ECCM 2010
IV European Conference on Computational Mechanics
Palais des Congrès, Paris, France, May 16-21, 2010

Dynamic buckling of axially impacted cylindrical composite shells

E. Eglitis[1], C. Bisagni[2], K. Kalnins[1],
O. Ozolinsh[1], K. Dzelzitis[1]

[1] *Institute of Materials and Structures, Riga Technical University, Latvia, edgars.eglitis@rtu.lv*, kaspars.kalnins@sigmanet.lv, olgerts@bf.rtu.lv, karlisdzelzitis@inbox.lv*
[2] *Dipartimento di Ingegneria Aerospaziale, Politecnico di Milano, Italy, chiara.bisagni@polimi.it*

Laminated composite shells are very efficient structural elements that are being employed in aerospace, automotive and other industries that require the minimum weight of the structures. Conventional design procedures of such structures simplify the buckling loads as quasi-static, because there is a reasonably good understanding of the static buckling phenomena. Significant research effort has been devoted to static buckling and experimentally validated analysis methods are available, while the dynamic buckling of composite shells still has to be investigated. Besides, the simplification of time-dependant loads as quasi-static can lead to both over-designed and unreliable structures. The effect of applying a load over a short time has been studied, and a significant increase in the dynamic buckling stress with a reduction of loading time duration has been observed in analytical study [1], which has been verified experimentally [2]. Other investigations show that buckling strength can be significantly less than under static loading when loading frequency is close to the lowest natural frequency of the structure [3-4]. Therefore, experimentally validated analysis procedures that take into account the time-dependency of the load would contribute for further improvement of both efficiency and reliability of the structures.

The present investigation focuses on the differences of the buckling behaviour of thin laminated composite cylinders under static axial compression and axial impact. The adopted computational approach is based on the equations of motion, which are numerically solved using a finite element code (ABAQUS/Explicit). Different time histories of pulse loadings are achieved using various masses and velocities of the weight that impacts the cylinder. The influence of load magnitude and duration is studied numerically and the dynamic buckling results are related to the static buckling ones. The numerical results are compared to experiments.

Two cylindrical glass fibre fabric reinforced plastic specimens are prepared at Riga Technical University for the experimental validation of the numerical results. The specimens are produced manually and have nominal diameter of 300 mm, length of 660 mm, and thickness of 0.85 mm. The ends of the cylinders are encasted in flat aluminium plates using polyester resin with aluminium powder as aggregate to ensure clamped boundary conditions at the ends of the specimens. Flat specimens are also produced using the same fibres, resin and production technology for identification of material mechanical properties.

The validation tests are performed at the Politecnico di Milano, Dipartimento di Ingegneria Aerospaziale. First, the initial imperfections of the manufactured specimens are identified using a custom built device that employs a laser displacement sensor (Figure 1). The measured imperfection data are applied to the numerical models to study the imperfection influence numerically. Subsequently, buckling tests are performed, recording the load-shortening curves and buckling shapes. The experimental results are compared to the numerical ones to validate the finite element models, which can be used for further numerical studies.

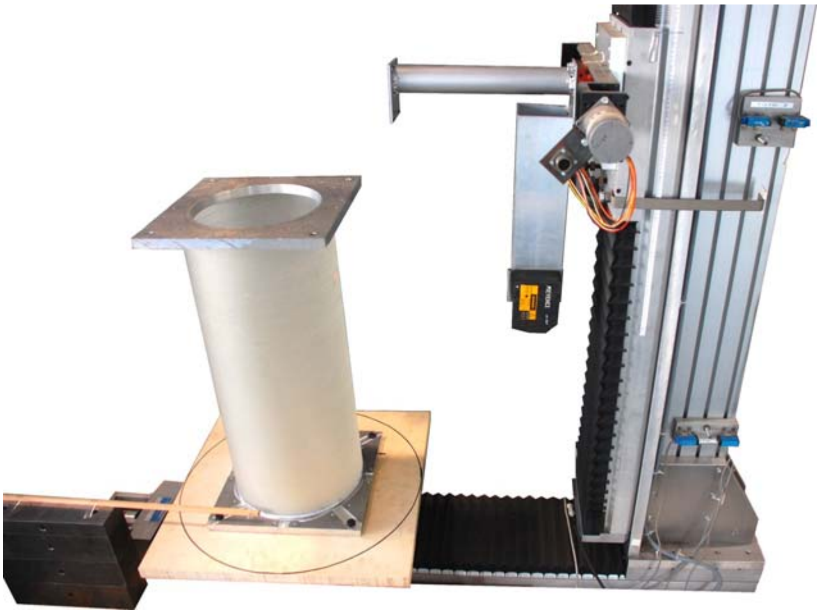
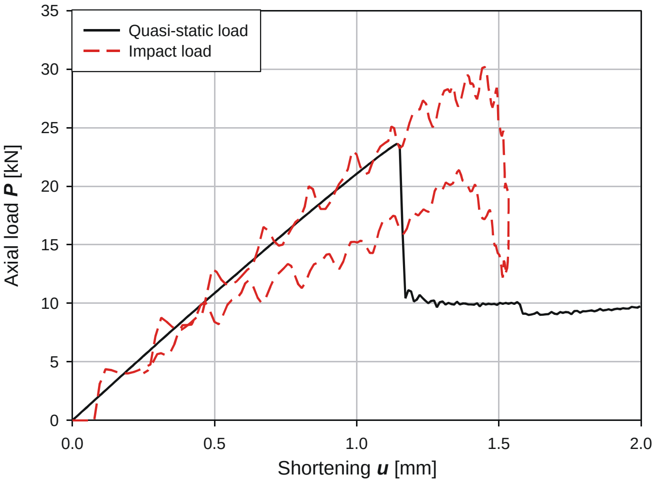
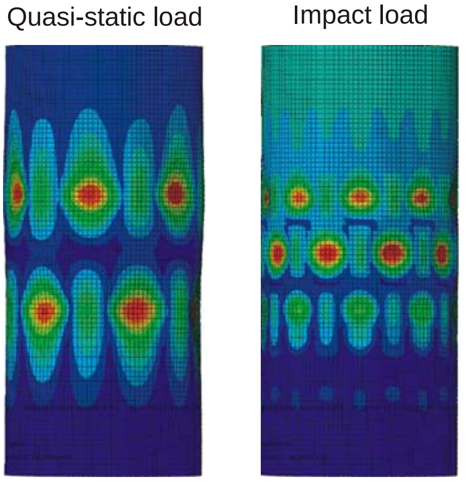


Figure 1: Glass fibre cylindrical shell in the equipment for the imperfection measurement

The preliminary numerical results show that the dynamic buckling load can be higher than the static buckling load (Figure 2 *a*). The numerical results also show that under impact loads the cylindrical composite shell can buckle in another shape than under quasi-static buckling load (Figure 2 *b*).



a



b

Figure 2: Quasi-static and impact buckling loads
a – load-shortening curves; b – buckling mode shapes

References

[1] R.S. Roth, J.M. Kolsner, *Structural responses to dynamic loading*, AIAA Aerospace Sciences Meeting, New York, 1964

[2] J.S. Humphreys, C. Sve, *Dynamic buckling of cylinders under axial shock-tube loading*, 3rd AIAA Aerospace Sciences Meeting, New York, 1966

[3] R. Yaffe, H. Abramovich, *Dynamic buckling of cylindrical stringer stiffened shells*, Computers and Structures 81, 2003, pp. 1031-1039

[4] C. Bisagni, *Dynamic buckling of fiber composite shells under impulsive axial compression.* Thin-Walled Structures 43, 2005, pp. 499-514