CITTÀ METROPOLITANA DI BOLOGNA

Comune di Crevalcore | Comune di San Giovanni in Persiceto | Comune di Casalecchio di Reno | Comune di Bologna | Comune di Sasso Marconi | Comune di Marzabotto

Ciclovia del Sole: tratto 3 attraversamento dei centri abitati di Crevalcore, San Giovanni in Persiceto, Sala Bolognese - tratto 4: Casalecchio - Marzabotto

CUP n° C61B21013060002

PROGETTO DEFINITIVO

CICLOVIA DEL SOLE

Coordinamento e integrazione delle prestazioni specialistiche:
arch. Enrico Guaitoli Panini

Il Responsabile Unico del Procedimento:
ing. Maurizio Martelli

Progettazione ciclabile e paesaggistica:
arch. Irene Esposito, paes. Giulia Mazzali, arch. Eleonora Vaccari, arch. Michela Gessani, dott. paes. Sara Martignoni, arch. Alberto Coppi

Supporto al RUP:
ing. Chiara Ferrari
arch. Federica Sodano
ing. Sara Destro
dott.ssa Silvia Mazza
arch. Giulia Maroni

Progettazione delle strutture:
prof. ing. Massimo Majowiecki, ing. Giovanni Berti, ing. Monica Mingozzi, ing. Elisa Sammarco, ing. Marco Chinni

Geologia, Ambiente, Idraulica:
geol. Pierluigi Dallari, geol. Arianna Casarini, geol. Lisa Gasparini, geol. Emiliano Quadernari, ing. Yos Zorzi

Coordinamento della sicurezza:
ing. Fausto Gallarello, ing. Roberto Perlangeli

Consolidamento e Mitigazione del Rischio di Dissesto

Marzabotto - Monte Baco - Opera 1

SCALA	FORMATO
-	Varie
CODICE	DATA
GEO_1_1_A	30/11/2023

N. REV.	DATA	DESCRIZIONE	DISEGNATO	CONTROLLATO	APPROVATO
A	*30/11/2023*	*Prima Emissione*	*E.Q.*	*P.D.*	

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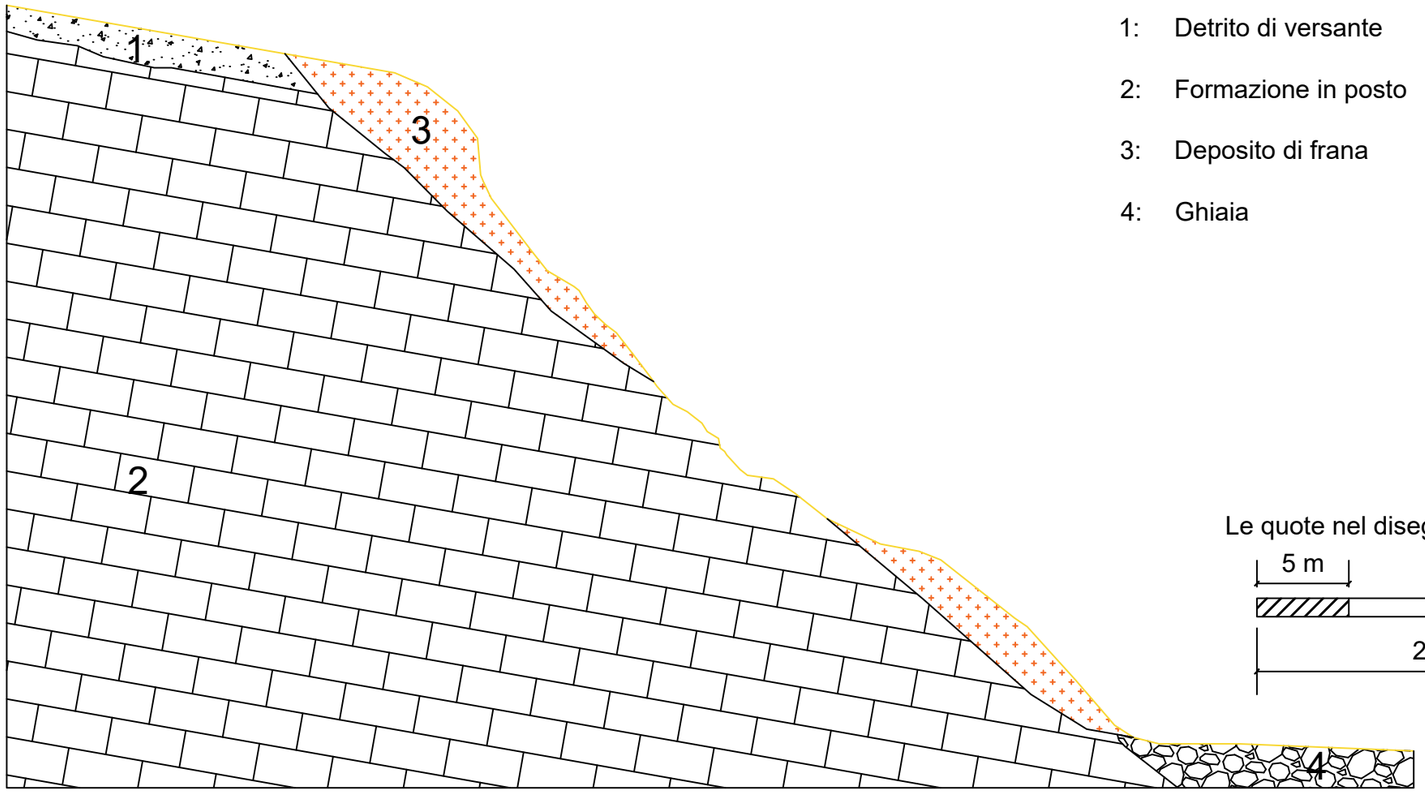
STATO DI FATTO

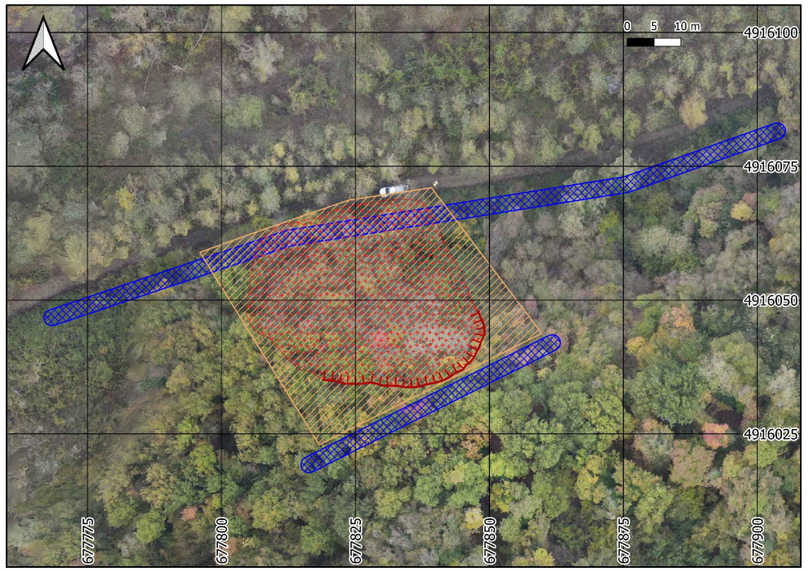


1: Detrito di versante

2: Formazione in posto

3: Deposito di frana

4: Ghiaia



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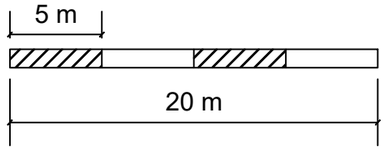
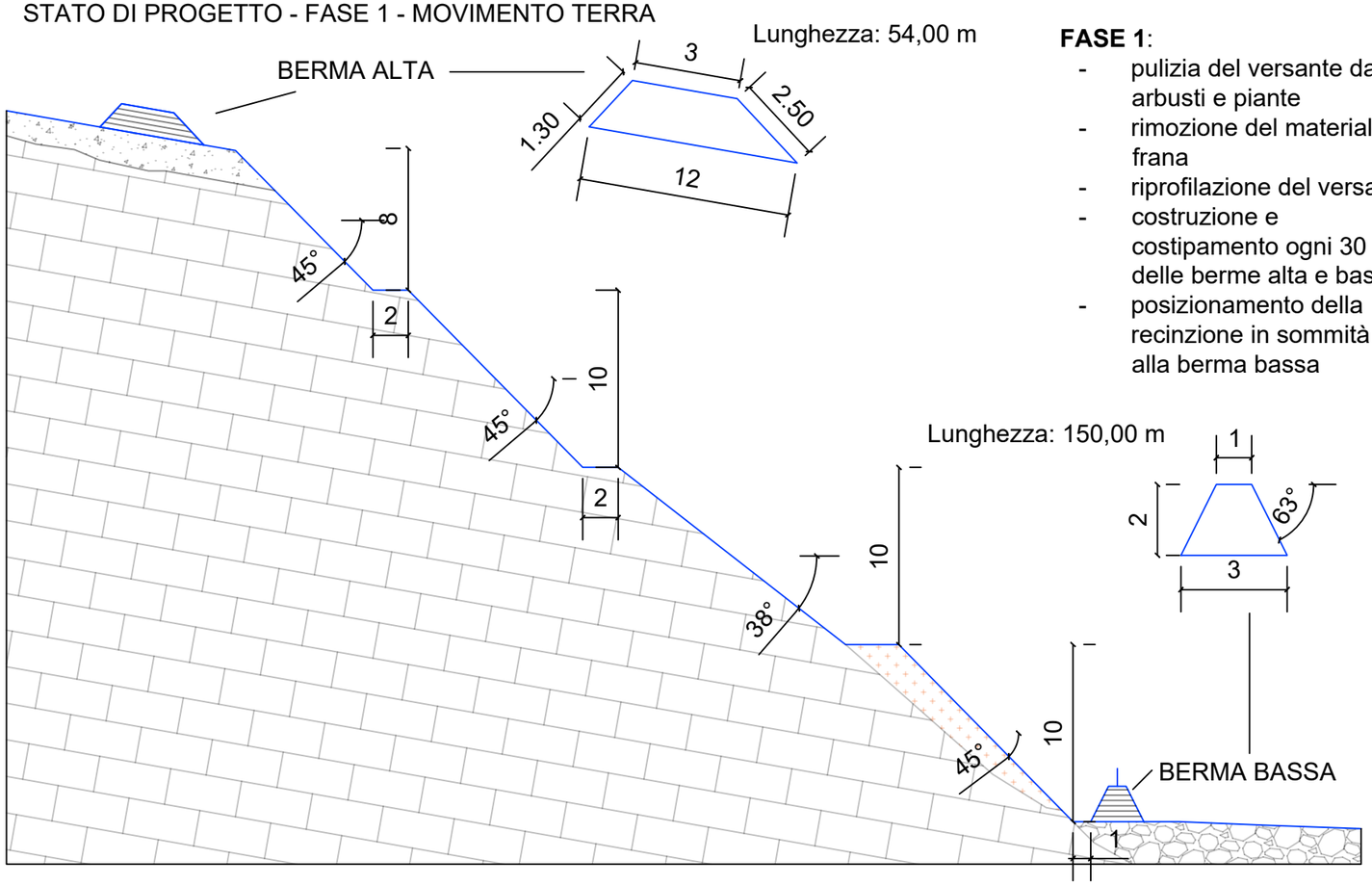


STATO DI PROGETTO - FASE 1 - MOVIMENTO TERRA



FASE 1:

- pulizia del versante da arbusti e piante
- rimozione del materiale in frana
- riprofilazione del versante
- costruzione e costipamento ogni 30 cm delle berme alta e bassa
- posizionamento della recinzione in sommità alla berma bassa

CITTÀ METROPOLITANA DI BOLOGNA

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Ciclovia del Sole: tratto 3 attraversamento dei centri abitati di Crevalcore, San Giovanni in Persiceto, Sala Bolognese - tratto 4: Casalecchio - Marzabotto

CUP n° C61B21013060002

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Coordinamento della sicurezza:
ing. Fausto Gallarello, ing. Roberto Perlangeli

Opera di consolidamento e mitigazione del rischio caduta massi

Marzabotto - Monte Baco - Tavola 1a - Movimento Terra

SCALA	FORMATO
GRAFICA	A3
CODICE	DATA
GEO_1_1_A	30/11/2023

N. REV.	DATA	DESCRIZIONE	DISEGNATO	CONTROLLATO	APPROVATO
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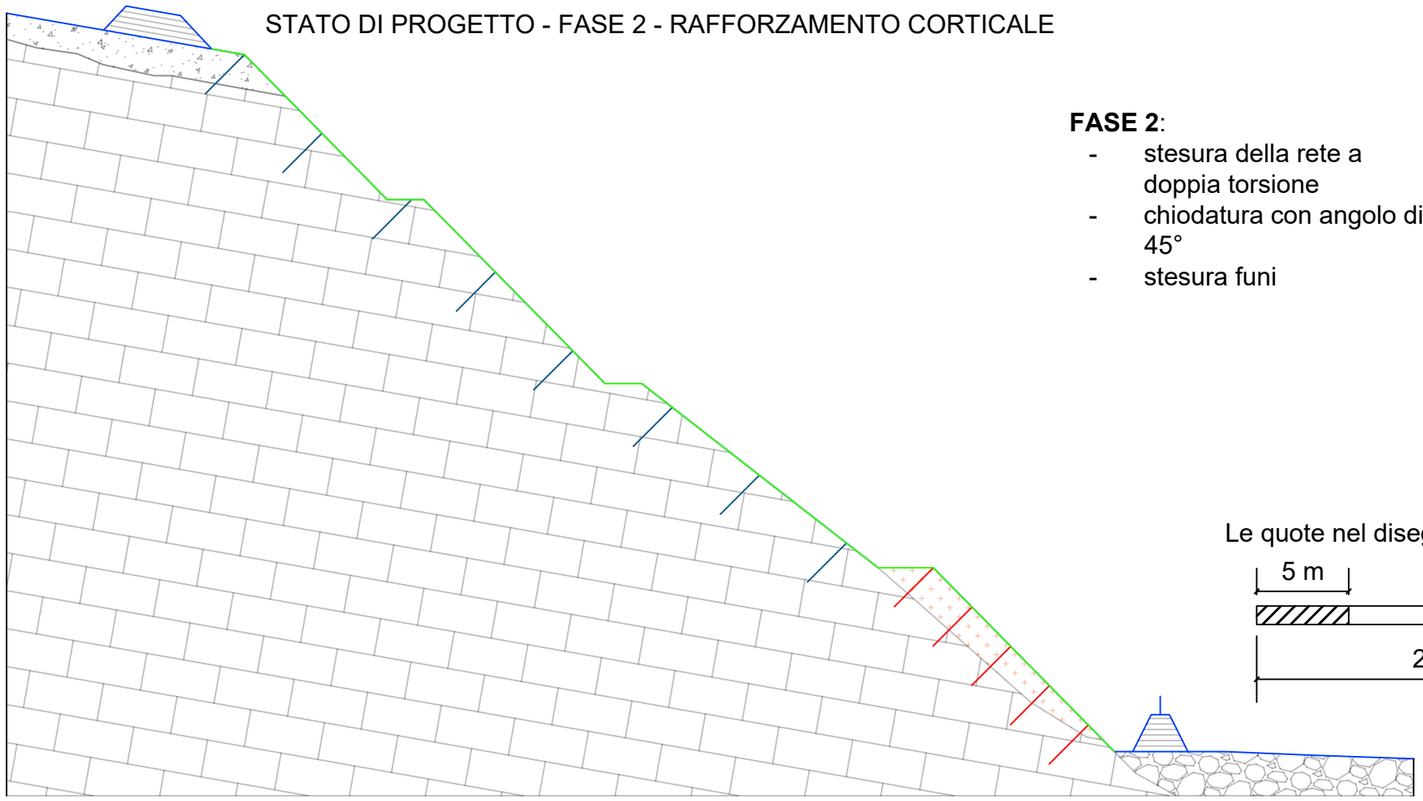
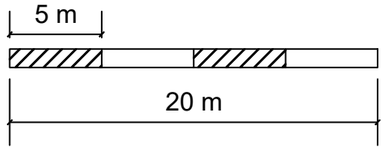
STATO DI PROGETTO - FASE 2 - RAFFORZAMENTO CORTICALE

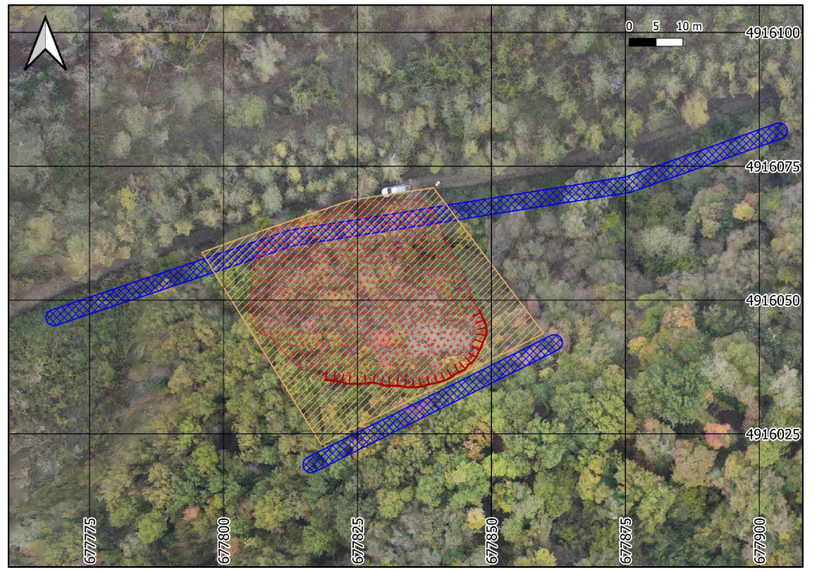


FASE 2:

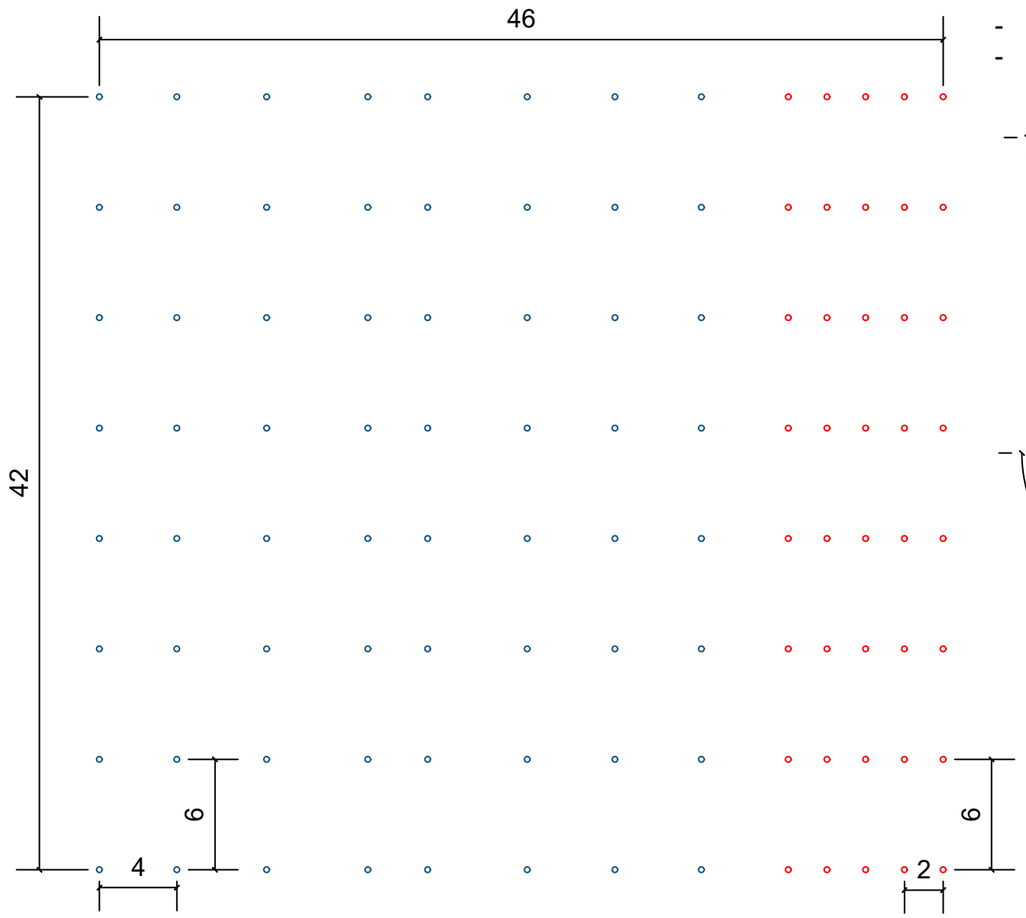
- stesura della rete a doppia torsione
- chiodatura con angolo di 45°
- stesura funi

Le quote nel disegno esprimo metri



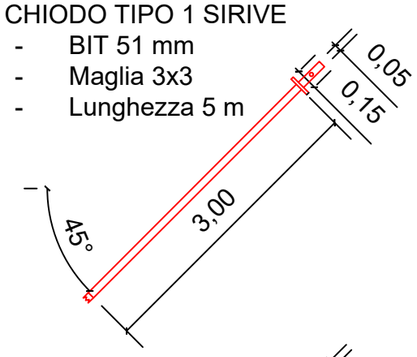


MAGLIA CHIODATURA



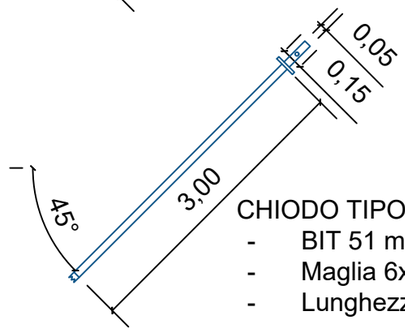
CHIODO TIPO 1 SIRIVE

- BIT 51 mm
- Maglia 3x3
- Lunghezza 5 m



CHIODO TIPO 1B SIRIVE

- BIT 51 mm
- Maglia 6x3
- Lunghezza 3 m



La maglia della chiodatura ha considerato l'angolo d'inclinazione del versante e la gradonatura, la maglia è stata derivata dalla sezione di progetto.

La risultante della maglia 6x3 si presenterà come una 6x2 in appoggio al versante.
La risultante della maglia 6x6 si presenterà come una 6x4 in appoggio al versante.

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CUP n° C61B21013060002

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Opera di consolidamento e mitigazione del rischio caduta massi

Marzabotto - Monte Baco - Tavola 1b - Rafforzamento corticale

SCALA	FORMATO
GRAFICA	A3
CODICE	DATA
GEO_1_1_A	30/11/2023

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Coordinamento della sicurezza:
ing. Fausto Gallarello, ing. Roberto Perlangeli

Consolidamento e Mitigazione del Rischio di Dissesto
Verifiche di Progetto - Analisi Probabilistica Caduta Massi
Marzabotto - Monte Baco - Opera 1

SCALA	FORMATO
-	Varie
CODICE	**DATA**
GEO_1_1_A	30/11/2023

N. REV.	DATA	DESCRIZIONE	DISEGNATO	CONTROLLATO	APPROVATO
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rocscience

GEO 1 1 A - ANALISI CADUTA MASSI

GEO 1 1 A

Geo Group

Date Created: 16/11/2023, 15:51:31

Software Version: 8.024

Table of Contents

GEO 1 1 A - ANALISI CADUTA MASSI

GEO 1 1 A

Project Summary

File Name	GEO 1 1 A - ANALISI CADUTA MASSI
File Version	8.024
Project Title	GEO 1 1 A
Author	Emiliano Quadernari
Company	Geo Group
Date Created	16/11/2023, 15:51:31

Project Settings

General Settings

Engine	Rigid Body
Units	Metric (m, kg, kJ)
Rock throw mode	Number of rocks controlled by seeder
Use tangential CRSP damping	Yes

Engine Conditions

Maximum steps per rock	20000
Normal velocity cutoff (m/s)	0.1
Stopped velocity cutoff (m/s)	0.1
Maximum timestep (s)	0.01
Switch velocity (m/s)	-1e-09

Random Number Generation

Sampling method	Latin-Hypercube
Material Properties Sampling	Per simulation
Random seed	Pseudo-random seed: 12345234

Slope Geometry

Vertex	X	Y	X Std.Dev.	Y Std.Dev.
1	1925.54	1756.77		
2	1931.87	1756.89		
3	1938.2	1758.14		
4	1944.54	1758.91		
5	1950.87	1759.95		
6	1957.2	1762.47		
7	1963.54	1764.32		
8	1969.87	1767.53		
9	1976.2	1771.93		
10	1982.54	1769.67		
11	1988.87	1763.67		
12	1995.2	1761.36		
13	2001.54	1754.15		
14	2007.87	1748.59		
15	2014.2	1743.85		
16	2020.54	1741.36		
17	2026.87	1738.08		
18	2039.54	1728.28		
19	2045.87	1726.75		
20	2071.2	1705.43		
21	2077.54	1702.37		
22	2090.2	1691.42		
23	2096.54	1684.68		
24	2102.87	1682.59		
25	2109.2	1675.15		
26	2109.2	1646.46		
27	2128.2	1639.04		
28	2134.53	1634.88		
29	2147.2	1623.25		
30	2153.53	1616.15		
31	2166.2	1605.83		
32	2172.53	1601.27		
33	2185.2	1593.47		
34	2197.87	1584.35		
35	2204.2	1579.53		
36	2210.53	1576.97		
37	2216.87	1573.77		
38	2223.2	1568.73		
39	2229.53	1566.07		
40	2235.87	1561.74		
41	2242.2	1557.95		
42	2248.53	1554.92		
43	2254.87	1552.21		
44	2261.2	1550.95		
45	2267.53	1548.5		
46	2267.64	1548.48		
47	2284.44	1545.56		

48	2285.73	1546.85
49	2288.6	1544.83
50	2290.39	1544.52
51	2298.15	1536.64
52	2300.15	1536.64
53	2310	1526.64
54	2312	1526.64
55	2324.84	1516.64
56	2327.84	1516.64
57	2337.69	1506.64
58	2339.43	1506.64
59	2340.43	1508.64
60	2341.43	1508.64
61	2342.43	1506.64
62	2344.43	1506.64
63	2349.19	1506.45
64	2353.96	1506.25
65	2359.37	1505.84
66	2375.2	1504.51
67	2381.53	1504.3
68	2387.87	1504.66
69	2397.37	1503.01
70	2413.2	1500.4
71	2432.2	1500.3
72	2438.53	1501.05
73	2444.87	1501.32

Slope Material Assignment

Material	From Vertex	To Vertex
Bedrock Outcrops	1	47
MAN MADE	47	61
Asphalt	61	63
GRAVEL	63	73

Material Properties

Bedrock Outcrops

"Bedrock Outcrops" Properties					
Color					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Normal Restitution	0.32	Normal	0.04	0.12	0.12
Tangential Restitution	0.71	Normal	0.04	0.12	0.12
Dynamic Friction	0.58	Normal	0.04	0.12	0.12
Rolling Friction	0.4	Normal	0.02	0.06	0.06
"Bedrock Outcrops" Advanced Properties					
Forest and Vegetation Damping		Disabled			
Scarring		Disabled			
Viscoplastic Damping		Disabled			

Asphalt

"Asphalt" Properties					
Color					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Normal Restitution	0.4	Normal	0.04	0.12	0.12
Tangential Restitution	0.9	Normal	0.03	0.09	0.09
Dynamic Friction	0.5	Normal	0.04	0.12	0.12
Rolling Friction	0.1	Normal	0.01	0.03	0.03
"Asphalt" Advanced Properties					
Forest and Vegetation Damping		Disabled			
Scarring		Disabled			
Viscoplastic Damping		Disabled			

MAN MADE

"MAN MADE" Properties					
Color					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Normal Restitution	0.3	Uniform		0	0
Tangential Restitution	0.9	Uniform		0	0
Dynamic Friction	0.35	Uniform		0	0
Rolling Friction	0.59	Uniform		0	0

"MAN MADE" Advanced Properties		
Forest and Vegetation Damping	Disabled	
Material Type		Medium
Scarring	Enabled	
Max Dynamic Friction		2.00
Beta		150.00
Kappa		2.00
Viscoplastic Damping	Enabled	
Ground Drag Coefficient(1/m		0.60

GRAVEL

"GRAVEL" Properties					
Color					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Normal Restitution	0.4	None			
Tangential Restitution	0.9	None			
Dynamic Friction	0.55	None			
Rolling Friction	0.1	None			

"GRAVEL" Advanced Properties	
Forest and Vegetation Damping	Disabled
Scarring	Disabled
Viscoplastic Damping	Disabled

Seeders

Seeder 4

Seeder Properties					
Name	Seeder 4				
Location	(2301.02, 1535.75)				
Rocks to Throw					
Number of Rocks	15 Per Rock Type				
Rock Types	VERY SMALL ROCK				
Initial Conditions					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (m/s)	0	None			
Vertical Velocity (m/s)	0	None			
Rotational Velocity (deg/s)	0	None			
Initial Rotation (deg/s)	0	Uniform		0	360

Seeder 5

Seeder Properties					
Name	Seeder 5				
Location	(2312.61, 1526.16)				
Rocks to Throw					
Number of Rocks	5 Per Rock Type				
Rock Types	VERY SMALL ROCK				
Initial Conditions					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (m/s)	0	None			
Vertical Velocity (m/s)	0	None			
Rotational Velocity (deg/s)	0	None			
Initial Rotation (deg/s)	0	Uniform		0	360

Seeder 6

Seeder Properties					
Name	Seeder 6				
Location	(2291.24, 1543.66)				
Rocks to Throw					
Number of Rocks	50 Overall				
Rock Types	VERY SMALL ROCK				
Initial Conditions					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (m/s)	0	None			
Vertical Velocity (m/s)	0	None			
Rotational Velocity (deg/s)	0	None			
Initial Rotation (deg/s)	0	Uniform		0	360

Seeder 7

Seeder Properties					
Name	Seeder 7				
Location	(2109.2, 1675.15)				
Rocks to Throw					
Number of Rocks	15 Per Rock Type				
Rock Types	LARGE ROCK,	SMALL ROCK,	VERY SMALL ROCK		
Initial Conditions					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (m/s)	0	None			
Vertical Velocity (m/s)	0	None			
Rotational Velocity (deg/s)	0	None			
Initial Rotation (deg/s)	0	Uniform		0	360

Seeder 8

Seeder Properties					
Name	Seeder 8				
Location	(2104.63, 1680.52)				
Rocks to Throw					
Number of Rocks	15 Overall				
Rock Types	LARGE ROCK,	SMALL ROCK,	VERY SMALL ROCK		
Initial Conditions					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (m/s)	0	None			
Vertical Velocity (m/s)	0	None			
Rotational Velocity (deg/s)	0	None			
Initial Rotation (deg/s)	0	Uniform		0	360

Seeder 9

Seeder Properties					
Name	Seeder 9				
Location	(2109.2, 1661.1)				
Rocks to Throw					
Number of Rocks	15 Per Rock Type				
Rock Types	LARGE ROCK,	SMALL ROCK,	VERY SMALL ROCK		
Initial Conditions					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (m/s)	0	None			
Vertical Velocity (m/s)	0	None			
Rotational Velocity (deg/s)	0	None			
Initial Rotation (deg/s)	0	Uniform		0	360

Seeder 10

Seeder Properties					
Name	Seeder 10				
Location	(1985.9, 1766.47)				
Rocks to Throw					
Number of Rocks	30 Per Rock Type				
Rock Types	LARGE ROCK,	SMALL ROCK			
Initial Conditions					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (m/s)	0	None			
Vertical Velocity (m/s)	0	None			
Rotational Velocity (deg/s)	0	None			
Initial Rotation (deg/s)	0	Uniform		0	360

Seeder 11

Seeder Properties					
Name	Seeder 11				
Location	(2045.87, 1726.75)				
Rocks to Throw					
Number of Rocks	15 Per Rock Type				
Rock Types	LARGE ROCK,	SMALL ROCK,	VERY SMALL ROCK		
Initial Conditions					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (m/s)	0	None			
Vertical Velocity (m/s)	0	None			
Rotational Velocity (deg/s)	0	None			
Initial Rotation (deg/s)	0	Uniform		0	360

Seeder 1

Seeder Properties					
Name	Seeder 1				
Location	(1995.2, 1761.36), (2001.54, 1754.15), (2007.87, 1748.59), (2014.2, 1743.85)				
Rocks to Throw					
Number of Rocks	20 Per Rock Type				
Rock Types	SMALL ROCK, VERY SMALL ROCK				
Initial Conditions					
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Horizontal Velocity (m/s)	0	None			
Vertical Velocity (m/s)	0	None			
Rotational Velocity (deg/s)	0	None			
Initial Rotation (deg/s)	0	Uniform		0	360

Rock Types

LARGE ROCK

Properties					
Name	LARGE ROCK				
Color					
Smooth Shapes	Sphere				
Polygons	Polygon Triangle, Polygon Square, Polygon Pentagon, Polygon Hexagon, Polygon Octagon				
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (kg)	66420	None			
Density (kg/m3)	2460	None			

SMALL ROCK

Properties					
Name	SMALL ROCK				
Color					
Smooth Shapes	Sphere				
Polygons	Polygon Triangle, Polygon Square, Polygon Pentagon, Polygon Hexagon, Polygon Octagon				
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (kg)	307.5	None			
Density (kg/m3)	2460	None			

VERY SMALL ROCK

Properties					
Name	VERY SMALL ROCK				
Color					
Smooth Shapes	Sphere				
Polygons	Polygon Triangle, Polygon Square, Polygon Pentagon, Polygon Hexagon, Polygon Octagon				
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (kg)	16.9	None			
Density (kg/m3)	2460	None			

Barriers

Barrier 1	
Name	Barrier 1
Type	Fence
Model	Custom
Capacity	15.00kJ
Location	(2340.91, 1508.64) to (2340.91, 1510.14)
Length (m)	1.5
Sensitivity Barrier	False

Summary Results

Run Properties			
Simulation Time (s)	1101.87		
Envelope data:			
	Max	Mean	95%
Envelope Bounce Height (m)	37.03	20.42	32.86
Envelope Total Kinetic Energy (kJ)	2.217e+04	8737	2.217e+04
Envelope Translational Kinetic Energy (kJ)	2.146e+04	7740	2.146e+04
Envelope Rotational Kinetic Energy (kJ)	2143	997.2	2143
Envelope Translational Kinetic Velocity (m/s)	27.17	15.27	27.17
Envelope Rotational Kinetic Velocity (rad/s)	107.6	63.21	107.6

Stopping Reason	
CONTINUE	0
Invalid Start Location	0
Invalid Slope Geometry	0
Invalid bad crest loss definition	0
Invalid relative size between rock and slope	0
Max Steps	57
Edge Model	0
Stopped	232
Stopped (wedged)	0
Stopped (chattering)	0
Hit Barrier	0
Hit Berm with infinite capacity	0
No collision found	1
Bad Collision Geometry (location before)	30
Rock is freefalling onto a spike or a trough	0
END_ERROR_UNKNOWN	0
END_ERROR_POSITIVE_GAP	0
Bad collision calculation	0
Bad Collision Geometry (0 intersection)	0
Bad Collision Geometry (location after)	0
Bad Collision Geometry (missing intersection)	0
Error during results reading	0
Total Rocks	320

Generated Path Details

Run ID	Rock Type	Shape	X (m)	Y (m)	Rotation (deg)	VX (m/s)	VY (m/s)	VR (deg/s)
0	VERY SMALL ROCK	Sphere	2301	1536	30.25	0	0	0
1	VERY SMALL ROCK	Polygon Triangle	2301	1536	161.3	0	0	0
2	VERY SMALL ROCK	Polygon Square	2301	1536	192	0	0	0
3	VERY SMALL ROCK	Polygon Pentagon	2301	1536	109.4	0	0	0
4	VERY SMALL ROCK	Polygon Hexagon	2301	1536	217.3	0	0	0
5	VERY SMALL ROCK	Polygon Octagon	2301	1536	291.1	0	0	0
6	VERY SMALL ROCK	Sphere	2301	1536	270.8	0	0	0
7	VERY SMALL ROCK	Polygon Triangle	2301	1536	331.4	0	0	0
8	VERY SMALL ROCK	Polygon Square	2301	1536	89.89	0	0	0
9	VERY SMALL ROCK	Polygon Pentagon	2301	1536	204.7	0	0	0
10	VERY SMALL ROCK	Polygon Hexagon	2301	1536	240.6	0	0	0
11	VERY SMALL ROCK	Polygon Octagon	2301	1536	135.8	0	0	0
12	VERY SMALL ROCK	Sphere	2301	1536	343.8	0	0	0
13	VERY SMALL ROCK	Polygon Triangle	2301	1536	54.67	0	0	0
14	VERY SMALL ROCK	Polygon Square	2301	1536	7.133	0	0	0
15	VERY SMALL ROCK	Sphere	2313	1526	324.8	0	0	0

16	VERY SMALL ROCK	Polygon Triangle	2313	1526	64.8	0	0	0
17	VERY SMALL ROCK	Polygon Square	2313	1526	144.2	0	0	0
18	VERY SMALL ROCK	Polygon Pentagon	2313	1526	254.2	0	0	0
19	VERY SMALL ROCK	Polygon Hexagon	2313	1526	102.5	0	0	0
20	VERY SMALL ROCK	Sphere	2291	1544	305.2	0	0	0
21	VERY SMALL ROCK	Polygon Triangle	2291	1544	69.11	0	0	0
22	VERY SMALL ROCK	Polygon Square	2291	1544	329.2	0	0	0
23	VERY SMALL ROCK	Polygon Pentagon	2291	1544	91.42	0	0	0
24	VERY SMALL ROCK	Polygon Hexagon	2291	1544	123.4	0	0	0
25	VERY SMALL ROCK	Polygon Octagon	2291	1544	228.8	0	0	0
26	VERY SMALL ROCK	Sphere	2291	1544	172.5	0	0	0
27	VERY SMALL ROCK	Polygon Triangle	2291	1544	112.7	0	0	0
28	VERY SMALL ROCK	Polygon Square	2291	1544	289.7	0	0	0
29	VERY SMALL ROCK	Polygon Pentagon	2291	1544	309.7	0	0	0
30	VERY SMALL ROCK	Polygon Hexagon	2291	1544	209.6	0	0	0
31	VERY SMALL ROCK	Polygon Octagon	2291	1544	46.81	0	0	0
32	VERY SMALL ROCK	Sphere	2291	1544	93.65	0	0	0
33	VERY SMALL ROCK	Polygon Triangle	2291	1544	7.855	0	0	0
34	VERY SMALL ROCK	Polygon Square	2291	1544	180.6	0	0	0

35	VERY SMALL ROCK	Polygon Pentagon	2291	1544	201.5	0	0	0
36	VERY SMALL ROCK	Polygon Hexagon	2291	1544	77.17	0	0	0
37	VERY SMALL ROCK	Polygon Octagon	2291	1544	246.4	0	0	0
38	VERY SMALL ROCK	Sphere	2291	1544	322.1	0	0	0
39	VERY SMALL ROCK	Polygon Triangle	2291	1544	159.2	0	0	0
40	VERY SMALL ROCK	Polygon Square	2291	1544	176.3	0	0	0
41	VERY SMALL ROCK	Polygon Pentagon	2291	1544	331.8	0	0	0
42	VERY SMALL ROCK	Polygon Hexagon	2291	1544	121.3	0	0	0
43	VERY SMALL ROCK	Polygon Octagon	2291	1544	237.2	0	0	0
44	VERY SMALL ROCK	Sphere	2291	1544	260.9	0	0	0

Run ID	Rock Type	Shape	X (m)	Y (m)	Rotation (deg)	VX (m/s)	VY (m/s)	VR (deg/s)
45	VERY SMALL ROCK	Polygon Triangle	2291	1544	252.6	0	0	0
46	VERY SMALL ROCK	Polygon Square	2291	1544	53.44	0	0	0
47	VERY SMALL ROCK	Polygon Pentagon	2291	1544	287.2	0	0	0
48	VERY SMALL ROCK	Polygon Hexagon	2291	1544	156.5	0	0	0
49	VERY SMALL ROCK	Polygon Octagon	2291	1544	5.365	0	0	0
50	VERY SMALL ROCK	Sphere	2291	1544	138.5	0	0	0
51	VERY SMALL ROCK	Polygon Triangle	2291	1544	82.03	0	0	0
52	VERY SMALL ROCK	Polygon Square	2291	1544	354.7	0	0	0
53	VERY SMALL ROCK	Polygon Pentagon	2291	1544	18.57	0	0	0
54	VERY SMALL ROCK	Polygon Hexagon	2291	1544	145.2	0	0	0
55	VERY SMALL ROCK	Polygon Octagon	2291	1544	274.2	0	0	0
56	VERY SMALL ROCK	Sphere	2291	1544	218.1	0	0	0
57	VERY SMALL ROCK	Polygon Triangle	2291	1544	266.5	0	0	0
58	VERY SMALL ROCK	Polygon Square	2291	1544	102.9	0	0	0
59	VERY SMALL ROCK	Polygon Pentagon	2291	1544	296.1	0	0	0
60	VERY SMALL ROCK	Polygon Hexagon	2291	1544	206.1	0	0	0
61	VERY SMALL ROCK	Polygon Octagon	2291	1544	339.7	0	0	0
62	VERY SMALL ROCK	Sphere	2291	1544	62.21	0	0	0

63	VERY SMALL ROCK	Polygon Triangle	2291	1544	350.4	0	0	0
64	VERY SMALL ROCK	Polygon Square	2291	1544	43.15	0	0	0
65	VERY SMALL ROCK	Polygon Pentagon	2291	1544	238.6	0	0	0
66	VERY SMALL ROCK	Polygon Hexagon	2291	1544	29.48	0	0	0
67	VERY SMALL ROCK	Polygon Octagon	2291	1544	25.28	0	0	0
68	VERY SMALL ROCK	Sphere	2291	1544	136.1	0	0	0
69	VERY SMALL ROCK	Polygon Triangle	2291	1544	194.1	0	0	0
70	LARGE ROCK	Sphere	2111	1676	141.6	0	0	0
71	LARGE ROCK	Polygon Triangle	2111	1677	355	0	0	0
72	LARGE ROCK	Polygon Square	2111	1676	217.3	0	0	0
73	LARGE ROCK	Polygon Pentagon	2111	1676	158.3	0	0	0
74	LARGE ROCK	Polygon Hexagon	2110	1676	77.21	0	0	0
75	LARGE ROCK	Polygon Octagon	2110	1676	283.1	0	0	0
76	LARGE ROCK	Sphere	2111	1676	253.9	0	0	0
77	LARGE ROCK	Polygon Triangle	2111	1677	117.7	0	0	0
78	LARGE ROCK	Polygon Square	2110	1676	180.2	0	0	0
79	LARGE ROCK	Polygon Pentagon	2111	1676	341	0	0	0
80	LARGE ROCK	Polygon Hexagon	2111	1676	147.4	0	0	0
81	LARGE ROCK	Polygon Octagon	2110	1676	244.1	0	0	0
82	LARGE ROCK	Sphere	2111	1676	62.77	0	0	0
83	LARGE ROCK	Polygon Triangle	2111	1677	210.6	0	0	0
84	LARGE ROCK	Polygon Square	2111	1676	8.235	0	0	0
85	SMALL ROCK	Sphere	2109	1675	261.1	0	0	0
86	SMALL ROCK	Polygon Triangle	2109	1675	124.2	0	0	0

87	SMALL ROCK	Polygon Square	2109	1675	332.6	0	0	0
88	SMALL ROCK	Polygon Pentagon	2109	1675	344.9	0	0	0
89	SMALL ROCK	Polygon Hexagon	2109	1675	321.2	0	0	0

Run ID	Rock Type	Shape	X (m)	Y (m)	Rotation (deg)	VX (m/s)	VY (m/s)	VR (deg/s)
90	SMALL ROCK	Polygon Octagon	2109	1675	188.7	0	0	0
91	SMALL ROCK	Sphere	2109	1675	130	0	0	0
92	SMALL ROCK	Polygon Triangle	2109	1675	293.1	0	0	0
93	SMALL ROCK	Polygon Square	2109	1675	80.34	0	0	0
94	SMALL ROCK	Polygon Pentagon	2109	1675	163.6	0	0	0
95	SMALL ROCK	Polygon Hexagon	2109	1675	16.67	0	0	0
96	SMALL ROCK	Polygon Octagon	2109	1675	66.69	0	0	0
97	SMALL ROCK	Sphere	2109	1675	315.8	0	0	0
98	SMALL ROCK	Polygon Triangle	2110	1675	107.5	0	0	0
99	SMALL ROCK	Polygon Square	2109	1675	205.6	0	0	0
100	VERY SMALL ROCK	Sphere	2109	1675	278.2	0	0	0
101	VERY SMALL ROCK	Polygon Triangle	2109	1675	45.94	0	0	0
102	VERY SMALL ROCK	Polygon Square	2109	1675	227.9	0	0	0
103	VERY SMALL ROCK	Polygon Pentagon	2109	1675	304	0	0	0
104	VERY SMALL ROCK	Polygon Hexagon	2109	1675	90.22	0	0	0
105	VERY SMALL ROCK	Polygon Octagon	2109	1675	52.98	0	0	0
106	VERY SMALL ROCK	Sphere	2109	1675	24.21	0	0	0
107	VERY SMALL ROCK	Polygon Triangle	2109	1675	7.03	0	0	0
108	VERY SMALL ROCK	Polygon Square	2109	1675	195	0	0	0
109	VERY SMALL ROCK	Polygon Pentagon	2109	1675	173.3	0	0	0
110	VERY SMALL ROCK	Polygon Hexagon	2109	1675	36.09	0	0	0

111	VERY SMALL ROCK	Polygon Octagon	2109	1675	100.6	0	0	0
112	VERY SMALL ROCK	Sphere	2109	1675	270.1	0	0	0
113	VERY SMALL ROCK	Polygon Triangle	2109	1675	236.9	0	0	0
114	VERY SMALL ROCK	Polygon Square	2109	1675	305.6	0	0	0
115	LARGE ROCK	Sphere	2106	1682	38.45	0	0	0
116	LARGE ROCK	Polygon Triangle	2106	1682	78.04	0	0	0
117	LARGE ROCK	Polygon Square	2106	1682	71.65	0	0	0
118	LARGE ROCK	Polygon Pentagon	2106	1682	311.4	0	0	0
119	LARGE ROCK	Polygon Hexagon	2106	1682	182	0	0	0
120	SMALL ROCK	Sphere	2105	1681	112.1	0	0	0
121	SMALL ROCK	Polygon Triangle	2105	1681	347.3	0	0	0
122	SMALL ROCK	Polygon Square	2105	1681	244.9	0	0	0
123	SMALL ROCK	Polygon Pentagon	2105	1681	277.9	0	0	0
124	SMALL ROCK	Polygon Hexagon	2105	1681	21.26	0	0	0
125	VERY SMALL ROCK	Sphere	2105	1681	147.8	0	0	0
126	VERY SMALL ROCK	Polygon Triangle	2105	1681	194.5	0	0	0
127	VERY SMALL ROCK	Polygon Square	2105	1681	321	0	0	0
128	VERY SMALL ROCK	Polygon Pentagon	2105	1681	140.6	0	0	0
129	VERY SMALL ROCK	Polygon Hexagon	2105	1681	224.1	0	0	0
130	LARGE ROCK	Sphere	2111	1661	54.03	0	0	0
131	LARGE ROCK	Polygon Triangle	2111	1661	213.5	0	0	0
132	LARGE ROCK	Polygon Square	2111	1661	153.1	0	0	0
133	LARGE ROCK	Polygon Pentagon	2111	1661	34.61	0	0	0

134	LARGE ROCK	Polygon Hexagon	2111	1661	85.51	0	0	0

Run ID	Rock Type	Shape	X (m)	Y (m)	Rotation (deg)	VX (m/s)	VY (m/s)	VR (deg/s)
135	LARGE ROCK	Polygon Octagon	2111	1661	78.83	0	0	0
136	LARGE ROCK	Sphere	2111	1661	28.04	0	0	0
137	LARGE ROCK	Polygon Triangle	2112	1661	66.82	0	0	0
138	LARGE ROCK	Polygon Square	2111	1661	344.6	0	0	0
139	LARGE ROCK	Polygon Pentagon	2111	1661	279.5	0	0	0
140	LARGE ROCK	Polygon Hexagon	2111	1661	5.764	0	0	0
141	LARGE ROCK	Polygon Octagon	2111	1661	63.38	0	0	0
142	LARGE ROCK	Sphere	2111	1661	334.6	0	0	0
143	LARGE ROCK	Polygon Triangle	2112	1661	193.1	0	0	0
144	LARGE ROCK	Polygon Square	2111	1661	173.3	0	0	0
145	SMALL ROCK	Sphere	2110	1661	325.5	0	0	0
146	SMALL ROCK	Polygon Triangle	2109	1661	250.8	0	0	0
147	SMALL ROCK	Polygon Square	2110	1661	160.7	0	0	0
148	SMALL ROCK	Polygon Pentagon	2109	1661	201	0	0	0
149	SMALL ROCK	Polygon Hexagon	2109	1661	16.26	0	0	0
150	SMALL ROCK	Polygon Octagon	2109	1661	342.7	0	0	0
151	SMALL ROCK	Sphere	2110	1661	108	0	0	0
152	SMALL ROCK	Polygon Triangle	2110	1661	314.1	0	0	0
153	SMALL ROCK	Polygon Square	2110	1661	244.5	0	0	0
154	SMALL ROCK	Polygon Pentagon	2110	1661	184	0	0	0
155	SMALL ROCK	Polygon Hexagon	2109	1661	119.1	0	0	0
156	SMALL ROCK	Polygon Octagon	2109	1661	92.33	0	0	0
157	SMALL ROCK	Sphere	2110	1661	310.9	0	0	0
158	SMALL ROCK	Polygon Triangle	2110	1661	262.3	0	0	0
159	SMALL ROCK	Polygon Square	2110	1661	355	0	0	0
160	VERY SMALL ROCK	Sphere	2109	1661	142.9	0	0	0

161	VERY SMALL ROCK	Polygon Triangle	2109	1661	227.3	0	0	0
162	VERY SMALL ROCK	Polygon Square	2109	1661	15.72	0	0	0
163	VERY SMALL ROCK	Polygon Pentagon	2109	1661	282.6	0	0	0
164	VERY SMALL ROCK	Polygon Hexagon	2109	1661	223.5	0	0	0
165	VERY SMALL ROCK	Polygon Octagon	2109	1661	131.5	0	0	0
166	VERY SMALL ROCK	Sphere	2109	1661	180.4	0	0	0
167	VERY SMALL ROCK	Polygon Triangle	2109	1661	98.3	0	0	0
168	VERY SMALL ROCK	Polygon Square	2109	1661	236	0	0	0
169	VERY SMALL ROCK	Polygon Pentagon	2109	1661	290.9	0	0	0
170	VERY SMALL ROCK	Polygon Hexagon	2109	1661	127.9	0	0	0
171	VERY SMALL ROCK	Polygon Octagon	2109	1661	46.75	0	0	0
172	VERY SMALL ROCK	Sphere	2109	1661	296.4	0	0	0
173	VERY SMALL ROCK	Polygon Triangle	2109	1661	267.6	0	0	0
174	VERY SMALL ROCK	Polygon Square	2109	1661	149.3	0	0	0
175	LARGE ROCK	Sphere	1987	1768	97.82	0	0	0
176	LARGE ROCK	Polygon Triangle	1988	1768	346.3	0	0	0
177	LARGE ROCK	Polygon Square	1987	1768	257.5	0	0	0
178	LARGE ROCK	Polygon Pentagon	1987	1768	177.1	0	0	0
179	LARGE ROCK	Polygon Hexagon	1987	1768	24.84	0	0	0

Run ID	Rock Type	Shape	X (m)	Y (m)	Rotation (deg)	VX (m/s)	VY (m/s)	VR (deg/s)
180	LARGE ROCK	Polygon Octagon	1987	1768	144.6	0	0	0
181	LARGE ROCK	Sphere	1987	1768	116.4	0	0	0
182	LARGE ROCK	Polygon Triangle	1987	1768	313.2	0	0	0
183	LARGE ROCK	Polygon Square	1987	1768	282.3	0	0	0
184	LARGE ROCK	Polygon Pentagon	1987	1768	9.952	0	0	0
185	LARGE ROCK	Polygon Hexagon	1987	1768	212.7	0	0	0
186	LARGE ROCK	Polygon Octagon	1987	1768	109.2	0	0	0
187	LARGE ROCK	Sphere	1987	1768	81.17	0	0	0
188	LARGE ROCK	Polygon Triangle	1988	1768	1.183	0	0	0
189	LARGE ROCK	Polygon Square	1987	1768	105.5	0	0	0
190	LARGE ROCK	Polygon Pentagon	1987	1768	328.4	0	0	0
191	LARGE ROCK	Polygon Hexagon	1987	1768	63.61	0	0	0
192	LARGE ROCK	Polygon Octagon	1987	1768	151.8	0	0	0
193	LARGE ROCK	Sphere	1987	1768	279.8	0	0	0
194	LARGE ROCK	Polygon Triangle	1987	1768	202.2	0	0	0
195	LARGE ROCK	Polygon Square	1987	1768	307.8	0	0	0
196	LARGE ROCK	Polygon Pentagon	1987	1768	304.9	0	0	0
197	LARGE ROCK	Polygon Hexagon	1987	1768	241.4	0	0	0
198	LARGE ROCK	Polygon Octagon	1987	1768	166	0	0	0
199	LARGE ROCK	Sphere	1987	1768	358.9	0	0	0
200	LARGE ROCK	Polygon Triangle	1987	1768	131	0	0	0
201	LARGE ROCK	Polygon Square	1987	1768	207.5	0	0	0
202	LARGE ROCK	Polygon Pentagon	1987	1768	125.6	0	0	0
203	LARGE ROCK	Polygon Hexagon	1987	1768	158.4	0	0	0
204	LARGE ROCK	Polygon Octagon	1987	1768	94.25	0	0	0
205	SMALL ROCK	Sphere	1986	1767	173.4	0	0	0

206	SMALL ROCK	Polygon Triangle	1986	1767	293	0	0	0
207	SMALL ROCK	Polygon Square	1986	1767	331.6	0	0	0
208	SMALL ROCK	Polygon Pentagon	1986	1767	40.82	0	0	0
209	SMALL ROCK	Polygon Hexagon	1986	1767	143.3	0	0	0
210	SMALL ROCK	Polygon Octagon	1986	1767	269.3	0	0	0
211	SMALL ROCK	Sphere	1986	1767	193.5	0	0	0
212	SMALL ROCK	Polygon Triangle	1986	1767	43.18	0	0	0
213	SMALL ROCK	Polygon Square	1986	1767	296.7	0	0	0
214	SMALL ROCK	Polygon Pentagon	1986	1767	86.86	0	0	0
215	SMALL ROCK	Polygon Hexagon	1986	1767	233.5	0	0	0
216	SMALL ROCK	Polygon Octagon	1986	1767	338.4	0	0	0
217	SMALL ROCK	Sphere	1986	1767	186.3	0	0	0
218	SMALL ROCK	Polygon Triangle	1986	1767	16.21	0	0	0
219	SMALL ROCK	Polygon Square	1986	1767	249.9	0	0	0
220	SMALL ROCK	Polygon Pentagon	1986	1767	49.55	0	0	0
221	SMALL ROCK	Polygon Hexagon	1986	1767	223.3	0	0	0
222	SMALL ROCK	Polygon Octagon	1986	1767	31.57	0	0	0
223	SMALL ROCK	Sphere	1986	1767	66.56	0	0	0
224	SMALL ROCK	Polygon Triangle	1986	1767	236.6	0	0	0

Run ID	Rock Type	Shape	X (m)	Y (m)	Rotation (deg)	VX (m/s)	VY (m/s)	VR (deg/s)
225	SMALL ROCK	Polygon Square	1986	1767	216.2	0	0	0
226	SMALL ROCK	Polygon Pentagon	1986	1767	185.4	0	0	0
227	SMALL ROCK	Polygon Hexagon	1986	1767	23.3	0	0	0
228	SMALL ROCK	Polygon Octagon	1986	1767	77.34	0	0	0
229	SMALL ROCK	Sphere	1986	1767	258.4	0	0	0
230	SMALL ROCK	Polygon Triangle	1986	1767	134.5	0	0	0
231	SMALL ROCK	Polygon Square	1986	1767	350.3	0	0	0
232	SMALL ROCK	Polygon Pentagon	1986	1767	59.96	0	0	0
233	SMALL ROCK	Polygon Hexagon	1986	1767	321.2	0	0	0
234	SMALL ROCK	Polygon Octagon	1986	1767	274.3	0	0	0
235	LARGE ROCK	Sphere	2046	1729	14.56	0	0	0
236	LARGE ROCK	Polygon Triangle	2046	1729	222.1	0	0	0
237	LARGE ROCK	Polygon Square	2046	1728	309.7	0	0	0
238	LARGE ROCK	Polygon Pentagon	2046	1728	19.22	0	0	0
239	LARGE ROCK	Polygon Hexagon	2046	1728	254.2	0	0	0
240	LARGE ROCK	Polygon Octagon	2046	1728	96.98	0	0	0
241	LARGE ROCK	Sphere	2046	1729	234.4	0	0	0
242	LARGE ROCK	Polygon Triangle	2046	1729	54.91	0	0	0
243	LARGE ROCK	Polygon Square	2046	1729	271.3	0	0	0
244	LARGE ROCK	Polygon Pentagon	2046	1728	0.9651	0	0	0
245	LARGE ROCK	Polygon Hexagon	2046	1728	127.7	0	0	0
246	LARGE ROCK	Polygon Octagon	2046	1728	321.3	0	0	0
247	LARGE ROCK	Sphere	2046	1729	87.56	0	0	0
248	LARGE ROCK	Polygon Triangle	2046	1729	352.4	0	0	0
249	LARGE ROCK	Polygon Square	2046	1729	336.8	0	0	0
250	SMALL ROCK	Sphere	2046	1727	130.4	0	0	0

251	SMALL ROCK	Polygon Triangle	2046	1727	211.5	0	0	0
252	SMALL ROCK	Polygon Square	2046	1727	245.9	0	0	0
253	SMALL ROCK	Polygon Pentagon	2046	1727	171.7	0	0	0
254	SMALL ROCK	Polygon Hexagon	2046	1727	190.2	0	0	0
255	SMALL ROCK	Polygon Octagon	2046	1727	296.1	0	0	0
256	SMALL ROCK	Sphere	2046	1727	280.6	0	0	0
257	SMALL ROCK	Polygon Triangle	2046	1727	194.6	0	0	0
258	SMALL ROCK	Polygon Square	2046	1727	61.5	0	0	0
259	SMALL ROCK	Polygon Pentagon	2046	1727	77.41	0	0	0
260	SMALL ROCK	Polygon Hexagon	2046	1727	90.57	0	0	0
261	SMALL ROCK	Polygon Octagon	2046	1727	318.4	0	0	0
262	SMALL ROCK	Sphere	2046	1727	179.3	0	0	0
263	SMALL ROCK	Polygon Triangle	2046	1727	335.7	0	0	0
264	SMALL ROCK	Polygon Square	2046	1727	119.5	0	0	0
265	VERY SMALL ROCK	Sphere	2046	1727	34.1	0	0	0
266	VERY SMALL ROCK	Polygon Triangle	2046	1727	278.1	0	0	0
267	VERY SMALL ROCK	Polygon Square	2046	1727	161.6	0	0	0
268	VERY SMALL ROCK	Polygon Pentagon	2046	1727	68.21	0	0	0
269	VERY SMALL ROCK	Polygon Hexagon	2046	1727	111.9	0	0	0

Run ID	Rock Type	Shape	X (m)	Y (m)	Rotation (deg)	VX (m/s)	VY (m/s)	VR (deg/s)
270	VERY SMALL ROCK	Polygon Octagon	2046	1727	345.1	0	0	0
271	VERY SMALL ROCK	Sphere	2046	1727	203.2	0	0	0
272	VERY SMALL ROCK	Polygon Triangle	2046	1727	144.6	0	0	0
273	VERY SMALL ROCK	Polygon Square	2046	1727	260.7	0	0	0
274	VERY SMALL ROCK	Polygon Pentagon	2046	1727	26.25	0	0	0
275	VERY SMALL ROCK	Polygon Hexagon	2046	1727	295.7	0	0	0
276	VERY SMALL ROCK	Polygon Octagon	2046	1727	139.2	0	0	0
277	VERY SMALL ROCK	Sphere	2046	1727	43.78	0	0	0
278	VERY SMALL ROCK	Polygon Triangle	2046	1727	227.2	0	0	0
279	VERY SMALL ROCK	Polygon Square	2046	1727	157	0	0	0
280	SMALL ROCK	Sphere	2011	1747	342.2	0	0	0
281	SMALL ROCK	Polygon Triangle	2003	1754	127.3	0	0	0
282	SMALL ROCK	Polygon Square	2004	1752	203.7	0	0	0
283	SMALL ROCK	Polygon Pentagon	1997	1760	190.2	0	0	0
284	SMALL ROCK	Polygon Hexagon	2000	1757	83.83	0	0	0
285	SMALL ROCK	Polygon Octagon	2013	1745	63.5	0	0	0
286	SMALL ROCK	Sphere	2011	1746	26.37	0	0	0
287	SMALL ROCK	Polygon Triangle	2004	1753	123.8	0	0	0
288	SMALL ROCK	Polygon Square	2006	1751	224.1	0	0	0
289	SMALL ROCK	Polygon Pentagon	1997	1759	111.6	0	0	0
290	SMALL ROCK	Polygon Hexagon	2012	1746	183.4	0	0	0

291	SMALL ROCK	Polygon Octagon	2000	1756	174.6	0	0	0
292	SMALL ROCK	Sphere	1999	1758	148.5	0	0	0
293	SMALL ROCK	Polygon Triangle	2013	1745	44.27	0	0	0
294	SMALL ROCK	Polygon Square	2007	1750	163.7	0	0	0
295	SMALL ROCK	Polygon Pentagon	2007	1750	327.4	0	0	0
296	SMALL ROCK	Polygon Hexagon	2008	1749	105	0	0	0
297	SMALL ROCK	Polygon Octagon	1999	1757	256.8	0	0	0
298	SMALL ROCK	Sphere	2010	1748	306.1	0	0	0
299	SMALL ROCK	Polygon Triangle	2009	1748	251	0	0	0
300	VERY SMALL ROCK	Sphere	2003	1753	289.4	0	0	0
301	VERY SMALL ROCK	Polygon Triangle	2001	1755	281	0	0	0
302	VERY SMALL ROCK	Polygon Square	1998	1758	78.84	0	0	0
303	VERY SMALL ROCK	Polygon Pentagon	2013	1745	55.55	0	0	0
304	VERY SMALL ROCK	Polygon Hexagon	2009	1748	227.7	0	0	0
305	VERY SMALL ROCK	Polygon Octagon	2002	1754	51.63	0	0	0
306	VERY SMALL ROCK	Sphere	2005	1751	161.3	0	0	0
307	VERY SMALL ROCK	Polygon Triangle	2007	1749	304.7	0	0	0
308	VERY SMALL ROCK	Polygon Square	1998	1759	315.2	0	0	0
309	VERY SMALL ROCK	Polygon Pentagon	2010	1747	3.934	0	0	0
310	VERY SMALL ROCK	Polygon Hexagon	1995	1761	142	0	0	0
311	VERY SMALL ROCK	Polygon Octagon	2001	1755	12.68	0	0	0

312	VERY SMALL ROCK	Sphere	2000	1756	214.3	0	0	0
313	VERY SMALL ROCK	Polygon Triangle	2005	1751	262.8	0	0	0
314	VERY SMALL ROCK	Polygon Square	2002	1754	98.64	0	0	0

Run ID	Rock Type	Shape	X (m)	Y (m)	Rotation (deg)	VX (m/s)	VY (m/s)	VR (deg/s)
315	VERY SMALL ROCK	Polygon Pentagon	2004	1752	274	0	0	0
316	VERY SMALL ROCK	Polygon Hexagon	1996	1760	27.73	0	0	0
317	VERY SMALL ROCK	Polygon Octagon	2011	1746	354.9	0	0	0
318	VERY SMALL ROCK	Sphere	1996	1761	242.1	0	0	0
319	VERY SMALL ROCK	Polygon Triangle	2014	1744	341.8	0	0	0

Generated Rock Geometries

Run ID	Mass (kg)	Density (kg/m^3)	Size (m)	Area (m^2)	Depth (m)	Moment of Inertia
0	16.9	2460	0.1179	0.04369	0.1572	0.09401
1	16.9	2460	0.2775	0.03334	0.206	0.1084
2	16.9	2460	0.1826	0.03334	0.206	0.09391
3	16.9	2460	0.1392	0.03334	0.206	0.0912
4	16.9	2460	0.1133	0.03334	0.206	0.09037
5	16.9	2460	0.0831	0.03334	0.206	0.08989
6	16.9	2460	0.1179	0.04369	0.1572	0.09401
7	16.9	2460	0.2775	0.03334	0.206	0.1084
8	16.9	2460	0.1826	0.03334	0.206	0.09391
9	16.9	2460	0.1392	0.03334	0.206	0.0912
10	16.9	2460	0.1133	0.03334	0.206	0.09037
11	16.9	2460	0.0831	0.03334	0.206	0.08989
12	16.9	2460	0.1179	0.04369	0.1572	0.09401
13	16.9	2460	0.2775	0.03334	0.206	0.1084
14	16.9	2460	0.1826	0.03334	0.206	0.09391
15	16.9	2460	0.1179	0.04369	0.1572	0.09401
16	16.9	2460	0.2775	0.03334	0.206	0.1084
17	16.9	2460	0.1826	0.03334	0.206	0.09391
18	16.9	2460	0.1392	0.03334	0.206	0.0912
19	16.9	2460	0.1133	0.03334	0.206	0.09037
20	16.9	2460	0.1179	0.04369	0.1572	0.09401
21	16.9	2460	0.2775	0.03334	0.206	0.1084
22	16.9	2460	0.1826	0.03334	0.206	0.09391
23	16.9	2460	0.1392	0.03334	0.206	0.0912
24	16.9	2460	0.1133	0.03334	0.206	0.09037
25	16.9	2460	0.0831	0.03334	0.206	0.08989
26	16.9	2460	0.1179	0.04369	0.1572	0.09401
27	16.9	2460	0.2775	0.03334	0.206	0.1084
28	16.9	2460	0.1826	0.03334	0.206	0.09391
29	16.9	2460	0.1392	0.03334	0.206	0.0912
30	16.9	2460	0.1133	0.03334	0.206	0.09037
31	16.9	2460	0.0831	0.03334	0.206	0.08989
32	16.9	2460	0.1179	0.04369	0.1572	0.09401
33	16.9	2460	0.2775	0.03334	0.206	0.1084
34	16.9	2460	0.1826	0.03334	0.206	0.09391
35	16.9	2460	0.1392	0.03334	0.206	0.0912
36	16.9	2460	0.1133	0.03334	0.206	0.09037
37	16.9	2460	0.0831	0.03334	0.206	0.08989
38	16.9	2460	0.1179	0.04369	0.1572	0.09401
39	16.9	2460	0.2775	0.03334	0.206	0.1084
40	16.9	2460	0.1826	0.03334	0.206	0.09391
41	16.9	2460	0.1392	0.03334	0.206	0.0912
42	16.9	2460	0.1133	0.03334	0.206	0.09037
43	16.9	2460	0.0831	0.03334	0.206	0.08989
44	16.9	2460	0.1179	0.04369	0.1572	0.09401

Run ID	Mass (kg)	Density (kg/m^3)	Size (m)	Area (m^2)	Depth (m)	Moment of Inertia
45	16.9	2460	0.2775	0.03334	0.206	0.1084
46	16.9	2460	0.1826	0.03334	0.206	0.09391
47	16.9	2460	0.1392	0.03334	0.206	0.0912
48	16.9	2460	0.1133	0.03334	0.206	0.09037
49	16.9	2460	0.0831	0.03334	0.206	0.08989
50	16.9	2460	0.1179	0.04369	0.1572	0.09401
51	16.9	2460	0.2775	0.03334	0.206	0.1084
52	16.9	2460	0.1826	0.03334	0.206	0.09391
53	16.9	2460	0.1392	0.03334	0.206	0.0912
54	16.9	2460	0.1133	0.03334	0.206	0.09037
55	16.9	2460	0.0831	0.03334	0.206	0.08989
56	16.9	2460	0.1179	0.04369	0.1572	0.09401
57	16.9	2460	0.2775	0.03334	0.206	0.1084
58	16.9	2460	0.1826	0.03334	0.206	0.09391
59	16.9	2460	0.1392	0.03334	0.206	0.0912
60	16.9	2460	0.1133	0.03334	0.206	0.09037
61	16.9	2460	0.0831	0.03334	0.206	0.08989
62	16.9	2460	0.1179	0.04369	0.1572	0.09401
63	16.9	2460	0.2775	0.03334	0.206	0.1084
64	16.9	2460	0.1826	0.03334	0.206	0.09391
65	16.9	2460	0.1392	0.03334	0.206	0.0912
66	16.9	2460	0.1133	0.03334	0.206	0.09037
67	16.9	2460	0.0831	0.03334	0.206	0.08989
68	16.9	2460	0.1179	0.04369	0.1572	0.09401
69	16.9	2460	0.2775	0.03334	0.206	0.1084
70	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
71	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
72	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
73	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
74	6.642e+04	2460	1.788	8.304	3.252	8.845e+04
75	6.642e+04	2460	1.311	8.304	3.252	8.798e+04
76	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
77	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
78	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
79	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
80	6.642e+04	2460	1.788	8.304	3.252	8.845e+04
81	6.642e+04	2460	1.311	8.304	3.252	8.798e+04
82	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
83	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
84	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
85	307.5	2460	0.3102	0.3022	0.4136	11.83
86	307.5	2460	0.7299	0.2307	0.5419	13.65
87	307.5	2460	0.4803	0.2307	0.5419	11.82
88	307.5	2460	0.3662	0.2307	0.5419	11.48
89	307.5	2460	0.298	0.2307	0.5419	11.38

Run ID	Mass (kg)	Density (kg/m^3)	Size (m)	Area (m^2)	Depth (m)	Moment of Inertia
90	307.5	2460	0.2186	0.2307	0.5419	11.31
91	307.5	2460	0.3102	0.3022	0.4136	11.83
92	307.5	2460	0.7299	0.2307	0.5419	13.65
93	307.5	2460	0.4803	0.2307	0.5419	11.82
94	307.5	2460	0.3662	0.2307	0.5419	11.48
95	307.5	2460	0.298	0.2307	0.5419	11.38
96	307.5	2460	0.2186	0.2307	0.5419	11.31
97	307.5	2460	0.3102	0.3022	0.4136	11.83
98	307.5	2460	0.7299	0.2307	0.5419	13.65
99	307.5	2460	0.4803	0.2307	0.5419	11.82
100	16.9	2460	0.1179	0.04369	0.1572	0.09401
101	16.9	2460	0.2775	0.03334	0.206	0.1084
102	16.9	2460	0.1826	0.03334	0.206	0.09391
103	16.9	2460	0.1392	0.03334	0.206	0.0912
104	16.9	2460	0.1133	0.03334	0.206	0.09037
105	16.9	2460	0.0831	0.03334	0.206	0.08989
106	16.9	2460	0.1179	0.04369	0.1572	0.09401
107	16.9	2460	0.2775	0.03334	0.206	0.1084
108	16.9	2460	0.1826	0.03334	0.206	0.09391
109	16.9	2460	0.1392	0.03334	0.206	0.0912
110	16.9	2460	0.1133	0.03334	0.206	0.09037
111	16.9	2460	0.0831	0.03334	0.206	0.08989
112	16.9	2460	0.1179	0.04369	0.1572	0.09401
113	16.9	2460	0.2775	0.03334	0.206	0.1084
114	16.9	2460	0.1826	0.03334	0.206	0.09391
115	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
116	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
117	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
118	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
119	6.642e+04	2460	1.788	8.304	3.252	8.845e+04
120	307.5	2460	0.3102	0.3022	0.4136	11.83
121	307.5	2460	0.7299	0.2307	0.5419	13.65
122	307.5	2460	0.4803	0.2307	0.5419	11.82
123	307.5	2460	0.3662	0.2307	0.5419	11.48
124	307.5	2460	0.298	0.2307	0.5419	11.38
125	16.9	2460	0.1179	0.04369	0.1572	0.09401
126	16.9	2460	0.2775	0.03334	0.206	0.1084
127	16.9	2460	0.1826	0.03334	0.206	0.09391
128	16.9	2460	0.1392	0.03334	0.206	0.0912
129	16.9	2460	0.1133	0.03334	0.206	0.09037
130	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
131	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
132	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
133	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
134	6.642e+04	2460	1.788	8.304	3.252	8.845e+04

Run ID	Mass (kg)	Density (kg/m^3)	Size (m)	Area (m^2)	Depth (m)	Moment of Inertia
135	6.642e+04	2460	1.311	8.304	3.252	8.798e+04
136	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
137	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
138	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
139	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
140	6.642e+04	2460	1.788	8.304	3.252	8.845e+04
141	6.642e+04	2460	1.311	8.304	3.252	8.798e+04
142	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
143	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
144	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
145	307.5	2460	0.3102	0.3022	0.4136	11.83
146	307.5	2460	0.7299	0.2307	0.5419	13.65
147	307.5	2460	0.4803	0.2307	0.5419	11.82
148	307.5	2460	0.3662	0.2307	0.5419	11.48
149	307.5	2460	0.298	0.2307	0.5419	11.38
150	307.5	2460	0.2186	0.2307	0.5419	11.31
151	307.5	2460	0.3102	0.3022	0.4136	11.83
152	307.5	2460	0.7299	0.2307	0.5419	13.65
153	307.5	2460	0.4803	0.2307	0.5419	11.82
154	307.5	2460	0.3662	0.2307	0.5419	11.48
155	307.5	2460	0.298	0.2307	0.5419	11.38
156	307.5	2460	0.2186	0.2307	0.5419	11.31
157	307.5	2460	0.3102	0.3022	0.4136	11.83
158	307.5	2460	0.7299	0.2307	0.5419	13.65
159	307.5	2460	0.4803	0.2307	0.5419	11.82
160	16.9	2460	0.1179	0.04369	0.1572	0.09401
161	16.9	2460	0.2775	0.03334	0.206	0.1084
162	16.9	2460	0.1826	0.03334	0.206	0.09391
163	16.9	2460	0.1392	0.03334	0.206	0.0912
164	16.9	2460	0.1133	0.03334	0.206	0.09037
165	16.9	2460	0.0831	0.03334	0.206	0.08989
166	16.9	2460	0.1179	0.04369	0.1572	0.09401
167	16.9	2460	0.2775	0.03334	0.206	0.1084
168	16.9	2460	0.1826	0.03334	0.206	0.09391
169	16.9	2460	0.1392	0.03334	0.206	0.0912
170	16.9	2460	0.1133	0.03334	0.206	0.09037
171	16.9	2460	0.0831	0.03334	0.206	0.08989
172	16.9	2460	0.1179	0.04369	0.1572	0.09401
173	16.9	2460	0.2775	0.03334	0.206	0.1084
174	16.9	2460	0.1826	0.03334	0.206	0.09391
175	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
176	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
177	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
178	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
179	6.642e+04	2460	1.788	8.304	3.252	8.845e+04

Run ID	Mass (kg)	Density (kg/m^3)	Size (m)	Area (m^2)	Depth (m)	Moment of Inertia
180	6.642e+04	2460	1.311	8.304	3.252	8.798e+04
181	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
182	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
183	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
184	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
185	6.642e+04	2460	1.788	8.304	3.252	8.845e+04
186	6.642e+04	2460	1.311	8.304	3.252	8.798e+04
187	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
188	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
189	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
190	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
191	6.642e+04	2460	1.788	8.304	3.252	8.845e+04
192	6.642e+04	2460	1.311	8.304	3.252	8.798e+04
193	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
194	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
195	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
196	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
197	6.642e+04	2460	1.788	8.304	3.252	8.845e+04
198	6.642e+04	2460	1.311	8.304	3.252	8.798e+04
199	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
200	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
201	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
202	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
203	6.642e+04	2460	1.788	8.304	3.252	8.845e+04
204	6.642e+04	2460	1.311	8.304	3.252	8.798e+04
205	307.5	2460	0.3102	0.3022	0.4136	11.83
206	307.5	2460	0.7299	0.2307	0.5419	13.65
207	307.5	2460	0.4803	0.2307	0.5419	11.82
208	307.5	2460	0.3662	0.2307	0.5419	11.48
209	307.5	2460	0.298	0.2307	0.5419	11.38
210	307.5	2460	0.2186	0.2307	0.5419	11.31
211	307.5	2460	0.3102	0.3022	0.4136	11.83
212	307.5	2460	0.7299	0.2307	0.5419	13.65
213	307.5	2460	0.4803	0.2307	0.5419	11.82
214	307.5	2460	0.3662	0.2307	0.5419	11.48
215	307.5	2460	0.298	0.2307	0.5419	11.38
216	307.5	2460	0.2186	0.2307	0.5419	11.31
217	307.5	2460	0.3102	0.3022	0.4136	11.83
218	307.5	2460	0.7299	0.2307	0.5419	13.65
219	307.5	2460	0.4803	0.2307	0.5419	11.82
220	307.5	2460	0.3662	0.2307	0.5419	11.48
221	307.5	2460	0.298	0.2307	0.5419	11.38
222	307.5	2460	0.2186	0.2307	0.5419	11.31
223	307.5	2460	0.3102	0.3022	0.4136	11.83
224	307.5	2460	0.7299	0.2307	0.5419	13.65

Run ID	Mass (kg)	Density (kg/m^3)	Size (m)	Area (m^2)	Depth (m)	Moment of Inertia
225	307.5	2460	0.4803	0.2307	0.5419	11.82
226	307.5	2460	0.3662	0.2307	0.5419	11.48
227	307.5	2460	0.298	0.2307	0.5419	11.38
228	307.5	2460	0.2186	0.2307	0.5419	11.31
229	307.5	2460	0.3102	0.3022	0.4136	11.83
230	307.5	2460	0.7299	0.2307	0.5419	13.65
231	307.5	2460	0.4803	0.2307	0.5419	11.82
232	307.5	2460	0.3662	0.2307	0.5419	11.48
233	307.5	2460	0.298	0.2307	0.5419	11.38
234	307.5	2460	0.2186	0.2307	0.5419	11.31
235	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
236	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
237	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
238	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
239	6.642e+04	2460	1.788	8.304	3.252	8.845e+04
240	6.642e+04	2460	1.311	8.304	3.252	8.798e+04
241	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
242	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
243	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
244	6.642e+04	2460	2.197	8.304	3.252	8.927e+04
245	6.642e+04	2460	1.788	8.304	3.252	8.845e+04
246	6.642e+04	2460	1.311	8.304	3.252	8.798e+04
247	6.642e+04	2460	1.861	10.88	2.481	9.202e+04
248	6.642e+04	2460	4.379	8.304	3.252	1.061e+05
249	6.642e+04	2460	2.882	8.304	3.252	9.192e+04
250	307.5	2460	0.3102	0.3022	0.4136	11.83
251	307.5	2460	0.7299	0.2307	0.5419	13.65
252	307.5	2460	0.4803	0.2307	0.5419	11.82
253	307.5	2460	0.3662	0.2307	0.5419	11.48
254	307.5	2460	0.298	0.2307	0.5419	11.38
255	307.5	2460	0.2186	0.2307	0.5419	11.31
256	307.5	2460	0.3102	0.3022	0.4136	11.83
257	307.5	2460	0.7299	0.2307	0.5419	13.65
258	307.5	2460	0.4803	0.2307	0.5419	11.82
259	307.5	2460	0.3662	0.2307	0.5419	11.48
260	307.5	2460	0.298	0.2307	0.5419	11.38
261	307.5	2460	0.2186	0.2307	0.5419	11.31
262	307.5	2460	0.3102	0.3022	0.4136	11.83
263	307.5	2460	0.7299	0.2307	0.5419	13.65
264	307.5	2460	0.4803	0.2307	0.5419	11.82
265	16.9	2460	0.1179	0.04369	0.1572	0.09401
266	16.9	2460	0.2775	0.03334	0.206	0.1084
267	16.9	2460	0.1826	0.03334	0.206	0.09391
268	16.9	2460	0.1392	0.03334	0.206	0.0912
269	16.9	2460	0.1133	0.03334	0.206	0.09037

Run ID	Mass (kg)	Density (kg/m^3)	Size (m)	Area (m^2)	Depth (m)	Moment of Inertia
270	16.9	2460	0.0831	0.03334	0.206	0.08989
271	16.9	2460	0.1179	0.04369	0.1572	0.09401
272	16.9	2460	0.2775	0.03334	0.206	0.1084
273	16.9	2460	0.1826	0.03334	0.206	0.09391
274	16.9	2460	0.1392	0.03334	0.206	0.0912
275	16.9	2460	0.1133	0.03334	0.206	0.09037
276	16.9	2460	0.0831	0.03334	0.206	0.08989
277	16.9	2460	0.1179	0.04369	0.1572	0.09401
278	16.9	2460	0.2775	0.03334	0.206	0.1084
279	16.9	2460	0.1826	0.03334	0.206	0.09391
280	307.5	2460	0.3102	0.3022	0.4136	11.83
281	307.5	2460	0.7299	0.2307	0.5419	13.65
282	307.5	2460	0.4803	0.2307	0.5419	11.82
283	307.5	2460	0.3662	0.2307	0.5419	11.48
284	307.5	2460	0.298	0.2307	0.5419	11.38
285	307.5	2460	0.2186	0.2307	0.5419	11.31
286	307.5	2460	0.3102	0.3022	0.4136	11.83
287	307.5	2460	0.7299	0.2307	0.5419	13.65
288	307.5	2460	0.4803	0.2307	0.5419	11.82
289	307.5	2460	0.3662	0.2307	0.5419	11.48
290	307.5	2460	0.298	0.2307	0.5419	11.38
291	307.5	2460	0.2186	0.2307	0.5419	11.31
292	307.5	2460	0.3102	0.3022	0.4136	11.83
293	307.5	2460	0.7299	0.2307	0.5419	13.65
294	307.5	2460	0.4803	0.2307	0.5419	11.82
295	307.5	2460	0.3662	0.2307	0.5419	11.48
296	307.5	2460	0.298	0.2307	0.5419	11.38
297	307.5	2460	0.2186	0.2307	0.5419	11.31
298	307.5	2460	0.3102	0.3022	0.4136	11.83
299	307.5	2460	0.7299	0.2307	0.5419	13.65
300	16.9	2460	0.1179	0.04369	0.1572	0.09401
301	16.9	2460	0.2775	0.03334	0.206	0.1084
302	16.9	2460	0.1826	0.03334	0.206	0.09391
303	16.9	2460	0.1392	0.03334	0.206	0.0912
304	16.9	2460	0.1133	0.03334	0.206	0.09037
305	16.9	2460	0.0831	0.03334	0.206	0.08989
306	16.9	2460	0.1179	0.04369	0.1572	0.09401
307	16.9	2460	0.2775	0.03334	0.206	0.1084
308	16.9	2460	0.1826	0.03334	0.206	0.09391
309	16.9	2460	0.1392	0.03334	0.206	0.0912
310	16.9	2460	0.1133	0.03334	0.206	0.09037
311	16.9	2460	0.0831	0.03334	0.206	0.08989
312	16.9	2460	0.1179	0.04369	0.1572	0.09401
313	16.9	2460	0.2775	0.03334	0.206	0.1084
314	16.9	2460	0.1826	0.03334	0.206	0.09391

Run ID	Mass (kg)	Density (kg/m^3)	Size (m)	Area (m^2)	Depth (m)	Moment of Inertia
315	16.9	2460	0.1392	0.03334	0.206	0.0912
316	16.9	2460	0.1133	0.03334	0.206	0.09037
317	16.9	2460	0.0831	0.03334	0.206	0.08989
318	16.9	2460	0.1179	0.04369	0.1572	0.09401
319	16.9	2460	0.2775	0.03334	0.206	0.1084

Path Results Summary

ID	Compute Time (s)	Events	Stopping Reason	End Loc
0	0.001332	189	Stopped	2311
1	11.4	3758	Stopped	2311
2	Incomplete	-	-	-
3	0.0003956	3	Stopped	2301
4	1.138	421	Stopped	2339
5	0.0005712	3	Stopped	2301
6	0.001901	189	Stopped	2311
7	13.08	3693	Stopped	2311
8	Incomplete	-	-	-
9	Incomplete	-	-	-
10	0.0004955	3	Stopped	2301
11	0.0003994	3	Stopped	2301
12	0.00131	189	Stopped	2311
13	Incomplete	-	-	-
14	Incomplete	-	-	-
15	0.0003384	3	Stopped	2313
16	Incomplete	-	-	-
17	Incomplete	-	-	-
18	0.0003841	3	Stopped	2313
19	0.0003843	3	Stopped	2313
20	0.00224	185	Stopped	2299
21	10.58	3034	Stopped	2299
22	Incomplete	-	-	-
23	0.0002921	3	Stopped	2291
24	0.0002813	3	Stopped	2291
25	0.0003039	3	Stopped	2291
26	0.001826	185	Stopped	2299
27	10.89	2938	Stopped	2299
28	Incomplete	-	-	-
29	0.0003941	3	Stopped	2291
30	1.427	683	Stopped	2339
31	0.0004763	3	Stopped	2291
32	0.002149	185	Stopped	2299
33	9.493	2873	Stopped	2299
34	Incomplete	-	-	-
35	Incomplete	-	-	-
36	Incomplete	-	-	-
37	0.0004016	3	Stopped	2291
38	0.001791	185	Stopped	2299
39	10.67	3043	Stopped	2299
40	Incomplete	-	-	-
41	0.0004511	3	Stopped	2291
42	0.0004019	3	Stopped	2291
43	0.0004454	3	Stopped	2291
44	0.002186	185	Stopped	2299

ID	Compute Time (s)	Events	Stopping Reason	End Loc
45	10.7	2906	Stopped	2299
46	Incomplete	-	-	-
47	Incomplete	-	-	-
48	58.58	1967	Stopped	2300
49	0.0005804	3	Stopped	2291
50	0.00233	185	Stopped	2299
51	11.75	3052	Stopped	2299
52	Incomplete	-	-	-
53	0.0004379	3	Stopped	2291
54	20.03	1072	Stopped	2338
55	0.0004508	3	Stopped	2291
56	0.001884	185	Stopped	2299
57	9.229	2983	Stopped	2299
58	Incomplete	-	-	-
59	0.0003897	3	Stopped	2291
60	6.502	776	Stopped	2327
61	10.34	2274	Stopped	2339
62	0.001854	185	Stopped	2299
63	10.44	2911	Stopped	2299
64	Incomplete	-	-	-
65	0.0003922	3	Stopped	2291
66	22.78	1507	Stopped	2311
67	22.37	1349	Stopped	2339
68	0.00143	185	Stopped	2299
69	10.79	3059	Stopped	2299
70	0.005349	279	Stopped	2258
71	1.163	20000	Max Steps	2125
72	0.1289	573	Stopped	2117
73	1.021	4599	Stopped	2256
74	1.719	1073	Stopped	2276
75	1.303	1469	Stopped	2271
76	0.004583	278	Stopped	2260
77	1.296	20000	Max Steps	2134
78	0.04579	196	Stopped	2117
79	0.07481	342	Stopped	2261
80	0.7348	2082	Stopped	2269
81	0.7146	1513	Stopped	2276
82	0.004064	249	Stopped	2261
83	1.093	20001	Max Steps	2131
84	1.716	20000	Max Steps	2139
85	0.004121	251	Stopped	2257
86	1.3	20000	Max Steps	2121
87	1.224	20000	Max Steps	2144
88	105	6117	Stopped	2269
89	638.4	20000	Max Steps	2270

ID	Compute Time (s)	Events	Stopping Reason	End Loc
90	631.3	20000	Max Steps	2256
91	0.002935	243	Stopped	2258
92	0.78	20000	Max Steps	2117
93	0.06671	363	Stopped	2121
94	3.916	20000	Max Steps	2129
95	0.7951	1415	Stopped	2274
96	5.231	4350	Stopped	2256
97	0.3018	255	Stopped	2256
98	0.8477	20000	Max Steps	2125
99	0.8735	20000	Max Steps	2119
100	0.002766	239	Stopped	2258
101	0.03747	44	Stopped	2111
102	1.733	1092	Stopped	2126
103	10.95	4562	Stopped	2256
104	3.959	768	Stopped	2339
105	0.7655	648	Stopped	2284
106	0.00475	233	Stopped	2260
107	60.99	20000	Max Steps	2210
108	Incomplete	-	-	-
109	1.97	568	Stopped	2256
110	0.0004317	3	Stopped	2109
111	610.3	20000	Max Steps	2255
112	0.003129	254	Stopped	2258
113	9.579	20000	Max Steps	2152
114	0.2822	245	Stopped	2122
115	0.002629	195	Stopped	2258
116	1.152	20001	Max Steps	2147
117	0.0003403	3	Stopped	2106
118	0.0003015	3	Stopped	2106
119	0.0002998	3	Stopped	2106
120	0.0048	202	Stopped	2258
121	2.614	20001	Max Steps	2131
122	0.00046	3	Stopped	2105
123	18.72	1824	Stopped	2255
124	1.246	1073	Stopped	2271
125	0.003723	207	Stopped	2260
126	1.222	20000	Max Steps	2105
127	Incomplete	-	-	-
128	11.43	770	Stopped	2259
129	0.0005275	3	Stopped	2105
130	0.007023	292	Stopped	2256
131	0.9375	20000	Max Steps	2114
132	0.2023	614	Stopped	2122
133	0.334	1917	Stopped	2256
134	1.519	2779	Stopped	2258

ID	Compute Time (s)	Events	Stopping Reason	End Loc
135	0.9326	999	Stopped	2278
136	0.005134	273	Stopped	2257
137	0.005667	18	Stopped	2112
138	0.1418	317	Stopped	2120
139	0.5207	2586	Stopped	2261
140	1.534	999	Stopped	2260
141	209.4	20000	Max Steps	2375
142	0.003457	248	Stopped	2258
143	0.949	20000	Max Steps	2113
144	0.2107	810	Stopped	2117
145	0.003017	225	Stopped	2259
146	0.794	20001	Max Steps	2119
147	0.1916	1091	Stopped	2119
148	20.42	8161	Stopped	2256
149	579.8	20000	Max Steps	2271
150	3.624	8413	Stopped	2256
151	0.004944	227	Stopped	2259
152	0.9816	20000	Max Steps	2110
153	0.02842	157	Stopped	2123
154	Incomplete	-	-	-
155	26.92	1517	Stopped	2284
156	635.2	20000	Max Steps	2260
157	0.003063	241	Stopped	2258
158	0.6563	20001	Max Steps	2113
159	0.8683	20001	Max Steps	2113
160	0.005276	244	Stopped	2260
161	10.54	5246	Stopped	2121
162	0.8573	479	Stopped	2110
163	1.828	554	Stopped	2111
164	1.811	1950	Stopped	2257
165	7.325	4370	Stopped	2269
166	0.00562	257	Stopped	2257
167	10.96	5248	Stopped	2119
168	0.4035	237	Stopped	2121
169	Incomplete	-	-	-
170	24.59	6398	Stopped	2255
171	Incomplete	-	-	-
172	0.00292	243	Stopped	2259
173	2.328	1274	Stopped	2113
174	Incomplete	-	-	-
175	0.00896	693	Stopped	2257
176	0.9591	20001	Max Steps	1989
177	0.0003781	3	Stopped	1987
178	0.000379	3	Stopped	1987
179	13.44	1089	Stopped	2284

ID	Compute Time (s)	Events	Stopping Reason	End Loc
180	0.0006538	3	Stopped	1987
181	0.001493	33	Stopped	1995
182	1.582	20001	Max Steps	1988
183	1.113	20001	Max Steps	1988
184	1.963	3547	Stopped	2283
185	0.206	736	Stopped	2283
186	0.0003912	3	Stopped	1987
187	0.007187	451	Stopped	2258
188	0.0003077	3	Stopped	1988
189	1.229	20000	Max Steps	1988
190	0.0007924	3	Stopped	1987
191	0.0005289	3	Stopped	1987
192	0.000558	3	Stopped	1987
193	0.008757	463	Stopped	2258
194	0.9577	20000	Max Steps	1988
195	0.05229	493	Stopped	1991
196	0.0003846	3	Stopped	1987
197	0.0003743	3	Stopped	1987
198	1.993	5240	Stopped	2271
199	0.00626	389	Stopped	2260
200	0.0004033	3	Stopped	1987
201	1.779	20000	Max Steps	1992
202	3.286	4386	Stopped	2268
203	0.8575	3065	Stopped	2269
204	0.0004269	3	Stopped	1987
205	0.00708	411	Stopped	2258
206	0.0003717	3	Stopped	1986
207	0.0003676	3	Stopped	1986
208	0.0003687	3	Stopped	1986
209	606.9	20000	Max Steps	2044
210	1.959	1221	Stopped	2268
211	0.006926	386	Stopped	2259
212	0.000401	3	Stopped	1986
213	1.147	20000	Max Steps	1987
214	0.0004171	3	Stopped	1986
215	Incomplete	-	-	-
216	12.36	2110	Stopped	2044
217	0.005997	370	Stopped	2260
218	0.0003424	3	Stopped	1986
219	0.0003527	3	Stopped	1986
220	2.112	20000	Max Steps	1987
221	36.88	4486	Stopped	2044
222	704.3	20000	Max Steps	2284
223	0.004643	411	Stopped	2258
224	0.0002764	3	Stopped	1986

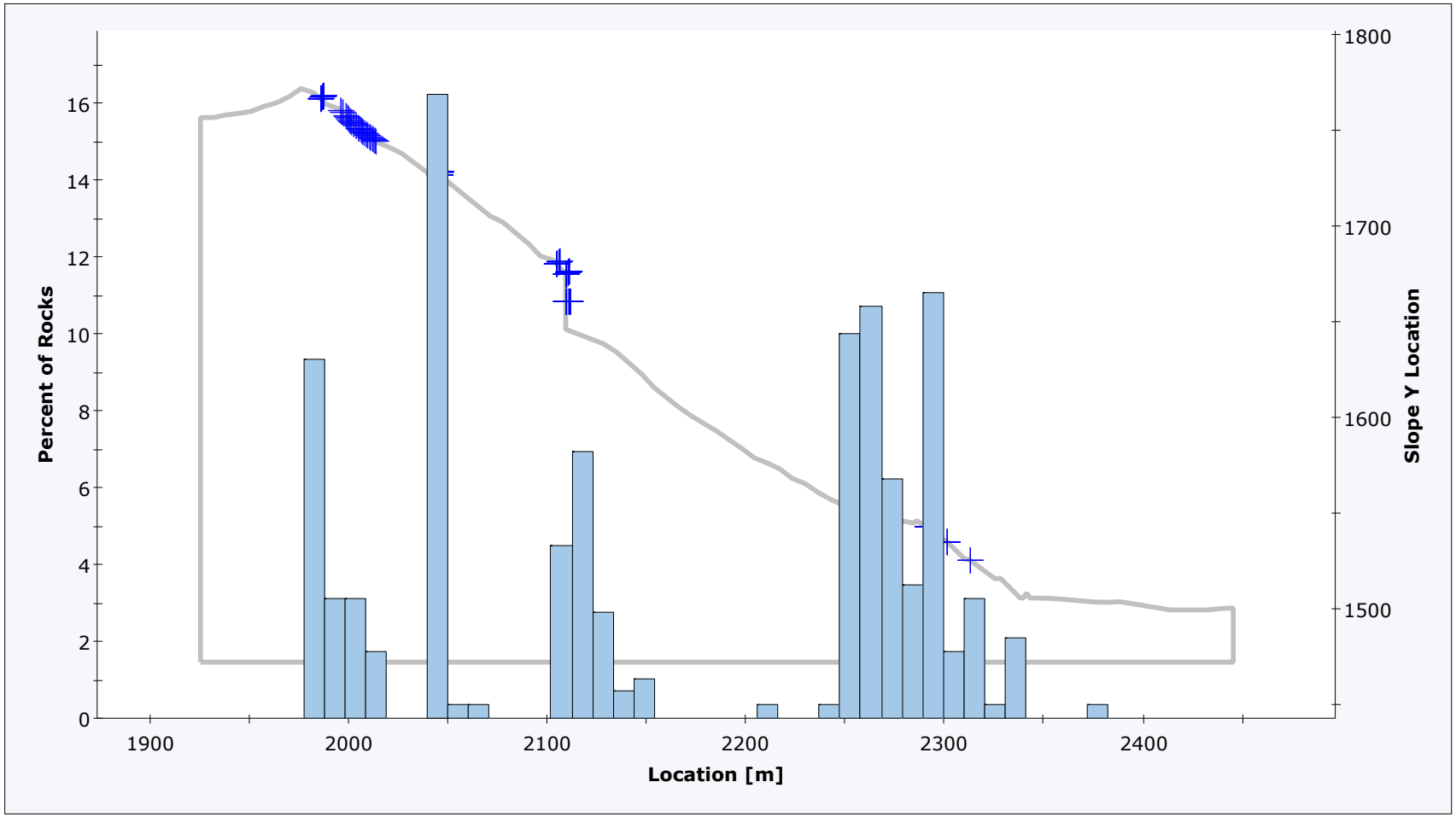
ID	Compute Time (s)	Events	Stopping Reason	End Loc
225	0.7404	20000	Max Steps	1987
226	0.0003043	3	Stopped	1986
227	0.6008	887	Stopped	2284
228	2.568	3345	Stopped	2041
229	0.004193	394	Stopped	2258
230	0.0004148	3	Stopped	1986
231	0.0003935	3	Stopped	1986
232	594.8	20000	Max Steps	1993
233	363.7	18681	Stopped	2043
234	7.285	2528	Stopped	2041
235	0.0004157	2	Stopped	2046
236	0.6201	20000	Max Steps	2049
237	0.7888	20000	Max Steps	2056
238	0.2624	3212	Stopped	2256
239	0.001452	7	Stopped	2046
240	6.788	20000	Max Steps	2046
241	0.0005187	2	Stopped	2046
242	1.126	20000	Max Steps	2047
243	1.309	20000	Max Steps	2047
244	5.393	20000	Max Steps	2046
245	0.01039	8	Stopped	2046
246	6.972	20000	Max Steps	2046
247	0.0004272	2	Stopped	2046
248	1.092	20001	Max Steps	2049
249	5.087	17116	Stopped	2244
250	0.000581	2	Stopped	2046
251	0.0004124	3	Stopped	2046
252	3.447	4582	Stopped	2102
253	2.455	3784	Stopped	2270
254	0.1483	11	Stopped	2046
255	0.002591	6	Stopped	2046
256	0.0003379	2	Stopped	2046
257	1.329	20000	Max Steps	2046
258	1.247	20001	Max Steps	2047
259	11.3	10611	Stopped	2284
260	3.374	20000	Max Steps	2046
261	122.6	20000	Max Steps	2273
262	0.0003576	2	Stopped	2046
263	0.0002656	3	Stopped	2046
264	4.695	20000	Max Steps	2046
265	0.0003432	2	Stopped	2046
266	0.1357	1873	Stopped	2046
267	0.1045	12	Stopped	2046
268	39.63	16578	Stopped	2259
269	4.072	2508	Stopped	2260

ID	Compute Time (s)	Events	Stopping Reason	End Loc
270	0.1549	11	Stopped	2046
271	0.0004391	2	Stopped	2046
272	0.219	1685	Stopped	2046
273	Incomplete	-	-	-
274	2.411	1896	Stopped	2256
275	5.621	3474	Stopped	2268
276	0.5521	2502	Stopped	2046
277	0.0004943	2	Stopped	2046
278	22.83	20000	Max Steps	2068
279	17.92	13597	Stopped	2128
280	0.006406	376	Stopped	2257
281	0.0003376	3	Stopped	2003
282	1.096	20001	Max Steps	2004
283	1.275	2690	Stopped	2044
284	668.7	20000	Max Steps	2284
285	430	20000	Max Steps	2046
286	0.004292	368	Stopped	2257
287	0.0002499	3	Stopped	2004
288	0.7214	20001	Max Steps	2007
289	0.0003078	3	Stopped	1997
290	12.04	3288	Stopped	2275
291	41.41	4830	Stopped	2044
292	0.006793	375	Stopped	2258
293	0.0003747	3	Stopped	2013
294	0.000385	3	Stopped	2007
295	0.000411	3	Stopped	2007
296	3.282	3027	Stopped	2041
297	1.906	2160	Stopped	2043
298	0.002674	91	Stopped	2044
299	0.0004761	3	Stopped	2009
300	0.006487	358	Stopped	2258
301	24.42	10214	Stopped	2017
302	Incomplete	-	-	-
303	23.82	8915	Stopped	2041
304	4.698	2892	Stopped	2284
305	0.0004715	3	Stopped	2002
306	0.005201	313	Stopped	2268
307	4.202	1260	Stopped	2008
308	Incomplete	-	-	-
309	68.98	7945	Stopped	2043
310	Incomplete	-	-	-
311	0.0004205	3	Stopped	2001
312	0.005958	370	Stopped	2257
313	19.28	11239	Stopped	2016
314	Incomplete	-	-	-

ID	Compute Time (s)	Events	Stopping Reason	End Loc
315	Incomplete	-	-	-
316	3.003	2861	Stopped	2040
317	60.13	6679	Stopped	2046
318	0.004226	359	Stopped	2260
319	1.398	636	Stopped	2014

Barrier(s) Impact Results

Distribution of Rock Path End Locations

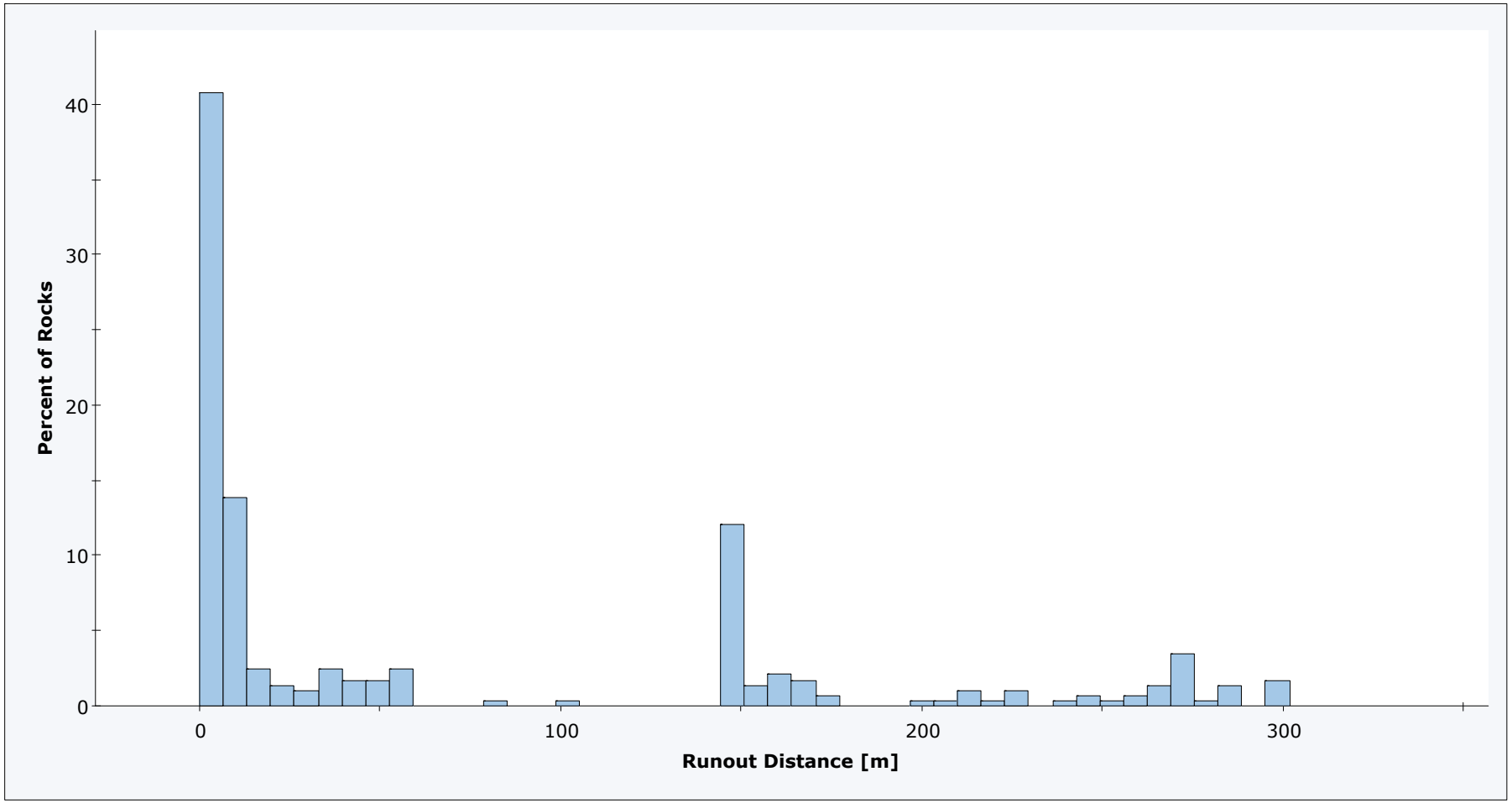


Total number of rock paths: 289

rocscience	*Project*	GEO 1 1 A	
	Analysis Description	Analisi caduta massi stato di progetto	
	Drawn By	Emiliano Quadernari	*Company* Geo Group
	Date	16/11/2023, 15:51:31	*File Name* GEO 1 1 A - ANALISI CADUTA MASSI.fal8

ROCFALL 8.024

Distribution of Rock Path End Locations



Total number of rock paths: 289

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	Analysis Description	Analisi caduta massi stato di progetto	
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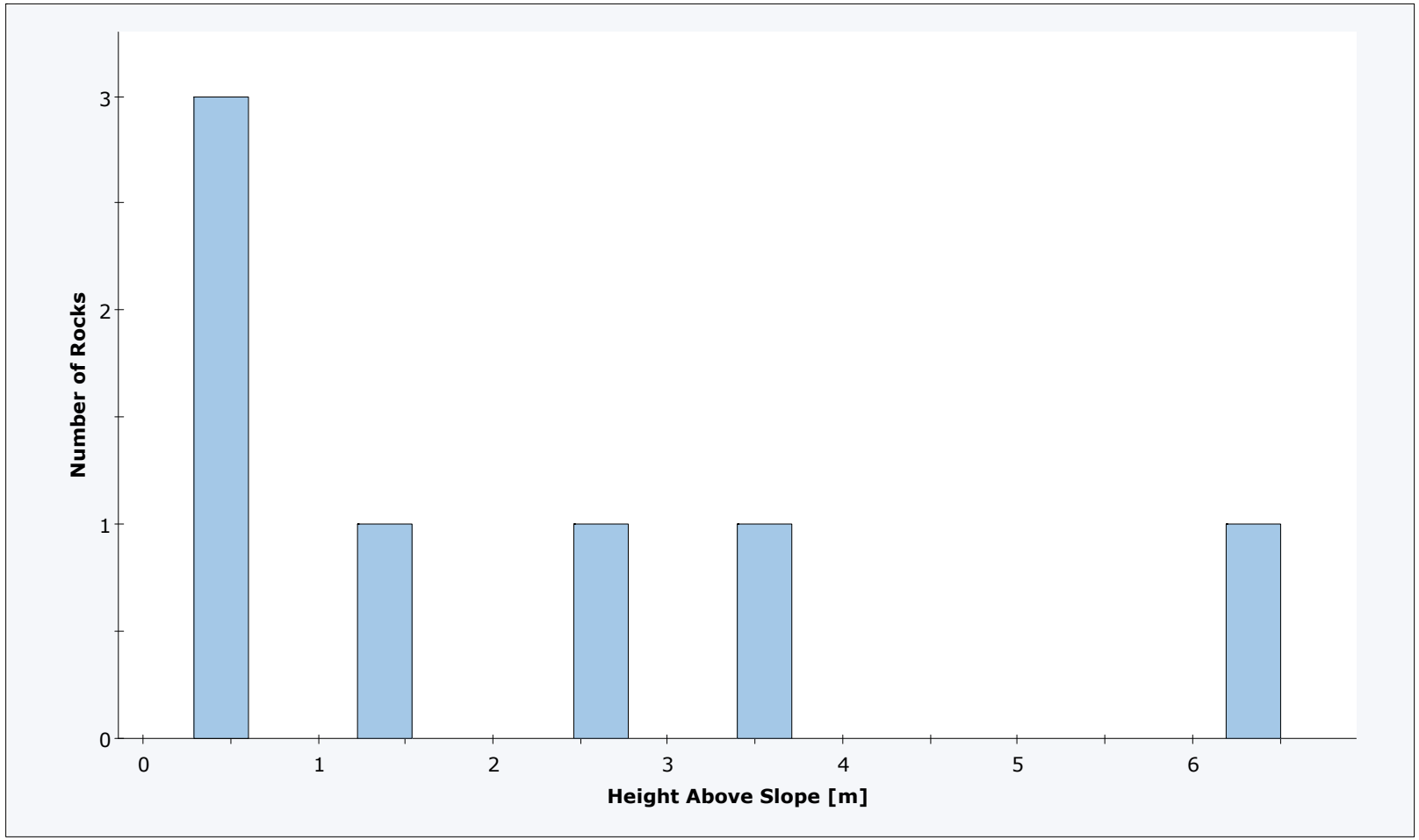
ROCFALL 8.024

Bounce Height Distribution at x = 2332.1



Total number of rock paths: 289

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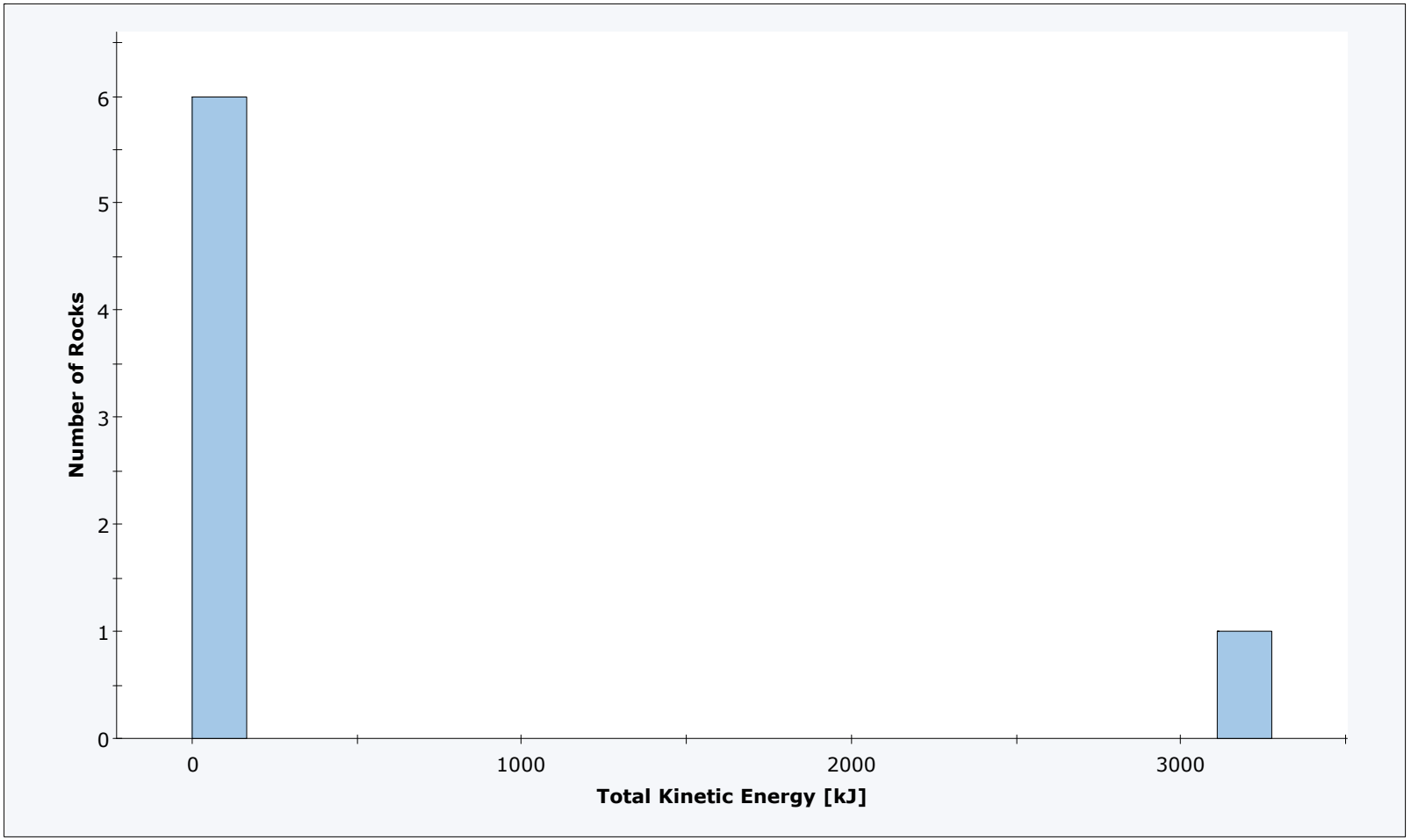
ROCFALL 8.024

Total Kinetic Energy Distribution at x = 2329.46



Total number of rock paths: 289

rocscience	*Project*	GEO 1 1 A	
	Analysis Description	Analisi caduta massi stato di progetto	
	Drawn By	Emiliano Quadernari	*Company* Geo Group
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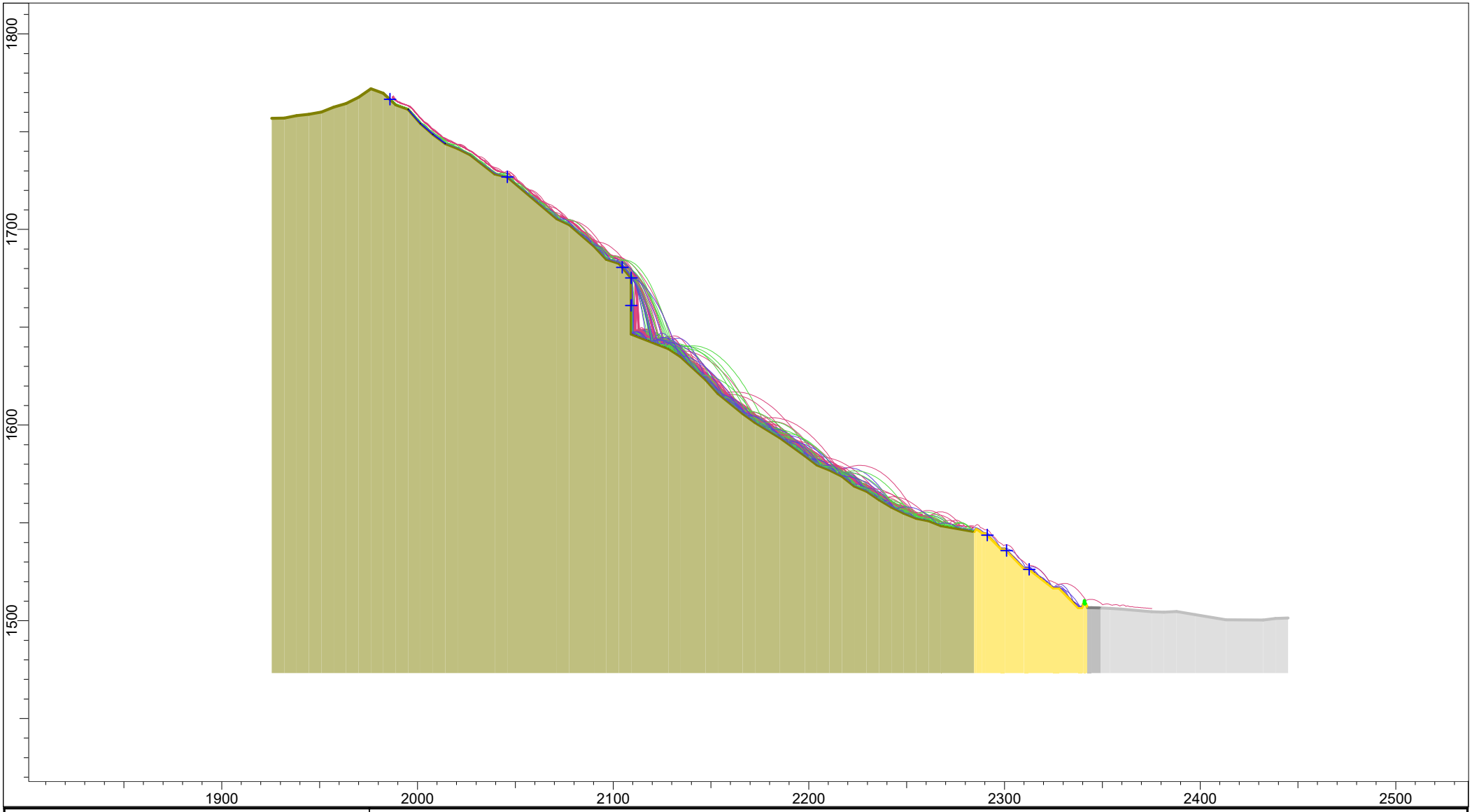
ROCFALL 8.024



rocscience	*Project*	GEO 1 1 A	
	Analysis Description	Analisi caduta massi stato di progetto	
	Drawn By	Emiliano Quadernari	*Company* Geo Group
	Date	16/11/2023, 15:51:31	*File Name* GEO 1 1 A - ANALISI CADUTA MASSI.fal8

ROCFALL 8.024

CITTÀ METROPOLITANA DI BOLOGNA

Comune di Crevalcore | Comune di San Giovanni in Persiceto | Comune di Casalecchio di Reno | Comune di Bologna | Comune di Sasso Marconi | Comune di Marzabotto

Ciclovia del Sole: tratto 3 attraversamento dei centri abitati di Crevalcore, San Giovanni in Persiceto, Sala Bolognese - tratto 4: Casalecchio - Marzabotto

CUP n° C61B21013060002

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Coordinamento della sicurezza:
ing. Fausto Gallarello, ing. Roberto Perlangeli

Consolidamento e Mitigazione del Rischio di Dissesto Verifiche di Progetto - Analisi di Stabilità di Versante Marzabotto - Monte Baco - Opera 1

SCALA	FORMATO
-	Varie
CODICE	**DATA**
GEO_1_1_A	30/11/2023

N. REV.	DATA	DESCRIZIONE	DISEGNATO	CONTROLLATO	APPROVATO
A	*30/11/2023*	*Prima Emissione*	*E.Q.*	*P.D.*	

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Slide Analysis Information

Document Name

File Name: Verifica Opera 1.sli

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: SI Units
Pore Fluid Unit Weight: 9.81 kN/m3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Bishop simplified
Janbu simplified

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: ROCCIA IN POSTO
Strength Type: Generalised Hoek-Brown
Unit Weight: 23 kN/m3
Unconfined Compressive Strength (intact): 50000 kPa
mb: 0.477966
s: 8.10625e-005
a: 0.51595
Water Surface: None

Material: DETRITO VERSANTE
Strength Type: Mohr-Coulomb
Unit Weight: 20 kN/m3
Cohesion: 4 kPa

Friction Angle: 27.5 degrees
Water Surface: None

Material: DEPOSITO DI FRANA
Strength Type: Undrained
Unit Weight: 17 kN/m3
Cohesion Type: Constant
Cohesion: 10 kPa
Water Surface: None

Material: GHIAIA
Strength Type: Mohr-Coulomb
Unit Weight: 20 kN/m3
Cohesion: 0 kPa
Friction Angle: 43 degrees
Water Surface: None

Material: RICOSTITUITO
Strength Type: Mohr-Coulomb
Unit Weight: 20 kN/m3
Cohesion: 10 kPa
Friction Angle: 30 degrees
Water Surface: None

Support Properties

Support: RETE
RETE
Support Type: GeoTextile
Force Application: Active
Force Orientation: Parallel to Reinforcement
Anchorage: Slope Face
Shear Strength Model: Linear
Strip Coverage: 100 percent
Tensile Strength: 50 kN/m
Pullout Strength Adhesion: 10 kN/m2
Pullout Strength Friction Angle: 40 degrees

Support: CHIODI
CHIODI
Support Type: Soil Nail
Force Application: Active
Out-of-Plane Spacing: 3 m
Tensile Capacity: 100 kN
Plate Capacity: 100 kN
Bond Strength: 50 kN/m

Global Minimums

Method: bishop simplified
FS: 1.854690
Center: 2738.202, 1878.540
Radius: 37.895
Left Slip Surface Endpoint: 2712.335, 1850.846
Right Slip Surface Endpoint: 2721.562, 1844.494
Resisting Moment=4260.75 kN-m
Driving Moment=2297.28 kN-m

Method: janbu simplified
FS: 1.684200
Center: 2737.475, 1876.311
Radius: 35.744
Left Slip Surface Endpoint: 2712.391, 1850.846
Right Slip Surface Endpoint: 2721.923, 1844.128
Resisting Horizontal Force=95.3149 kN
Driving Horizontal Force=56.5936 kN

Valid / Invalid Surfaces

Method: bishop simplified
Number of Valid Surfaces: 69630
Number of Invalid Surfaces: 42581
Error Codes:
Error Code -102 reported for 123 surfaces
Error Code -105 reported for 1 surface
Error Code -106 reported for 690 surfaces
Error Code -107 reported for 25859 surfaces
Error Code -108 reported for 333 surfaces
Error Code -111 reported for 44 surfaces
Error Code -112 reported for 527 surfaces
Error Code -1000 reported for 15004 surfaces

Method: janbu simplified
Number of Valid Surfaces: 69005
Number of Invalid Surfaces: 43206
Error Codes:
Error Code -102 reported for 123 surfaces
Error Code -105 reported for 1 surface
Error Code -106 reported for 690 surfaces
Error Code -107 reported for 25859 surfaces
Error Code -108 reported for 1120 surfaces
Error Code -111 reported for 167 surfaces
Error Code -112 reported for 242 surfaces
Error Code -1000 reported for 15004 surfaces

Error Codes

The following errors were encountered during the computation:

-102 = Two surface / slope intersections,
but resulting arc is actually outside soil region.

-105 = More than two surface / slope
intersections with no valid slip surface.

-106 = Average slice width is less than
0.0001 * (maximum horizontal extent of soil region).
This limitation is imposed to avoid numerical errors
which may result from too many slices, or too
small a slip region.

-107 = Total driving moment or
total driving force is negative. This will occur
if the wrong failure direction is specified,

or if high external or anchor loads are applied against the failure direction.

-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).

-111 = safety factor equation did not converge

-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.

-1000 = No valid slip surfaces are generated at a grid center. Unable to draw a surface.

List of All Coordinates

Search Grid

2715.271	1875.993
2751.670	1875.993
2751.670	1907.831
2715.271	1907.831

Material Boundary

2670.197	1880.057
2676.068	1879.036

Material Boundary

2664.917	1879.557
2680.076	1876.468

Material Boundary

2712.307	1850.846
2720.609	1843.525
2724.524	1841.486

Material Boundary

2725.148	1840.853
2731.662	1836.369
2741.419	1836.369

Material Boundary

2726.148	1840.853
2729.148	1840.853

External Boundary

2664.917	1830.461
2741.419	1830.461
2741.419	1836.369
2741.419	1840.461
2731.145	1840.853

2729.148 1840.853
2728.148 1842.853
2727.148 1842.853
2726.148 1840.853
2725.148 1840.853
2724.524 1841.486
2715.307 1850.846
2712.307 1850.846
2699.460 1860.846
2697.460 1860.846
2687.613 1870.846
2685.613 1870.846
2680.076 1876.468
2677.853 1878.726
2676.068 1879.036
2674.374 1880.853
2671.418 1881.367
2670.197 1880.057
2664.917 1880.974
2664.917 1879.557

Support
2676.068 1879.036
2677.853 1878.726

Support
2677.853 1878.726
2685.613 1870.846

Support
2685.613 1870.846
2687.613 1870.846

Support
2687.613 1870.846
2697.460 1860.846

Support
2697.460 1860.846
2699.460 1860.846

Support
2699.460 1860.846
2712.307 1850.846

Support
2712.307 1850.846
2715.307 1850.846

Support
2725.148 1840.853
2715.307 1850.846

Support
2677.853 1878.726
2675.732 1876.604

Support
2682.063 1874.451
2679.942 1872.329

Support
2686.554 1870.846
2684.433 1868.725

Support
2691.080 1867.325
2688.958 1865.204

Support
2695.289 1863.050
2693.168 1860.929

Support
2700.175 1860.289
2698.054 1858.168

Support
2704.910 1856.604
2702.789 1854.482

Support
2709.645 1852.918
2707.523 1850.797

Support
2715.307 1850.846
2713.186 1848.725

Support
2717.412 1848.709
2715.290 1846.587

Support
2719.517 1846.571
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Support
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Support
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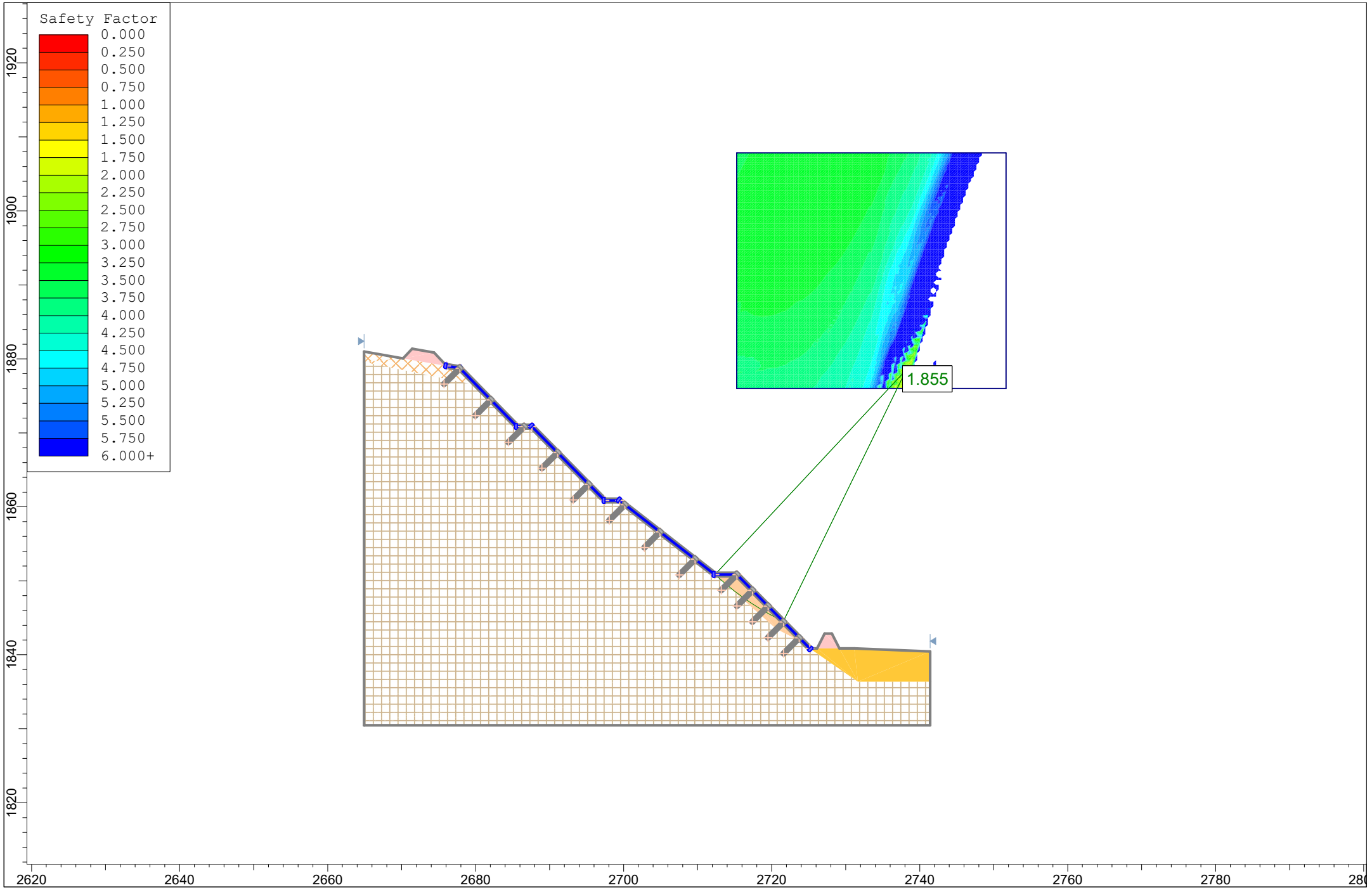
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0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
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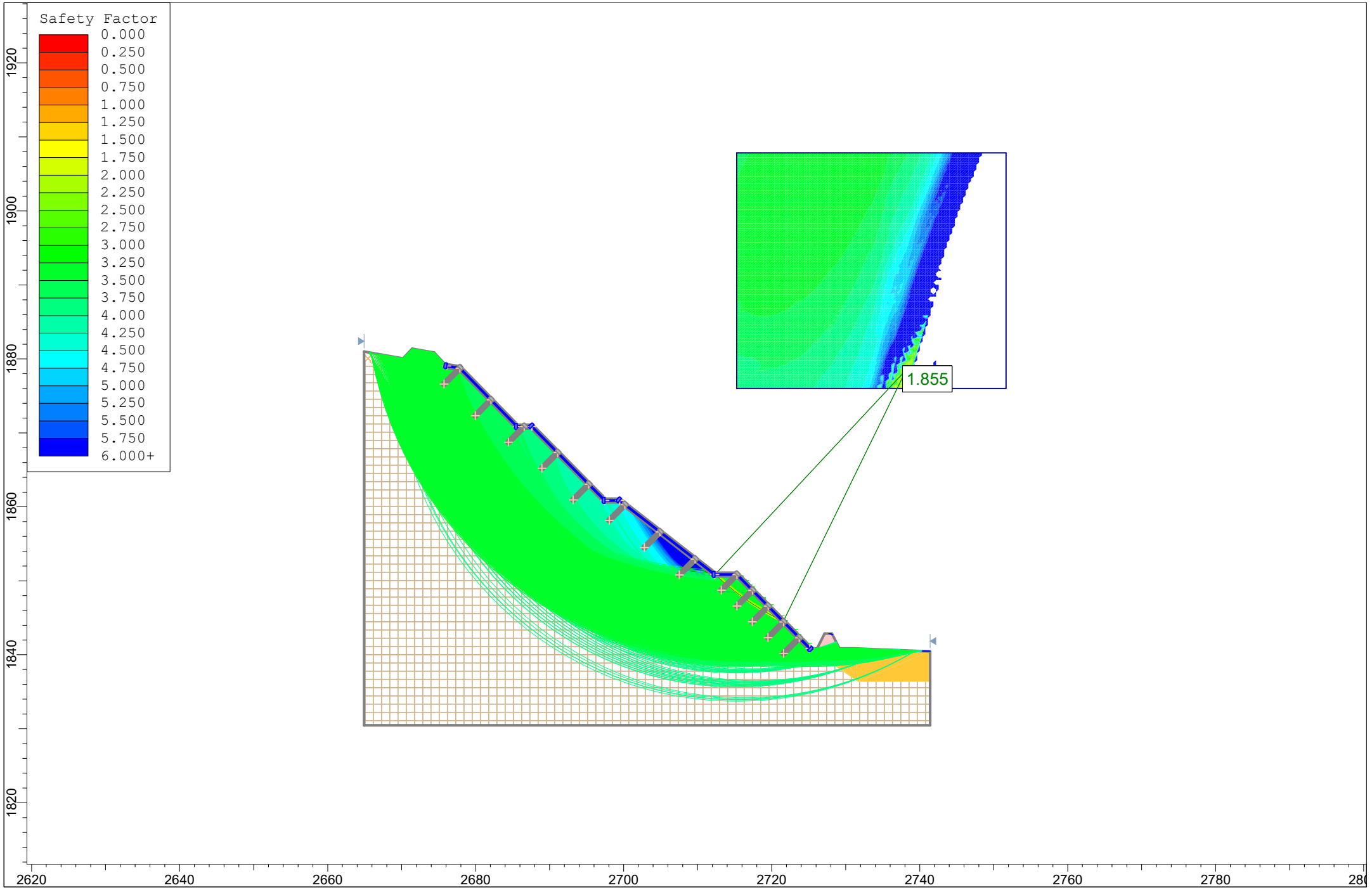
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.855
1920
1900
1880
1860
1840
1820
2620
2640
2660
2680
2700
2720
2740
2760
2780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2.500
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3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.855
1920
1900
1880
1860
1840
1820
2620
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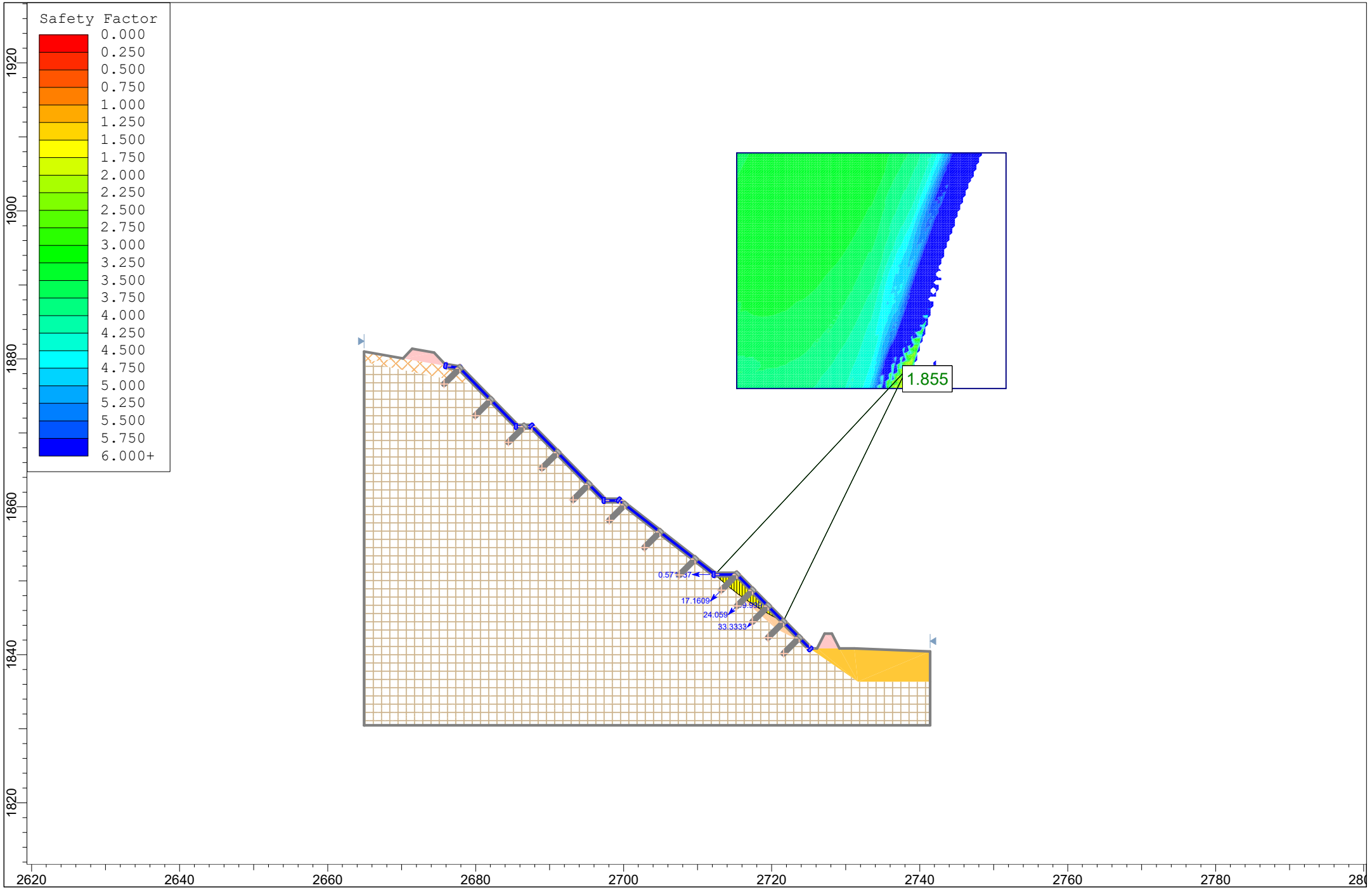
2660
2680
2700
2720
2740
2760
2780


Safety Factor
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3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
1.855
0.57
17.1609
24.059
33.3333
1920
1900
1880
1860
1840
1820
2620
2640
2660
2680
2700
2720
2740
2760
2780

CITTÀ METROPOLITANA DI BOLOGNA

Comune di Crevalcore | Comune di San Giovanni in Persiceto | Comune di Casalecchio di Reno | Comune di Bologna | Comune di Sasso Marconi | Comune di Marzabotto

Ciclovia del Sole: tratto 3 attraversamento dei centri abitati di Crevalcore, San Giovanni in Persiceto, Sala Bolognese - tratto 4: Casalecchio - Marzabotto

CUP n° C61B21013060002

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Consolidamento e Mitigazione del Rischio di Dissesto
SINTESI NON TECNICA
Marzabotto – Monte Baco - Opera 1

SCALA	FORMATO
-	Varie
CODICE	DATA
GEO_1_1_A	30/11/2023

N. REV.	DATA	DESCRIZIONE	DISEGNATO	CONTROLLATO	APPROVATO
A	*30/11/2023*	*Prima Emissione*	*E.Q.*	*P.D.*	*E. Guaitoli Panini*

FAHRE ASSOCIATI | MJW structures | GEO GROUP GEOLOGIA E AMBIENTE | Galileo ingegneria

Sommario

1. Premessa

Il presente elaborato illustra le caratteristiche del progetto GEO_1_1_A o Opera 1 inerente la messa in sicurezza attraverso consolidamento di versante di una porzione del Monte Baco attualmente interessata dalla presenza di un deposito franoso.

Il presente elaborato andrà ad illustrare le caratteristiche previste in sede di progettazione definitiva e sintetizzerà i principali aspetti del progetto e gli elementi migliorativi rispetto alla sicurezza del tratto di ciclovia interessato.

1.1 Riferimenti normativi

Il presente studio è stato condotto secondo la seguente Normativa Tecnica e documentazione di riferimento:

- **OPCM 3274/2003 -** Primi elementi in materia di criteri generali per la classificazione sismica del territorio nazionale e normative tecniche per le costruzioni in zona sismica;
- **D.M. 17.01.2018** - Norme Tecniche per le Costruzioni 2018;
- **Circolare 21 gennaio 2019 n. 7/C.S.LL.PP. -** Circolare esplicativa delle NTC 2018;
- **D.G.R. 476/2021**– Aggiornamento dell'"Atto di coordinamento tecnico sugli studi di microzonazione sismica per la pianificazione territoriale e urbanistica (artt. 22 e 49, L.R. n. 24/2017)" di cui alla deliberazione della Giunta regionale 29 aprile 2019 n. 630.

2. Inserimento opera

L'opera in progetto va ad inserirsi alle pendici di un tratto del Monte Baco all'interno di un'area inserita nel perimetro del Parco di Monte Sole.

L'opera va inoltre a trovarsi in destra idrografica rispetto al Fiume Reno nei pressi dello sbarco della passerella in Comune di Marzabotto.

Di seguito si propone un'immagine che identifica l'inserimento urbanistico ambientale del consolidamento in progetto.

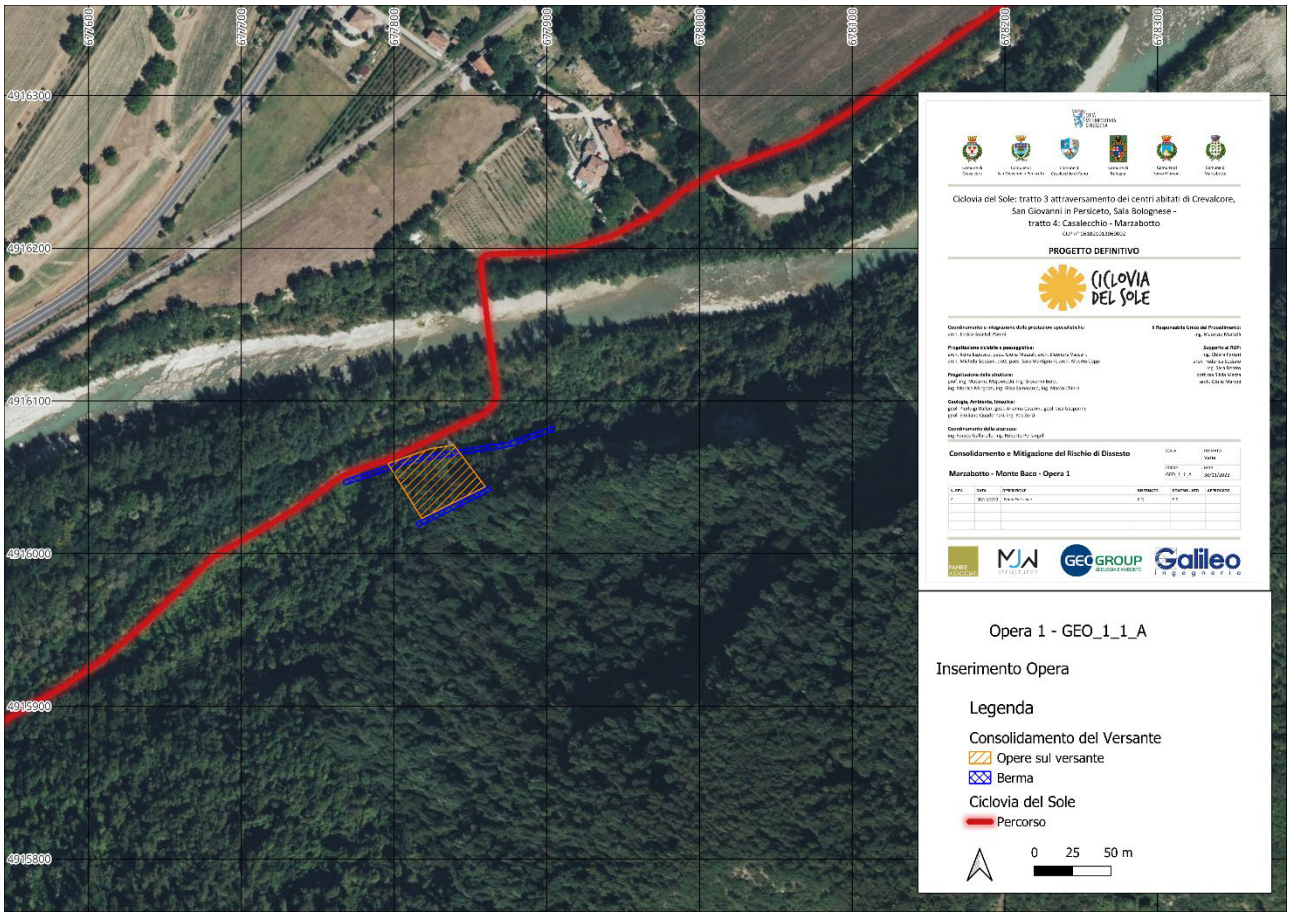

Figura 1: inserimento opera 1

3. Caratteristiche opere in progetto

Per l'opera in progetto è prevista la realizzazione in numero 2 fasi di lavorazione principale, il primo intervento sarà quello di disboscamento della vegetazione ad alto e basso fusto interferente con l'opera a cui seguirà il ripristino morfologico del versante secondo le caratteristiche di progetto. La seconda fase invece vedrà la realizzazione di un'opera di rafforzamento corticale con l'utilizzo di ancoraggi di tipo Sirive e la posa in opera di rete a doppia torsione e funi in acciaio.

3.1 Fase 1 – Movimento Terra

Nella prima fase di esecuzione dell'opera sarà necessaria la rimozione della vegetazione arbustiva per un'area complessiva pari a circa 2000 m^2. L'area di disboscamento è rappresentata dal poligono arancione presente in figura 1. In questa prima fase dovranno intervenire, per ragioni di sicurezza, operatori qualificati come rocciatori per eseguire tutte le operazioni di esbosco.

La riprofilazione del versante è resa necessaria dalla presenza di un deposito di frana complessa. Il ripristino morfologico è da attuarsi attraverso la rimozione di terreno, per un volume pari 3500 m^3, e la realizzazione di 4 gradoni ed altrettante banche, per i primi due gradoni partendo dalla sommità è previsto che questi abbiano un angolo di inclinazione pari a 45° e un'altezza pari a 8 metri per il primo e 10 metri per il secondo. Il terzo gradone è previsto con un angolo di inclinazione pari 38° ed un'altezza pari a 10 metri, mentre per l'ultimo gradone è previsto che questo abbia un angolo di inclinazione pari a 45° ed un'altezza pari a 10 metri.

Lo scopo del ripristino morfologico del versante è duplice: da un lato risulta necessario per rimuovere il materiale in frana e dall'altro per poter esporre la roccia in posto e offrire una buona superficie di adesione per l'opera di rafforzamento corticale.

In relazione alle evidenze raccolte e alle analisi di tipo probabilistico eseguite rispetto alla possibilità di caduta massi e anche al fine di recuperare almeno in parte il materiale terrigeno che verrà escavato durante il ripristino morfologico, si è prevista la realizzazione di due berme una a monte del pendio oggetto di lavorazione e una a valle dello stesso, che si frapponga con una distanza di 1.00 metri dal piede del versante.

Le berme sono state progettate di due tipologie:

- Berma Alta: la berma alta assume la forma di un trapezio scaleno in sezione e ha lo scopo di intercettare i materiali potenzialmente provenienti dalla porzione più alta del versante. La berma ha un'altezza di 150 cm ed una lunghezza di 54 m per un volume complessivo pari a 350 m^3.
- Berma Bassa: la berma alta assume la forma di un trapezio isoscele in sezione e ha lo scopo di intercettare i materiali potenzialmente provenienti dalla porzione più bassa del versante. La berma ha un'altezza di 200 cm ed una lunghezza di 150 m per un volume complessivo pari a 600 m^3.

  Al termine della costruzione della berma è prevista l'installazione sulla sua sommità di una rete da recizione.

Le tavole di progetto riportano i disegni e le quote dei dettagli di progetto.

3.2 Fase 2 – Rafforzamento Corticale

Nella seconda fase di realizzazione dell'opera, al fine di rendere meno impattante l'effetto del weathering sulla formazione in posto esposta dalle lavorazioni precedenti e per evitare che frammenti rocciosi possano staccarsi dal versante, si è prevista la realizzazione di un rafforzamento corticale con l'utilizzo di sola rete a doppia torsione, funi e ancoraggi.

Per l'ora si è valutato l'utilizzo di una maglia di ancoraggio 6x6 per i primi 3 gradoni e di una maglia di ancoraggio 3x6 per l'ultimo gradone in modo da contenere meglio il deposito non rimosso nella fase 1. Il tipo di ancoraggio stimato è il Sirive Autoperforante e tutti le chiodature sono previste di lunghezza pari a 5 metri con inserimento a 45° dal profilo orizzontale, questo per garantire maggiore resistenza all'opera. A ciascun chiodo Sirive dovrà essere applicata una piastra d'acciaio da 15 cm che permetta di trattenere in sede la rete sottostante.

Per quanto concerne le reti si è optato per reti a doppia torsione a maglia esagonale con rivestimento in zinco alluminio, la maglia di progetto è la 8x10 con un diametro di filo pari a 3 mm.

4. Verifica opere in progetto

4.1.Analisi caduta massi

L'analisi di caduta massi è stata eseguita con l'ausilio del software RocFall di RocScience.

Partendo dal profilo dello stato di progetto sono state modellate le possibili sorgenti di distacco del materiale roccioso. I materiali potenzialmente distaccabili sono stati caratterizzati in rocce di grandi dimensioni, di piccole dimensioni e di dimensioni molto piccole in modo da cercare di simulare nel modo più accurato possibile quanto è stato osservato in sito.

Rock Types

LARGE ROCK

Properties					
Name	LARGE ROCK				
Color					
Smooth Shapes	Sphere				
Polygons	Polygon Triangle, Polygon Octagon	Polygon Square,	Polygon Pentagon,	Polygon Hexagon,	
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (kg)	66420	None			
Density (kg/m3)	2460	None			

SMALL ROCK

Properties					
Name	SMALL ROCK				
Color					
Smooth Shapes	Sphere				
Polygons	Polygon Triangle, Polygon Octagon	Polygon Square,	Polygon Pentagon,	Polygon Hexagon,	
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (kg)	307.5	None			
Density (kg/m3)	2460	None			

VERY SMALL ROCK

Properties					
Name	VERY SMALL ROCK				
Color					
Smooth Shapes	Sphere				
Polygons	Polygon Triangle, Polygon Octagon	Polygon Square,	Polygon Pentagon,	Polygon Hexagon,	
	Mean	Distribution	Std.Dev.	Rel. Min	Rel. Max
Mass (kg)	16.9	None			
Density (kg/m3)	2460	None			

Figura 2: tipologia di rocce simulate e loro geometria.

Per ciascuno punto sorgente si è scelto di fornire un numero di rocce in distacco sempre superiore a 20 per tipo di roccia in modo da cercare di simulare il maggior numero di eventi.

Tutta l'analisi è stata condotta simulando un versante privo di vegetazione, questo al fine di porsi nella condizione più cautelativa possibile poiché in questo modo l'effetto di rallentamento delle piante è escluso.

Sulla base dei dati di input forniti il software ha restituito risultati ragionevolmente confortanti, infatti solamente in uno dei casi analizzati un masso ha superato la berma bassa a protezione della ciclovia. L'evento rappresenta lo 0,34% dei possibili percorsi di crollo e rotolamento presi in considerazione. Inoltre il blocco in questione è rotolato lungo l'intero percorso, sul quale in condizioni reali incontrerebbe piante e avrebbe la tendenza a rompersi, per cui è ragionevole ritenere che le probabilità che detto siano possibilmente anche inferiori allo 0,34%.

Al termine dell'analisi condotta si ritiene ragionevole assumere come accettabile la probabilità di superamento di un blocco verificata pari a 0,34% dei percorsi possibili.

4.2.Verifica di stabilità di versante

L'analisi di stabilità di versante è stata eseguite con l'approccio LEM o dell'Equilibrio Limite ed è stata condotta con particolare attenzione per la porzione terminale del versante ossia quella che il progetto intende venga riprofilata. L'analisi è stata eseguita attraverso il software Slide di RocScience.

La modellazione geotecnica per definire la definizione dei parametri dell'ammasso roccioso è stata eseguita attraverso l'approccio GSI, mentre la parametrizzazione del materiale terrigeno o pseudo terrigeno deriva dalle indagini eseguite nei pressi del sito oggetto di analisi. Di seguito si propongono i parametri in ingresso alla verifica.

Material Properties

Material: ROCCIA IN POSTO
Strength Type: Generalised Hoek-Brown
Unit Weight: 23 kN/m3
Unconfined Compressive Strength (intact): 50000 kPa
mb: 0.477966
s: 8.10625e-005
a: 0.51595
Water Surface: None

Material: DETRITO VERSANTE
Strength Type: Mohr-Coulomb
Unit Weight: 20 kN/m3
Cohesion: 4 kPa
Friction Angle: 27.5 degrees
Water Surface: None

Material: DEPOSITO DI FRANA
Strength Type: Undrained
Unit Weight: 17 kN/m3
Cohesion Type: Constant
Cohesion: 10 kPa
Water Surface: None

Material: GHIAIA
Strength Type: Mohr-Coulomb
Unit Weight: 20 kN/m3
Cohesion: 0 kPa
Friction Angle: 43 degrees
Water Surface: None

Material: RICOSTITUITO
Strength Type: Mohr-Coulomb
Unit Weight: 20 kN/m3
Cohesion: 10 kPa
Friction Angle: 30 degrees
Water Surface: None

L'analisi è stata condotta nelle sole condizioni non drenate dal momento che si è prevista la rimozione del deposito e che la roccia in posto non appare in grado di costituire condizioni di quel tipo. Per l'analisi si è diviso il valore dei parametri geotecnici di 1.25 come previsto da normativa.

L'analisi condotta ha modellato anche la presenza delle opere di consolidamento così come disegnate in progetto, si osserva dunque il contributo di resistenza fornito dalle chiodature e dalla rete di rinforzo corticale.

L'analisi può ritenersi superata poiché il fattore di sicurezza è pari a F.S. = 1.85.