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# Design of Reinforced Concrete Silo Groups

 Springer

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# Preface

Groups of reinforced concrete silos are structures commonly used in the food industry, where it is usually necessary to separate the storage of different types and sources of grain.

The grouped layout of silos has numerous benefits when compared with single-cell silos in which the emphasis is on creating further space for silage, normally referred to as interstice—a space formed between the edges of the group's cells.

This economic benefit, on the other hand, raises a structural problem for the designer of this type of building, which is to assess the magnitude of bending moments and hoop forces due to the structural continuity of the walls in the interstice region of the cells.

Bending moments assume extreme values exactly when the interstice is loaded and the other cells in the group are empty. In order to be able to achieve economic and safe designs, it is, therefore, essential to understand the structural behaviour of this type of structure, considering the loading imposed upon it.

The purpose of this book is to present a new calculation procedure of those moments, easy to use and with satisfactory responses when compared to the three-dimensional analysis using the finite element method (FEM), which today is the state-of-the-art structural analysis of this type of construction.

To develop the formulation of the proposed analysis models, a parametric study was carried out that allowed the adequate consideration of the variables involved. The book is divided into six chapters.

Chapter 1 contemplates the characterization of the problem to be solved. It provides a bibliographical review on the methods of calculation of the bending moments due to the structural continuity in a group of silos available in the literature with brief comments on their foundations.

Chapter 2 presents the geometry of the groups of silos analysed and a review of the aspects related to the applied loads. It is also defined as the physical parameters of the stored material and the procedures for calculating the design of horizontal pressure diagrams to be used.

Chapter 3 is integrally dedicated to 2D analysis using the *Slice Method*. It includes the definition of the method, the load cases considered, the finite element meshes used in the analysis of the resulting structure and concepts related to the application of the loads to the models generated. The theoretical formulation for the imposition of constraint equations (required in the modelling with frame elements) and the procedure used to calculate the stresses resultants in the solid element modelling are also included in this chapter. In the end, a comparison of results between the analyses carried out and conclusions about the use of the exposed method is presented.

Chapter 4 addresses the three-dimensional analysis of groups of reinforced concrete silos. Three types of modelling strategies are presented—solid elements, shell elements, and shell and solid elements—with their respective finite element meshes. In the modelling with shell and solid elements—here called mixed modelling—the procedure to be used in the generation of the constraint equations, necessary for the connection between the two types of mesh elements, is presented. At the end, a comparison of results between the analysed models is presented.

Chapter 5 presents the interpretation of the structural behaviour and the formulation of the proposed analysis models. The parametric study developed, which enabled the establishment of the recommended calculation procedure, is also discussed. Finally, a comparison between the results obtained with the application of the proposed analysis model and those resulting from the calculation methods available in the literature and the Finite Element Method—FEM—are presented.

Chapter 6 summarizes the conclusions of the study carried out and contemplates the recommendations about the analysis of groups of reinforced concrete silos. Detailed and commented description of the steps required to use the proposed model, with an example of application, are also presented.

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