Buckling of thin pressurized cylinders under a bending load

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Extensive theoretical and experimental studies (see for example [1, 2]) have been conducted during decades to clarify the buckling of thin cylindrical shells submitted to combined axial compression and internal pressure. It has been shown that internal pressure decreases the natural imperfection sensitivity of the structure and consequently increases the buckling load to the "classical" stress. Another consequence of the pressurization is the modification of the post-critical behaviour of the shell [2]; Schnell [3] proposes a threshold pressure, which separates stable or unstable behaviour.

Many authors have supposed that global bending and axial compression of short and thin cylindrical shell are indistinguishable. Here, a careful examination of the differences of behaviour between these two loading forms is presented, which identifies the key features in the elastic regime. The effect of internal pressure is then considered and a classification of the different possible behaviours is described thanks to experimental tests. We will present here more than 200 experimental results [4] on shells with a radius-to-thickness ratio varying between 600 and 1400, obtained by copper electro-deposition. The effect of pressurisation on geometrical imperfections in different forms is numerically simulated. This shows how internal pressure effectively reduces geometric deviations, and the extent to which this occurs depends on the form (axisymmetric or asymmetric), on the extent of localisation (characterised by a harmonic) and on the level of internal pressure. The conducted numerical study provides a clear explanation of the reason why internal pressure can have such differing effects on the bearing capacity of shells with different forms of imperfections. The difference between axial compression and bending load configuration are highlighted. Finally, the post-bifurcation response is examined, first looking at observations from experiments and analyses of the experiments, then with simulations conducted in geometrical and material non-linear domain with FE codes ABAQUS. It brings out the critical importance of the post-bifurcation path to the overall behaviour of the shell. Global flexure differs considerably from the simple load cases of axial compression or external pressure, in that the appearance of the first buckle does not mean that the maximum load is reached even if the local post-buckling response is softening.

Considering these experimental results and a large parametrical numerical study conducted with FE code ABAQUS, the design recommendations formulated in two codes (NASA SP8007 and Eurocode 3) are also examined.

References

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