**Ain Shams University**
**Faculty of Engineering**
**Structural Engineering Department**

Abstract of the M.Sc. Thesis submitted by:

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Title of Thesis:

**Finite Element Modeling of Steel Containment Structures under Lateral Loads.**

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## ABSTRACT

The research presents a 3-D finite element modeling for simulating the progressive filling process of flat-bottomed square and rectangular steel silos filled with granular materials (*wheat*) using ABAQUS software. The material, silo, and base are discretized by finite elements of type hexahedron with 8 nodes (cubic brick element) with 3 degrees of freedom per node. An axisymmetric finite-element model is used to represent both the stored granular material and the structure. The granular materials are modeled using an elastic-plastic model, while the steel silo is modeled using a linear elastic model.

In this research, the granular material was simulated by Mohr-Coulomb model to define the yield surface and flow potential parameters for elastic-plastic model.

Surface-to surface interface contact is used between the steel silo wall and the granular materials to admit laws of behavior of the granular materials and boundary conditions with the walls. (no contact elements

are used). Contact pair is used for simulating the interaction between the stored granular material and the silo wall. This interaction is between the outer surface of granular material and the inner surface of silo wall which applies friction properties into a mechanical surface interaction model governing the interaction of contact pair.

The influence of mechanical properties of granular materials on the lateral wall pressure is studied. The influence of silo dimensions on the lateral wall pressure is investigated. The distribution of the lateral wall pressure in the horizontal section along the silo height is studied. A progressive filling process is conducted to fulfill actual filling process of the silo and analyzes the static lateral wall pressure at the end of filling which is compared to one time filling process.

**Keywords:** Finite-element modeling, Three dimensional steel silos, Square silos, Silo filling, Lateral wall pressure, Silo Dimensions, Mechanical properties of stored material.

# APPROVAL SHEET

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# STATEMENT

This dissertation is submitted to Ain Shams University for the degree of M. Sc. in Civil Engineering.

The work included in this thesis was carried out by the author in the Department of structural Engineering, Ain Shams University from 2009 to 2014.

No part of this thesis has been submitted for a degree or for qualification at any other University or Institution.

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**Al-Hussein Ibrahim**
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# NOTATIONS & SYMBOLS

| | | |
|---|---|---|
| $A$ | : | Area of the horizontal section of the silo. |
| $U$ | : | Perimeter of the rectangular section. |
| $D$ | : | Diameter of circular silo. |
| $h_0$ | : | Height of the vertical part of the silo. |
| $h_t$ | : | Height of the hopper. |
| $h_c$ | : | Height of the flow cone during draining. |
| $dz$ | : | Horizontal layer thickness. |
| $P_y$ | : | Vertical pressure. |
| $P_x$ , $S_{11}$ | : | Horizontal pressure along the X axis. |
| $P_z$ | : | Horizontal pressure along the Z axis. |
| $P_n$ | : | Normal pressure at the wall. |
| $z$ | : | Section depth from the free surface of the silage material. |
| $z_t$ | : | Depth of the section from the junction of vertical hopper part. |
| $\mu$ | : | Coefficient of friction to the wall. |
| $\varpi$ | : | Specific gravity of the ensiled material. |
| $K$ | : | Ratio between horizontal stress and vertical stress, multiplied by friction Coefficient of the wall. $K= \frac{Px}{Py} \times \mu$ |

| | | |
|---|---|---|
| $\lambda$ | : | Ratio between horizontal stress and vertical stress, Rankine's coefficient of active earth pressure. |
| $\phi$ | : | The internal friction angle of the material. |
| $\phi_r$ | : | The dilatation angle of the material. |
| $\delta_r$ | : | The angle of friction between the wall and the material for filling. |
| $E$ | : | Young's modulus of the material. |
| $\nu$ | : | Poisson's ratio of the material. |
| $\alpha$ | : | The angle of inclination of the hopper with the vertical. |
| $a$ | : | Bigger side of rectangle. |
| $b$ | : | Smaller side of rectangle. |
| $a/b$ | : | Rectangularity Ratio. |