Study on the vibration performance of wooden floor coverings

Shiyang Liu*; Shuanzhong Li

Colleague of Civil Engineering, Lanzhou Jiaotong University, Lanzhou, 730000, China

*e-mail:1287651540@qq.com

Abstract. In order to explore the vibration performance of the wooden floor cover, the basic modal parameters of the structure are obtained on the basis of the on-site dynamic test, and the modal analysis of the wooden floor cover is carried out by finite element software to obtain the self-oscillating frequency, which is extremely close to that of the on-site dynamic test for comparison. On this basis, the vibration response of the wooden floor cover under walking load is analyzed. On the basis of finite element analysis, the experimental and calculated values for the vibration of the wooden floor cover match well, indicating that the method is suitable for the calculation of the self-oscillation frequency of the wooden floor cover with a certain degree of accuracy guarantee.

Keywords: Wooden floor; Vibration performance; Finite element analysis; Anthropogenic excitation.

1 Introduction

Wooden floor cover is an important component of wood structure, which is widely used in the United States, Canada, and Japan because of its environmental friendliness and energy saving, high construction efficiency, and good seismic performance compared with concrete floor slab. However, due to the light weight of the wooden floor cover, vibration often occurs in the actual use process due to the occupants walking, jumping and other life behaviors. Domestic and foreign engineering researchers and designers have done a lot of research work on such problems. In this paper, a study has been done on the vibration response of wooden floor cover by anthropogenic excitation.

Chang et al.[1]measured vibrations of various wood flooring systems in Europe and found differences in the dynamic response of these floors. Zhou Haibin[2] summa- rized the progress in the research on vibration suitability design methods for wooden floor covers, and pointed out the problems of the current design codes for wooden floor covers and the development direction of the vibration research of wooden floor covers. Guo Ting[3] carried out the dynamic characterization and human induced vibration analysis of a three-story column network structure of a standalone building in a Ti- betan-style corridor structure. Zhang Yan et al.[4] identified

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P. Liu et al. (eds.), *Proceedings of the 2024 5th International Conference on Civil, Architecture and Disaster Prevention and Control (CADPC 2024)*, Atlantis Highlights in Engineering 31,
https://doi.org/10.2991/978-94-6463-435-8_45

the modal parameters of the floor slab structure of a typical Tibetan ancient building under crowd loading.Dai et al.[5] carried out on-site measurements of the dynamic characteristics of a typical Tibetan ancient corridor structure, and obtained the in-plane and out-of-plane vibration characteristics of the wooden frame and the vertical vibration characteristics of the floor slab.

In summary, the vibration performance work of wooden building cover structure based on dynamic testing is less studied, and numerical modeling work based on vi-bra- tion performance has not been carried out. In order to further reveal the vibration char- acteristics and human-induced excitation response law of the wooden building cover, this paper carries out experimental research on the dynamic characteristics of the wooden building cover under natural excitation and the vibration performance under pedestrian excitation. In order to provide basic data and reference basis for the study of the vibration characteristics and human-induced excitation response of the wooden building cover. Numerical models are used to compare and analyze their measured data to verify the accuracy of the data.

2 Overview of the experiment

2.1 Structural design of wooden floor cover

The actual view of the wooden floor cover structure is shown in Fig.1.

Fig. 1. Actual view of wooden building cover structure

2.2 Material properties

Wooden floor cover is composed of wooden floor slabs, wooden secondary beams and wooden main beams, after reviewing the relevant information and specifications, its timber is used for pine squares, wooden floor cover in the mechanical properties of the load-bearing panels and the expansion properties of the requirements of the modulus of elasticity is taken to be 3,500MPa, Poisson's ratio of 0.37, density of 640kg / m^3.

WDW-50 microcomputer-controlled electronic universal testing machine was used to analyze the me-chanical properties of materials for pine and fir wood. The test was carried out in accordance with the "wood bending test method" GB/T1936.1-2009.

2.3 Modal test

In this paper, the experimental test of the pickup oscillator using 941B type, its sampling frequency is set to 128Hz, the sampling time is taken as 1200 s. The data acquisition instrument uses the INV3062A type 24-bit network distributed 16-channel intelligent acquisition instrument. The acquisition software uses DASP software. The digital signal output through the software is used as the raw data of the test for subsequent analysis.

2.4 Anthropogenic vibration test

The excitation load in the anthropogenic vibration test is divided into single person load and multi-person (2, 3, 4 persons) load. The human-induced excitation load frequency is generally 1.5~3.5Hz, for this reason, three types of slow walking step frequency1.7Hz, normal walking step frequency 2Hz, and fast walking step frequency 2.3Hz are set to study the vibration of the building cover under different loading frequencies and loading types. Anthropogenic loads are applied to study the vibration response of the building cover under different number of pedestrians.

2.5 Measurement point arrangement and measurement

Arrange the measurement points in the possible vibration pattern of the wooden floor cover and the position where a large acceleration response may occur, and the acceler- ation sensor arrangement scheme is shown in Fig.2.

In order to test the influence of vibration characteristics of the wooden floor cover structure, the measurement points of this test are laid at the main beams, secondary beams and the plate of the structure, with a total of 75 measurement points. the whole test is divided into four working conditions for modal test by setting reference points.

Condition D: overall vibration of the structure at 75 points.

Observe wooden beams and wooden floor, wooden beams and wooden beams between the constraints in the process of change in the change rule of the vibration characteristics of the wooden floor cover. In the human vibration test, the measurement point arrangement as shown in the figure, observe the human vibration situation changes in the process of wooden floor cover vibration characteristics of the change rule.

3 Modal test results and their analysis

The frequency domain identification method is used to obtain the modal frequencies of the wooden floor cover structure for comparative validation. The first 5 orders of self- oscillation frequencies for Case D are shown in Table. From Table 1, it can be seen that the measured first-order self-oscillation frequency is slightly lower than the SSI and IIR methods, which is due to the influence of the external environment, the vibration signal pre-processing will be filtered out of noisy waveforms, resulting in a slightly lower self-oscillation frequency,but the overall self-oscillation frequency is still basi- cally similar, but also verifies the accuracy of the self-oscillation frequency of the wooden floor cover structure obtained by the fre-quency domain identification method.

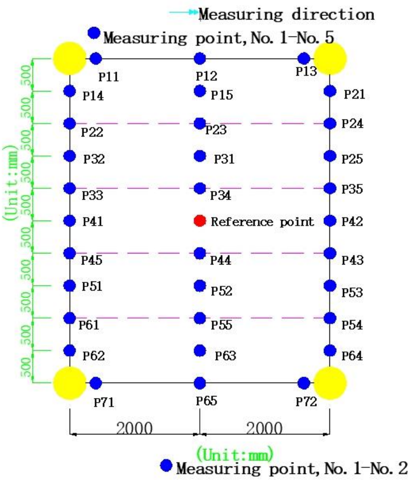


Fig. 2. Acceleration sensor arrangement under natural excitation

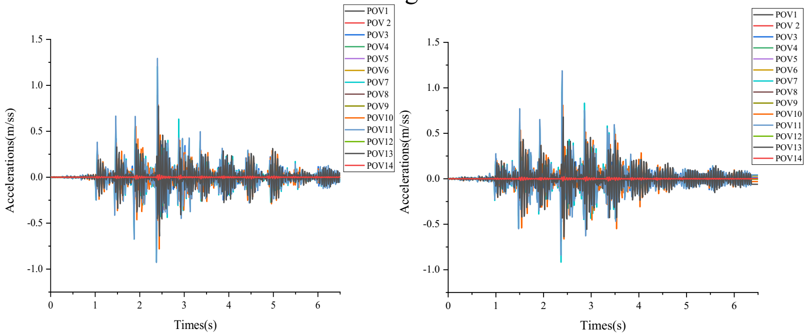
Table 1. First 5 orders of self-oscillation frequency

Amphibious	Overall-SSI(Hz)	Overall-IIR (Hz)	Overall-test(Hz)
1	15.528	16.375	14.375
2	18.107	18.490	18.375
3	22.038	21.459	21.500
4	26.489	25.813	25.875
5	33.142	33.251	33.250

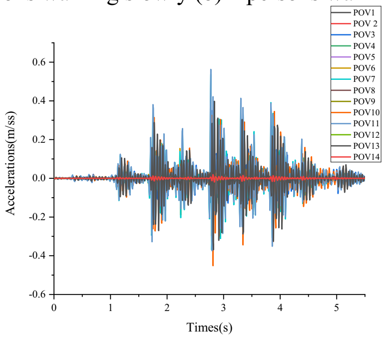
4 Anthropogenic vibration test results and their analysis

4.1 Vibration response for different number of pedestrians

In order to investigate the effect of different numbers of pedestrians on the vibration response of the wooden building cover, single, two and three person tests were con- ducted in Route 1 and Route 2, and the acceleration responses are shown in Fig.3 and Fig.4. As can be seen from the figures:1) The vibration response at each measurement point increases significantly when the number of pedestrians increases from one to two for both horizontal and vertical walking. However, when the number of pedestrians in-creases from two to three, the RMS acceleration remains almost constant. This indi- cates that the rela-tionship between the number of pedestrians and the vibration response of the building cover is not line-ar.2) The acceleration of the wooden build-ing cover during multi-person excitation is consistent with the results of single-person excitation, but the time-range curve of acceleration response is smoother because of the uncoordi- nated nature of crowd walking.

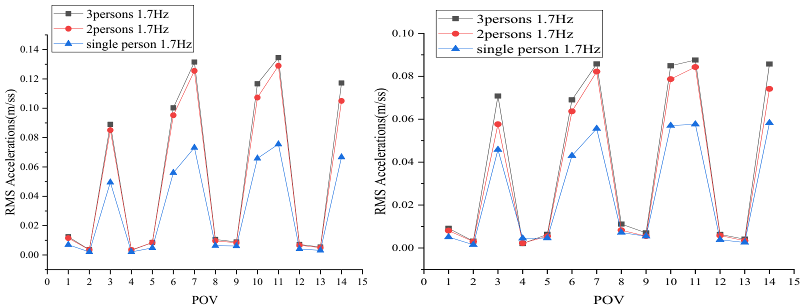


(a) 3 persons walking slowly (b) 2 persons walking slowly



(c) Single slow walk

Fig. 3. Acceleration time-range response for different number of pedestrians



(a)Route 1 (b)Route 2

Fig. 4. Acceleration for Different Number of Pedestrians

5 Comparison of Finite Element Modeling and Measured Results Analysis

The finite element software ABAQUS is used to establish the three-dimensional solid unit model of the wooden floor cover, as shown in Fig.5.

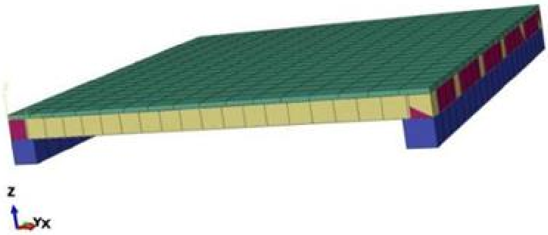


Fig. 5. Finite element model of wood floor cover structure

5.1 Finite element modal parameter identification analysis

A total of modal analysis calculations are performed on the established finite ele-ment model. Modal calculations were performed on the finite element model of the wooden floor cover structure to obtain the first 5 orders of modal parameters of the model vibration. The results of modal calculations are shown in Table 2.

Table 2. Modal calculation results

Modal	1	2	3	4	5
Self-oscillation Frequency(Hz)	15.791	18.924	22.749	26.499	30.898
Self-oscillation cycle(s)	0.063	0.053	0.044	0.038	0.032

From Table 2, it can be seen that as the modal order increases, the self-oscillation frequency increases and the self-oscillation period decreases.

5.2 Comparison of Finite Element and Measured Results Analysis

The model analysis adopts the ideal complete wooden building cover model, the model analysis adopts the homogeneous continuum to simulate the wooden building cover, and the wooden building cover structure has the existence of plate joints, this phenom- enon will weaken the structural stiffness, which will also lead to the measured value and the model calculation results of the difference. However, by comparing the varia- tion rule of measured and calculated modal values of each order, the analytical model can still accurately reflect the structural dynamic characteristics of the building.

6 Conclusion

(1) With the increase of the frequency of human-caused excitation and the in-crease of the number of people, the peak acceleration of the wooden floor cover gradually in-creases; the load is more obvious to the lateral human-caused excita-tion, so it is neces- sary to pay more attention to the control of the number of people loaded.

(2) Based on the finite element model and experimental model measured calculation results comparison, finite element model and experimental model to get the first five orders of vibration law phenomenon is basically the same, and for the wooden floor cover vibration, experimental values and calculated values match well, indicating that the method is suitable for the calculation of the self-oscillation frequency of the wooden floor cover, and there is a certain degree of accuracy guarantee.

(3) Subsequent studies should consider more factors for artificial excitation, such as vibration response under different forms of load distribution. Random walking of pedestrians on its vibration response.

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