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Research Article

Deformation, Bearing Capacity, and Reliability of Building Formwork System Based on Real-Time Monitoring

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The deformation performance of aluminum alloy formwork under stress is investigated in this research using static tests. The entire model of aluminum alloy formwork under load during construction is investigated using finite element simulation. And then, there's the project's actual value. The function is established during the construction period under the limit state of typical use of the wall in terms of reliability. The fluctuation characteristics of the dependability index of the out-of-plane deformation of the concrete wall are explored, and various results are produced, by taking into account the various reinforcement variables of the aluminum formwork. The study discovered that when the number of uses increases during the turnover usage process, the bearing capacity of the building formwork support gradually decreases, and the associated reliability index falls below 2. Adding horizontal and vertical rods above 3.6 m to the single support system, in combination with other elements, is recommended to strengthen its stability. The results reveal that joint semirigidity and wall thickness have a significant influence on the ultimate bearing capacity of construction formwork. The change characteristics of building formwork ultimate bearing capacity in the process of repeated turnover use are studied by increasing the initial defect method to simulate the increase of building formwork turnover times, with the conclusion that the more repeated use times, the lower the building formwork ultimate bearing capacity.

1. Introduction

The foundation of every architectural design is the building's safety. As a result, in order to verify building safety, the related parameters must be collected prior to construction in order to comprehend the rationality of building connections and to identify the construction process and buildability [1]. The formwork system, support system, and early demolition technology are the three basic components of the building formwork system. Basic building structures such as walls, columns, and beams, as well as some corner connections, etc., are included in the formwork composition. These are the fundamental guarantee structures for controlling the quality of concrete formwork. A single-structure support system and a full-house support system are the two types of support systems. Both support structures serve to increase the construction's safety factor, with single-structure support being the more prevalent application. To provide height control, the structural model is a structure in which the plug is put into the connector in one direction [2].

Generally speaking, the deformation of the building formwork refers to the deformation of the formwork system. When studying the state of the deformed structure, the load type and strength can be calculated first, the degree of deformation can be analyzed, and the relevant experiments can be used for research and analysis, and then, the static change analysis can be carried out according to the actual situation. To determine the load, a load diagram needs to be made, the integral part of the load is displayed graphically to reflect the analytical force, the load size is calculated, the reasonable value is calculated after checking, and then, the bar graph is used to reasonably represent it. Finally, the static load limit is analyzed according to the bar graph. Whether the value meets the requirements is usually determined according to the building load limit specification and static limit specification [3].

There are several specific requirements that must be met when performing static analysis. To begin with, it is not essential to consider the decrease of the error stiffness when computing the local static load of the component; instead, the primary load is immediately distributed to the three main ribs to reduce the difficulty of the analysis. The static restrictions of the floors at the hinges must be considered during analysis and load calculations. The resulting static load data are represented by three-dimensional graphics [4] that identify the type of formwork, the division of formwork connections, and so on, in accordance with these specifications. There are two different types of drawing techniques. The majority of them are flat geometric composite diagrams, with the other being the use of load distribution grids for drawing, which allows for direct observation of load changes [5]. It is also possible to determine the load limit point. The major bearing capacity mechanism of the aluminum formwork system is the support system. The support system employs its one-of-a-kind stress and compression analysis framework, which frequently results in eccentric bending moment variations. The load limit is exceeded when the bending moment reaches a particular magnitude. There is deformation or irreversible damage [6]. As a result, it is required to review the bearing capacity test prior to the test to see whether it fits the bearing criteria. The purpose of the research on the formwork system's reliability is to manage the formwork system's application feasibility rate in order to assure the safety of engineering structures [7]. And, because the main erosion during the operation of the formwork system is load erosion, and more than half of the structures in the formwork system are required to support the load, the reliability research at this time is truly an analysis of the formwork bearing capacity limit's safety performance. The bearing capacity reliability evaluation is the criterion for judging the calculation's establishment, and it is also a crucial step in determining the building's overall reliability. As a result, the reliability assessment should be based on the previous verification results. To decide the research results, reasonable analysis, and calculation, the comparison of specification parameters and indicators is required [8].

This paper's unique feature: the static test of the aluminum alloy formwork under focused load is used to investigate the deformation performance of the aluminum alloy formwork under stress. To establish the deformation analysis model of the building formwork, a finite element simulation of the test process is used. The system reliability evaluation procedure of the bearing capacity of the building formwork is presented on the basis of assessing the structural properties of the building formwork and their influence on the reliability of the system. Changes in design parameters have an impact on system reliability.

The following is the breakdown of the article's structure: the first section introduces related building formwork research, the second section introduces various algorithms for analyzing the reliability index of building formwork, the third section is based on building formwork experimentation and wall deformation and bearing capacity analysis, and the fourth section is a summary of the full text.

2. Related Work

This paper describes the new building formwork system's type, composition, construction method, benefits, and drawbacks. It is thought that increasing the number of times aluminum alloy formwork is turned is the key to achieving supremacy. It also looks into how to improve aluminum alloy formwork from the standpoints of research and development, design, and project management, and the number of times the template has been used. The formwork systems used in house construction are currently divided into three categories based on materials: wood formwork (including wood plastic and wood glue formwork), steel formwork (including profile steel combination and steel frame formwork), and aluminum alloy formwork, with a small amount of plastic template.

Riza describes the successful application of aluminum formwork in the Shenton Way super high rise in Singapore, including the structural design and construction method of the aluminum formwork [9]. The equivalent treatment is to act horizontally in the middle of the column, and the magnitude of the force depends on the situation [10]. Sakuma studied the collapse of construction scaffolding. Studies have shown that there are two main failure modes of scaffolding: one is the instability of the weak side of the scaffold as a whole, and the other is the failure of the scaffolding and wall connectors [11]. Shan et al. obtained the stable bearing capacity of the support system under this assumption by making semirigid assumptions on the connection nodes of the scaffold and through finite element analysis. Under the assumption of this semirigid connection node, the computational model is closer to the actual situation, and the analysis results are more realistic [12]. Rusenova et al. conducted a full-scale test study on several groups of portal scaffolds with different forms and also conducted buckling analysis and geometric nonlinear simulation analysis through finite-element ANSYS. The results show that the latter is closer to the actual results [13]. Liu et al. conducted a series of full-scale tests on the fastener-type steel pipe support. The test showed that the failure mode of the support was overall instability, and the arrangement of scissor braces could improve the bearing capacity of the support frame. In the calculation, the theory of the frame with side shift should be used, and the influence of the rotational stiffness of the joints should be considered [14]. Yang et al. conducted an experimental study on the fastener type tall formwork support under different working conditions and different erection parameters and summarized the influence of different erection parameters on the overall bearing capacity of the formwork support. Comparing the simulation and test results, it is pointed out that in the design and calculation of the tall formwork support system, only the introduction of defects can be consistent with the actual situation [15]. In Rui et al., the influencing factors of the bearing capacity of the full-chamber support were obtained through finite element analysis and experimental verification [16]. Xie et al. carried out the reliability analysis of the bearing capacity of the CFST members when the eccentricity is constant and variable, respectively. The results show that when the eccentric distance is constant, the reliability index meets the requirements of the specification; when the eccentric distance is variable, the reliability index is related to the correlation between the axial force and the bending moment. The higher the correlation, the greater the reliability index, but the reliability index has some values and does not meet the requirements in the specification [17]. Luo and Wang pointed out that the modular low-level jacking steel platform formwork has the advantages of fast jacking speed, good sealing, high bearing capacity, and high safety. At the same time, it is pointed out that the safety of the pylon system is ensured by two methods of coefficient safety and measure safety; in the load analysis and calculation, the maximum live load of 3.0 kN/m^2 is considered at the same time on each floor [18]. Li et al. pointed out the importance of stress monitoring in the construction process of the lifting formwork members with variable slightly convex fulcrum. According to the calculation results of the finite element software, the measuring points are arranged [19]. Zhou et al. carried out ANSYS modeling for a partially disassembled climbing formwork steel platform, focusing on the loading analysis of the machine with the largest span, and obtained the maximum stress and maximum displacement of the steel platform, which provided guidance for construction [20].

In this paper, the method of applying different equivalent horizontal forces at the nodes is used to simulate the size of the initial defect in the process of turning over the full house. The reliability of the bearing capacity limit state is studied, and the reliability index of the bearing capacity of the full support under different initial defects is obtained. It is believed that the more repeated use, the more the reliability index decreases.

3. Reliability Index Analysis of Building Formwork

3.1. Reliability Analysis Algorithm. The capacity of a structure to execute a predetermined function within the specified time and within the stated use environment is referred to as dependability. The possibility that a structure will fulfill a predetermined function within a specified time and under a specified operating environment is referred to as reliability. The latter is a probabilistic representation of the former. The limit state is separated into two categories: bearing capacity limit and regular service limit [21]. The aforementioned two limit states must be taken into account when designing a structure. The typical approach is to design according to the bearing capacity's limit state. The probability density function for a continuous random variable is given in the following equation:

$$f_z(z) = \frac{1}{\sqrt{2\pi\sigma_z}} \exp\left[\frac{(z-\mu_z)^2}{2\sigma_z^2}\right]. \quad (1)$$

The probability density function after converting (1) into a standard normal distribution variable is $\phi(y) = 1/\sqrt{2\pi}\exp(y^2/2)$. The distance of the obtained mean value can be measured by the standard deviation, as shown in the following formula:

$$P_f = \Phi(-\beta) + \frac{\mu_2}{\sigma_2}. \quad (2)$$

It can be seen from formula (2) that there is a one-to-one correspondence between β and P_f, as shown in Figure 1.

The above-mentioned method for calculating the reliability index is called the center point method. Since the center point is not on the limit state surface, for limit state equations with the same meaning but different forms, the center point method will give different solutions of reliability indicators. It is assumed that the components of the basic random variables of the structure function are independent of each other, the mean is $\mu_x = (\mu_1, \mu_2, \ldots, \mu_{xm})^T$, and the standard deviation is $\sigma_x = (\sigma_1, \sigma_2, \ldots, \sigma_{xm})^T$. The first-order Taylor expansion at the center point of the function is shown in the following equation:

$$Z_c = gx(\mu_x) + \sum_{i=1}^{n} \frac{\partial g_x(\mu_x)}{\sigma X_i}(X_i - \mu_{x1}). \quad (3)$$

In the space force of the random variable X, the equation $Z_S = 0$ is the tangent plane of the limit state surface obtained from the checkpoint x, and the mean and contrast of Z_x are given in the following equation:

$$\beta = \frac{g_x(x) + \sum_{i=1}^{n} \partial g_X(x)/\partial X_i(\mu_{Xi} - x_i)}{\sqrt{\sum_{i=1}^{n}[\partial g_X(x)/\partial X_i]^2 \sigma_{X_i}^2}}. \quad (4)$$

Rewrite the limit state equation $Z_s = 0$ corresponding to formula (4) with the standardized variable $Y_i = (X_i - \mu x_i)$ of X_i and obtain as shown in the following equation:

$$\alpha_{Xi} = -\frac{\sum_{i=1}^{n} \partial g_X(x)/\partial X_i \sigma_{Xi}}{\sqrt{\sum_{i=1}^{n}[\partial g_X(x)/\partial X_i]^2 \sigma_{X_i}^2}} \cos\theta_{Y_i}. \quad (5)$$

And formula (5) satisfies the condition of the following formula:

$$\sum_{i=1}^{n} \cos\theta_{Yi} Y_i = 0. \quad (6)$$

It can be better applied when the random variables are all normally distributed. When using the checkpoint method, if the basic variable X contains nonnormal random variables, then these nonnormal random variables need to be dealt with accordingly. The iterative method is more effective and more versatile. The value of the probability density function at the checkpoint is equal before and after the equivalent normalization. When performing equivalent normalization, two

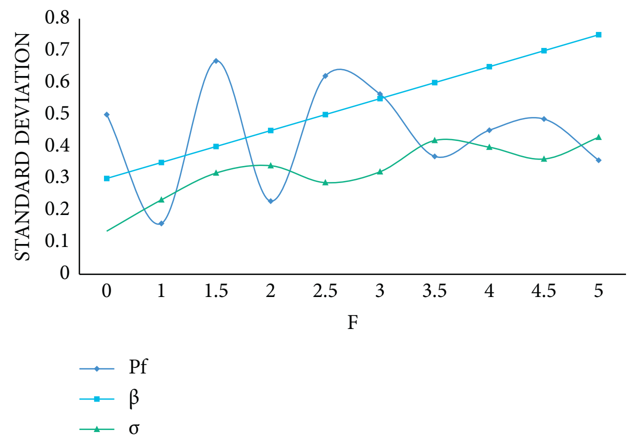

Figure 1: Correspondence.

conditions should be satisfied: first, the value of the probability distribution function at the checkpoint is equal before and after the equivalent normalization; second, the value of the probability density function at the checkpoint is equal before and after the equivalent normalization. Assuming that X_i in the random variable space X is a nonnormal random variable, the probability density function $f_{xi}(x_i)$ of μ_{xi} and σ_{xi} is known, and the cumulative probability distribution function is $F_{X_i}(x_i)$ According to the above conditions,

$$F_{Xi} = \frac{1}{f_{x_i}}\phi\left(\frac{x_i - \mu_{xi}}{\sigma_{Xi}}\right). \tag{7}$$

It can be seen from the above that the mean of the overall F_{Xi} is the $\alpha/2$ quantile of the standard normal distribution of the absolute error confidence interval length of the P_f simulation, and the relative error of the simulation can be obtained from the previous article as given in the following equation:

$$\mu_\alpha V_{\widehat{P}f} \geq \frac{\Delta}{P_f}. \tag{8}$$

Assuming that the significance level α is a given value, the upper quantile μ_α of the standard normal distribution is also a given value. The chance of sample values in the reliable domain increases, and the chance of falling into the invalid domain decreases. Further, the simulation error can be reduced and the simulation accuracy can be improved, and the corresponding number of sampling simulations will be reduced. The process implemented in the algorithm is shown in Figure 2.

3.2. Reliability Index. Static load deformation test research and numerical simulation analysis of veneer; finite element simulation research on the overall deformation of the formwork system; reliability analysis and influencing factor analysis of the normal usage limit state of concrete walls. Architectural research on formwork support systems, including bearing capacity of single-column steel pipes with variable cross sections; static analysis of the overall model of single-branch building formwork systems and research on the scope of application of working heights; research on support bearing capacity and analysis of influencing factors; and research on support bearing capacity and analysis of influencing factors. The load-carrying capacity of the whole-chamber support frame with increased defects is considered. A schematic diagram of the target reliability index is shown in Table 1, according to the logarithmic or Weibull distribution of resistance, the normal distribution of permanent action, and the extreme value I-type distribution of variable action.

4. Deformation and Reliability Analysis of Building Formwork and Wall Surface

4.1. Formwork Deformation Load Experiment and Finite Element Analysis. When the verticality and flatness of the molded wall cannot meet the quality requirements, the general practice of the actual project is as follows: when a few sampling points cannot meet the requirements, plastering is carried out; when the surface is seriously uneven and affects the appearance, it needs to be repaired or reworked; and when the verticality deviation seriously affects the bearing capacity and stability of the wall column, it is necessary to scrap and rebuild. As a new form of formwork, building formwork does not need plastering and chiseling, and the concrete forming effect is good at one time, which can achieve the effect of facing fair-faced concrete. In the actual project, due to the mistakes of the designers and the improper operation of the on-site construction personnel, the quality of the formwork assembly is uneven, and the lengths of the steel bars such as pull screws and back bars are different, which will affect the quality of concrete pouring and increase the project cost. Under the load during the construction period, the deformation control of the straight wall belongs to the control range of the normal service limit state, that is, the deformation determines the construction quality. In this paper, the static load test method is used to simulate the deformation characteristics of the main rib of the aluminum alloy formwork under the lateral concrete pressure load, and the finite element simulation is carried out. Research on the overall deformation performance of

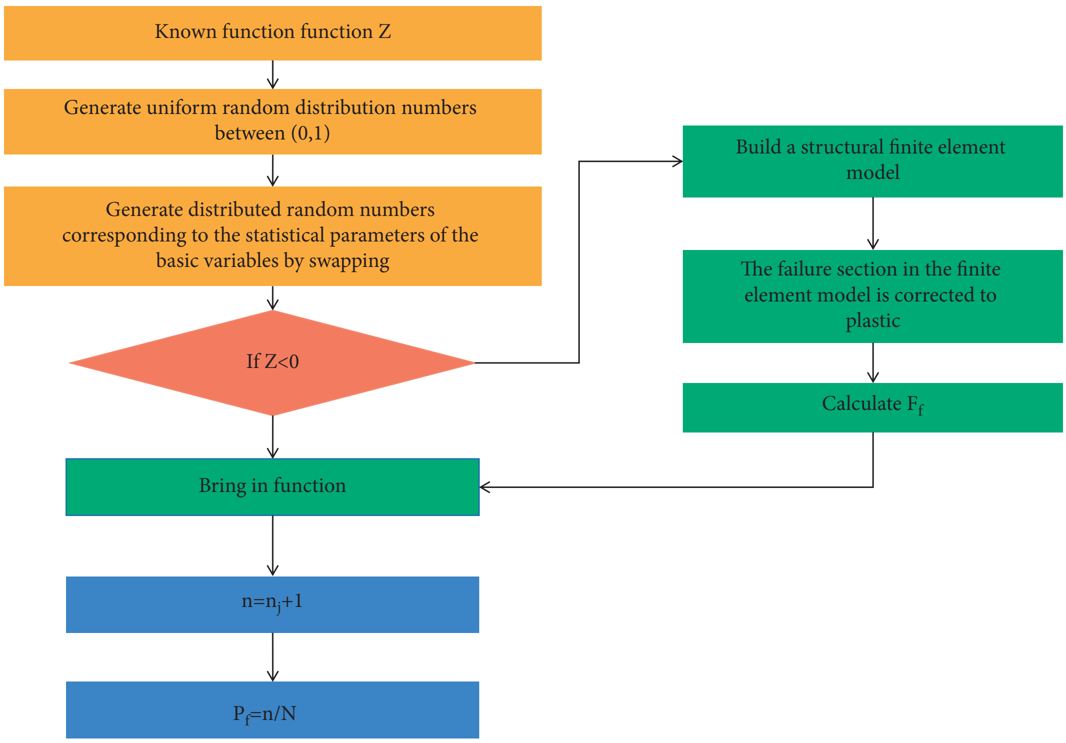

Figure 2: Algorithm implementation process.

Table 1: Minimum value of reliability index of bearing capacity limit state.

Limit state	Reliability level	1a base period	50a base period
Carrying capacity	RC3	5.2	4.3
Limit state	RC2	4.7	3.8
Limit state	RC1	4.2	3.3
Fatigue limit state			1.5–3.8
Use limit state (irreversible)		2.9	1.5

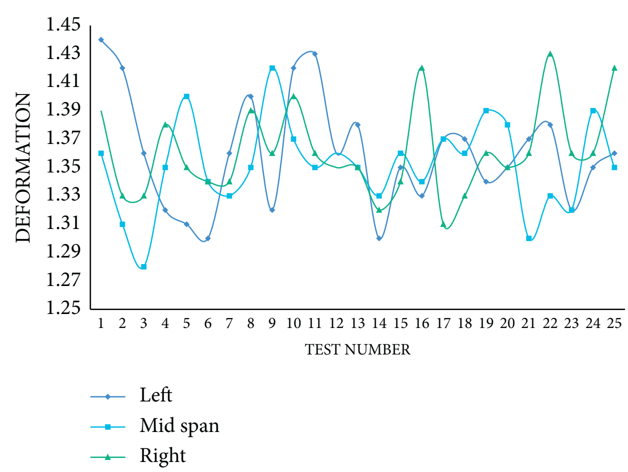

Figure 3: Mean deformation of main rib of formwork under load.

building formwork under construction load: study the reliability of the normal limit state of concrete pouring quality during the construction of building formwork and analyze its influencing factors.

Referring to the requirements of the load test, several sets of static load tests were carried out on the Guangya P400 aluminum alloy formwork in this paper, and the formwork was loaded by means of concentrated load. The deformed heavy loads of the formwork under the action of loads at all levels are as follows: two large weights of 500 kg, ten small weights of 20 kg, and several packages of pins. The experimental results are shown in Figure 3 and Table 2.

Figure 3 shows that fixed connections are used to simulate the actual welding connection between the main rib and the stiffener, as well as between the panel and the stiffener; the strength and stiffness of the base metal at the local welding part will be reduced, and the adverse effects of the welding process will not be considered in the simulation. And the load is concentrated and equally distributed across the three major ribs; the connection between the left rib and the support is set as a three-way hinge, while the connection between the right rib and the support is set as a two-way hinge, relieving the plate vertical constraint. The building formwork is always in the elastic working range under the load during the construction period, and the bearing capacity has a large surplus; the building formwork is in normal use under the load during the construction period, according to the comparative analysis of the load test and the finite element results.

4.2. Statistical Parameters of the Formwork Resistance When the Building Formwork Is Pouring the Wall. Under the action of the lateral pressure of the concrete during the

Table 2: Mean deformation of main rib of formwork under load.

Test number	1	2	3	4	5	6	7	8	9	10	11	12	13
Left	1.44	1.42	1.36	1.32	1.31	1.30	1.36	1.40	1.32	1.42	1.43	1.36	1.38
Mid span	1.36	1.31	1.28	1.35	1.40	1.34	1.33	1.35	1.42	1.37	1.35	1.36	1.35
Right	1.39	1.33	1.33	1.38	1.35	1.34	1.34	1.39	1.36	1.4	1.36	1.35	1.35
Test number	14	15	16	17	18	19	20	21	22	23	24	25	
Left	1.30	1.35	1.33	1.37	1.37	1.34	1.35	1.37	1.38	1.32	1.35	1.36	
Mid span	1.33	1.36	1.34	1.37	1.36	1.39	1.38	1.30	1.33	1.32	1.39	1.35	
Right	1.32	1.34	1.42	1.31	1.33	1.36	1.35	1.36	1.43	1.36	1.36	1.42	

construction period, when the aluminum alloy formwork is deformed, the tension screw and the back corrugation will also be deformed accordingly. From the installation of the formwork to the pouring of the concrete, the concrete solidifies to a certain design strength, and the deviation of the out-of-plane verticality of the wall consists of four parts: the vertical rib deformation of the formwork Δ1, the out-of-plane bending deformation of the back corrugation Δ2, the deviation of the tension screw axial elongation deformation Δ3, and panel bending deformation Δ4 as shown in Figure 4.

The lateral concrete pressure load on the formwork is related to many factors such as concrete material properties (including aggregate properties, water-cement ratio, and chemical admixtures), pouring speed and method, and the internal temperature of the concrete. The calculated lateral pressure distribution varies linearly within the effective head range. In this paper, the measured data of the pressure on the side of the mold base is obtained through experiments as shown in Figure 5.

The experimental conditions are as follows: the wall height is 3m, the pouring speed is 1~3 m/h, the temperature is 25°C, and the slump is 5~8 mm. It is fully proved that the lateral pressure of the formwork during the construction period approximately obeys the normal distribution. From the point of view of the reliability of the normal service limit state, the deformation performance of the building formwork system under the load during the construction period is studied. By analyzing different reinforcement factors, including the calculated length of the back corrugation, the distance between the tension screws, and the thickness of the wall, it is understood that when the deformation control index is constant, with the increase of the three groups of variables in the reinforcement scheme, the reliability has different degrees.

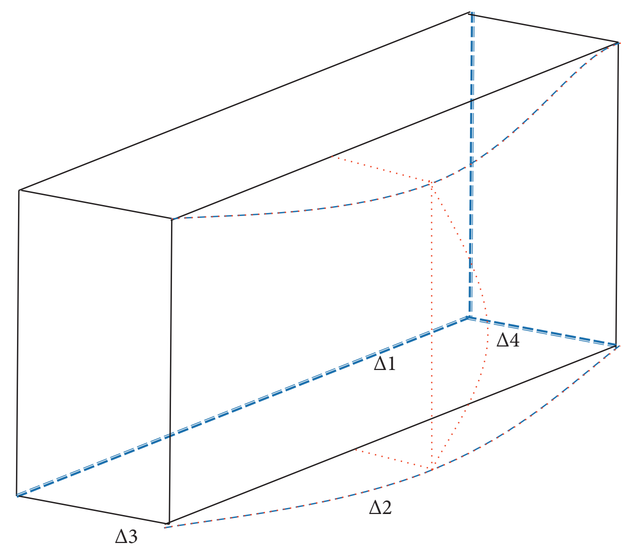

Figure 4: Schematic diagram of the deformation of the unit interval.

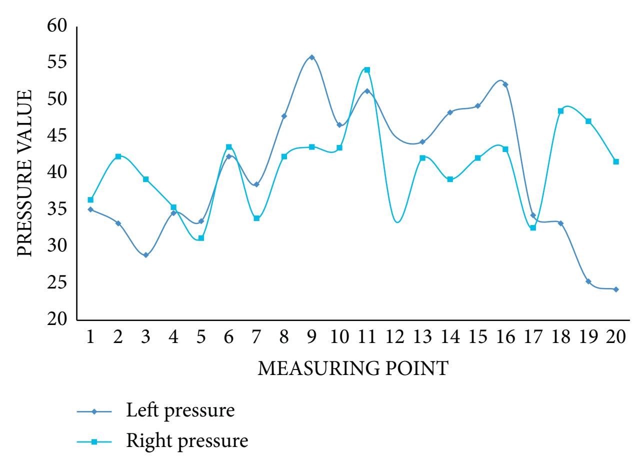

Figure 5: Pressure on the wall side of the mold base.

4.3. Finite-Element Static Analysis of Deformation of Building Formwork Support. The supports used for the building formwork system are mostly single support systems, with the support being thin at the bottom and thick at the top. For the compression structure, this eccentricity will generate additional bending moment, which has a great influence on the bearing capacity of the support and often plays a decisive role. The value of the eccentricity is the diameter of the bottom half of the steel pipe as shown in the following equation:

$$\frac{N}{\phi_x A}+\frac{\beta_x M_x}{W_{1x}\left(1-0.8N/N_{EX}\right)}\leq f. \quad (9)$$

It is unreasonable to consider the initial defect uniformly according to half the diameter of the steel pipe without distinguishing the eccentricity value at different heights. The reality is that the greater the height, the greater the eccentricity. In this paper, the overall model of the building formwork is used, considering the influence of initial defects on the bearing capacity of single support, and a set of sizes of 0.25 kN, 0.3 kN, 0.35 kN, 0.4 kN, 0.45 kN, and 0.5 kN is applied to the connection of the upper and lower pipes. The average stress value can reflect the general stress of a single support system under the load during the construction period. There are differences in the stress state. In order to discuss the stable bearing capacity of single support within a certain height range, increase the support heights of 2.4 m, 3.6 m, and 4.8 m to add equivalent horizontal force in the same way as shown in Figure 6.

It can be seen from Figure 6 that the stress levels of the corresponding supports in each model are different, which reflects that there are indeed differences in the working state of single support during the construction period; the initial defects have a particularly large impact on the support force, and in practice, the more the initial defects are, the higher the stress level of the support. Let the wall thickness and the vertical spacing of the pull screws be fixed values, that is, the wall thickness of 400 mm and the spacing of the pull screws of 800 mm, and the reliability values under the control of the verticality deformation index of each wall outside the plane are shown in Figure 7.

When the deformation index remains constant, the dependability index drops as the predicted length of the back corrugation increases as shown in Figure 7. The reliability index drops when the length rises by 100 mm, while the fixed calculation length remains unchanged. When the calculated length of back corrugation is 900 mm and the deformation index is controlled at 2.4 mm, the reliability index shows a gradual upward trend as the deformation index control changes from small to large; when the calculated length is 900 mm and the deformation index is controlled at 2.4 mm, the reliability index is related to the corresponding failure probability. The difference is the lowest, suggesting that the current circumstance does not satisfy the standards of the typical use limit state. Set the calculated length of the vertical spacing and back corrugation of the pull screw as a fixed value and change the wall thickness. Let the calculated length of the vertical spacing and the back corrugation of the pull screw are both 800 mm, and when the wall thickness is 200 mm, 300 mm, and 400 mm, the failure probability and reliability value under the control of the verticality deformation index of each wall are shown in Figure 8.

Referring to the above method, the reliability index trend chart is obtained as shown in Figure 8. It can be seen that when the wall thickness changes, most of the three curves overlap, indicating that the difference in wall thickness has limited influence on the reliability index. For every 100 mm increase, the reliability index decreases by about 0.1; when the wall thickness is 400 mm and the deformation index a is controlled at 1.8 mm, the reliability index is about 1.4 to meet the requirements of the normal use limit state.

The upper part is overlapped with the formwork, and the lower part is connected by friction with the concrete. There is no reliable connection between the support and the support. The stability of the support is provided by the outside, and it is an unstable structural form. Then, the ability of this single support system to resist the action of accidental factors is very weak. For example, if a support collapses due to some accidental factor in a local part of the construction period, the redistribution of the load and the local impact of the

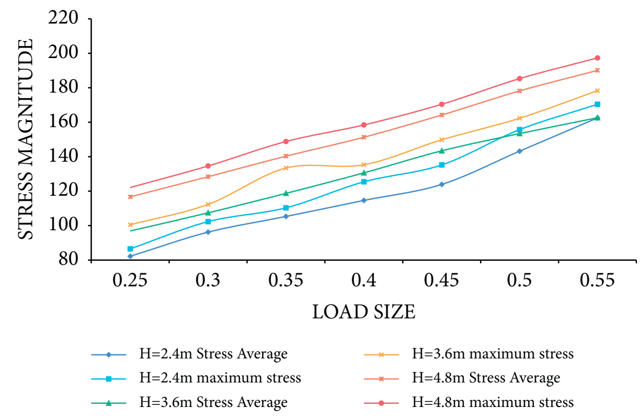

FIGURE 6: Average and maximum stress of single support under different heights and different equivalent horizontal loads.

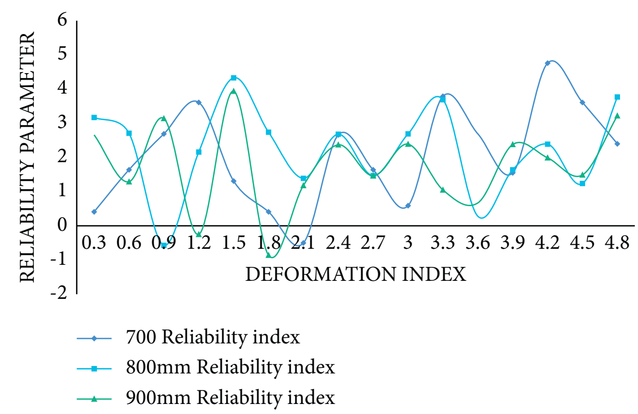

FIGURE 7: Influence of bending calculation length on reliability index.

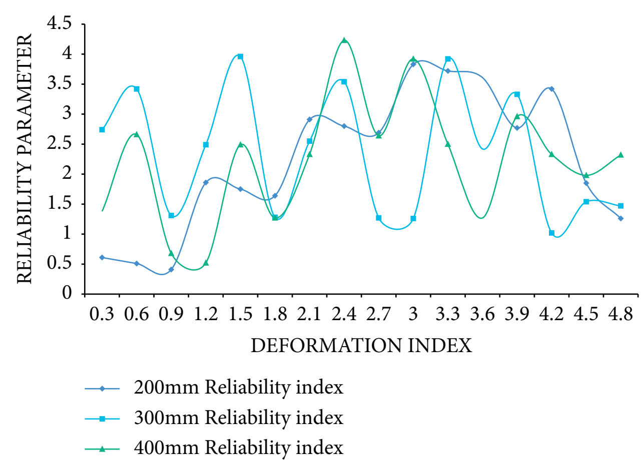

FIGURE 8: Influence of bending calculation length on reliability index.

collapse will have a greater adverse impact on the surrounding supports and even lead to formwork and supports. For the prevention of this potential threat, the single support system appears powerless. Especially as the height of the building increases, this defect will be magnified, bringing about consequences that are not conducive to the safety of building construction.

4.4. Modeling Analysis of the Bearing Capacity of Building Formwork. In the actual working state, the building formwork will have initial defects, including initial bending and initial eccentricity; the influence of geometric nonlinearity on the stability and bearing capacity of the actual structure needs to be considered during finite-element simulation; the main structure uses Q235 steel, and the nonlinearity of the material also needs to be considered. There are many factors that affect the bearing capacity of steel pipe scaffolding and support frames. In the existing research on the wheel buckle-type full-house support, the main focus is on erection parameters, such as vertical and horizontal distance, step distance, scissor support, sweeping pole, and vertical pole extension. Few studies have been devoted to the change in the bearing capacity of steel pipe scaffolding during turnaround use. However, in actual engineering, with the increase in the number of repeated use, due to the influence of the external construction environment, the joint stiffness will be reduced to varying degrees, the wall thickness caused by the corrosion of the steel pipe will be reduced, and the bearing capacity of the steel pipe support will gradually weaken. In actual engineering, whether it is a new building formwork or a building formwork that has been used many times, there are initial defects, including the initial bending and initial eccentricity of the structure, the eccentricity of the horizontal rod and the longitudinal rod connection, and some fabrication, processing, and installation. The initial defect grows larger as it is reused. The reasons are as follows: with the increase in the number of times of use, the wall thickness of the steel pipe corrodes, the stiffness of the joint connection will gradually decrease during the on-site assembly and disassembly process of workers, and the deviation of the verticality of the steel pipe itself due to the on-site operation will continue to accumulate with time.

In this paper, the increase of initial defects in the process of repeated use is considered by increasing the equivalent horizontal force so as to reflect the change in the bearing capacity of the wheel-type steel pipe support during the repeated use of turnover. The selected equivalent horizontal force is 0.5%, 1%, 1.5%, 2%, and 3% of the buckling load direction which is the first-order mode under each erection parameter and is uniformly applied to each node as shown in Figure 9.

It can be seen from Figure 9 that when the erection parameters of the building formwork are constant, as the initial defect becomes larger, the initial tangent slope of the displacement-load curve becomes smaller, indicating that the increase in the initial defect reduces the lateral

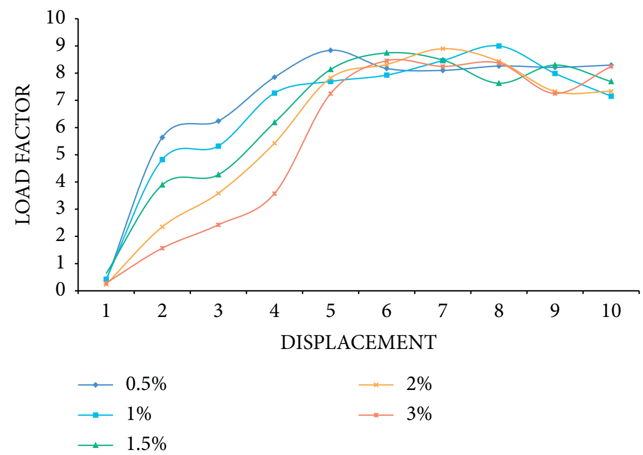

Figure 9: Load displacement diagram.

force stiffness of the structure. As the initial defect increases, the corresponding critical load factor decreases. It is assumed that when the equivalent horizontal force is 0.0%, the critical load factor of the structure is equal to the buckling load factor; when the equivalent horizontal force is infinite, the critical load of the structure tends to zero at this time. With the increase of initial defects, the curve shows an obvious downward trend; when the equivalent horizontal force increases from 0% to 1.5%, the downward slope of the curve is approximately the same and steeper, indicating that the lateral stiffness of the structure decreases rapidly at this time. When the effective horizontal force is between 1.5% and 2%, the curve is in the transition to a smooth change; after the equivalent horizontal force is 2%, the downward trend of the curve tends to be gentle.

The theoretical bearing capacity of a single-supported column with changing cross section is inferred in this chapter using a simplified mechanical model, and the eigenvalue formula for its bearing capacity is established by considering the influence of the initial eccentricity. The force formula was theoretically deduced, and MATLAB was used to calculate and compare the results before and after the limitations were enforced. The carrying capacity of the single support was considerably improved once the limitations were placed, according to the findings. The out-of-plane deformation of the building formwork is the key influencing element under load throughout the construction period, according to the experiment and numerical simulation of the formwork. This relates to the limit state control of normal use. The reinforcement variables of the formwork, including the calculated length of the back corrugation, the spacing of the pull screw, the wall thickness, and the deformation control index, are analyzed for reliability using the reliability theory by establishing the function of the deformation index of the wall during the construction period. The semirigid size of the node will reduce to variable degrees as the number of times it is used grows. The bearing capacity of building formwork support will steadily diminish as the number of uses grows during the turnaround process, and the related dependability index will drop below 2. This study advises that while writing specifications, take into account the differences between old and new steel pipe supports or scaffolding and reduce the bearing capacity of the used steel pipe supports to some extent.

5. Conclusions

The semirigidity of the full-house support node decreases to varied degrees as the number of uses increases, according to the experimental study. The bearing capacity of the full-body support is heavily influenced by the steel pipe wall thickness and the rotational stiffness of the joints. When the full equivalent initial defect is considered, the stress ratio level reaches above 0.8 when the story height is 3.6 m. This is due to the increase of unfavorable factors such as corrosion of the steel pipe, reduction of the rotational stiffness of the joint, and increase of the initial eccentricity of the vertical rod. Due to the limited ability of single support to withstand abrupt forces, the formwork system should be chosen in practical engineering based on the size of the floor height. The erected formwork supports are mixed with human factors due to factors such as the on-site construction management system and the quality and level of the construction staff; thus, the influence of human factors on the reliability of the formwork supports is also of considerable importance. The natural conditions of the construction site, the manufacturing standards of material manufacturers, the technical level of construction employees, and the construction management system all varied significantly. The statistical parameters and distribution types of various random variables, such as step distance, horizontal distance, vertical distance, length of the sweeping rod, and others, have a significant impact on the dependability of the formwork support when calculating its reliability. The target reliability index is used to assess the building formwork's capacity to perform the planned function. It is an important parameter in the building formwork's probability limit state design. It has to do with the project's permitted failure probability. The type of damage and its financial impact differ. The calculation of the goal reliability index is a difficult statistical task. Currently, there is a scarcity of study and analysis on the reliability of constructing formwork.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors do not have any possible conflicts of interest.

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