國立中央大學
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Evaluation of Rock Slope Model Parameters under the Influence of Anisotropic Inherent Joints

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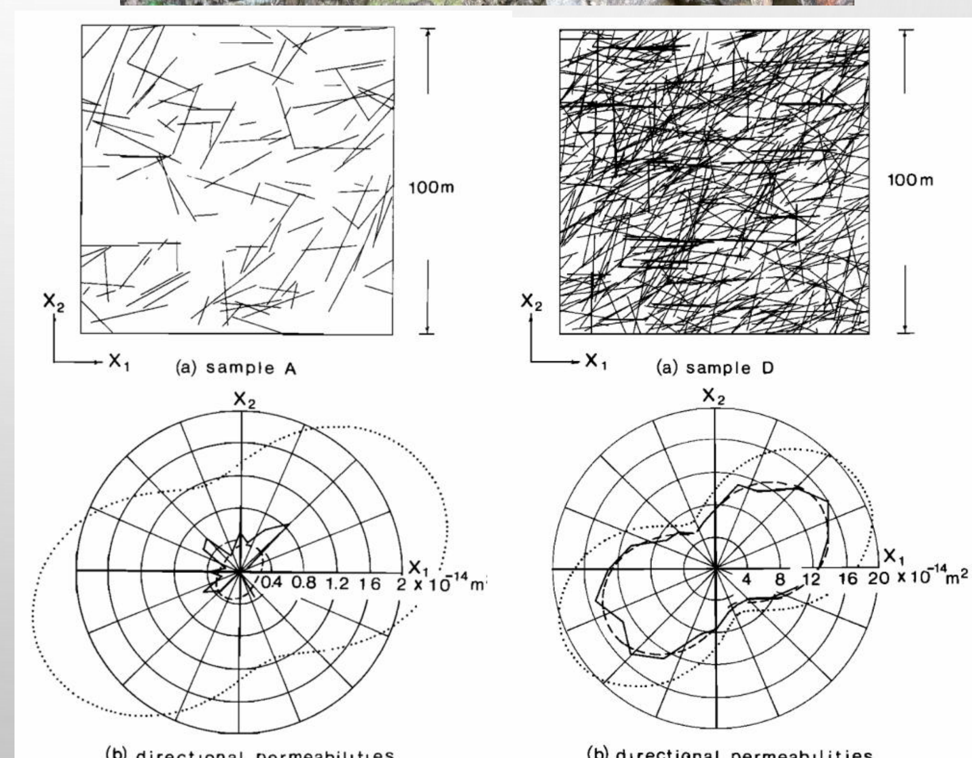
INTRODUCTION

RESEARCH BACKGROUND:

- Fractured rock masses exhibit complex permeability anisotropy, significantly influenced by joint properties such as cohesion and friction angle.
- Understanding the relationship between joint strength, fracture density , and the connectivity parameter(λ) is essential for accurate rock slope stability assessment.



Polar diagram showing corresponding permeabilities

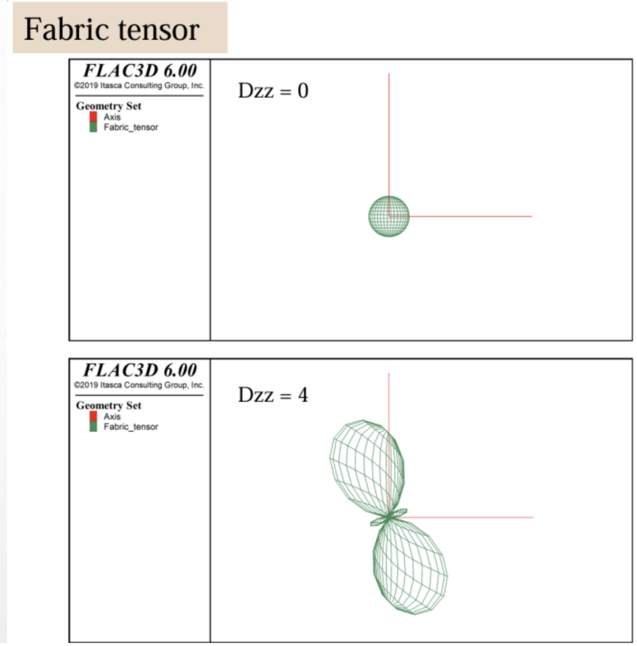
(ODA,1987)

INTRODUCTION

MOTIVATION:

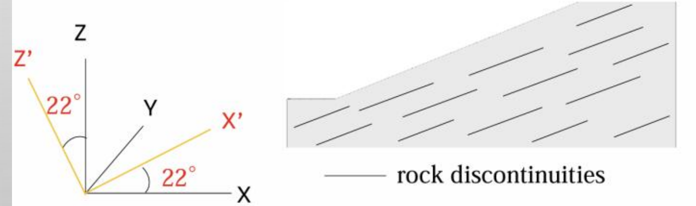
- Our laboratory utilizes the fabric tensor to calculate the equivalent anisotropic permeability coefficient, which serves as the initial parameter for the model.
- This approach allows for investigating pore water pressure variations and conduct slope stability analyses. However, the current permeability coefficient calculations assume fully connected joints.

the connectivity parameter
$\lambda=1/12$?



Fabric tensor is normal vector function of discontinuity density.

Dxx = Dyy , Dxx + Dyy + Dzz = 0 (Kanatani, 1984)



(Jia-Yi Wu,2025)

INTRODUCTION

(ODA,1987)

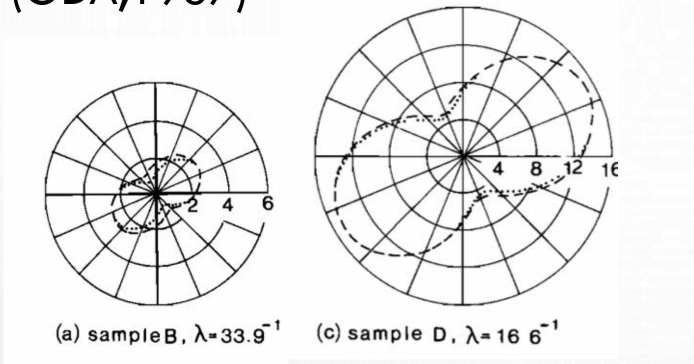


Fig. 8. Adjustment of λ. (Note that using the adjusted value, the theoretical permeabilities (dotted curves) are well fitted to the numerically determined ones (dashed curves).)

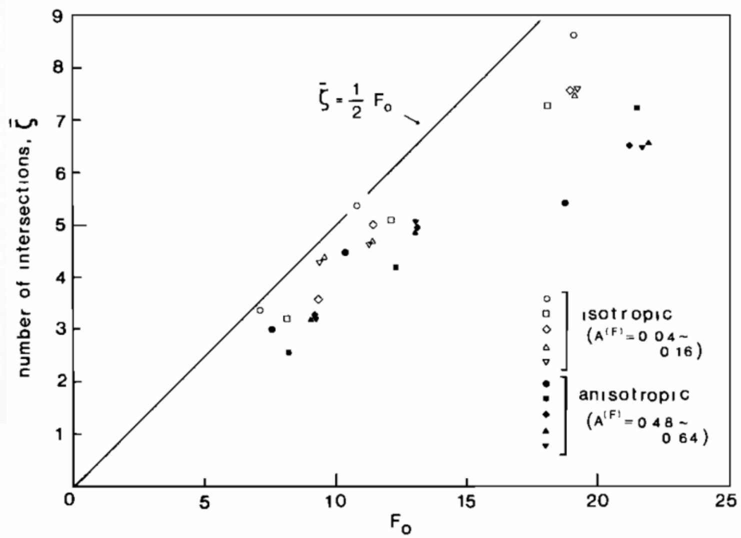


Fig. 10. Relation between the number of intersections per joint and the trace F_0 of the tensor F_{ij}.

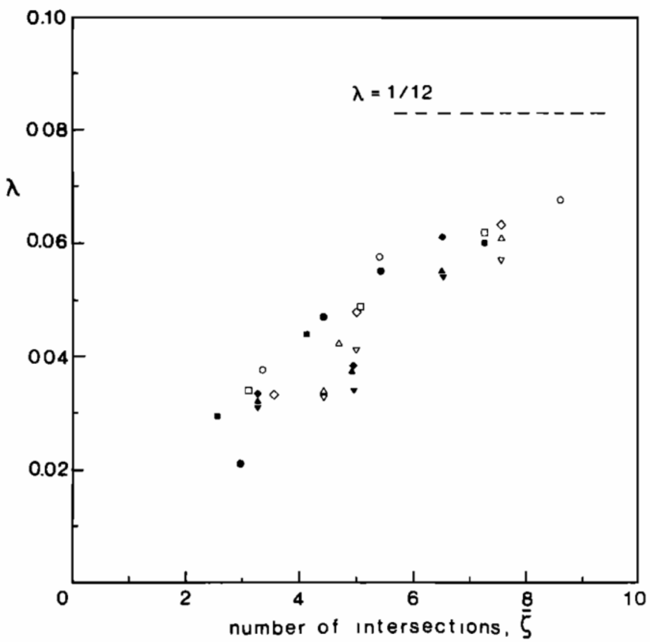


Fig. 11. Relation between the number of intersections per joint and the dimensionless scalar λ.

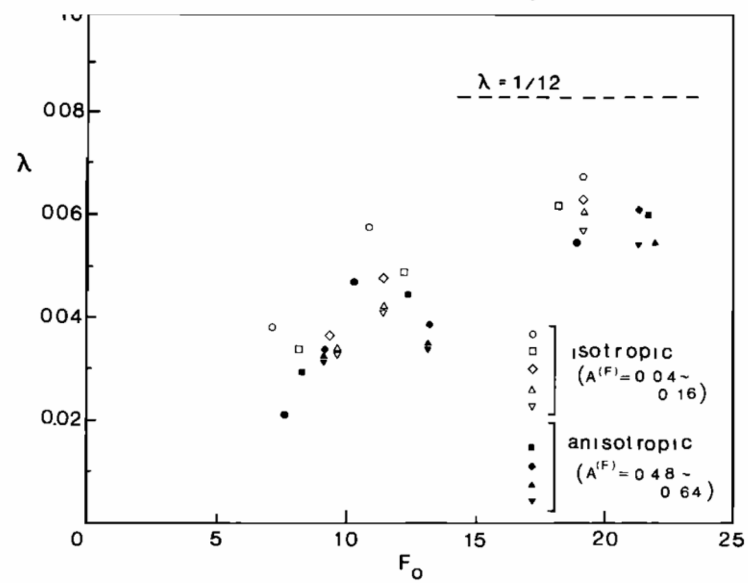


Fig. 12. Alternative method for estimating λ by using F_{ij} instead of

INTRODUCTION

LITERATURE REVIEW:

- Oda (1985, 1987): Established permeability tensor theory for fractured rock masses.
- Barton & Choubey (1977): Investigated joint shear stiffness and its dependence on friction angle.
- Bandis et al. (1983): Developed a joint closure model, linking stress to fracture permeability changes.
- Robinson (1984): Examined percolation in fracture networks and critical density thresholds.
- Mauldon et al. (2001): Developed an improved permeability tensor model for anisotropic fractured rock masses.

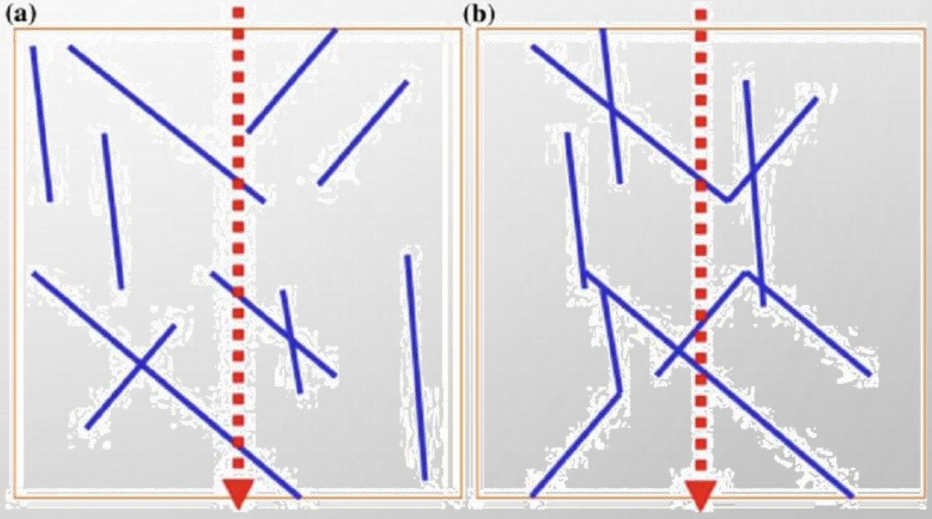
INTRODUCTION

PROBLEM STATEMENT:

- Current models assume fully connected joints, neglecting the effects of joint mechanical properties on fracture connectivity and permeability anisotropy.

RESEARCH OBJECTIVES:

- Develop a numerical model integrating joint strength, anisotropic permeability, and stress-fracture interactions.
- Investigate the effects of joint connectivity on permeability.
- Validate the proposed model through numerical simulations.



Schematic of connectivity of fracture network (Red dash represents water flow through fractured rock mass, blue lines represent fractures)

(Xiaoyan Liu et al. 2008)

METHODOLOGY

THEORETICAL FRAMEWORK:

- Extend Oda's permeability tensor model to incorporate joint mechanical properties.
- Establish the relationship between cohesion (C) and friction angle (ϕ) with fracture density evolution.

MATHEMATICAL MODEL:

- Fracture Density Function:

$$F_o = f(\sigma_n, \tau, c, \phi)$$

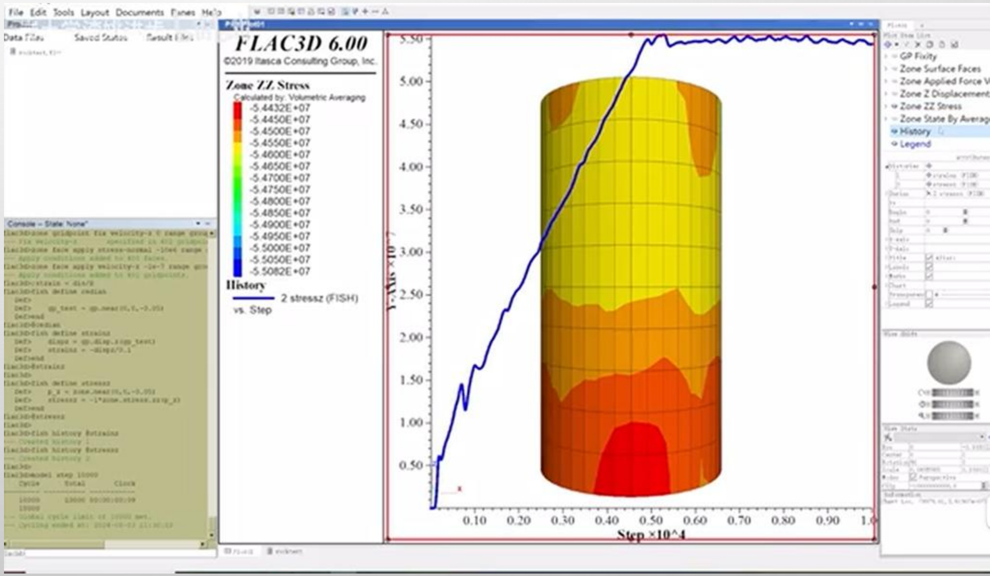
- Stress-Dependent Connectivity Parameter (λ) Correction:

$$\lambda = g(F_o, \sigma_n, \tau)$$

METHODOLOGY

NUMERICAL SIMULATION SETUP:

- **Software:** FLAC3D
- **Test Setup:** Triaxial test conditions applied to rock slope models with anisotropic joints.
- **Analysis:**
    - Relationship between joint strength and permeability anisotropy.
    - Influence of anisotropic strength on slope stability.



METHODOLOGY

Model Geometry Construction

Material Property Definition

Boundary Condition and Loading Setup

Numerical Computation

Result Analysis

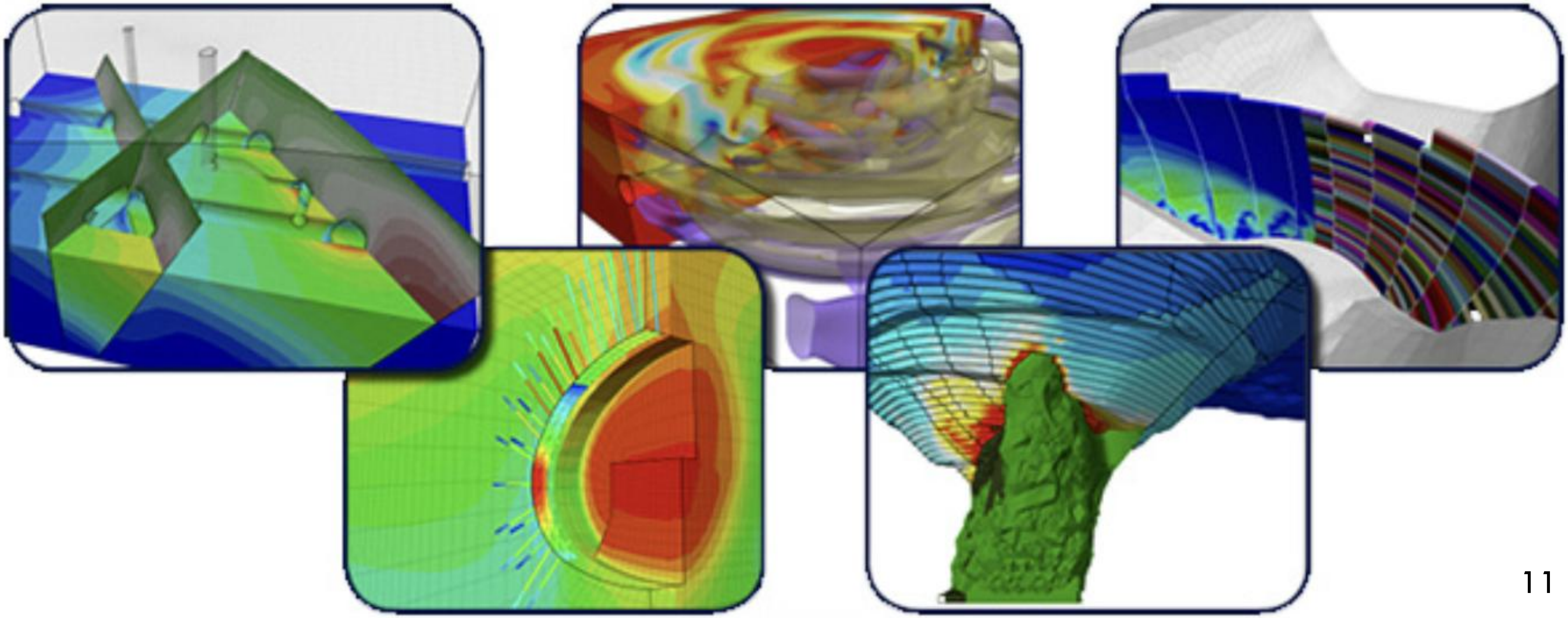
Engineering Applications

EXPECTED RESULTS & DISCUSSION

1.Effect of Joint Strength on Fracture Density

2.Relationship Between λ and Fracture Connectivity

3.Comparison of Numerical and Theoretical Results



FUTURE WORK

Model Refinement:

- Extend the model to include time-dependent fracture evolution.

Engineering Applications:

- Apply the model to rock slope stability assessment, groundwater flow modeling, and tunnel design.

Field Data Integration and Validation:

- Validate results with permeability tests and inherent joint strength measurements.

CONCLUSION

This study proposes a 3D numerical model incorporating joint strength, permeability connectivity, and strength anisotropy, providing a more realistic assessment of fractured rock slope stability

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THANK YOU FOR LISTENING

- OPEN FLOOR FOR AUDIENCE QUESTIONS.