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Buckling of cylindrical shells with large cutouts

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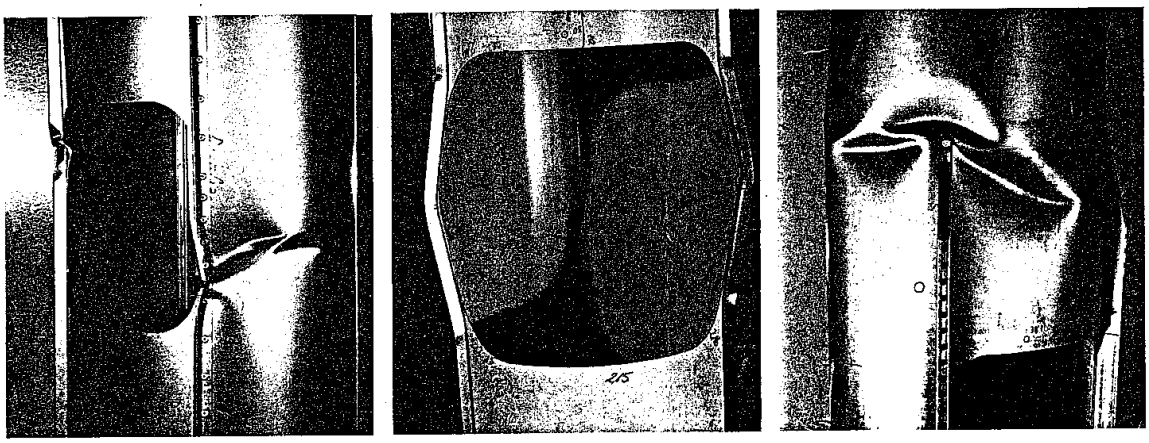
Abstract

From 1984 onwards a series of 46 buckling tests on cylindrical shells with large cutouts was carried out at the Versuchsanstalt fuer Stahl, Holz und Steine (University of Karlsruhe), the results of which were published by Knoedel and Schultz in a research report (1985), a journal (1988) and a Festschrift (1988). Subsequently a design proposal was adopted into DASt 017 guideline for buckling of shells.



Three types of buckling modes (Knoedel/Schulz 1988)

The scope of the program was to find simple design rules for steel chimney stacks. Therefore specimens were tested in a 4-point-bending test rig. The structural mild steels DX51D and S235 were used, with a yield stress range of f_y = 150–250 N/mm^2. The radius to thickness ratio ranged from 110 to 350, and used three aperture opening angles 80°, 100° and 120°. Three different stringer reinforcements were investigated: none, light, medium and heavy, the influence of which can be seen in the buckling modes in the figure. With light stiffeners the buckling modes are very similar to those of the unstiffened cutout: the stiffener increases the capacity but does not change the buckling mode. Medium stiffeners change the buckling mode; the openings fail large deformations ultimate load. With heavy stiffeners failure does not occur at the opening, but near the ends of the stiffeners, where the stiffener termination causes a local frown buckle.

Despite of the different failure modes, which included shell-type distortion of the cross section, a global criterion proved to be sufficient. The beam theory meridional stress at the edge of the opening was used as a reference stress, on which a simple empirical design formula was based.