Available online at www.sciencedirect.com
SCIENCE DIRECT®
Thin-Walled Structures 43 (2005) 209–224
THIN-WALLED STRUCTURES
www.elsevier.com/locate/tws

Buckling of cracked thin-plates under tension or compression

Roberto Brighenti*

Department of Civil Engineering, Environment and Architecture, University of Parma, Parco Area delle Scienze 181/A, 43100 Parma, Italy

Received 18 December 2003; accepted 27 July 2004

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.
© 2004 Elsevier Ltd. All rights reserved.

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

* Tel.: +39 521 905 910; fax: +39 521 905 924.
E-mail address: brigh@unipr.it.

0263-8231/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tws.2004.07.006

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
C resultant of the compressive stresses along the X-axis in the interval $0 \le x \le b$
D plate's flexural rigidity
E plate's Young modulus
k minimum value attained by a function of the dimensionless parameter $W^* = W/L$
K_{eq} equivalent stress-intensity factor in Mixed mode of fracture
K_I, K_{II} mode I and mode II stress-intensity Factors
K_I^*, K_{II}^* dimensionless mode I and mode II stress-intensity Factors
K_{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
R resultant of the applied external uniform stress distribution σ_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_γ, u_η 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
λ^-, λ^+ buckling stress multipliers in compression and in tension, respectively
ν Poisson's ratio
θ crack orientation angle
σ_0^-, σ_0^+ actual applied compressive or tensile stress, respectively
$\sigma_{E,c}$ 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:

https://daneshyari.com/en/article/10296109

Download Persian Version:

https://daneshyari.com/article/10296109

Daneshyari.com