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Optimization of the Ductility about the High Reinforced Concrete Frame -Shear Wall Structure

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The specific exemplification and application of the structural stiffness and ductility theory have been elaborated in PKPM model adjustment and optimization and structural design process in the paper. The structural stiffness and ductility theory are combined with PKPM practical skills so that the methods and ideas of the structural stiffness and ductility design are generalized, that are completely helpful and strongly operational for PKPM model adjustment and optimization. The result shows that when the displacement angle, displacement ratio, cycle ratio, stiffness ratio, the ratio of stiffness to weight, shear weight ratio, axial compression ratio meet the requirements of the building code and are in a specific range, the structure is not only safe but also economical and the ratios of the structural design are also easier to implement.

1. Introduction

High rise frame shear wall structure ductility design is mainly to complete the ductility frame and shear wall design and so as to meet the effect of shock. Ductility design (Bianchini et al., 2007) sources in the following several aspects: (1) Through the adjustment member between the bearing capacity of relative size which can achieve a reasonable yield mechanism which named "strong column and weak beam", "strong wall piers and weak beam", "strong core region and the weak members"; (2) By adjusting component oblique section bearing capacity and normal section bearing force between the relative size which can realize the ductility and failure modes which named "strong shear weak bending"; (3) The component itself has good ductility and energy dissipation capacity by adopting seismic structural measures (Hertel et al., 1994).

2. Ductility design idea

2.1 The overall size of the control

Structure of maximum suitable height, the height to width ratio, the ratio of length to width control is actually from a macro perspective of structural stiffness, stability, bearing capacity and economy control, then the essence is economic rather than a safety issue. As mentioned above, high-rise buildings can be seen as a "cantilever beam" what embedded in the ground " (George and Arthur, 2006).. Therefore, the maximum applicable height, width ratio and length or width ratio of the control structure is to be controlled the length of the cantilever beam and the size of the cross section, so as to control the overall stiffness of the structure. Regulations for the maximum applicable height, aspect ratio and length or width ratio of the structure. When it reached 6, 7 degrees, the maximum length of the structure is 6, while the 8, 9 degree fortification, the maximum length width ratio of L/B is 5.0.

2.2 Displacement angle control

The displacement angle is defined according to the elastic calculation (Ospina and Alexander, 1997)method of wind load or earthquake standard value under maximum interlayer Horizontal displacement and layer ratio. Control displacement angle of the following two points: the first is to make the structure to remain elastic force State and avoid wall cracks. At the same time, it can happen cracks in the beam height, width and number of control in the specification. The second is to ensure filling walls and other non structural components which can be used normally. The provisions: high regulation calculation stage in elasticity, building height is less

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than 150m, calculated displacement angle to calculate coupling. However, for the eccentric frame shear wall structure, displacement angle is less than 1/800. But the displacement angle is not as small as possible, displacement angle. The smaller, indicating the overall stiffness of the structure is larger, the seismic force of the structure is bound to increase absorption. At the same time, the structure stiffness is too big under the earthquake and the structure has been in a state of elasticity. The ductility design of the structure is not easy to realize. So it seems that the stiffness is too large which can not only save costs but also the existence of security risks. Comprehensive design institute design experience, then bit shift angle control in error and norms within 20% which is more economical and reasonable, the displacement angle for optimal value 1/960~1/800.

2.3 Displacement ratio and period ratio control

For frame-shear wall structure (Rojas-Zerpa et al., 2015), the key is to rationally arrange the shear wall. The symmetrical arrangement of shear wall can reduce the torsion. The stability and stiffness of the shear wall can be increased by using the shear wall as well as the combined shear wall. The wall is arranged on the periphery of the structure which can increase the torsional rigidity of the structure. Even if the structure is completely symmetrical, the phenomenon of torsion will occur under strong earthquake. The reason is due to the construction, the actual structure of the axis size, the section size of the component, concrete strength, reinforcement and so on can not be completely symmetrical; live load. The distribution of the load can not be completely symmetrical. Therefore, the elastic stage of seismic calculation and consider the impact of accidental eccentricity (Virdi and Dowling, 2009).

2.3.1 Displacement ratio control

When determining the specific number of displacement ratio (Ross, 2009) it cannot be more than 1.2, because the displacement ratio is larger, the maximum displacement of the structure. The difference with the smallest displacement is larger, that is, the stiffness center of the structure and the eccentric distance of the center of mass is larger, so the effect of the structure is obvious. At this point, the structure of the earthquake is not safe, and in order to resist the need to reverse the larger reinforcement, it is not economical. In the case, the stiffness center and mass center of the structure are completely coincident, and the maximum displacement of the structure is equal to the minimum displacement. Shift than the minimum value is 1, the structure of complete translation. Therefore, the design experience of the comprehensive design institute. When the displacement ratio and the standard error are within 20%, the structure torsion effect is controlled properly, which is both safe and economical. When the displacement ratio of the PKPM calculation results can not meet the requirements of the specification, the following method can be adopted to adjust the displacement ratio:

(1) SATWE program control: the program can not be automatically adjusted.

(2) Artificial control: can only change the structure plane layout, as far as possible to make the structural stiffness and mass distribution Uniform and symmetrical and reduce the structure of the center and the center of the eccentric distance, the adjustment method is as follows:

Pay attention to the symmetry of the structure layout, the symmetry of the structure include mass symmetry and rigidity symmetry. In the fruit of "each layer of reinforcement component number diagram in view of structure stiffness, the offset distance and the centroid of the heart. The lateral stiffness or increase the stiffness center offset on the side of the stiffness, minimize the eccentricity and centroid distance Xiaogang heart. The displacement calculations find the maximum displacement Max- (X) or Max- (Y) corresponding to the node number. And then, in the "graphics file output", "the node search" function is used to determine the maximum node number.

Corresponding component location. At last, the section of the member is enlarged or steel reinforced concrete beam is adopted to increase the stiffness of the member. Also This method can be adopted to determine the minimum displacement of the component, until the displacement ratio meets the specification requirements .The additional layers beam (with ring beam, the beam type model), increasing of interlayer torsional rigidity, reduce the torsion effect.

2.3.2 Cycle ratio control

Cycle ratio should be reasonable, the torsional stiffness relative to the translational stiffness is too small, the structure Prone to torsion effect, when the ratio is too small, the structure of said torsion stiffness and translational stiffness. Compared with too large, the structure of the external wall of the shear wall arrangement too much or column and beam section is too large, the structure is not economical. The practical experience of the cycle than in the control and the error is within 20%, the structure of the torsional stiffness is suitable, safe and economical structure. At the same time, the period is also easier to achieve than the value, that is, the cycle than the optimal range is 0.72~0.9.When the PKPM calculation results in the cycle ratio does not meet the specification requirements, can be adjusted according to the following methods:

(1) SATWE program control: the program can not be automatically adjusted.

(2) Artificial control: adjusting the structure and layout, enhancing the torsional stiffness around the structure. According to the structural rigidity and the period. The inverse relationship shows that the adjustment principle is to strengthen the structure of the surrounding walls, columns and beams of the stiffness. The stiffness of the middle part of the structure can be reduced appropriately. The structure of the external input beam, increasing the torsional stiffness. In the SATWE output, the cycle is arranged in the order of their length. In general, translation

Mode is generally the first, torsional vibration mode for the third mode (here should pay attention to distinguish between the first vibration. The difference between a translation mode and the first torsional mode. The first mode is according to the SATWE output results in the mode of vibration Define, and the first translation mode or the first torsion mode is the cycle mode determined in accordance with the corresponding. The translational long cycle or reverse cycle corresponding mode is the first translation mode or the first torsion mode, and arrange mode Order independent. If the structure of the first or second modes to reverse the formation can be adjusted according to the following ideas (Sadi-Nezhad et al., 2010):

(1) The first mode is torsional vibration mode, which indicates that the torsional stiffness is too small for the lateral stiffness of the two main shaft. At this time it should be along the two main axis of the structure of the external stiffness, but also to the appropriate weakening of the internal structure of the stiffness. When the mode is torsional vibration mode, the period ratio must not be in conformity with the specification limits.

(2) When the second mode is torsional vibration mode and the lateral stiffness of the structure in the direction of the two principal axes is expressed. The stiffness of the weak axis can be increased, and the stiffness of the strong axis can be reduced. The torsional stiffness of the structure is relative to the first vibration mode. The lateral stiffness of the moving direction is appropriate, but the equivalent lateral stiffness of the third modes is relatively small.

(3) When the third modes are reversed, the period ratio can meet the demand, but the ratio of the ratio is controlled. Like structure can be safe and reliable and economical. When the cycle ratio is less than 0.72, it indicates that the torsional stiffness is too large and should be reduced. The cross section of the small peripheral torsion member is adjusted in the range of 0.72 to 0.9.

2.5 stiffness ratio control

Ratio of stiffness to lateral stiffness ratio of the lower floor and adjacent upper layer. Mainly to the vertical stiffness distribution of the structure. To control the irregularities, so that we can avoid caused by the weak layer vertical stiffness changes suddenly, the latest National Award Hair in the high regulation pointed out: the frame shear structure stiffness ratio should be greater than 0.9.If the output of the PKPM is more rigid than does not conform to the standard, it needs to be entered in the following Line adjustment:

(1) SATWE program control: if the stiffness of a floor does not conform to the specification standard, then SATWE. It will automatically put the floor as a weak layer, and in accordance with the latest high gauge 3.5.8 to the floor of the seismic shear Big 1.25 times.

(2) Artificial control: if it is necessary for human intervention, the following methods can be adjusted: Reduce the height of the lower floor, improve the lower stiffness, or increase the upper layer, lower the stiffness of the upper layer. Strengthen the stiffness of the wall, column and beam, or properly weaken the stiffness of the upper floors, columns and beams.

In the lower structure, the steel or the steel pipe column or the steel plate wall are adopted to improve the lower rigidity, but the method cost is relatively low. High, should be taken into account.

2.6 Rigid weight ratio control

Stiffness ratio is the ratio of the lateral stiffness of the structure to the design value of the gravity load. Earthquake, the two order effect of gravity load generated (P-delta effect) is not too large which can avoid greater additional structure. The internal forces and the collapse of the collapse are the main parameters to control the two order effects of gravity. In order to ensure the overall stability of the structure, the shear stress ratio of frame shear structure should be greater than 1.4. But the structural stiffness is not particularly large, and the additional bending moment caused by the deformation of the structure can not be ignored. The PKPM should be considered for the calculation of P-delta effect, when the shear weight ratio is greater than 2.7, the structural stiffness is large enough, small deformation. When the additional moment is small what can not consider P- a effect. When the PKPM calculation results in a just weight ratio does not meet the requirements of the adjustment method:

1) SATWE program adjustment: the program can not be automatically adjusted.

(2) Human adjustment: only by artificially enhancing the stiffness of vertical members (shear wall and column). Do not allow. In the case of wall column section, the steel or concrete filled steel tubular column can be used, and the weight of the structure is basically not increased. The structural stiffness and ductility are significantly increased. However, the cost of this method is relatively high, the designer should combine the actual situation.

2.7 shear weight ratio control.

Ratio of shear to weight ratio is the ratio of the horizontal seismic shear force to the representative value of the gravity load. Its main function is to control each floor. The seismic shear forces can not be too small, especially some of the structure of the basic cycle Time is greater than 3.5s or contain weak layer of the building. The seismic response spectrum theory shows that the seismic influence coefficient is small, so that the seismic response of the structure is small. For security reasons, the designer should strengthen the control of the ratio of the shear to ensure the minimum earthquake action of the structure. The weight ratio is like the minimum reinforcement ratio of the component. If the PKPM calculation result does not conform to the standard, it is important to make the adjustment. According to the rules, when the earthquake action is calculated, the structure of each floor corresponds to the shear of the standard value of earthquake action. minimum floor seismic shear coefficient. When the shear weight ratio is not satisfied, the PKPM calculation results are not satisfied:

(1) SATWE program control: in the parameters of the SATWE set out "according to the seismic code regulation. After the seismic internal forces of the options, if the structure can not meet the shear weight ratio of the standard limit value, SATWE will be in accordance with the regulation requirements of initiative will be multiplied by the minimum total gravity seismic shear coefficient- the layer and the layers, ensure the structure By the earthquake is not too small.

(2) Human control: if it is necessary for human intervention, the following three methods can be adjusted: When the seismic shear force is small and the lateral displacement angle of the story is too large, the structure is too soft, it is appropriate to increase the wall and column section increase stiffness. When the seismic shear force is large and the lateral shift angle of the layer is too small, the structure is too rigid, it is appropriate to reduce the section of wall and column what can reduce the stiffness to obtain the appropriate economic and technical indicators. When the seismic shear force is small and the lateral displacement angle of the layer is just at that time, it can be in the "adjustment information" of SATWE.

The coefficient of input greater than 1 in the seismic amplification factor of the building increases the earthquake action, so as to meet the requirement of the shear weight ratio.

2.8 Axial compression ratio control

2.8.1 Axial compression ratio model adjustment

The axial compression ratio of the column (wall) is the design value of the compressive strength of the concrete column (wall) and the compressive strength of the concrete column (wall).Ratio of the product of the total cross section area of the column (wall). Axial compression ratio is one of the main parameters to ensure the plastic deformation capacity of the column (wall).

In order to ensure that the column (wall) has a good ductility, high gauge on the column axial compression compared to the provisions of the detailed. If the axial compression ratio does not conform to the specification limits in the output of the PKPM, it can be adjusted by the following methods:

(1) SATWE program adjustment: the program can not be automatically adjusted.

(2) Artificial adjustment: if the axial compression ratio is too small, then the column (wall) cross section is too large, not the economy, it is appropriate to reduce small section area; if the axial standard value is larger, the column (wall) section is smaller. If you are not good, then you should increase the wall, column section or improve the grade of concrete. If the building restrictions can not increase the column, the section area of the (wall) can be added at the bottom of the structure or in the axial compression ratio, which does not meet the requirements of the specification. Concrete column (wall) in order to improve the ductility of the structure. However, the cost of this method is relatively high, the designer should combine the actual situation.

3. Engineering applications

The project is located in a high-rise residential building in Jinan. The main structure of the residential underground 1 floors, 19 floors, the standard storey is 3 meters, the floor is 57 meters high. Internal and external walls with fly ash hollow block, outside the 80mm thick polystyrene insulation.

3.1The establishment and adjustment of structural model

After each part of the components of the size and the parameters are determined, you can set up a structural model in PKPM, as shown in Figure 1

According to the above stiffness and ductility design theory, the model is adjusted and optimized to make the displacement ratio (Salmeron et al., 2010). Displacement angle, period ratio, stiffness ratio, stiffness ratio, shear stress ratio, axial compression ratio and so on are the most important structural stiffness and ductility index. Optimal range, while obtaining the best economic benefits.

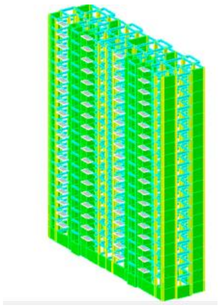

Figure 1: Structure model

3.2 structural stiffness and ductility performance analysis

The structure meets the requirements of the standard, and the structure of the structure is high and wide ratio and the length and width ratio under the condition of 4~5 and so on. Compared with the structural stiffness and ductility, such as displacement ratio, displacement angle, period ratio, stiffness ratio, stiffness ratio, shear Weight ratio, axial compression ratio, etc. Based on the comparison of the calculated results of the example project, the structural stiffness and ductility are compared. Analysis of the design principle and significance of each control index.

In addition to adjust and optimize the structure model which can move among force and soft structure. If the overall stiffness and ductility of the structure are in conformity with the requirements of the specification, but with a larger error, the structure stiffness is too large or the stiffness distribution is not appropriate. If the correlation ratio does not meet the structural requirements, the structure stiffness is too small or the structure layout is not reasonable, and the structure is not safe. Therefore, it is necessary to adjust and optimize the relative ratio so that it can reach the optimum range.

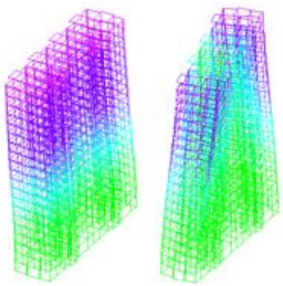

Figure 2: Modal structure diagram

Above analysis, it can be seen that the displacement angle, displacement ratio and period ratio are all in line with the requirements of the specification. The limit value of the error is within 20%, indicating the structure of the anti torsion stiffness for move among force and soft. If the control index is not meet the requirements. According to the above stiffness and ductility theory to adjust the structural model, so that it can meet the requirements of the analysis of the stiffness ratio, the ratio of stiffness to weight ratio and the shear weight ratio of the.3 project.

(1) Stiffness ratio

In SATWE, the PKPM output file inside the "structural design information" in the structural stiffness ratio of the relevant rules Set. We can see that, in addition to the basement and the bottom of the strengthening layer (one or two layers). The ratio is not only in conformity with the requirements of the specification, but also within the range of the optimal value of 0.9~1.08. According to the results of PKPM analysis, the ratio of the basement to the upper layer is 3.7. Therefore, the roof of the basement can be used as the calculation of the fixed end. The regularity of the vertical distribution of the structure is proved. It should be noted that the distinction is whether the floors of the weak layer needs to use the "earthquake". The stiffness calculation method of the ratio of the shear force to the storey displacement is used to confirm the floor stiffness ratio, and to determine whether the roof of the basement can be used as a calculation method of "shear stiffness" is adopted to calculate the structure. Two different stiffness calculation methods are compared.

(2)Analysis of axial compression ratio

The axial compression ratio is an important control parameter which affects the ductility of the structure, and the axial compression ratio of the columns is discussed here. In PKPM.In the SATWE output file, "beam elastic deflection, column axial compression ratio, wall edge member" can view the column axial compression ratio size. As shown in Figure 5.7, the independent columns (i.e., the columns that are not associated with the shear wall) are most of the axial compression ratio.0.72, the axial compression ratio of a small number of columns is less than 0.72. The reason is that there is a mandatory requirement for the minimum size of the seismic column. Axial compression ratio can not be too small. The axial compression ratio of the columns is in conformity with the specification requirements, and most of the axial compression ratio of the columns is in the optimal range. Within 0.72~0.9. The axial compression ratio ensures the ductility of the structure.

4. Conclusions

It is mandatory to have conclusions in the manuscript**.** This ensures completeness of the presentation as well as provides the readers with an idea about the significance of the achievements in the presented work. The conclusions should point out the significance of the presented work. It is advised that the contained quantitative reasoning where appropriate, comparing the obtained results to previous work or appropriate benchmarks.

(1)The ductility design method and PKPM model adjustment and optimization method are summarized for the high reinforced concrete frame -shear wall structure. The concrete embodiment and application of the theory with ductility are used in PKPM.

(2)Compared with the engineering examples, the displacement angle, displacement ratio, period ratio, stiffness ratio, the ratio of the stiffness to weight ratio, the ratio of the axial compression ratio and other structural stiffness and ductility index are precisely calculated.

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