Int.J.Impact Engng. Vol.2,No.2, pp.179-208, 1984
Printed in Great Britain

0734-743X/84 $3.00 + 0.00
Pergamon Press Ltd.

DYNAMIC AXIAL CRUSHING OF SQUARE TUBES

Wlodzimierz Abramowicz[1] and Norman Jones

Department of Mechanical Engineering, The University of Liverpool, P.O. Box 147, Liverpool L69 3BX, U.K.

(*Received* 18 *April* 1984; *in revised form* 8 *June* 1984)

Summary - Eighty-four dynamic tests on thin-walled square steel tubes having two different cross-sections with c/h = 30.25 and c/h = 32.18 and various lengths were crushed axially on a drop hammer rig. Approximate theoretical predictions were developed for the axial progressive crushing of square box columns using a kinematically admissible method of analysis. This theoretical study predicts four deformation modes which govern the behaviour for different ranges of the parameter c/h. New asymmetric deformation modes were predicted theoretically and confirmed in the experimental tests. These asymmetric modes cause an inclination of a column which could lead to collapse in the sense of Euler even for relatively short columns. The effective crushing distance is considered in the approximate theoretical analysis together with the influence of material strain rate sensitivity, which is important for steel even when the loadings are quasi-static. The simple equations presented herein for the design of axially crushed square box columns give reasonable agreement with the corresponding experimental results.

NOTATION

b, b_f	radius of toroidal shell element [15, 16]
c	length of side of a square cross-section
h	wall thickness
p	Cowper-Symonds exponent in equation (37)
v_m	mean velocity of striking mass during crushing
x_0	b/h
A	4ch
$A_1,\ldots,A_5$	coefficients in equation (6)
D	Cowper-Symonds coefficient in equation (37)
E_1, E_2, E_t	internal energy absorption
$2H$	initial distance between plastic hinges at top and bottom of a basic folding element (Fig. 12)
I_1, I_3	integrals in equation (1) [16]
K	initial kinetic energy
L	initial length of column
M	striking mass
M_0	$\sigma_0 h^2/4$
N_0	$\sigma_0 h$
P_m	theoretical prediction for mean static crushing load
P_m^d	average value of dynamic force in experimental tests
P_m^s	average value of static force in experimental tests

[1]Assistant Professor, Institute of Fundamental Technological Research, Swietokrzyska 21, 00-049 Warsaw, Poland. SERC Visiting Fellow, University of Liverpool, Autumn 1983.