Experimental Study on Seismic Performance of Collet Tenon

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Abstract. In Southeast Asia, the frequent occurrence of earthquakes makes the earthquake relief work after the earthquake extremely important. How to provide the simple ward and temporary residence in the shortest time is an urgent problem. In this experiment, a vibration platform equipped with two ranging sensors and two position five-way valve is built to simulate the actual earthquake situation. Place a tenon and mortise structure building and a control building on the shaking table. In addition to the building connection style, ensure that the other parameters of the two buildings are consistent. The Arduino design program is used to change the vibration frequency of the vibration platform and record the deformation degree of the building under different frequencies. The experimental result shows that compared with modern building, the seismic performance of tenon and mortise structure buildings is more prominent.

1. Introduction

1.1. Research background and significance
As we all know, ancient wooden buildings in China have experienced many earthquake tests in hundreds and even thousands of years, and they still stand. It is proved that it has good seismic performance. The tenon and mortise structure plays a rare role in earthquake resistance.

Now with the passage of time, the ancient traditional woodwork art of tenon and mortise gradually fades out of people's perspective and is replaced by modern reinforced concrete buildings. It is hoped that through the experimental study, the tenon and mortise structure can be more used in the earthquake relief and provide a timely shelter for the post disaster reconstruction. At the same time, I hope to inherit and carry forward the ingenuity art culture of Chinese traditional woodwork, and more people can understand the wisdom and strength contained in the tenon and mortise structure.

1.2. Research background and significance
The tenon and mortise node connection mode of ancient buildings in the Forbidden City is very rich. In terms of horizontal and vertical component connection, in addition to dovetail tenon, there are half tenon, collet tenon, pipe tenon, steamed bread tenon and so on. Refer to figure 1 for installation method of dovetail tenon.
In this experiment, it is obvious that the tenon and mortise node structure plays an indispensable role in earthquake resistance. But the disadvantage is that the structure of collet tenon model is too complex, which leads to its popularity and utilization rate in seismic application is far from that in modern wooden furniture.

The experiment in this paper chooses the collet tenon which is easy to assemble and relatively simple in structure as the research object.

2. Theoretical research and analysis

2.1. Experimental device
In this experiment, the collet tenon structure is selected, which has the advantages of durability, stability and good seismic performance. The table structure of the collet tenon is that four foot legs with tenon at the top, and close to the mortise at the bottom of the table. The structure of the collet tenon enables four legs to clamp the threaded rods and connect them into square frame. The angle between the case surface and the foot leg is not easy to change. Four legs can share the weight of the case evenly. As a result, this kind of structure is very strong and durable.

The model space specified in the experiment is "0.6m×0.6m×0.6m". According to the scale to reduce the building, with a height of "400mm" and a length of "500mm". As shown in Figure 2, the building of tenon and mortise seismic experiment is composed of eight collet tenons. The buildings in the control group were only fixed with some long strips of wood in the middle, as shown in Figure 3.
2.2. Experimental base platform
The whole structure is fixed together by hinge and corner code, and each part is closely connected with high durability. All the wood in this experiment is made of wood with a thickness of "3mm" and laser cut. The experimental building and vibration platform are shown in Figure 4.

3. Hardware system design
Use the air source to adjust the compressed air to the proper pressure through the pressure reducing valve. The opening and closing of the solenoid valve makes it stable at a certain frequency to ensure that the shaking amplitude of the building body is within the fluctuation range. The gas path diagram is shown in Figure 5.
4. Analysis and arrangement of experimental data

4.1. Relationship between vibration amplitude of different building platforms and shaking degree of buildings (without load)

![Graphs showing experimental data for different vibration frequencies](image)

Figure 6. The function image of 1hz-3hz collet tenon experimental data.

The experimental data is shown in Figure 6. Distance 1 represents the travel distance of the vibration platform, and Distance 2 represents the shaking degree of the building. The larger the value is, the greater the shaking degree is.

Through the comparison of the above three groups of data, it can be clearly seen that for the collet tenon building, the longitudinal comparative analysis of the distance 1 begins to shorten and change gradually with the increase of vibration frequency.

It can be seen from this that with the increase of frequency, the shaking amplitude of the building increases gradually, and the stroke decreases gradually.
4.2. Comparison of shaking degree and the seismic performance analysis of different buildings under different earthquake frequencies (5kg load)

Figure 7. The 1hz-3hz data function diagram of control group building.

Figure 8. The 1hz-3hz data function diagram of control group building.
From the data comparison between the two buildings in the figure, it can be seen that the distance trend of different buildings under different frequencies after the 5kg load test is not much different. Which shows that the stroke of the vibration platform is fixed, and the cylinder in the test does not produce too much error.

It is concluded that in the vibration frequency range of 1hz-10hz, the collet tenon can keep the building stable, and the building in the control group may shake violently or even collapse. From the analysis of Figure 8, it is found that the average value of the two distances reaches the peak between 7Hz and 8Hz, which is not in the 10Hz part with the highest frequency. The results show that the vibration amplitude is not only affected by the frequency, but also by the size of the building stroke.

5. Summary and Prospect

5.1. Generalization and analysis
In this experiment, the actual earthquake response is reduced in proportion. And a fixed base and vibration platform are built to keep the vibration frequency in the range of 1hz-10hz. The experiment only changes the connection between the beam column and the plane of the building, and keeps other factors the same. The relevant images are drawn and compared by acquiring the data recorded by the sensor from Arduino. In order to test the seismic performance of the collet tenon.

5.2. Conclusion
Through the analysis of the experimental data, it is found that with the increase of the vibration frequency, the stroke of the vibration platform is gradually shortened, and the shaking degree of the building body is gradually increased. Through the image comparison, it is found that compared with the control group, the collet tenon building is very stable in the vibration, and the shaking degree is small, which proves that it has good seismic performance.

5.3. Prospect
In the future experiments, we can explore the impact of stroke size on the seismic performance of the building without changing the good seismic performance of the collet tenon.

It can combine the collet tenon with other tenon and mortise structure, and analyze and compare its seismic performance.

The combination of the model materials of the collet tenon should be simplified as much as possible. To a certain extent, the optimized collet tenon model is applied to earthquake relief. The stable temporary hospital and disaster relief room are built in the disaster area, and it is easy to operate and assemble.

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