This report was generated by LimitState:GEO2.0.b.10662 - www.limitstate.com

About this Report

This report has been generated using LimitState:GEO, a software application capable of directly identifying the critical collapse mechanism for a wide variety of geotechnical stability problems, including those involving slopes, retaining walls, footings etc.
The software utilizes the Discontinuity Layout Optimization (DLO) procedure to obtain a solution (Smith and Gilbert 2007). The main steps involved are: (i) distribution of nodes across the problem domain; (ii) connection of every node to every other node with potential discontinuities (e.g. slip-lines); (iii) application of rigorous optimization techniques to identify the critical subset of potential discontinuities, and hence also the critical failure mechanism and margin of safety.
The accuracy of the DLO solution is controlled by the specified nodal density. Within the set of all possible discontinuitiues linking pairs of nodes, all potential translational failure mechanisms are considered, whether anticipated or not by the engineer. Failure mechanisms involving rotations along the edges of solid bodies in the problem can also be identified. Thus in this case the solution identified by the DLO procedure is guaranteed to be the most critical solution for the problem posed. This means that there is no need to prescribe any aspect of the collapse mechanism prior to an analysis, or to separately consider different failure modes. The critical mechanism and collapse load factor are determined according to the well established upper bound theorem of plasticity.
LimitState:GEO reports the solution to a problem both visually as a collapse mechanism and numerically in terms of an Adequacy Factor. This is the factor by which pre-specified boundary loads and/or self weight loads must be multiplied by in order to cause collapse.
REFERENCE
Smith, C.C. and Gilbert, M. (2007) Application of discontinuity layout optimization to plane plasticity problems, Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences, Vol. 463, 2086, pp 2461-2484.

Summary

Name	Reference No.	Location	Map Reference	Name of engineer	Organization
Gravity Wall - Factor of Safety on Strength					

Date of analysis	Comments
Wed Jun 17 2009	A gravity retaining wall is holding back a slope with a surcharge load on it. Stability analysis is required to determine the partial factor of safety on material strength.

Target nodal density	Nodal spacing scale factor	Water table	Model translational failures?	Model rotational failures?	Seismic accelerations (g)
Coarse (250 nodes)	0.917986	Disabled	True	False	False

Scenario	Partial factor set	Analysis type	Adequacy factor
1	PF 1.0	Short Term	1.508
2	PF 1.05	Short Term	1.406
3	PF 1.1	Short Term	1.314
4	PF 1.15	Short Term	1.23
5	PF 1.2	Short Term	1.152
6	PF 1.25	Short Term	1.081
7	PF 1.3	Short Term	1.015
8	PF 1.35	Short Term	0.9546
9	PF 1.4	Short Term	0.8982
10	PF 1.45	Short Term	0.8456
11*	**PF 1.5**	**Short Term**	**0.7965**

**This report provides details of this scenario, which has been identified as the most critical.*

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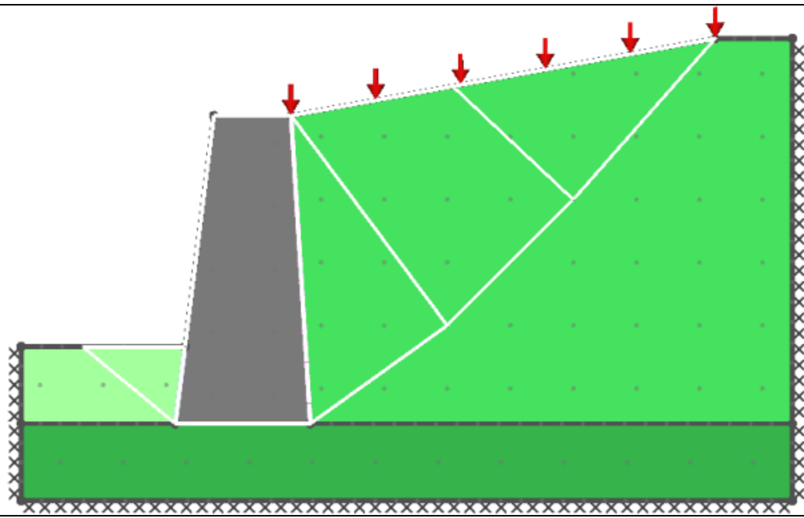
Critical failure mechanism (Scenario 11)



Geometry

(all distances in m)

All geometrical objects

No. of vertices (V)	No. of boundaries (B)	No. of solids (S)
12	15	4

Boundary objects

ID	Start vertex ID (x, y)	End vertex ID (x, y)	Baseline nodal spacing	Support type	Material(s)
B1	V1 (2, 1)	V2 (2.1, 2)	0.25	Free	Soil B-Wall interface
B2	V2 (2.1, 2)	V3 (2.5, 5)	0.25	Free	-
B3	V3 (2.5, 5)	V4 (3.5, 5)	0.25	Free	-
B4	V4 (3.5, 5)	V5 (3.8, 1)	0.25	Free	Soil A-Wall interface
B5	V1 (2, 1)	V5 (3.8, 1)	0.25	Free	Soil C-Wall interface
B6*	V4 (3.5, 5)	V12 (9, 6)	0.25	Free	-
B7	V6 (10, 6)	V7 (10, 1)	0.25	Fixed	-
B8	V7 (10, 1)	V5 (3.8, 1)	0.25	Free	-
B9	V8 (0, 2)	V2 (2.1, 2)	0.25	Free	-
B10	V1 (2, 1)	V9 (0, 1)	0.25	Free	-
B11	V8 (0, 2)	V9 (0, 1)	0.25	Fixed	-
B12	V7 (10, 1)	V10 (10, 0)	0.25	Fixed	-
B13	V10 (10, 0)	V11 (0, 0)	0.25	Fixed	-
B14	V9 (0, 1)	V11 (0, 0)	0.25	Fixed	-
B15	V12 (9, 6)	V6 (10, 6)	0.25	Free	-

** Loaded boundary.*

Solid objects

ID	Vertex IDs (x, y)	Boundary IDs	Baseline nodal spacing (x / y)	Material(s)
S1	V1 (2,1) V2 (2.1,2) V3 (2.5,5) V4 (3.5,5) V5 (3.8,1)	B1 B2 B3 B4 B5	0.75 / 0.75	Wall
S2*	V4 (3.5,5) V12 (9,6) V6 (10,6) V7 (10,1) V5 (3.8,1)	B6 B15 B7 B8 B4	0.75 / 0.75	Soil A
S3*	V8 (0,2) V2 (2.1,2) V1 (2,1) V9 (0,1)	B9 B1 B10 B11	0.75 / 0.75	Soil B
S4*	V9 (0,1) V1 (2,1) V5 (3.8,1) V7 (10,1) V10 (10,0) V11 (0,0)	B10 B5 B8 B12 B13 B14	0.75 / 0.75	Soil C

** Loaded solid (self weight).*

Water Table

(all distances in m)

Water table status	Vertices (x, y)
Disabled	

Materials

(unit weights in kN/m³, strengths in kN/m² (kPa), angles in degrees)

Mohr Coulomb material(s)

Key	Name	Unit weight: dry (saturated)	c' (ϕ')	c_u (datum) (gradient)
	Wall	0 (0)	0 (0)	5000 (0) (0)
	Soil B-Wall interface	18 (20)	0 (16.1021)	20 (0) (0)
	Soil A-Wall interface	16 (20)	1.5 (13.1243)	17.5 (0) (0)
	Soil C-Wall interface	20 (22)	0 (19.2953)	27.5 (0) (0)
	Soil A	16 (20)	3 (25)	35 (0) (0)
	Soil B	18 (20)	0 (30)	40 (0) (0)
	Soil C	20 (22)	0 (35)	55 (0) (0)

Partial factors

Factor	PF 1.0	PF 1.05	PF 1.1	PF 1.15
Unfavourable: permanent	1	1	1	1
Unfavourable: variable	1	1	1	1
Unfavourable: accidental	1	1	1	1
Favourable: permanent	1	1	1	1

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Favourable: variable	1	1	1	1
Favourable: accidental	1	1	1	1
c'	1	1.05	1.1	1.15
tanφ'	1	1.05	1.1	1.15
c_u	1	1.05	1.1	1.15
Factor	**PF 1.2**	**PF 1.25**	**PF 1.3**	**PF 1.35**
Unfavourable: permanent	1	1	1	1
Unfavourable: variable	1	1	1	1
Unfavourable: accidental	1	1	1	1
Favourable: permanent	1	1	1	1
Favourable: variable	1	1	1	1
Favourable: accidental	1	1	1	1
c'	1.2	1.25	1.3	1.35
tanφ'	1.2	1.25	1.3	1.35
c_u	1.2	1.25	1.3	1.35
Factor	**PF 1.4**	**PF 1.45**	**PF 1.5***	
Unfavourable: permanent	1	1	1	
Unfavourable: variable	1	1	1	
Unfavourable: accidental	1	1	1	
Favourable: permanent	1	1	1	
Favourable: variable	1	1	1	
Favourable: accidental	1	1	1	
c'	1.4	1.45	1.5	
tanφ'	1.4	1.45	1.5	
c_u	1.4	1.45	1.5	

**These partial factors were used in Scenario 11 (described in this report).*

Loads

(normal and shear loads in kN/m² (kPa))

Boundary objects

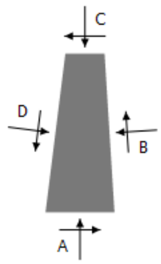
Loaded object	Type	Favourable?	Adequacy?	Normal	Shear
B6	Variable Load	false	true	49.2	-8.5

Solid objects

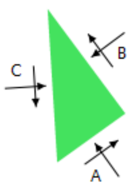
Loaded object	Type	Favourable?	Adequacy?
S2	Permanent (unfactored self weight: 16 kN/m³)	false	false
S3	Permanent (unfactored self weight: 18 kN/m³)	false	false
S4	Permanent (unfactored self weight: 20 kN/m³)	false	false

Free-body diagrams

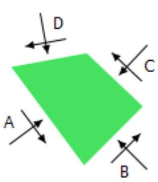
(Scenario 11; normal and shear forces are reported as total forces in kN per m width which include the effects of water pressures; angles in degrees [clockwise +ve, measured from horizontal], distances in m)



Face	Start Point (x, y)	End Point (x, y)	Angle (θ)	Normal (N)	Shear (S)	Horizontal equilibrium term: S.cosθ + N.sinθ	Vertical equilibrium term: -S.sinθ + N.cosθ
A	(2, 1)	(3.75, 1)	0	48.1259	32.0833	32.0833	48.1259
B	(3.75, 1)	(3.5, 5)	-93.5763	103.54	-46.7577	-100.422	-53.1253
C	(3.5, 5)	(2.5, 5)	-180	0	0	0	0
D	(2.5, 5)	(2, 1)	97.125	67.1904	-13.4371	68.3382	4.99939
					Self Weight (kN/m):		0
					Sum:	0	0

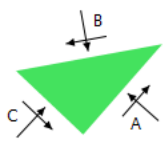


Face	Start Point (x, y)	End Point (x, y)	Angle (θ)	Normal (N)	Shear (S)	Horizontal equilibrium term: S.cosθ + N.sinθ	Vertical equilibrium term: -S.sinθ + N.cosθ
A	(3.75, 1)	(5.52, 2.27)	-35.687	144.919	50.9776	-43.1345	147.443
B	(5.52, 2.27)	(3.5, 5)	-126.605	130.206	-79.2199	-57.2871	-141.236
C	(3.5, 5)	(3.75, 1)	86.4237	103.54	-46.7577	100.422	53.1253
					Self Weight (kN/m):		-59.3327
					Sum:	0	0

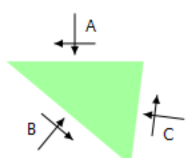


Face	Start Point (x, y)	End Point (x, y)	Angle (θ)	Normal (N)	Shear (S)	Horizontal	Vertical

						equilibrium term: S.cosθ + N.sinθ	equilibrium term: -S.sinθ + N.cosθ
A	(3.5, 5)	(5.52, 2.27)	53.3953	130.206	-79.2199	57.2871	141.236
B	(5.52, 2.27)	(7.16, 3.91)	-45	118.009	53.9196	-45.3179	121.572
C	(7.16, 3.91)	(5.6, 5.38)	-136.713	71.7407	-50.1091	-12.7126	-86.5797
D	(5.6, 5.38)	(3.5, 5)	169.695	83.4572	14.4184	0.743429	-84.6902
					Self Weight (kN/m):		-91.5377
					Sum:	0	0



Face	Start Point (x, y)	End Point (x, y)	Angle (θ)	Normal (N)	Shear (S)	Horizontal equilibrium term: S.cosθ + N.sinθ	Vertical equilibrium term: -S.sinθ + N.cosθ
A	(7.16, 3.91)	(9, 6)	-48.6371	75.7974	65.0221	-13.9207	98.8905
B	(9, 6)	(5.6, 5.38)	169.695	135.618	23.4299	1.20807	-137.622
C	(5.6, 5.38)	(7.16, 3.91)	43.2866	71.7407	-50.1091	12.7126	86.5797
					Self Weight (kN/m):		-47.8486
					Sum:	0	0



Face	Start Point (x, y)	End Point (x, y)	Angle (θ)	Normal (N)	Shear (S)	Horizontal equilibrium term: S.cosθ + N.sinθ	Vertical equilibrium term: -S.sinθ + N.cosθ
A	(2.12, 2)	(0.797, 2)	-180	0	0	0	0
B	(0.797, 2)	(2, 1)	39.7323	56.7191	41.7187	68.3382	16.9525
C	(2, 1)	(2.12, 2)	-82.875	67.1904	-13.4371	-68.3382	-4.99939
					Self Weight (kN/m):		-11.9531
					Sum:	0	0