Seismic horizontal forces exerted by granular material on flat bottom silos: experimental and analytical results

Luca Pieraccini, Michele Palermo, Stefano Silvestri, Giada Gasparini, Tomaso Trombetti

Department DICAM, University of Bologna, Italy

Contact: luca.pieraccini5@unibo.it

Abstract

Seismic response of grain-silos still presents strong uncertainties and open issues. For this reason, seismic design of silos is not yet consolidated as the design in static conditions (filling and discharging scenarios) and current design codes tend to provide too conservative formulations for the estimation of the seismic actions induced by the stored material.

Experimental tests have been conducted during the last decades, including shaking table tests on scaled models for better understand the coupled behaviour of grain-silos. Recently, the authors proposed a theory for the evaluation of the horizontal seismic forces exerted by granular material on silos. The main purpose of the present study is to provide a set of simplified code-like formula for the evaluation of the seismic horizontal forces acting on the silo wall and to compare them with the results of experimental shaking-table tests and with the actual code provisions.

Keywords: Ground-supported flat-bottom circular silos; Grain-like material; seismic response; shaking-table tests; effective mass; code-like formula

1. Introduction

Seismic design of flat-bottom silos is mainly conducted referring to the response of the ensiled content and taking into account the additional dynamic overpressure exerted by the grain on the silo wall. However, to date, the seismic response of grain-silos presents many open issues, because of the strong uncertainties related to the overall seismic behaviour of flat-bottom silos containing bulk solid. For these reasons, current design codes (e.g. [1], [2], [3]) tend to provide too conservative formulations for the estimation of the seismic actions induced by the stored material and their provisions are still not explicitly covering some important issues related to the seismic design of silos.

During the last century, few theoretical efforts, numerical simulations via finite element modelling and experimental tests (most of them via shaking-table on scaled specimens) have been performed in order to investigate the dynamic behaviour of circular on-ground grain-silos and the interaction between cylindrical shell and granular ensiled content. Some recent findings indicate that the actual knowledge about seismic response of grain silos could be enhanced. In the present paper, the theoretical works recently proposed by some of the Authors are synthetized and a set of simplified code-like formula for the estimation of the seismic forces acting on silo is provided and compared with shaking-table test results and actual code provisions.

https://doi.org/10.2749/stockholm.2016.1050
Distributed by structurae