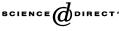


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## Buckling of cracked thin-plates under tension or compression

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## Abstract

Plates are easily susceptible to buckling under compression, in particular when plate's thickness becomes sufficiently small with respect to others plate's sizes; such a mode of failure is often prevalent with respect to strength failure. The buckling phenomena under tension loading can also occur, especially in plates containing defects such as cracks or holes; when the buckling load is reached, complex wrinkling deflection patterns in compressed regions develops around such imperfections.

In the present paper, the buckling analysis of variously cracked rectangular elastic thin-plates under tension and compression is considered. A short explanation of the buckling phenomena in plates is recalled and several numerical analyses, carried out by using the Finite Element Method (FEM), are performed in order to determine the critical load multiplier, both in compression and in tension, by varying some plates' parameters. In particular, the critical load multiplier is determined for different relative crack length, crack orientation and Poisson's coefficient of the plate's material which is made to range between 0.1 and 0.49.

Moreover a simple approximate theoretical model to explain and predict the buckling phenomena in cracked plates under tension is proposed and some comparisons are made with FE numerical results in order to assess its reliability in predicting buckling load multipliers.

Finally, the obtained results are graphically summarised (in dimensionless form) in several graphs and some interesting conclusions are drawn.

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Keywords: Buckling; Wrinkling; Cracked tensioned plates; Fracture mechanics

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Nomenclature	
a crack half length	
$a^* = a/W$ dimensionless crack length	
$A_n, B_n, C_n, D_n$ coefficients involved in the solution of a deep beam under bending	
<b>C</b> resultant of the compressive stresses along the <i>X</i> -axis in the interval $0 \le x \le b$	,
D plate's flexural rigidity	
<i>E</i> plate's Young modulus	
k minimum value attained by a function of the dimensionless parameter $W^* =$	
W/L	
$K_{\rm eq}$ equivalent stress-intensity factor in Mixed mode of fracture	
$K_{\rm I}, K_{\rm II}$ mode I and mode II stress-intensity Factors	
$K_{\rm I}^*$ , $K_{\rm II}^*$ dimensionless mode I and mode II stress-intensity Factors	
$K_{\rm IC}$ fracture toughness	
L, W plate's half length and width	
$N_x$ , $N_y$ , $N_{xy}$ membrane and shearing forces (per unit length of the plate) in the	
corresponding directions	
<b>R</b> resultant of the applied external uniform stress distribution $\sigma_0$	
s span of a deep beam corresponding to half of the cracked plate	
t plate's thickness	
$t^* = t/W$ dimensionless plate's thickness	
$u_{\gamma}, u_{\eta}$ displacements normal and parallel to the crack, respectively	
V(w(x,y)) total potential energy	
$\tilde{V} = V(\tilde{w}(x, y))$ approximate total potential energy	
w(x,y) plate's elastic surface (transversal displacements)	
$\tilde{w}(x, y)$ transversal trial displacements plate's field	
$W^* = W/L$ dimensionless plate's width	
$\Phi(\xi,y)$ stress function	
$\lambda^-$ , $\lambda^+$ buckling stress multipliers in compression and in tension, respectively	
$\nu$ Poisson's ratio	
$\theta$ crack orientation angle	
$\sigma_0^-, \sigma_0^+$ actual applied compressive or tensile stress, respectively	
$\sigma_{\rm E,c}$ Euler buckling (uniform) stress in compression	

## 1. Introduction

It is a common practical observation that plates can easily undergo to buckling collapse under membrane loading; this mode of failure can prevail over strength mode of failure, especially when plate's thickness is sufficiently small with respect to others plate's sizes. Even for plates under tension loading, the buckling phenomena can take place: it becomes a quite important occurrence particularly in structures where the presence of cracks or holes is involved. In these situations, tensioned plates can easily buckle, showing complex wrinkling deflection patterns in compressed regions around such defects. Download English Version:

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