PERGAMON

Available online at www.sciencedirect.com
SCIENCE @ DIRECT®

Computers and Structures 81 (2003) 1031–1039

Computers & Structures

www.elsevier.com/locate/compstruc

Dynamic buckling of cylindrical stringer stiffened shells

R. Yaffe, H. Abramovich *

Faculty of Aerospace Engineering, Technion, Israel Institute of Technology, Haifa 32000, Israel

Abstract

The dynamic buckling of cylindrical stringer stiffened shells was investigated both numerically and experimentally. A new criterion to define the numerical "dynamic" buckling load was developed yielding consistent results. The ADINA finite element code was applied to simulate the static and dynamic buckling loads of the shells. It was shown numerically that when the period of the applied loading (half-wave sine) equals half the lowest natural period of the shell, there is a slight drop in the dynamic load amplification factor (DLF). The DLF is defined, as the ratio of the dynamic buckling to the static buckling of the shell. This factor drops below unity, when the ratio of the given sound speed in solids, *c*, to the velocity developed axially due to the applied dynamic loading, approaches unity. It means that, for this particular loading period, the dynamic buckling load would be lower than the static one.

It was shown numerically that the shape of the loading period, half-wave sine, a shape encountered during the tests, as well as the initial geometric imperfections have a great influence on the dynamic buckling of the shells. The relatively simple test set-up design to cause a shell to buckle dynamically did not fulfill our expectations. Although, the process leading to eventually the dynamic buckling of the shell worked properly, still no test results were obtained to form a sound experimental database for this phenomenon. Based on the numerical predictions, correct guidelines were formulated for better test procedures to be applied in future tests, which will be reported in due time.

Keywords: ADINA code; Dynamic buckling; Impact; Stringer stiffened shells; Tests; DLF

1. Introduction

The need to design structures that have to withstand time dependent dynamic loads, sometimes quite severe, and thus may be susceptible to "dynamic buckling", also referred to in literature as dynamic stability or dynamic instability is the driver behind the increasing interest in this phenomenon. A few excellent monographs treating the various aspects and issues of the dynamic instability can be found for instance in Refs. [1–5]. Though many classes of problems and many physical phenomena are encompassed by the term dynamic buckling, the term dynamic buckling has in particular been assigned in the literature to two essentially different phenomena (see Refs. [2,5]). One is associated with the response of a structure to the action of oscillating loads, namely, *vibration buckling*, where the transverse vibrational deflection becomes unacceptably large at critical combinations of load amplitude, load frequency and damping. For the case of a column, it can be shown that for sufficiently small values of the axial force, vibration buckling (resonance) will occur when the loading frequency is twice the lowest natural bending frequency of the column. This column behavior is often called "vibration buckling" or "parametric resonance" and was extensively studied (see Refs. [1,3,6]). The second phenomenon, which is the subject of the present study, relates to the behavior of the structures subjected to pulse loads, and represents the loss of stability or the deformation of a structure to unbounded amplitudes as the result of a transient response to an applied pulse, i.e. *dynamic buckling* under impact loads (see Refs. [3,5] for detailed

* Corresponding author. Tel.: +972-4-829-2308; fax: +972-4-829-3193.

E-mail addresses: ronith@aer5101.techunix.ac.il (R. Yaffe), haim@aerodyne.technion.ac.il (H. Abramovich).

0045-7949/03/$ - see front matter © 2003 Elsevier Science Ltd. All rights reserved.
doi:10.1016/S0045-7949(02)00417-0