# A New Loading Fixture for Direct Rock Fracture Toughness Determination Using pCT and Short Rod Specimens

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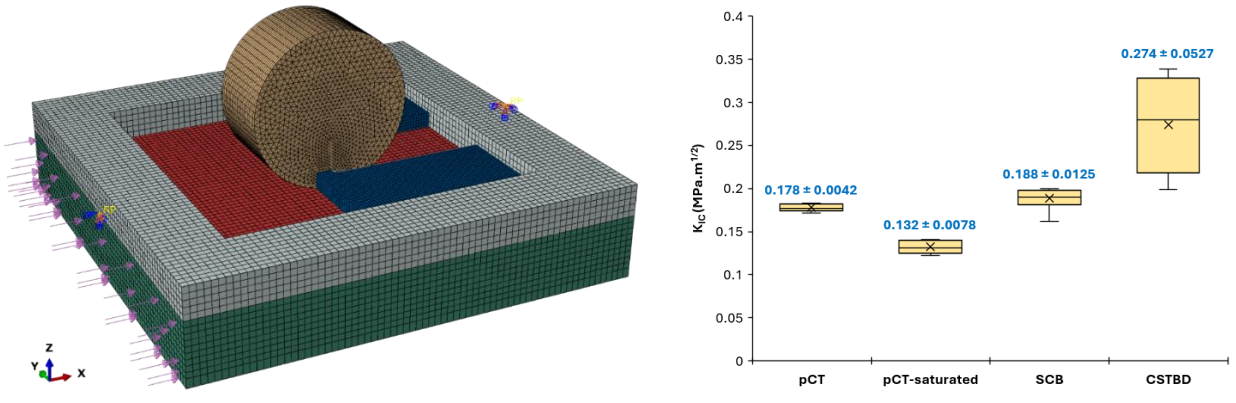
**KEYWORDS :** *fracture toughness, pCT, short rod, direct shear apparatus, experimental methods*

Determination of Mode I fracture toughness in brittle geomaterials typically requires complex and specialized loading systems, limiting the practical use of established methods such as the pseudo-Compact Tension (pCT) and ISRM Short Rod (SR) tests [1,2]. This study presents a simplified and cost-effective approach that enables both methods to be performed using a conventional direct shear apparatus. A novel shear-to-tensile (ST) loading fixture is developed to generate controlled tensile loading within the shear box. The fixture consists of CNC-cut structural steel plates and can be easily installed without additional equipment. This setup allows the execution of pCT, proposed here as a direct fracture mechanics test, and SR testing within a single, accessible system. Finite element simulations in Abaqus were conducted to design and optimize the fixture prior to manufacturing, ensuring adequate stiffness and load transfer. The numerical model and representative pCT results are shown in Fig. 1. The method supports both dry and submerged testing conditions and enables stable crack propagation with post-peak response capture. Experimental validation on gypsum specimens shows that the obtained fracture toughness values are consistent with standard methods, including Semi-Circular Bend (SCB) and Cracked Straight Through Brazilian Disc (CSTBD) tests. For SR, an average $K_{IC}$ of approximately 0.287 MPa√m was obtained, compared to approximately 0.288 MPa√m from SCB, demonstrating good agreement. The proposed approach significantly reduces experimental complexity, cost, and setup time, while eliminating the need for external displacement measurement devices such as LVDTs. It provides a practical and efficient alternative for fracture toughness testing, with potential for broader application to stronger rock materials.




a) b)

**Figure 1.** (a) FEM model of the ST tool for pCT. (b) Comparison of $K_{IC}$ results from pCT, SCB, and CSTBD tests.

[1] Muñoz-Ibáñez, A., Delgado-Martín, J., Costas, M., & Juncosa-Rivera, R. (2020). Pure Mode I fracture toughness determination in rocks using a pseudo-compact tension (pCT) test approach. Rock Mechanics and Rock Engineering, 53, 3267–3285. https://doi.org/10.1007/s00603-020-02102-6

[2] Ouchterlony, F. (1988). ISRM commission on testing methods: Suggested methods for determining the fracture toughness of rock. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, 25(2), 71–96.