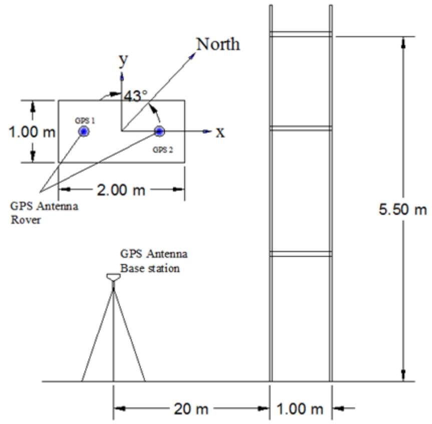

Fig. 3. Overview of the structure and position of the GPSs

4- Results

Fig. 4 shows the movement of the roof structure in global UTM system during 1600 seconds measured every tenth of a second by GPS in the X direction.

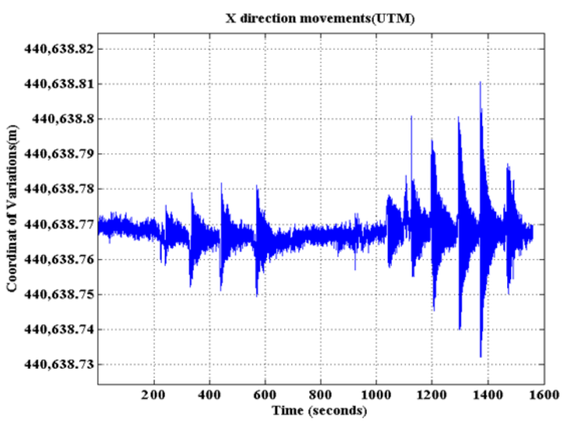

Fig. 4. Structural vibration in UTM system in the X direction

Fig. 5 shows the structural vibration in the X direction in the local system.

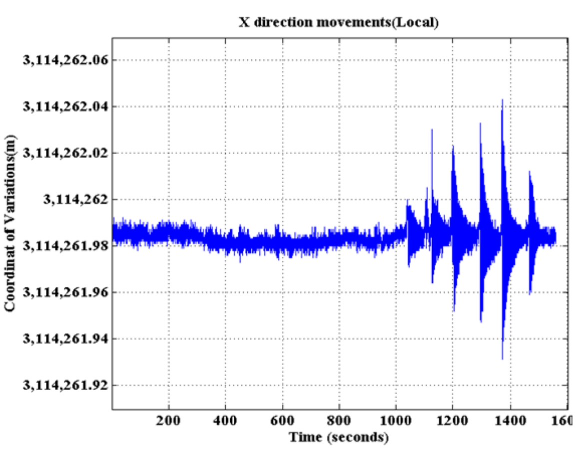

Fig. 5. Structural vibration in the local system in the X direction

4-1- Natural frequency. Using Fourier transform, the dominant frequencies were determined for each of the charts. Fig. 6 shows the Fourier spectrum in the X direction.

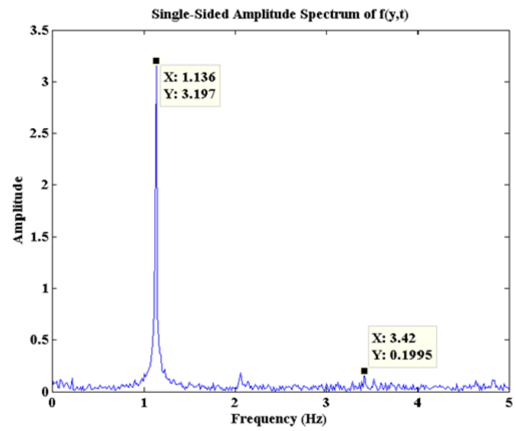

Fig. 6. Fourier spectrum in X direction

Table 1 represents the natural frequencies in two directions perpendicular to each other.

Table 1. Natural frequencies in two directions

natural frequencies (Hz)	First mode	Second mode
X direction	1.08	3.23
Y direction	1.14	3.31

4-2- Damping ratio. Damping ratio can be determined in two ways:

A- Logarithmic decrement method

B- half-domain method

Damping ratios are presented in Table 2.

Table 2. damping ratios in two directions

Methods	X	Y
half-domain	0.0087	0.0051
half-domain	0.0085	0.0041

The results from the analytical method are approximately the same as the experimental results. For example, the natural period in the X direction was determined to be 1.07 and 0.93 Hz using GPS and analytical methods. Comparing the results of the experiments and the results of the computer analysis shows good accuracy in determining the parameters.

Determination of Structural Dynamic Characteristics Using the GPS Device

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1- Introduction:

Structural dynamic characteristics: natural period, shape modes and damping ratio of vibration play a decisive role in the seismic behavior of structures. The time in full oscillation of the structure will be the natural period of vibration. The damping ratio is determined using logarithmic formulation. The seismic codes suggest empirical equations or mathematical models for calculation of dynamic characteristics of structures that are substantially approximate. There are several exact methods for determination of the structural dynamic parameters such as: free vibration, ambient vibration and force vibration tests. There are various means to record the vibrations of structures such as accelerometers, speedometers and displacement transducers. In experiments in which there is a significant acceleration in structural vibration, the accelerometer device is used to record the response of the structure. Otherwise the speedometer and displacement transducers are used. One way to measure the static and dynamic displacement is the use of Global Positioning System (GPS). Global Positioning System is a navigation system that is composed of a network of 32 satellites. In this research the structural response of a three-story building (the natural frequencies of vibration and the structural damping values) are monitored by a two-frequency GPS device mounted on the structure (Fig. 1).

Fig. 1. GPS receiver

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2- Methods for calculation of structural dynamic characteristics:

There are two groups of methods for determining dynamic characteristics of structures:
- Analytical method using software
- Experimental Methods

2-1- Analytical Method. In analytical method, the dynamic characteristics of the structures (time period and mode shapes) can be determined by solving the equations of motion for multi degree of freedom. Free vibration equations of motion for a system with N degrees of freedom are written as follows:

$$[M]\{\ddot{U}\}+[K]\{U\}=\{0\} \quad (1)$$

where [M] and [K] are the mass and stiffness matrix and U and $\ddot{U}$ are the displacement and acceleration vectors.

2-2- Experimental Methods. Experimental methods are divided into three groups: ambient vibration test, free vibration test and force vibration test.

In ambient vibration test the natural forces such as wind loads and exploitation loads are used as the stimulating forces.

In free vibration test, the vibration of the structure is created with drags and drops suddenly. After dropping, a vibration-free structure test is performed.

In the forced vibration test, the structure is induced by external force during vibration.

3- Test model

The model tested in this study is a three-story steel moment frame having 2 meters length, 1 meter width and 5.5 meter height (Figs. 2 and 3).

Fig.2. structural model overview