Investigation of Frictional Behavior on Corrugated Silo Walls During Confined Granular Flow

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Bulk solid-structure interfaces commonly occur in the field of silo constructions. The study investigates the interface between granular material and silo walls during confined flow, with particular emphasis on frictional behavior and wall geometry. The interface behavior is characterized by the formation of shear zones in the material region adjacent to the construction surface which play a critical role in governing flow kinematics and stress transmission in silo structures [1]. For this purpose, a series of experimental and numerical tests of granular flow in a model-scale silo have been carried out.

Laboratory experiments and numerical simulations were conducted using a rectangular silo. In the experimental part, Digital Image Correlation (DIC) was applied to quantify displacement and strain fields, enabling identification of shear localization zones near the wall. Tests were performed for different wall geometries (shallow and wavy), using sand as bulk material. In addition, during the experimental study, forces acting on corrugated walls and on the silo bottom were measured. The results demonstrate that wall geometry-especially corrugation depth-strongly influences flow patterns and the development of shear zones at the interface.

Complementary numerical analyses were carried out using the Discrete Element Method (DEM) [2]. In the study, the granular material was modelled as hundreds of thousands spheres with rolling resistance. The simulations reproduced the experimental setup and provided insight into both macroscopic flow behavior and grain-scale mechanisms, including particle rotations, force chains, and void distribution. The numerical results showed good agreement with experiments and confirmed that wall profile significantly affects flow force distribution. During the flow, the forces between the grains and the walls of the silo were measured along the entire height of the silo wall. It has been shown that the increase of the, e.g. corrugation depth induced the increase of the pressures exerted on these walls.

Overall, the study demonstrates that wall geometry has a substantial impact on interface behavior and pressures exerted on silo walls. These findings contribute to a more accurate assessment of loads in corrugated silo structures.

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