PE CIVIL GEOTECHNICAL FORMULA AND METHOD SHEET

A study reference for recognizing methods, tracking units, and checking assumptions across soil mechanics, groundwater, earth structures, retaining systems, and foundations.

CURRENT EXAM NOTICE	As of August 2026, NCEES lists an April 2024 PE Civil: Geotechnical specification and has published a revised specification effective April 2027. Confirm which specification applies to your scheduled exam. Personal notes are not permitted as exam references; NCEES supplies the electronic handbook and listed standards.

How to use this sheet

1. Identify the mechanism and the requested quantity before selecting an equation.
2. Sketch the profile, groundwater, loads, pressure diagram, drainage paths, or candidate failure surface.
3. Write units beside every variable and convert once at the beginning.
4. State the strength and drainage condition: total stress or effective stress; short term or long term; peak or residual.
5. Use the supplied references to confirm method-specific factors, criteria, and standard-of-practice requirements.

Topic map

Topic	First questions to ask	High-frequency error
Site characterization	What data support the model and how variable are conditions?	Treating a correlation as a measured property
Soil mechanics	Which phase, stress, drainage, and unit basis applies?	Mixing total and effective stress
Groundwater	What controls head, gradient, drainage path, and exit condition?	Using pressure head as total head
Earth structures	What is the credible failure surface and adverse water case?	Using one dry factor of safety
Retaining systems	Can the wall move and which loads act at each stage?	Omitting water or compaction pressure
Foundations	Is strength, settlement, or constructability controlling?	Reporting bearing capacity without settlement

PHASE RELATIONSHIPS AND CLASSIFICATION

Basic definitions

```
w = Ww / Ws
e = Vv / Vs
n = Vv / V = e / (1 + e)
Sr = Vw / Vv
gamma = W / V
gamma_d = Ws / V
```

Useful identities

```
gamma_d = gamma / (1 + w)
gamma_d = Gs * gamma_w / (1 + e)
Se = w * Gs
gamma_sat = gamma_w * (Gs + e) / (1 + e)
gamma' = gamma_sat - gamma_w
```

Classification workflow

- Percent retained No. 4 separates gravel and sand fractions.
- Percent passing No. 200 is the fines content used in USCS coarse/fine decisions.

```
PI = LL - PL; A-line PI = 0.73(LL - 20).
Gradation coefficients: Cu = D60/D10; Cc = D30^2/(D10*D60).
```

TOTAL STRESS, PORE PRESSURE, AND EFFECTIVE STRESS

Vertical stress

```
sigma_v = sum(gamma_i * H_i)
```

```
u = gamma_w * h_p
```

```
sigma'_v = sigma_v - u
```

- Below the water table, effective-stress increments often use gamma'.

Stress distribution

```
Uniform infinite surcharge: Delta sigma = q.
```

- Point/line/area loads require the influence method supplied for the geometry.
- For settlement, divide the compressible layer and evaluate stress increase at representative depths.

Method check

- Total stress uses total unit weight and undrained strength where appropriate.
- Effective stress uses effective normal stress and effective c'-phi' parameters.
- Do not subtract pore pressure twice by combining buoyant unit weight with a second u subtraction.

GROUNDWATER, SEEPAGE, AND DEWATERING

Head and Darcy flow

```
h = z + u/gamma_w + v^2/(2g)
```

```
i = Delta h / L
```

```
q = k * i * A
```

```
v_s = q/A; seepage velocity v = v_s/n
```

Flow nets

```
q per unit width = k * H * Nf/Nd for isotropic soil.
```

- Pore pressure at a point follows the remaining pressure head.

```
Each equipotential drop is Delta h = H/Nd.
```

Exit and uplift checks

```
Critical gradient i_c = (Gs - 1)/(1 + e) = gamma'/gamma_w.
```

- FS against heave/piping is commonly i_c/i_exit for the selected model.

- Dewatering design must consider drawdown, recharge, base stability, settlement, and adjacent wells/structures.

COMPACTION, CONSOLIDATION, AND SETTLEMENT

Compaction

```
Relative compaction RC = gamma_d,field/gamma_d,max * 100%.
gamma_d = gamma_wet/(1 + w).
```

- Acceptance may require both density and moisture criteria.
- Oversize correction and test-method limitations follow the governing specification.

One-dimensional consolidation

```
Cc = Delta e / log10(sigma'_2/sigma'_1)
Cr = recompression slope in e-log sigma' space.
S = H0/(1+e0) * Delta e
Tv = cv*t/Hdr^2
```

- Hdr is the maximum drainage path, not automatically the layer thickness.

Settlement structure

- Immediate + primary consolidation + secondary compression.
- Check total and differential movement, construction sequence, load distribution, and layer variability.
- A bearing-capacity factor of safety does not establish acceptable settlement.

SHEAR STRENGTH AND SLOPE STABILITY

Mohr-Coulomb

```
tau_f = c' + sigma'_n tan(phi') for drained effective-stress strength.
Undrained total-stress idealization: tau_f = su when phi_u = 0.
```

- Select peak, critical-state, or residual strength based on material history and mechanism.

Infinite slope screening

```
FS = [c' + (gamma*z*cos^2 beta - u)tan(phi')] / [gamma*z*sin beta*cos beta]
```

- Use only for shallow translational failure approximately parallel to a long uniform slope.
- Water-pressure assumptions often control the result; evaluate credible wet conditions.

Limit equilibrium concepts

- FS compares available shear strength with mobilized shear demand along an assumed surface.
- Circular and noncircular methods require force and/or moment equilibrium assumptions.
- Search strategy, interslice forces, seismic loading, reinforcement, and pore pressure affect the model.

LATERAL EARTH PRESSURE AND RETAINING SYSTEMS

Rankine coefficients - level backfill

```
Ka = tan^2(45 - phi'/2) = (1-sin phi')/(1+sin phi')
Kp = tan^2(45 + phi'/2) = (1+sin phi')/(1-sin phi')
Jaky estimate for normally consolidated soil: K0 = 1 - sin phi'
```

Resultants

```
Soil self-weight: Pa = 0.5*Ka*gamma*H^2 acting H/3 above base.
Uniform surcharge: Pq = Ka*q*H acting H/2 above base.
Hydrostatic water: Pw = 0.5*gamma_w*Hw^2 acting Hw/3 above base.
```

- Draw each distribution separately before summing forces and moments.

System checks

- Wall movement condition selects active, at-rest, or passive behavior.
- Check sliding, overturning, bearing/eccentricity, structural capacity, global stability, and internal stability where applicable.
- Temporary support systems require staged loading, apparent pressure diagrams, groundwater, anchors/bracing, and deformation compatibility.

SHALLOW AND DEEP FOUNDATIONS

Shallow bearing

```
qu = c*Nc + q*Nq + 0.5*gamma*B*N-gamma before method-specific correction factors.
q = gamma*Df for a simple level-ground surcharge term.
```

- Apply one internally consistent bearing-capacity method and its shape/depth/inclination factors.
- Check groundwater, layering, eccentricity, slope, local shear, and settlement.

Stress and eccentricity

```
Average base pressure q_avg = V/A.
For linear pressure distribution, q = V/A +/- M/S.
```

- Resultant should satisfy the selected no-tension or effective-area criterion.
- Net and gross pressures must be defined consistently.

Deep foundations

- Axial geotechnical capacity combines shaft and tip resistance using the selected ASD/LRFD framework.
- Evaluate settlement, downdrag, group behavior, lateral response, uplift, scour, seismic effects, and constructability.
- Static load tests, dynamic testing, integrity testing, and installation records answer different questions.

EXAM EXECUTION AND FINAL CHECK

Four-pass workflow

- Pass 1: identify topic, requested quantity, units, and supplied data.
- Pass 2: sketch and select the governing model.
- Pass 3: calculate with units and preserve intermediate values.
- Pass 4: check magnitude, sign, location, mechanism, and answer wording.

Reference navigation

- Study with the current NCEES electronic handbook and the design standards listed for your exam date.
- Practice keyword searches, chapter navigation, and switching between only the references allowed by the exam interface.
- Build recognition from problem wording to reference location; do not rely on memorizing an unofficial equation list alone.

Last-minute traps

- Water table and drainage condition.
- Degree versus radian mode.
- pcf versus kN/m3; psf versus kPa; ft versus in.
- Pressure versus resultant force; H/2 versus H/3 location.
- Total versus effective stress; peak versus residual; short term versus long term.

Official sources and update check

NCEES FE exam and FE Civil specification: https://ncees.org/exams/fe-exam

NCEES PE Civil exam specifications and supplied standards: https://ncees.org/exams/pe-exam/civil/

NCEES Examinee Guide: https://ncees.org/examinee-guide/

Use the handbook version available in your MyNCEES account and verify the specification effective date for your scheduled exam.

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