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Experimental and numerical investigation on the effect of u shape cutter force on the non-persistent joint

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Abstract

The aim of this paper is to study the effect of spacing of the joint from 'u' shape cutter on the fracture mechanism and to investigate the effect of joint angularity under 'u' shape cutter loading on the shear failure mechanism. For this purpose nine sample with dimension of 5 cm ×10 cm×10cm consisting non-persistent joints were prepared. The first sets of three specimens have one non-persistent joint with length of 2cm and angularity of 0°, 45° and 90°. The spacing between joint and top of the sample was 2cm. The second sets of three specimens have one non-persistent joint with length of 2cm and angularity of 0°, 45° and 90°. The spacing between joint and top of the sample was 4cm. The third sets of three specimens have two non-persistent joint with length of 2cm and angularity of 0°, 45° and 90°. The spacing between upper joint and top of the sample was 2cm and the spacing between lower joint and upper joint was 2cm. the samples were tested under loading rate of 0.01 mm/s. concurrent with experimental investigation, numerical simulation were performed on the non-persistent joint using FRANC2D. The results show that the spacing between joint and specimen edge and joint angularity have important effect on the crack growth mechanism. Also, failure mode and failure pattern in experimental test and numerical simulation are similar.

Keywords: *U shape cutter, non-persistent joint angle, joint number, joint spacing*

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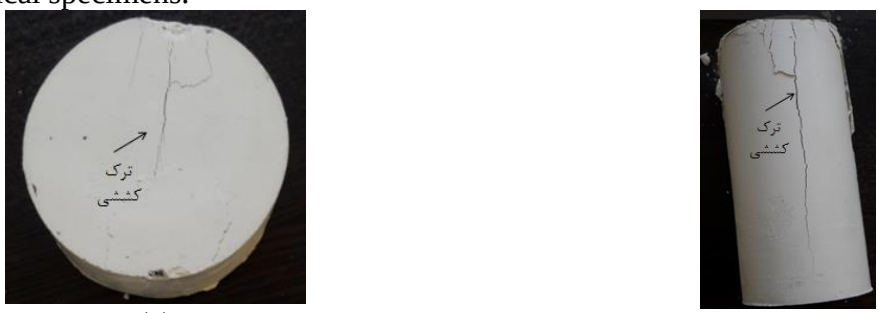
Extended Abstract:

1. Introduction

Nowadays, the excavation of underground structures has been performed using mechanical apparatus. TBMs are used for drilling of circular tunnels. Gong et al. 2005 developed a cereterea for prediction of a relashionship between TBM penetration rate and intact rock compressive strength. Gong et al. 2005, 2006 developed a cereterea for prediction of a relashionship between TBM penetration rate and rock mass compressive strength. Yang 2008, predicted the effect of intact rock compressive strength, tensile strength, britllness, joint direction and joint spacing on the TBM penetration rate. In this paper, the effect of non-persistent joint angularity and its place from U shape cutter on the crack propagation mechanism has been studied.

2. Mechanical properties of specimens

The samples are built from mixture of gypsum and water by ratio of 2:1. Fig 1 shows the failure pattern in physical specimens.



(a) (b)

Fig 1. Failure pattern in physical specimens.

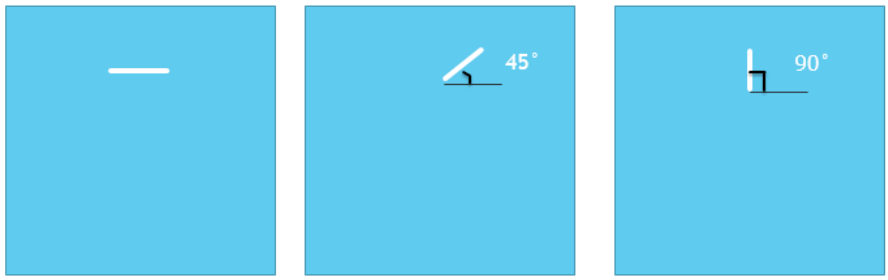
Table 1 shows the mechanical properties of gypsum specimen.

Table 1. mechanical properties of gypsum specimen

Compressive strength	Brazilian tensile strength
7.2 MPa	1.3 MPa

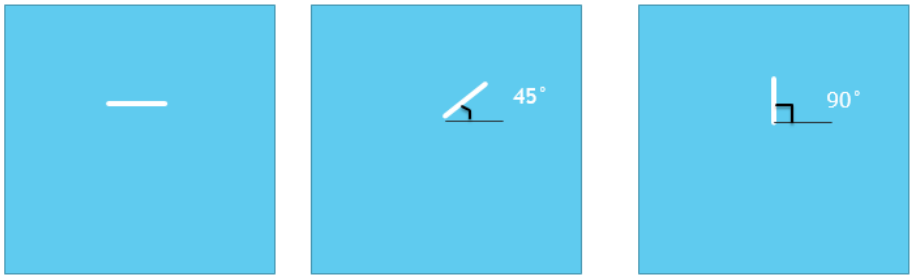
3. The samples consisting non-persistent joint:

Fig 2 shows the samples consisting non-persistent joint. These sampels are situated in uniaxial test machine. A U shape cutter is placed between samples and upper loading frame (fig 5). The loading rate was 0.01 mm/s. concurrent with experimental set up, numerical simulation was performed using FRANC2D.



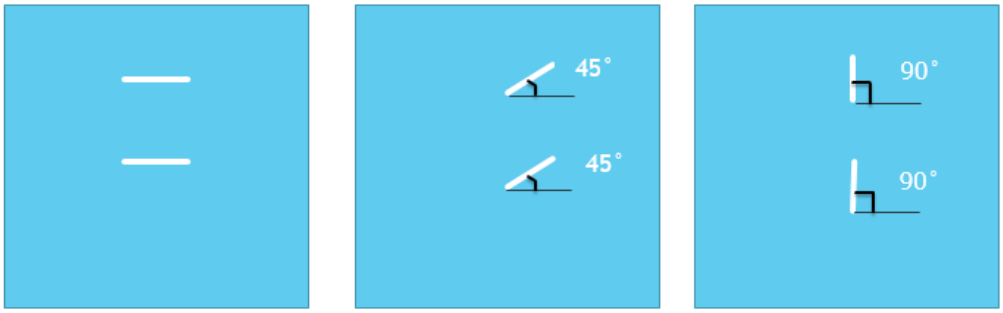
(a) (b) (c)

Fig 2. The non persistent joint with spacing of 2cm from U shape cutter and angularity of a) 0°, b)45° and c) 90°.



(a) (b) (c)

Fig 3. The non persistent joint with spacing of 4cm from U shape cutter and angularity of a) 0°, b)45° and c) 90°.



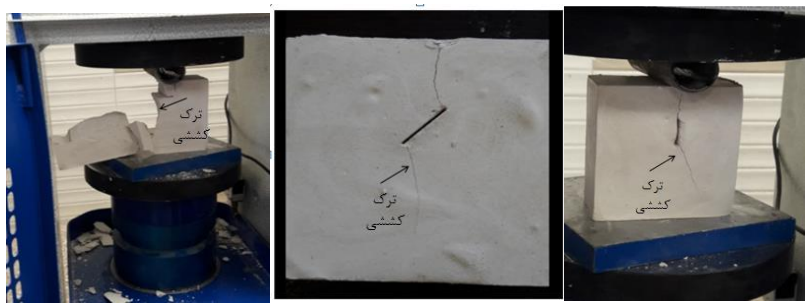
(a) (b) (c)

Fig 4. two non persistent joint with spacing of 2cm from U shape cutter and angularity of a) 0°, b)45° and c) 90°.

Fig 5. The uniaxial compression test with sample set up.

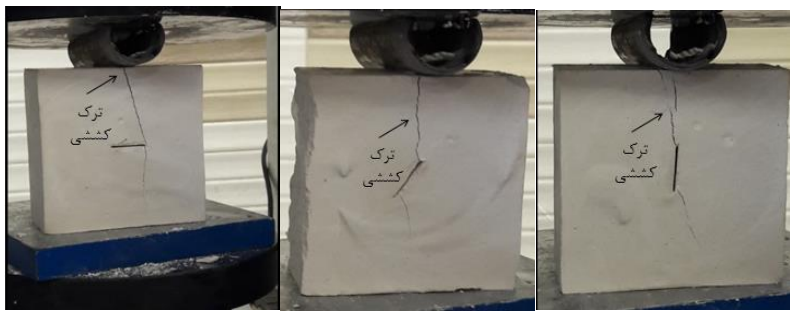
4. Experimental results

Fig 6-8 shows the failure mode and failure pattern in experimental. From this figure, it's clear that the tensile failure occurs in rock bridge.



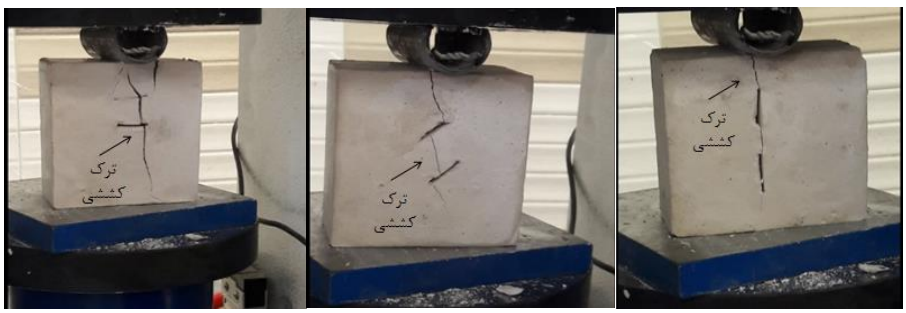
(a) (b) (c)

Fig 6. Failure pattern in non persistent joint with spacing of 2cm from U shape cutter and angularity of a) 0°, b)45° and c) 90°.



(a) (b) (c)

Fig 6. Failure pattern in non persistent joint with spacing of 4cm from U shape cutter and angularity of a) 0°, b)45° and c) 90°.

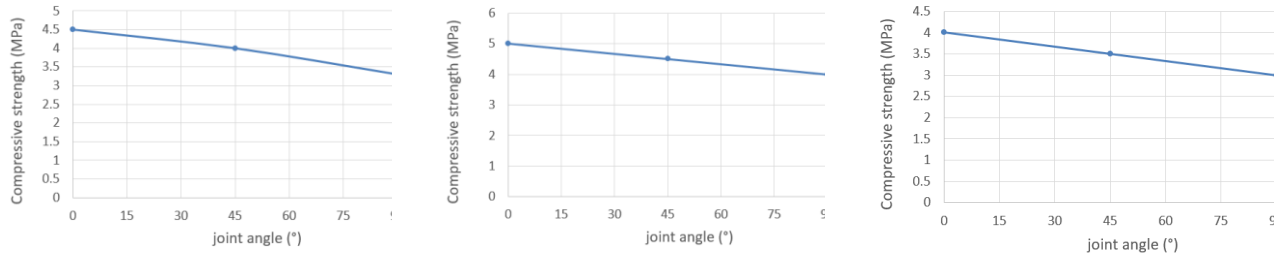


(a) (b) (c)

Fig 6. Failure pattern in two non persistent joint with spacing of 2cm from U shape cutter and angularity of a) 0°, b)45° and c) 90°.

5. The effect of non-persistent joint on the uniaxial compression strength

Fig 7 shows the effect of non-persistent joint on the uniaxial compression strength. The results show that the compressive strength was decrease by increasing the joint angularity.

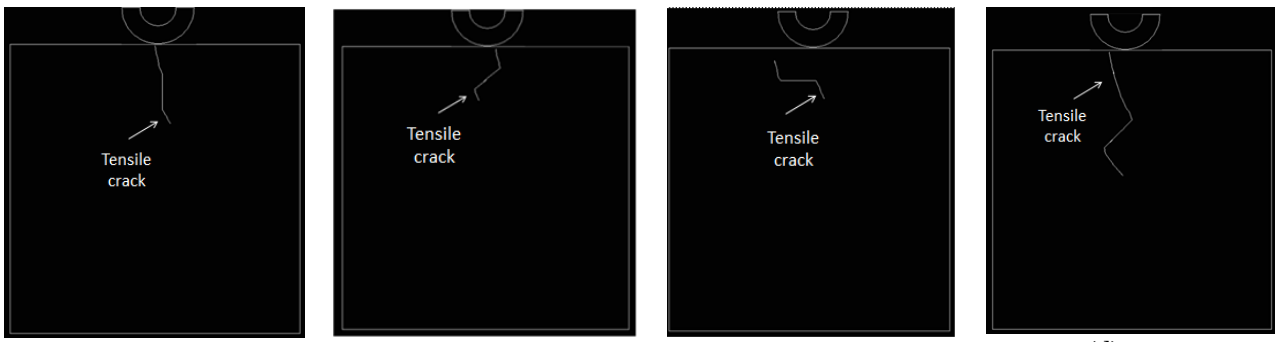


(a) (b) (c)

Fig 7. a) the effect of angularity of one joint on the compressive strength, the spacing between non-persistent joint and u shape cutter was 2cm.b) the effect of angularity of one joint on the compressive strength, the spacing between non-persistent joint and u shape cutter was 4cm. c) the effect of angularity of two joint on the compressive strength, the spacing between non-persistent joint and u shape cutter was 2cm.

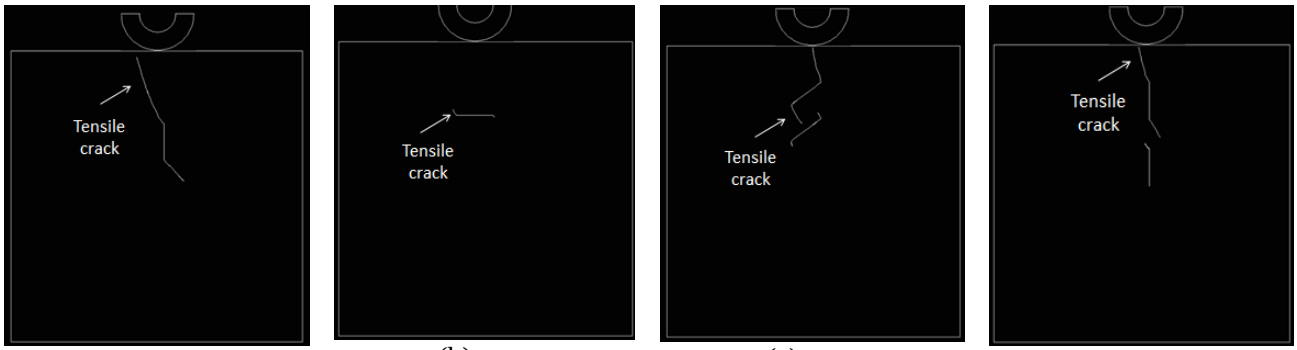
6.numerical results:

Fig 8 shows the effect of non-persistent joint on the failure mode and failure pattern by numerical simulation.



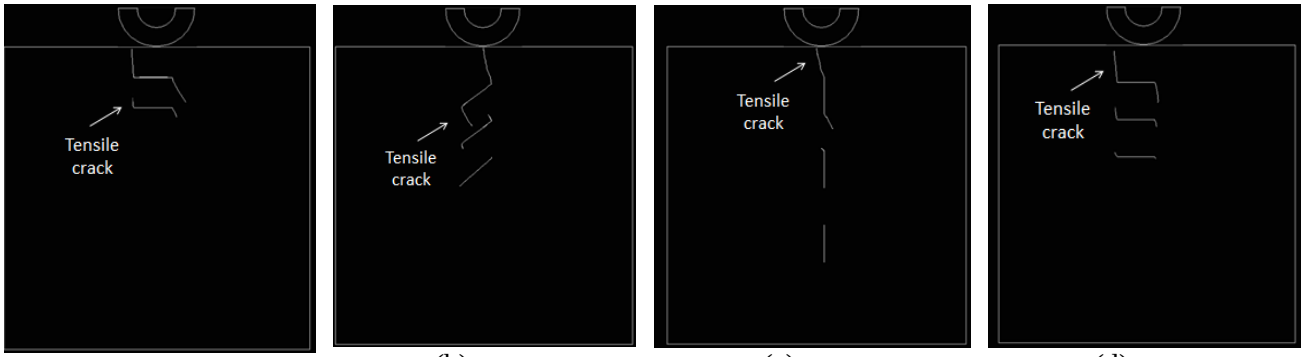
(a) (b) (c) (d)

Fig 8. Failure pattern in numerical model.



(a) (b) (c) (d)

Fig 8. Continued, failure pattern in numerical model.



(a) (b) (c) (d)

Fig 8. Continued, failure pattern in numerical model.

7. Conclusion

The results show that the spacing between joint and specimen edge and joint angularity have important effect on the crack growth mechanism. Also, failure mode and failure pattern in experimental test and numerical simulation are similar.

Refrences:

Gong, Q.M., Zhao, J., Jiao, Y.Y., 2005. Numerical simulation of influence of joint orientation on rock fragmentation process by TBM cutters. Tunneling and Underground Space Technology 20 (2), 183–191.

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