Dynamic characteristics of a RC building on Niigata University Campus during the 2011 off the Pacific coast of Tohoku Earthquake and microtremor measurements

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SUMMARY:
The strong motions are observed in a five-story reinforced concrete building on Niigata University Campus during the 2011 off the Pacific coast of Tohoku Earthquake. The records are longer than for 700 seconds. We calculated the spectra ratios of Fourier amplitude spectra of roof floor and first floor for each 40.96 seconds acceleration record. The natural period of a building changes during the earthquake. During high acceleration, the natural period of the building is longer. After acceleration is decrease, the period returned to the original.
We also conduct microtremor observation in same building. The amplitude level changes in all seasons. We compare a natural period with meteorological conditions such as temperature, wind speed and wave height. The changes of natural period are correlated with temperatures. The natural period is more longer in low winter temperatures. Wind speed and wave height was low correlation with the period.

Keywords: Reinforced Concrete Building, Strong motion observation, Microtremor observation

1. INTRODUCTION

A strong motion observation system in a building was operated by our laboratory of Architectural course, Niigata University since 2001. The observation records during the 2004 Niigata-ken Chuetsu Earthquake and the 2007 Niigata-ken Chuetsu-oki Earthquake had also recorded in the past. The building is five-story Reinforced concrete building and there is three observation points that it roof floor, first floor and free field near the building. The 2011 East Japan Earthquake has triggered roof floor and ground level. The building was not damaged by these earthquakes. We also conducted microtremor measurements in this building for eleven times in year 2010. We discuss dynamic characteristics by these records.

2. OVERVIEW OF THE BUILDING

There is the observation system in Building-E of School of Engineering on the Niigata University Campus, Niigata. The building-E is five-story reinforced concrete structure with piles which was built in 1982. The structure is moment resisting frame with shear walls. The building is separated from adjacent building by expansion joint. The Figure 2.1 shows first floor plan and view of the building. In the figure 2.1, a circle shows the place of first floor observation point and a triangle shows roof floor observation point. The direction of strong motion observation is not magnetic north-south and east-west but the longitudinal and the span direction of this building. (These directions term NS and EW for descriptive purposes in this paper)

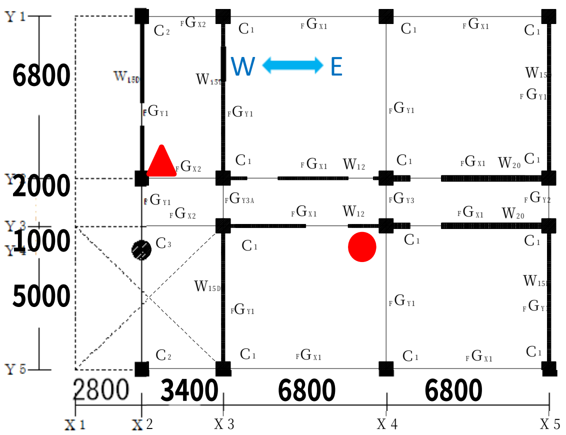


Figure 2.1 View of building and the first floor plan

3. OBSERVATION RECORDS DURING THE TOHOKU EARTHQUAKE

Strong motion records during the 2011 off the Pacific Coast of Tohoku Earthquake were observed at roof floor and free field by the building. Peak acceleration and peak velocity of each direction are shown in Table 3.1. Response spectra are shown in Figure 3.1 and time-history of acceleration record are shown in Figure 3.2 and 3.3. These are long period records and velocity is not decrease for long time. The duration of these records was more than 700 seconds, therefore the spectra using each 34 acceleration records for 40.96 seconds as running spectra were analysed. In Figure 3.4 shows running spectra of Fourier spectra and in Figure 3.5 shows running spectra of the spectra ratio of roof floor to ground revel. The numbers in the right of the Figure are start time of each 40.96 seconds record for spectrum. The peak period of spectrum ratio of roof floor to ground revel is natural period of the building. In the first part that is large acceleration part, the period of the building elongation is occured. The period in the last part of earthquake duration is return.

Table 3.1 Peak acceleration and peak velocity

		EW	NS	UD
Ground level by a building	Acceleration(gal)	37.8	30.5	14.0
	Velocity(cm/s)	14.9	12.2	6.69
Roof floor	Acceleration(gal)	67.3	58.3	14.7
	Velocity(cm/s)	14.1	13.7	6.41

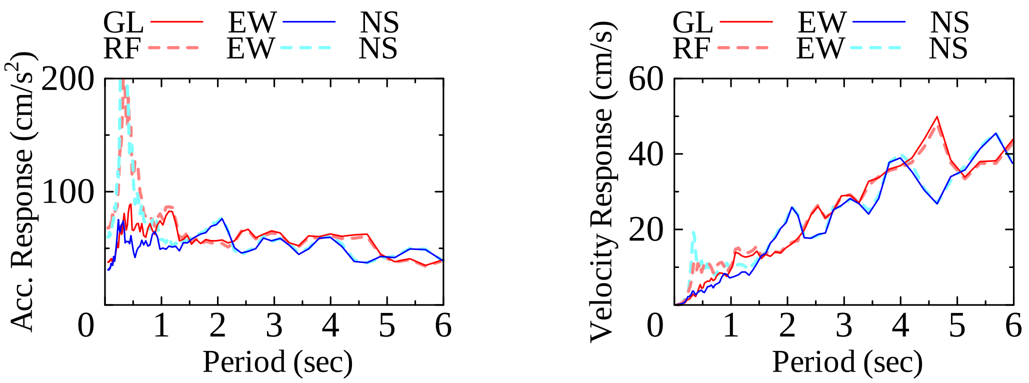


Figure 3.1 Acceleration and velocity response spectrum

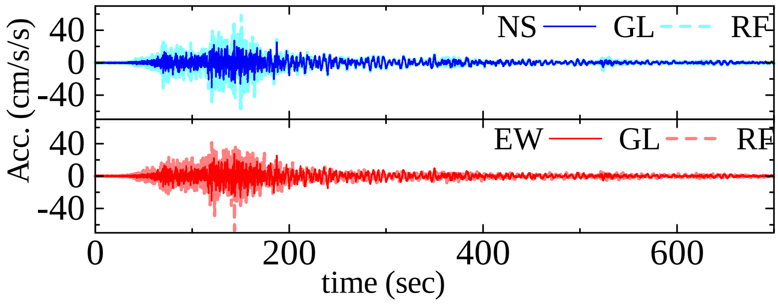


Figure 3.2 Accelerations for ground level (GL) and roof floor (RF)

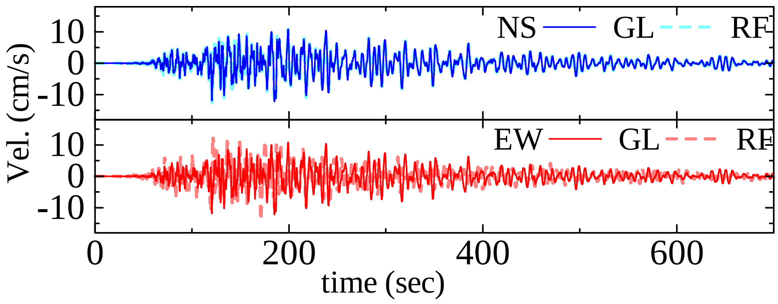


Figure 3.3 Velocity for ground level (GL) and roof floor (RF)

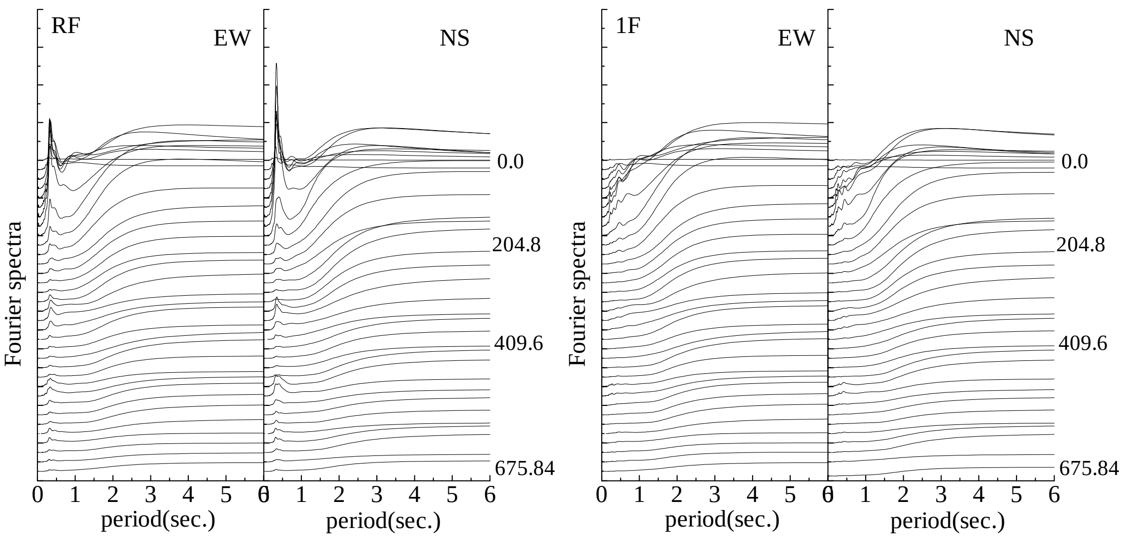


Figure 3.4 Running spectra of Fourier spectrum roof floor and ground revel

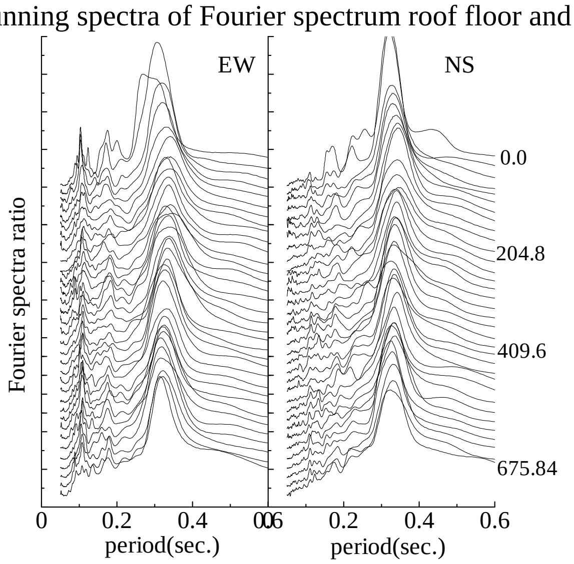


Figure 3.5 Running spectra of Fourier spectrum ratio of roof floor and ground revel

4. MICROTREMOR OBSERVATION

4.1. Microtremor observation throughout the year

In Niigata, amplitude of ground microtremor observation record tends to more large in winter. High wind speed and wave height in Japan Sea is the higher during winter in Niigata is expected as part of these reasons.

We conducted microtremor observation in this building throughout the year 2010 to compare with meteorological condition. The relation of natural period of the building to temperature, humidity, wind speed (Niigata Local Meteorological Observatory) and wave height in Japan Sea (NOWPHAS) shows in Figure 4.1-4.4. Figures in the left, periods using ground floor and roof floor records are shown. These are thought periods of soil-structure interaction system. Figures in right side, periods using first floor and roof floor records are shown. These are thought periods of upper structure. In winter, the natural periods become more longer with low temperature. But, it is low correlation between natural period of the building and wind speed and wave height.

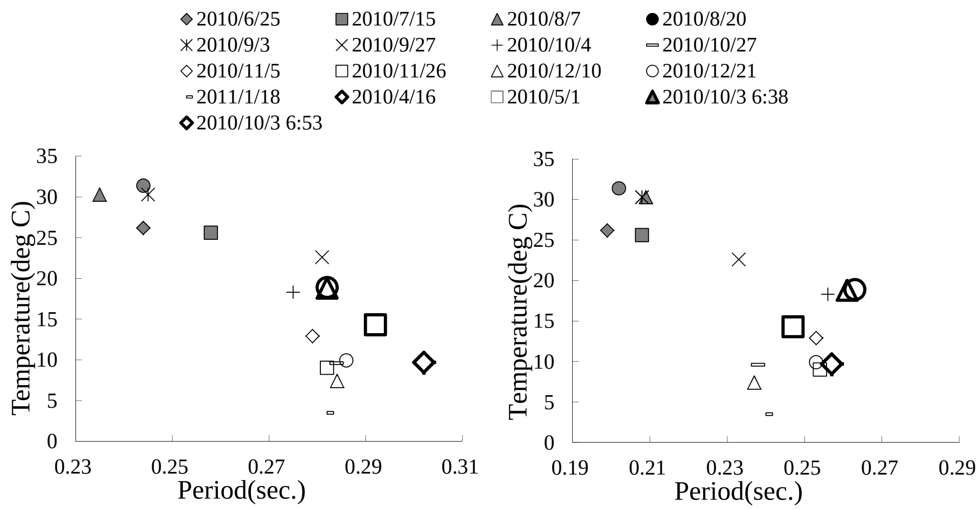


Figure 4.1 The relation of period to temperature

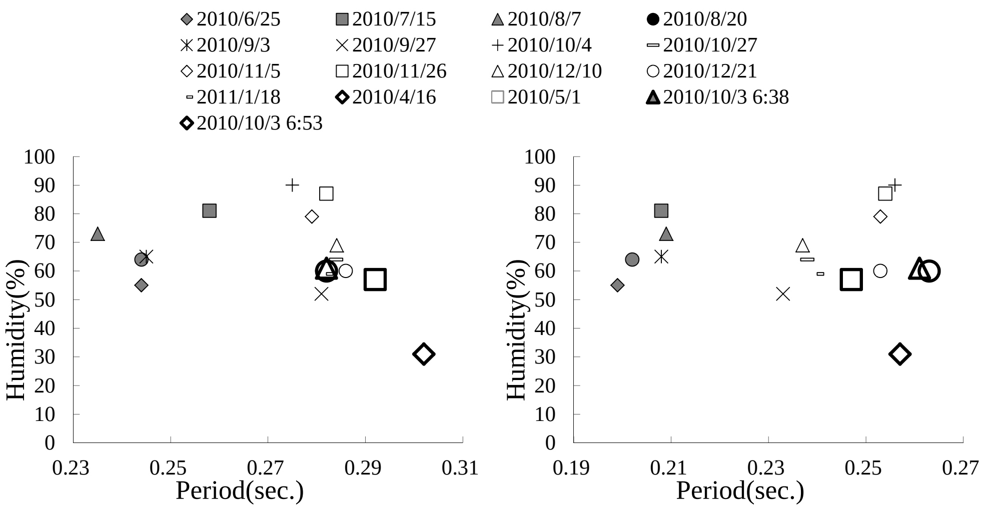


Figure 4.2 The relation of period to humidity

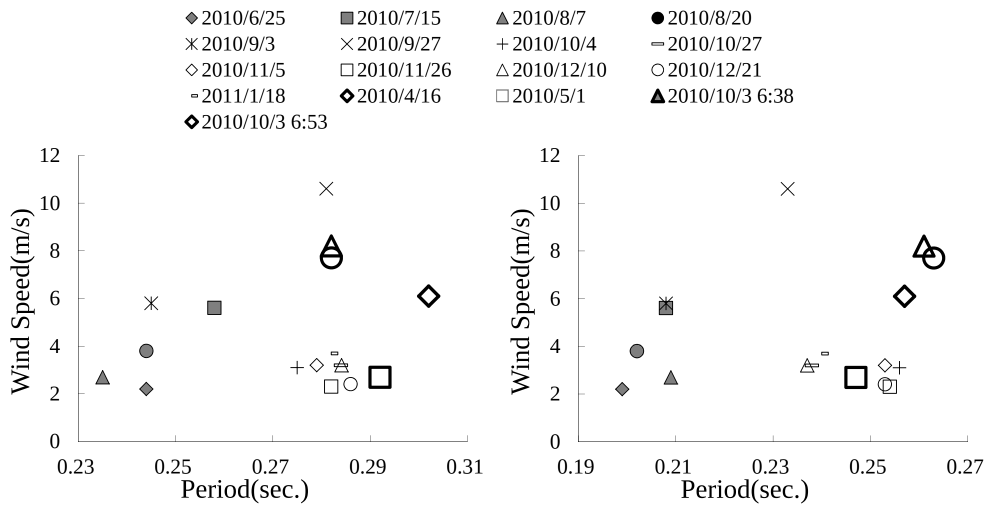


Figure 4.3 The relation of period to wind speed

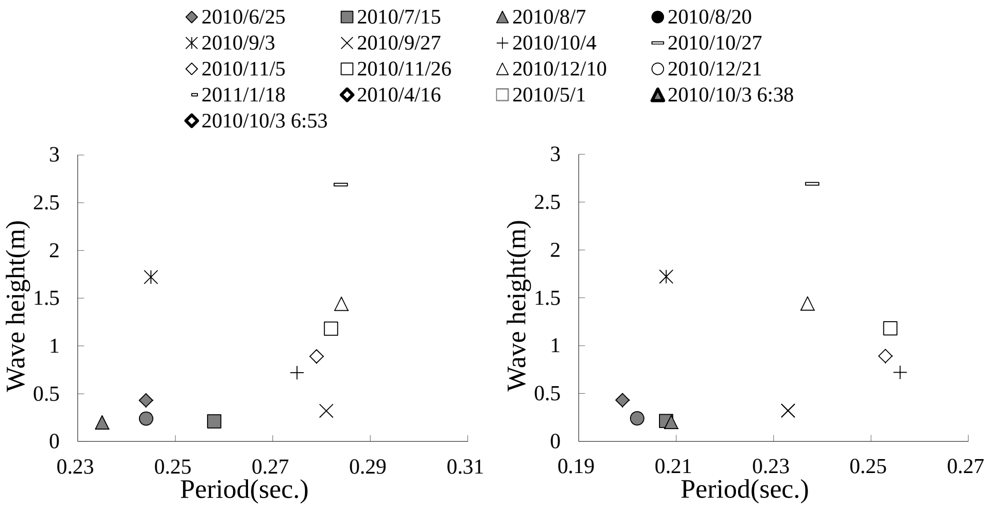


Figure 4.4 The relation of period to wave height

4.2. Comparison of Fourier spectra ratio and H/V spectra

To identify natural period of building, transfer function of ground level or first floor and upper floor was used. Consequently, it needs at least two sensors in a building. Although the theoretical understanding should be speculated separately, we examined one alternative to estimate building natural period using H/V spectrum by reference to previous study (Nagao 2010). Figure 4.5 shows Fourier spectra (above) and H/V spectra with Fourier spectrum ratio (below). Two spectrum ratios which were divided roof floor spectra by ground level spectra (RF/GL) and first floor record (RF/FL) are shown. Most of peak period of H/V spectrum is close to the peak of RF/GL, the peak periods which are in January, October and November are close to the peak of RF/FL. When microtremor observation record in building are more larger in winter, the peak of H/V spectrum tend to appear around the peak of Fourier spectrum ratio using first floor record(RF/FL) not only ground level record(RF/GL).

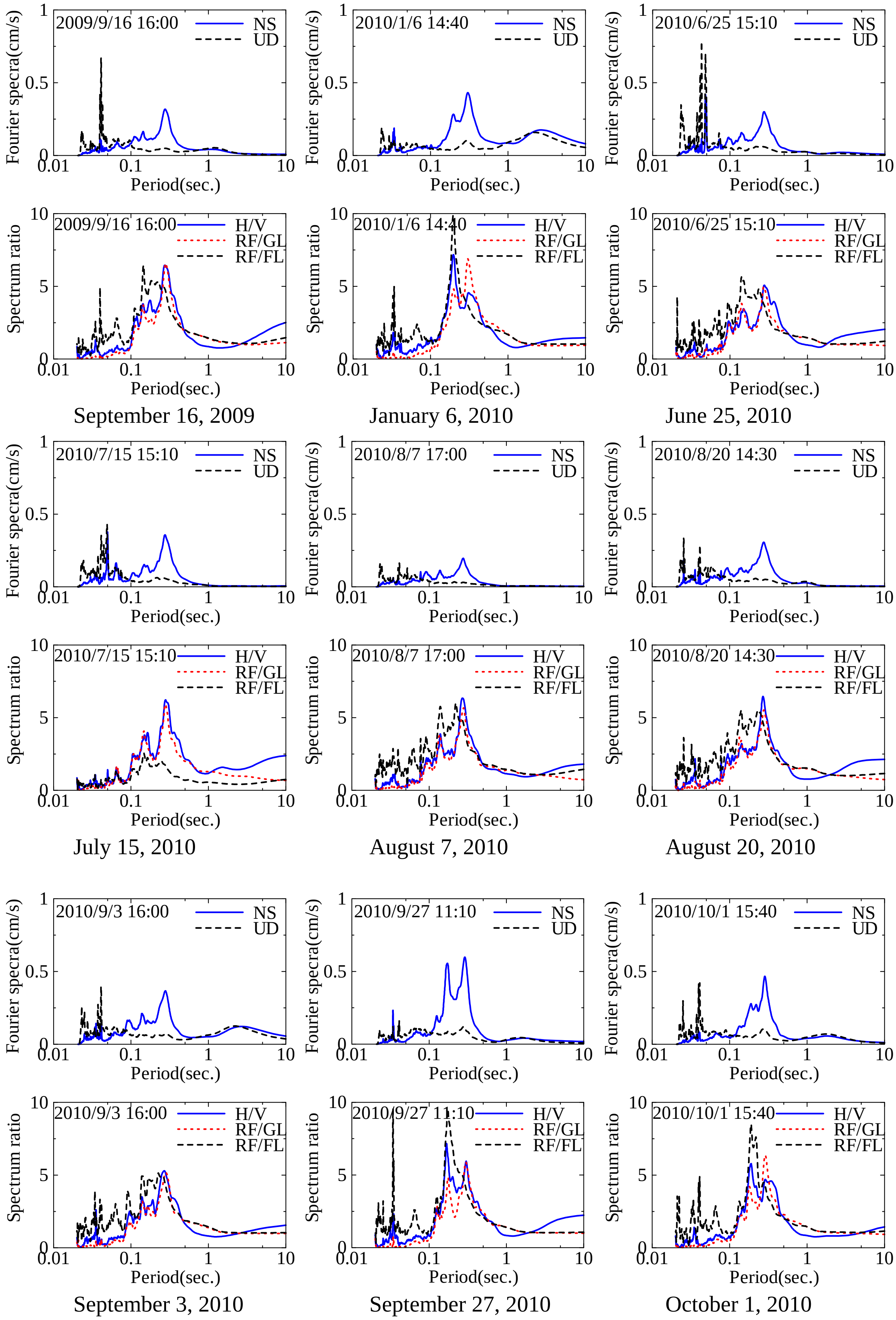
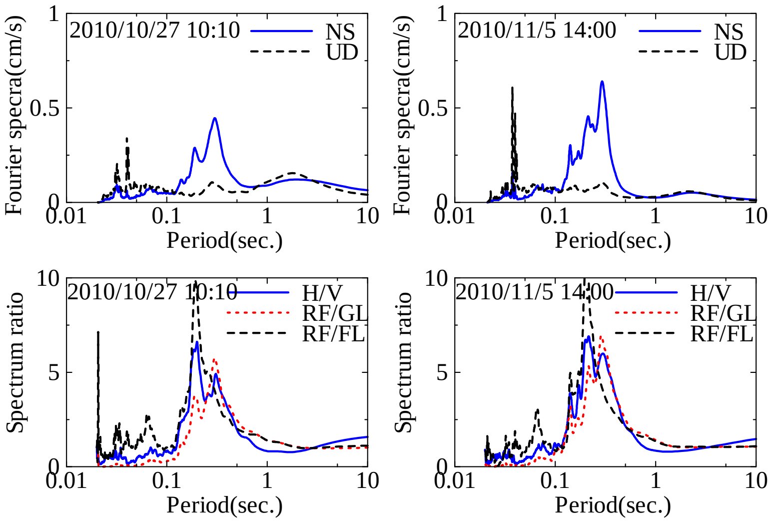


Figure 4.5 Fourier spectra (above) Fourier spectrum ratio and H/V spectra (below) (1/2)



October 27, 2010 November 5, 2010

Figure 4.5 Fourier spectra (above) Fourier spectrum ratio and H/V spectra (below) (2/2)

5. CONCRUSION

The dynamic characteristics of RC building on Niigata University Campus using strong motions during the 2011 off the coast of Tohoku Earthquake and microtremor measurement were investigated. The strong motion record was more than 700 seconds duration and included long period component. Running spectra of the spectrum ratio of roof floor to ground revel were shown. In the first part that is large acceleration part, the period of the building elongation is occurred. The period in the last part of earthquake duration is return. We conducted microtremor observation in this building throughout the year to compare with meteorological condition. The natural period of the building correlate with temperature. The alternative to estimate building natural period using H/V spectrum was examined.

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NOWPHAS The Nationside Ocean Wave Information network for Port and Harbours, http://www.mlit.go.jp/kowan/nowphas/

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