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Construction method of pre assembled unit of bolt sphere grid

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Abstract. The traditional construction of bolt sphere grid has many disadvantages, such as high cost, large amount of work at high altitude and long construction period, in order to make up for these shortcomings, in this paper, a new and applicable construction method is explored: setting up local scaffolding, installing the bolt sphere grid starting frame on the local scaffolding, then the pre assembled unit of bolt sphere grid is assembled on the ground, using small hoisting equipment to lift pre assembled unit to high altitude and install. Compared with the traditional installation method, the construction method has strong practicability and high economic efficiency, and has achieved good social and economic benefits.

1. Introduction

The bolt sphere grid structure is a new type of roof load-bearing structure, which belongs to the multi-statically indeterminate space structure system. Grid structure has many advantages, such as novel and beautiful, uniform grid, integrity, large space stiffness, good seismic performance, bolt connection between the rods, easy to install, the force is clear. The traditional construction method of bolt sphere grid is the high bulk method, this method has very high requirements for site conditions, involves a large amount of high-altitude work, and need to build full scaffolding, so the construction speed is slow, the cost is higher.

It is very important to develop and innovate a new, economical and practical construction method to solve the technical problem of the installation of bolt sphere grid. In the construction project of the No.1 middle school gymnasium in Qingdao Development Zone, we have carried out technical innovation, and adopted a new construction method in the installation process of the grid. In case of unsuitable use of large hoisting equipment, we use the construction method of pre assembled unit of bolt sphere grid. Compared with the traditional installation method, the construction method has strong practicability and high economic efficiency, and has achieved good social and economic benefits.

2. Characteristics of Construction Method

This method makes the pre assembled unit work on the ground instead of a large amount of high bulk work, the construction operation is convenient and quick, this can not only ensure the connection quality between the sleeve and the rod but also reduce the risk of construction and the difficulty of the project management.

In case of unsuitable use of large hoisting equipment, this method uses small hoisting equipment to lift the pre assembled unit and install it in the high air. This not only makes full use of the small
hoisting equipment but also saves the construction time of the full scaffold construction and disassembly work, speeds up the construction schedule and reduces the construction cost.

There are two methods for location and monitor, one method is the direct measurement with a reflective film, another method is to calculate the measurement by measuring point position, the combination of the two methods makes the measurement data accurate and reliable. When the reflective film is measured, the height of the stadium stand can be utilized, this method can reduce the elevation angle of the total station, and it is convenient to use and improves the accuracy of measurement.

3. Process Principle
A bolt ball and four bars are assembled into a quadrangular pyramid unit on the ground, then the quadrangular pyramid unit is lifted by the small hoisting equipment to the specified position in the high air, and bolt connection by the aerial workers.

In the middle part of the bolt sphere grid, a local scaffold is set up, extending to the bearing of the bolt sphere grid at both sides, and the local scaffolding extends forward to form a T shape scaffolding, formed a mechanical system capable of bearing self-weight and construction load. After the bolt sphere grid starting frame is assembled on the local scaffolding, expand the assembly until the assembly of the bolt sphere grid is completed.

Some research shows that when measured by the reflective film, data measurement accuracy will decrease with the increase of total station elevation. On the stadium stand, a total station is installed, the ground axis and positioning point can be measured downwards, and the reflective film of the bolt ball node can be measured upwards. This method can measure the data more directly and accurately, and the angle of measurement is smaller than the angle directly measured on the ground, which is more convenient and has high precision.

4. Operating Points

4.1. Installation of local scaffolding
The erection height of the T shape scaffolding should be adapted to the height of the grid designed, to ensure that the assembled grid structure can be connected with the bearing and improve the stability.

Local scaffolding height should be easy to operate, if use the jack to adjust the elevation of the grid, the upper surface of local scaffolding and the lower chord node has a distance of about 80cm; if not, the distance should be 20~30cm.

The operation surface of local scaffolding to be covered with scaffold floor, scaffold floor with fir or pine production, its width is larger than 200mm; the thickness is larger than 50mm, the two ends with No. 10~14 galvanized steel wire bundling, prohibit the use of decayed wood.

When the local scaffolding is set up, the load of the upper space grid, the construction load and the weight of the scaffold board should be considered to ensure the rigidity and stability of the scaffolding.

4.2. Positioning measurement and Installation of the aseismic bearing

4.2.1. Positioning measurement. Be sure to use the total station to measure the top elevation of embedded parts and the longitudinal and horizontal axis size before installation, repeatedly detected and recorded by the surveyor. Strict control of the position and verticality in the pre assembled unit installation. Before the bolt sphere grid is hoisted to the high altitude, mark the position of the reflective film on the bolt sphere, before the measurement, the position of the mark on the bolt ball can be pasted with the reflective film.

4.2.2. Installation of the aseismic bearing. Bearing installation is the most important part of the whole installation work, and whether the bearing is stable or not directly affects the value of the deflection after the installation of the grid. According to the elevation axis have been checked, the
bearing installed on the top embedded parts. Reinforcement of the bearing around the positioning bolts, to prevent the installation of the grid in the process of displacement. Until the entire grid is fully installed, the bearing and embedded steel plate full of welding.

4.3. Ground splicing and high-altitude installation of pre assembled units

4.3.1. Ground splicing of pre assembled units. The connection angles of each bolt sphere and rod are different. Therefore, the pre assembled unit of the bolt sphere grid should be assembled in strict accordance with the drawing number. If a bolt sphere or rod is wrong, it may cause rework, thus reducing efficiency. The connection bolts between the bolt sphere and the rod must be tightened in place, and there is no gap, and can’t be loosened. The assembly team should work in accordance with the assembly sequence, and cooperate with each other.

4.3.2. High-altitude installation of pre assembled units. After the installation of the starting frame of the bolt sphere grid, the installation of the pre assembled unit along the horizontal direction continues. Assemble pre assembled unit on the ground, pre assembly unit is divided into the top chord quadrangular pyramid and the bottom chord quadrangular pyramid.

A small lifting equipment is used to lift the pre assembled unit into the high altitude, and the installation worker sits on the node. When the high-strength bolt is aligned with the screw hole on the bolt ball, the bolt is tightened and the installation of a unit node is completed.

Install a row of the bottom chord quadrangular pyramid, then a row of the top chord quadrangular pyramid, installed in this order until the installation is finished, and the bolt sphere grid and bearings are welded and fixed.

The wrench used for tightening bolts is a special tool, and the handle of the wrench can’t be lengthened or forced by many people, to avoid excessive torque. If the bolt can’t be screwed in and cannot be forcibly screwed in, the reason should be found out in time to repair the thread or replace the parts.

5. Quality Control and Safety Measures

5.1. Quality Control

Before the construction, organization construction and management personnel should learn about the specification and construction plan, familiar with the sequence of various processes, grasp the operation standard, so that the majority of workers are fully aware of the importance of quality.

The quality department and materials departments should strictly control the quality of material, material specifications and models should meet the material department requirements, the sample material is sent to the laboratory with corresponding qualification grade for the experiment, and the qualified material can be processed or applied.

The specifications, varieties and welding materials of joints, bars and connectors of the steel grid structure must comply with the design requirements.

After the construction of the steel grid structure and the roof construction, the deflection value shall be measured separately, and the measured deflection value shall not exceed 15% of the corresponding design value.

In the installation process of the bolt sphere grid, the deviation of the datum axis position, elevation and verticality should be checked at any time. If the deviation is found to be greater than the allowable deviation of the design and construction specifications, it must be corrected in time.

After the installation of the bolt sphere grid, the construction units, design units, supervision units and other parties execute the completion acceptance, and then construction workers spray fire retardant coatings. The bonding strength and compressive strength of fire retardant coatings should be in accordance with the regulations.
The overall quality control of each process, adhere to self-inspection, mutual inspection and special inspection, to ensure the quality of construction.

5.2. Safety Measures
The construction site shall have full-time safety personnel to implement and manage on-site safety measures, and conduct unified management of on-site construction personnel, on-site mechanical equipment and on-site power consumption. The special workers engaged in the construction must be trained and certificated. Personnel who enter the construction site must wear a helmet, wear non-slip shoes, electrician and electric welder should wear insulated shoes. Aerial operation personnel must fasten the safety belt.

The operating surface should be a reliable platform and body, checked before operation. The binding method of component should be correct. Hanging points should have anti-slip measures. Tools and materials used in height operations should be placed in a safe place and not allowed to be placed anywhere.

When lifting or lowering the steel member, the lifting equipment should be stable, avoiding emergency braking or impact. Lifting equipment should be directed by special personnel, the signal clear, loud, clear, strictly prohibited illegal operation.

All possible falling objects, such as screw, nut, hand tool, electrode and cutting block used in high altitude operation, must be placed in the intact tool bag. The tool bag fixed, not directly placed on the surface of the beam, flange plate, walkway plate and other objects, so as not to impede the passage. After each process is completed, the work surface is not allowed to leave debris, to avoid falling objects, so that people were hurt.

6. Environmental Protection Measures
Construction waste is transported by container, and it is strictly prohibited to throw it freely. Construction waste should be timely removal, the construction site should be appropriate watering, reduce dust.

In the steel structure welding, cutting and grinding, will produce a lot of smoke, the smoke is small metal particles harmful to human body, a mobile welding smoke purifier device should be adopted to reduce the air pollution of the welding fume.

The oil storage yard must be anti-seepage treatment. Storage and use should be careful to prevent oil spills and water pollution.

The construction site can’t be long time light, construction at night, in addition to the necessary lighting, avoid excessive light irradiation.

Strictly control the operation time with noise. In general, stop noise work from 10 pm to 6 am the next day, and reduce the night construction as much as possible. In case of special circumstances, the night construction shall be carried out after the "night construction permit", and corresponding measures should be taken to minimize the noise.

Special waste temporary storage sites should be set up on the construction site. The waste should be classified and stored, and the waste that may cause secondary pollution must be stored separately. Safety precautions should be set up and eye-catching marks should be set up.

7. Conclusion
The construction method is successfully used in the construction process. The construction quality is excellent, and the construction period is shortened. The construction project is highly appraised and approved by the construction unit. The results have broad application fields and broad prospects for popularization.

7.1. Social benefits
Bolt sphere grid construction quality, construction schedule, construction safety and other aspects have achieved very good results. The method solves the problems of high cost and high risk coefficient
caused by the traditional method, accelerates the construction period, and saves the resources. There is no safety accident in the construction process. The function of the building and the life safety of the students are fully guaranteed, and good social benefits have been achieved.

7.2. Economic benefits
Compared with the usual construction method, the construction method saves the cost and shortens the construction period. Compared with the past full scaffolding, the construction of T type scaffolding saves rental costs, reduces the time of scaffold construction and disassembly, saves the cost and reduces the construction period. In the construction process, large lifting equipment is not used, and small lifting equipment is used to transport small units assembled on the ground. Small lifting equipment has been fully utilized, saving the cost of leasing large hoisting equipment.

7.3. Environmental benefits
The lifting equipment used in this method is small lifting equipment with low noise and low energy consumption. The amount of sand, stone and ash is greatly reduced in the construction of steel structure. Compared with the welded ball grid, the installation of the bolt sphere grid is simple and convenient, the construction speed is fast, the on-site welding can be reduced, the pollution to the surrounding environment is reduced, and the energy conservation and emission reduction and green construction are realized.

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