

Original Research Article

Study on the stability of cement silo foundation under wind-induced vibration*Zhang Ning**Hebei University of Engineering, Handan, Hebei, 056038, China*

Abstract: With the rapid development of industrial buildings, the stability of cement silos, as an important storage facility, has attracted increasing attention. Wind-induced vibration is one of the main factors affecting the stability of silo. The purpose of this paper is to study the influence of wind-induced vibration on the stability of cement silo foundation. Through theoretical analysis, numerical simulation and field monitoring, the influence mechanism of wind-induced vibration on the stability of silo foundation is discussed, and the corresponding reinforcement measures are put forward. The results show that wind-induced vibration has a significant effect on the stability of the silo foundation, and reasonable reinforcement measures can effectively improve the stability of the silo.

Keywords: Wind-induced vibration; Cement silo; Foundation foundation; Stability; Reinforcement measures

1. Introduction

Cement silo is a common storage facility in industrial production, and its stability is directly related to production safety and economic benefits. As a common natural phenomenon, wind-induced vibration poses a potential threat to the stability of the silo. In recent years, with the increase of extreme weather events, the influence of wind-induced vibration on the stability of silos has been paid more and more attention. In this paper, the influence of wind-induced vibration on the stability of cement silo foundation is studied by means of theoretical analysis, numerical simulation and field monitoring.

As an important industrial building, the stability of cement silo under bad weather conditions is particularly important. Especially in windy areas, wind not only has a significant impact on the main body of the silo, but also poses a potential threat to its foundation. Therefore, it is of great significance to study the stability of silo foundation under wind force for ensuring production safety and preventing accidents.

2. Literature review

Scholars at home and abroad have done a lot of research on the influence of wind-induced vibration on the stability of buildings. Studies have shown that wind speed, wind direction, structural characteristics of buildings and other factors will affect the effect of wind-induced vibration. For the cement silo, the influence of wind-induced vibration on its stability is more complicated due to its structural characteristics and the particularity of the use environment. This paper reviews the relevant literature and provides a theoretical basis for subsequent research.

3. Theoretical analysis**3.1. Mechanism of wind-induced vibration**

Wind-induced vibration is a phenomenon of building vibration caused by the dynamic effect of wind.

The dynamic effect of wind includes wind pressure, wind speed change and other factors. In this paper, the mechanism of wind-induced vibration is analyzed by the theory of fluid mechanics and structural dynamics.

3.2. Stability analysis of silo foundation

The stability of foundation is the key to the stability of silo. In this paper, the stability of silo foundation under wind-induced vibration is analyzed by the theory of soil mechanics and structural mechanics.

4. Numerical simulation

4.1. Modelling

In this paper, a numerical model of cement silo is established, including silo structure, foundation and foundation. The model takes into account the geometric characteristics, material properties and boundary conditions of the silo.

4.2. Simulation result analysis

Through numerical simulation, the response of silo foundation under different wind speed and wind direction is analyzed. The simulation results show that the wind-induced vibration has a significant effect on the stability of the silo foundation.

5. Field monitoring

5.1. Monitoring scheme design

In this paper, the field monitoring scheme is designed, including the layout of monitoring points, the selection of monitoring equipment and the processing method of monitoring data.

5.2. Analysis of monitoring results

Through on-site monitoring, the data of the silo under actual wind-induced vibration were collected. The monitoring results are compared with the numerical simulation results to verify the accuracy of the numerical simulation.

6. Study on reinforcement measures

6.1. Theoretical analysis of reinforcement measures

In this paper, several possible reinforcement measures are proposed, including increasing the depth of the foundation, strengthening the foundation, setting the isolation device, etc., and the theoretical effects of these measures are analyzed.

6.2. Numerical simulation of reinforcement measures

Through numerical simulation, the influence of different reinforcement measures on the stability of silo foundation is evaluated.

6.3. On-site verification of reinforcement measures

Through on-site implementation of reinforcement measures and monitoring, the actual effect of reinforcement measures was verified.

7. Results discussion and engineering application

(1) The influence of wind-induced vibration on the stability of foundation

The stress and deformation differences of the silo foundation under the action of wind or not are compared and analyzed, and the adverse consequences of wind load are clarified.

(2) Optimized design proposal recommendation

A series of improvement strategies to enhance the wind resistance of the silo are proposed, such as adding counterweight blocks, improving the shape of the foundation, setting wind barriers, etc., to ensure the long-term stability of the structure.

8. Conclusions and prospects

In this paper, through theoretical analysis, numerical simulation and field monitoring, the influence of wind-induced vibration on the stability of cement silo foundation is systematically studied, and effective reinforcement measures are put forward. It provides strong support for the planning, construction and daily operation and maintenance of similar projects. Future research will focus on exploring more accurate wind prediction models, as well as developing new materials and structural forms, with a view to solving this challenging topic at a higher level.

References

- [1] Zheng Xiaowei. Risk analysis and load factor correction of high-rise buildings under the coupling of earthquake and strong wind [D].Dalian University of Technology, 2020.
- [2] Gao Wei. Construction treatment technology of building foundation and pile foundation [J].Residential facilities in China, 2024, (06) : 190-192.
- [3] Sun Guoguang, Xue Yan, Diao Changfu, et al. Design and Application of Automatic Control System for Dust Removal and Card Blowing of Cement Powder Silo [J].Building Technology Development, 2015,42 (11) : 46-48.
- [4] Pastoral Long. Discussion on construction technology of deep foundation pit support in industrial building construction [J].bulk cement, 2024, (02) : 138-140.
- [5] Liu Yang. Study on the multi-disaster resistance of steel-concrete composite structures under the combined action of earthquake and strong wind [D].Dalian University of Technology, 2021.