

Research on the Application and Status of Tall Formwork Support in Construction

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Abstract

Tall formwork support, a temporary facility used to support the formwork structure in construction projects, is commonly used in high-rise buildings, large-scale factories and other projects. It has the characteristics of large bearing capacity, good stability, high construction efficiency, and is an indispensable and important equipment in modern building construction. This paper introduces the background and significance of the research on tall formwork stent, analyzes the commonly used stents and the causes of safety accidents occurring in construction applications and the methods to be taken, and summarizes the current research status of the elevated system at home and abroad, which provides a reliable theoretical basis for the development of future highly supported formwork.

Keywords

Tall Formwork Support; Construction; Application; Condition Exploration.

1. Introduction

With the increasing demand for architectural aesthetics and functionality in modern society, tall formwork is increasingly widely used in the construction industry. These tall formwork not only provide architects with more design space, but also bring higher construction efficiency and quality requirements for construction units. However, the design, construction and management of tall formwork face many challenges, such as structural stability, construction safety, cost control and other issues. Therefore, it is of great significance to explore the construction application and condition of tall formwork supports, which can prevent major safety accidents and promote the better development of the construction industry.

2. Background and Significance of the Study

With the acceleration of global urbanization, urban land resources are becoming increasingly tense, and high-rise buildings have become an important way to solve the problem of population living and working space. As the core support structure of high-rise buildings, the innovation of its design and construction technology directly affects the development of the construction industry. And modern buildings should not only meet the basic residential and office needs, but also pursue higher aesthetic value and functionality. The research and application of tall formwork enables architects to realize more complex and innovative architectural designs to meet diversified architectural functional requirements. Therefore, tall formwork steel pipe support frame body (referred to as high support mold) is often used in building construction.

On the one hand, in high-rise residential construction, the tall formwork can effectively improve the construction efficiency and quality, and ensure the safety and stability of the building. In office buildings and factories and other projects, the flexibility and diversity of the tall formwork makes it able to adapt to a variety of complex building forms and structural requirements. For example, a large-

scale commercial complex project adopts the tall formwork system, which realizes the fast and efficient construction, and at the same time ensures the quality and safety of the building.

However, on the other hand, there have been some problems and challenges in the technical application of tall formwork, such as insufficient rigidity of the bracing system, unreliable connections, and large deflection of the bracing beams. The existence of these problems will have an impact on the construction safety of the project and the structural stability of the support, and in recent years, there have been constant casualties caused by the collapse of the support, which are vivid in our minds, see Table.1.

Table 1. Typical cases of collapses of highly supported molds

serial number	timing	Project location	Causes of accidents and casualties
1	August 2018	Shandong Dezhou City, a neighborhood underground garage project	Formwork support frame collapsed, killing six people and injuring two others
2	January 2019	A construction site in Putian City, Fujian Province	Seven people were killed and five were injured when a support frame slipped.
3	January 2020	A tourism development project in Jiangxia District, Wuhan	Six people were killed and five injured when the support frame collapsed on a large scale
4	September 2022	A project in Juxian, Shandong Province	Structural defects in scaffolding erection, substandard quality, excessive loads, 5 deaths and 2 injuries
5	November 2023	A construction project of Shanxi Yongxin Tonghai Railway Co.	Insufficient load bearing capacity and stability of the mold support system, 7 fatalities

3. Construction Applications

Safety accidents in the construction application of formwork support systems have become a matter of extreme concern in the construction industry in recent years. According to some literature reports, 72% of the 85 engineering collapse accidents in the United States in the past 23 years originated from the concrete pouring period, and more than 50% were due to construction design errors. In China, even 5,198 construction casualties occurred in the past 5 years from 2003 to 2007, of which the collapse accidents accounted for 16% [1]. The collapse accidents accounted for. Therefore, it is of great significance to do a good job of safety management of formwork support system in construction application to ensure the construction safety, to improve the safety level of the project and to prevent the occurrence of major accidents.

3.1 Common Scaffolding

The main role of scaffolding in construction is to provide a safe and stable working platform for the construction workers, and it is also a temporary storage place for construction materials and construction equipment. Different types of scaffolding and formwork supports are used for different types of projects. Common types of scaffolding include fastened steel pipe scaffolding, bowl fastened steel pipe scaffolding, portal steel pipe scaffolding, etc., and their advantages and disadvantages, see [Table 2](#).

Table 2. Advantages and disadvantages analysis of common scaffolding

typology	vantage	drawbacks
Fastener type steel pipe scaffolding	Flexible erection, suitable for various irregular structures; standardization of components for easy transportation and management	Inefficient erection and dismantling, requiring specialized personnel; easy to loosen, requiring regular inspection and maintenance
Bowl-button steel pipe scaffolding	High strength and good stability of node connection; fast erection speed and high working efficiency	Higher costs, more varied components, more difficult to manage
Portal type steel pipe scaffolding	Good stress performance, high stability; easy and fast erection, suitable for large area construction	Limited applicability, mainly suitable for frame structure construction; high requirements for the ground, need to be hardened

3.2 Analysis of the Reasons for the Collapse of the Tall Formwork Support System

3.2.1 Substandard Raw Materials

Failure to use the specification of scaffolding steel pipe according to the code requirements, so that the cross-sectional area and resistance moment of the steel pipe is greatly reduced, resulting in the scaffolding of the actual bearing capacity is insufficient and the overall damage occurs. The thin wall thickness of steel pipe will lead to the reduction of its axial pressure, and the bending deformation of steel pipe will also reduce its bearing capacity. Quality defects such as small thickness of pallets and insufficient height of connection welds affect the effective transmission of loads. Low qualification rate of fasteners, such as cracked fastener cover or slipped wire rod, will greatly reduce the anti-slip bearing capacity of fasteners.

3.2.2 Failure of the Design Parameters for Erection of the Frame

Vertical scissor braces have a great impact on the stability of the vertical rod bearing capacity, set up scissor braces than not set up the critical load increased by 26% to 64%, can increase the rigidity of the frame, improve the scaffolding bearing capacity. However, the construction site scissor support rod lengthening, scissor support and vertical rod or horizontal rod connection fasteners set does not meet the requirements, so that the scissor support role can not give full play to the scaffolding will also affect the overall stability [2]. The overall stability of the scaffold will also be affected. The influence of the height of the frame, the increase of the height of the frame may cause the stability of the template bracket to reduce, and the reasonable scissor brace arrangement can effectively improve the stability of the template bracket bearing capacity. When the vertical rod extends the top length and the height of sweeping rod increases, the stable bearing capacity of the formwork bracket will show a decreasing trend on the whole. There are also horizontal rod step distance and vertical rod spacing will decide the overall structure and layout of formwork support. Therefore, the construction factors have a significant impact on the stable bearing capacity of the formwork support, and need to be considered comprehensively in the design and construction application.

3.3 Strengthen the Safety Management of High Formwork Construction

In the construction of tall formwork, the establishment of a sound production safety responsibility system and management system is the key to ensuring safety. Managers at all levels should clarify their own safety responsibilities and ensure that safety measures are effectively implemented. Operators should receive strict safety training, enhance safety awareness and skills, and establish a set of effective safety supervision system, timely detection and elimination of hidden dangers to ensure the safety of the construction process [3].

First of all, the construction safety risk analysis of tall formwork. The construction of tall formwork involves many links, and each link has potential safety risks. The stability of the support system, the standardization of material handling, and the operating skills of the operating personnel are all prone

to safety accidents. Among them, the instability of the support system is one of the main causes of the collapse of tall formwork. Unstandardized operation during material handling also easily leads to accidents such as object strikes. In addition, weak safety awareness and irregular operation of operators are also important sources of safety risks.

Secondly, a series of specific safety control measures are adopted. It is necessary to ensure the stability of foundation treatment to avoid accidents caused by unstable foundations. The stability and reliability of the support system should also be checked regularly, so that potential safety hazards can be detected and dealt with in a timely manner. In addition, training and guidance should be strengthened for operators to enhance their safety awareness and operational skills.

Once again, detailed emergency plans and accident handling procedures should be formulated as a means of coping with possible safety accidents. The plan should include the types of accidents, emergency response procedures, rescue measures and so on. At the same time, it should also establish an accident handling process to clarify the responsibilities and action steps of all parties after an accident occurs, so as to ensure that the accident is dealt with in a timely and effective manner.

Finally, regular supervision, inspection and evaluation. Check whether the design and construction program of the tall formwork complies with the relevant standards and regulations, whether the structure is reasonable, and whether it can meet the project requirements. The materials of the tall formwork entering the construction site are strictly inspected to ensure that their quality, specifications and performance meet the design requirements. It is also necessary to check the foundation, column spacing, horizontal step spacing, exposed fillet height, sweeping rod, horizontal tie rod, vertical tie rod, horizontal scissors, vertical scissor bracing, etc. of the bracket, to check whether the frame is intact and whether the formwork is firm, and to invite the relevant experts to the site to carry out the acceptance and to put forward the improvement opinions, so as to ensure the smooth implementation of the project. It is also necessary to carry out real-time monitoring of the construction process such as installation, reinforcement and removal of the template to ensure the construction quality and safety.

4. Status of Research

The design of the formwork support system is related to the frequency of safety accidents. The collapse of formwork support can bring large economic benefits to the society, and it can also cause casualties to a great extent. Therefore, both at home and abroad focus on the research of formwork construction support system.

4.1 The Current Status of Domestic Research on Supporting Frame for Highly Supported Molds

In terms of theoretical analysis, Zhang Dao and other scholars [4] analyzed the influence of four factors, namely, initial defects of stent riser, connection strength of steel pipe fasteners, settlement of foundation of stent system and lateral shift of stent system on stable bearing capacity of structure, and concluded that: the overall stable bearing capacity of stent decreases with the increase of initial defects of riser, and the bearing capacity decreases rapidly when the horizontal virtual load is greater than 1.5%Pu. With the increase of defects of riser, the form of destabilization of stent system is slowly transitioned to local destabilization from overall destabilization; the stable bearing capacity of stent increases with the increase of fastener stiffness, and the reasonable stiffness of fastener is 40-60k N N. With the increase of the defects of the vertical rod, the instability of the stent system is slowly transitioned to local instability; the stable bearing capacity of the stent increases with the increase of the stiffness of the fasteners, the reasonable stiffness of the fasteners is 40-60k N-m/rad; the bearing capacity of the stent decreases with the increase of the local settlement at the base, and the rate of decline is slow and then fast, and when the amount of settlement is greater than 0.02m, the bearing capacity decreases rapidly, the uneven settlement of the stent should be strictly controlled in the project to ensure that the settlement value is within the safe range; the bearing capacity of the stent is decreased rapidly when the horizontal virtual load is greater than 1.5%Pu. In the project, the uneven

settlement of the stent should be strictly controlled to ensure that the settlement value is within the safe range; the bearing capacity of the stent decreases with the increase of the side shift, and in the same side shift, the bearing capacity of the stent system caused by the X side shift decreases more than that of the stent system caused by the Y side shift.

In terms of practical application, China's application of high supporting mold is relatively early, as early as 1988, China's Ministry of Construction has begun to prepare for the application of template engineering in China's projects and coverage. 1994 "new template and scaffolding application technology" project was selected by the Ministry of Construction as the focus of the construction industry. After many years of steady economic development, China has greatly promoted the technological progress of the construction industry, ultra-high-rise and large-span buildings gradually increased, and the height and span increased year by year, in order to ensure the safe construction of these buildings, high supporting mold technology has become an essential key technology in construction technology [5]. In order to ensure the safe construction of these buildings, high supporting mold technology has become an essential key technology in construction technology.

4.2 The Current Situation of Foreign Research on the Supporting Frame of High Supporting Molds

Wang and Hasipriono [6] According to the analysis of the causes of 100 formwork collapse and overturning accidents in the world in the past 30 years, they found that most of the formwork collapses occurred in the process of pouring concrete, and divided the causes of formwork support system collapse and overturning into two causes, which are intrinsic and extrinsic causes, intrinsic causes refer to the theoretical design calculations and the existence of material defects in the construction process that can lead to the collapse and overturning of the formwork support system accident, and extrinsic causes refer to the external factors that can trigger the phenomenon of formwork construction system collapse and overturning. Intrinsic causes refer to the existence of flaws in the theoretical design calculations and materials used in the construction process that can lead to the collapse and overturning of the formwork construction system.

Y.L. Huang, T. Yen, W.F. Chen and other experts through the investigation and analysis of more than 20 construction enterprise projects concluded that different methods of reinforced concrete pouring have different impacts on the results of the role of formwork structural support systems [7]. The results of this study are summarized in the following table.

American researcher Pengetal [8] Using numerical analysis methods, the bearing capacity of supporting mold frame under different loads applied is analyzed, and it is proposed that the change of loads in the actual process has an effect on the stability of the frame.

5. Conclusion

Tall formwork support plays an important role in modern building construction. Through in-depth understanding of its construction application of technology, causes of accidents and the establishment of a sound safety management system, to explore the current situation of domestic and foreign high supporting mold supporting frame aspects, in order to better promote the development of high formwork support technology and application level, and to make greater contributions to the sustainable development of the construction industry.

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