# Buckling behavior of open-top, stocky flat bottom tanks subject to wind load

Andreas Jäger-Cañás*, Peter Knödel[a]

* EHS beratende Ingenieure für Bauwesen GmbH
Am Alten Rathaus 5, 34253 Lohfelden, Germany
a.jaeger_ehs@t-online.de

[a] Karlsruhe Institute of Technology, Steel & Lightweight Structures

## Abstract

Flat bottom tanks are widely employed to store liquids, such as water, sludge and oil. In many cases, no roof is necessary to cover the tank or a floating roof is employed. When these structures are loaded by wind, a complex bearing behavior develops, since the load pattern is not axis-symmetric but non-linearly distributed around the circumference.

The research in the last few years either focused on tanks covered by dome roofs or, more recently, was limited to rather slender structures, such as chimneys or silos. Lately, a study of flat bottom tanks with membrane roofs was published, which focused on a limited range of geometries. The codified rules regarding cylindrical shells subject to wind load remained unchanged since the compulsory introduction of the Eurocodes. While an extension of a more sophisticated design rule has been drafted only for silo like structures, an approach for tanks with low aspect ratios still is not available but necessary, since the boundary conditions have a huge influence on the resistance in the latter case.

With this paper, a contribution to the steady improvement of current design codes shall be made. Employing a parametrical FE study, the complexity of the buckling behavior of cylindrical, open-top shells with low aspect ratios subject to wind load is explored. A wide range of parameters is considered. The radius over thickness ratios (r/t) are chosen between 500 and 5000 in five steps to represent common tank geometries. The wind girders' stiffness' are varied between rather weak to quite heavy stiffening in four steps. The length to radius ratio (l/r) is chosen to either 0.5 or 1.0. Very small up to very deep imperfection depths (five values) are studied, employing six different patterns.

It will be shown that a single constant value of a buckling reduction factor only depending on the natural imperfections of a tank is not sufficient, neither for an economical nor for a safe design. It was observed that it is impossible to detect *the* most unfavorable imperfection pattern for the load case studied, so that recommendations for practitioners are deduced from the study on how to numerically analyze the cylindrical shell. The influence of each parameter will be pointed out and an attempt will be made to link the single parameters, to derive design criteria suitable for a hand calculation.