Stability Analysis of the Slope above the Road

Project	SSA user manual tutorial case
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Date	2026-11-01
Software	SSA Slope Stability Analysis (web edition) v2.10.2 (2026-11-01), https://cychen59.github.io/ssa-slope-stability/
Method	simplified Janbu method, judged by uncorrected Fs
Notes	Tutorial case; parameters are assumed values.

1. Method of analysis

Slope stability is analysed by the two-dimensional limit equilibrium method of slices. The critical slip surface of arbitrary shape is searched by dynamic programming (DP) (Nakamura and Kubota, 1987; Baker, 1980), with entry and exit points determined by the computation. Pore pressure is obtained from the water table, u = γw·hw, and earthquake loading by the pseudo-static method with horizontal and vertical coefficients kh and kv.

The factor of safety is computed by the simplified Janbu method, which satisfies force equilibrium only; the correction factor f0 follows the selected formula.

2. Input data

2.1 Geometry

Line	Points (x, z) (m)
Ground surface	(0.00, 10.00) (9.07, 10.00) (10.50, 12.50) (15.00, 12.50) (35.00, 22.50) (50.00, 24.00) (70.00, 25.00)
Top of Weathered rock	(0.00, 6.00) (15.00, 7.50) (35.00, 16.00) (70.00, 19.00)
Top of Bedrock	(0.00, 2.00) (35.00, 9.00) (70.00, 12.00)
Water table	(0.00, 7.00) (15.00, 8.50) (35.00, 17.00) (70.00, 21.00)
Model base elevation	0.00 m

2.2 Soil properties

Layer	γ (kN/m³)	γsat (kN/m³)	c′ (kPa)	φ′ (°)	Pore pressure	Bedrock
Colluvium	18.00	20.00	5.00	28.0	water table	—
Weathered rock	21.00	22.00	30.00	32.0	water table	—
Bedrock	24.00	24.00	200.00	40.0	—	yes

2.3 Surface loads

Name	Type	Position x (m)	Magnitude	Seismic inertia
Traffic	Distributed	36.00 – 44.00	10.00 kPa	no

2.4 Reinforcement (passive method)

No.	Type	Head (x, z)	θ (°)	L (m)	Sh (m)	Capacities
1	Soil nail	16.00, 13.00	15.0	9.00	1.50	Tt 180.00, q 40.00, Tf 150.00
2	Soil nail	18.57, 14.29	15.0	9.00	1.50	Tt 180.00, q 40.00, Tf 150.00
3	Soil nail	21.14, 15.57	15.0	9.00	1.50	Tt 180.00, q 40.00, Tf 150.00
4	Soil nail	23.71, 16.86	15.0	9.00	1.50	Tt 180.00, q 40.00, Tf 150.00
5	Soil nail	26.29, 18.14	15.0	9.00	1.50	Tt 180.00, q 40.00, Tf 150.00
6	Soil nail	28.86, 19.43	15.0	9.00	1.50	Tt 180.00, q 40.00, Tf 150.00

No.	Type	Head (x, z)	θ (°)	L (m)	Sh (m)	Capacities
7	Soil nail	31.43, 20.71	15.0	9.00	1.50	Tt 180.00, q 40.00, Tf 150.00
8	Soil nail	34.00, 22.00	15.0	9.00	1.50	Tt 180.00, q 40.00, Tf 150.00

2.5 Retaining walls

Name	Type	γ (kN/m³)	Dimensions	Vertices (x, z) (m)
Gravity wall at the toe	Gravity	23.50	H 3.50, B 3.00, b 1.00 m ; toe at (8.50, 9.00)	(8.50, 9.00) (11.50, 9.00) (11.50, 12.50) (10.50, 12.50)

2.6 Analysis settings

Seismic kh / kv	0.000 / 0.000
Unit weight of water γw	9.81 kN/m³
Inclined water table correction	no
Tension crack	not considered
Search grid (lines × nodes)	60 × 80, slices per segment 4
Minimum slip depth	1.00 m
Concavity / no boundary crossing	✓ / ✓
Tolerance ΔF / max iterations	0.0001 / 30
Correction factor f0	f0 = (50d/L)^0.03
Required Fs (current model)	1.50

3. External stability of retaining walls

External stability treats the wall and the soil above its base slab as a rigid body and checks sliding, overturning, the position of the resultant and bearing capacity from force equilibrium. For gravity walls the active earth pressure on the back is computed by the Coulomb formula; for cantilever and counterfort walls it acts on a vertical virtual back through the heel, by the Rankine formula (δ = β), with the soil above the base slab counted in the wall weight. In seismic cases the earth pressure follows the Mononobe–Okabe formula and the inertia kh·W of the wall and soil is included. Water pressure behind the wall and uplift on the base follow the water table; bearing capacity is computed by the Meyerhof formula (effective width B′ = B − 2e, with depth and load inclination factors).

Required values follow “Soil and Water Conservation Technical Regulations Art. 120”: sliding Fs ≥ 1.5 (seismic 1.2), overturning Fs ≥ 2.0 (seismic 1.5), bearing Fs ≥ 3.0 (seismic 3.0); the resultant must lie in the middle third of the base on soil (e ≤ B/6) and in the middle half on rock (e ≤ B/4).

3.1 W1 Gravity wall at the toe (Gravity)

Item	Normal	Heavy rain	Earthquake（kh 0.15）
Sliding Fs	4.13 ≥ 1.5 OK	2.77 ≥ 1.5 OK	1.35 ≥ 1.2 OK
Overturning Fs	22.85 ≥ 2.0 OK	5.29 ≥ 2.0 OK	5.47 ≥ 1.5 OK
Eccentricity |e| (m)	0.319 ≤ 0.500 OK	0.346 ≤ 0.500 OK	0.074 ≤ 0.500 OK
qmax / qmin (kPa)	95.85 / 21.19	82.36 / 15.00	68.62 / 50.96
Bearing	Fs 6.44 ≥ 3.0 OK	Fs 3.72 ≥ 3.0 OK	Fs 5.21 ≥ 3.0 OK
Result	OK	OK	OK
Backfill / foundation φ′	Colluvium 28.0° / Colluvium 28.0°	Colluvium 28.0° / Colluvium 28.0°	Colluvium 28.0° / Colluvium 28.0°
β / δ / K	0.0° / 18.7° / 0.3213	0.0° / 18.7° / 0.3213	0.0° / 18.7° / 0.4362 (M–O)
h (m) / q (kPa)	3.50 / 0.00	3.50 / 0.00	3.50 / 0.00
Pa (kN/m) / height (m)	18.36 / 0.84	16.69 / 0.89	30.30 / 0.93
Pw / U (kN/m)	0.00 / 0.00	6.49 / 29.43	0.00 / 0.00
ΣW / ΣV / ΣH (kN/m)	169.67 / 175.55 / 17.40	170.12 / 146.03 / 22.30	169.67 / 179.37 / 54.16
Mr / Mo (kN/m·m)	333.94 / 14.61	332.40 / 62.84	345.40 / 63.09
μ / Pp (kN/m)	0.338 / 12.46	0.338 / 12.46	0.338 / 12.46
qu (kPa) / B′ (m)	617.12 / 2.36	306.38 / 2.31	357.27 / 2.85

Moments are about the toe; ΣH includes the horizontal earth thrust, water pressure and seismic inertia, and ΣV is net of uplift.

4. Results (current model)

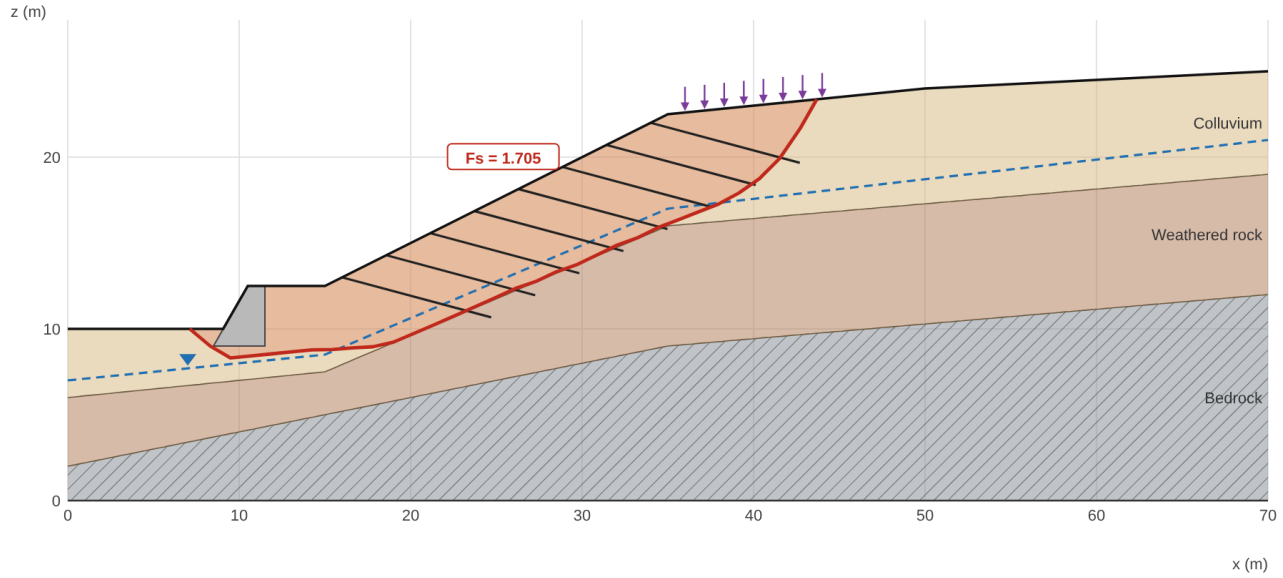


Figure 1 Cross-section and critical slip surface (search)

Factor of safety for judgement	1.705 (simplified Janbu, uncorrected)
Required Fs / result	1.50 / OK
Simplified Janbu Fs / f0·Fs	1.705 / 1.800 (f0 = 1.056)
Spencer Fs (λ)	1.848 (0.327)
Morgenstern–Price Fs (λ)	1.786 (0.450)
Sliding mass area / max depth	172.2 m²/m / 6.38 m
Toe exit / crest entry (x, z)	(7.12, 10.00) / (43.68, 23.37)
Fs without reinforcement	1.263
Fs without loads	1.753

Critical slip surface (x, z):(7.12, 10.00) (8.31, 9.00) (9.49, 8.31) (10.68, 8.43) (11.86, 8.54) (13.05, 8.66) (14.24, 8.77) (15.42, 8.80) (16.61, 8.89) (17.80, 8.96) (18.98, 9.23) (20.17, 9.73) (21.36, 10.23) (22.54, 10.75) (23.73, 11.27) (24.92, 11.81) (26.10, 12.35) (27.29, 12.76) (28.47, 13.31) (29.66, 13.72) (30.85, 14.30) (32.03, 14.88) (33.22, 15.30) (34.41, 15.89) (35.59, 16.34) (36.78, 16.81) (37.97, 17.27) (39.15, 17.92) (40.34, 18.75) (41.53, 19.93) (42.71, 21.66) (43.68, 23.37)

Member	Crossing (x, z)	Le (m)	T (kN/m)	Governed by
1 Soil nail	23.25, 11.06	1.50	39.97	pullout
2 Soil nail	25.99, 12.30	1.32	35.08	pullout
3 Soil nail	28.95, 13.48	0.92	24.50	pullout
4 Soil nail	31.71, 14.72	0.72	19.31	pullout
5 Soil nail	34.52, 15.93	0.48	12.76	pullout
6 Soil nail	37.54, 17.10	0.01	0.34	pullout
7 Soil nail	39.90, 18.44	0.23	6.15	pullout
8 Soil nail	41.55, 19.98	1.18	31.43	pullout

4.1 Slice details

124 slices in total; every 3th slice is listed below. The full table can be copied as CSV from “Slice details” on the web page.

x (m)	b (m)	z (m)	α (°)	W (kN/m)	u (kPa)	c′ (kPa)	φ′ (°)	Layer	R (kN/m)	D (kN/m)
7.27	0.30	9.87	-40.2	0.67	0.00	5.00	28.0	Colluvium	4.27	-0.56
8.16	0.30	9.12	-40.2	4.68	0.00	5.00	28.0	Colluvium	9.22	-3.94
9.05	0.30	8.57	-30.2	9.21	0.00	5.00	28.0	Colluvium	10.45	-5.37
9.94	0.30	8.35	5.8	20.98	0.00	5.00	28.0	Colluvium	12.38	2.13
10.83	0.30	8.44	5.6	27.37	0.00	5.00	28.0	Colluvium	15.71	2.67
11.72	0.30	8.53	5.6	21.20	0.00	5.00	28.0	Colluvium	12.50	2.06

x (m)	b (m)	z (m)	α (°)	W (kN/m)	u (kPa)	c′ (kPa)	φ′ (°)	Layer	R (kN/m)	D (kN/m)
12.61	0.30	8.62	5.6	20.74	0.00	5.00	28.0	Colluvium	12.26	2.02
13.50	0.30	8.70	5.6	20.28	0.00	5.00	28.0	Colluvium	12.02	1.97
14.39	0.30	8.78	1.1	19.88	0.00	5.00	28.0	Colluvium	11.98	0.39
15.28	0.30	8.80	1.1	20.52	0.00	5.00	28.0	Colluvium	12.32	0.41
16.17	0.30	8.86	4.6	22.64	1.35	5.00	28.0	Colluvium	13.07	1.82
17.06	0.30	8.92	3.2	24.88	4.46	5.00	28.0	Colluvium	13.81	1.41
17.94	0.30	8.99	12.7	27.03	7.43	5.00	28.0	Colluvium	14.42	6.11
18.83	0.30	9.20	12.7	28.43	9.17	5.00	28.0	Colluvium	14.88	6.42
19.72	0.30	9.54	22.7	28.99	9.50	5.00	28.0	Colluvium	16.01	12.14
20.61	0.30	9.92	23.1	29.36	9.52	5.00	28.0	Colluvium	16.27	12.53
21.50	0.30	10.30	23.5	29.70	9.50	5.00	28.0	Colluvium	16.52	12.91
22.39	0.30	10.68	23.5	30.01	9.41	5.00	28.0	Colluvium	16.70	13.04
23.28	0.30	11.08	23.9	30.28	9.27	5.00	28.0	Colluvium	59.66	13.40
24.17	0.30	11.47	24.2	30.52	9.08	5.00	28.0	Colluvium	17.17	13.75
25.06	0.30	11.87	24.6	30.74	8.85	5.00	28.0	Colluvium	17.40	14.09
25.95	0.30	12.28	24.6	30.92	8.56	5.00	28.0	Colluvium	55.00	14.17
26.84	0.30	12.60	18.9	31.61	9.11	5.00	28.0	Colluvium	17.01	10.81
27.73	0.30	12.97	25.2	32.07	9.28	5.00	28.0	Colluvium	18.18	15.07
28.62	0.30	13.37	19.1	32.29	9.07	5.00	28.0	Colluvium	17.41	11.18
29.51	0.30	13.67	19.1	33.07	9.76	5.00	28.0	Colluvium	17.71	11.44
30.40	0.30	14.08	25.7	33.24	9.46	5.00	28.0	Colluvium	18.93	16.02
31.29	0.30	14.51	26.1	33.28	8.92	5.00	28.0	Colluvium	19.11	16.30
32.18	0.30	14.93	19.5	33.41	8.56	5.00	28.0	Colluvium	18.14	11.83
33.07	0.30	15.25	19.5	34.14	9.18	5.00	28.0	Colluvium	18.43	12.08
33.96	0.30	15.67	26.6	34.22	8.72	5.00	28.0	Colluvium	19.81	17.17
34.85	0.30	16.06	20.6	34.51	8.60	5.00	28.0	Colluvium	18.87	12.95
35.74	0.30	16.40	21.5	33.39	6.75	5.00	28.0	Colluvium	18.69	13.14
36.63	0.30	16.75	21.5	31.85	4.31	5.00	28.0	Colluvium	19.87	13.70
37.52	0.30	17.10	21.5	30.30	1.87	5.00	28.0	Colluvium	19.79	13.11
38.41	0.30	17.52	28.6	28.43	0.00	5.00	28.0	Colluvium	20.16	17.12
39.30	0.30	18.02	34.9	26.20	0.00	5.00	28.0	Colluvium	20.74	20.33
40.19	0.30	18.64	34.9	23.36	0.00	5.00	28.0	Colluvium	18.90	18.35
41.08	0.30	19.49	45.0	19.33	0.00	5.00	28.0	Colluvium	20.33	22.29
41.97	0.30	20.58	55.5	13.97	0.00	5.00	28.0	Colluvium	22.49	24.64
42.86	0.30	21.92	60.4	7.29	0.00	5.00	28.0	Colluvium	18.36	18.06
43.75	0.08	23.30	60.4	0.10	0.00	5.00	28.0	Colluvium	5.38	5.39

5. Multi-case check

Water table, seismic coefficients and required factor of safety of each case are listed below; required values default to Art. 73 of the Soil and Water Conservation Technical Regulations (permanent slopes) and may be changed by the analyst according to the applicable code. The critical surface is searched separately for each case.

Case	Water table	kh	kv	Loads / reinf.	Fs	Required	Result
Normal	Water table of the profile	0.000	0.000	✓ / ✓	1.705	1.50	OK
Heavy rain	Water table raised by Δh 2.00 m	0.000	0.000	✓ / ✓	1.414	1.20	OK
Earthquake	Water table of the profile	0.150	0.000	✓ / ✓	1.187	1.10	OK

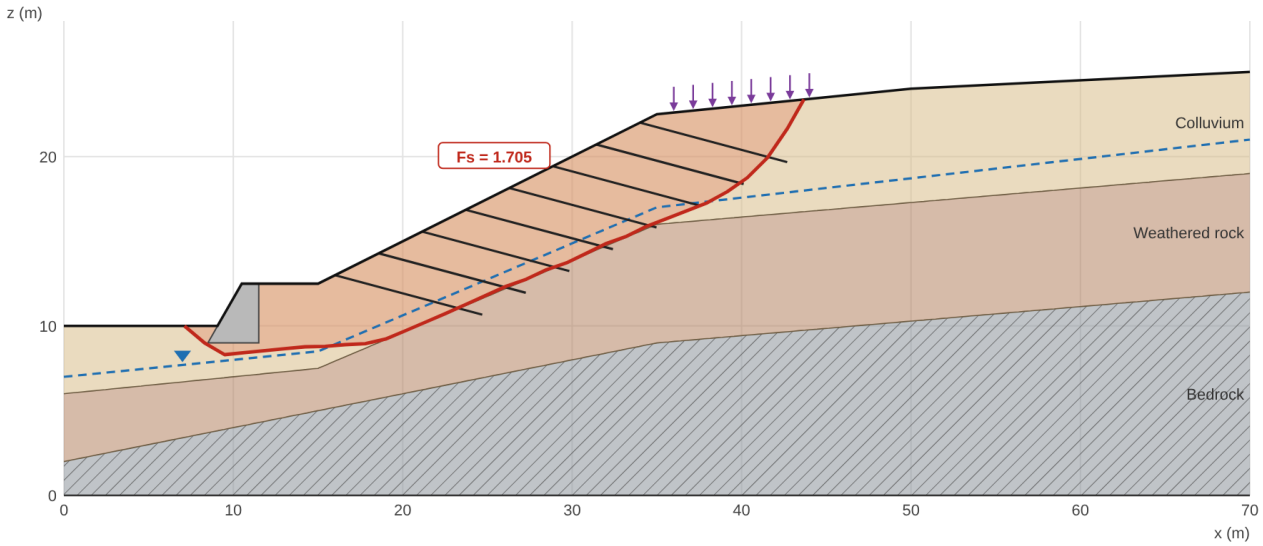


Figure 2 Critical slip surface, case “Normal”

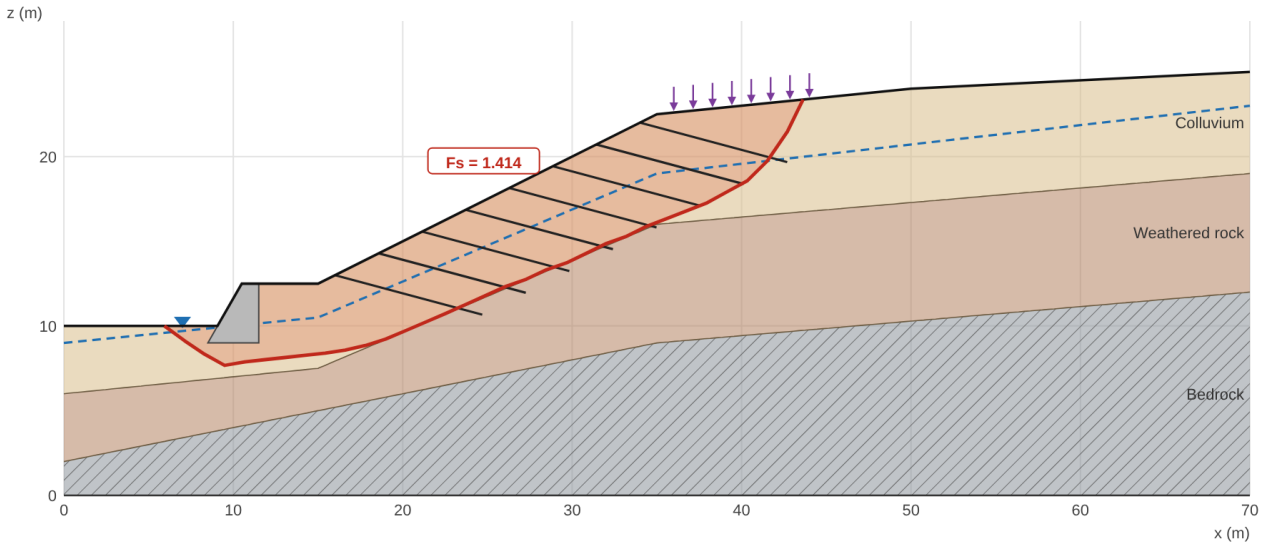


Figure 3 Critical slip surface, case “Heavy rain”

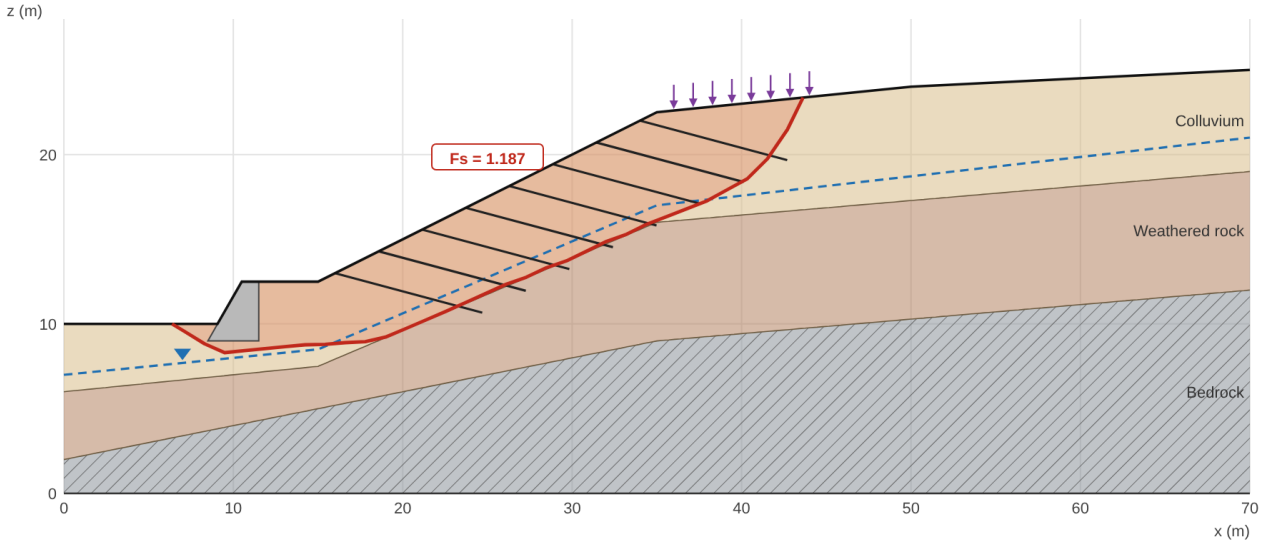


Figure 4 Critical slip surface, case “Earthquake”

6. Notes

This is a two-dimensional plane-strain limit equilibrium analysis; matric suction is not considered, pore pressure comes from water lines (hydrostatic) or ru without seepage analysis, and ponded water is treated as hydrostatic. Reinforcement carries tension only. External wall stability treats the wall as a rigid body and the earth pressure behind it includes uniform loads only; the structural strength of the stem and base slab must be checked separately. Results are for reference; engineering judgement and design remain the responsibility of qualified professionals based on site investigation and the applicable codes.

References: Chen, Fujita and Tsutsumi (2014), J. Chinese Soil and Water Conservation 45(4), 243-256; Nakamura and Kubota (1987), PWRI Technical Memorandum 2425; Spencer (1967); Morgenstern and Price (1965); Janbu (1973); Baker (1980); Coulomb (1776); Rankine (1857); Okabe (1926); Mononobe and Matsuo (1929); Meyerhof (1963).

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