**Medra Mühendislik**

# SLOPE BACK ANALYSIS REPORT

*TBDY 2018 Chapter 16*

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| Info | Value |
|---|---|
| Project name | Smith Residence – Foundation Study |
| Client | EXAMPLE-2 |
| Location | California / Alameda County / Oakland |
| Block / parcel | Pafta Book 48, Page 3216 / Ada Block 12 / Parsel Lot 7 (APN 048-3216-012-00) |
| Revision | 00 |
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| Prepared by | Gökhan Demirbaş |

*This report was prepared with GeoteknikPro Studio slope stability software. The results depend on the soil parameters and model geometry entered; their interpretation and the final engineering decision remain the responsibility of the engineer preparing the report.*

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# 1. BACK ANALYSIS

Back analysis treats the drained shear strength parameters (c′, ϕ′) of one layer only as unknown in a slope that has failed or is at the point of failure; the parameters of all other layers are held fixed. The parameters are sought such that the lowest factor of safety (FS) of the slope equals the target: for each ϕ′, the c′ giving FS = 0.95 / 1.00 / 1.05 is found by bisection / regula falsi (FS does not decrease with c′). The calculation is static, in effective stresses, using the slip surface search and solver of the slope analysis.

## 1.1 Inputs

| Parameter | Value |
|---|---|
| Unknown layer | Clayey Sand |
| Analysis mode | Mode 2 — global circular search (nothing entered) |
| Unknown | c′ and ϕ′ (fresh failure; c′–ϕ′ curve) |
| Target factors of safety | 0.95 / 1.00 / 1.05 |
| ϕ′ range [°] | 10 … 35 (6) |
| Layer values before the analysis | c′ = 9.81 kPa; ϕ′ = 28° |
| Solver | TBDY 2018 (16.30) / Janbu |
| Surface types scanned | Circular |
| Groundwater | none in the model |

*Table 1: Back analysis inputs*

| Layer | γ [kN/m³] | $\gamma_{sat}$ [kN/m³] | c′ [kPa] | ϕ′ [°] | Status |
|---|---|---|---|---|---|
| Clayey Sand | 17.65 | 18.63 | ? | ? | UNKNOWN |
| Low Plasticity Clay | 18.14 | 18.93 | 14.22 | 22.5 | fixed |
| Silty Sand | 18.04 | 18.73 | 7.36 | 30 | fixed |
| Non-Plastic Silt | 17.46 | 18.44 | 1.96 | 30 | fixed |

*Table 2: Layers (all except the unknown are fixed)*

## 1.2 Search type and searched slip surfaces

Search type: Mode 2 — global circular search (full search without entry / exit points). The circular surface search of the slope analysis was actually run 25 times during the (c′, ϕ′) trials; the lowest-FS candidates of every search were taken into the surface pool (420 surfaces) and the root was found with this pool and verified by the full search. The figure shows 40 samples from the pool evenly spaced by depth, the shallowest and the deepest surface of the pool (envelope) and the critical surface; the left ends of the surfaces in the pool lie at x = 3.45 … 26.64 m and the right ends at x = 22.89 … 41.98 m. The pool is not every surface tried by the search but the lowest-FS candidates that represent the critical region.

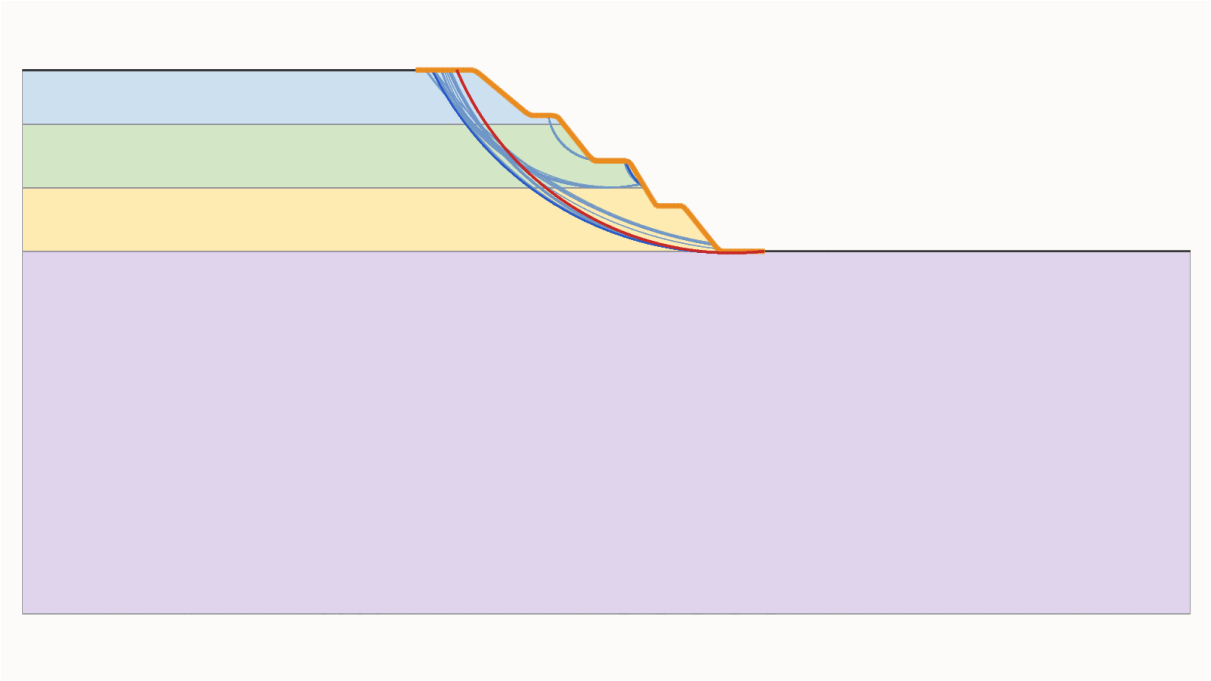


*Figure 1: Searched slip surfaces — faint blue: sample surfaces from the pool (40 / 420); dark blue: the shallowest and the deepest surface (envelope); thick red: critical surface (φ′ = 25°, c′ = 6.9 kPa, FS = 1.00); orange strips: the range of the left and right ends of the surfaces in the pool on the ground.*

| Quantity | Value |
|---|---|
| Search type | Mode 2 — global circular (full search) |
| Surfaces evaluated (pool) | 420 |
| Samples drawn in the figure | 40 |
| Number of full searches | 25 |
| Left end range x [m] | 3.45 … 26.64 |
| Right end range x [m] | 22.89 … 41.98 |
| Maximum depth: shallowest … deepest surface [m] | 1.01 … 9.94 |

*Table 3: Extent of the back analysis surface search*

## 1.3 Result: c′–ϕ′ relationship

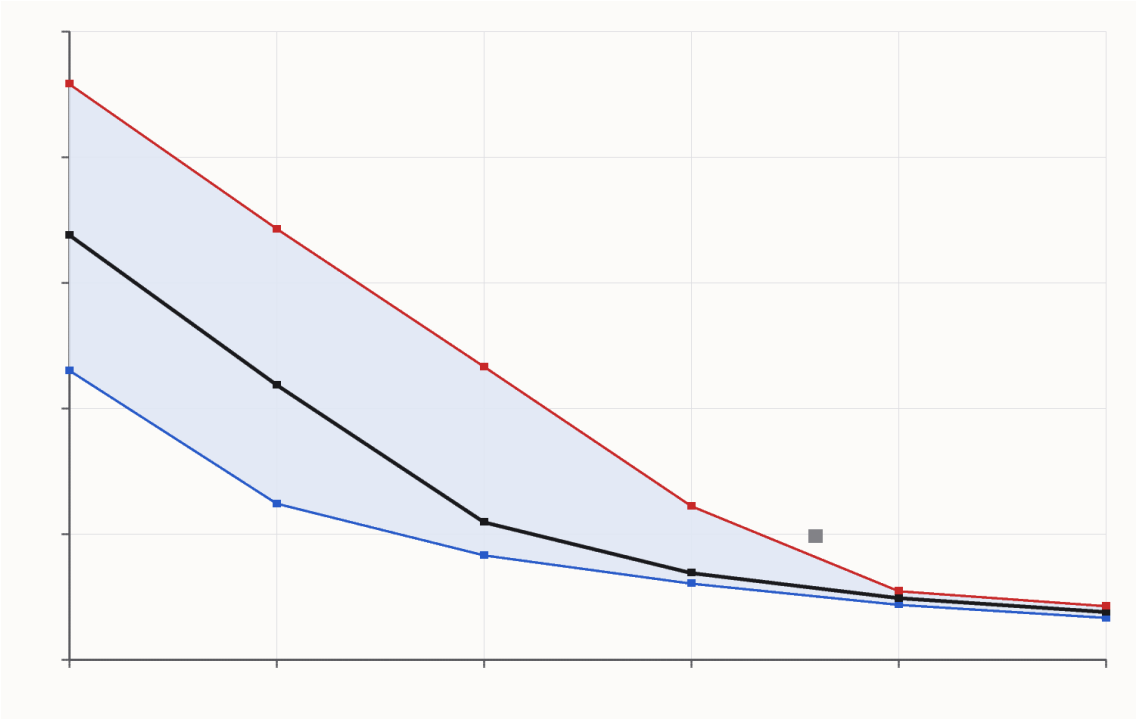


*Figure 2: c′–φ′ relationship. Thick black line: FS = 1.00; blue line: FS = 0.95 (lower bound); red line: FS = 1.05 (upper bound); the light band lies between the two bounds. Purple diamonds are laboratory / correlation points, the green square is the selected pair, the grey square is the value before the analysis. Horizontal axis φ′ [°]: 10 … 35 (grid 5°); vertical axis c′ [kPa]: 0 … 50 (grid 10 kPa).*

| ϕ′ [°] | c′ [kPa] (FS = 0.95) | c′ [kPa] (FS = 1.00) | c′ [kPa] (FS = 1.05) |
|---|---|---|---|
| 10 | 23.02 | 33.8 | 45.82 |
| 15 | 12.43 | 21.87 | 34.3 |
| 20 | 8.31 | 10.94 | 23.33 |
| 25 | 6.06 | 6.9 | 12.23 |
| 30 | 4.37 | 4.91 | 5.46 |
| 35 | 3.34 | 3.8 | 4.27 |

*Table 4: c′ giving the target FS for each φ′*

## 1.4 Critical slip surface

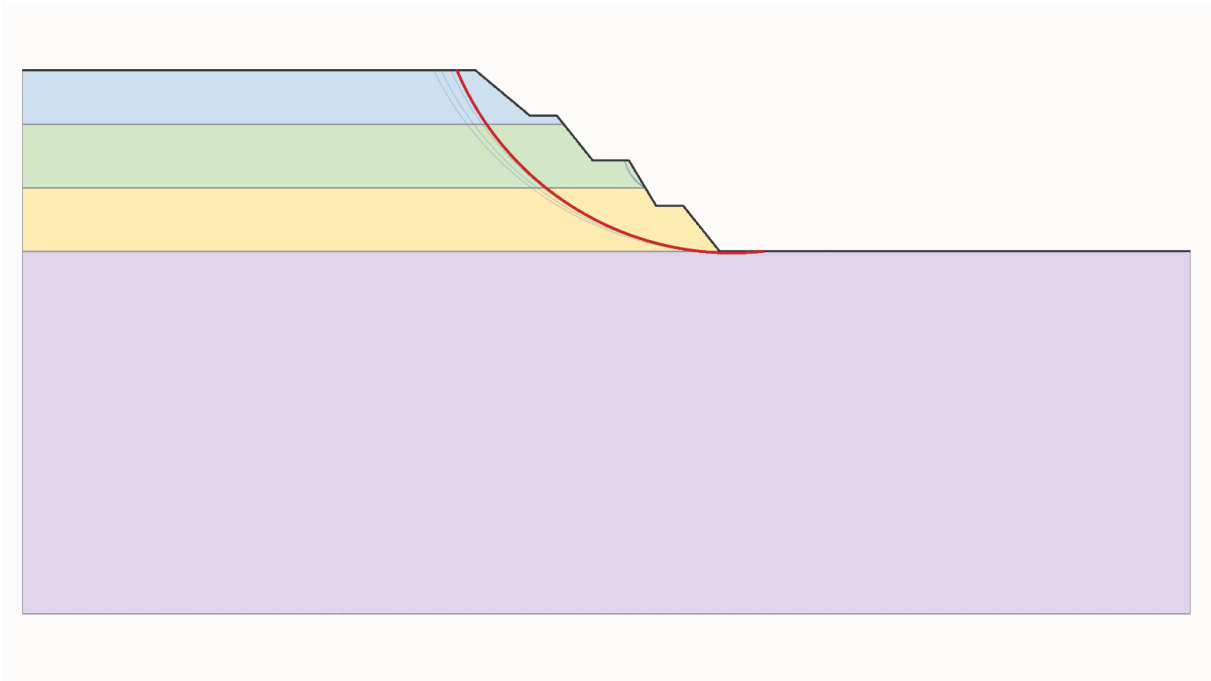


*Figure 3: Back analysis critical surface (red: φ′ = 25°, c′ = 6.9 kPa, FS = 1.00; faint blue: critical surfaces of the other φ′ values).*

| ϕ′ [°] | c′ [kPa] | Type | Entry (x; y) | Exit (x; y) | Depth [m] | Centre; R |
|---|---|---|---|---|---|---|
| 10 | 33.8 | Circular | 5.39; 0 | 41.16; -20 | 9.73 | 37.79; 15.95; 36.11 |
| 15 | 21.87 | Circular | 6.21; 0 | 41.67; -20 | 9.44 | 38.23; 15.33; 35.5 |
| 20 | 10.94 | Circular | 7.29; 0 | 42.21; -20 | 9.02 | 38.62; 14.22; 34.41 |
| 25 | 6.9 | Circular | 7.98; 0 | 41.91; -20 | 8.82 | 38.38; 12.79; 32.98 |
| 30 | 4.91 | Circular | 26.49; -10 | 28.8; -13 | 1.34 | 30.68; -9.17; 4.27 |
| 35 | 3.8 | Circular | 26.58; -10 | 28.8; -13 | 1.13 | 31.22; -8.89; 4.77 |

*Table 5: Mode 2 — critical surface of each φ′ for target FS = 1.00 (entry / exit points from the search)*

## 1.5 Warnings and limitations

• The analysis is 2D; the resistance of the lateral boundaries, loads outside the section and the 3D shape of the failed mass are neglected. Since 3D effects generally add resistance, the strength found may differ (usually low) from the strength actually mobilised.

• Peak / residual: in a fresh failure the mobilised strength may lie between peak and residual; in progressive failures the average strength is below peak. On old landslide surfaces c′ ≈ 0 and the residual $\phi'_r$ should be used. The value found is the AVERAGE strength mobilised along a surface, not the peak strength of the material.

• The FS = 1.00 assumption is an APPROXIMATION: the real FS at failure may not be exactly 1.00 because of geometry, pore pressure and the resolution of the surface search (the 0.95–1.05 band shows this uncertainty). Also, the solution is NOT a single (c′, ϕ′) pair but a curve: every point on it gives the same FS. The pair must be chosen with laboratory / correlation data and engineering judgement.

• Groundwater: no water is defined in the model. If pore pressure developed during failure (rain / seepage), ignoring it makes the strength found LOWER than the strength actually mobilised.

• Mode 2 scans CIRCULAR surfaces only; wedge, composite (bedrock), weak-layer-following and undermining mechanisms were not scanned. If the real failure was not circular the strength band may be misleading; in that case Mode 1, with known entry / exit points, should be used.

## 2. REFERENCES

[1] Janbu, N. (1973). Slope stability computations. In R. C. Hirschfeld & S. J. Poulos (Eds.), Embankment-dam engineering: Casagrande volume (pp. 47–86). Wiley.

[2] Republic of Turkey Ministry of Environment and Urbanization. (2018). Turkish Building Earthquake Code (TBDY 2018).