# CiviLab 7.1 — Validation report

## Slope stability: Bishop, Spencer, Morgenstern-Price, Fellenius; pseudo-static earthquake; non-circular surfaces

Bakhti Softwares — edition of 06/11/2026 — "Stability" module (StabiliteTalus.vb)

## 1. Purpose and approach

This report checks the slope stability module of CiviLab 7.1 against **published cases**: for each case, the data of the publication are entered in CiviLab, the calculation is run with the automatic search of CiviLab, and the factor of safety obtained is compared with the published reference value and with the results of the GeoStudio SLOPE/W software published in its verification manual. It is completed by **analytical solutions**, a check of the **seismic coefficients** of the codes, an **independent recalculation** in Excel and the **automated tests** of the code.

Only cases whose data are fully published were retained. Cases with tension cracks, reinforcement, variable loads or water tables without levels are not covered by CiviLab or are not fully defined; they are not included here (see §8).

## 2. Methods checked

| Item | Formulation | Reference |
|---|---|---|
| Simplified Bishop | moment equilibrium, circles; F = Σ[c'b + (W − ub) tan φ'] / mα ÷ Σ W sin α | Bishop (1955) |
| Fellenius | ordinary method, circles (comparison) | Fellenius (1936) |
| Spencer, Morgenstern-Price | force and moment equilibrium, X = λ f(x) E (f = 1 or half-sine) | Spencer (1967); Morgenstern and Price (1965); algorithm of Zhu et al. (2005) |
| Non-circular surfaces | specified polygon; three-block search along a weak layer | NF P 94-270 §10.3, fig. 10.3 and 10.4 |
| Earthquake | kh·W at the centre of gravity of the slice, ±kv·W; combinations (kh, ±kv) | RPA 2024 §10.3; NF P 94-270 annex I.4 |
| EC7 check | design approach 3, A2 + M2 + R3, Fd ≥ γR;e·γR;d (10.2.1), γR;d = 1.10 | NF P 94-270 §10, annex C |

## 3. Published cases

### Summary

| Case | Method | Published reference | GeoStudio | CiviLab 7.1 | Difference / GeoStudio |
|---|---|---|---|---|---|
| ACADS 1(a) — simple homogeneous slope | Bishop | 1.00 | 0.993 | **0.985** | -0.8 % |
| ACADS 1(a) — simple homogeneous slope | Spencer | 1.00 | – | **0.984** | – |
| ACADS 1(a) — simple homogeneous slope | Morgenstern-Price | 1.00 | 0.993 | **0.985** | -0.8 % |
| ACADS — non-homogeneous slope (3 layers) | Bishop | 1.39 | 1.413 | **1.393** | -1.4 % |
| ACADS — non-homogeneous slope (3 layers) | Spencer | 1.39 | – | **1.365** | – |
| ACADS — non-homogeneous slope (3 layers) | Morgenstern-Price | 1.39 | 1.382 | **1.365** | -1.2 % |
| ACADS — non-homogeneous slope with earthquake, kh = 0.15 | Bishop | 1.00 | 1.016 | **1.011** | -0.5 % |
| ACADS — non-homogeneous slope with earthquake, kh = 0.15 | Spencer | 1.00 | – | **0.984** | – |
| ACADS — non-homogeneous slope with earthquake, kh = 0.15 | Morgenstern-Price | 1.00 | 0.989 | **0.983** | -0.6 % |
| Arai and Tagyo (1985) — homogeneous slope | Bishop | 1.451 | 1.417 | **1.404** | -0.9 % |
| Arai and Tagyo (1985) — homogeneous slope | Spencer | 1.451 | – | **1.401** | – |
| Arai and Tagyo (1985) — homogeneous slope | Morgenstern-Price | 1.451 | 1.414 | **1.400** | -1.0 % |
| Greco (1996), example 4 — multilayer slope | Bishop | 1.40 to 1.42 | 1.405 | **1.440** | +2.5 % |
| Greco (1996), example 4 — multilayer slope | Spencer | 1.40 to 1.42 | – | **1.421** | – |
| Greco (1996), example 4 — multilayer slope | Morgenstern-Price | 1.40 to 1.42 | 1.389 | **1.414** | +1.8 % |
| ACADS — weak layer, specified surface | Spencer | 1.34 | – | **1.276** | – |
| ACADS — weak layer, specified surface | Morgenstern-Price | 1.34 | 1.261 | **1.260** | -0.1 % |
| ACADS — weak layer, search (three blocks) | Spencer | 1.26 | – | **1.253** | – |
| ACADS — weak layer, search (three blocks) | Morgenstern-Price | 1.26 | 1.261 | **1.243** | -1.4 % |
| ACADS — weak layer, circles (comparison) | Bishop | 1.26 | – | **1.506** | mechanism not found by circles |

Difference = (CiviLab − GeoStudio) / GeoStudio, same method. GeoStudio does not publish Spencer for these cases. The searches of CiviLab (refined grid of centres and radii, or three-block search) generally find an F slightly lower than GeoStudio ("entry-exit" search), i.e. a more unfavourable surface. On the specified surface (case 3.6), where the surface is the same in both programs, the difference is 0.001.

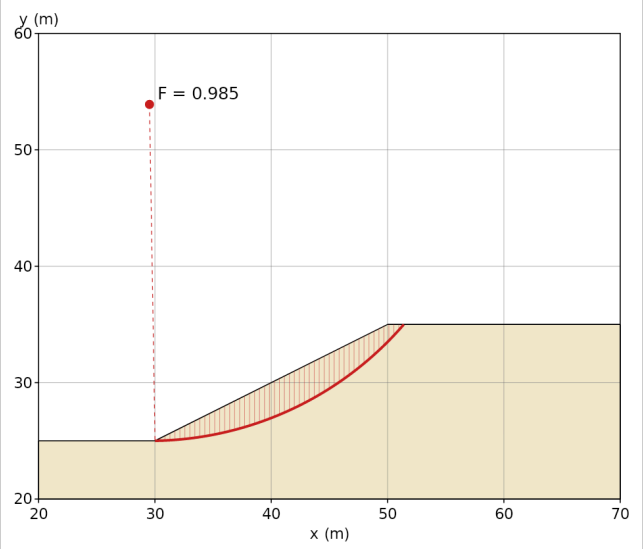
## 3.1 ACADS 1(a) — simple homogeneous slope

Source: ACADS (Giam and Donald, 1989); GeoStudio verification manual §2.1. Published reference value: **F = 1.00**.

**Data entered in CiviLab:** Ground (20; 25) – (30; 25) – (50; 35) – (70; 35); base y = 20. Soil: c' = 3 kPa, φ' = 19.6°, γ = 20 kN/m³. No water table.

| Method (CiviLab search) | F CiviLab | F GeoStudio | Difference | Fd EC7 | Surfaces | Critical surface |
|---|---|---|---|---|---|---|
| Bishop | **0.985** | 0.993 | -0.8 % | 0.788 | 4655 | Xc = 29.53; Yc = 53.90; R = 28.90 m |
| Spencer | **0.984** | – | – | 0.787 | 4507 | Xc = 29.50; Yc = 53.90; R = 28.90 m |
| Morgenstern-Price | **0.985** | 0.993 | -0.8 % | 0.788 | 4512 | Xc = 30.37; Yc = 51.40; R = 26.40 m |

Comparison of methods on the critical surface of the last row: Fellenius 0.946; Bishop 0.986; Spencer 0.985 (λ = 0.433); Morgenstern-Price 0.985 (λ = 0.532).



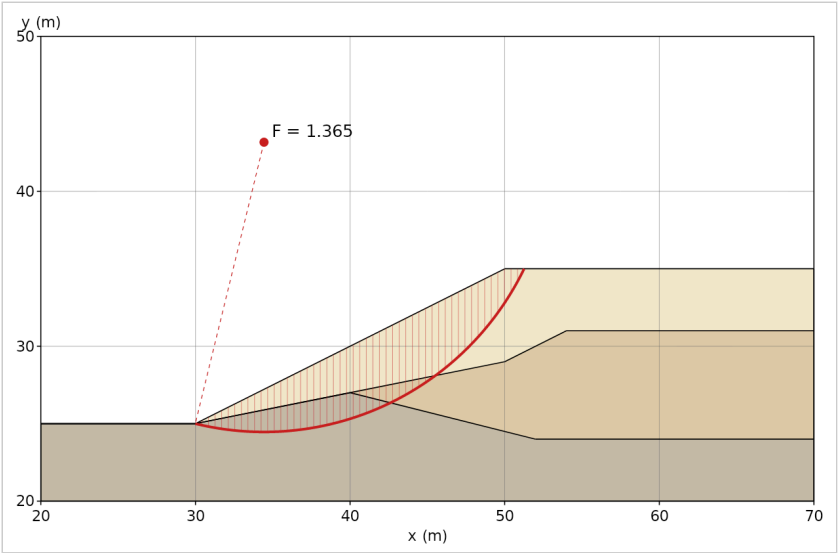

## 3.2 ACADS — non-homogeneous slope (3 layers)

Source: ACADS; GeoStudio §2.3. Published reference value: **F = 1.39**.

**Data entered in CiviLab:** Ground (20; 25) – (30; 25) – (50; 35) – (70; 35); top of soil 2: (30; 25) – (40; 27) – (50; 29) – (54; 31) – (70; 31); top of soil 3: (40; 27) – (52; 24) – (70; 24); base y = 20. Soil 1: c' = 0, φ' = 38°; soil 2: 5.3 kPa, 23°; soil 3: 7.2 kPa, 20°; γ = 19.5 kN/m³.

| Method (CiviLab search) | F CiviLab | F GeoStudio | Difference | Fd EC7 | Surfaces | Critical surface |
|---|---|---|---|---|---|---|
| Bishop | **1.393** | 1.413 | -1.4 % | 1.115 | 4846 | Xc = 34.50; Yc = 43.23; R = 18.93 m |
| Spencer | **1.365** | – | – | 1.092 | 4708 | Xc = 34.33; Yc = 43.27; R = 18.82 m |
| Morgenstern-Price | **1.365** | 1.382 | -1.2 % | 1.092 | 4708 | Xc = 34.43; Yc = 43.17; R = 18.70 m |

Comparison of methods on the critical surface of the last row: Fellenius 1.252; Bishop 1.394; Spencer 1.365 (λ = 0.384); Morgenstern-Price 1.365 (λ = 0.485).



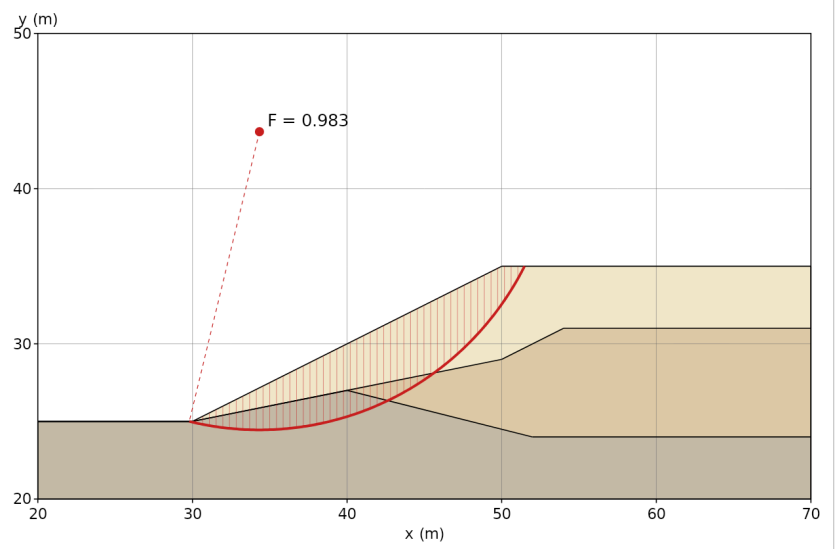
## 3.3 ACADS — non-homogeneous slope with earthquake, kh = 0.15

Source: ACADS; GeoStudio §2.4. Published reference value: **F = 1.00**.

**Data entered in CiviLab:** Geometry and soils of the previous case; horizontal seismic force kh·W, kh = 0.15 (kv = 0); total stress analysis.

| Method (CiviLab search) | F CiviLab | F GeoStudio | Difference | Fd EC7 | Surfaces | Critical surface |
|---|---|---|---|---|---|---|
| Bishop | **1.011** | 1.016 | -0.5 % | 0.809 | 4846 | Xc = 35.77; Yc = 51.27; R = 27.03 m |
| Spencer | **0.984** | – | – | 0.787 | 4780 | Xc = 34.33; Yc = 43.67; R = 19.21 m |
| Morgenstern-Price | **0.983** | 0.989 | -0.6 % | 0.786 | 4837 | Xc = 34.33; Yc = 43.67; R = 19.21 m |

Comparison of methods on the critical surface of the last row: Fellenius 0.898; Bishop 1.007; Spencer 0.984 (λ = 0.559); Morgenstern-Price 0.983 (λ = 0.709).



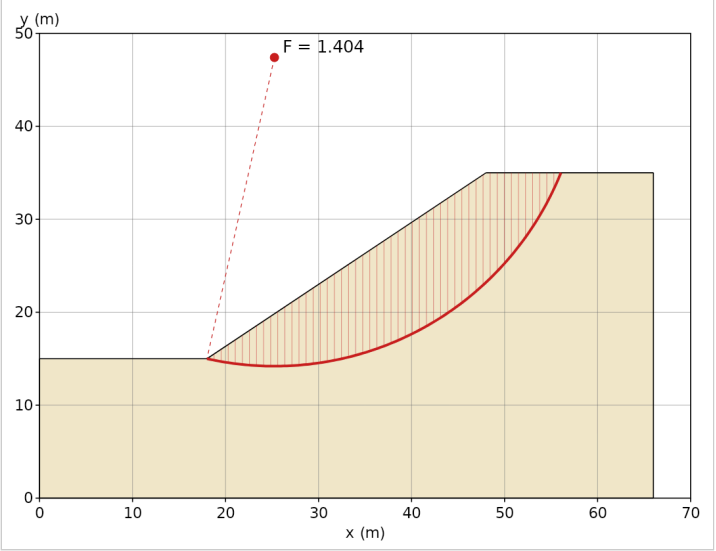

## 3.4 Arai and Tagyo (1985) — homogeneous slope

Source: Arai and Tagyo (1985); GeoStudio §2.11. Published reference value: **F = 1.451**.

**Data entered in CiviLab:** Ground (0; 15) – (18; 15) – (48; 35) – (66; 35); base y = 0. Soil: c' = 41.65 kPa, φ' = 15°, γ = 18.82 kN/m³. No water table.

| Method (CiviLab search) | F CiviLab | F GeoStudio | Difference | Fd EC7 | Surfaces | Critical surface |
|---|---|---|---|---|---|---|
| Bishop | **1.404** | 1.417 | -0.9 % | 1.123 | 4552 | Xc = 25.26; Yc = 47.40; R = 33.21 m |
| Spencer | **1.401** | – | – | 1.121 | 4506 | Xc = 25.26; Yc = 47.40; R = 33.21 m |
| Morgenstern-Price | **1.400** | 1.414 | -1.0 % | 1.120 | 4527 | Xc = 25.26; Yc = 47.40; R = 33.21 m |

Comparison of methods on the critical surface of the last row: Fellenius 1.348; Bishop 1.404; Spencer 1.401 (λ = 0.331); Morgenstern-Price 1.400 (λ = 0.384).



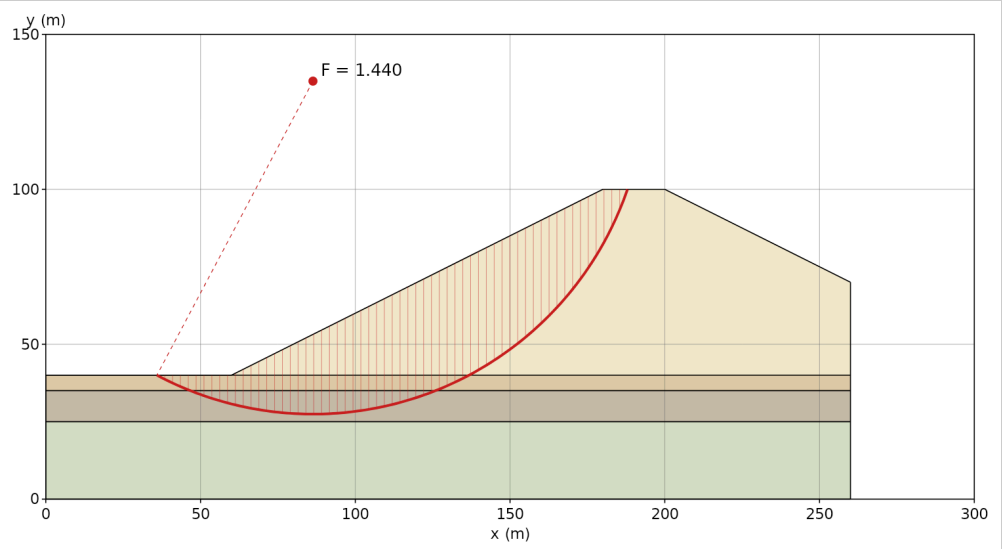
## 3.5 Greco (1996), example 4 — multilayer slope

Source: Greco (1996); Yamagami and Ueta (1988); GeoStudio §2.13. Published reference value: **F = 1.40 to 1.42**.

**Data entered in CiviLab:** Ground (0; 40) – (60; 40) – (180; 100) – (200; 100) – (260; 70); horizontal boundaries y = 40, 35 and 25; base y = 0. Top layer: 49 kPa, 29°, 20.38 kN/m³; layer 2 (40 → 35): 0, 30°, 17.64; layer 3 (35 → 25): 7.84 kPa, 20°, 20.38; bottom layer: 0, 30°, 17.64.

| Method (CiviLab search) | F CiviLab | F GeoStudio | Difference | Fd EC7 | Surfaces | Critical surface |
|---|---|---|---|---|---|---|
| Bishop | **1.440** | 1.405 | +2.5 % | 1.152 | 5044 | Xc = 86.32; Yc = 134.91; R = 107.46 m |
| Spencer | **1.421** | – | – | 1.137 | 4978 | Xc = 86.32; Yc = 134.91; R = 107.46 m |
| Morgenstern-Price | **1.414** | 1.389 | +1.8 % | 1.132 | 4979 | Xc = 86.32; Yc = 134.91; R = 107.46 m |

Comparison of methods on the critical surface of the last row: Fellenius 1.285; Bishop 1.440; Spencer 1.421 (λ = 0.333); Morgenstern-Price 1.414 (λ = 0.425).



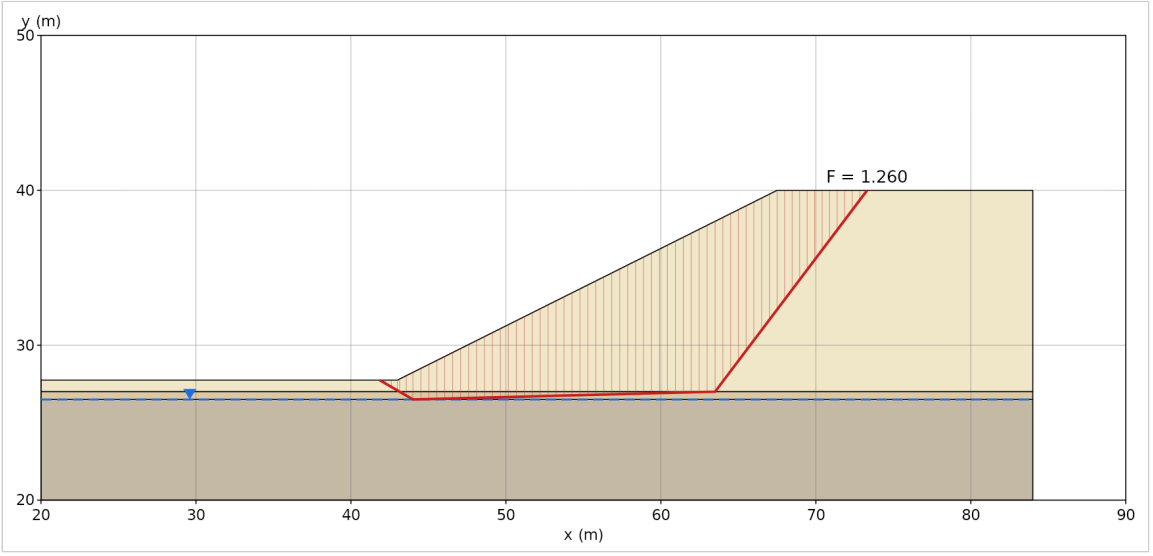

## 3.6 ACADS — weak layer, specified surface

Source: ACADS; GeoStudio §2.8. Published reference value: **F = 1.34**.

**Data entered in CiviLab:** Ground (20; 27.75) – (43; 27.75) – (67.5; 40) – (84; 40); weak layer between y = 27 and y = 26.5 (c' = 0, φ' = 10°); clay above and below (c' = 28.5 kPa, φ' = 20°); γ = 18.84 kN/m³; water table y = 26.5. Specified surface: (41.85; 27.75) – (44; 26.5) – (63.5; 27) – (73.31; 40).

| Method (CiviLab search) | F CiviLab | F GeoStudio | Difference | Fd EC7 | Surfaces | Critical surface |
|---|---|---|---|---|---|---|
| Spencer | **1.276** | – | – | 1.021 | 1 | (41.85; 27.75) – (44.00; 26.50) – (63.50; 27.00) – (73.31; 40.00) |
| Morgenstern-Price | **1.260** | 1.261 | -0.1 % | 1.008 | 1 | (41.85; 27.75) – (44.00; 26.50) – (63.50; 27.00) – (73.31; 40.00) |

Comparison of methods on the critical surface of the last row: Fellenius –; Bishop –; Spencer 1.276 (λ = 0.198); Morgenstern-Price 1.260 (λ = 0.236).



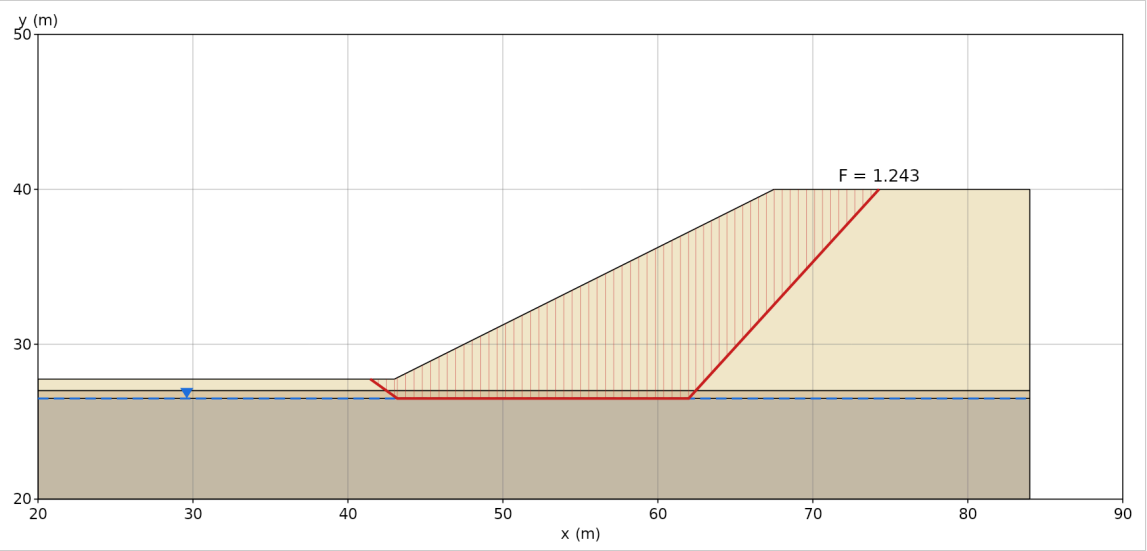
### 3.7 ACADS — weak layer, search (three blocks)

Source: ACADS; GeoStudio §2.7; NF P 94-270 fig. 10.4. Published reference value: **F = 1.26**.

**Data entered in CiviLab:** Geometry and soils of the previous case; automatic "three-block" search along the weak layer (CiviLab); circles for comparison.

| Method (CiviLab search) | F CiviLab | F GeoStudio | Difference | Fd EC7 | Surfaces | Critical surface |
|---|---|---|---|---|---|---|
| Spencer | **1.253** | – | – | 1.002 | 6048 | (41.18; 27.75) – (43.29; 26.50) – (61.90; 26.50) – (74.42; 40.00) |
| Morgenstern-Price | **1.243** | 1.261 | -1.4 % | 0.994 | 6072 | (41.44; 27.75) – (43.19; 26.50) – (61.99; 26.50) – (74.27; 40.00) |

Comparison of methods on the critical surface of the last row: Fellenius –; Bishop –; Spencer 1.255 (λ = 0.178); Morgenstern-Price 1.243 (λ = 0.207).




## 4. Analytical solutions

### 4.1 Exact moment equilibrium, φ = 0

Slope (0; 10) – (10; 10) – (20; 0) – (40; 0), $c_u$ = 30 kPa, φ = 0, γ = 18 kN/m³, circle Xc = 22, Yc = 18, R = 19. With φ = 0 the resistance does not depend on the interslice forces: F = c R L / (W d), calculated by fine integration of the area and lever arm, equals **1.39264**.

| Method | CiviLab (200 slices) | Difference |
|---|---|---|
| Bishop | 1.39259 | −0.004 % |
| Spencer | 1.39258 | −0.004 % |
| Morgenstern-Price | 1.39258 | −0.004 % |

### 4.2 Cohesionless infinite slope, static and seismic

Slope 1V:2H (β = 26.565°), c' = 0, φ' = 35°, γ = 20 kN/m³, plane surface parallel to the slope at 1 m depth (specified surface, Morgenstern-Price, 400 slices). Infinite slope solution: F = tan φ' / tan β = 1.4004; with a pseudo-static earthquake kh: F = (cos β − kh sin β) tan φ' / (sin β + kh cos β), i.e. 1.1087 for kh = 0.10.

| Case | Theory | CiviLab, L = 96 m | CiviLab, L = 496 m | Difference (L = 496 m) |
|---|---|---|---|---|
| Static | 1.4004 | 1.4049 | 1.4012 | +0.06 % |
| kh = 0.10 | 1.1087 | 1.1124 | 1.1093 | +0.05 % |

L: length of the parallel part of the surface; the residual difference comes from the ends of the surface and decreases as L increases.

## 5. Seismic coefficients

| Code | Data | Formula | Expected | CiviLab |
|---|---|---|---|---|
| RPA 2024 §10.3 | zone III (A = 0.15), group 2 (I = 1), site S3 (S = 1.55, type 2) | kh = A·I·S/3; kv = kh/3 | 0.0775; 0.02583 | identical |
| RPA 2024 §10.3 | zone V (A = 0.25), group 1B (I = 1.2), site S2 (S = 1.2, type 1), ST = 1.2 | kh = A·I·S·ST/3; kv = kh/2 | 0.1440; 0.0720 | identical |
| RPA 2024 §10.3.6 | seismic situation | required F | 1.15 | 1.15 |

| | | | | |
|---|---|---|---|---|
| NF P 94-270 I.4 | ag/g = 0.2; S = 1.2; avg/ag = 0.9 then 0.5 | kh = ½·(ag/g)·S; kv = 0.5·kh or 0.33·kh | 0.12; 0.06; 0.0396 | identical |

Values of tables 3.2 (A), 3.3 and 3.4 (S) and 3.10 (I) of RPA 2024; formulas (10.22) and (10.23); NF P 94-270 (I.4.1) to (I.4.3).

## 6. Independent recalculation (Excel)

The workbook **Validation-Essais-7.1.xlsx** redoes the calculations slice by slice, using Excel formulas only, on the same surfaces as CiviLab:

| Sheet | Calculation | Excel | CiviLab |
|---|---|---|---|
| Stabilité talus (Bishop) | ACADS 1(a), Bishop, F and Fd (EC7) | 0.98508; 0.78806 | 0.98508; 0.78806 |
| Talus séisme (Bishop) | ACADS 1(a), kh = 0.15: Fellenius; Bishop | 0.68711; 0.71586 | 0.68711; 0.71586 |
| Talus Morgenstern-Price | ACADS 1(a): M-P (λ); Spencer with kh = 0.15 | 0.98410 (0.529); 0.71711 | 0.98410 (0.529); 0.71711 |
| Talus surface imposée (M-P) | ACADS §2.8: Morgenstern-Price; Spencer | 1.26033; 1.27602 | 1.26033; 1.27602 |
| Séisme kh kv | RPA 2024 and NF P 94-270 coefficients | identical | |

## 7. Automated tests

The CiviLabTests project (xUnit) contains 14 stability tests, run at every change: exact equilibrium φ = 0 (Bishop, Spencer, Morgenstern-Price), undrained case (γcu), c'–φ' with and without water table and with design values (independent Python implementation), ACADS 1(a), non-homogeneous (Bishop and Morgenstern-Price), earthquake kh = 0.15, weak layer (specified surface and three blocks), RPA 2024 and NF P 94-270 coefficients, JSON storage, sorting of calculations by group. Result: **all passed**.

## 8. Differences, limits and cases not covered

- **Search:** CiviLab most often finds an F 0.5 to 1.5 % lower than GeoStudio (more unfavourable surface). Exception: Greco (case 3.5), where Bishop gives 1.440 against 1.405 (+2.5 %); the search was checked with finer grids (30 × 40 then 40 × 40, up to 100 slices: 1.440 to 1.443); Morgenstern-Price (1.414) and Spencer (1.421) lie within the range published by Greco (1.40 to 1.42).
- **Weak layer:** circles give F = 1.506 whereas the mechanism through the weak layer gives 1.24 to 1.26: non-circular surfaces are essential in this case.
- **Not covered by CiviLab 7.1:** tension cracks, reinforcement (nails, geosynthetics, piles), point loads or loads varying along the surface, pore pressures other than hydrostatic ($r_u$), dynamic analysis. The corresponding cases of the GeoStudio manual (§2.2, 2.9, 2.15, 2.31 to 2.34, 2.38, 2.39…) are therefore not treated here; cases §2.12 (water table without levels) and §2.14 (layer-material correspondence not published) are not fully defined.
- The seismic calculation is pseudo-static; it does not apply to liquefiable soils (RPA 2024 §10.3.3).

## 9. References


- Arai K., Tagyo K. (1985). Determination of noncircular slip surface giving the minimum factor of safety in slope stability analysis. Soils and Foundations 25(1).
- Bishop A.W. (1955). The use of the slip circle in the stability analysis of slopes. Géotechnique 5(1).
- Giam P.S.K., Donald I.B. (1989). Example problems for testing soil slope stability programs. Civil Engineering Research Report 8/1989, Monash University (ACADS study).
- Greco V.R. (1996). Efficient Monte Carlo technique for locating critical slip surface. Journal of Geotechnical Engineering 122(7).
- Morgenstern N.R., Price V.E. (1965). The analysis of the stability of general slip surfaces. Géotechnique 15(1).
- Seequent / GeoStudio (2025). Slope stability verification manual (SLOPE/W), §2.1 to 2.14.
- Spencer E. (1967). A method of analysis of the stability of embankments assuming parallel inter-slice forces. Géotechnique 17(1).
- Zhu D.Y., Lee C.F., Qian Q.H., Chen G.R. (2005). A concise algorithm for computing the factor of safety using the Morgenstern–Price method. Canadian Geotechnical Journal 42.
- Algerian seismic code RPA 2024, §3.3, §10.3, annex C.
- NF P 94-270 (2009). Retaining structures — Reinforced fill and soil nailing structures: §10, annexes C and I.