Contract No. 48 of 1999
Site Formation Works for Public Housing
Development at Tung Tau Cottage Area

Cellular Confinement Slope Reinforcement System

MiraCell Cellular Confinement System

Table of Content:

Project Introduction

Contract No.:	48 of 1999
Contract Title:	Site Formation Works for Public Housing Development at Tung Tau Cottage Area
Client:	Hong Kong Housing Authority
Consultant:	Hong Kong Housing Authority Geotechnical Engineering Office (GEO), CED
Main Contractor:	Kin Shing Construcion Co. Ltd.
Scope of Work:	MiraCell cellular confinement erosion control system

Two slopes were to be reformed in the site formation work. Cutting, re-trimming and rockfilling were the method of construction. The final profile is at an angle of 1:1.43, of a maximum height of 37m with maximum 6 intermediate berms and the total area is 6000m^2. At the toe is a retaining structure. There is a requirement of establishing vegetation coverage on these slopes. An erosion resistant system to retain growing medium on the rockfill slopes was sought.

General grade 200 compacted rockfill was used to form the slope. However, the introduction of a growing medium on rockfill surface posed a challenge. The engineer's design on slope surface involved a 150mm no fine concrete to smooth the rockfill surface, a 50mm shotcrete layer to prevent infiltration of water into the slope, a 200gsm non-woven geotextile to prevent growing medium from being washed into the rockfall and a 150mm thick cellular confinement system to retain and stabilize the growing medium, an erosion mat to prevent surface erosion on the top of cellular confinement system, a layer of hydroseeding to introduce vegetation and a biodegradable scrim to offer germination protection.

While concrete and shotcrete as well as the installation of geotextile and hydroseeding are widely known construction methods, the use of cellular confinement in this type of application is indeed of limited reference, whether in design durability and effectiveness, material selection, installation concerns and after care. MiraCell cellular confinement of 150mm thick was proposed for the project. It is manufactured by International Erosion Control System Sdn. Bhd., a specialist geocell producer based in Thailand. MiraCell is made from High Density Polyethylene, a durable and inert polymer used mostly for environmental hazard condition. It is of sufficient strength to contain the growing medium, is in collapsible unit to minimize shipping volume and can be stabilized by mechanical means.

Miracell Introduction & Description

Part 1 General

MiraCell cellular confinement sections are manufactured under U.S. Army Corps of Engineers' Patent Mo. 4,797,026 from High Density Polyethylene strips ultrasonically welded under ISO 9002. Key components of MiraCell slope stabilization system consist of MiraCell cellular confinement, selected infill, tendon, J-pin anchor and non-woven geotextile.

Main applications of MiraCell cellular confinement system are slope protection, earth protection, load support and channel protection. The advantages of MiraCell system include low handling costs, low wastage rate, minimum maintenance required and ease of installation.

Part 2 Typical Specification of MiraCell

Material Properties	Test Method	Technical Data	Unit
Base polymer	-	HDPE	-
Density	ASTM D1505	0.940	g/cm^2
Nominal sheet thickness	ASTM D5199	1.2-2.5	mm
Carbon black content	ASTM D1603	2.0-3.0	%
Environmental stress crack resistance	ASTM D1693	1500	hrs

Cell Properties	Unit	Typical Value				
Depth	mm	50	75	100	150	200
Seam peel strength	N	500	750	1000	1500	2000
Seam hang strength	-	A 102mm ultrasonic welded supporting a load of 72.5kg for a minimum of 30 days.				

Dimensional Properties	Individual Cell Expanded		Expanded Section	
	Dimension	Area	Dimension	Area
Standard Cell	203mm x 244mm	$248cm^2$	10 cells x 30 cells	$14.86m^2$
Large Cell	406mm x 488mm	$993cm^2$	10 cells x 30 cells	$29.72m^2$

Notes: Collapsed section has a dimension of 125mm x 3350mm for varied depth from 50-205mm.

Miracell Introduction & Description

Part 3 Project Specification (Contract No. 48 of 1999 – Tung Tau Cottage Area)

Standard cell of 150mm in depth with tendon was used in this project. The summary of MiraCell specification and load supporting system is as follows:

MiraCell MC-150-30	Unit	Technical Data
Polymer Type	-	HDPE
Geocell Weight (expanded)	g/m^2	2,490
Standard Colour	-	Black
Cell Area (expanded)	cm^2	248
Cell Depth (expanded)	mm	150
Cell Length (expanded)	mm	203
GeoCell Section Length	m	6.1
GeoCell Section Width	m	2.44
Minimum Cell Seam Peel Strength	N	1500

Components	Items	Rockfill Slope	Soil Cut Slope
J-pin on slope	Length	400mm	400mm
	Diameter	12mm	12mm
	Horizontal spacing	488mm	488mm
	Vertical spacing	1,000mm	1,000mm
J-pin at crest	Length	400mm	600mm
	Diameter	16mm	12mm
	Horizontal spacing	488mm	488mm
	Vertical spacing	500mm	500mm
Tendon	Strength	5kN	5kN
	Horizontal spacing	488mm	488mm

Method Statement

Part 1 Installation of MiraCell

1.1 Remove debris and vegetative cover if any from the grade 200 rock fill surface;

1.2 Apply 100mm thick spray concrete on top of grade 200 rock fill slope surface;

1.3 Place non-woven geotextile (ProPex 4551, Amoco) on shotcrete surface;

1.4 Drill 10mm dia holes through the spray concrete surface in every 800mm c/c to receive J-pin hooks;

1.5 Install the tendons in MiraCell. Tie off tendon ends with a knot that cannot pass through holes in the cell wall. Knots shall be tie to provide full tendon strength and should not slip under tension;

1.6 Tie tendon to anchor system at crest, expand the MiraCell section down the slope from the crest to its fully expanded length of 6.1m, use additional panels or partial panel to reach toe;

1.7 Drive in the 12mm dia MS J-pin hooks to stabilize the MiraCell. Ensure that the J-pins hooks are capped over the cell walls and tendons are tightened;

1.8 Fastened MiraCell sections together using stapler;

1.9 Repeat across slope.

Part 2 Placement of Infill in MiraCell Sections

2.1 After MiraCell sections are secured to the slope, infilling begins;

2.2 Place infill in expanded cells with suitable material handling equipment such as backhoe;

2.3 Limit drop height of infill material to 1m maximum. Avoid displacement of MiraCell sections by infilling from the embankment crest to the toe.

Project Name	**Tung Tau Cottage**
Description	**MiraCell Slope Cover on Cut Slope**
Designed by	IECS
Date	17-04-2002

Design Parameters

α =	***SLOPE ANGLE***	**35.0**	degrees	**1 : 1.4**	
L =	***DESIGN SLOPE LENGTH***	**12.2**	metres	**V : H**	
ϕ =	***ANGLE OF INTERNAL FRICTION ,***	**28**	degrees		
l =	***CELL SIZE (200/400)***	**200**	mm		
h =	***CELL HEIGHT (75/100/150/200)***	**150**	mm		
γi =	***INFILL DENSITY***	**17.00**	kN/cu.m		
	ADDITIONAL COVER After installation no additional cover	**0**	mm		
ω_c =	***COVER UNIT WEIGHT***	**0**	kN/sq.m		
	TOE LOAD	**0**	kN/cu.m		
fos =	***DESIGN FACTOR OF SAFETY***	**1.30**			
	INFILL TYPE , 1 Soil, 2 Concrete	**1**			
τ =	***TENDON TENSILE FORCE***	**5.00**	kN	510 kg	

	Slope (H : V)	1.4		
	Sin α	0.574		
	Cos α	0.819		
	Friction Coefficient = tan ϕ	0.532		
H =	**Vertical Height =** L x sin α	**7.0 m**	23.0 m	
w_i =	Infill Weight = (L x h x γi) /1000	31.1 kN/m		
w_c=	Cover Weight = L x ω_c	0 kN/m		
$\tau_{w=}$	Factored Web Tensile	2.25 kN/m	Design Tensile (Property of MiraCell)	
F_D =	Driving Force = (w_i+w_c) x sin α	17.8 kN/m	Weight + Toe load	
	Factored Driving force = fos x F_D	23.2 kN/m	Weight only	
	Factored Driving force	23.2 kN/m	Weight + Toe load	
F_R=	Frictional Resistance			
	=(w_i+w_c) cos α x tan ϕ	13.5 kN/m		
	Factor of Safety Sliding only = F_R / F_D	0.76	Shear Only	
	Max. Available Factor of Safety = (F_R+τ_w)/F_D	0.89	with MiraCell	

J-pin Anchor Details

F_{dnet} =	Net Driving			
	(fos x F_D - F_R)/L	0.79 kN/sq.m	Factored	
	Max. MiraCell Length (Unrestrained)	1500 mm		
	i.e. Max. J-pin spacing along the slope	1421 mm	(7 cells spacing)	

	Length of J pin	**600**	mm		
d =	Diameter	**12**	mm		
l_b =	Buried Length of J pin	**450**	mm	(length of J pin -MiraCell cell height)	
ϕ_f =	Soil Friction at Base	**28**	degrees		
C_f =	Soil Cohesion	**20**	kN/sq.m		
γ_f =	Unit Weight	**20.0**	kN/cu.m		

Ka = (1-sin ϕ_f)/(1+sin ϕ_f) 0.361

Kp = 1 / ka 2.770

J pin spacing

S_H =	Horizontal Spacing	@ every	**2**	Cells	=	488	mm
S_V =	Spacing Along Slope	@ every	**5**	Cells	=	1000	mm

R = J pin Resistance 283 N Single Pin

= {0.5 kp γ_f $(l_b/1000)^2$ (d/1000) + 2 C_f (d/1000) $(l_b/1000)$}1000

Passive pressure coefficient

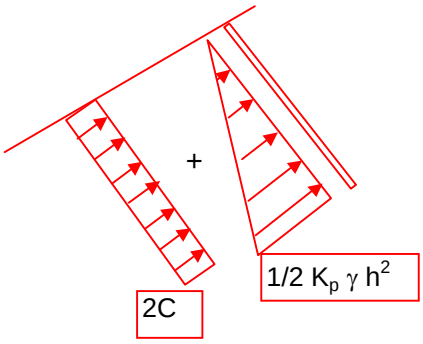
Fill dendity

ied length of J-pin in `m

neter (width) of J-pin in `m

This is calculated as the passive pressure on the J-pin. Contributing factors are friction angle and cohesion of fill

Cohesion of fill materia



Total Force Acting on a J pin

= F_{dnet} (S_V x S_H) x 1000 = 386 N ***Unsatisfactory Tendon Required or Reduce Stakes Spacing***

n = No of Rows of J pins = L / S_V 12

R^1 = J pin Resistance (kN/m) = R x n / S_H 7.0 Resultant

J pin Resistance (kN/sq.m) = R / S_H 0.57 Net Resultant

F^2_R = Resisting Force (kN/m) = R^1+F_R 20.5

Factor of Safety = F^2_R / F_D 1.15 Shear, Stakes

Maximum Available F.S = (F^2_R + τ_w)/F_D 1.28 Anchored MiraCell

Unsatisfactory, Tendons Required

Tendons

Required Tension

= fos x F_D - τ_w - F^2_R 0.43 kN/m

τ =	Ultimate Strength	5	kN		
	FOS - Tendons < 3 >	3			
S_T =	Tendon Spacing @ every	**2**	Cell	488	mm
	Tendons / Slot	**1**			

$\tau_{A\ =}$ Available Tension / Slot = τ / fos_{tendon} 1.7 kN

τ^1_A = Available Tension = τ_A x 1000 / S_T 3.42 kN/m ***Satisfactory***

Maximum available F.S **1.47** **Anchored Tendons with MiraCell**
= (F^2_R + τ_w + τ^1_A) / F_D

Crest Slope Anchorage

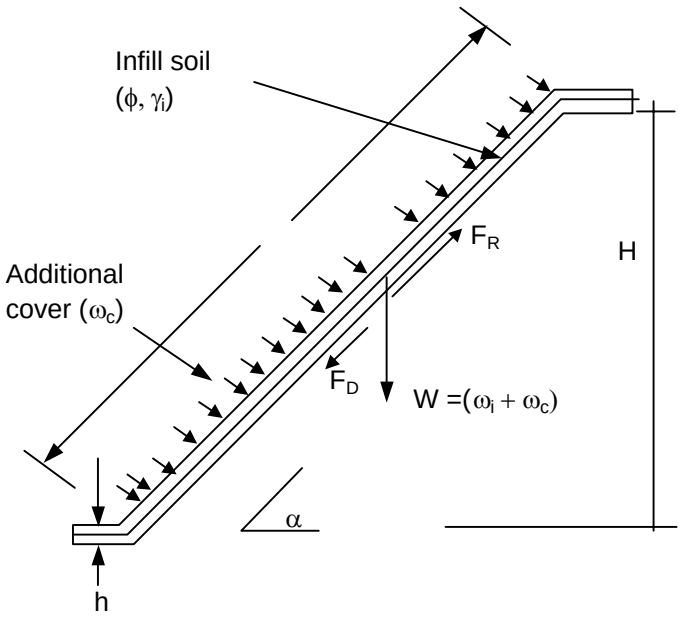
Required Anchorage	0.8	kN/m	
Depth Below Crest	150	mm	
Embedment Length	**0.00**	m	Weight of Concrete neglected
Infill Unit Weight	**0.0**	kN/cu.m	Compacted infill at the berm
Soil Friction	**28**	degree	
Surcharge	0.00	kN/m	
Resisting Force	0.00	kN/m	
Capacity of Crest Anchor required	0.81	kN/m	no. Tendons per meter = 2.0
Capacity of Crest Anchor required	0.40	kN/tendon	= 400N
Tendon spacing =	488.00	mm	

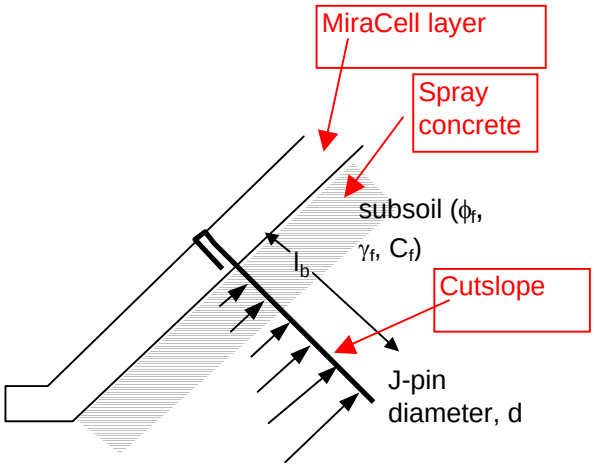
Provide J-pins at every cell spacing at berm and embed J-pins in concrete

J-pin resistance of single pin =	283	N	
For 2 J-pins within 488mm spacing =	566.6	N	> 400 N Satisfactory

Summary

1 MiraCell	MC-150-30, Standard cell	150mm high (6")	MiraCell sections		
2 J-pins	Steel J-pins,	600	mm long	12	mm dia.
	spacing	488	mm horizontally (every	2	cells)
		1000	mm along slope (every	5	cells)
3 Tendon	Polypropylene tendon of breaking strength			5.00	kN
4 Infil	Topsoil on slope surface, Gr. 20 concrete in berm drains				





Project Name	**Tung Tau Cottage**
Description	**MiraCell Slope Cover on Rockfill slope**
Designed by	IECS
Date	17-04-2002

Design Parameters

α =	***SLOPE ANGLE***	**35.0**	degrees	**1 : 1.4**	
L =	***DESIGN SLOPE LENGTH***	**12.2**	metres	**V : H**	
ϕ =	***ANGLE OF INTERNAL FRICTION ,***	**28**	degrees		
l =	***CELL SIZE (200/400)***	**200**	mm		
h =	***CELL HEIGHT (75/100/150/200)***	**150**	mm		
γi =	***INFILL DENSITY***	**17.00**	kN/cu.m		
	ADDITIONAL COVER After installation no additional cover	**0**	mm		
ω_c =	***COVER UNIT WEIGHT***	**0**	kN/sq.m		
	TOE LOAD	**0**	kN/cu.m		
fos =	***DESIGN FACTOR OF SAFETY***	**1.30**			
	INFILL TYPE , 1 Soil, 2 Concrete	**1**			
τ =	***TENDON TENSILE FORCE***	**5.00**	kN	510 kg	

	Slope (H : V)	1.4		
	Sin α	0.574		
	Cos α	0.819		
	Friction Coefficient = tan ϕ	0.532		
H =	**Vertical Height =** L x sin α	**7.0 m**	23.0 m	
w_i =	Infill Weight = (L x h x γi) /1000	31.1	kN/m	
w_c=	Cover Weight = L x ω_c	0	kN/m	
$\tau_{w=}$	Factored Web Tensile	2.25	kN/m	Design Tensile (Property of MiraCell)
F_D =	Driving Force = (w_i+w_c) x sin α	17.8	kN/m	Weight + Toe load
	Factored Driving force = fos x F_D	23.2	kN/m	Weight only
	Factored Driving force	23.2	kN/m	Weight + Toe load
F_R=	Frictional Resistance			
	=(w_i+w_c) cos α x tan ϕ	13.5	kN/m	

Factor of Safety Sliding only = F_R / F_D	0.76	Shear Only
Max. Available Factor of Safety = (F_R+τ_w)/F_D	0.89	with MiraCell

J-pin Anchor Details

F_{dnet} =	Net Driving			
	(fos x F_D - F_R)/L	0.79	kN/sq.m	Factored
	Max. MiraCell Length (Unrestrained)	1500	mm	
	i.e. Max. J-pin spacing along the slope	1421	mm	(7 cells spacing)
	Length of J pin	**400**	mm	

d =	Diameter	**12**	mm	
l_b =	Buried Length of J pin	**250**	mm	(length of J pin -MiraCell cell height)
ϕ_f =	Soil Friction at Base	**35**	degrees	
C_f =	Soil Cohesion	**40**	kN/sq.m	
γ_f =	Unit Weight	**20.0**	kN/cu.m	

Ka = (1-sin ϕ_f)/(1+sin ϕ_f) 0.271

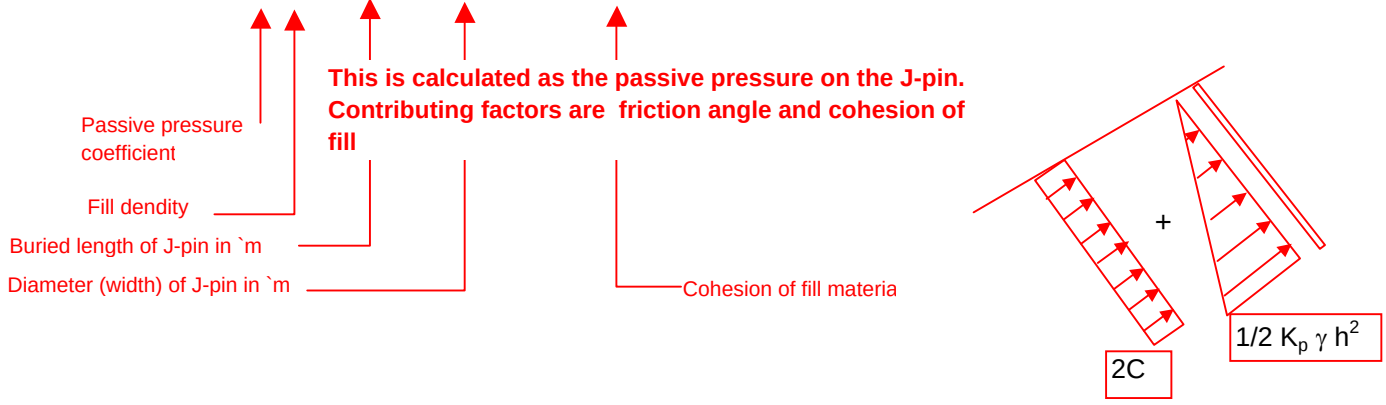
Kp = 1 / ka 3.690

J pin spacing

S_H =	Horizontal Spacing	@ every	**2**	Cells	=	488 mm
S_V =	Spacing Along Slope	@ every	**5**	Cells	=	1000 mm

R = J pin Resistance 268 N Single Pin

= {0.5 kp γ_f $(l_b/1000)^2$ (d/1000) + 2 C_f (d/1000) $(l_b/1000)$}1000



Total Force Acting on a J pin

= F_{dnet} (S_V x S_H) x 1000 = 386 N ***Unsatisfactory Tendon Required***

or Reduce Stakes Spacing

n = No of Rows of J pins = L / S_V 12

R^1 = J pin Resistance (kN/m) = R x n / S_H 6.6 Resultant

J pin Resistance (kN/sq.m) = R / S_H 0.54 Net Resultant

F^2_R = Resisting Force (kN/m) = R^1+F_R 20.1

Factor of Safety = F^2_R / F_D 1.13 Shear, Stakes

Maximum Available F.S = (F^2_R + τ_w)/F_D 1.25 Anchored MiraCell

Unsatisfactory, Tendons Required

Tendons

Required Tension

= fos x F_D - τ_w - F^2_R 0.81 kN/m

τ =	Ultimate Strength	5	kN	
	FOS - Tendons < 3 >	3		
S_T =	Tendon Spacing @ every	**2**	Cell	488 mm
	Tendons / Slot	**1**		

τ_A = Available Tension / Slot = τ / fos_{tendon} 1.7 kN

τ^1_A = Available Tension = τ_A x 1000 / S_T 3.42 kN/m ***Satisfactory***

Maximum available F.S **1.45** **Anchored Tendons with MiraCell**

= $(F^2_R + \tau_w + \tau^1_A) / F_D$

Crest Slope Anchorage

Required Anchorage	1.4	kN/m	
Depth Below Crest	150	mm	
Embedment Length	**0.00**	m	Weight of concrete neglected
Infill Unit Weight	**0.0**	kN/cu.m	Compacted infill at the berm
Soil Friction	**30**	degree	
Surcharge	0.00	kN/m	
Resisting Force	0.00	kN/m	
Capacity of Crest Anchor required	1.41	kN/m	no. Tendons per meter = 2.0
Capacity of Crest Anchor required	0.69	kN/tendon	=690 N
Tendon spacing =	488.00	mm	

Provide J-pins at every cell spacing at berm and embed J-pins in concrete

J-pin resistance of single pin 12mm dia. = 268 N

J-pin resistance of single pin 16mm dia. = 357 N

For 2 J-pins within 488mm spacing using 16mm d 714.0 N > 690 N Satisfactory

Summary

1 MiraCell MC-150-30, Standard cell 150mm high (6") MiraCell sections

2 J-pins Steel J-pins, 400 mm long **12 mm dia.**

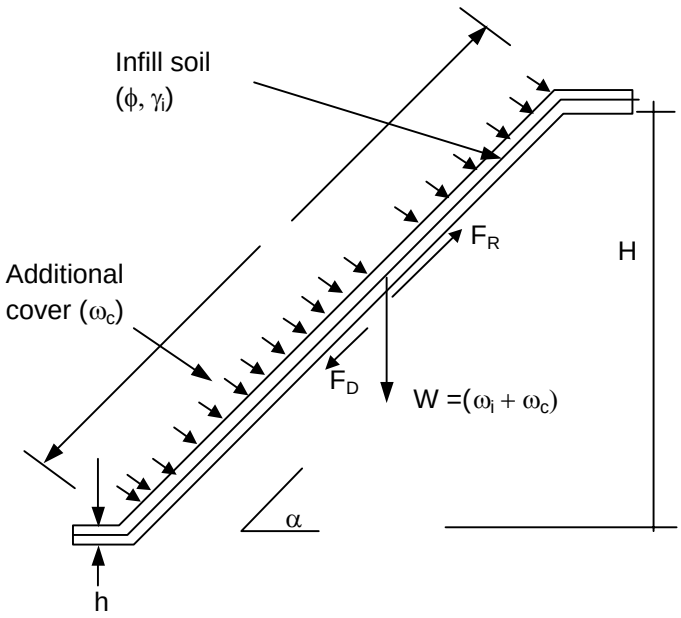
spacing 488 mm horizontally (every 2 cells)

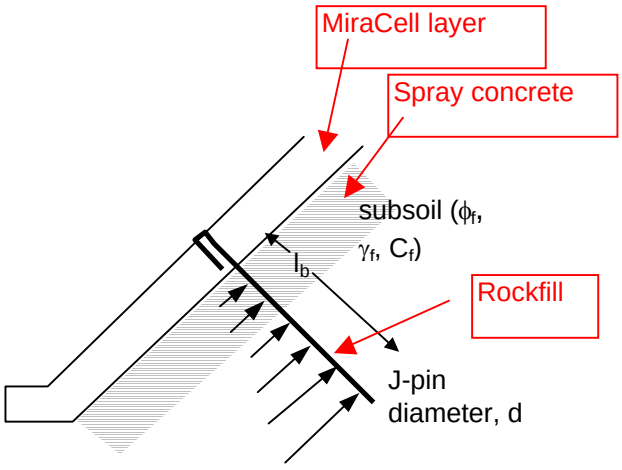
1000 mm along slope (every 5 cells)

Use J-pins 16mm dia. 400mm long (250 mm embedment) along the crest at every cell spacing

3 Tendon Polypropylene tendon of breaking strength 5.00 kN

4 Infil Top soil on slope surface, Gr. 20 concrete in berm drains.





Project Name	**Tung Tau Cottage**
Description	**MiraCell Slope Cover - Stability during infilling**
Designed by	IECS
Date	17-04-2002

This calculation was prepared based on your 1st letter. However, it is assumed this issue does not arise as per your second letter

Design Parameters

α =	***SLOPE ANGLE***	**35.0**	degrees	**1 : 1.4**	
L =	***DESIGN SLOPE LENGTH***	**12.2**	metres	**V : H**	
ϕ =	***ANGLE OF INTERNAL FRICTION ,***	**28**	degrees		
l =	***CELL SIZE (200/400)***	**200**	mm		
h =	***CELL HEIGHT (75/100/150/200)***	**150**	mm		
γi =	***INFILL DENSITY***	**17.00**	kN/cu.m		
	ADDITIONAL COVER	**0**	mm		
ω_c =	***COVER UNIT WEIGHT***	**1.4**	kN/sq.m		
	TOE LOAD	**0**	kN/cu.m		
fos =	***DESIGN FACTOR OF SAFETY***	**1.30**			
	INFILL TYPE , 1 Soil, 2 Concrete	**1**			
τ =	***TENDON TENSILE FORCE***	**5.00**	kN	510 kg	

	Slope (H : V)	1.4		
	Sin α	0.574		
	Cos α	0.819		
	Friction Coefficient = tan ϕ	0.532		
H =	**Vertical Height =** L x sin α	**7.0 m**	23.0 m	
w_i =	Infill Weight = (L x h x γi) /1000	31.1 kN/m		
w_c=	Cover Weight = L x ω_c	17.08 kN/m		
$\tau_{w=}$	Factored Web Tensile	2.25 kN/m	Design Tensile (Property of MiraCell)	
F_D =	Driving Force = (w_i+w_c) x sin α	27.6 kN/m	Weight + Toe load	
	Factored Driving force = fos x F_D	35.9 kN/m	Weight only	
	Factored Driving force	35.9 kN/m	Weight + Toe load	
F_R=	Frictional Resistance			
	=(w_i+w_c) cos α x tan ϕ	21.0 kN/m		

Factor of Safety Sliding only = F_R / F_D	0.76	Shear Only
Max. Available Factor of Safety = (F_R+τ_w)/F_D	0.84	with MiraCell

J-pin Anchor Details

$F_{dnet=}$	Net Driving		
	(fos x F_D - F_R)/L	1.22 kN/sq.m	Factored
	Max. MiraCell Length (Unrestrained)	1500 mm	

	i.e. Max. J-pin spacing along the slope	1421 mm		(7 cells spacing)
	Length of J pin	**400** mm		
d =	Diameter	**12** mm		
$l_{b=}$	Buried Length of J pin	**250** mm		(length of J pin -MiraCell cell height)
$\phi_{f=}$	Soil Friction at Base	**35** degrees		
C_f =	Soil Cohesion	**35** kN/sq.m		
γ_f =	Unit Weight	**20.0** kN/cu.m		

Ka = $(1-\sin \phi_f)/(1+\sin \phi_f)$ 0.271

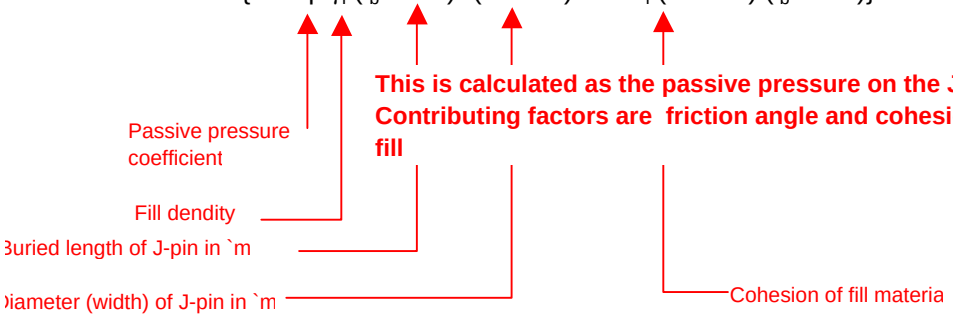
Kp = 1 / ka 3.690

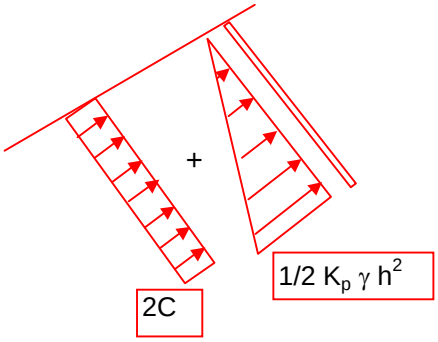
J pin spacing

S_H =	Horizontal Spacing	@ every	**2**	Cells	=	488 mm
S_V =	Spacing Along Slope	@ every	**5**	Cells	=	1000 mm

R = J pin Resistance 238 N Single Pin

$= \{0.5\ kp\ \gamma_f\ (l_b/1000)^2\ (d/1000) + 2\ C_f\ (d/1000)\ (l_b/1000)\}1000$





Total Force Acting on a J pin

$= F_{dnet}\ (S_V \times S_H) \times 1000$ = 598 N ***Unsatisfactory Tendon Required***

or Reduce Stakes Spacing

n = No of Rows of J pins = L / S_V 12

R^1 = J pin Resistance (kN/m) = $R \times n / S_H$ 5.8 Resultant

J pin Resistance (kN/sq.m) = R / S_H 0.48 Net Resultant

$F^2_{R=}$ Resisting Force (kN/m) = R^1+F_R 26.8

Factor of Safety = F^2_R / F_D 0.97 Shear, Stakes

Maximum Available F.S = $(F^2_R + \tau_w)/F_D$ 1.05 Anchored MiraCell

Unsatisfactory, Tendons Required

Tendons

Required Tension

$= fos \times F_D - \tau_w - F^2_R$ 6.85 kN/m

τ = Ultimate Strength 5 kN

	FOS - Tendons < 3 >	3			
S_T =	Tendon Spacing @ every	**2**	Cell	488	mm
	Tendons / Slot	**1**			

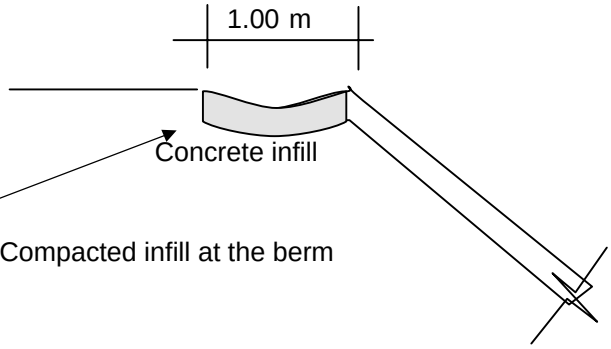
$\tau_{A\ =}$ Available Tension / Slot = τ / fos_{tendon} 1.7 kN

τ^1_A = Available Tension = τ_A x 1000 / S_T 3.42 kN/m ***Unsatisfactory, Reduce Tendon Spacing***

Maximum available F.S **1.18** **Anchored Tendons with MiraCell**

= (F^2_R + τ_w + τ^1_A) / F_D

Crest Slope Anchorage

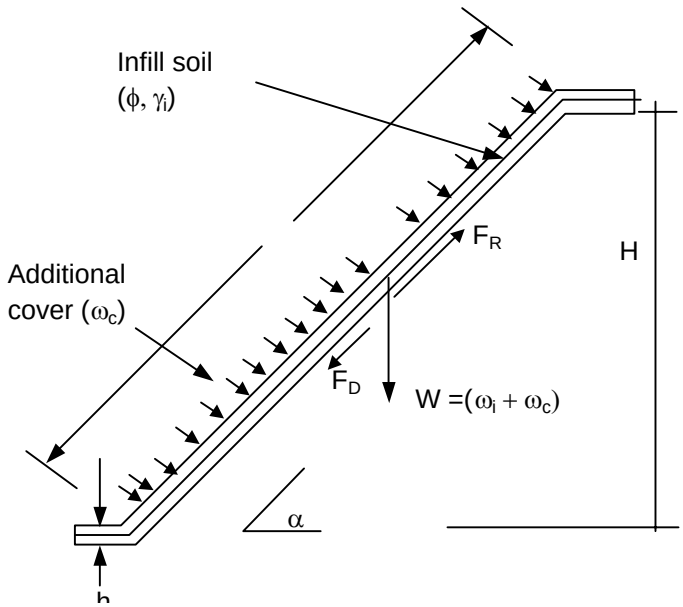


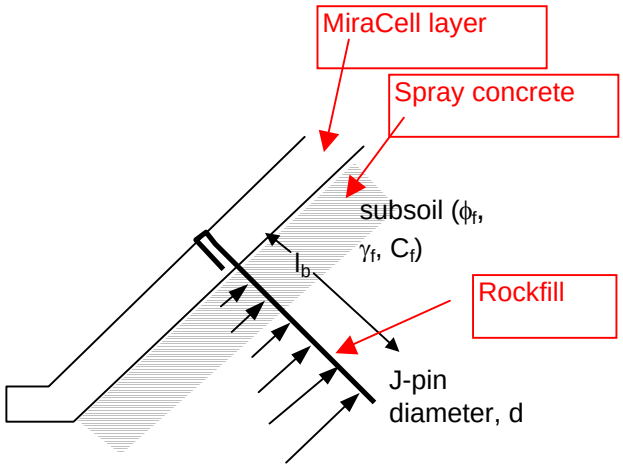
Required Anchorage	12.9	kN/m	
Depth Below Crest	150	mm	
Embedment Length	**1.00**	m	
Infill Unit Weight	**23.6**	kN/cu.m	Compacted infill at the berm
Soil Friction	**28**	degree	
Surcharge	3.54	kN/m	
Resisting Force	1.88	kN/m	
Capacity of Crest Anchor required	11.00	kN/m	no. Tendons per meter = 2.0
Capacity of Crest Anchor required	5.37	kN/tendon	= 1207.02 lb/ tendon

Provide J-pins at every cell spacing at berm and embed J-pins in concrete

Summary

1 MiraCell	MC-150-30, Standard cell	150mm high (6")	MiraCell sections		
2 J-pins	Steel J-pins,	400	mm long	12	mm dia.
	spacing	488	mm horizontally (every	2	cells)
		1000	mm along slope (every	5	cells)
3 Tendon	Polypropylene tendon of breaking strength			5.00	kN
4 Infil	Gr. 20 concrete.				





1- Cover Unit Weight

Cover unit weight is to allow for any thickly grown vegetation, shrubs etc. or any artificial objects (e.g concrete paving slabs for landscaping). It is not possible to design for a load of 5 Ton (50kN) acting on an area of only 2.4 sq.m at a time (2x0.4x3.0) as a uniform load over the entire slope surface.

Instead, some precaution should be used when moving the excavator. It is possible to distribute the load on the two tracks to wider area by using timber/ metal plates across the tracks (say 3m wide). Considering full length of slope (berm to berm) as the area of acting of this load assuming load distribution due to tendons along the slope, then the distributed load become {50 /(3 x 12.2)} = 1.37 kN/m2

I used 1.4kN/m2 as additional cover and do the calculation.
I get FOS of 1.18 (anchored MiraCell with Tendons)
Eventhough this is less than the normally allowed 1.3 due to the fact this additional cover weight is acting only during installation, FOS above 1.0 can be taken as satisfactory.

However, it should be left to the site supervisors to decide the allowing of excavator movement depending on the first few trial runs. Other suitable arrangements (hoist / crane) may be considered as alternative.
As per your second letter this issue will be disregarded.

2 - Angle of Internal Friction

Angle of internal friction is used to calculate the frictional resistance between MiraCell cover and geotextile layer. A value of 30 deg. can be assumed as reasonable considering possible rough surface due to stones below which can give rise to friction. In the calculation however if a lesser friction angle is used for lesser compaction then the weight of infill will also reduce. In the calculation I used 28 deg. for friction angle and 17kN/m2 as density

3 -Calculation for slope cover on cut slope

Please refer the sheet ` cut slope'. Cohesion value is reduced to 20kN/m2 for cut slope. For rockfill with spray concrete a value of 40kN/m2 is assumed. These should be very reasonable assumptions for the given conditions

4 -Pin Resistance on the crest anchorage

Please note that 1.0m embedment does not mean the driving depth of J-pin. It is the embedment (or the extension) of the MiraCell layer over the berm. This will give rise to friction resistance to a certain value based on weight of MiraCell cover (1.0m x 0.15m x 23.6kN/m3) and the friction angle. As per ypur second letter I have neglected this friction component in the design

Rockfill Slope

With the reduction of Friction angle and due to the concerns of machinery movement and limitations due to friction values, it is recommended to modify the J-pin Spacing to 2 cell horizontally (488mm) and 5 cell along slope (1000mm).

With this arrangement the number of J-Pin requirement will be increased by approx. 20%

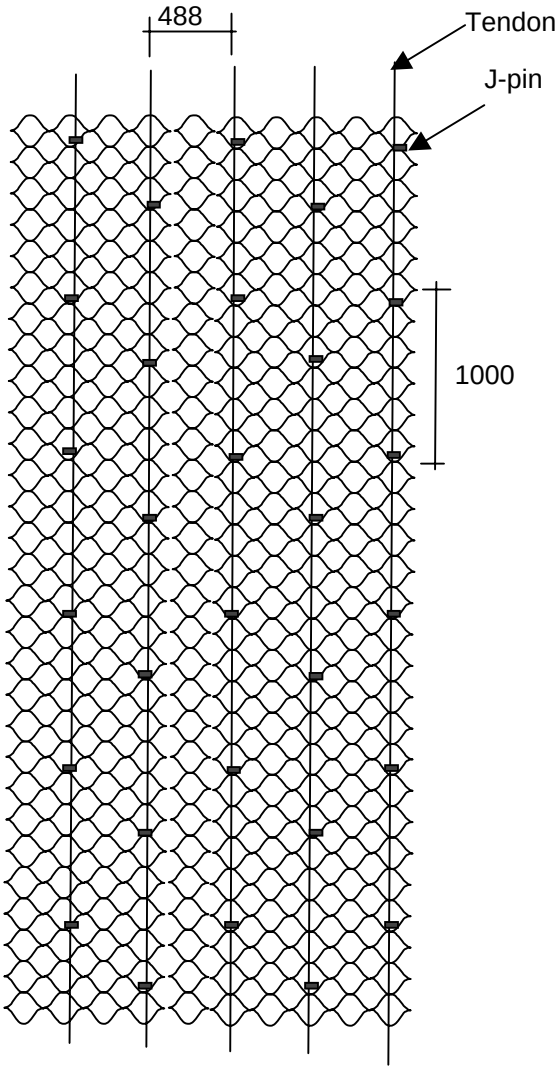
Cut Slope

Due to low friction angle and cohesion values it is recommended to use normal J-pin of 600mm length (450mm buried length) . Installation of 600mm long pins will not be a problem in cut slope.

The J-pin spacing need to be re-arranged to 2 cell horizontally (488mm) and 5 cell along slope (1000mm).

Selecting 2 cell horizontal spacing for J-pin will make the tying of tendons with J-pins easier as the tendon spacing also every 2 cell.

Following diagram illustrates the J-pin and Tendon arrangement

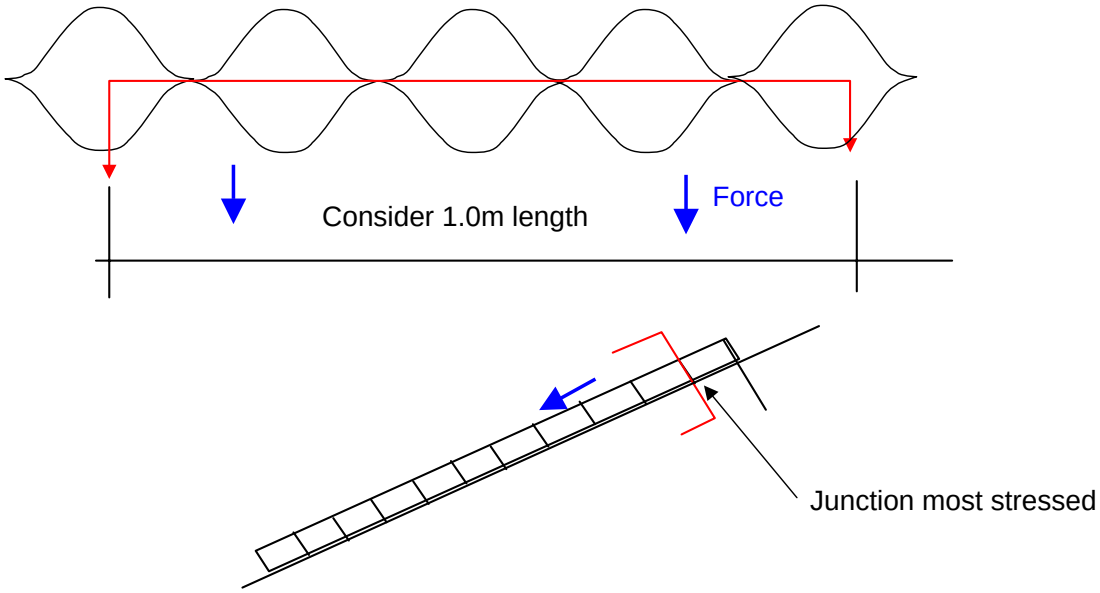


J-pin and Tendon Arrangement for
Rockfill slope and cut slope

MiraCell Cellular Confinement System

Calculation of Joint Strength Based on Test Results

A Considering Joint Strength as Critical



Junction Strength = 570 lbf/ 8"
(As Per Tests Carried out by Independent Laboratory in Singapore)

$$= \frac{570 \times 9.81}{2.206 \times 1000} \text{ kN/ 8"}$$

= 2.53 kN/(0.2m)
= 2.53 x 5 = 12.65 kN/m

In the design disturbing forces are calculated based on a 1m width of MiraCell slope cover
Therefore,
Consider 1m length of MiraCell section
spacing of weld joints = 244mm (fully stretched section)
Therefore, number of joints / 1m length = 1000 / 244 = 4.09
say 4.0
Total joints length of 150mm thick section = 4 x 0.15 = 0.6m

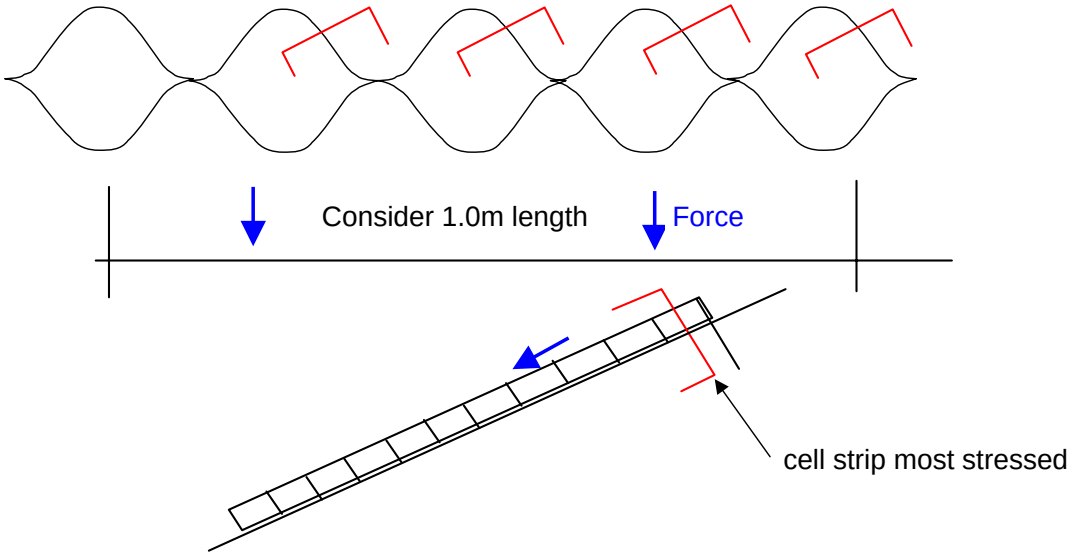
Therefore, total joint strength = 0.6 x 12.65 = 7.59 kN/m (m width of MiraCell protection)

For Safety Factor of 2.5
= 7.59 / 2.5

Joint Strength = **3.04 kN/m**

Value used in the calculation 2.25 kN/m is therefore conservative

B Considering Web Tensile Strength as Critical



Based on Test Results by GSE

Tensile Strength at Yield = 15N/mm per 1.0mm thick section

MiraCell height = 150mm and thickness is 1.2mm
Therefore, corresponding Tensile strength = 15 x 1.2 x 0.15 = 2.7 kN per 6"
This value is based on minimum test results with low elongation %
2.7kN is for a single cell.
Considering 1m width having 4 cells
Total web tensile strength = 2.7 x 4 = 10.8 kN/m (m width of MiraCell protection)
For FOS of 2 Design Web Tensile = 5.4 kN/m

Value used in the calculation 2.25 kN/m is therefore conservative

J-Pin Stability Check

Diameter of J-pin 12mm and length 400mm
Buried 250mm including 100mm in Spay concrete and 150mm in Roackfill

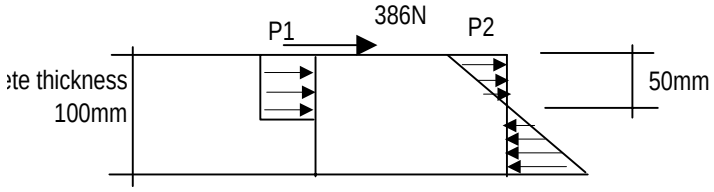
J-pin is inserted in pre-drilled hole and will be grouted.

Assumptions.

1 Corrosion of J-pin
2mm outer serface is allowed for corrosion over the design period.
2 Concrete Strength
20 N/mm2
3 Steel shear force f_{sv}
80 N/mm2
4 Bond stress of re-bar embedded in concrete
1.7N/mm2
5 Thickness of spray concrete
100 mm
6 Load load transfer from J-Pin to concrete
takes within top 50mm.

Given J-pin resistance
= 386 N

Check for Maximum Concrete Stress



P1 = Force = 386 = 0.97 N/mm2
Area 50 x (12-4)

M = 386 x 50 = 9650 N. mm
2

P2 = 6 M = 6 x 9650 = 57900
bd2 8 x 50^2 20000
= 2.895

Max pressure = P1+P2 = 0.97 + 2.895 = 3.86 N/mm2

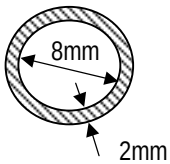
3.86N/mm2 < 20 N/mm2 Satisfactory

Check For Bearing Pressure of spray concrte

Area of J-pin bearing against shotcrete = (12-4) x 100 = 800mm2
Concrete strength = 20N/mm2
Therefore, concrete bearing capacity = 20 x 800 = 16,000N
> 386 N, O.K.

Check for Shear of J-pin

Effective diameter of J-pin = 12-4 = 8mm



Shear strength (fsv) for mild steel
= 80 N/mm2

Pin area = π x 4^2 = 50.3 mm2

J-pin shear strength = 80 x 50.3 = 4024 N
> 386 N, O.K.

Check for Pull-out Resistance of J-pin

Steel bond stress = 1.7 N/mm2
Safety Factor = 3
Allowable bond stress = 1.7/3 = 0.57
Perimeter of J-pin = π x 8 = 25.13
Bond length = 100mm
Pull-out resistance = total bond force
= 1424.2 N > 386 N, O.K.

i) A theoretical 10mm dia. hole will be suitable. Actual size of drill hole is most probably larger than 10mm if drilled with 10mm drill bit. A few installations on site can determine if driving is difficult and if it tend to break the concrete layer. In this case a larger size hole with grout fill can be used.

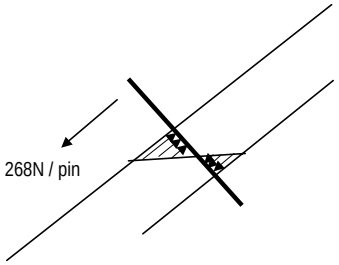
ii) For ultimate corrosion protection galvanizing of J-pins will be required. Applying two coats of anticorrosive paint is recommended if they are installed in pre-drilled holes without the need of forced driving.

However, it should be noted that it will take several years to corrode 1mm of road diameter. By this time a well grown root system of vegetation can add to the anchorage of protection layer

iii) Pullout resistance of the J-pin is not an issue in this type of installation. Main criteria is to resist shearing. Applied loads direction are perpendicular to the direction of pullout

The design J-pin resistance (soil shear) is 268N per 12mm dia. pin
(please refer to previous design calculations)
J-pin resistance is limited to soil shear in our calculation

Normally the shear resistance of mild steel is 250N/mm2. Therefore, 12mm dia. rod provides shearing resistance of nearly100 times higher than the anticipated soil shear value.



Assuming sprayed concrete is grade 15
Compressive strength of Gr. 15 concrete is > 15N/mm2

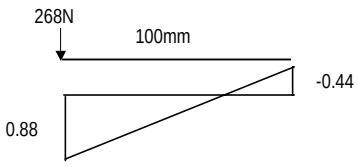
Maximum force applied by J-pin (P) = 268 N
spread over area (A) of 12mm (dia. / width of J-pin) x 100mm (length in concrete)

Avg. loading on concrete (P/A) = 268 / (12 x 100) =
0.22 N/mm2 < 15N/mm2
Therefore, Bearing of concrete Satisfactory

Max. load = (P/A) + {1+6e/L) L=100mm
max. e = L/2

Max load = (P/A) x (1+6/2)
= 0.22 x 4 = 0.88 N/mm2 < 15 N/mm2 O.K.

Min. load = (P/A) x (1-6e/L)
= 0.22 x -2 = -0.44N/mm2

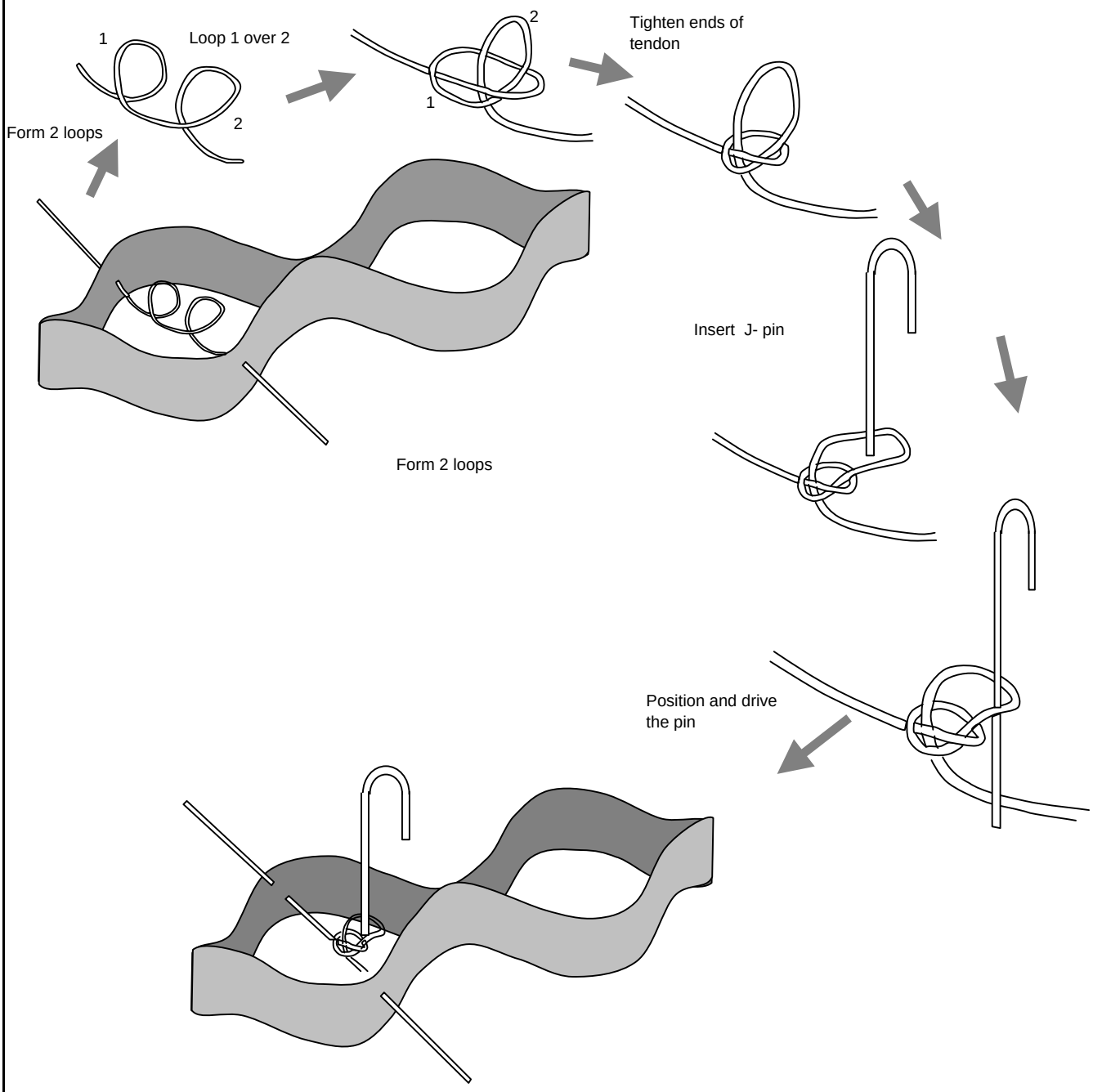


From above it is clear that in our design calculations the J-pin resistance is limited to soil shear. The J-pin and concrete are much stronger to have any impact on them by the applied load.

iv) No change in connection details of J-pins with tendons and anchorage detail of the tendon at the crest / toe (ref. next sheet)

v) Laboratory Test Results

vi) No change

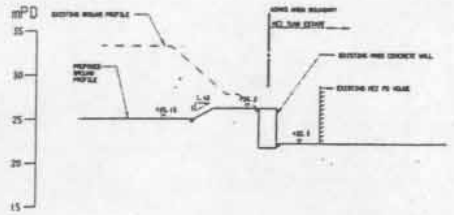


Attachment of Tendons Through MiraCell to J-pin Anchors

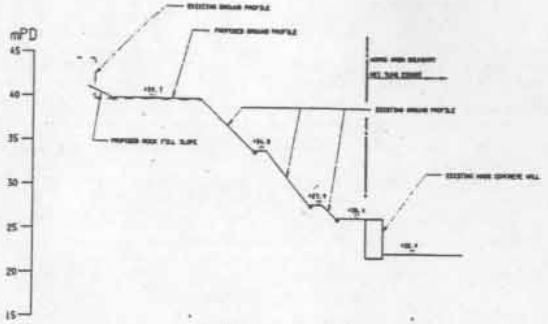
International Erosion Control Systems Sdn Bhd
No. 13A, Lot 40299, Simpang 544-22
Jalan Jerudong BG 3122, Brunei Darussalam,
Tel: 673-2-612717 Fax: 673-2-612720
Website: http://www.miracell-ccs.com
email: sales@miracell-ccs.com

DATE	
DRAWN BY	DRAWING NUMBER

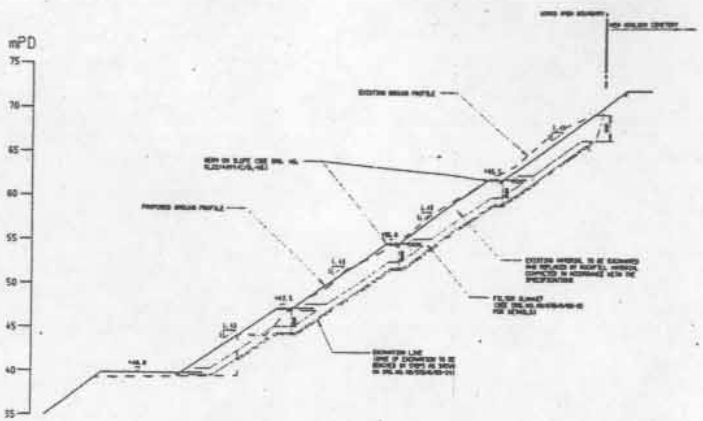

N
837550E
837650E
837700E
821700N
821650N
821600N
PROPOSED RETAINING WALL B
PROPOSED BORED PILE WALL
PROPOSED RETAINING WALL C
PROPOSED RETAINING WALL A
PROPOSED RE-ALIGNED PUI MAN STREET
TUNG TAU TSUEN ROAD
TUNG TSING ROAD
ESTATE ROAD
MEI TUNG HOUSE
RUN-IN
STAGGERED ISLANDS AT TUNG TAU TSUEN ROAD AND TUNG TSING ROAD TO BE CONSTRUCTED BY HyD.
LEGEND :-
EXISTING SLOPE
PROPOSED CUT SLOPE
PROPOSED FILL SLOPE
EXISTING GROUND LEVEL
PROPOSED FORMATION LEVEL
PROPOSED FINISHED ROAD LEVEL
EXISTING RETAINING WALL
PROPOSED BORED PILE WALL
PROPOSED SLOPE MAINTENANCE STAIRWAY
PROPOSED CONCRETE FOOTWAY/STAIRWAY/SLAB
PROPOSED 150 THICK GRADE 40/20 CONCRETE PAVING WITH 225 THICK GRANULAR SUB-BASE MATERIAL
PROPOSED FLEXIBLE CARRIAGEWAY FOR RE-ALIGNED PUI MAN STREET
PROPOSED FLEXIBLE CARRIAGEWAY FOR ESTATE ROAD OF MEI TUNG ESTATE
PROPOSED DRAINAGE WALL/AMENITY AREA
PROPOSED CUT/FILL SLOPE WITH SPRAYED CONCRETE SURFACING
PROPOSED CUT SLOPE WITH SPRAYED CONCRETE PROTECTION AND CELLULAR CONFINEMENT FOR HYDROSEEDING SURFACING
PROPOSED ROCKFILL SLOPE WITH SPRAYED CONCRETE PROTECTION AND CELLULAR CONFINEMENT FOR HYDROSEEDING SURFACING
S.V. SLOPE ANGLE VARIES
WORKS AREA BOUNDARY
P.C. PEDESTRIAN CROSSING
REVISIONS
INITIAL AND DESIGNATION
AUTHORISED K. K. CHEUNG CCE
CHECKED C.K. CHIU SCE/1
C. H. FUN CE/21
C. L. HO SRDC1/H
DRAWN L. P. WONG TDC1/16
PROJECT
SITE FORMATION WORKS FOR PUBLIC HOUSING DEVELOPMENT AT TUNG TAU COTTAGE AREA
DRAWING TITLE
GENERAL LAYOUT OF WORKS - EAST SITE
SCALE 1 : 250
DRAWING NO
KL22/4899/C/GA-01/B
DEVELOPMENT AND CONSTRUCTION BRANCH HOUSING DEPARTMENT



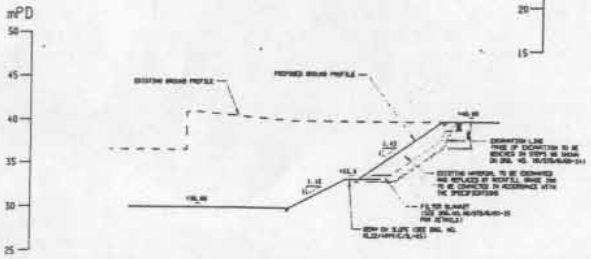
SECTION W1 - W1



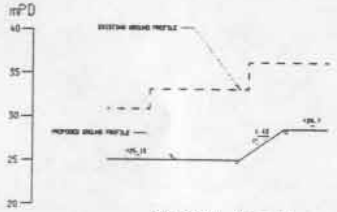
SECTION W2 - W2



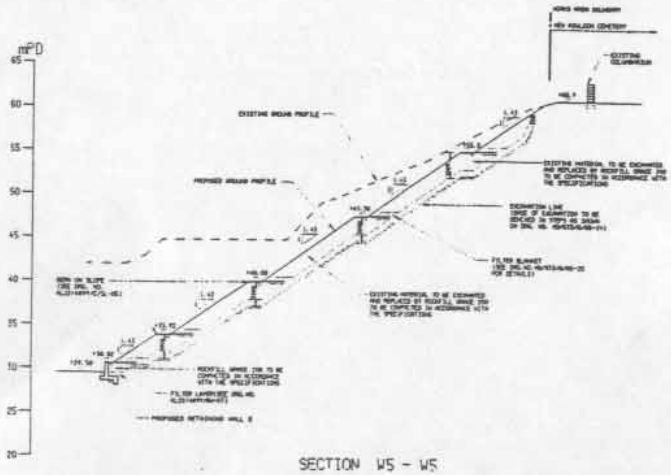
SECTION W3 - W3



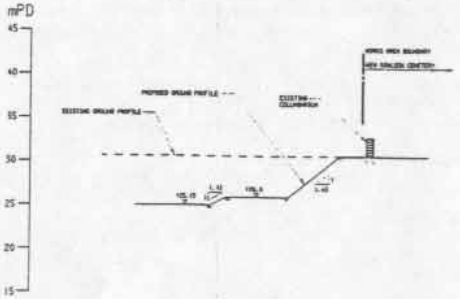
SECTION W4 - W4



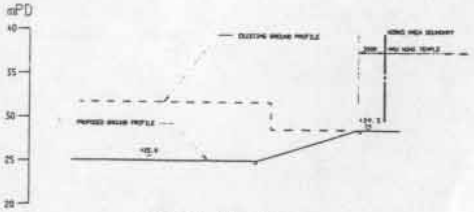
SECTION W7 - W7



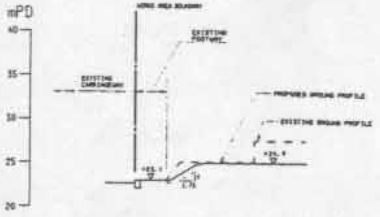
SECTION W5 - W5



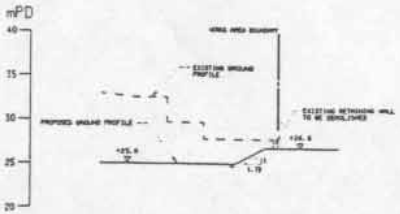
SECTION W6 - W6



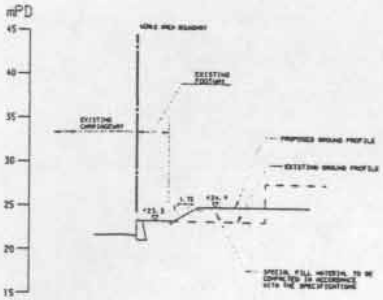
SECTION W8 - W8



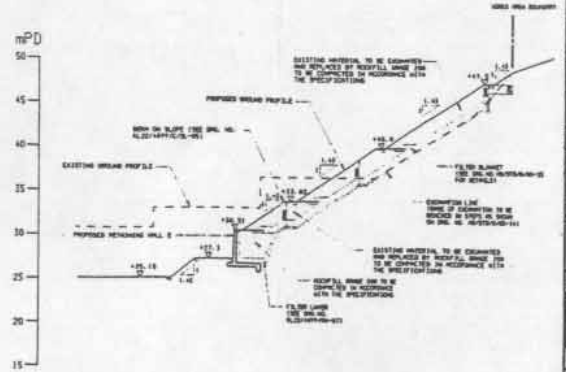
SECTION W9 - W9



SECTION W10 - W10



SECTION W11 - W11



SECTION W12 - W12

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE STATED.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRG. NO. KL22/4899/C/GM-02.
4. ALL PROPOSED UNDERGROUND SERVICES ARE NOT SHOWN FOR CLARITY.
5. SHOW WIDTH TO BE 1.5 M UNLESS OTHERWISE STATED.
6. ALL LEVELS SHOWN ARE APPROXIMATE ONLY.
7. THE EXACT DEPTH AND EXTENT OF EXCAVATION FOR SLOPE WORKS SHALL BE CONFIRMED ON SITE BY THE CE.

REVISIONS		INITIAL AND DESIGNATION		
NO	DESCRIPTION AND DATE	DAH	CKD	AUTH
A	1. SECTIONS W4 - W4, W5 - W5 AND W12 - W12 REVISED. 15.6.21	SIGN	SIGN	SIGN
B	1. SECTIONS W1 -W1, W3 - W3 TO W12 -W12 REVISED. 2. NOTE 7 ADDED. 25.6.21	SIGN	SIGN	SIGN
C	1. SECTION W8 - W8 REVISED. 15.11.21	SIGN	SIGN	SIGN

	NAME AND DESIGNATION		INITIAL	DATE
AUTHORISED	K.K.CHEUNG	CE	ORIGINAL SIGNED	25.5.21
CHECKED	C.K.CHIU	SCE/3	ORIGINAL SIGNED	22.5.21
	C.N.YUK	CE/21	ORIGINAL SIGNED	22.5.21
	C.L.NG	SSO(CH)4	ORIGINAL SIGNED	22.5.21
DRAWN	S.F.HOK	SSO(CH)4	ORIGINAL SIGNED	22.5.21

PROJECT

SITE FORMATION WORKS FOR PUBLIC HOUSING DEVELOPMENT AT TUNG TAU COTTAGE AREA

DRAWING TITLE

CROSS SECTIONS OF SLOPEWORKS - WEST SITE

SCALE 1 : 250

DRAWING NO

KL22/4899/C/SL-03/C

SOURCE

DEVELOPMENT AND CONSTRUCTION BRANCH HOUSING DEPARTMENT

NOTES

1. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
2. ALL DIMENSIONS ARE IN MILLIMETRES.
3. LEVELS OF BORING INDICATED ARE SUBJECT TO CONFIRMATION BY THE CIC TO SUIT ACTUAL SITE CONDITIONS.
4. THE LIMITS OF PROPOSED SLOPES ARE APPROXIMATE ONLY AND SHALL BE DETERMINED ON SITE ACCORDING TO INITIAL GROUND SURVEY AFTER SITE CLEARANCE.
5. FOR SECTION W1-W1 TO SECTION W12-W12, REFER TO DRG. NO. KL22/4899/SL-02.
6. SETTING OUT OF WORKS AREA BOUNDARY IS TO BE CONFIRMED ON SITE.
7. ALL PROPOSED FILL SLOPES SHALL BE CONSTRUCTED OF SPECIAL FILL MATERIAL.
8. ALL PROPOSED ROCKFILL SLOPES SHALL BE CONSTRUCTED OF ROCKFILL GRADE 200.
9. ALL SOIL SLOPES TO BE HYDROSEEDED UNLESS OTHERWISE STATED.

LEGEND :-

- EXISTING SLOPE
- PROPOSED CUT SLOPE
- PROPOSED FILL SLOPE
- PROPOSED CUT/FILL SLOPE WITH SPRAYED CONCRETE SURFACING
- PROPOSED ROCK FILL SLOPE WITH SPRAYED CONCRETE PROTECTION AND CELLULAR COMPONENT FOR HYDROSEED SURFACING
- 19.8 EXISTING GROUND LEVEL
- PROPOSED FORMATION LEVEL (+22.00 mPD)
- WORKS AREA BOUNDARY
- PW1 SETTING OUT POINT
- PROPOSED SLOPE MAINTENANCE STAIRWAY
- S.V. SLOPE SNAKE WIRES

REVISIONS

NO.	DESCRIPTION AND DATE	INITIAL
A	1. EXTENT OF ROCKFILL SLOPE REVISED. 2. RETAINING WALL E REVISED. 3. SETTING OUT POINTS REVISED ACCORDINGLY.	
B	1. SURFACE TREATMENT TO SLOPES REVISED. 2. SITE FORMATION LAYOUT REVISED. 3. SETTING OUT POINTS REVISED ACCORDINGLY.	
C	1. WORKS AREA BOUNDARY AND SLOPE LAYOUT ADJACENT TO HAU WONG TEMPLE REVISED. 2. SETTING OUT POINTS REVISED ACCORDINGLY.	

	NAME AND DESIGNATION	INITIAL
AUTHORISED	K.K. CHEUNG (CE)	
CHECKED	C.K. CHIU (SE/3)	
	C.K. PUN (SI/3)	
	C.L. HO (STAO/I)	
DRAWN	S.F. WONG (TO(C)I/I)	

PROJECT

SITE FORMATION WORKS FOR PUBLIC HOUSING DEVELOPMENT AT TUNG TAU COTTAGE AREA

DRAWING TITLE

GENERAL LAYOUT OF WORKS & SETTING OUT PLAN - WEST SITE

SCALE 1 : 250

DRAWING NO. KL22/4899/C/GA-02/C

SETTING OUT POINT	CO-ORDINATES N	CO-ORDINATES E	REMARKS
PW1	821610.989	837383.682	STRAIGHT
PW2	821601.344	837405.352	R=13.50m
PW3	821592.219	837415.294	R=45.00m
PW4	821574.060	837428.190	STRAIGHT
PW5	821567.338	837432.724	R=4.00m
PW6	821563.775	837433.902	
PW7	821578.792	837448.886	
PW8	821564.904	837468.537	
PW9	821598.731	837384.551	

SETTING OUT POINT	CO-ORDINATES N	CO-ORDINATES E	REMARKS
PW11	821569.305	837469.316	R=8.00m
PW12	821572.681	837418.588	R=51.50m
PW13	821587.722	837421.617	R=25.00m
PW14	821558.596	837428.445	STRAIGHT
PW15	821603.112	837386.610	R=4.00m
PW16	821599.909	837359.814	STRAIGHT
PW17	821548.802	837350.676	R=8.00m
PW18	821540.422	837334.829	R=5.00m
PW19	821535.370	837357.155	

SETTING OUT POINT	CO-ORDINATES N	CO-ORDINATES E	REMARKS
PW22	821527.260	837374.403	
PW23	821524.507	837382.263	
PW24	821527.234	837348.920	STRAIGHT
PW25	821533.280	837356.928	STRAIGHT
PW26	821525.740	837382.582	STRAIGHT
PW27	821528.288	837384.807	STRAIGHT
PW28	821525.019	837371.031	STRAIGHT
PW29	821522.036	837381.267	STRAIGHT
PW30	821516.945	837380.814	STRAIGHT
PW31	821600.644	837538.568	

G AND E COMPANY LIMITED

Rm. B, 13/F Cheung Lee Ind. Bldg.
9 Cheung Lee Street
Chai Wan, Hong Kong
Tel: 2508 0028 / 2570 0103 Fax: 2570 0089

October 31, 2002
Rockfill slope ready for shotcrete

December 20, 2002
Laying of geotextile on shotcrete surface

G AND E COMPANY LIMITED

Rm. B, 13/F Cheung Lee Ind. Bldg.
9 Cheung Lee Street
Chai Wan, Hong Kong
Tel: 2508 0028 / 2570 0103 Fax: 2570 0089

January 11, 2003
Installation of Miracell cellular confinement system

February 13, 2003
Spreading of soil into Miracell

G AND E COMPANY LIMITED

Rm. B, 13/F Cheung Lee Ind. Bldg.
9 Cheung Lee Street
Chai Wan, Hong Kong
Tel: 2508 0028 / 2570 0103 Fax: 2570 0089

February 13, 2003
Laying of erosion control mat on soil infilled Miracell

March 11, 2003
Brushing of soil into erosion control mat

G AND E COMPANY LIMITED

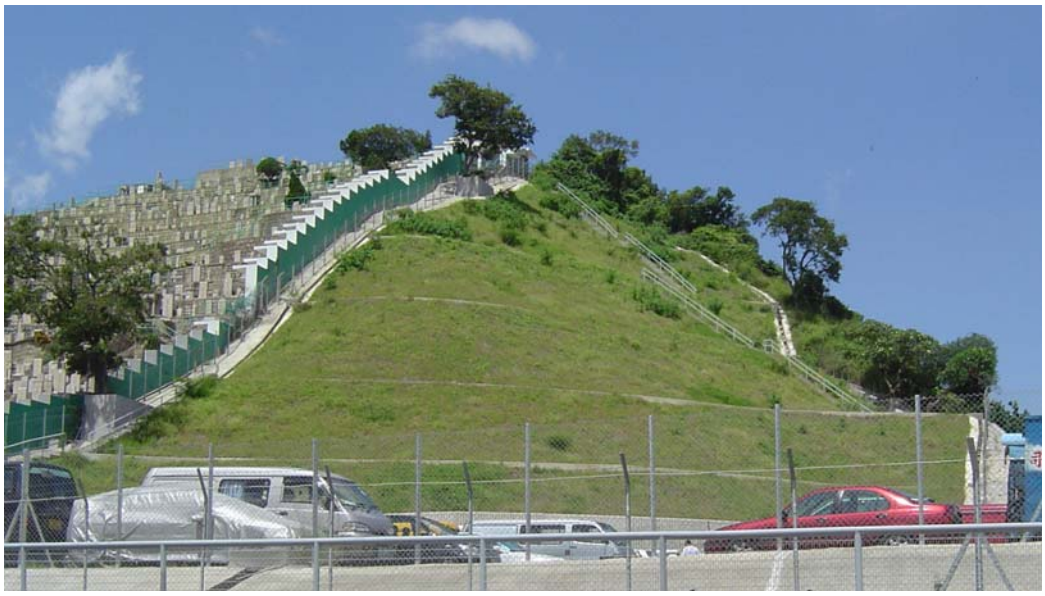
Rm. B, 13/F Cheung Lee Ind. Bldg.
9 Cheung Lee Street
Chai Wan, Hong Kong
Tel: 2508 0028 / 2570 0103 Fax: 2570 0089

April 22, 2003
Application of hydroseeding and seed protection mat

May 11, 2003
Full establishment of grass

G AND E COMPANY LIMITED

Rm. B, 13/F Cheung Lee Ind. Bldg.
9 Cheung Lee Street
Chai Wan, Hong Kong
Tel: 2508 0028 / 2570 0103 Fax: 2570 0089



June 28, 2004

July 6, 2005

G AND E COMPANY LIMITED

Rm. B, 13/F Cheung Lee Ind. Bldg.
9 Cheung Lee Street
Chai Wan, Hong Kong
Tel: 2508 0028 / 2570 0103 Fax: 2570 0089

Mar 08, 2008