Research and analysis on seismic performance of steel - polypropylene fiber concrete box type

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Abstract

In this study, a reinforced concrete large ash rock was constructed on top of a reinforced concrete using thermal concrete instead of reinforced concrete. Using rigorous analysis algorithms such as ABAQUS, four ballast basket models were simulated to measure the compressed concrete model as it was carried from the bottom to the cruciform. Analysis of mixing curves, bone spines, tensile coefficients and alkali solution yield showed that the long-term durability of the metal fibres under certain conditions affects the long-term durability of polypropylene. Studies have shown that reinforced concrete concrete has a stronger wax/vacuum conversion capacity than reinforced concrete fiber concrete, which enhances its texture to concrete through glacier diffusion and calculations. The thicker the steel plate and the higher the quality, the stronger the wooden box will be.

Keywords

Steel Hybrid fiber concrete, Box column, Seismic performance, Finite element analysis.

1. Introduction

The nonlinear and non-linear methods of reinforced concrete are important theoretical methods, and they became widely used due to the development of computer technology and detonation technology. Experiments of structural reform and characteristics of the structure on the hallway or even micron physics results and zerstorungsmerkmale can be determined to be more reliable, but experiments of the structure will not benefit the cost they are less It is also caused by long, high and many unpredictable factors, leading to error and uberproportionen. Simulation with limited software is a good complement to experiments, as researchers usually use non-binding techniques to check and improve the simulation operations of existing experiments. In practice, simulating a more accurate prediction structure based on basic operations and simulation costs will allow for a wide range of duo-fit experiments adding prediction and structure ab's can understand the physical properties of reinforced concrete You can analyze it, but this is a large number of non-linear analyses, as well as other templates. Use abaqus software to simulate the seismic resistance of stamping concrete machines, and to conduct exploratory research to improve common problems in common stamping models. However, since the results of specific experiments and simulations are not compared, a theoretical basis for ensuring reliability and reliability is necessary. In fact, structural models accurately predict their destructive forces and accurately reflect the properties of the material.

2. Box column model design

2.1. Model basic parameter

In the experiments compared with the tests of Peking University, tongji university, the institute, the model method of the change of the model method is first model, and the characteristics of the model are verified.

In this paper, a total of four finite element analysis models were designed, numbered C0 -- C3, in which C0 was the reference control model and steel fiber concrete matrix material without adding polypropylene fiber was used, while C1, C2 and C3 were mixed fiber concrete box columns for specific configuration, see Table 1. All the models adopt the same geometric section size, the outer contour section size is 500mm×360mm, the inner hollow section size is 260mm×120mm, the wall thickness is 120mm, the box column is equipped with solid column head and base at both ends, and the effective loading height is 2880mm. HRB335 reinforcement is used for longitudinal reinforcement and stirrup, among which the diameter of longitudinal reinforcement is 8mm, the diameter of stirrup is 6mm, and the space between stirrup is 40mm. The size and reinforcement of box column are shown in Fig 1

Table 1 Specimen number and parameter

Model number	Fiber combination mode	Polypropylene fiber volume content	Axial pressure (kN)	Stirrup spacing (mm)	Stirrup ratio (%)
C0	SF0PP0	0	280	40	0.035
C1	SF1.5PP0.05	0.05%	280	40	0.035
C2	SF1.5PP0.1	0.10%	280	40	0.035
C3	SF1.5PP0.15	0.15%	280	40	0.035

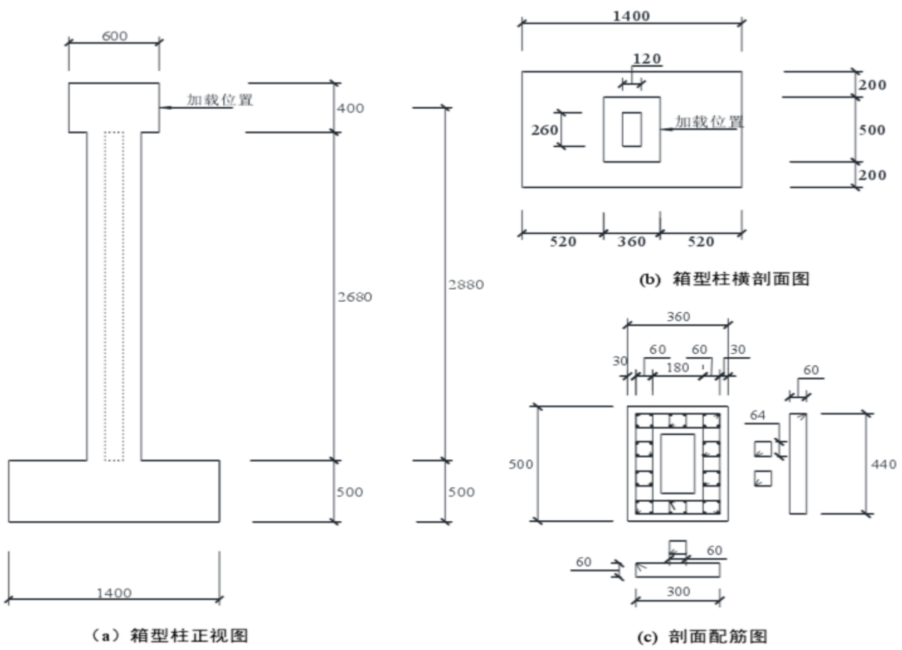


Fig. 1 Size and reinforcement drawing of box column

2.2. Material basic parameter

In the definition of reinforcement material attributes in the model, measured material parameters of reinforcement in the reference test model are used, as shown in Table 2. The mechanical properties of steel fiber are shown in Table 3. The material parameters of fiber are shown in Table 4.

Table 2 Material parameters of reinforcement

Type	Diameter (mm)	Yield strength (MPa)	Ultimate strength (MPa)	Elastic modulus (N/mm2)	Poisson's ratio
Longitudinal bar	8	393.2	624.0	196600	0.3
Stirrup	6	388.6	609.3	194300	0.3

Table 3 Mechanical property parameters of fiber reinforced concrete

Fiber combination mode	Polypropylene fiber volume dosage	Yield strength (MPa)	Compressive strength (MPa)
SF1.5PP0	0	53.80	4.41
SF1.5PP0.05	0.05%	55.10	4.21
SF1.5PP0.1	0.10%	53.60	4.41
SF1.5PP0.15	0..5%	58.50	4.55

Table 4 Fiber material parameter

Fibre number	Fiber length-diameter ratio	Fiber type	Tensile strength (MPa)	Elastic modulus (N/mm2)
SF	60	Steel fibre	≥600	220000
PP	396	Monofilament polypropylene fiber	>400	>3500

3. Finite element analysis of seismic performance of steel fiber reinforced concrete box column

3.1. Establish finite element model

3.1.1. Analysis step setting

Setting up the analysis steps is directly related to how fast you can run your model. It depends on whether the problem is solved or not. In the main analysis, the true limit condition of the field is defined as maintenance. The defenders see one person in the garden and think he has moved. They will find someone who will analyze your behavior they are fun partners they are at a higher level these step Settings are mainly the type of step, the maximum number of steps, the size of the first step and these steps It will automatically increase or decrease buhmann based on the result. In order to achieve the maximum increase in Numbers, sufficient Numbers must be provided. Ensure that the comprehensive analysis process is not completed fast. While you choose the size of step 1 based on the model, you can add extra computational power to make the data 0 in the meeting. Also install folding in g linear.

3.1.2. Meshing

The mesh division will directly affect the speed of analysis and calculation process and the precision of simulation results. In the grid division of the model, in order to make the grid division of the model more regular, it is necessary to cut the concrete part first. As shown in Figure 2, the box column can be cut into a cube with several regular parts. In terms of the selection of elements in the model, C3D8R hexahedral reduced integral elements were used for concrete, and the grid division results were all 60mm×60mm, as shown in Figure 3. T3D2 truss element is used for the rebar.

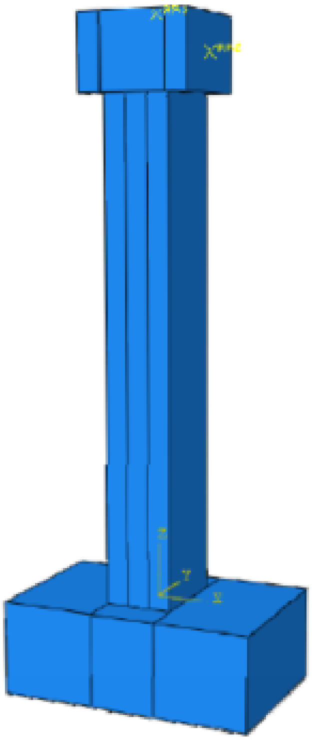


Fig.2 Model cutting

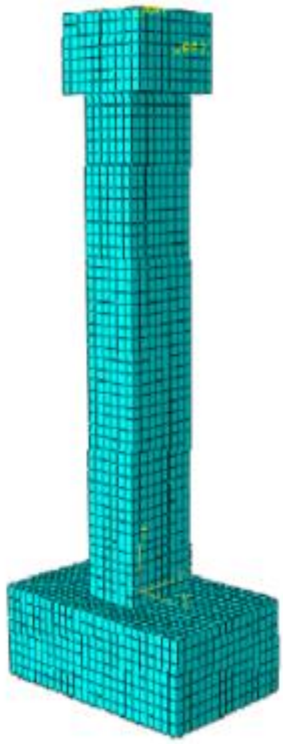


Fig.3 Mesh generation of finite element model

3.1.3. Loading mode

The loads involved in the model include axial concentrated force and repeated horizontal load in which the axial concentrated force is applied to the column top center of the box column model. In the simulation process, 280kN and 580kN axial compression were used to compare the effects of different axial compression ratios on the seismic performance of the box column. The axial force is applied once and remains unchanged until the entire calculation is complete. Horizontal loading adopts displacement control loading mode, and each stage displacement amplitude is cyclically loaded three times. The loading scheme is shown in Figure 4. In the simulation process, it is found that if the initial loading displacement amplitude is too large, the calculation process and results will be abnormal. Therefore, in the initial loading, the non-cyclic displacement of small value is first used as the transition, and then the normal cyclic loading scheme is adopted. When the horizontal bearing capacity of the box column is reduced to 85% of the ultimate horizontal load, the column is considered damaged and the loading should be terminated. However, since there was no specific test to judge and control the loading degree in advance, the total duration of all model loading analysis steps was set to 184 in the simulation, that is, the complete displacement loading cycle process was completed. But in the actual calculation, when the model bearing capacity decreases greatly and the column is completely destroyed, the incremental step size changes little, and the calculation efficiency decreases obviously. It no longer makes sense to continue the calculation, so some models choose to terminate the calculation after failure.

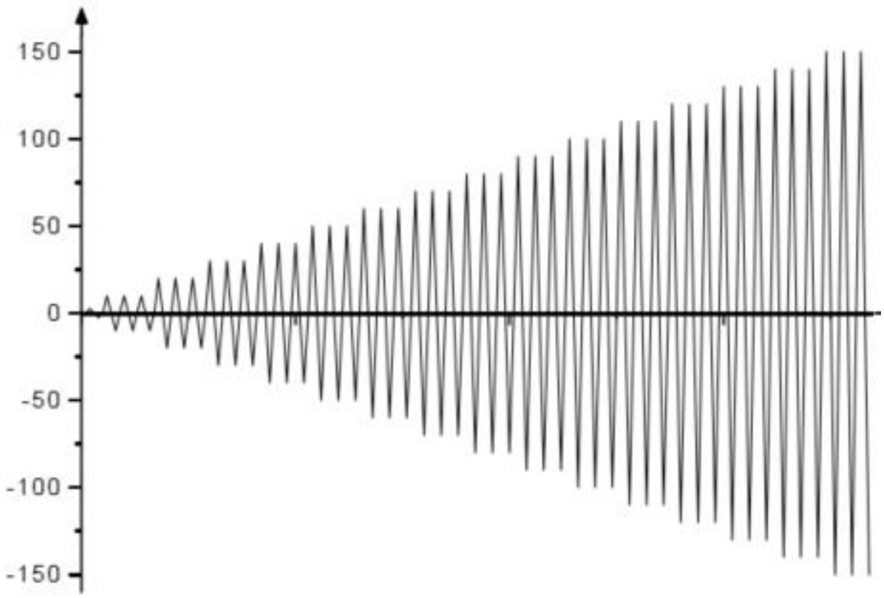
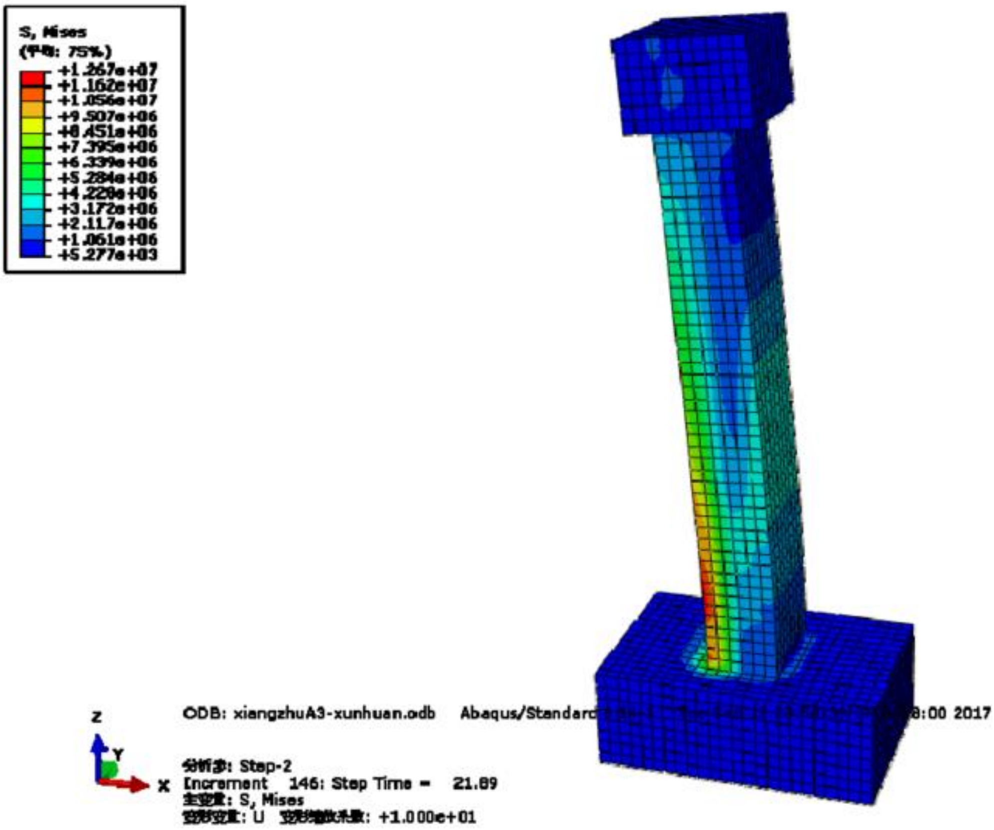


Fig.4 Loading scheme

3.2. Summary and analysis of finite element calculation results

3.2.1. Stress nephogram

FIG. 5 and FIG. 6 show the stress moire diagram of fiber concrete box columns simulated by low cyclic horizontal load applied by BAQUS software.



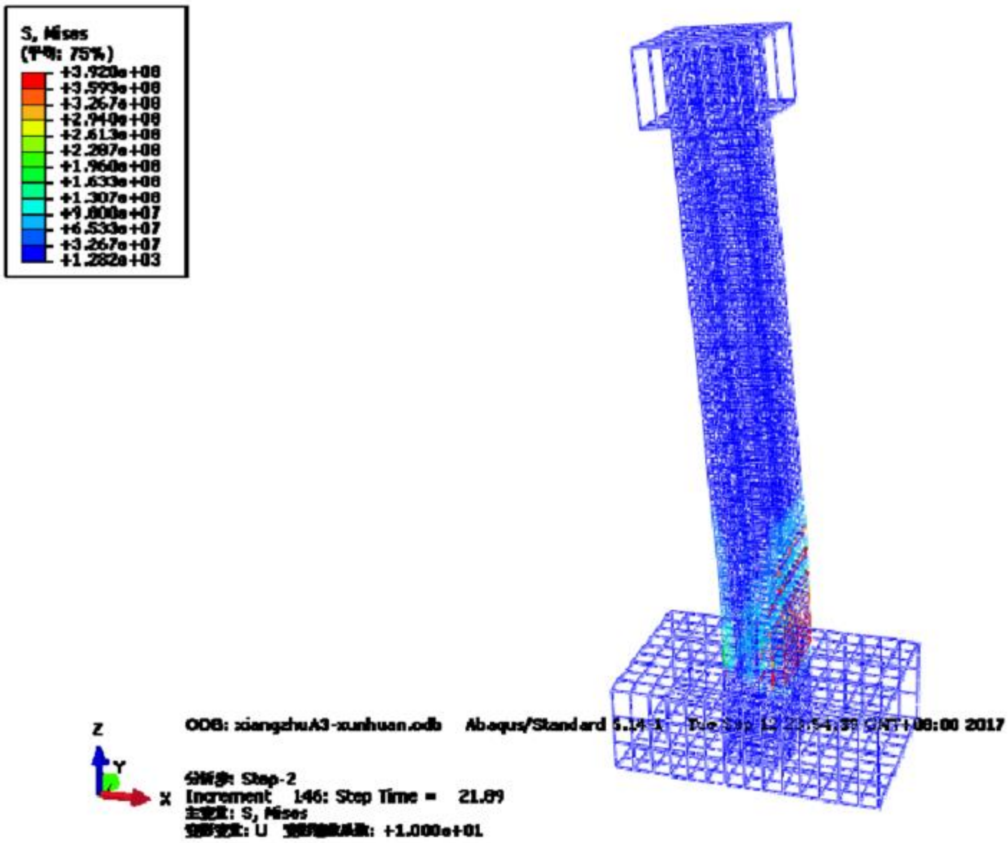


Fig.6 Stress cloud diagram of box column steel bar

As can be seen from the stress momograph of concrete and steel skeleton of box columns, the load is mainly distributed in the lower part of box columns, and the closer to the column end, the lower part of the column with greater stress will be the first to crack, which is the weak area of the structure. This is consistent with the failure characteristics of box-column structure in engineering practice and experimental research. Observing the change process of the concrete stress curve during the whole loading process, it can be seen that with the increase of the loading displacement, the larger stress area gradually expands and moves upward, the stress in the compression area is obviously greater than that in the tension area, the stress at the foot of the column is relatively concentrated, and the stress in the thin-wall side area of the concrete is small. Compared with the concrete stress, the reinforcement stress is concentrated, and mainly concentrated in the lower part of the box column. By observing the stress moire pattern of concrete and reinforcement simultaneously, it is found that the larger stress regions are distributed on opposite sides.

3.2.2. Hysteresis curve

Hysteretic curve refers to load-displacement curve of model member under cyclic and repeated load. The whole process of the model component in the whole loading process was recorded, from the elastic stage to the elastic-plastic stage to the plastic stage and then to the failure stage. It can comprehensively reflect the seismic capacity of the specimen, such as the stiffness, strength, deformation and energy dissipation capacity of the structure. A week after loading, the resulting curve closes into a loop called the hysteresis loop. The size of the graph area surrounded by hysteresis loop represents the energy consumption of the sample. The larger the enclosed area, the fuller the hysteresis curve, indicating that the energy dissipation capacity of the specimen is stronger, which is conducive to bearing the seismic load.

According to the hysteretic curve of the model obtained, when the horizontal load amplitude of the column top of the box column is small, the deformation of the specimen is still in the elastic deformation stage of concrete material. In this case, the loading curve and unloading curve of the model are approximately straight lines, and the area of hysteresis loop surrounded by them is very small. The concrete material has no cracking phenomenon in the loading process and no deformation residue after loading. With the increase of the horizontal displacement amplitude of the top of the column, the loading curve and unloading curve gradually changed from straight line to curved, and the enclosed area gradually increased, forming a spindle shape, indicating that the material in the model was damaged and a certain amount of energy was consumed. Finally, the specimen retains some residual deformation after unloading, which is reflected in the actual test. The specimen cracks and the material stiffness decreases. When the load continued to the peak of the model bearing capacity, the model bearing capacity began to decline, and the corresponding hysteretic curve of the model gradually appeared "pinch" phenomenon.

It can be seen from FIG. 7 that the hysteretic curves of fiber reinforced concrete box column models with polypropylene fiber mixed are significantly larger than those of ordinary reinforced concrete box column models C0 without polypropylene fiber mixed. As can be seen from the figure, the maximum bearing capacity of the specimen was improved, and the addition of polypropylene fiber played a positive role. When the bearing capacity changes greatly, the bearing capacity decline section becomes gentle and the column top displacement becomes large, which indicates that the ductility performance of the member can be analyzed well. The increase of fiber content can effectively improve the tensile properties of concrete and inhibit the development of cracks. When the box column bends under horizontal load and small bending cracks are formed on the loading surface, the fiber bridging between cracks can inhibit the development of cracks and delay the failure process of the component.

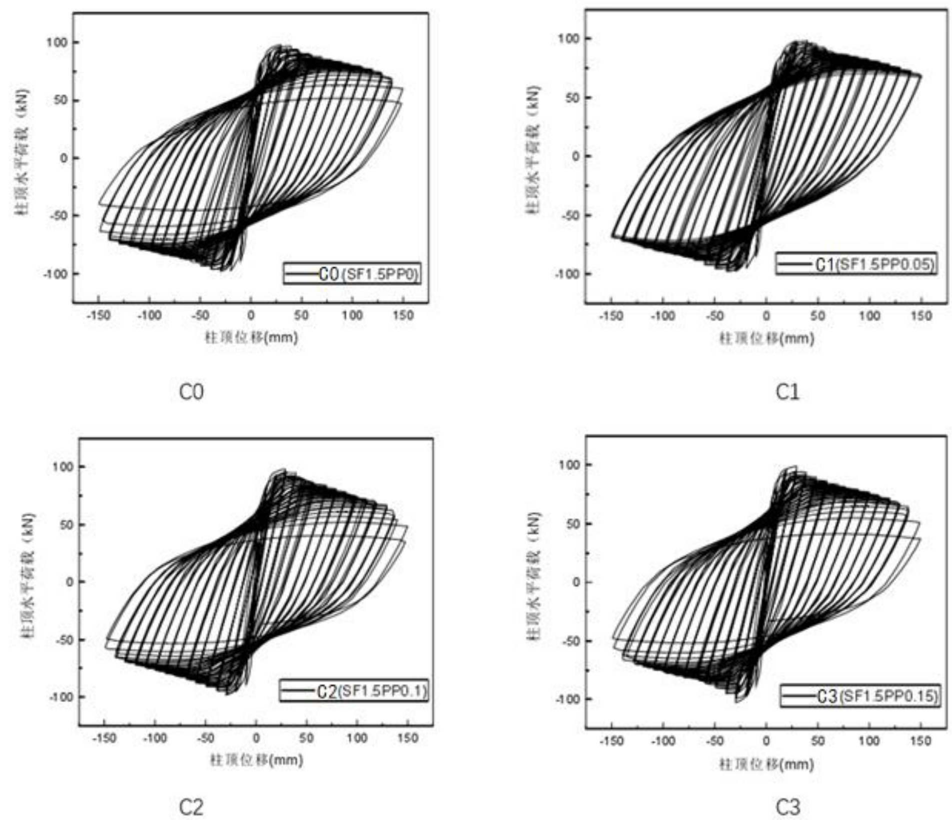


Fig.7 Model hysteresis curve

3.2.3. Skeleton curve

As shown in Fig. 9, the peak points of each hysteresis loop in the hysteresis curve are connected to form an outsourcing complex line of the hysteresis curve, which is called skeleton curve. Skeleton curve reflects the variation of the relationship between load and deformation in cyclic loading mode, but its curve form is very close to that of load-deformation curve under monotone load. Characteristic parameters such as strength change information, yield load, peak load, failure load and corresponding displacement of specimens can be extracted from skeleton curve. The skeleton curve can also reflect the ductility and seismic capacity of the specimen. In this paper, the peak point of hysteretic curve in the first cycle of each level of load is connected, and the connected track is used as the skeleton curve of the model.

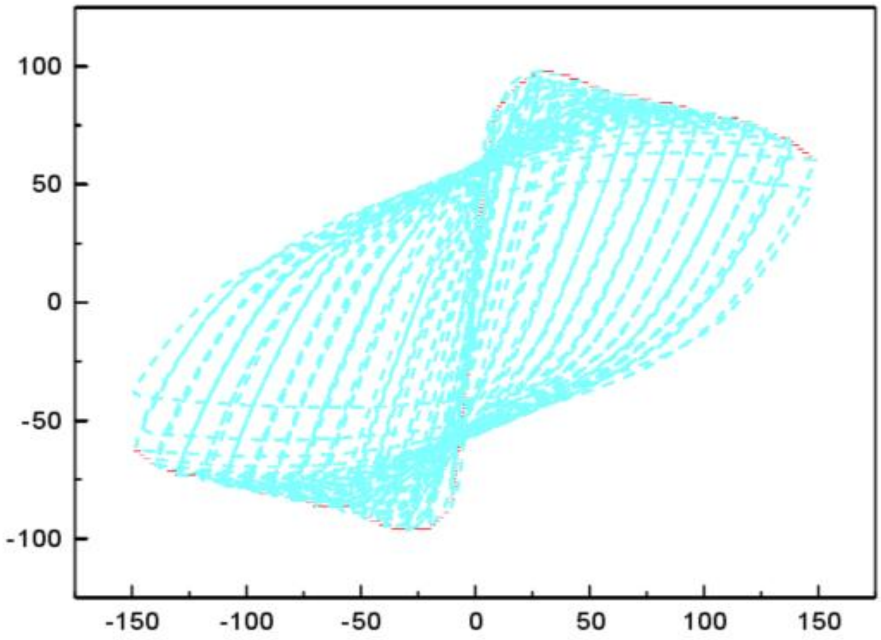


Fig.8 Schematic diagram of skeleton curve

Figure 9 shows the skeleton curve of the hybrid fiber concrete box column model with 1.5% steel fiber mixed with 0.05%, 0.1%, 0.15% polypropylene fiber. With the increase of polypropylene fiber content, the bearing capacity and ductility of the specimens are improved.

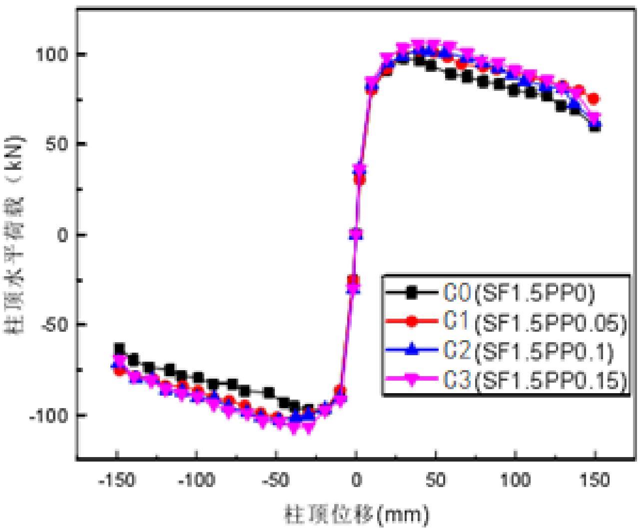


Fig.9 Skeleton curve of fiber concrete box column model

3.2.4. Ductility analysis

The ductility coefficients of C1, C2 and C3 are significantly larger, respectively increasing by 6.9%, 9.8% and 14.9% compared with the C0 model, indicating that although polypropylene fiber has little effect on improving the bearing capacity of components, it has significant effect on improving the ductility seismic performance of components.

Table5 Calculation of Displacement Ductility Coefficient

model number	Yield load (kN)	yield Displacement (mm)	Ultimate load (kN)	Ultimate displacement (mm)	Ductility coefficient	Average ductility coefficient
C0	84.32	12.49	29.65	83.17	90.16	7.22
	-84.96	-12.21	-29.94	-82.99	-86.85	7.11
C1	87.36	14.84	39.86	86.90	112.38	7.57
	-89.20	-12.93	-37.63	-86.39	-100.34	7.76
C2	88.57	12.84	39.63	87.40	100.34	7.81
	-90.97	-13.78	-48.41	-87.30	-107.59	7.93
C3	89.13	13.49	38.81	89.97	111.17	8.24
	-94.58	-12.93	-39.12	-90.78	-106.59	-8.25

3.2.5. Energy dissipation capacity

Under low cyclic load, unrecoverable plastic deformation and damage occur in the process of energy absorption and release. In the hysteresis curve of the model, the graph area enclosed by the loading curve and the horizontal axis represents the energy absorbed by the specimen during the loading process, while the graph area enclosed by the unloading curve and the horizontal axis represents the energy released by the specimen during the unloading process. The hysteresis area enclosed by loading curve and unloading curve represents the energy dissipated by plastic deformation and damage during the loading cycle. In order to accurately describe the energy dissipation capacity of the specimen, the equivalent viscous damping ratio is usually used to describe it. As shown in Figure 10, the equivalent viscous damping ratio is the ratio of energy dissipation in the cyclic loading process to energy consumed by the equivalent linear elastic system to reach the same displacement. The formula is as follows:

$$h_e = \frac{1}{2\pi}\frac{S_{(ABC+CDA)}}{S_{(OBE+ODE)}}$$

Where, is the enclosed area of hysteresis loop, represents the energy dissipated by the structure during cyclic loading, is the sum of the area of triangle OBE and triangle ODE, represents the energy consumed by the equivalent linear elastic system to reach the same displacement. The hysteretic loop corresponding to the first cycle of each load level was extracted from the hysteretic curve of each fiber reinforced concrete box column model obtained above, and the equivalent viscous damping coefficient of the specimen was calculated. FIG. 11 shows the comparison between the equivalent viscous damping coefficient of each fiber reinforced concrete box column and the horizontal displacement of the column top.

The equivalent viscous damping coefficient can reflect the fullness of the hysteretic curve and the energy dissipation capacity of the model. The larger the equivalent viscous damping coefficient is, the richer the hysteretic curve of the model is, and the stronger the seismic energy dissipation capacity of the model is. As can be seen from the curve in Figure 11, the equivalent viscous damping coefficients of all specimen models are above 0.3 when they fail, indicating that the box-type column model with this section form has good energy dissipation capacity. With the increase of top horizontal displacement load, the equivalent viscous damping coefficient and dissipated energy increase gradually. Before the cracking of the specimen model, the cylinder deformation is small, the energy absorption and dissipation is small, and the

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equivalent viscous damping coefficient increases gently. After the failure of the model, the damping coefficient increases rapidly, the hysteresis curve becomes full, and the energy dissipation ability increases greatly. When the ultimate displacement model is completely destroyed, the curve of equivalent viscous damping coefficient tends to be gentle. The energy dissipation capacity of mixed fiber column is better than that of polypropylene fiber column.

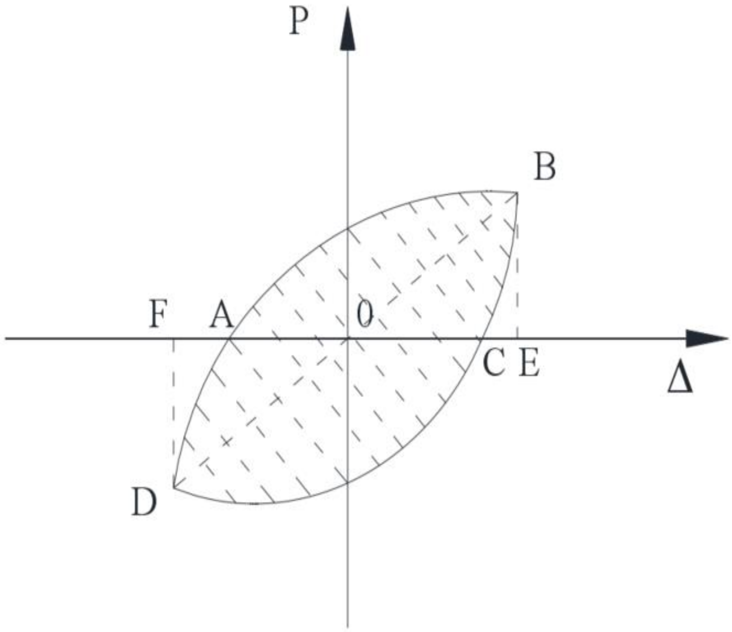

Fig.10 Equivalent viscous damping coefficient calculation sketch map

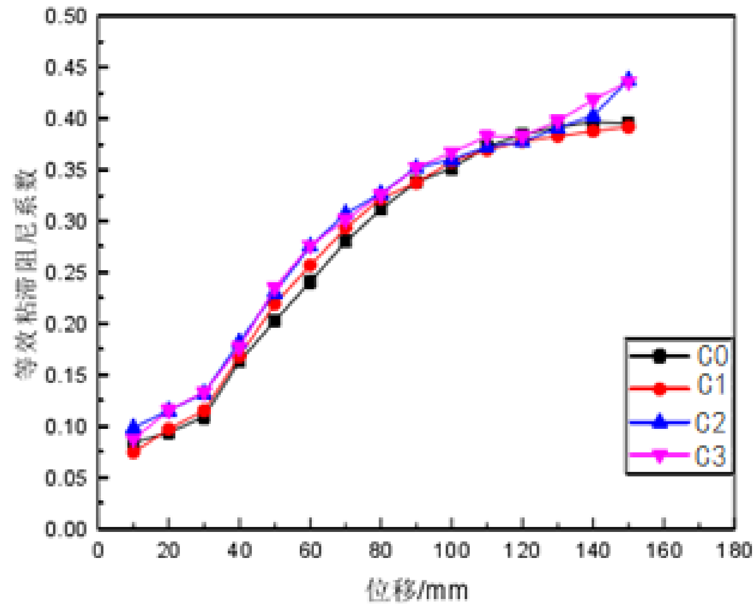

Fig.11 Comparison of equivalent viscous damping coefficients

4. Conclusion

In this paper, four different steel fiber reinforced concrete box column models are designed and their seismic performance is analyzed by ABAQUS finite element software. After the finite element software simulation results are obtained, the changes of bearing capacity, deformation, ductility and seismic energy dissipation of the box column model are analyzed through the hysteretic curve, skeleton curve and ductility coefficient of the model. The results are as follows:

1) The seismic capability of hybrid fiber reinforced concrete box column is obviously stronger than that of steel fiber reinforced concrete box column without polypropylene fiber. The addition of polypropylene fiber improves the bearing capacity, deformation, ductility and energy consumption of box columns. The addition of polypropylene fiber inhibits the generation and development of cracks, and then delays the failure process of the box column. The fiber pulling out and breaking consumes a lot of energy and improves the seismic energy dissipation capacity of the box column.

2) The increase of fiber content has the most significant effect on the performance improvement of box column. The volume content of polypropylene fiber increases from 0 to 0.05%, 0.10% and 0.15%. The maximum bearing capacity of the model is not improved significantly, but the displacement ductility coefficient is increased by 6.9%, 9.8% and 14.9%, respectively. The results show that although polypropylene fiber has little effect on improving the bearing capacity of the component, it has remarkable effect on improving the ductility and seismic performance of the component.

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