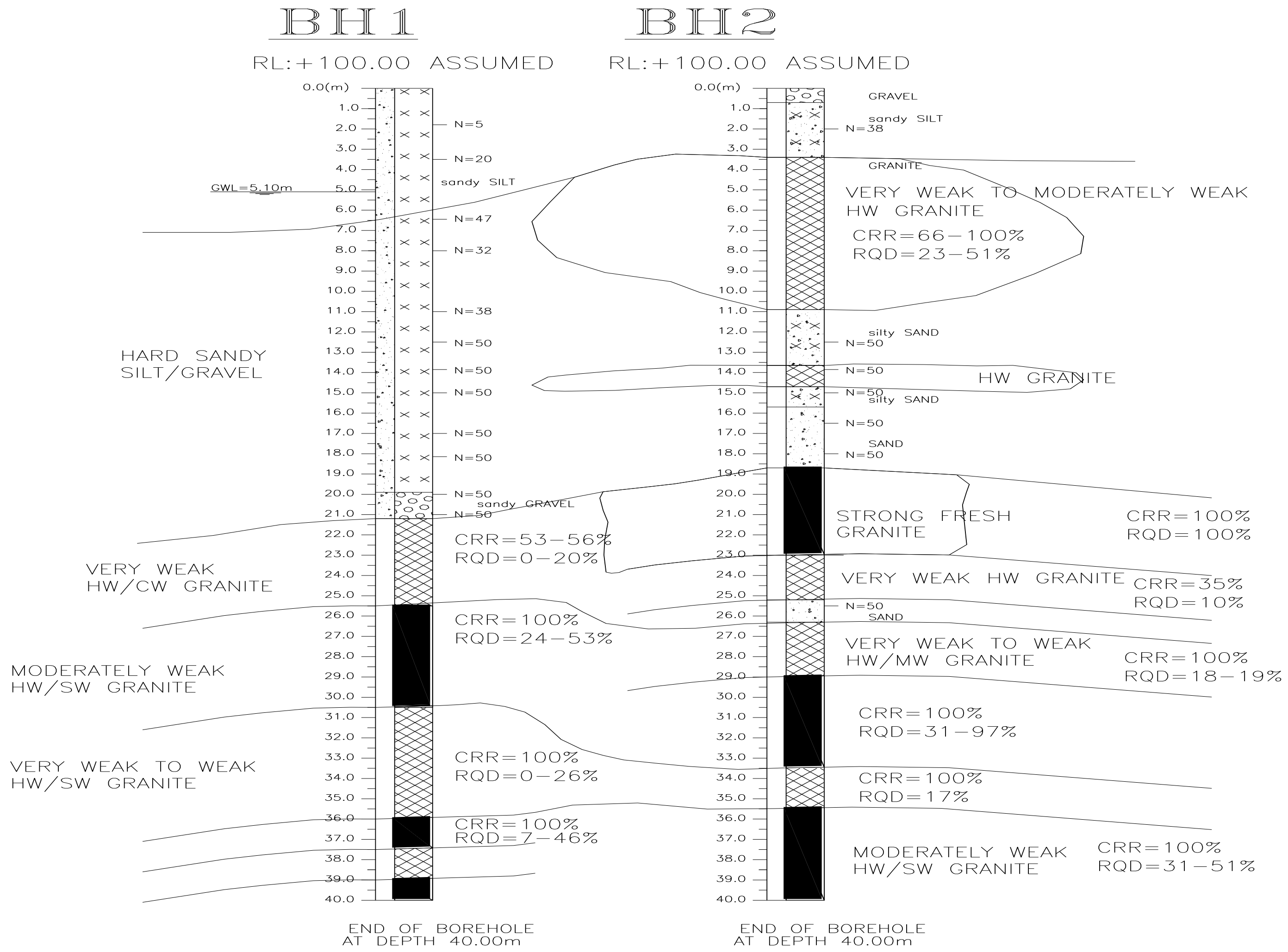
DOWNSLOPE - FT 55

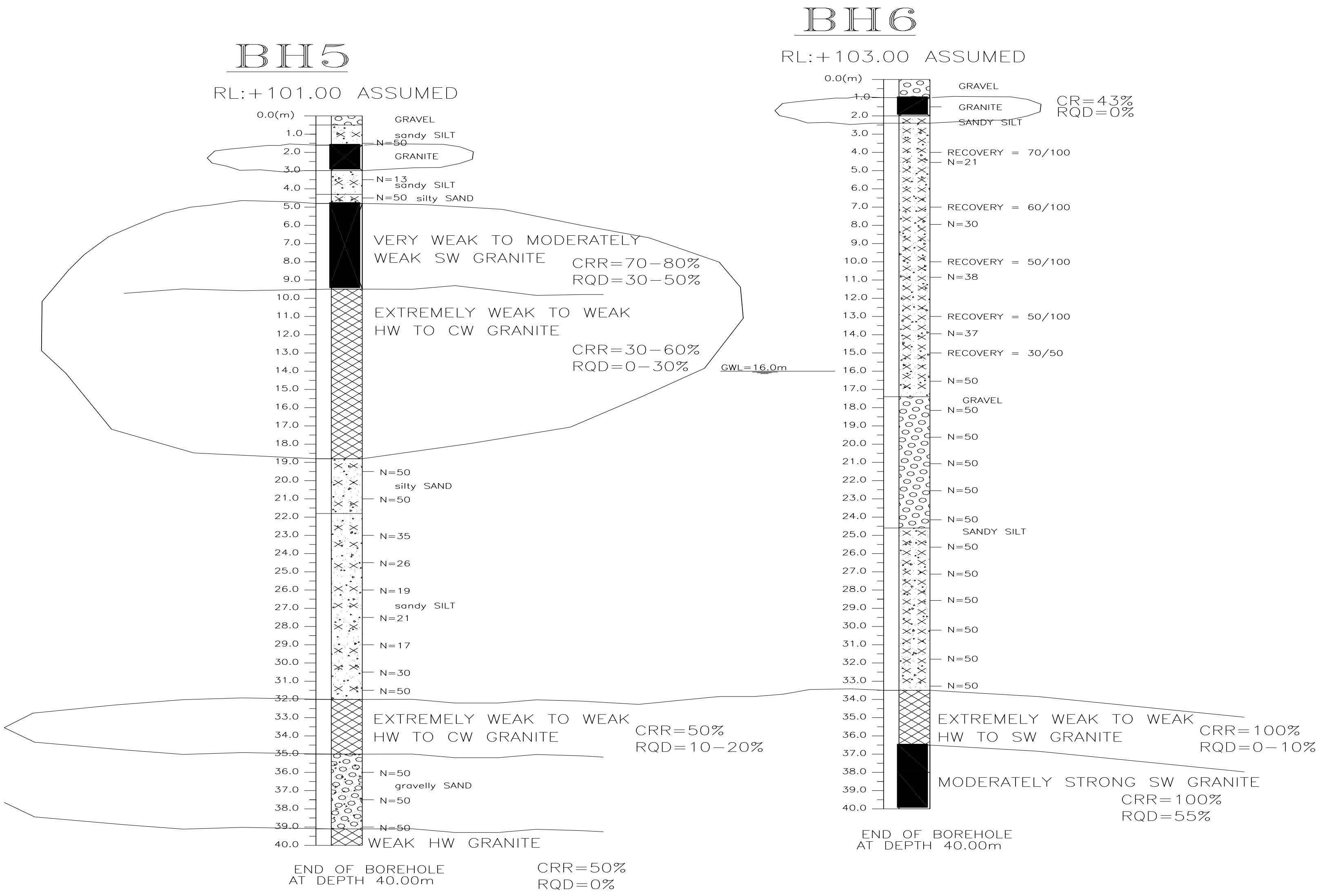
FT 55

DEBRIS FLOW FLEXIBLE BARRIER

FT148

ANALISA


BH1
RL:+100.00 ASSUMED
0.0(m)
GWL=5.10m
N=5
N=20
sandy SILT
N=47
N=32
N=38
N=50
N=50
N=50
N=50
N=50
N=50
sandy GRAVEL
N=50
HARD SANDY SILT/GRAVEL
CRR=53-56%
RQD=0-20%
VERY WEAK HW/CW GRANITE
CRR=100%
RQD=24-53%
MODERATELY WEAK HW/SW GRANITE
CRR=100%
RQD=0-26%
VERY WEAK TO WEAK HW/SW GRANITE
CRR=100%
RQD=7-46%
END OF BOREHOLE
AT DEPTH 40.00m
BH2
RL:+100.00 ASSUMED
0.0(m)
GRAVEL
sandy SILT
N=38
GRANITE
VERY WEAK TO MODERATELY WEAK
HW GRANITE
CRR=66-100%
RQD=23-51%
silty SAND
N=50
N=50
HW GRANITE
N=50
silty SAND
N=50
SAND
N=50
STRONG FRESH
GRANITE
CRR=100%
RQD=100%
VERY WEAK HW GRANITE
CRR=35%
RQD=10%
N=50
SAND
VERY WEAK TO WEAK
HW/MW GRANITE
CRR=100%
RQD=18-19%
CRR=100%
RQD=31-97%
CRR=100%
RQD=17%
MODERATELY WEAK
HW/SW GRANITE
CRR=100%
RQD=31-51%
END OF BOREHOLE
AT DEPTH 40.00m



BH5
RL:+101.00 ASSUMED
GRAVEL
sandy SILT
N=50
GRANITE
N=13
sandy SILT
N=50 silty SAND
VERY WEAK TO MODERATELY WEAK SW GRANITE
CRR=70-80%
RQD=30-50%
EXTREMELY WEAK TO WEAK HW TO CW GRANITE
CRR=30-60%
RQD=0-30%
N=50
silty SAND
N=50
N=35
N=26
N=19
sandy SILT
N=21
N=17
N=30
N=50
EXTREMELY WEAK TO WEAK HW TO CW GRANITE
CRR=50%
RQD=10-20%
N=50
gravelly SAND
N=50
N=50
WEAK HW GRANITE
END OF BOREHOLE AT DEPTH 40.00m
CRR=50%
RQD=0%
BH6
RL:+103.00 ASSUMED
GRAVEL
GRANITE
CR=43%
RQD=0%
SANDY SILT
RECOVERY = 70/100
N=21
RECOVERY = 60/100
N=30
RECOVERY = 50/100
N=38
RECOVERY = 50/100
N=37
RECOVERY = 30/50
GWL=16.0m
N=50
GRAVEL
N=50
N=50
N=50
N=50
N=50
SANDY SILT
N=50
N=50
N=50
N=50
N=50
N=50
EXTREMELY WEAK TO WEAK HW TO SW GRANITE
CRR=100%
RQD=0-10%
MODERATELY STRONG SW GRANITE
CRR=100%
RQD=55%
END OF BOREHOLE AT DEPTH 40.00m

- Subsoil Profile:

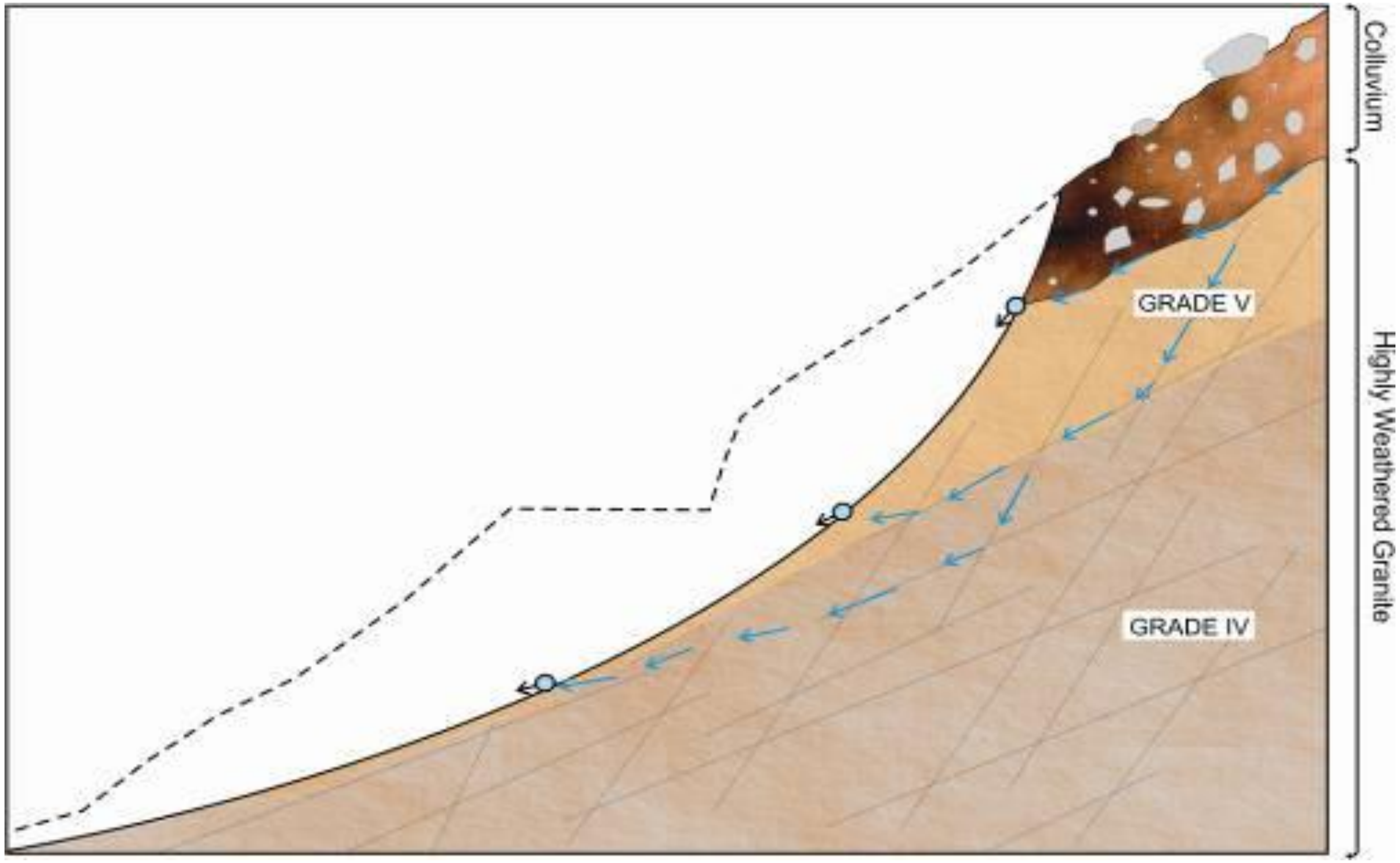
LAYER	TYPE OF SOIL	THICKNESS(M)	SPT-N VALUE
1	VERY STIFF SANDY SILT WITH BOULDER (COLLUVIUM)	4 - 11	13 - 38
2	HARD SANDY SILT/GRAVEL WITH BOULDER	13 - 28	50
3	MODERATELY WEATHRED (MW) GRANITE (BEDROCK)		

Note:

1) Granite is found at several spot in Layer 2 with thickness 7.5m – 14m.
2) Granite Bedrock is encountered at 38m – 39m below existing ground level

- Geological Findings
    - ❑Present of intersection of two relict discontinuities which form a wedge and the line of intersection is day lighting toward the valley axis. The relict structure are kaolinite-infilled.
    - ❑Geomorphic setting of the slope which located in uphill or hanging valley which is highly favourable for slope failure.

Closer view of the main failure scarp, exposing the unconformable contact between the overlying colluvium deposit and the underlying granitic regolith/in-situ soils. Note the seepages that developed along the boundary between the two different geologic materials.



A hypothetical cross section of the failed slope showing the interpretative geological profile and seepages development in the slope based on recent field observation. Figure is not to scale.

View of the failure scar exposing the two intersecting major relict discontinuities which defining a wedge-shaped geometry. Arrow indicates the line of intersection between the two planes (marked by lines with tick marks), and the exposed whitish materials are the kaolinite dyke.

DESIGN REQUIREMENTS

- BS 8081:1989, GROUND ANCHORAGES
- GEOTECHNICAL DESIGN CRITERIA (JKR)

- Based on the BS 8081:1989 Ground Anchorages

Table 2. Minimum safety factors recommended for design of individual anchorages

Anchorage category	Minimum safety factor			Proof load factor
	Tendon	Ground/grout interface	Grout/tendon or grout/encapsulation interface	
Temporary anchorages where a service life is less than six months and failure would have no serious consequences and would not endanger public safety, e.g. short term pile test loading using anchorages as a reaction system.	1.40	2.0	2.0	1.10
Temporary anchorages with a service life of say up to two years where, although the consequences of failure are quite serious, there is no danger to public safety without adequate warning e.g. retaining wall tie back.	1.60	2.5*	2.5*	1.25
Permanent anchorages and temporary anchorages where corrosion risk is high and/or the consequences of failure are serious, e.g. main cables of a suspension bridge or as a reaction for lifting heavy structural members.	2.00	3.0†	3.0*	1.50

* Minimum value of 2.0 may be used if full scale field tests are available.

† May need to be raised to 4.0 to limit ground creep.

NOTE 1. In current practice the safety factor of an anchorage is the ratio of the ultimate load to design load. Table 2 above defines minimum safety factors at all the major component interfaces of an anchorage system.

NOTE 2. Minimum safety factors for the ground/grout interface generally lie between 2.5 and 4.0. However, it is permissible to vary these, should full scale field tests (trial anchorage tests) provide sufficient additional information to permit a reduction.

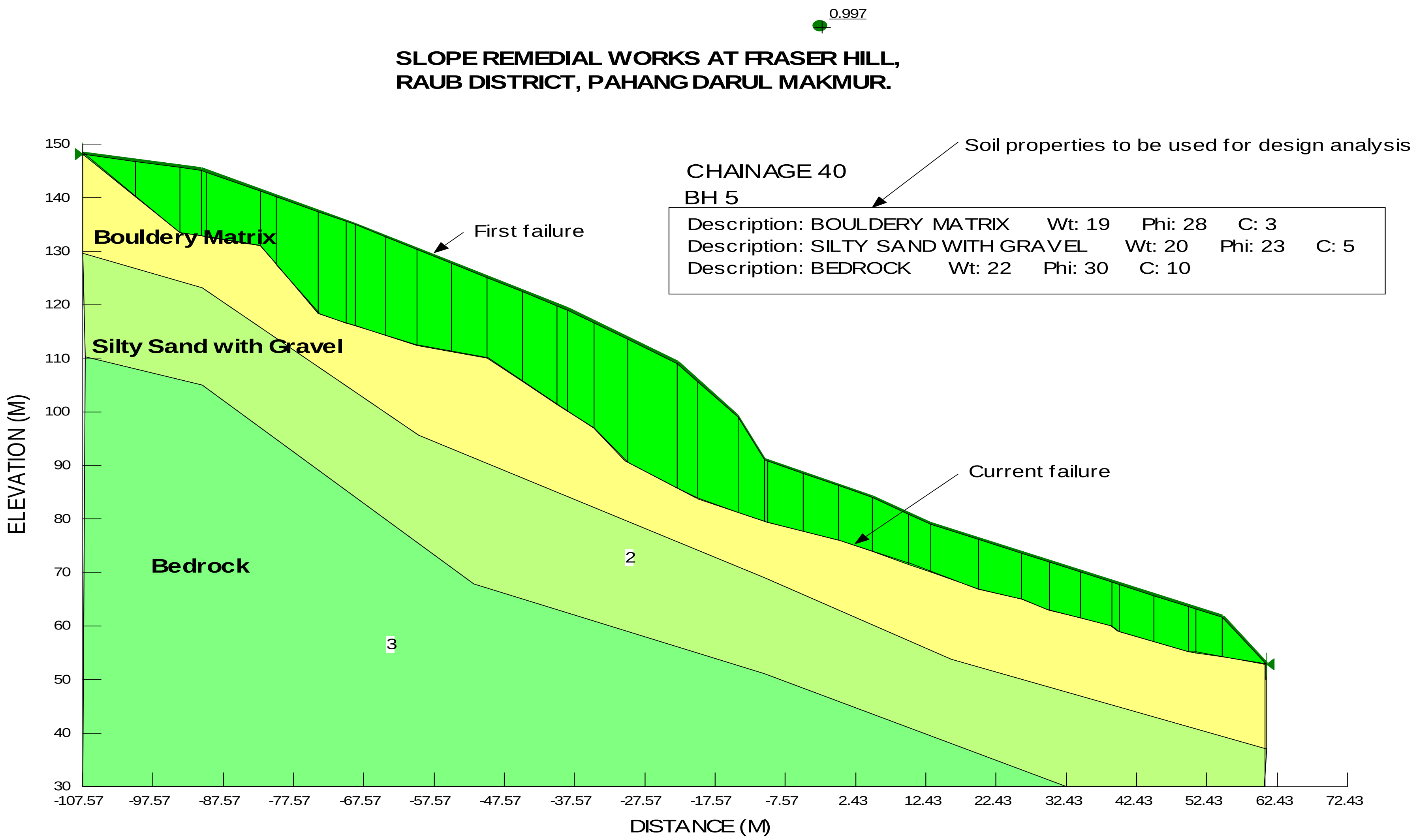
NOTE 3. The safety factors applied to the ground/grout interface are invariably higher compared with the tendon values, the additional magnitude representing a margin of uncertainty.

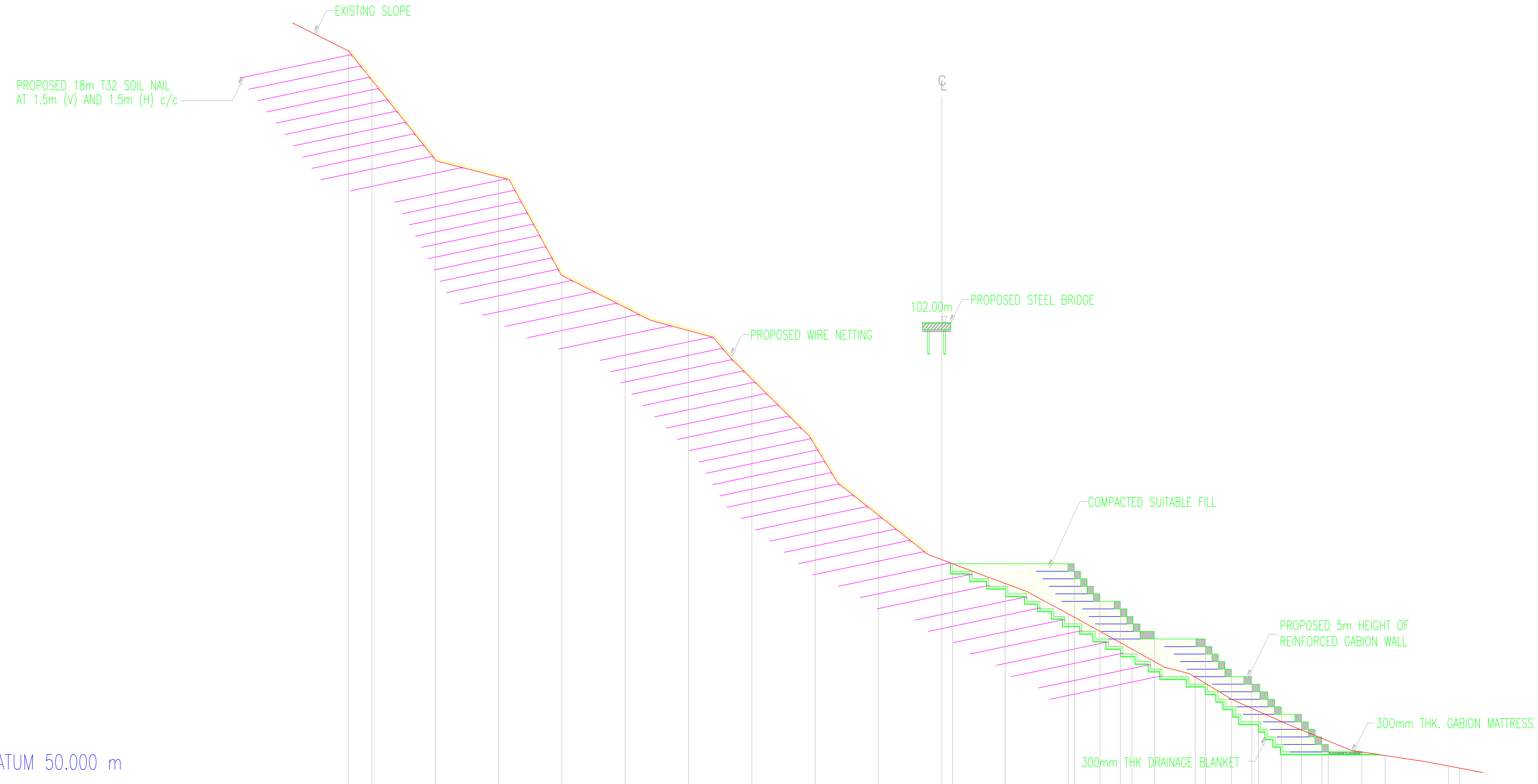
- # Geotechnical Design Criteria (JKR)

Table 1: SOME TYPICAL GEOTECHNICAL DESIGN CRITERIA FOR ROAD WORKS

DESIGN COMPONENT	MODE OF FAILURE	MINIMUM FACTOR OF SAFETY	DESIGN LIFE (durability of materials)	MAXIMUM PERMISSIBLE MOVEMENTS		
				VERTICAL	LATERAL	DIFFERENTIAL
1. Unreinforced Slopes	1.1 Local & global stability (cut & fill slopes) 1.2 Bearing (fill)	1.3 2.0	75 yrs	Analysis should be according to GEOTECHNICAL MANUAL FOR SLOPES (1984), GEO Hong Kong		
2. Reinforced or treated slopes (not on soft ground)	2.1 **Local & global stability (cut & fill slopes)**	1.5	75 yrs			
3. Permanent Anchors	3.1 Tensile Resistance 3.2 Resistance at Soil Grout Interface 3.3 Creep/corrosion	2.0 3.0	75 yrs	Geo Spec 1 (1989), GEO Hong Kong BS 8081		
4. Rigid Retaining Structures	4.1 Overturning 4.2 Sliding 4.3 Overall Stability 4.4 Bearing	1.8 1.6 1.5 2.0	75 yrs	15mm along face of wall Geoguide 1 (1983), GEO Hong Kong	15mm along face of wall	1 : 150 along face of wall
5. Reinforced fill walls/structures	External Stability Internal Stability	BS 8006	120 yrs	± 5mm per metre height	± 15mm from reference alignment	1 : 100 along face of wall
6. Individual Foundation Piles (mainly under axial loads)	6.1 Shaft Resistance 6.2 Base Resistance	2.0 2.0	75 yrs	12mm along axis of pile at pile head at design load. 38mm or 10% pile size at pile head at twice design load. BS 8004		
7. Individual Foundation loads (mainly under lateral & bending loads perpendicular to axis of pile)	Ultimate Lateral Resistance	2.5	75 yrs	*12mm along axis of pile at pile head at design load* BS 8004	12mm perpendicular to axis of pile at design load	
8. Pile group	Block Bearing Capacity	2.0	75 yrs	12mm at Working Load BS 8004		
9. Piles as retaining structures	As for 4, 6 & 7 above	As for individual foundation piles	75 yrs	As 4 above for rigid retaining structures BS 8004		
10. Embankment on Soft Ground	10.1 Bearing (short term) 10.2 Local & global slope stability (long term)	1.4 1.2	75 yrs	7 years post construction settlement : (i) within 10m from bridge approach < 100mm (ii) road < 250mm		

SLOPE REMEDIAL WORKS AT FRASER HILL, RAUB DISTRICT, PAHANG DARUL MAKMUR.





DATUM 50.000 m

DISTANCE (m)	PROPOSED LEVEL (m)	EXISTING GROUND LEVEL (m)
-93.691		148.120
-90.000		144.233
-80.000		133.700
-70.000		131.384
-60.000		118.304
-50.000		114.051
-40.000		110.971
-30.000		104.540
-20.000		95.695
-10.000		86.448
0.000		80.546
1.706	80.000	
10.000		77.374
20.000		73.333
20.912	80.000	
24.950	75.000	
28.203	75.000	
30.000		68.673
33.547	70.000	
40.000		64.941
41.613	70.000	
45.719	65.000	
48.943	65.000	
50.000		60.400
53.619	60.000	
56.798	60.000	
60.000		58.814
61.036	55.000	
66.333	55.000	
70.000		54.525
80.000		53.133
81.778		52.850

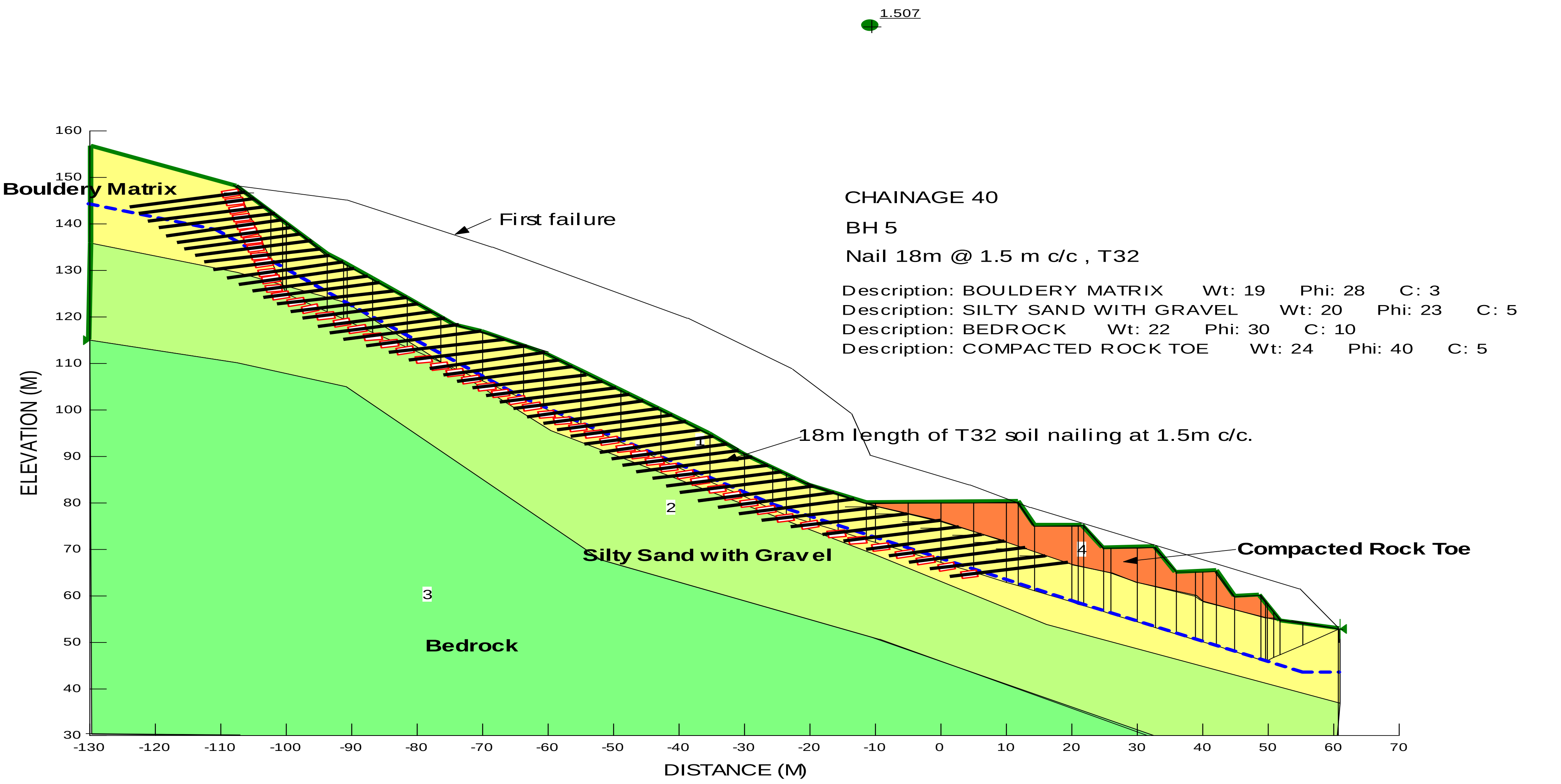
STRUCTURAL CAPACITY (SOIL NAILS=T32)

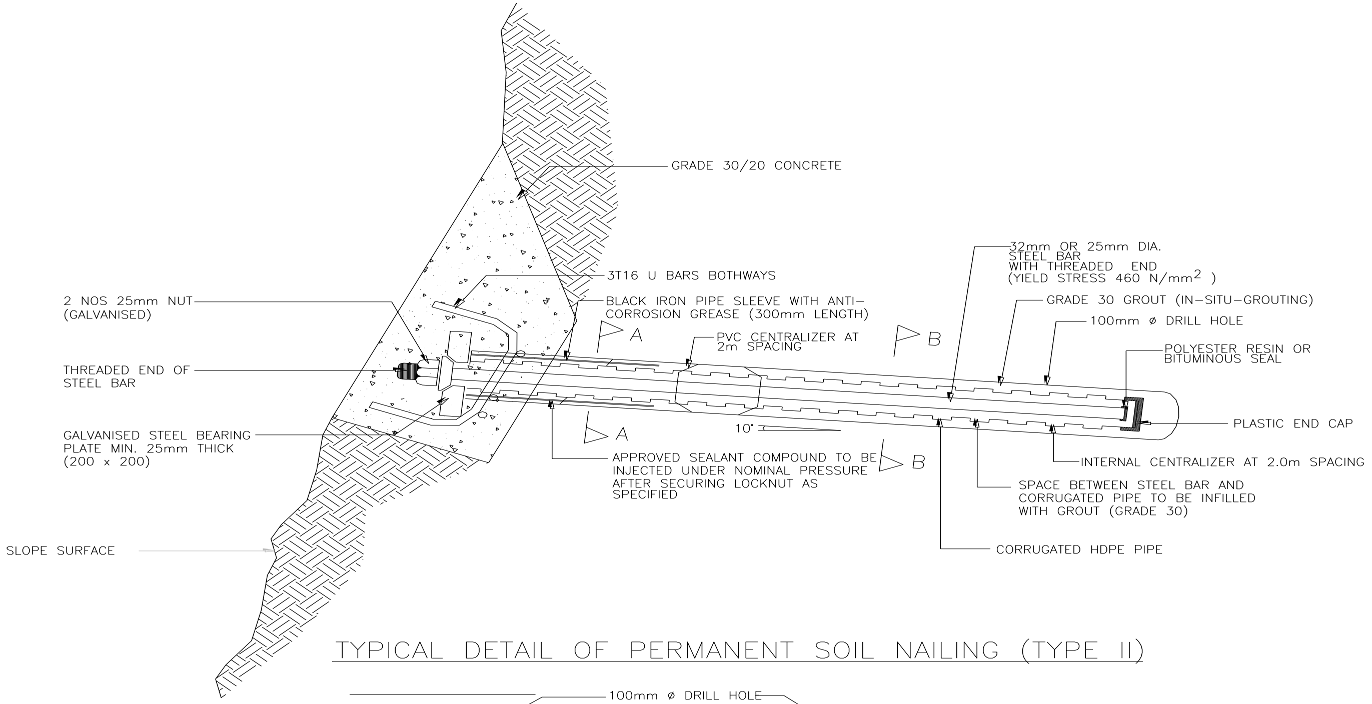
1. Cold Galvanised steel bar size = 32 mm
2. Characteristic strength of steel bar, fy = 460 N/mm
3. Area of steel bar, As = 804 mm²

Factor of safety against structural failure, FOS = 2.0

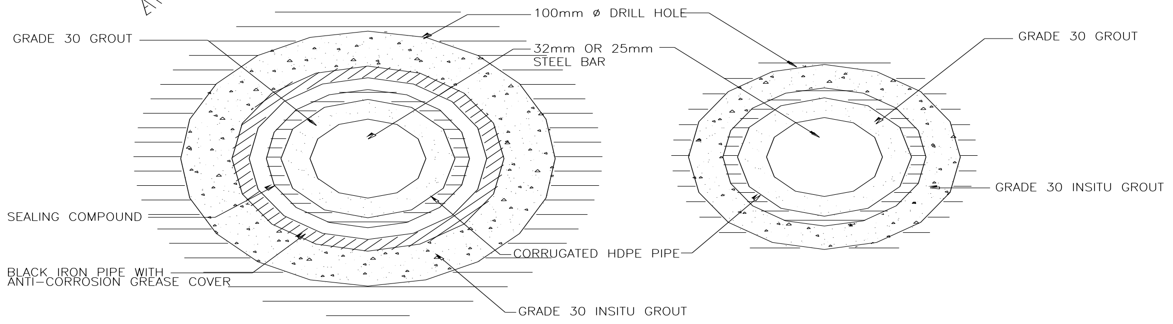
Structural Capacity (T32) = [0.87*fy*As*] / FOS
= **161 kN/bolt**

**SLOPE REMEDIAL WORKS AT FRASER HILL,
RAUB DISTRICT, PAHANG DARUL MAKMUR.**



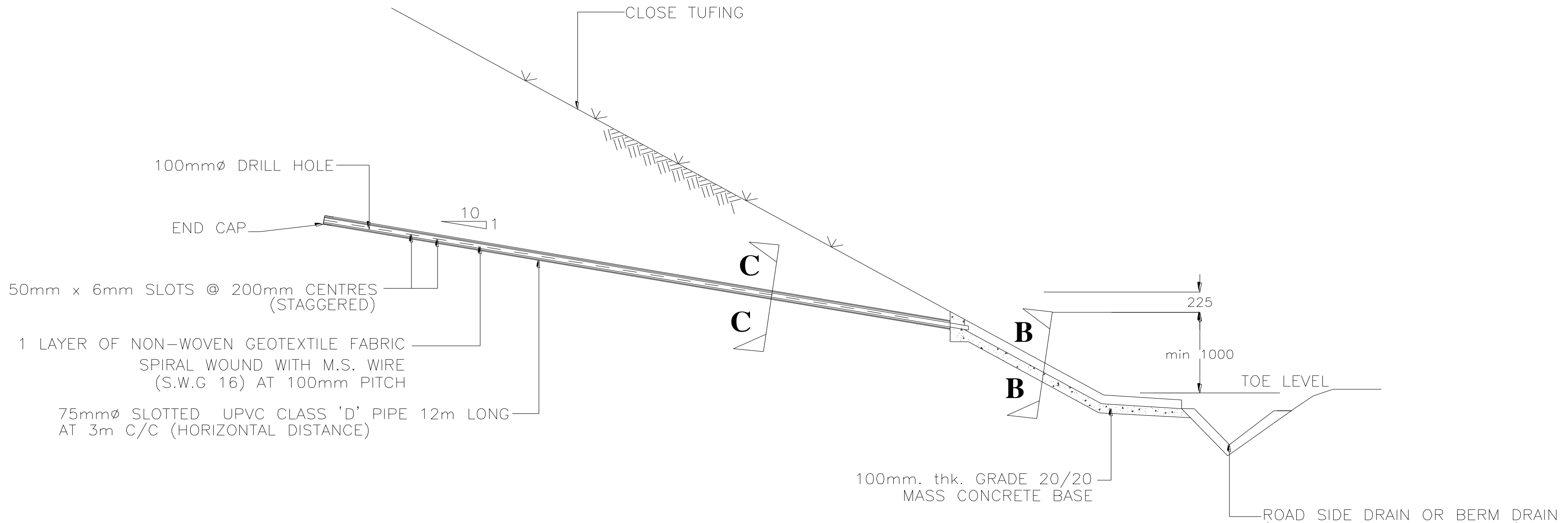


TYPICAL DETAIL OF PERMANENT SOIL NAILING (TYPE II)



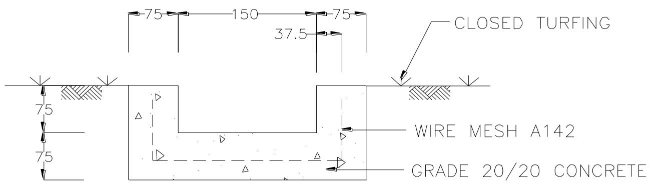
SECTION A–A
SCALE N.T.S

SECTION B–B
SCALE N.T.S



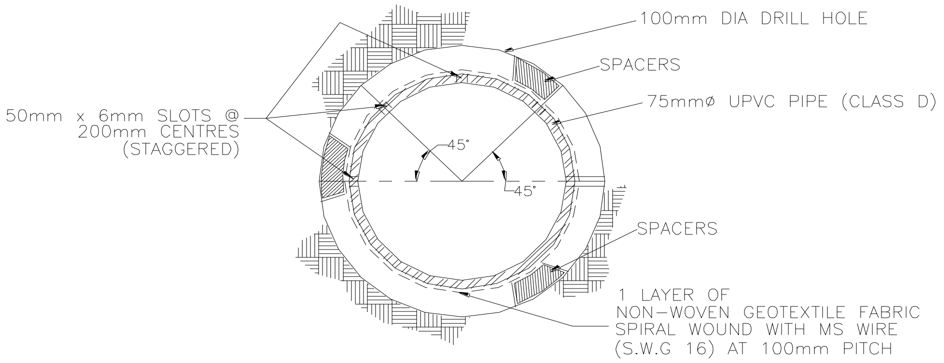
TYPICAL DETAIL OF HORIZONTAL DRAIN

SCALE NTS



SECTION B-B

SCALE : N.T.S



PELAJARAN DARIPADA KES

- Pastikan tiada halangan kepada laluan air semulajadi.
- Penekanan input kejuruteraan geologi, geomorfologi dan geoteknik diambil kira semasa pemilihan jajaran dan proses rekabentuk.
- Penyelenggaraan sistem saliran secara berkala.