Recent Silo Codes – and still Structural Failure?

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ABSTRACT: The present paper reviews some aspects of damages in metal silos, caused by buckling phenomena, with special regard to slender, thin-walled aluminium silos. Some of them can be explained or could have been avoided by employing the recent codes applicable in this field. Others seem to be unexplainable. Special considerations to imperfect cut are made.

1 INTRODUCTION

In the last years some new codes have been published, which are concerned with the loads (EC1-4:2006) and the structural design of silos (EC3-4-1:2007, EC3-1-6:2007, EC9-1-4:2007).

There are cases however, where we encounter presumed structural failure with metal silos, which does not seem to fit in the pattern of possible failure modes, against which we design a silo. Typically with aluminium silos we have buckles at about 80 % of the bin's height, sometimes at a change of wall-thickness.

There are different points of view from which this structural failure might be looked at:

A silo specialist, who shall establish expertise on the broken silo, wants to track down the reasons, which caused structural failure in the specific case.

A silo manufacturers wants learn, why some silos exhibit buckles during operation, although they seem to have been designed properly according to the codes.

Figure 1. Postbuckling shape of silo with internal underpressure (photo: anonymus)

2 PHENOMENOLOGY

2.1 *Buckling due to external pressure*

In dealing with the question of what and who caused the buckles the manufacturer tends to claim that there would have been a negative operating pressure, which was far below the one, the silo was designed for (see Figure 1).

This question can be decided by the form of the buckle: Evacuation of the silo causes buckles, which develop longitudinal over a long range of the meridian. They should have a length, which yields from the eave to the surface of the stored bulk solid. They should have a circumferential half-wave-length, which corresponds to Greiner's prediction (1972) of circumferential wave numbers

$$n = 2.74 \cdot \sqrt{C_\varphi \cdot \frac{R}{L} \cdot \sqrt{\frac{R}{T}}} \qquad (1)$$

where n should be big enough to satisfy