

## Structural Dynamic Characteristics Test for a Three-story Building in Beijing

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**Abstract**—Ambient dynamic test is applied to a 3-story building in Beijing and system identification is adopted to obtain the natural dynamic characteristics. The amplitudes of time histories recorded by different seismometers are compared. They increase with the floor number and two horizontal amplitudes are larger than the vertical one. Spectra analysis indicates that the spectra values of the recordings on the third floor are bigger than lower floors and Fourier spectra for vertical signals are relatively clearer and more remarkable than two horizontal recordings. Analysis suggests that ambient test is a useful tool for structural system identification.

**Keywords**—ambient test; fourier spectra; natural characteristics; system identification

### I. INTRODUCTION

Ambient test for a building is referred to the dynamic test when vibration of the building is excited by the environment. It is usually an effective method to identify the natural characteristics for structures and buildings. Ambient test is applied to the buildings with useful earthquake data recorded and dynamic characteristics identified from the recordings are used to compare with the information from the earthquake data (Kohler, et al, 2005). By compositing the natural characteristics obtained from system identification of ambient and earthquake, the actual measurements are introduced to update the numerical simulation models until

they are consistent with real structures (Skolnik, 2005). Therefore, the ambient test is considered as the basis of dynamic load tests and carried out on various buildings and bridges (Ren, et al, 2004; Wang, et al, 2011; 2015).

### II. BUILDING PROFILE AND TEST ARRANGEMENT

The building for test is located at Chaoyang District in Beijing. According to the Code for seismic design of buildings in China (GB 50011-2010), the seismic fortification intensity on its site is VIII and design basic earthquake acceleration value is 0.20g (g denotes acceleration of Gravity). It is a brick and concrete structure. The building has three floors, two over-ground floors and one underground floor, as shown in Figure 1. After communication with the owner, the final test plan was made based on the structural characteristics. An Etna Digital Recorder was respectively instrumented on geometric center of the third floor, the second floor and the first floor. It is a 3-channel recorder, with two horizontal sensors and one vertical sensor. The layout of the seismometers is shown in Figure 1 as well. For high accuracy, twice tests are recorded on the third floors. This instrument is a good cost-performance strong motion seismometers meeting the requirements of the broad seismic monitoring with excellent resolution in signal fidelity and data integrity. It also can be applied in seismic observation with large dynamic range.

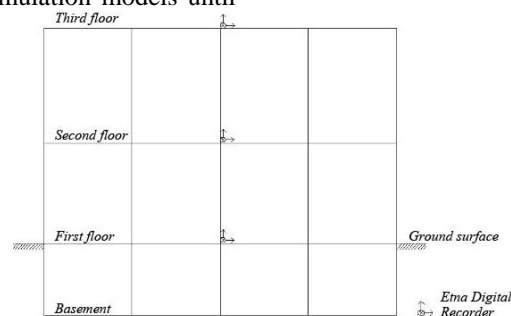


Figure 1. Building profile and layout of Etna digital recorders

### III. SEGMENTED TEST RECORDINGS

After in-situ ambient test, the time histories of the data recorded on different floors are shown in Fig.2. They respectively are time histories recorded on the first floor, the second floor, test 1 and test 2 on the third floor. The amplitudes enlarge with the increase of floor number.

These data are segmented and data of relatively smooth segment are selected to analyze identifying the dynamic characteristics of this building. To better demonstrate the different frequency components included in the building vibration, the fast Fourier transform is used to convert the signal into frequency domain signals. It is of more convenience to obtain the predominant frequency of the building. The Fourier spectrum plots are computed and they are indicated in Figure 3 and Figure 4. Among Figure 3, Fourier spectra in three directions including E-W (east-west), N-S (north-south) and U-D (up-down) on the first, the second and the third floor are respectively illustrated in the upper, the middle and the bottom plots. As indicated in Figure 4, Fourier spectra in E-W, N-S and U-D on three floors are respectively listed in the upper, the middle and the bottom plots.

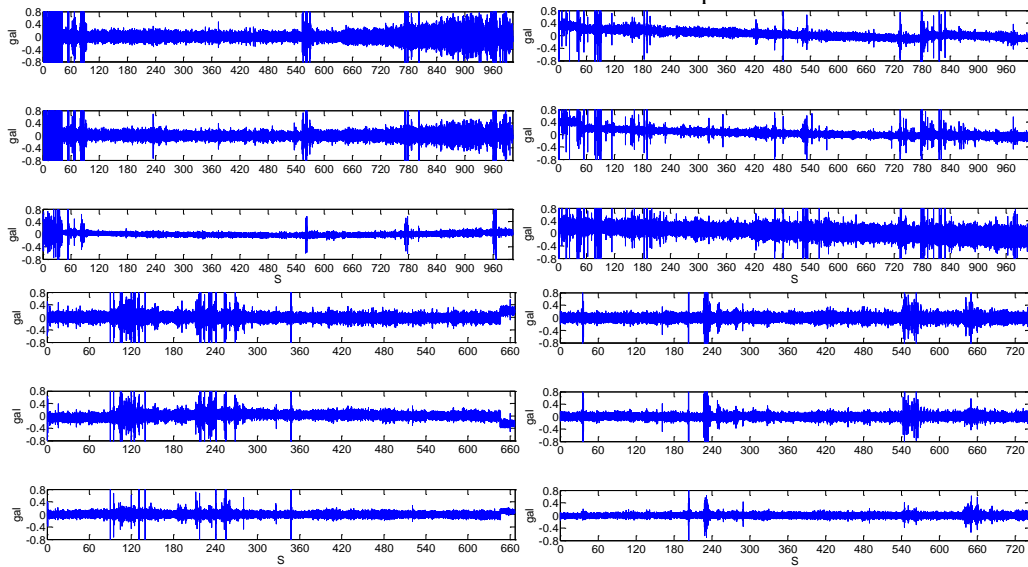


Figure 2. Three-channel time histories recorded on different floors (Upper left: First floor; Upper right: Second floor; Left bottom: Test 1 on the third floor; Right bottom: Test 1 on the third floor)

### IV. SPECTRUM ANALYSIS

As shown in Figure 3 and Figure 4, the amplitude of Fourier spectra increases with the floor number and it reaches the maximum on the third floor in every direction. It is also suggested that frequency contents on the third floor is clearer and the horizontal spectra shapes are complicated than vertical spectra. The frequency corresponding to the amplitude of the horizontal direction on the third floor is significantly higher than that of the first floor and the second floor. There is no significant amplitude difference in the U-D direction. This is because that the data in E-W and N-S on lower floors are disturbed by environment noises, like winds. However, the vertical signal is less affected. Therefore, the frequencies obtained from Fourier spectra are not consistent in different directions on three floors.

To facilitate fundamental period analysis, recordings of test 1 and 2 on the third floor are further computed. A suitable low-pass filter is designed to highlight the predominant frequency content of the building, as demonstrated in Figure 5. The fundamental frequency obtained from data of test 1 and 2 is mainly concentrated at 5.0Hz and the period is concluded as 0.2sec.

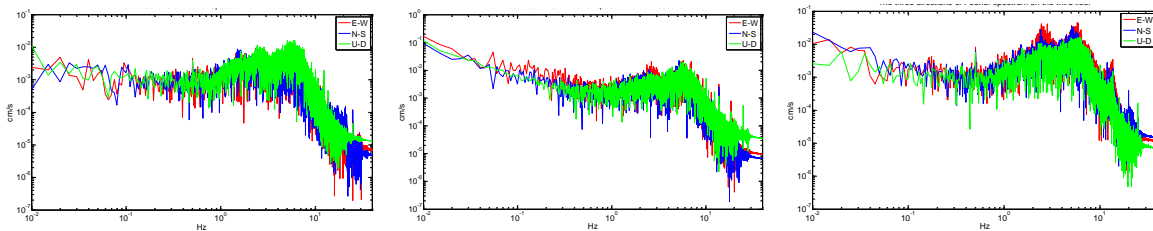


Figure 3. The Fourier spectrum plots in E-W, N-S and U-D directions on the first, the second and the third floor

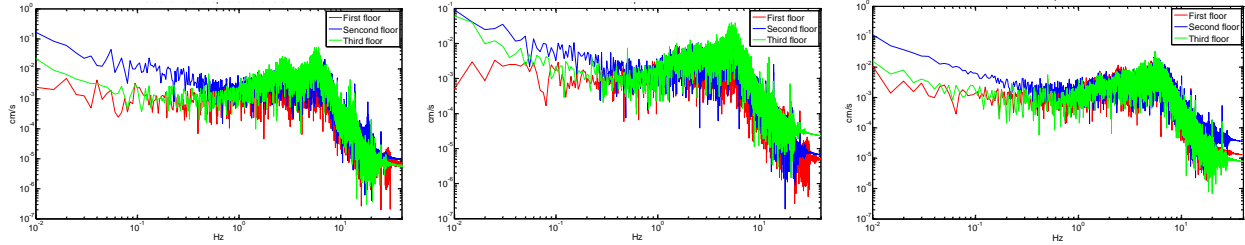


Figure 4. The Fourier spectrum plots in E-W, N-S and U-D directions on three floors

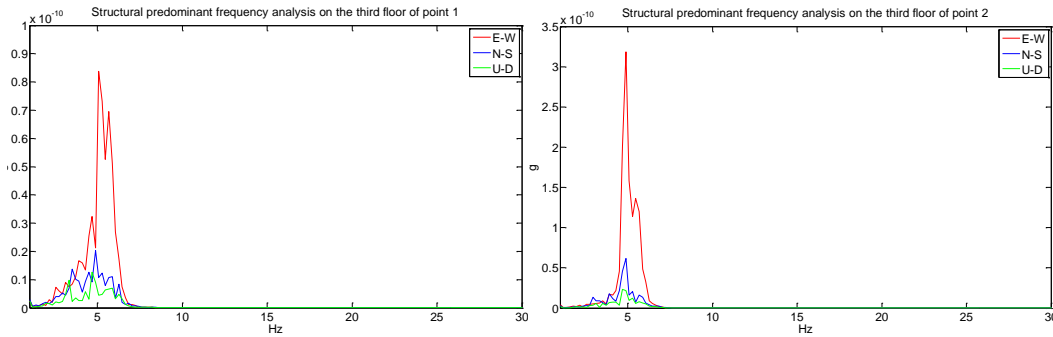


Figure 5. Fundamental frequency analysis based on Fourier spectra

#### V. CONCLUSION

Ambient test is carried out on a building in Beijing and natural dynamic characteristics are identified from the test recordings on different floors. Waveform analysis indicates that vibration amplitude increases with the increase of floor numbers. The amplitude in E-W direction is slightly larger than that in N-S direction and the amplitude in U-D direction is minimal. Spectrum analysis suggests that the fundamental natural period of this building is 0.2sec, which is basically identical with the statistical values of the natural vibration period for three-floor buildings. This practice states that ambient test is an effective method for the dynamic characteristics identification of structures and buildings.

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