Strength Envelopes for Florida Rock and Intermediate Geomaterials

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Design of Shallow Foundations on Florida Limestone

Miami

Suwannee

NCHRP 651 – Canadian Geotechnical Society (2006)

Table 7. Presumed preliminary design bearing pressure (Canadian Geotechnical Society, 2006).

Group	Types and conditions of rocks	Strength of rock material	Preliminary design bearing pressure [5] kPa (ksf)	Remarks
Rocks	Massive igneous and metamorphic rocks (granite, diorite, basalt, gneiss) in sound condition [2]	High-very high	10,000 (200)	These values are based on the assumption that the foundations are carried down to unweathered rock.
	Foliated metamorphic rocks (slate, schist) in sound condition [1] [2]	Medium-high	3,000 (60)	Not applicable
	Sedimentary rocks: cemented shale, siltstone, sandstone, limestone without cavities, thoroughly cemented in conglomerates, all in sound condition [1] [2]	Medium-high	1,000–4,000 (20–80)	Not applicable
	Compaction shale and other argillaceous rocks in sound condition [2][4]	Low-medium	500–1,000 (10–20) 1,000 (20)	Not applicable
	Broken rocks of any kind with moderately close spacing of discontinuities (0.3 m [11.8 in]) or greater), except argillaceous rocks (shale), limestone, sandstone, shale with closely spaced bedding	Not applicable	(See note 3)	Not applicable
	Heavily shattered or weathered rocks	Not applicable	(See note 3)	Not applicable

Notes:

1. The above values for sedimentary or foliated rocks apply where the strata or the foliation are level or nearly so, and, then, only if the area has ample lateral support. Tilted strata and their relation to nearby slopes or excavations should be assessed by a person knowledgeable in this field of work.
2. Sound rock conditions allow minor cracks at spacing not closer than 1 m (39.37 in).
3. To be assessed by examination in-situ, including test loading if necessary.
4. These rocks are apt to swell on release of stress, and on exposure to water they are apt to soften and swell.
5. The above values are preliminary estimates only and may need to be adjusted upwards or downwards in a specific case. No consideration has been made for the depth of embedment of the foundation. Reference should be made to other

Possible Failure Modes (NCHRP 651)

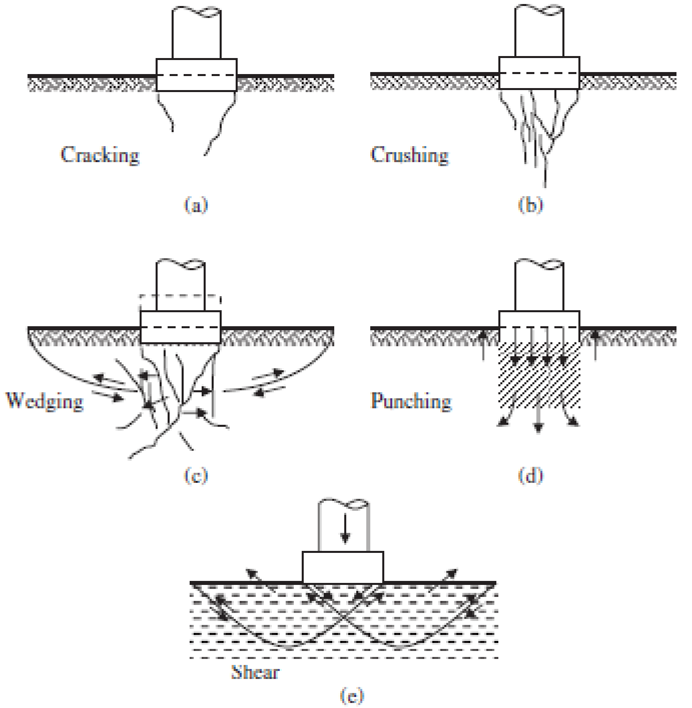


Figure 36. Modes of failure of a footing on rock including development of failure through crack propagation and crushing beneath the footing (a-c), punching through collapse of voids (d), and shear failure (e) (based on Goodman, 1989).

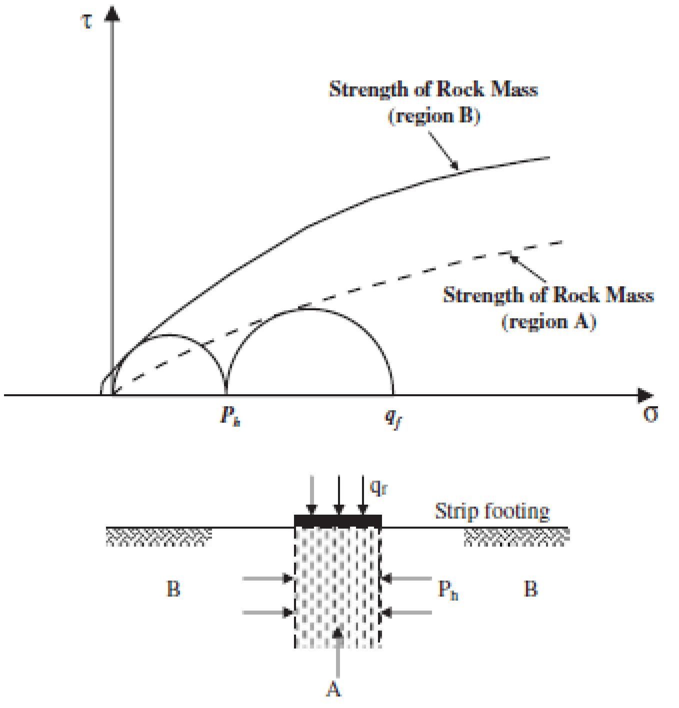


Figure 37. Analysis of bearing capacity on rock (based on Goodman, 1989).

Bearing Capacity (NCHRP 651)

Hoek and Brown

$$\sigma_1 = \sigma_3 + \left(mq_u\sigma_3 + sq_u^2\right)^{0.5} \quad (81)$$

where

σ_1 = major principal effective stress,
σ_3 = minor principal effective stress,
q_u = uniaxial compressive strength of the intact rock.
s and m = empirically determined strength parameters for the rock mass, which are to some degree analogous to c and ϕ_f of the Mohr-Coulomb failure criterion.

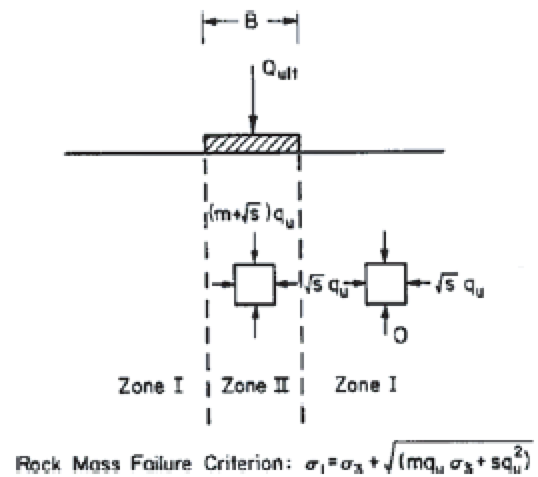


Figure 39. Lower bound solution for bearing capacity (Carter and Kulhawy, 1988).

$$q_{ult} = \left(\sqrt{s} + \left(m\sqrt{s} + s\right)^{0.5}\right)q_u$$

Scope of Work

- Task 1 – Acquire and Setup Triaxial Testing Equipment for Florida Limestone
  - Cell Pressures up to 1500 psi, Top Load 40 kips
- Task 2 – Field Acquisition of Florida Limestone and IGM
  - Obtain hundreds of specimen (2” to 4”) in top 10 to 20ft
    - Either through district drillers (example district3), SMO (Orlando to Jacksonville) or by contract
    - Record RQD, Recovery and Transport to Gainesville for Testing
- Task 3 – Perform qu, qt, and triaxial testing on specimens
  - Strain Controlled Testing (Possible Strain Softening)
  - Monitor Stress, Strain, and Pore Pressure
- Task 4 – Develop Stress-Strain and Strength Models for Florida Limestone (Hoek & Brown or other)
- Task 5 – Develop 2 layer Bearing model for Limestone

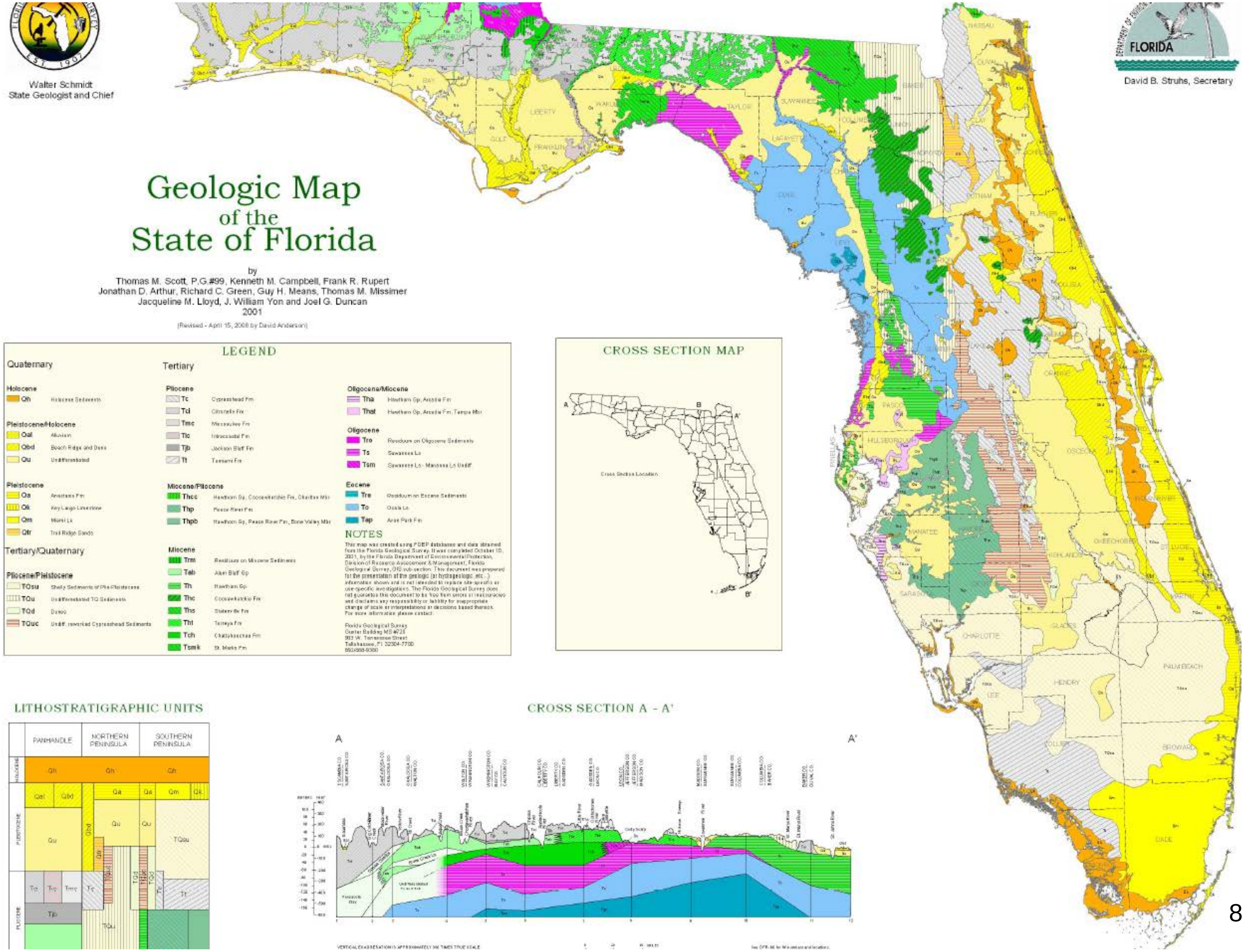
Triaxial Testing of Limestone

1500 psi
Cell Pressure

40,000 Lbs.
Load Capacity

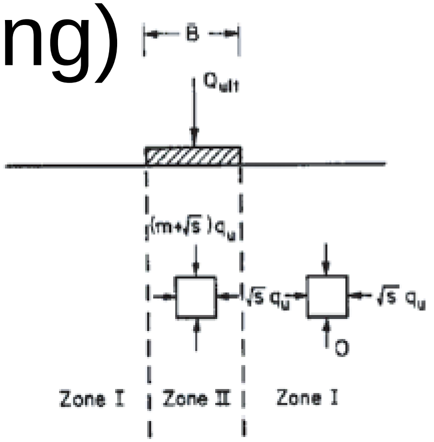
Monitor Sample
Stress, Strain & Pore Pressure

Task 2: Collection of Limestone Cores



Task 3&4 Testing and Models

- Conventional Unconfined and split tension
- Triaxial Compression Loading
  - 300, 800 and 1200 psi confining pressures
- Triaxial Extension Loading
- Strain Controlled (Strain Softening)
- Develop Stress-Strain & Strength Envelope for Limestone (Hoek & Brown?)



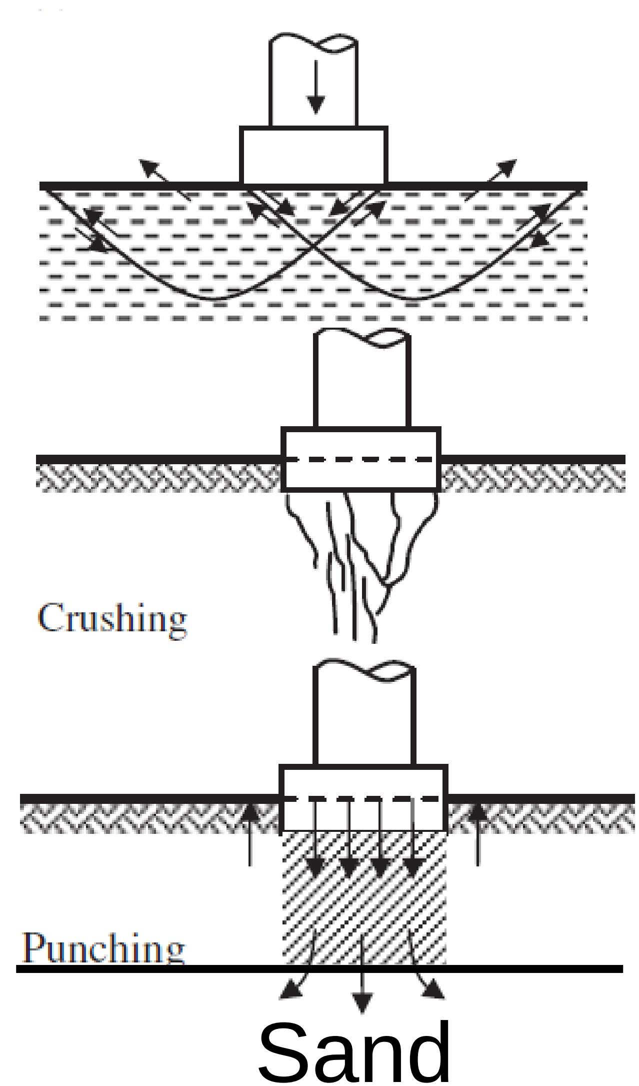
Rock Mass Failure Criterion: $\sigma_1 = \sigma_3 + \sqrt{(mq_u\sigma_3 + sq_u^2)}$

Figure 39. Lower bound solution for bearing
(Carter and Kulhawy, 1988).

Task 5 Numerical Modeling

- Employ Stress-Strain-strength in FEM code
  - Validate with Triaxial Data (Strength, softening, etc.)
- Model 2 layer boundary problem
- Develop Bearing Capacity Equation

$$q_u = ?$$



Thank You!

Questions?