Engineering Fracture Mechanics 149 (2015) 37–44

Contents lists available at ScienceDirect

Engineering Fracture Mechanics

journal homepage: www.elsevier.com/locate/engfracmech

T-stress for a centrally cracked Brazilian disk under confining pressure

Wen Hua, Yifan Li, Shiming Dong *, Nianbin Li, Qingyuan Wang

College of Architecture and Environment, Sichuan University, Chengdu 610065, China

ARTICLE INFO

Article history:
Received 23 July 2015
Received in revised form 22 September 2015
Accepted 23 September 2015
Available online 30 September 2015

Keywords:
Centrally cracked Brazilian disk
Confining pressure
Weight function
T-stress

ABSTRACT

An analytical formula for calculating the *T*-stress in a centrally cracked Brazilian disk under both diametric forces and confining pressure, is presented by using the weight function method. It is very accurate for $\alpha \leqslant 0.95$ with 100 terms, and can be expediently used for arbitrary crack lengths and loading angles. In addition, the effect of confining pressure on the *T*-stress is also investigated, and it is shown that the *T*-stress increases with increase of confining pressure. There is a significant effect of confining pressure on the *T*-stress for a centrally cracked Brazilian disk with a large crack length and loading angle.
© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

As is well known, the stress intensity factor and the elastic *T*-stress, which is the second term of the Williams [1] series expansion, are two significant parameters in crack brittle fracture. They are used to define the level of constraint at a crack tip and play an important role in fracture mechanics. For example, Smith et al. [2] suggested a fracture criterion, the generalized maximum tangential stress (GMTS) criterion, which takes into account the effects of both the singular terms and the non-singular constant term in the tangential stress around the crack tip. Ayatollahi and Aliha [3,4], and Hua et al. [5] pointed out that the elastic *T*-stress has a great influence on the crack propagation path and the mixed mode fracture toughness of brittle materials, and the GMTS criterion can predict the experimental results very well. Some experimental studies have demonstrated that the critical stress intensity factor (fracture toughness) of a given brittle material can be considerably dependent on the specimen geometry and size, as well as loading condition [6–9]. This geometry dependence of the critical stress intensity factor in a brittle material can be attributed to the value of the *T*-stress in the test specimen [8,10]. The effects of the elastic *T*-stress on the plastic zone around the crack tip have been investigated by Nazarali and Wang [11], and Matvienko [12]. The crack tip plastic zone is estimated by the von Mises yield criterion, taking into account the elastic *T*-stress in addition to the stress intensity factors. The results indicated that in small scale yielding, the sign and value of the *T*-stress have significant effects on the shape and size of the plastic zone near the crack tip.

The centrally cracked Brazilian disk specimen, diametrically subjected to compressive loads, has been extensively employed to investigate the fracture behavior of different brittle materials, owing to the advantages of the existence of closed-form solutions for stress intensity factors and easy realization of complete mode combinations [13,14]. Due to the elastic *T*-stress playing an important role in the crack fracture, it is essential to obtain accurate values of the *T*-stress for centrally cracked Brazilian disks. A number of methods for calculating the *T*-stress in a variety of loading conditions and

* Corresponding author.
E-mail address: smdong@scu.edu.cn (S. Dong).

http://dx.doi.org/10.1016/j.engfracmech.2015.09.048
0013-7944/© 2015 Elsevier Ltd. All rights reserved.

Nomenclature

a	half length of the crack
A_{ji}	coefficients/angular constants (j = 1,2; i = 1,2,...n)
B	thickness of the disk
C_1, C_2	coefficients
f_i	coefficient (i = 1,2,...n)
$h(x, a)$	weight function
K_I	mode I stress intensity factor
P	applied load (force)
r, θ	conventional polar co-ordinates
R	radius of the disk
t	confining pressure coefficient
T	T-stress
T^*	normalized T-stress
T_C	T-stress for confining pressure only
T_P	T-stress for diametric forces only
T_t^*	normalized T-stress with confining pressure
T_0^*	normalized T-stress without confining pressure
α	relative crack length
θ_c	critical loading angle for pure mode II
ρ	normalized radius
σ	stress
σ_c	confining pressure
σ_r, σ_θ	stress components
ω	degree of variation of T-stress

geometries have been suggested in the past [15]. For example, Fett [16,17] proposed a series of solutions for the T-stress for a centrally cracked Brazilian disk with different crack lengths and loading conditions, using the Green function and the boundary collocation method. In addition, Ayatollahi et al. [4,18] also obtained the elastic T-stress directly by evaluating the stresses along the crack flanks and near the crack tip using the finite element method (FEM). The results presented by Fett [16,17] and Ayatollahi et al. [4] are limited to very few crack length and loading angles. It is not convenient to make use of the values of the T-stress, besides, there is not a general formula for calculating the T-stress for centrally cracked Brazilian disks. Therefore, it is necessary to present an analytical formula for calculating the T-stress for a centrally cracked Brazilian disk with arbitrary different crack lengths and loading angles.

On the other hand, in many practical situations, the material is subjected to a confining pressure, such as underground rocks and structures in the deep water. The confining pressure usually has non-negligible effect on the mechanical properties of the material. A series of experimental studies of the effect of confining pressure on fracture toughness of materials have been conducted by a number of researchers [19–21], and the results showed that the fracture toughness increased with the increase of confining pressure in a certain range. Recently, we investigated the effect of confining pressure on the stress intensity factors for a centrally cracked Brazilian disk. The results indicated that both the mode I stress intensity factor and the critical loading angle for a pure mode II crack decrease with the increase of confining pressure [22]. However, so far, little has been reported on the study of the effect of the confining pressure on the T-stress. Therefore, investigating the effect of the confining pressure on the T-stress is also very important.

In this present paper, we conduct a closed form solution for the T-stress for a centrally cracked Brazilian disk under both diametric forces and confining pressure by using the weight function method and superposition principle. The results calculated by our formula are compared with those presented by other researchers.

2. *T*-stress for a centrally cracked Brazilian disk using the weight function method

2.1. Weight function method

The concept of the weight function, or the Green function was introduced by Bueckner [23], based on analytic function representation of the elastic fields in isotropic materials. The weight function method is a powerful technique for calculating the stress intensity factors and T-stress. It has been frequently used by many researchers for various specimen configurations under different loading conditions, such as edged cracked rectangular plates, rectangular plates, edged cracked circular disk, and centrally cracked circular disk. [14,16,17,22]. According to this method, the T-stress can be obtained by integrating over the crack length a product of the loads with the weight function, and the integral expression reads as follows:

Download English Version:

https://daneshyari.com/en/article/7169615

Download Persian Version:

https://daneshyari.com/article/7169615

Daneshyari.com