

Fracture Mechanics of Different Rocks

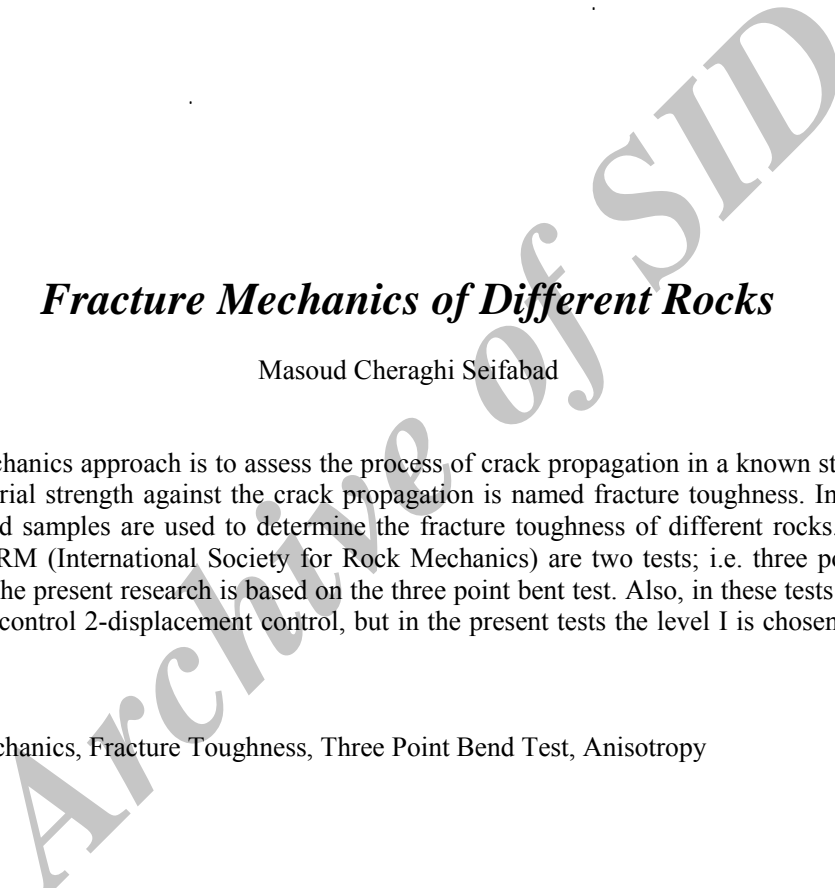
Masoud Cheraghi Seifabad

ABSTRACT

Fracture mechanics approach is to assess the process of crack propagation in a known stress field. The amount of material strength against the crack propagation is named fracture toughness. In this research, different cracked samples are used to determine the fracture toughness of different rocks. The methods proposed by ISRM (International Society for Rock Mechanics) are two tests; i.e. three point bend test and short rod. The present research is based on the three point bent test. Also, in these tests two levels are utilized, 1-load control 2-displacement control, but in the present tests the level I is chosen for two types of rocks.

KEYWORDS

Fracture Mechanics, Fracture Toughness, Three Point Bend Test, Anisotropy



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I [] ISRM

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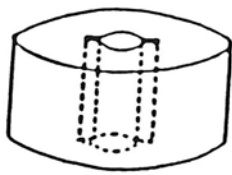
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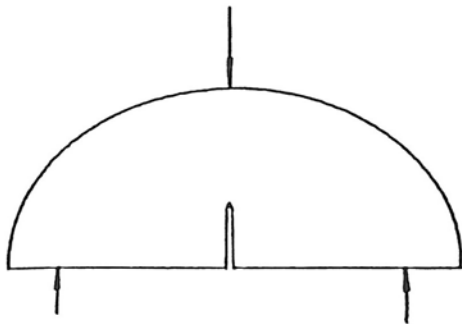
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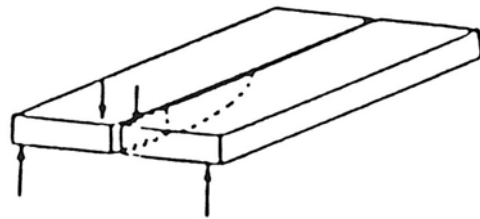
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(3PB)

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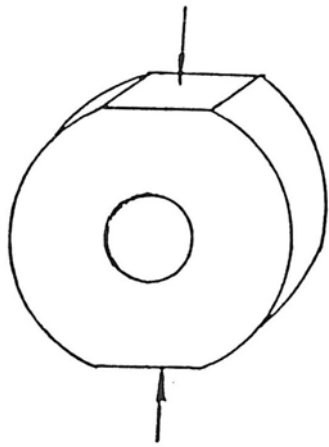
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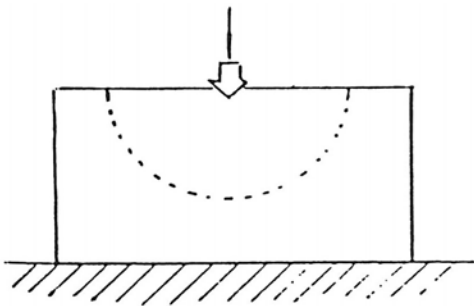
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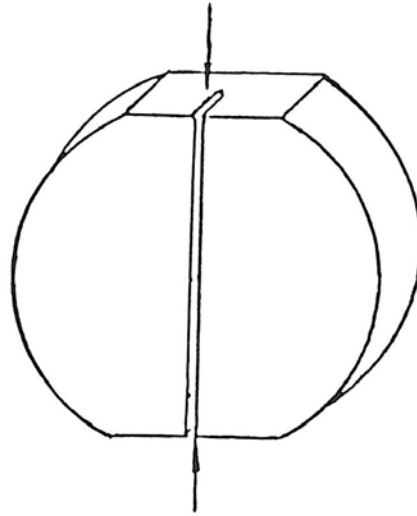


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	mm	
	≤ / D	(mm)t

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θ

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V

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$\frac{a}{W}$

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H

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a

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Pc

$$K_{IC} = \sqrt{P_c a (1 + 0.64 H/a)} (BH^{3/2}) \quad ()$$

K_{IC}

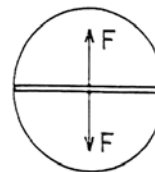
K_{IC} (MPa√m)

mode I (DCB)

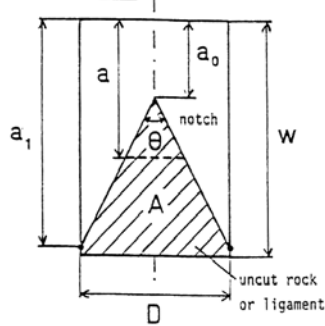
0.9 ± 0.1

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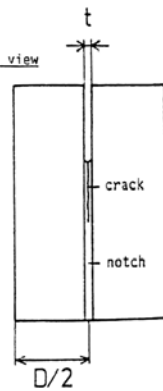
End view



Mid section view

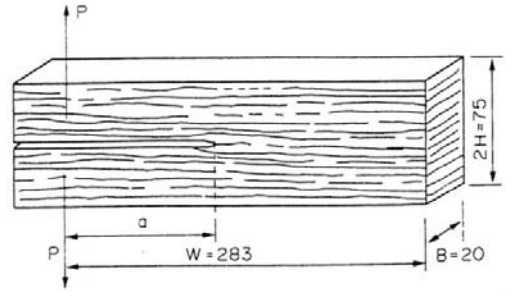


Side view



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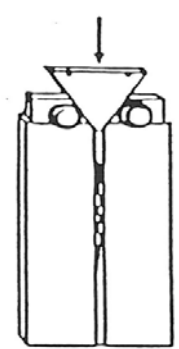
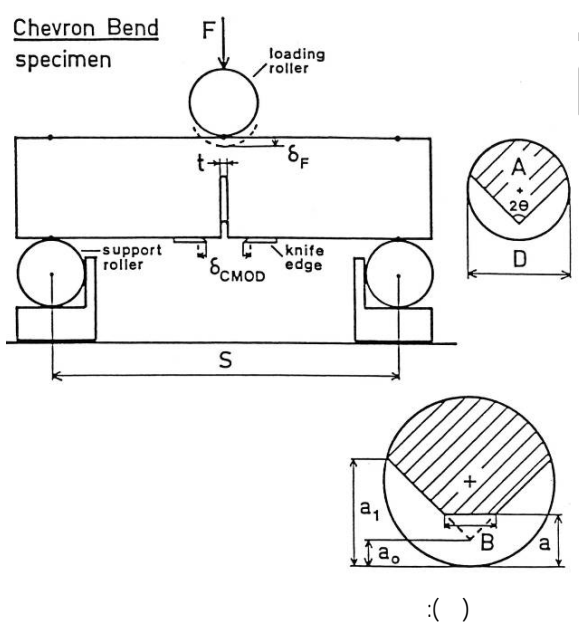
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() : ()

ISRM

(K_{IC}) () (F_{max})



() : ()

MPa

ISRM

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: ()

>	x	D	(mm)
>	/ D	D	(mm)
±	/ D		
±	°		θ°
±	/ D	/ D	a _o
		/ D mm	(mm)t
		≤	

D = √1mm, a_o = √1mm, a = √1mm

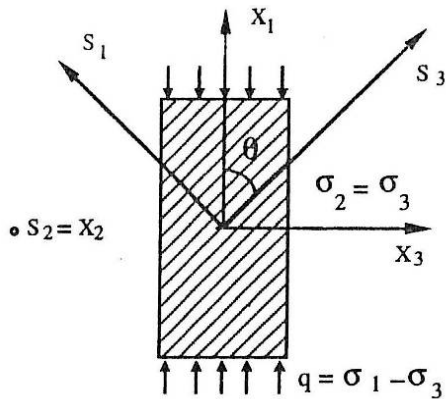
D = √1mm, a_o = √1mm, a = √1mm

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mm mm

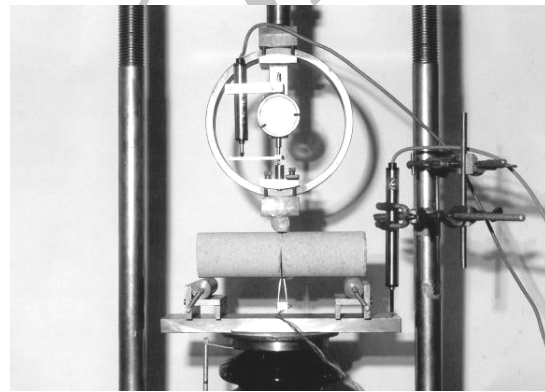
θ

() σ₁



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θ = 0°, 15°, 20°, 30°, 45°, 60°, 75°, 90°

σ_r = 1, 5, 10, 20, 30, 40, 50 MPa

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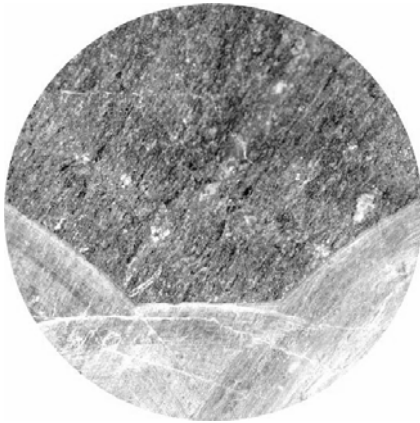
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	فشار جانبی کم	فشار جانبی زیاد
$0^\circ \leq \theta \leq 15^\circ$		
$15^\circ \leq \theta \leq 60^\circ$		
$65^\circ \leq \theta \leq 90^\circ$		

: ()

[] ISRM

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	(mm)	F_{max} (kN)	K_{IC} (MPa \sqrt{m})
A ₁	/	/	/
A ₂	/	/	/
A ₃	/	/	/
A ₄	/	/	/
A ₅	/	/	/
B ₁	/	/	/
C ₁₁	/	/	/
C ₂	/	/	/
C ₃₁	/	/	/
C ₄₁	/	/	/
C ₅	/	/	/
D ₁	/	/	/
D ₂	/	/	/
D ₃	/	/	/
E ₁	/	/	/
E ₂	/	/	/
E ₃	/	/	/

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ISRM

$$K_{IC} = A_{min} \frac{F_{max}}{D^{3/2}} \Rightarrow K_{IC} = 10/42 \frac{F_{max}}{D^{3/2}} \quad ()$$

$$A_{min} = 10/42$$

E D (C B A)

A₄

A₃

A₅

C₃₁

B₁

C₄₁

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- Niandou H., Shao J. F., Henry J.P. and Fourmaintraux D. Laboratory investigation of the mechanical behaviour of Tournemire Shale. *Int. J. Rock Mech Min Sci.* Vol 34 No.1 pp 3-16 (1997). []
- Singh R.N., Pathan A.G. Fracture toughness of some british rocks by diametral loading of discs. *Mining Science and Technology*, 6 pp 179-190 (1987). []
- Swain M.V., Lawn B.R., Indentation fracture in brittle rocks and glasses. *Int. J. Rock. Mech. Min. Sci.* Vol 13, pp 85-91 (1976). []
- Cheraghi Seifabad, M. Fracture toughness evaluation and the mechanical cutting characteristics, 8th international IAEG Congress, Vancouver, Canada, pp 3577-3582 (1998). []
- Fairhurst, C. and Cornet, F. H. Rock fracture and fragmentation, rock mechanics from research to applications, 2nd US Symp. Rock. Mech., Massachussetes Institute of Technology (1981). []
- Kemeny, J and Cook, N.G.W. Formation and stability of steeply joint sets. 26th US Symposium on rock mechanics, pp 471-479 (1985). []
- Peck I., Cording R. P. The effect of compressive stress on the fracture energy of Sioux Quartzite, *Geophysical Research Letters*, Volume 9, No.3, pp 186-189. []
- Schmidth, R. A., Fracture mechanics of oil shale-unconfined fracture toughness, stress corrosion cracking, and tension test results. In proc. 18th U.S. Symposium on Rock Mech., pp 2A2-1 2A2-6 (1977). []
- Swain M.V., Lawn B.R., Indentation fracture in brittle rocks and glasses. *Int. J. Rock. Mech. Min. Sci.* Vol 13, pp 85-91 (1976). []
- Tharp, T.M and Coffin D.I. Field application of fracture mechanics analysis to small rock samples, 26th US symposium on rock mechanics, pp 667-674 (1985). []
- Thiercelin M., Roegiers. Fracture toughness determinations wth modified ring test. Proc. 27th US sympo. on Rock Mechanics, H. L. Hartman ed., SME Co, pp 615-622. (1986). []
- Takahashi, H. Application of rock fracture mechanics to HDR geothermal reservoir design. *Fracture toughness and fracture energy*, pp 591-610 (1989). []
- Abou-Sayed A.S., An experimental technique for measuring the fracture toughness of rock under downhole stress conditions, *VDI-Berichte*, Nr. 313, pp 819-824 (1978). []
- Athkinson B.K., Fracture toughness of Tenesse sandstone and Carra marble using the Double Torsion Method. *Int. J. Rock. Mech. Min. Sci.* Vol 16, pp 49-53 (1979). []
- Athkinson B.K., Avdis V., Fracture mechanics parameters of some rock-forming minerals determined using an indentation technique. *Int. J. Rock. Mech. Min. Sci.* Vol 17, pp 383-386 (1980). []
- Chong K.P., Kruppa M.D. New specimen for fracture toughness determination of rock and other materials. *Int. J. Fract.* 26, R59-R62 (1984). []
- Henry J.P., Paquet J. and Tancrez J.P. Experimental study of crack propagation in calcite rocks. *Int. J. Rock. Mech. Min. Sci.* Vol 14, pp 85-91 (1977). []
- Hoagland R. G., Hahn R. G. and Rosenfield, A. R. Influence of microstructure on fracture propagation in rock, *Rock Mechanics*, Vol. 5, pp 77-106 (1973). []
- ISRM suggested method for determining the fracture toughness of rock. *Int. J. Rock Mech. Min. Sci & Geomech Abstr.* Vol 25, No.2, pp73-96 (1988). []
- ISRM on the background to the formulae and accuracy of rock fracture toughness measurements using ISRM standard core specimens. *Int. J. Rock Mech. Min. Sci & Geomech Abstr.* Vol 26, No.1, pp. 13-23 (1989). []
- Kannien M. F., An Augmented double cantilever beam model of studying crack propagation and arrest. *Int. J. Fract.* 9(1), 83-92 (1973). []
- Laqueche H., Rousseau A. and Valentin G. Crack propagation under Mode I and II loading in slate schist. *Int. J. Rock. Mech. Min. Sci.* Vol 23, pp 347-354 (1986). []



- ¹ Fracture Toughness
- ² ISRM, International Society for Rock Mechanics
- ³ Short rod
- ⁴ Three Point Bend Test
- ⁵ Load Control
- ⁶ Displacement Control
- ⁷ Level I
- ⁸ Linear Elastic Fracture Mechanics
- ⁹ Stress Intensity, K
- ¹⁰ Opening Mode
- ¹¹ Sliding Mode
- ¹² Tearing Mode
- ¹³ Double Torsion Method
- ¹⁴ St. Pons marble
- ¹⁵ Fallers micrite
- ¹⁶ The Burst Cylinder Specimen
- ¹⁷ Semi-Circular Specimen
- ¹⁸ Disc Diametral Loading Test
- ¹⁹ Modified Ring Test
- ²⁰ Direct Indentation Test
- ²¹ Short Rod Specimen
- ²² Double Cantilever Beam
- ²³ Indiana limestone
- ²⁴ Foliation
- ²⁵ Anvil Points oil shale
- ²⁶ Berea sandstone
- ²⁷ Salem limestone
- ²⁸ Tournemire shale

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