Research about the Hydro-Mechanical Coupling Effect on the Process of Rock Failure

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Outline

1. Introduction of the Project
2. Governing Equation
3. Simulation Model and Parameter
4. Results and Discussion
5. Future Work

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Introduction of the Project

Dam

Underground Liquefied Petroleum Gas Storage

Rock and cement will meet with obvious hydro-mechanical coupling effect under several situations, which will accelerate the failure process.

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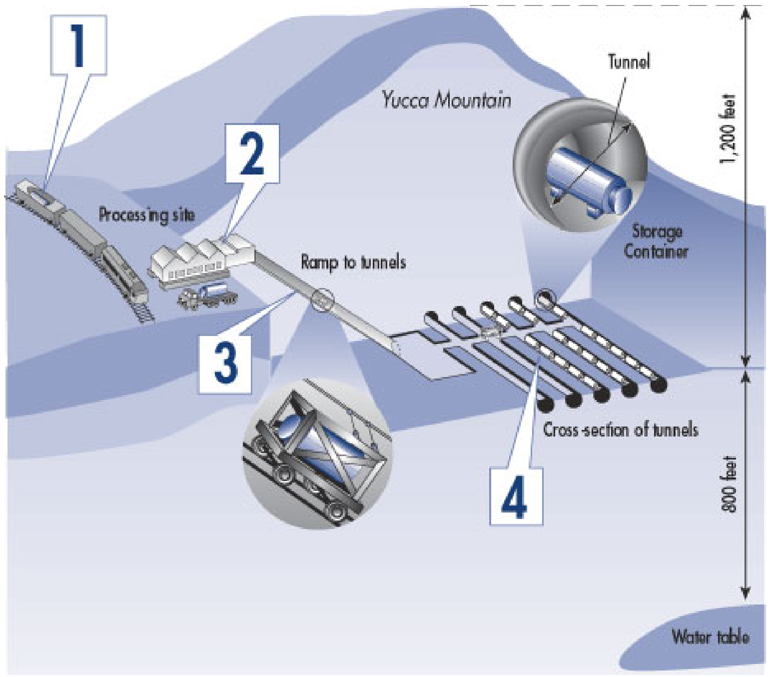
Introduction of the Project



Conceptual Nuclear Waste Repository

Thermal-Hydro-Stress coupling effect will occur in nuclear waste deposition. This effect can be simplified to hydro-stress effect by only considering the thermal effect on elastic modulus.

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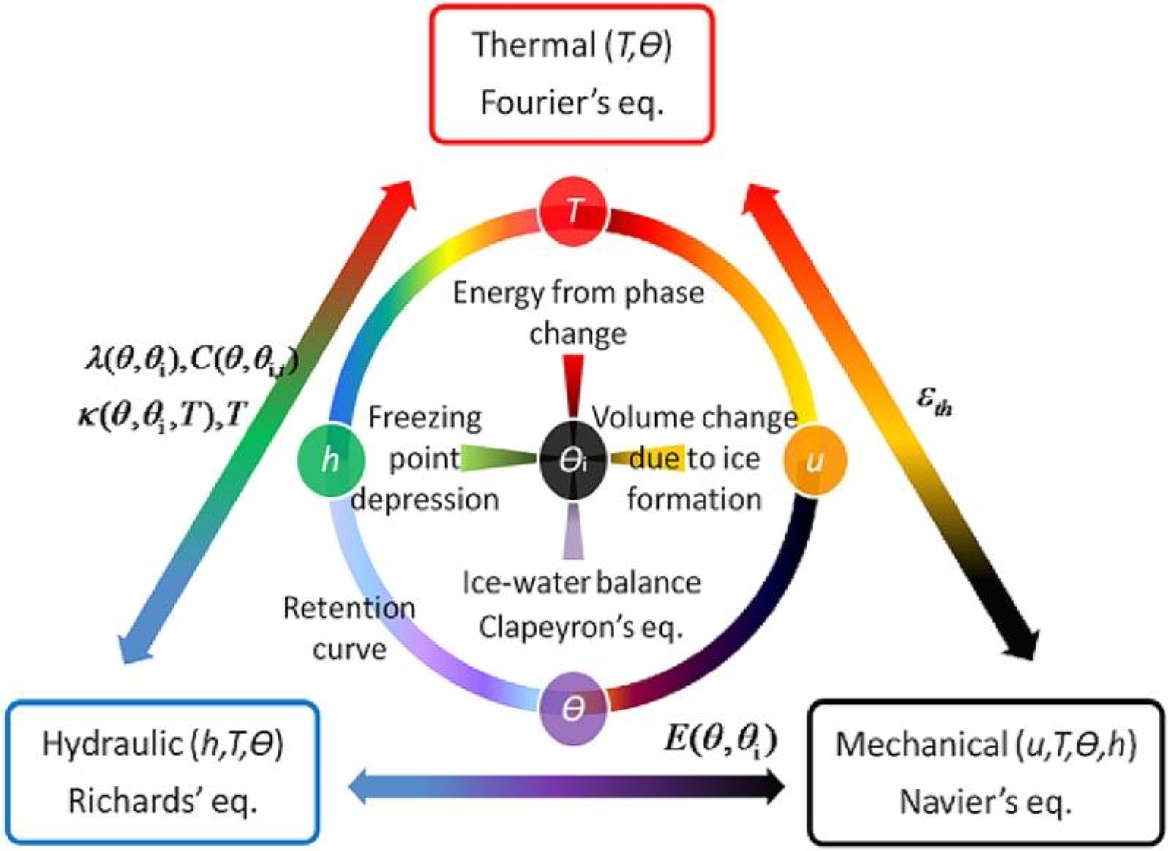
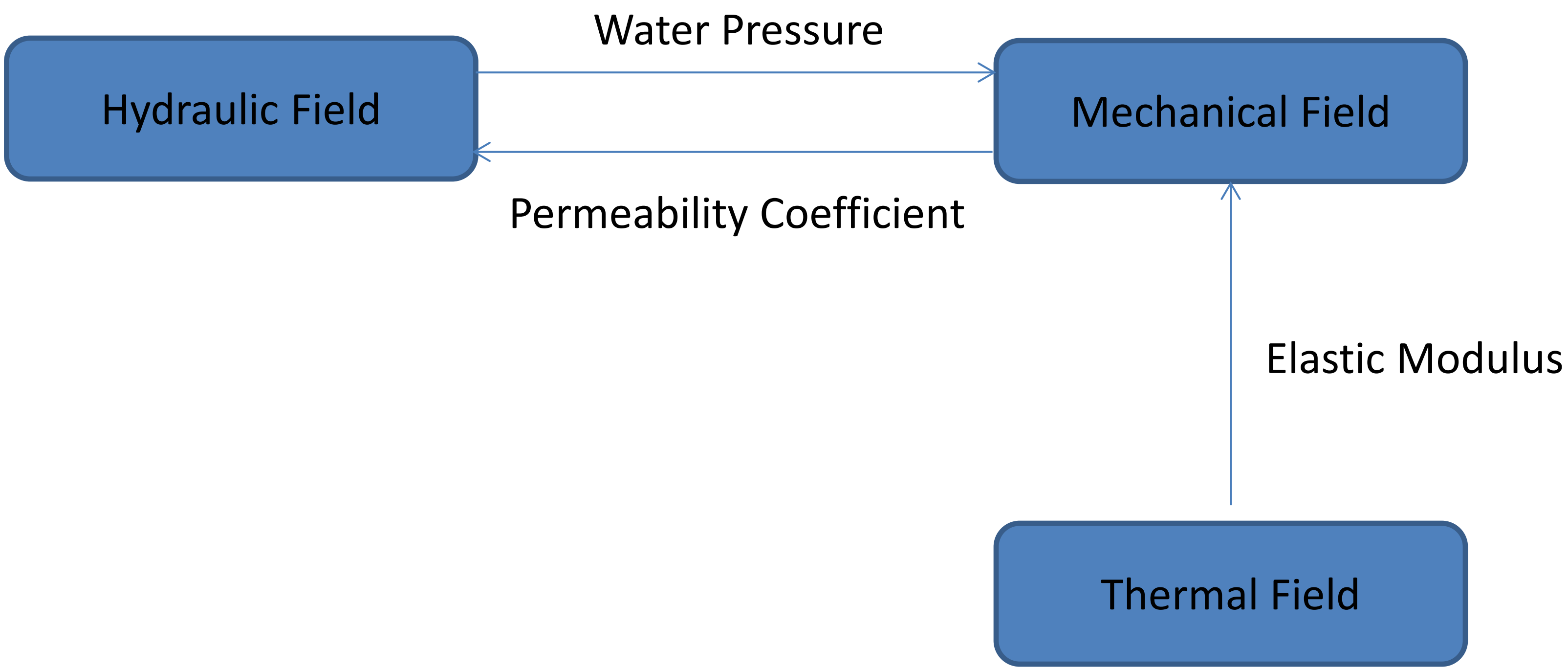
Introduction of the Project



Coupling effect of Thermal-Hydraulic-Mechanical effect

Introduction of the Project



Governing Equations

The Equilibrium Equation

$$\frac{\partial \sigma_{ij}}{\partial x_{ij}} + \rho X_j = 0$$

The Relationship between the Volume Strain and the Normal Strain

$$\varepsilon_v = \varepsilon_{ii}$$

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Governing Equations

The Constitutive Equations

$$\sigma'_{ij} = \sigma_{ij} - \alpha_w p \delta_{ij} = \lambda \delta_{ij} \varepsilon_v + 2G\varepsilon_{ij}$$

Seepage Equation

$$\Delta n = p / Q - \alpha_w \varepsilon_v = p / H - \sigma_{ii} / 3H$$

$$K_{ij} \nabla^2 p = \frac{1}{Q} \frac{\partial p}{\partial t} - \alpha \frac{\partial \varepsilon_v}{\partial t}$$

Effective stress is introduced to indicate the combined effect of water pressure and stress.

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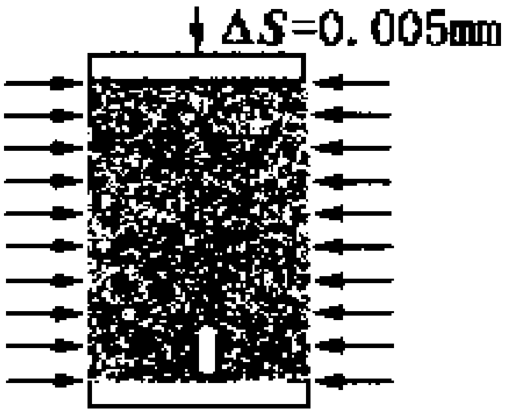
Simulation Model and Parameters

Simulation Parameters of the Continuous Rock Specimen

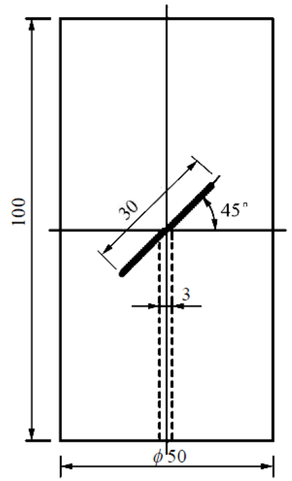
Elastic Modulus	Poisson's ratio	pore-water pressure coefficient	Water pressure at the bottom	Water pressure at the top
6000 MPa	0.25	0.8	2.8 MPa	1.3MPa

Simulation Model of the Continuous Rock Specimen



Simulation Model and Parameters

Simulation Model of the Rock Specimen with Fracture



Simulation Parameters of the Rock Specimen with Fracture

Elastic Modulus	Poisson's ratio	pore-water pressure coefficient
10.67 GPa	0.27	0.8

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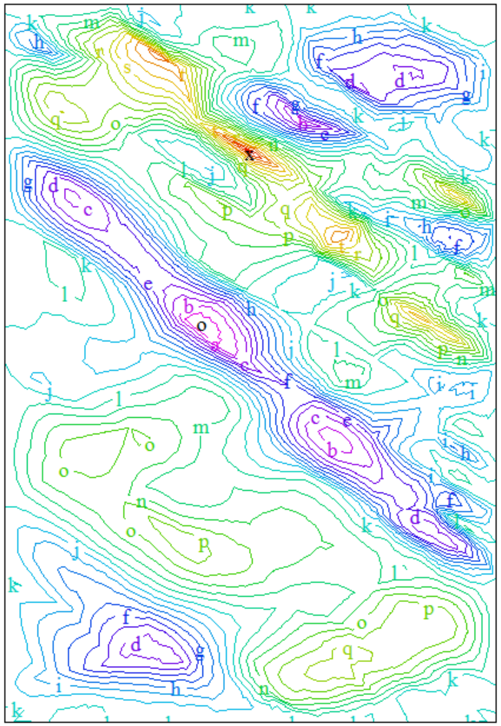
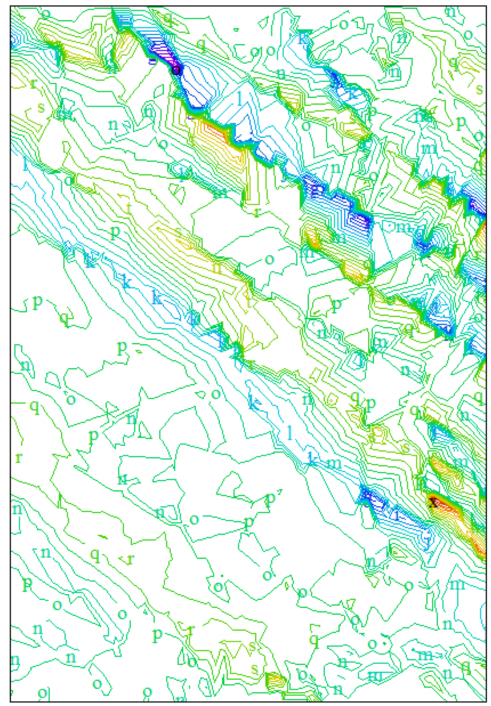
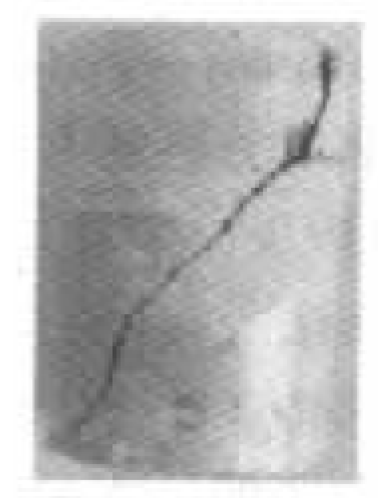
Results and Discussion



U-displacement



Stress-x

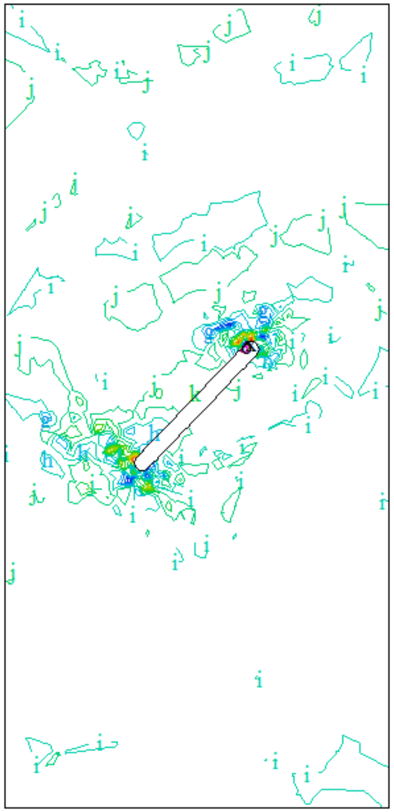


Experiment Result

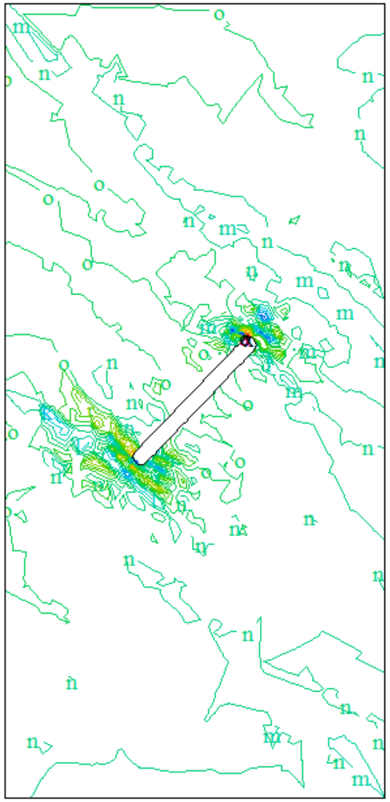
The fracture shape of the fracture result is compatible with the stress and displacement calculation results.

Results and Discussion

Simulation Results of the Rock Specimen with Fracture



Stress-x



Stress-y

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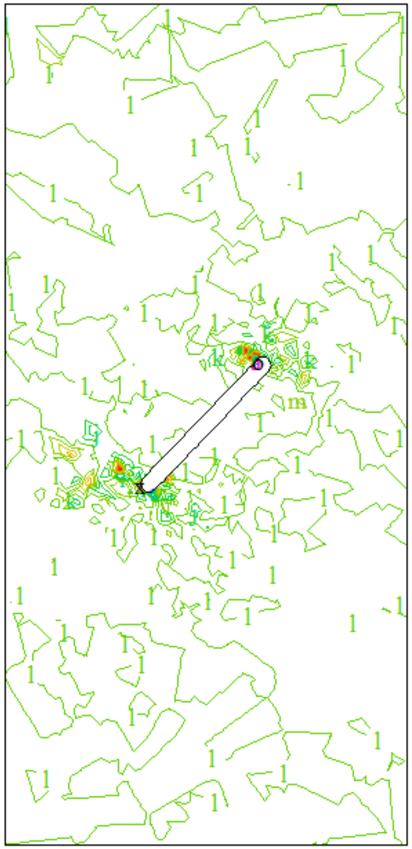
Results and Discussion

Calculation Results



Stress-xy

Experimental Results

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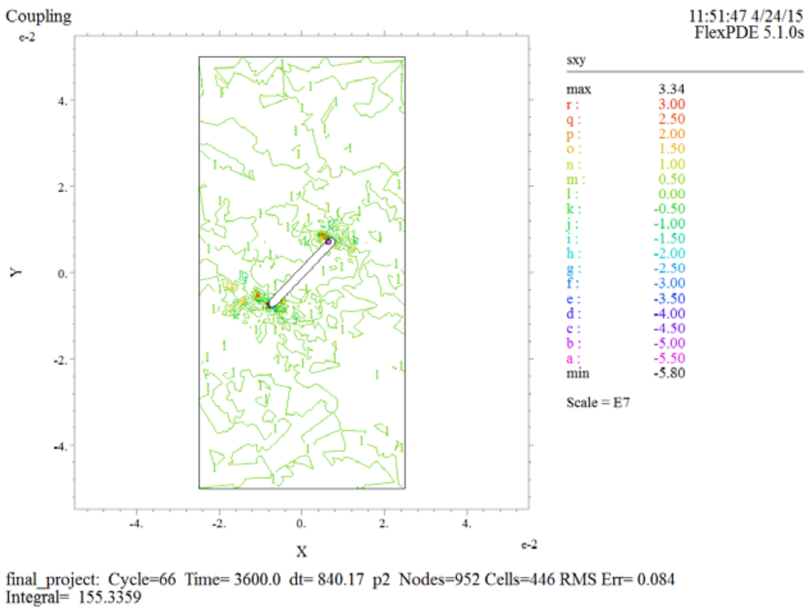
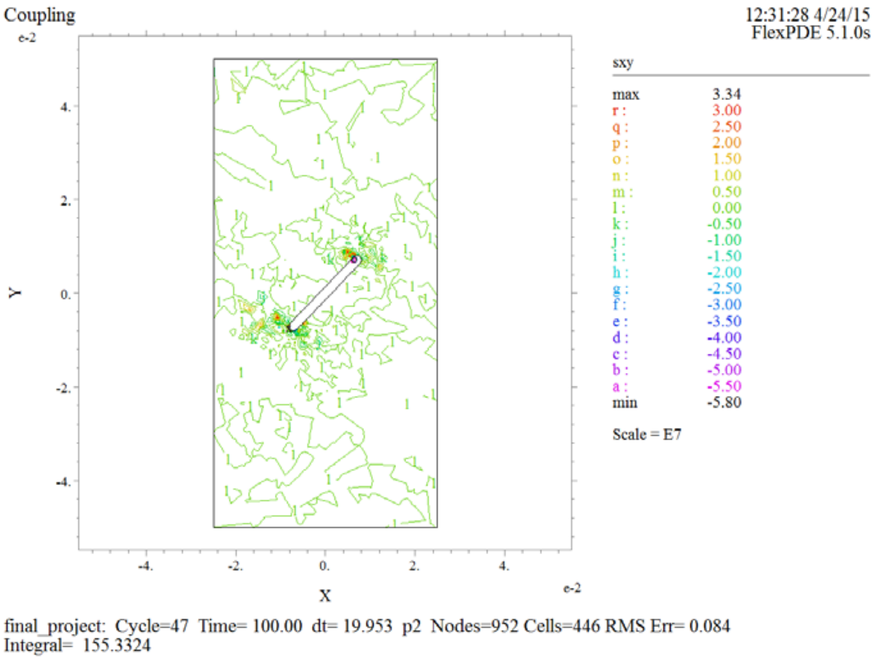
Results and Discussion

Elastic Modulus 1.067 e10 Pa



Stress-xy

Elastic Modulus 6 e9 Pa



Stress-xy

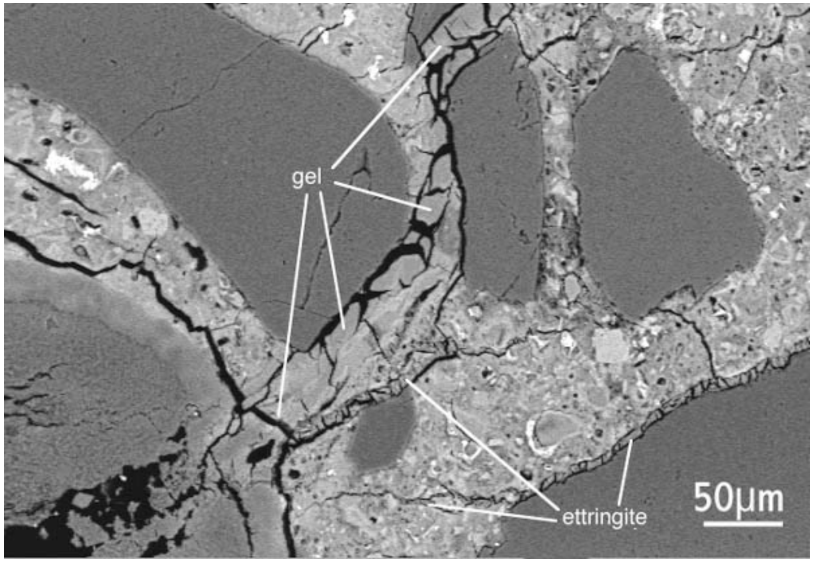
Conclusions

1. The calculation result of continuous rock is compatible with the experiment result.

2. The dropping down of elastic modulus will not result in the increasing of stress in rock with fracture, which is different from the result from reference.

3. The calculated stress distribution of rock with fracture is compatible with the experimental result that the highest stress is located around the fracture.

Future Work



Based on the stress-hydro model built in this project, further study will focus on the gel dynamics by simulating the process water absorption and expansion of gel.

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Main Reference

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Thank you for attention

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