El criterio de Hoek-Brown para roca intacta

Dr. Alejo O. Sfriso

Universidad de Buenos Aires | materias.fi.uba.ar/6408 | asfriso@fi.uba.ar

SRK Consulting (Argentina) | latam.srk.com | asfriso@srk.com.ar

AOSA | www.aosa.com.ar | asfriso@aosa.com.ar

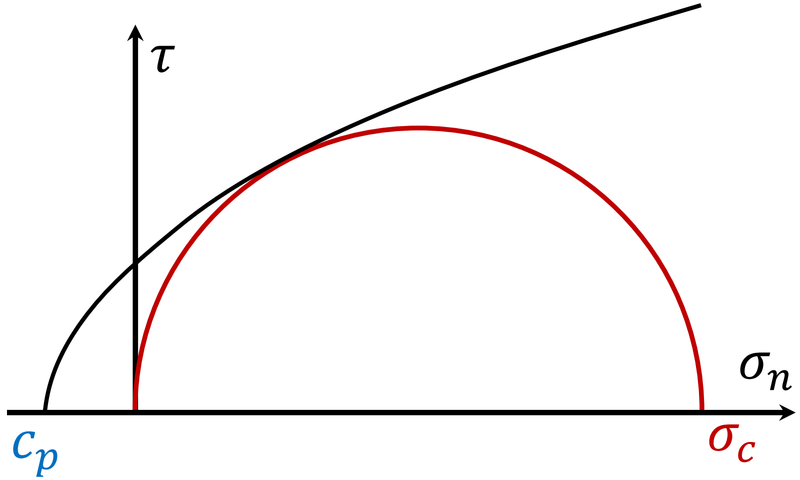
El criterio de Hoek-Brown

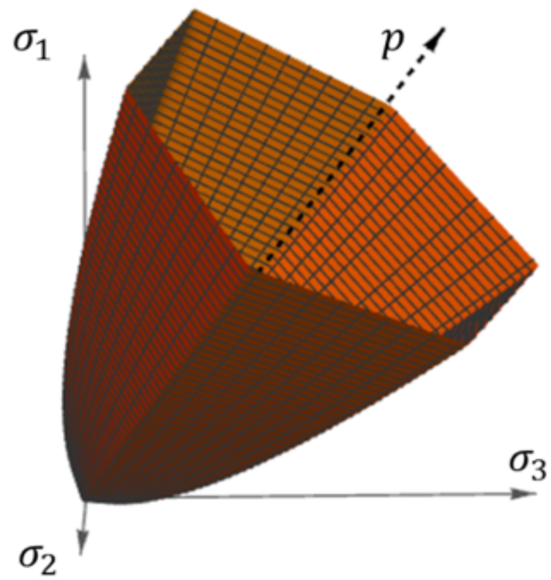
Criterio de fluencia al corte
en tensiones principales

$$\sigma_1 = \sigma_3 - \sigma_{ci}\left(s - m\frac{\sigma_3}{\sigma_{ci}}\right)^a$$

Parámetros: σ_{ci}, m, s, a

Genera una superficie de fluencia similar a Mohr-Coulomb con generatriz curva





Significado de los parámetros para **roca intacta** (σ_{ci}, m_i, s, a)

Compresión simple $(\sigma_3 = 0)$: $\sigma_1 = -\boldsymbol{\sigma_{ci}}$

$$-\sigma_{ci} = 0 - \sigma_{ci}\left(s - m_i \frac{0}{\sigma_{ci}}\right)^a \rightarrow \boldsymbol{s = 1}$$

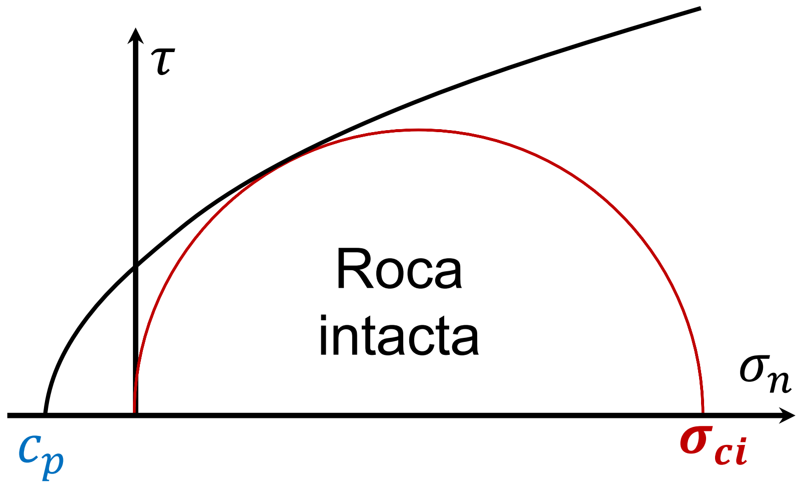
Tracción triaxial $(\sigma_1 = \sigma_3 = c_p)$

$$c_p = c_p - \sigma_{ci}\left(1 - m_i \frac{c_p}{\sigma_{ci}}\right)^a \rightarrow \boldsymbol{m_i = \frac{\sigma_{ci}}{c_p}}$$

Compresión triaxial: a ajusta la curvatura en el plano $\tau - \sigma$

$a = 0.5$ para roca intacta

$$\sigma_1 = \sigma_3 - \sigma_{ci}\left(1 - \frac{\sigma_3}{c_p}\right)^{\frac{1}{2}}$$



Resistencia a compresión simple σ_{ci}

Debe medirse en ensayos de compresión simple o triaxiales

	Term	σ_{ci} [MPa]	Field estimate of strength	Examples
R6	Extrem. strong	> 250	Can only be chipped with a geological hammer	Fresh basalt, chert, diabase, gneiss, granite,Quartzite
R5	Very strong	100 250	Requires many blows of a geological hammer to fracture it	Amphibolite, sandstone, basalt, gabbro, gneiss, granodiorite, limestone, marble, rhyolite, tuff
R4	Strong	50 100	Requires more than one blow of a geological hammer to fracture it	Limestone, marble, phyllite, sandstone, schist, shale
R3	Med. strong	25 50	Cannot be scraped or peeled with a pocket knife Can be fractured with a single blow from a geological hammer	Claystone, coal, concrete, schist, shale, siltstone
R2	Weak	5.00 25.0	Can be peeled with a pocket knife with difficulty Shallow indentation made by firm blow with point of a geological hammer	Chalk, rocksalt, potash
R1	Very weak	1.00 5.00	Crumbles under firm blows with point of a geological hammer Can be peeled by a pocket knife	Highly weathered or altered rock
R0	Extrem. weak	0.25 1.00	Indented by thumbnail	Stiff fault gouge

Parámetro m_i

Tracción isotrópica

$$m_i = \frac{\sigma_{ci}}{c_p}$$

Tracción simple

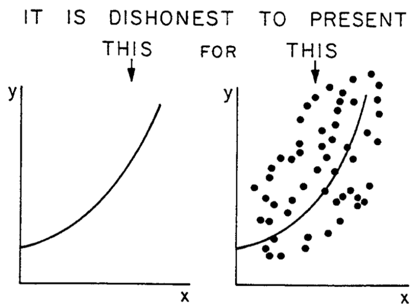
$$m_i = \frac{\sigma_{ci}}{\sigma_t} - \frac{\sigma_t}{\sigma_{ci}}$$

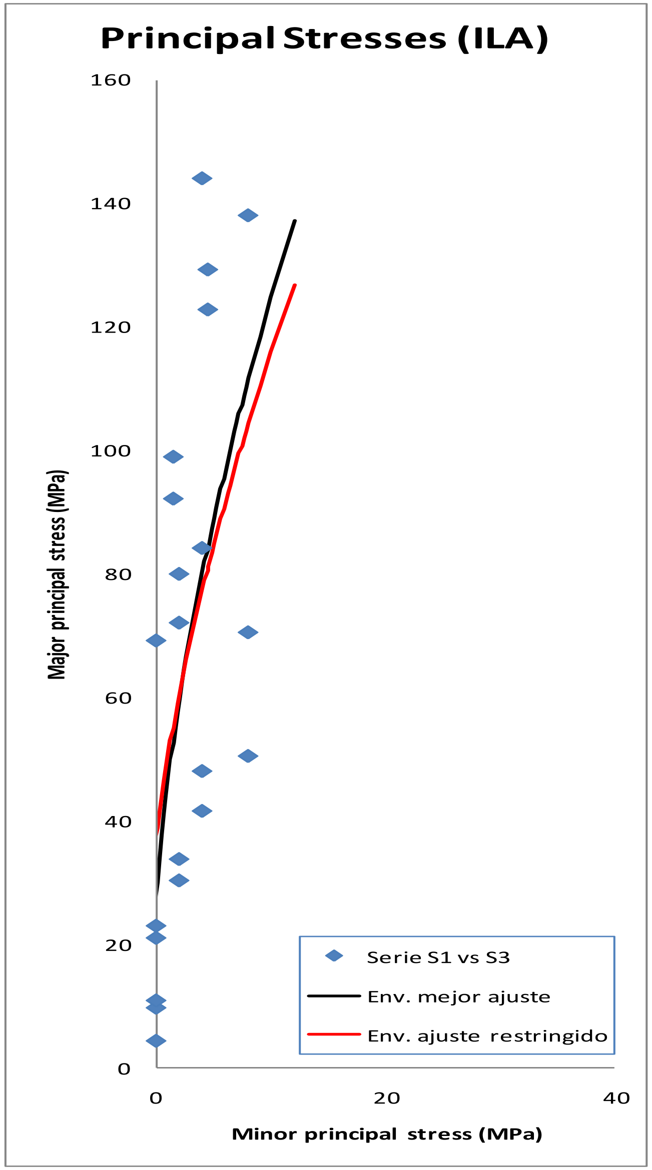
El vértice es (casi) tracción simple

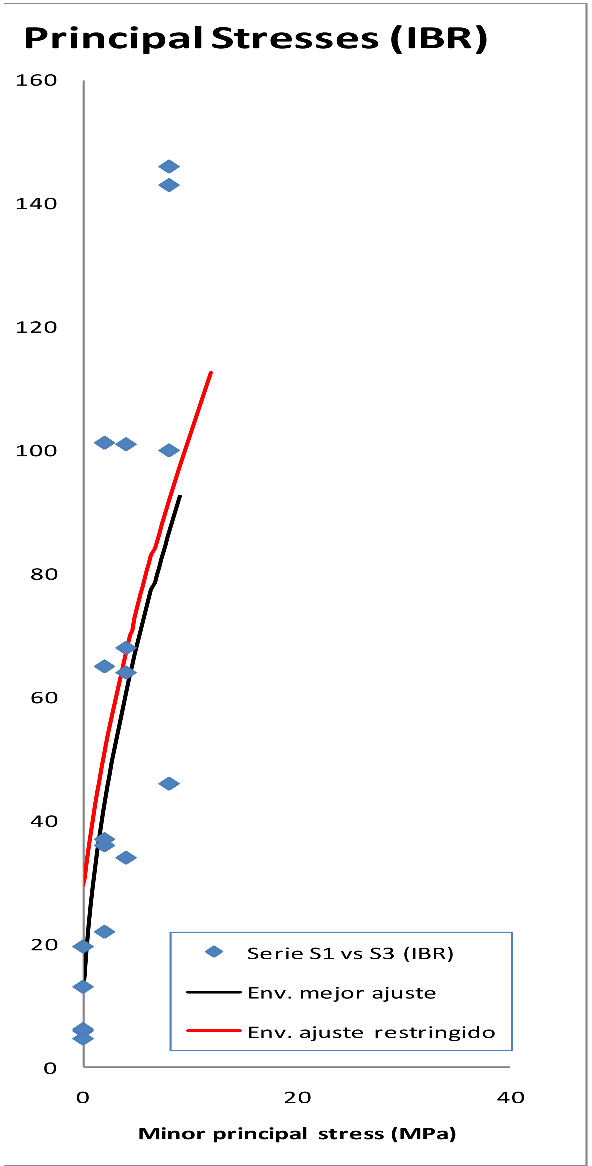
$$c_p = \frac{\sigma_t}{1 - \left(\frac{\sigma_t}{\sigma_{ci}}\right)^2} \cong \frac{\sigma_t}{0.99}$$

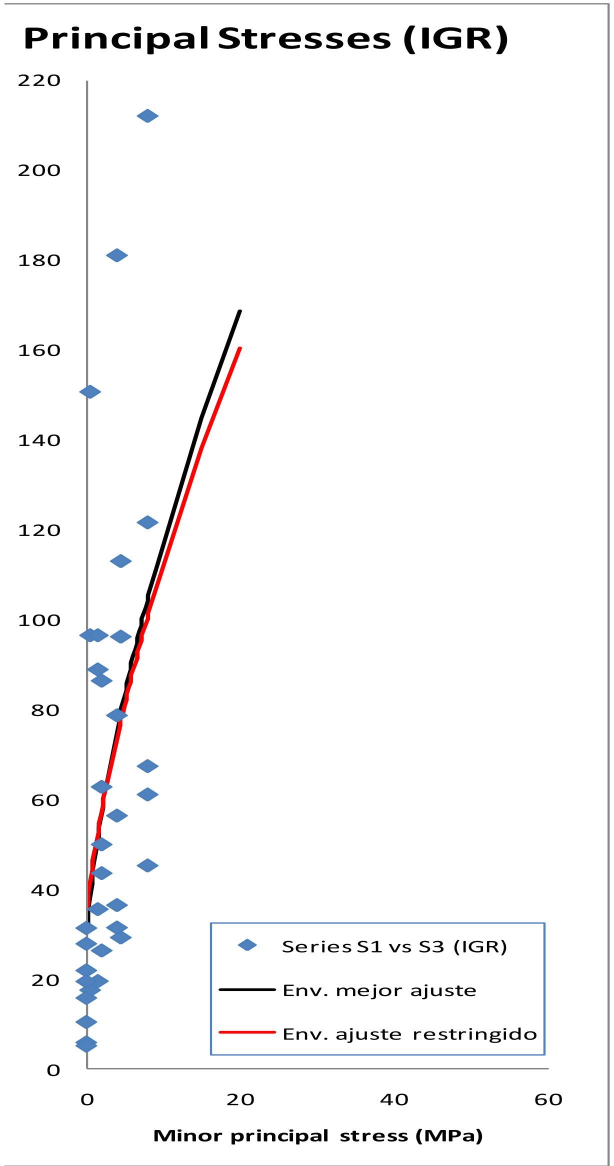
Rock type	Class	Group	Texture: Coarse	Medium	Fine	Very fine
SEDIMENTARY	Clastic		Conglomerates* (21 ± 3) Breccias (19 ± 5)	Sandstones 17 ± 4	Siltstones 7 ± 2 Greywackes (18 ± 3)	Claystones 4 ± 2 Shales (6 ± 2) Marls (7 ± 2)
	Non-Clastic	Carbonates	Crystalline Limestone (12 ± 3)	Sparitic Limestones (10 ± 2)	Micritic Limestones (9 ± 2)	Dolomites (9 ± 3)
		Evaporites		Gypsum 8 ± 2	Anhydrite 12 ± 2	
		Organic				Chalk 7 ± 2
METAMORPHIC	Non Foliated		Marble 9 ± 3	Hornfels (19 ± 4) Metasandstone (19 ± 3)	Quartzites 20 ± 3	
	Slightly foliated		Migmatite (29 ± 3)	Amphibolites 26 ± 6		
	Foliated**		Gneiss 28 ± 5	Schists 12 ± 3	Phyllites (7 ± 3)	Slates 7 ± 4
OUS	Plutonic	Light	Granite 32 ± 3 Diorite 25 ± 5 Granodiorite (29 ± 3)			
		Dark	Gabbro 27 ± 3 Norite 20 ± 5	Dolerite (16 ± 5)		
	Hypabyssal		Porphyries (20 ± 5)		Diabase (15 ± 5)	Peridotite (25 ± 5)
	Volcanic	Lava		Rhyolite (25 ± 5) Andesite 25 ± 5	Dacite (25 ± 3) Basalt (25 ± 5)	Obsidian (19 ± 3)
		Pyroclastic	Agglomerate (19 ± 3)	Breccia (19 ± 5)	Tuff (13 ± 5)	

Calibración de m_i



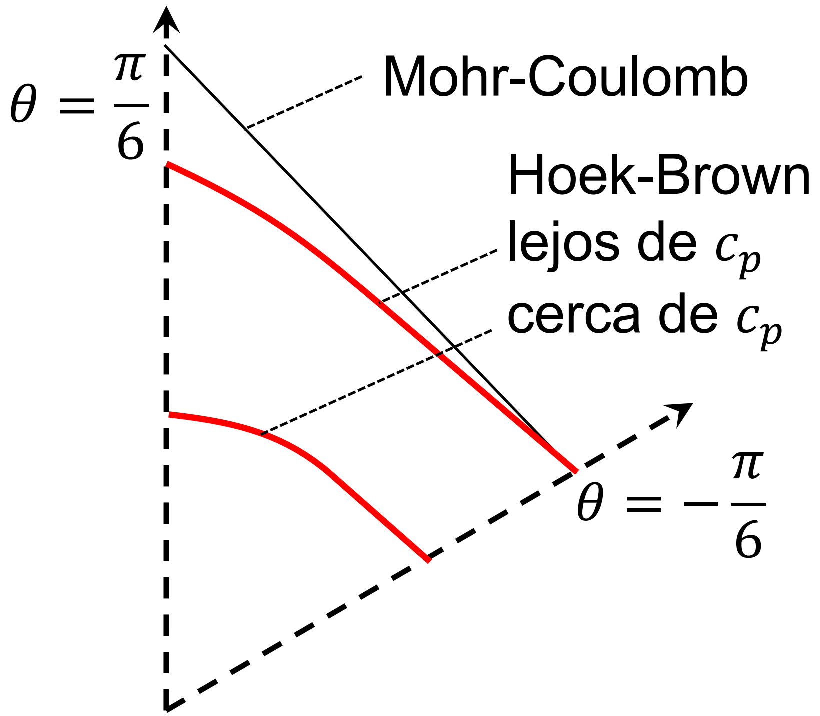


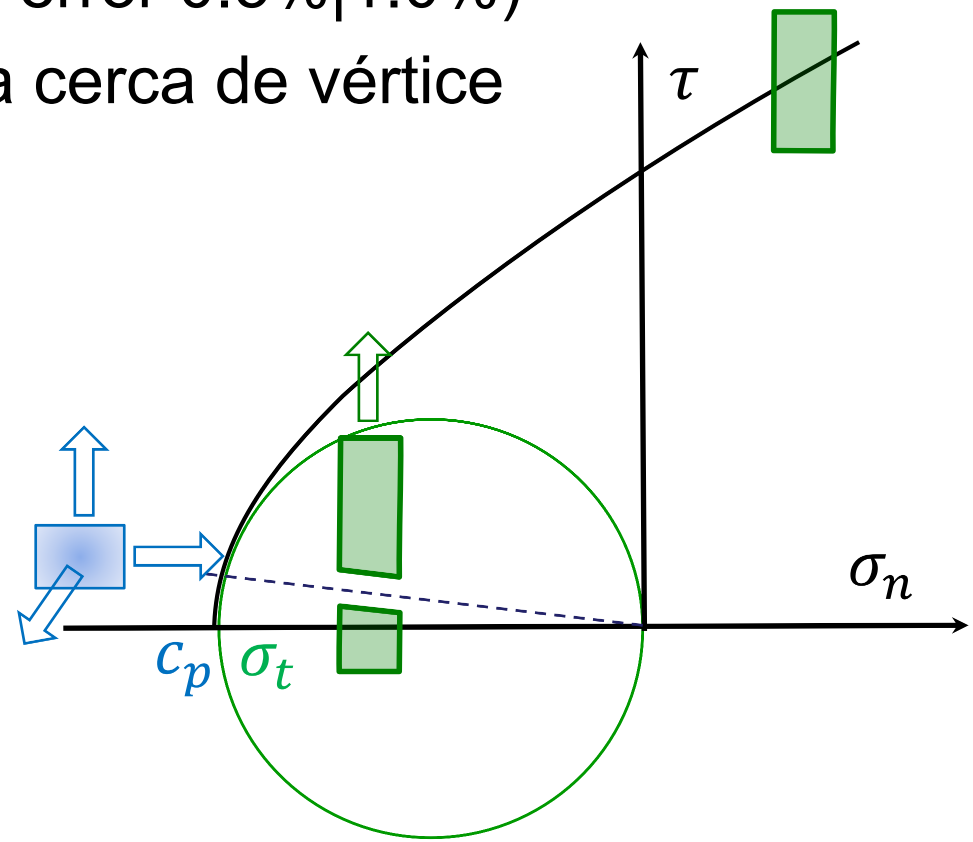




Críticas "académicas" al criterio de Hoek-Brown

- Un mismo criterio para falla al corte y a tracción
- Plano de ruptura oblicuo en el ensayo de tracción simple (indetectable en la práctica, error 0.5%|1.0%)
- Fuerte curvatura deviatórica cerca de vértice





Hoek-Brown complementado con falla por tracción simple

Hoek (2014) propuso un “**tension cut-off**”

- Mecanismos de corte y tracción independientes
- Resuelve el problema de la “falla oblicua”