

Analysis of Fast Calculation Method for Flat Foundation of Circular Flat-bottom Squat Steel Silos

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Keywords: Floor type circular cylinder storehouse, Foundation, Fast calculation, The finite element analysis

Abstract. This paper sums up the floor a fast calculation method on the basis of the circular plate steel cylinder storehouse. At the same time, by using Adina, the fast calculation results are verified, the results show that the quick calculation accuracy is higher, can be used in engineering practice.

Introduction

The storage of flat-bottom squat steel silo is large, as result acting on the basis of load per unit area is big, so the design of the basis is related to the safety of the silo. The main evidence for the selection of foundation forms diameter size and the foundation bearing capacity of steel cylinder storehouse. Floor type steel silo foundation is large and complex. Silo foundation in the event of uneven settlement or destroyed, will cause devastation to the silo structure. Large silo foundation area at the same time, concrete consumption, high cost, the thickness of base change on cost. So on silo design, need accurate for the silo foundation is calculated and designed.

The theoretical analysis

The basis of flat-bottom squat steel silo is under material effect, and the translate the upper load to the foundation. The raft foundation is different from general the structure of the raft. Floor type circular silo can be regarded as the basis of elastic foundation on circular plate under uniform distributed load, the force of the circular plate foundation affected by factors such as characteristics of foundation soil, the thickness of itself.

For arbitrary thin plate on elastic foundation, set perpendicular to the surface for the distribution of load, ground reaction force, thickness of h , the board of elastic curved surface differential equation is:

$$D\nabla^2\nabla^2 w(x, y) = q(x, y) - p(x, y) \quad (1)$$

$$D = \frac{Eh^3}{12(1-\mu^2)}$$

is known as the plate bending stiffness.

When internal force of the circular plate is solved, need to plate boundary conditions of differential equation and the equation to establish equations, by Bessel series and some other commonly used series transformation, omit small items, can calculate deflection of plate, and then the internal forces of plate can be obtained.

The simplified calculation method

Floor type circular flat steel cylinder storehouse foundation can be regard as a circular plate under uniformly distributed load. According to the foundation soil and the foundation slab of the elastic modulus, poisson's ratio and the radius and thickness of the floor, can draw a dimensionless parameter - flexible index S . Because the steel cylinder silo bottom average diameter is larger, the vast majority of

the flexible index S are more than 10, so the silo foundation slab can be thought of as absolutely flexible plate.

Steel cylinder storehouse foundation slab for cloth load q , under this kind of load, the basal counterforce distribution is almost uniform, and equal to q , just close to the plate edge pressure slightly decreased. The nonuniformity of the edges a bit on edge of subsidence, the impact is not big to the center of subsidence. Subsidence, therefore, can according to the cloth symplectic bernays g for directly in the soil surface and throughout all round pressure on the surface of the formula to calculate the q :

The center of the subsidence

$$w_0 = 1.2 \times \frac{2(1-n_0^2)qR}{E_0} \quad (2)$$

The edge of the subsidence

$$w_1 = \frac{4(1-n_0^2)qR}{pE_0} \quad (3)$$

The above formula is calculated assuming circular plate stiffness is zero, but apparently it is unlikely to be zero, so the subsidence calculation result is small. So in order to ensure safety when calculating the center of subsidence, multiplied by the correction coefficient of 1.2.

When solving circular plate bending moment, only a relative deflection value in the center of the plate ($w_0 - w_1$) is not greater than the $\frac{1}{5}$ thickness of the makes sense. If not, then the plate is soft like a film, subjected to tension, the situation is not consistent with what assumptions. If the requirements above is satisfied, the central part of the circular plate of the radial bending moment can be obtained from use

$$M_r = 0.05qh^2 \times \sqrt[3]{\frac{E_1^2}{E_0^2}} \quad (4)$$

Ring to the bending moment can take half of the radial bending moment approximation. Circular plate shear are generally not very big, meet the construction requirements of thickness can meet the requirements of shear.

A flexible circular plate on elastic foundation is closely related to the internal force and compression modulus of foundation soil, improve the compression of the foundation soil modulus can effectively reduce the plate bending internal force. On the soft soil layer, therefore, should use effective foundation treatment measures, improve the compression modulus of foundation soil.

The finite element validation

In this section the author actually met of a floor type circular cylinder storehouse project as an example, with large scaled finite element model is set up by Adina. The results scaled by Adina will be compared with the results calculated by simplified, to verify the accuracy of the simplified calculation.

Engineering background. A circular cylinder storehouse was built on floor somewhere in Xingjian, the diameter of it is 25m, and wall height is 17.5 m, with 5m of vector spherical shell, total height of 22.5 m. The silo is used for storage of fly ash, the density of fly ash take $10 \text{ KN} / \text{m}^3$. According to the geological survey report, the underground water level below the natural ground 20.45m to 20.95m. The planned area of site soil category for soft ground soil, after artificial processing, can carry on the construction of the project. The main soil physical and mechanical properties index recommendations are shown in table 4-2, the values are all the data after foundation treatment. Silo foundation use tablet foundation, foundation 25 m in diameter, the thickness of 300 mm, the C30 concrete.

the finite element model is established in this paper.For the foundation soil, in order to simplify calculation method should be relatively, this model USES linear elastic material, only defines the foundation soil compression modulus and poisson's ratio. For concrete material, this model USES linear elastic material, only defines the C30 concrete elastic modulus and Poisson's ratio.

The diameter of the plate geometry is 25m, and thickness of it is 300mm. The base diameter is 25m, the calculation model of foundation soil is 4 times the diameter of the base, that is, 100m. According to the geological survey report, the foundation soil model is set to a diameter of 100m, height 25m of the cylinder. The element types of the foundation soil and the foundation plate are made of solid element. The element density is 5m/pieces. In order to better simulate the mechanical properties of the base plate, the grid of the base plate is encrypted, and the grid density of the flat plate is 2m. On the foundation soil, the horizontal constraint is imposed on the bottom surface of the foundation soil, and the vertical constraint is imposed on the bottom surface of the foundation soil. In the calculation of internal forces, to determine the reinforcement and check the strength of the material, the upper structure of the role of the effect, should be based on the bearing capacity limit state of the role of the basic combination of design values. This model only applies 1.2 constant +1.3 material +1.4 live combination calculation value of 281.46 kN/m².

the results compared

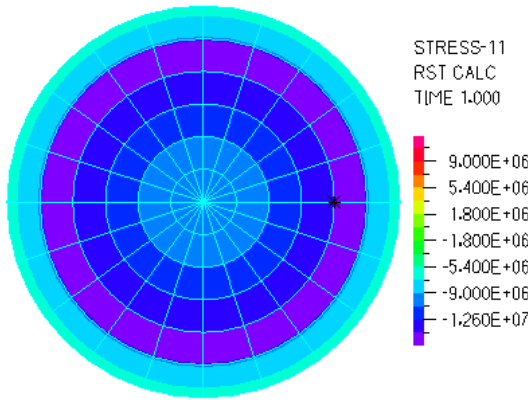


Fig.1 board top radial stress

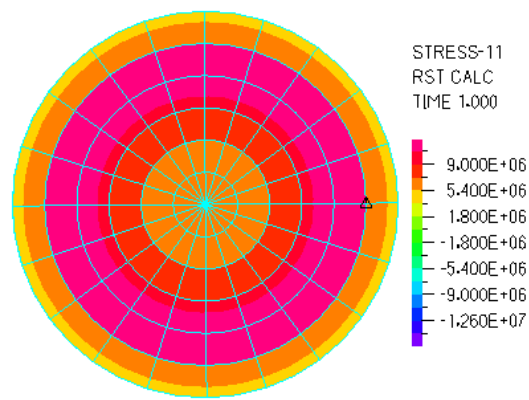


Fig.2slab bottom radial stress of concrete

Tablet foundation stress distribution.According to the top plate and concrete plate at the end of the radial stress, the plate top surface concrete compressive stress, plate bottom concrete tensile stress, explain silo base plate of the radial bending moment for positive bending moment (the side tension is positive). Into a circular ring radial stress distribution, stress of the same radius of each point on the same size. Radial compressive stress in the center of circular plate ($R = 0$) is the largest, circular plate edges ($R = 12.5$ m) minimum, shows that circular plate radial bending moment origin, the largest radiated outward from the center of the circle decrease gradually.

Tablet results of internal force.Query origin unit of radial stress and radial tensile and compressive stress $\pm 12.6 \text{ N/mm}^2$, and the radial bending moment can be approximate calculation of the linear meter for each:

$$M_r = S \cdot W = S \times \frac{bh^2}{6} = 12.6 \times \frac{1000 \times 300^2}{6} = 189.00 \text{ kN} \cdot \text{m} \quad (5)$$

The result of fast calculation is 16.41% larger than the Adina results. Considering the completely elastic materials are adopted to simulate the foundation soil and base plate, therefore, the calculation results can be used to rapidly in practical engineering.

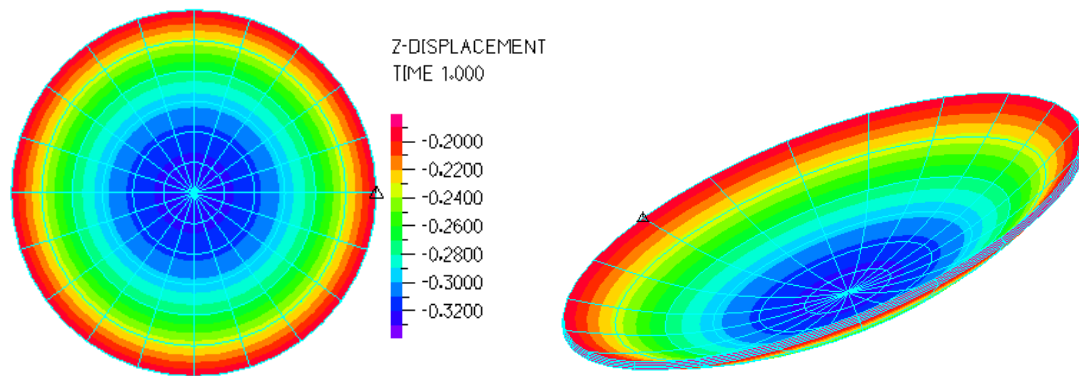


Fig.3 tablet based vertical displacement and deformation

The result of deformation calculated by Adina.Scaled calculated adina.the flat foundation deformation as shown in figure 4 to 6. Plate settlement center, the largest of 320 mm, plate edge settlement minimum, is 200 mm, deformation of circular plate's own internal force is 120 mm.

Conclusions

Directly under the basis of floor type circular cylinder storehouse material effect, and the upper load to the foundation. The raft foundation is different from general the structure of the raft. The calculation method involving less now. Reference books at home and abroad, this paper sums up the floor a fast calculation method on the basis of the circular plate steel cylinder storehouse. At the same time, using a large general finite element software scaled, adina.the fast calculation results are verified, the results show that the quick calculation accuracy is higher, can be used in engineering practice.

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