The Construction Characteristics of Group Silo Cement Storage Warehouse

Hongjun Wang[a], Zongfeng He*

Gansu First Construction Group Co., Ltd., Lanzhou 730070, China

[a]3053302912@qq.com; *231081402007@lut.edu.cn

Abstract. The Group silo cement storage facility is an important facility for large modern cement producers and its architectural features are crucial to the quality and efficiency of the project. Based on the cement storage facility project of Indonesia Nanga Conch 2×3200t/d clinker raw cement production line phase I project, this paper improves the construction progress and quality of cement storage warehouse by improving the construction technology of cement storage wall reinforcement, improving the construction technology of pressure relief cone of silo, and improving the construction progress and quality of cement storage warehouse of Silo. Reduced project costs.

Keywords: Group silo cement storage facility; slipform; decompression cone; construction technology.

1 Introduction

Cement storage facility is a key link in the cement production and supply chain, and its design and construction directly affect the quality and storage efficiency of cement. Tang[1] improved the construction progress and construction quality of dry process cement storage depot and reduced the project cost by improving the construction technology of dry process cement storage depot foundation structure, improving the construction technology of silo sliding mould joist lifting large steel beams and installation, and improving the construction technology of silo decompression cone. Ren et al.[2] in order to solve the collapse of the concrete decompression cone in the 10,000 tonnes of cement warehouse, the use of powder flow switch technology for the technical transformation of the concrete decompression cone in the cement warehouse, improve the original discharge method, to achieve the overall flow of non-powered discharge to achieve the stability of the discharge in the cement warehouse, extend the cycle of clearing the warehouse, reduce the cost of production and operation, and reduce the noise. Jin et al.[3] studied the sliding form system design considering tower erection. The structural analysis is carried out to verify the structural safety of the slip form. Hao et al.[4] introduced the process flow of sliding mould construction of cement depot, highlighted the key points such as the preparation of sliding up construction, installation of sliding mould system, construction of sliding mould and removal of sliding mould device, put

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forward the control measures of the accuracy of sliding mould and pointed out that sliding mould is more and more applied to the construction of rotary body due to its feature of fast construction speed. Zayed et al.[5] studied the application of sliding modes in silos, evaluated their productivity, and determined their appropriate combination of speed and auxiliary resources. A simulation model is established in which the potential control unit of the silo in the sliding mode system is described.. Pawluk et al.[6] examined the effectiveness of sustainable warehouse design in terms of fire regulations and costs. Xie et al.[7] through the Sanming Cement Plant cement warehouse slipform construction examples, detailed introduction of cement warehouse slipform from the foundation surface of the new method of construction and implementation of the new method of sliding over the base plate of the warehouse. Tang et al.[8] briefly described the cement plant project cement double cylindrical wall concrete silo inside and outside the silo wall at the same time lifting slipform construction, introduced the double cylindrical wall at the same time lifting mould design and assembly, the inside and outside the silo wall slipform platform as a whole, the platform is divided into the upper and middle and lower three floors, the flow of people, logistics interspersed with the order of the inside and outside of the cylindrical wall of the concrete poured in a reasonable order, to enhance the stability of the slipform platform as a whole, to ensure the quality of the slipform project, shorten the slipform This ensures the quality of the slip moulding project, shortens the slip moulding period and reduces the cost. Due to its large scale and complex structure, the technical difficulties and safety risks in the construction process of the cement storage warehouse are high. This paper aims to provide reference for related projects by discussing the construction characteristics of cement storage warehouse.

2 Three-Dimensional Numerical Simulation Analysis Model

In the Phase I project of 2×3200t/d clinker raw cement production line of Nanga Conch in Indonesia, the designed cement storage warehouse has four storage bodies, and the structure type is silo structure. The diameter of the single silo is 18m (inner diameter), the wall thickness of the silo is 380mm, the height of the silo is 45m; the silo is equipped with a base plate at the elevation of 7.9m, the thickness of which is 1300mm, and the structure is a reinforced concrete slab structure; there is an inverted conical decompression cone in the middle of the base plate of the silo, and the diameter of the decompression cone is 5000mm, and the height of the cone is 7471mm; the structure of the top of the silo is a steel beam - pressurised steel sheet base plate - reinforced concrete floor bearing plate structure. -Reinforced concrete floor slab structure. As shown in Fig. 1.

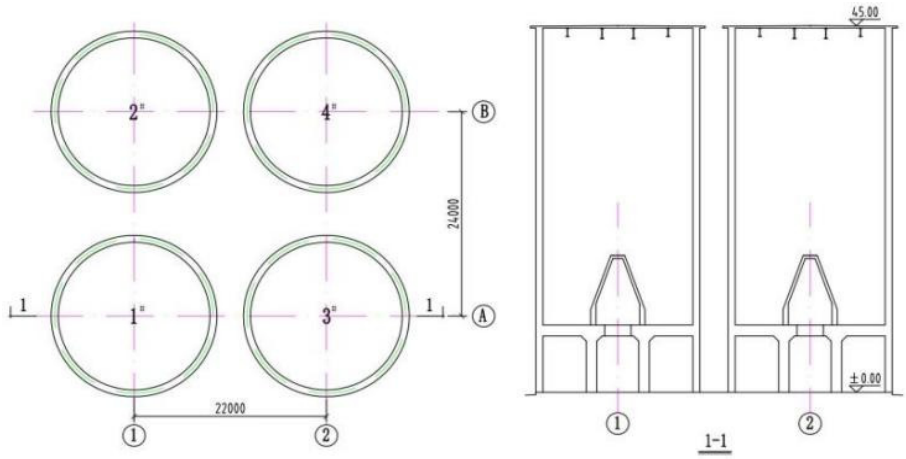

Fig. 1. Layout of cement storage facility

3 Features of Construction of Cement Storage in Group Silos

The wall reinforcement is designed as double-row reinforcement mesh, the vertical reinforcement is Ø16, the spacing below the base plate of the library @180, above the base plate of the library @200; the ring reinforcement changes with the height, the specifications and spacing are different. Vertical and ring reinforcement adopts lap joint, welding is strictly prohibited, vertical reinforcement needs "double control". Ring reinforcement configuration in the vertical reinforcement outside, spacing tolerance ± 5mm, lap length 52d, staggered joint arrangement. In order to ensure the spacing of ring reinforcement, set the skeleton reinforcement. When meeting the hole, the ring reinforcement needs to be bent and inserted into the inner side.

The construction of decompression cone adopts scaffolding steel pipe to set up internal mould support frame and external operation frame. The construction sequence is the erection of internal mould support frame, installation of internal and external formwork, reinforcement tying, concrete pouring and formwork removal. The key lies in the positioning of the cone tip of the inner formwork support frame, and the use of bamboo rubber formwork combined with wooden ribs to ensure the stability of the cylinder formwork. Reinforcing bar tying requires double control and staggered joints, and the outer formwork needs to be reinforced. Layered vibration is used when pouring concrete to ensure that the concrete is dense.

4 Main Construction Methods

4.1 Reinforcement Construction of the Reservoir Wall

The group wall reinforcement uses a double-row mesh with Ø16 vertical bars. Below the base plate, spacing is @180, above it's @200. Ring reinforcement varies in specs and spacing with the wall height, strictly following design specifications to prevent incorrect binding or tying leaks. Vertical reinforcement around the cylinder wall should be evenly spaced; spacing increases appropriately at workbench radiation beams, ensuring "double control" for total count and spacing. Vertical joints stagger, with joints not exceeding 25% per section, spaced out.

Vertical reinforcement should be uniformly arranged around the cylinder wall, in the workbench radiation beam, the spacing of reinforcement is appropriately increased, it is necessary to achieve the "double control", that is, the total number of requirements, but also the spacing requirements. Vertical reinforcement joints should be staggered, the number of joints in the same section shall not be greater than 25% of the total number of reinforcement, and must be spaced out.

Ring reinforcement outside vertical bars allows ± 5mm deviation in spacing; lap length is 52d (d for bar diameter), joints staggered, with vertical joints not exceeding 25% per section, allowing joints every 3 rows. Inside and outside ring reinforcement joints staggered by 22.5°.

To maintain ring reinforcement spacing, skeleton reinforcement is installed in the wall using Ø16 and Ø8 bars welded together. Ø16 vertical bars can substitute for wall reinforcement; Ø8 horizontal bars match ring reinforcement spacing. Skeleton bars set at 30° intervals along the wall, totaling 12 per silo with top and bottom lengths aligned to ring bar spacing, lap welded for 10d. If ring bars disconnect through holes, outer bar ends should bend and insert into inner bars as per design, ensuring outer bar insertion length into inner side is ≥ 15d.

4.2 Decompression Cone Construction

Cone Construction Process

Setting up the inner formwork support frame → setting up the outer operating frame → installing the inner formwork of the cone → tying up the cone reinforcement → installing the outer formwork of the cone → pouring the concrete → removing the outer formwork → removing the outer operating frame → removing the inner formwork and operating frame.

Construction Methods

The inner mould support frame of the cone is erected by scaffolding steel pipe. Before erecting the shelf, firstly, the cross centre line of the cone and the inner and outer side lines of the cone bottom are popped up on the base plate of the library. Setting up the formwork support frame must first find the position of the cone tip, so as to ensure that the formwork frame is set up in place at one time. Because the design height of this cone is high, in order to ensure safety, first set up a cross-shaped independent frame on the base plate to the design height position of the cone, find and mark the position of the cone tip, and then fix a piece of steel plate with the same size as the design size at the lower bottom of the cone tip, and fix it firmly with the frame (can be used to weld the spot firmly), which determines the exact position of the cone tip.

After determining the tip position of the cone, first install the template of the lower cylinder in place along the bottom of the cone. A total of four steel tube hoards are arranged in the cylinder body template, which are connected with each other through fasteners of L=2500mm long vertical steel pipe. One hoop at the upper end of the template is adjusted in place according to the position of the cone template. After the installation and reinforcement of the lower cylinder formwork is completed, start to build the support frame of the cone.

After the support frame is set up, use Ø20 steel bar along the shelf according to the spacing @300mm in order to surround the hoop, and the steel hoop and the steel pipe of the shelf are tied firmly, and then lay the wood ribs uniformly along the perpendicular direction of the hoop, and the wood ribs and the steel hoop are tied firmly with the No.22 lead wire, and then lay the bamboo glue boards according to the size of the sample, and lay them up one by one, and use the nails and the wood ribs to be inlaid and stapled firmly (or not to use the wood ribs, and you can lay the bamboo glue boards up directly, and then lay them with the No.22 lead wire, and use the nails and the steel ribs to be inlaid and stapled firmly). (or no wood ribs, can be directly laid on the bamboo glue board, with No. 22 lead wire and reinforcing steel around the hoop tied tightly and firmly).

Cone template installed, start tying the cone reinforcement. Before tying the reinforcement bars, the CAD sizing should be carried out according to the drawings to ensure that the material is accurate, and the steel bars under the material should be hung up with a good nameplate to prevent the reinforcement bars from being wrongly taken and wrongly ganged; the joints of the ring bars should be staggered, and the joints should be separated by at least three rows within the same cross-section and should not be less than 1000 mm; the vertical reinforcement bars should be tied according to the spacing and the number of roots with double control and even emission.

After the reinforcement bars are tied and accepted, the outer formwork of the cone is installed. Outer template adopts bamboo glue board outside the back of wooden ribs, wooden rib spacing @ 200, the outer mould should be installed before the design drawings for sampling, and then according to the template number in order to lay up, splicing together. The outer mould reinforcement adopts Ø20 steel bar hoop, arranged according to the spacing @300mm, and then the inner and outer moulds are tightened with Ø12 tensile bolts, and the spacing of tensile bolts is @800.

In order to ensure the protective layer of reinforcement, the protective layer of reinforcement should be fixed up in advance before installing the outer mould, so as to prevent the outer mould from being close to the reinforcement, resulting in the absence of protective layer of reinforcement.

To protect the reinforcement, short steel bars are placed strategically before outer formwork installation to ensure proper cover. Concrete is poured in sections, compacted with vibrating rods and external vibration to prevent voids and ensure density.

5 Conclusions

The construction of group cement storage has the characteristics of large-scale concrete construction, complex structure design and high safety risk. Through reasonable construction scheme, strict quality control and perfect safety management, the technical difficulties and safety challenges in the construction process can be effectively overcome to ensure the smooth completion of the project and ensure the quality of the storage. The stability and safety of the structure are effectively ensured by adopting double row of steel mesh, reasonable spacing and lap specification of vertical and circumferential steel bars, and setting skeleton steel bars to keep the spacing of annulus. The pressure reduction cone construction emphasizes the accurate positioning of the internal mold support frame, the stable installation of the formwork and the double control binding of the steel bar. These construction characteristics together ensure the stability and durability of reinforced concrete structures under various stress conditions, meet the strict engineering quality and safety standards, and provide important guidance and reference for engineering practice in related fields.

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