Research on Structural Optimization of Reinforced Concrete Frame Based on Parallel Cloud Computing

Qian-sha Li(✉) and Qian He

School of Civil Engineering and Hydraulic Engineering,
Xichang University, Xichang 615000, China
LIqiansha335@163.com

Abstract. In order to solve the problems of excessive wear and poor bearing capacity of reinforced concrete frame, the optimization of reinforced concrete frame structure is studied with cloud computing method. The bearing capacity and related parameters of reinforced concrete structure are calculated by cloud computing method, and the support degree and potential structural wear displacement range of reinforced concrete frame structure are obtained. According to the calculation results, load parameters of building concrete structure are regulated and adjusted. The reinforced concrete frame with X-type braces is strengthened by combining with the standard parameters, and the reinforced concrete frame connection is established. The orthogonal intersection model of the bearing capacity of the structure can effectively complete the optimization study of the reinforced concrete frame structure. Finally, the experiment proves that the research of RC frame structure optimization based on parallel cloud computing has better bearing capacity and anti-wear performance than the traditional RC frame structure, and fully meets the research objectives.

Keywords: Parallel cloud computing · Reinforced concrete · Frame structure

1 Introduction

With the increasing prosperity and development of the construction industry, reinforced concrete frame structures are widely used in the construction industry because of their high bearing capacity and good ductility. But at present, there are relatively few studies on Optimization of prefabricated assembly structure of steel reinforced concrete frame joints splicing form, which is difficult to fully meet the building requirements. Therefore, based on cloud computing method, the reinforced concrete frame structure is optimized, and the stability of the frame structure is improved by adding prefabricated joints to the reinforced concrete frame [1]. By optimizing the joint combination in reinforced concrete frame, the ductility and bearing capacity degradation of the structure frame are avoided. Finally, the experiment proves that the method is more effective and scientific than the traditional method.

S. Liu and L. Xia (Eds.): ADHIP 2020, LNICST 347, pp. 508–517, 2021.
https://doi.org/10.1007/978-3-030-67871-5_45

2 Method

2.1 Calculation of Bearing Capacity of Reinforced Concrete Structures

In order to effectively achieve the goal of optimizing the structure of reinforced concrete miners, it is necessary to calculate the bearing capacity of concrete at first. Whether the reinforced concrete structure and the reinforcement part can be successfully fused becomes an important part of the overall structural optimization, and the effectiveness of this part depends on the bearing capacity of the joint at the joint site [2]. In the construction process, the bearing capacity of concrete joint is usually low, so it is easy to reduce the bearing capacity of the structure in the process of structural optimization. In order to solve the above problems and better complete the optimization design of reinforced concrete frame structures, it is necessary to fully consider the stress factors and characteristics of buildings, so as to establish a more standard load standard for reinforced concrete structures [3]. Secondary combination and optimization design of reinforced concrete structural parameters of complex network buildings are carried out, and the performance parameters of reinforced concrete materials in building structures are accurately estimated and recorded. The results are shown in Table 1.

Table 1. Bearing capacity of reinforced concrete materials

Type	Level	Yield strength/MPa	Ultimate strength/MPa	Modulus of elasticity/GPa
12 mm Steel skeleton	Q235b	270	430	620
20 mm Steel skeleton	Q235b	275	43.5	625
Longitudinal bars of beams and columns with diameter of 18 mm	HRB335	280	440	630
Longitudinal bars of beams and columns with diameter of 22 mm	HRB335	285	445	635
Beam and column stirrups with diameter of 18 mm	HRB325	290	450	640
Beam-column stirrups with diameter of 22 mm	HRB325	295	455	645

As shown in the table above, in order to avoid the torsion of reinforced concrete in the construction process and subsequent use, HRB buckling-resistant brace reinforcement frame is set up to ensure the stability of the structure in the process of optimization of reinforced concrete structure [4]. The parameters of HRB buckling-resistant brace structure are calculated. Due to the problems of over-limit axial compression ratio in reinforced concrete frame structures of complex buildings, it is necessary to increase the section of frame columns in order to improve their load capacity in the process of rebuilding complex network buildings [5]. The influence factor of

HRB buckling-proof frame structure stability is introduced into parallel cloud computing to calculate the structural support. The algorithm is as follows:

$$S_0 = \frac{1 + 4e_{\mathrm{n}}^2}{(1 - \frac{\beta^2}{R_n^2})^2} \tag{1}$$

In the formula: β is the spectrum parameter reflecting the load characteristics of steel bars, R is the strength parameter of building structures, the strength range of reinforced concrete structures is n and in the range of [0,1], e represents the damping frequency of the structural characteristics of the surface soil layer of building structures, A is the stationary parameter of building structures, then:

$$A = \sqrt{\frac{2}{\beta R_0^2}} \exp(-\frac{\beta^2 + e^2}{R_0^2}) \tag{2}$$

In the application of reinforced concrete frame in construction, the displacement of its structural angle is prone to occur, and it is difficult to ensure the stability and accuracy of the structural system and load capacity [6]. Therefore, combined with parallel cloud computing method, the minimum deflection angle of reinforced concrete lateral component is calculated and strengthened. By restraining the structure frame, the stress degree of the structure frame is weakened, and the problems of displacement and angle deflection are avoided [7]. The least square method is used to fit the minimum deflection angle, and the algorithm of building reinforced concrete anti-variable function is obtained as follows:

$$S(\varpi) = \frac{A + 4\lambda_i^2 \alpha^2 / \alpha_i^2}{(A - \alpha^2/\alpha_i^2) + \lambda_n^2 \alpha^2 / \alpha_i^2} S_0 \tag{3}$$

In the formula, α_n and α_m are the maximum and minimum load-bearing damage coefficients in the random process, and λ is the responsiveness. Based on the above formulas and the static elastic-plastic principle, the anti-destructive capacity under buildings is deduced and calculated [8]. In general, if there are m nodes in the structure, the load-carrying capacity of the structural nodes is divided into n categories by parallel cloud computing method, then the classification matrix of the structural load-carrying capacity can be obtained by combining the numerical model theory as follows.

$$W = \begin{bmatrix} w_{11}, w_{12}, \ldots, w_n \\ w_{21}, w_{22}, \ldots, w_{2n} \\ w_{21}, w_{22}, \ldots, w_{2n} \\ \cdots \quad \cdots \quad \cdots \\ w_{m1}, w_{m2}, \ldots, w_{mn} \end{bmatrix} \tag{4}$$

Among them,

$$0 \leq w_{mn} \leq 1 \quad (n = 1, 2, 3\ldots., m = 1, 2, 3\ldots)$$

According to the above requirements, the initial classification matrix is designed. In the matrix, a is the next column of molecules, so the initial classification matrix is generated. If M = 1, the concrete bearing capacity formula of parallel cloud computing is as follows:

$$\xi = \sum_{n=1}^{a} S(\varpi)*\left(\frac{\|a_n - \beta_n\|}{\|a_i - \beta_i\|}\right)^2 * \log A \frac{a_i}{\sum_{i=1}^{n} W} \tag{5}$$

Through the above algorithm, the bearing capacity of reinforced concrete structures in buildings can be accurately obtained, so that the parameters of frame structures can be standardized according to the bearing capacity, so as to achieve the goal of structural optimization.

2.2 Reinforcement of Reinforced Concrete Frames

In order to solve the problem of serious damage of reinforced concrete frame in the construction process, it is necessary to reinforce the reinforced concrete frame structure. Firstly, the standard load capacity of reinforced concrete frame in our country's current buildings is analyzed by using the previous algorithm, and the relevant planning processing is carried out. The normative data of the damage resistance parameters of the building concrete structure are obtained as follows (Table 2):

Table 2. Specification for damage resistance parameters of building concrete structures

Serial number	Load category	Resistance loss parameter	Serial number	Resistance loss parameter	standard value
1	A steel bar	30 KG/m^2	6	Weight of reinforcing bar per meter	0.00617*d*d
3	Concrete	2500 KG/m^3	8	Reinforced concrete weight	2200 KG/m^3
4	Exterior wall	2.0	9	Conversion thickness	550 px
5	Interior wall	2.5	10	SPECT	5.0

In order to control the yield section of reinforced concrete accurately in the support section, it is necessary to make sure that any part other than the support section is in the elastic range. Because the connection of the reinforced frame with HRB buckling-resistant brace can be processed by the method of embedded parts, combined with the data in the table above and the previous algorithm, the standard dimensions of the connection plate and the additional reinforced frame in the reinforced concrete frame can be obtained by calculation. In order to ensure the stability of the frame structure, the composite wall of the complex network building model has its unique characteristics, and according to the building added. Solid Estimation Model is used to analyze the stress process and characteristics of buildings in the environment [9, 10]. Distribution beams are loaded on the building by jacks, and hidden beams are loaded on the top after secondary distribution of complex network buildings. Support is set on both sides of the building wall to ensure the stability of the building wall plane [11, 12]. The reinforced concrete frame with X-braced reinforcement frame is shown in the following Fig. 1.

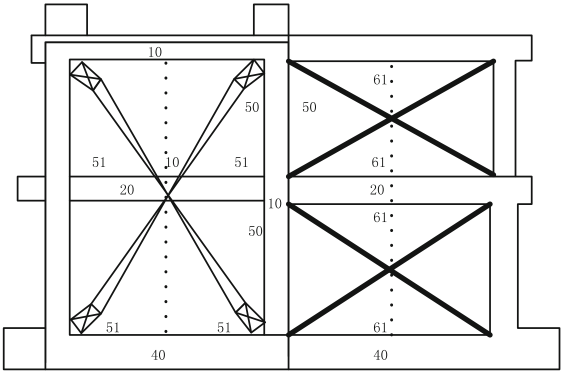

Fig. 1. Reinforced concrete frame reinforced with X-type braces

As shown in the figure, the reinforced concrete frame with X-brace reinforcement frame can effectively balance the internal force of reinforced concrete, balance the stiffness and the internal force that should be borne by the reinforcement design of the external structure. However, the vertical load of the structure is not considered for the external concrete frame. The external concrete frame, main frame and buckling-resistant brace bear the load and interlayer shear force together. In the process of design and treatment of reinforced concrete structures, the weight and bearing capacity of the building roof should be fully considered, and the weight and bearing capacity of the roof should always be kept in a moderate state to ensure that the ceiling is firm. In order to optimize the reinforced concrete frame structure, it is necessary to avoid the increase of ground load, ensure the stability and safety of the structure and reduce the bearing capacity of the members.

2.3 Structural Optimization of Reinforced Concrete Frame

According to the above ideas, the structure of the numerical model database system is standardized. After summarizing the existing structural criteria, the modal superposition method is proposed. Its iteration formula is as follows:

$$\left[A_{\lambda}^{R}\right]\Delta\overrightarrow{\mu}_{\lambda} = \xi\left(K^{n} - K_{\lambda}^{cn}\right) \tag{6}$$

Among them, K_{λ}^{cn} is the recovery load, $\left[A_{\lambda}^{R}\right]$ is the Jacobian matrix, and $\overrightarrow{\mu}_{\lambda}$ is the balanced iteration step. Before solving the problem, $\left[A_{\lambda}^{R}\right]$ is estimated by non-equilibrium load linearity and the convergence is checked. If the calculation results do not satisfy the convergence criterion, the deformation degree of reinforced concrete is studied. According to the results of deformation degree research of reinforced concrete frame structure, the displacement, velocity and acceleration of each layer of reinforced structure are geometrically non-linear. According to the elastic-plastic analysis, the ultimate load is calculated according to the previous calculation method. According to the calculation results, the above model is simplified to a unified orthogonal intersection model of the bearing capacity of ideal reinforced concrete frame structure. For the convenience of display and understanding, the section of the model is simplified and drawn. The specific section structure is shown in the following Fig. 2.

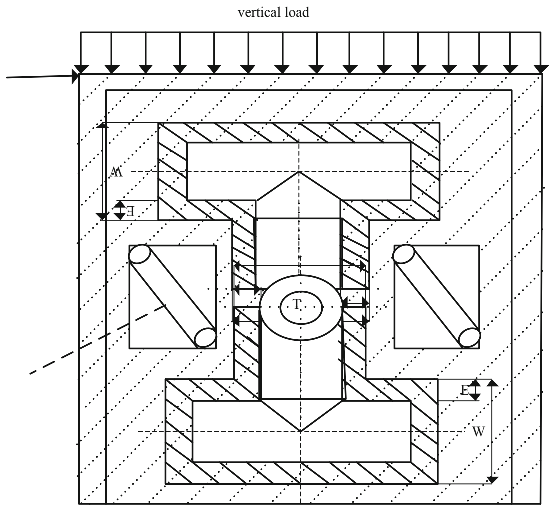

Fig. 2. Cross section of orthogonal intersection model for bearing capacity of reinforced concrete frame structure

According to the principle of load value and symmetry of building structure, only a quarter of the model is studied. Under lower loads, the model structure has not failed and can still bear loads, and the surrounding area is still in an elastic state. With the increase of transverse tension pressure, the plastic zone expands continuously. When the pressure reaches the limit value, the plastic zone almost extends to the whole range of reinforcement, and the building structure loses its bearing capacity. The information of steel bending degree under different pressure is as follows (Table 3):

Table 3. Ultimate moment of reinforced concrete frame structure

Number	K	D/r	Grade of concrete	Elevation	Bending moment
1–5	0.09	0.38549	C35	56.800	0.41021
6–10	1.00	0.51241	C40	48.600	0.54715
11–15	1.06	0.61254	C45	40.000	0.64852
16–20	1.12	0.77425	C50	28.900	0.74219
21–25	1.30	0.84573	C55	13.900	0.84528
26030	1.51	0.89135	C60	9.800	0.88452

In traditional buildings, with the increase of transverse tension and bearing pressure, the bending degree of steel bars in the same longitudinal section increases gradually, and the failure phenomenon is very easy to occur. The compressive strength and bearing capacity of reinforced concrete vertical members can be effectively improved by optimizing the frame structure with the ultimate bending moment specification parameters of reinforced concrete frame structure, so as to achieve the optimization of reinforced concrete frame structure. The goal of the study is to achieve the goal of modernization.

3 Result

In order to verify the research effect of RC frame structure optimization based on parallel cloud computing, simulation experiments were carried out. In order to simulate the stress of reinforced concrete in the building environment, the bottom wall of a real complex network building is used as the test wall in the simulation experiment, and the stress situation before the building reinforcement is analyzed and the secondary reinforcement is carried out. The reinforcement diagram of angle steel is as follows (Fig. 3).

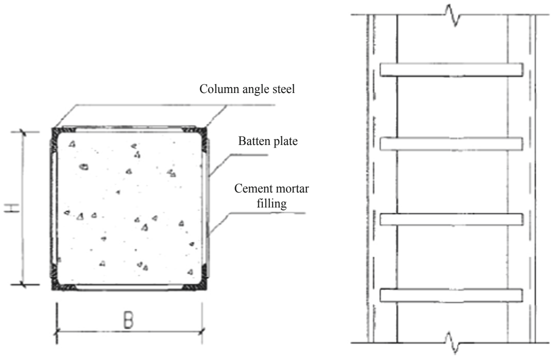

Fig. 3. Diagram of external angle steel reinforcement

The reinforced concrete columns strengthened by steel encasement can effectively improve the compression bearing capacity of the columns.

The reinforced structure is analyzed. Considering that the stiffness change of the member has some influence on the building structure, the method of converting section size is used to reflect it and then the structural analysis and detection are carried out. As the stiffness of frame beams changes little in building components, the effect of stiffness changes after strengthening of frame beams can be directly neglected. In the case of other conditions unchanged, the bearing capacity and bending degree of the traditional reinforced concrete frame structure and the optimized frame structure in this paper are compared and tested several times, and recorded. In order to facilitate the research, the traditional frame structure is set as A, and the optimized frame structure is recorded as B. At the same time, the multi-test results of two groups of structures are evaluated comprehensively, and the average parameters are drawn, and the following results are obtained (Fig. 4).

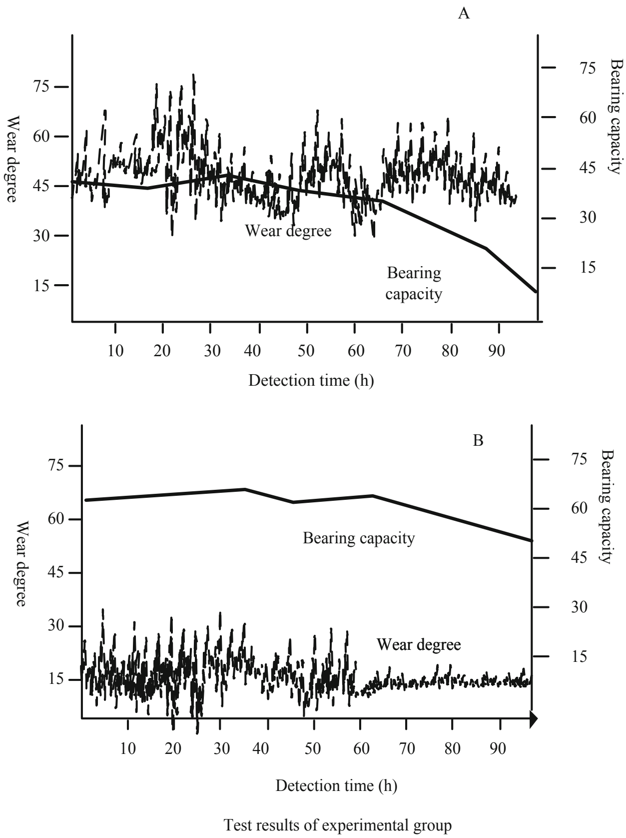

Fig. 4. Comparisons of experimental results

According to the analysis of the above test results, it is not difficult to find that the evaluation results clearly show that before the optimization of reinforced concrete frame structure, its bearing capacity is between 10% and 40%, the overall bearing capacity is relatively poor, and the wear degree is between 30% and 75%. This indicates that the worse wear degree of reinforced concrete frame is liable to cause linear deviation, which causes the torsion of building junction direction. Relatively speaking, the bearing capacity of the optimized frame structure is obviously increased, reaching 45%–60%. Although the anti-destructive reading of the structure is improved after optimizing the ultimate bending moment, it is difficult to improve the bearing capacity of the structure with a higher span, but the bearing capacity of this degree is enough to meet the current building needs. On the other hand, compared with the traditional reinforced concrete frame structure, the wear degree of the optimized frame structure decreases obviously in the process of experimental testing, and the wear situation tends to be stable with the extension of testing time. Due to the relatively large number of internal and external factors in the building, it is difficult to completely remove the damage of reinforced concrete. Therefore, it can be said that the research on Optimization of reinforced concrete frame structure based on parallel cloud computing can effectively reinforce the building structure frame, avoid the problems of frame structure direction displacement in the process of building, effectively guarantee the safety and stability of the building, and fully meet the research requirements.

The optimized frame structure is compared with the initial value, and the specific comparison is shown in Fig. 5. The left figure shows the model and stress analysis of the initial value, and the right figure shows the stress situation of the optimized model.

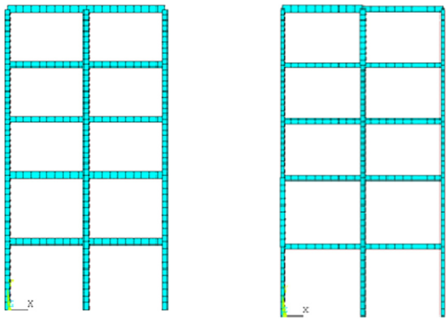

Fig. 5. Comparison of frame structure before and after optimization

Compared with the initial value, it has better optimization effect, which proves the feasibility and effectiveness of the algorithm in practical engineering.

4 Conclusions

The optimization effect of reinforced concrete frame structure based on parallel cloud computing is obviously improved. By standardizing the bearing capacity and load parameter information of reinforced concrete structure, the orthogonal intersection model of frame structure is improved to stabilize the bending moment of reinforced concrete frame structure. The optimization design of reinforced concrete frame structure is completed. Under the same environment, the bearing capacity of the optimized reinforced concrete frame structure is significantly improved, and its wear degree is significantly reduced, which fully meets the research requirements. In the structural system reinforcement analysis, we can further analyze the buildings with different seismic intensities and different structural forms, and obtain the corresponding relations, which can establish the analysis model more carefully and make the optimization analysis more accurate.

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