INFLUENCE OF LOADING RATE ON FAILURE PATTERN OF PRE-CRACKED ROCK SPECIMENS, A NUMERICAL STUDY

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Abstract: The effect of loading rate on the failure mechanism of rock specimens has been considered in many rock engineering research works, and it has been shown that when the loading rate rises, the strength of rock specimens increses. İn the present study, the effect of loading rate on the breakage process of pre-cracked specimens has been studied using numerical simulations. Extensive numerical simulations of uniaxial compression tests were made using RFPA2D code, and the effect of loading rate on the failure mechanism of pre-cracked specimens was investigated. Results of experimental tests showed that with an increase in the loading rate, the length of wing cracks in specimens decreases.

Keywords: Loading rate, Crack propagation, RFPA2D, pre-cracked specimen.

1- INTRODUCTION

Failure mechanism of various rock types containing pre-existing cracks under quasi-static loading condition have been extensively studied in the literature review (Ghazvinian et al. 2013). However there is a relative lack of basic information regarding the failure mechanism of rock specimens under the dynamic loadings. Loading rate fundamentally influences the strength and failure mechanism of rock specimens. Also, the initiation, propagation, and coalescence of fractures were significantly influenced by the loading rate. Fig. 1 schematically illustrates crack pattern of rock specimens with a single pre-existing fracture loaded in uniaxial quasi-static compression. Two types of cracks have been usually observed: (1) primary or wing cracks, which are tensile cracks and initiate on the tips of the pre-existing fractures, (2) secondary cracks which are shear cracks, usually responsible for failure of the specimens (Bobet and Einstein 1998). This pattern is particular to the specimens loaded with quasi-static loadings; an increase in the loading rate changes the crack pattern of the specimen with pre-existing cracks. In this study, the effect of loading rate and density of the pre-existing fracture on the failure pattern of specimens were studied numerically, using RFPA2D code.

2- METHODS

The specimens for modeling uniaxial compression tests were simulated as cores with a diameter of 54 mm and a length of 110 mm. The geo-mechanical properties required for modeling were derived from some experimental tests conducted on Granite specimens. The failure mechanism of simulated specimens was evaluated in three loading rates (0.002, 0.02 and 0.2 mm per steps). The effect of loading rate on the growth of the pre-crack and the failure mode of specimens was investigated. Fig. 1 illustrates the crack pattern of pre-cracked specimens subjected to a uniaxial compression.

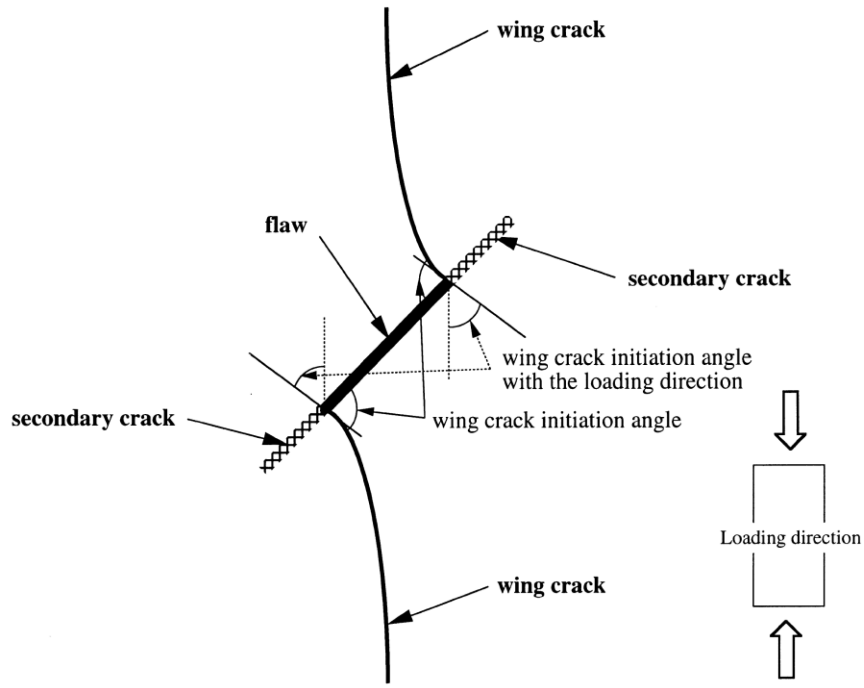

Figure 1. Schematic view of crack pattern in pre-cracked specimens of rock materials in uniaxial quasi-static compression (Bobet and Einstein 1998)

3- FINDINGS AND ARGUMENT

The density of pre-cracks and loading rate are two important factors affecting the failure mechanism of pre-caced specimens which were considered in this study. Results of numerical simulations showed that the failure mechanism of pre-cracked specimens are more influenced by the loading rate than the density of pre-cracks. İn other words, the loading rate dictates the crack pattern of pre-craked speciemns with different crack densities. Table 1 summarizes the types of responsible cracks on the failure pattern of specimens with different loading rates.

Table 1. Types of responsible cracks on the failure pattern of specimens at different loading rates

	Loading rate (mm/step)		
Number of pre-crack	0.002	0.02	0.2
	Responsible cracks on the failure pattern of specimens		
1	oblique cracks	oblique – coplanar cracks	coplanar cracks
3	oblique cracks	oblique – coplanar cracks	coplanar cracks
6	oblique – coplanar cracks	oblique – coplanar cracks	coplanar cracks
9	oblique cracks	oblique – coplanar cracks	coplanar cracks
36	coplanar cracks	oblique – coplanar cracks	coplanar cracks

4- CONCLUSIONS

In the first stage of the loading sequence, regardless of the loading rate, first some wing cracks initiated on the tips of the pre-existing cracks, which tend to propagate parallel to the loading direction. Then secondary cracks initiated on the tips of the wing cracks. Eventually, the propagation and coalescence of the cracks resulted in unstable collapse of the specimens. By increasing the loading rate, the length of wing cracks decreased and no wing cracks created at the loading rate of 0. 2 mm per step. It was shown that the failure modes of specimens under low loading rate was dominantly oblique shear, while the failure mode under high loading rate was in “X” shape. This was due to the fact that after increasing the loading rate to 0.2 mm per step, some second co-planar cracks formed on the tip of the main cracks.

Refrences

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