



Dynamic Characteristics of Historic Noshiro City Assembly Hall, Japan

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Carlos Cuadra, born 1959, received his civil engineering degree from the National University of Engineering, Lima, Peru. He worked for Tohoku University, Sendai, Japan before becoming Associate Professor at the Akita Prefectural University of Akita, Japan. His main area of research is related to structural mechanics.

Summary

In this research, a historical wooden structure was selected as target building to estimate its dynamic characteristics based on in-situ ambient vibration measurements. Also, finite element model was constructed considering the special characteristics of wooden frame joints by assigning a rotational stiffness at ends of structural elements. In general good agreement was observed between measurements results and analysis results.

Keywords: Ambient vibrations, wooden structure, Fourier analysis, finite element method, natural frequency of vibration, modes of vibration.

1. Introduction

In this study, the Noshiro city assembly hall was selected as target structure to estimate its dynamic properties as a first step for its repair and conservation. This building constructed in 1950 has been declared local cultural heritage building, and its structure corresponds to traditional wooden construction.

Measurements of ambient vibration for the target building were planned and undertaken by author to identify mainly its predominant frequency of vibration. Ambient vibration measurements combined with finite element method of analysis provided a valuable basis for evaluation of the dynamic characteristics of the selected historic wooden structure.

2. Target structure

The selected structure (Fig. 1) for this research corresponds to the Noshiro city assembly hall, located in Akita prefecture, in the north part of Japan.



Fig. 1: Façade of Noshiro city assembly hall



Fig. 2: View of main chamber.

Dimensions of the building are 20 m in front by 29 m in side direction. Fig. 2 shows a view of the interior of the assembly hall located at first floor.

3. Ambient vibration measurements

Since it is assumed that wooden structures are flexible, dynamic characteristics of this type of building can be estimated from Fourier spectrum analysis of signals recorded at upper floors.

Average values of 4.86 Hz and 3.09 Hz are obtained for longitudinal and short directions respectively. Average value for the frequency of torsional mode is 6.41 Hz.

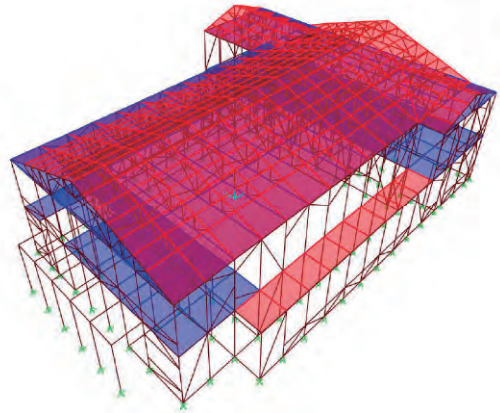
4. Finite element model

To compare the characteristics obtained from ambient vibration measurements with analytical results, finite element method is employed to formulate an analytical model

Finite element model consists of 2327 frame elements for main structure including roof truss and 400 area elements for slabs and roof.

To construct the FEM model, characteristics of the joints must be estimated considering that the joints present partial stiffness. Joints are modelled with specific rotational stiffness.

From analytical results frequencies of 4.55 Hz, 3.88 Hz and 5.50 Hz were obtained for vibration in longitudinal direction, short direction and torsional respectively.



5. Conclusions

Ambient vibration measurements have been successfully employed to determine the dynamic characteristics of historic Noshiro city assembly hall. Analytical model was formulated using finite element method to verify measurement results and to identify modes of vibration of target structure. Normal modes of vibration in the two main horizontal directions and torsional mode of vibration were identified from measurements and confirmed by analytical results

The analytical model will serve to investigate the response of target structure without administrative part which will be the case when this portion of the structure will be demolished.

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