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EXPERIMENTAL DETERMINATION OF THE NATURAL FREQUENCY OF VIBRATION OF ST. STEPHANOS CHURCH USING AMBIENT VIBRATIONS

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In this study, we evaluated St. Stepanos church building to determine the natural frequencies in different parts of it. This church is located in Jolfa city in the north-west of Iran.

We recorded the microtremor data in different parts of the church from 09/17/2015 to 09/19/2015. Generally, seven records were recorded in the St. Stepanos church that just three records including the northern and eastern walls around of church and the Bell Tower building were used and the others were passed up because of having the excessive noise.

The microtremor data were analyzed using two methods. The first was J-SESAME software and the second was four-spectral method. The data were processed based on concept of transfer function and horizontal-to-horizontal spectral ratio in the both methods and finally the results of them were compared.

The SESAME project group to process microtremor data with regard to all the microtremor-processing considerations designed J-sesame software. The SESAME European group has also put forward a number of criteria for having a reliable curve and a clear peak, among which several are used as the main criteria for validation.

Figure 1. St. Stepanos church.

The power of the four-spectral method is the simultaneous use of the properties of four spectra: 1) the power spectral density function (PSD) at different points in the structure; 2) Cross Power Spectral Density (CPS) of each point to reference point; 3) Communication Spectrum (CS); 4) Their cross-phase spectra. The peaks of the PSD spectrum are selected as candidates for the modes frequencies, which at the above frequencies also have the CPS amplitude spectrum, secondly the values of the spectrum amplitude have large values (near the unit) and thirdly the cross phase spectrum having values near zero or 180 degrees.

The position of sensors for northern and eastern walls was shown in Figure 2.

Table 1. Characteristics of microtremors recorded in St. Stepanos church.

Records	Record Num.	Duration (min)	Quality
Case 1	1	10	Poor
Case 2	1	10	Poor
	2	10	Poor
Case 3	1	10	Poor
Case 4	1	10	Good
Case 5	1	10	Good
	2	10	Poor
Case 6	1	10	Poor
	2	10	Very good
	3	10	Very Good
Case 7	1	10	Poor

Figure 2. Position of sensors for the northern wall (Case 4) (Left) and the eastern wall (Case 5) (Right).

Thus, the natural frequency of walls around the church is obtained 5.54 Hz (J-SESAME software) and 5.37 Hz (four-spectral method) in their weak direction. Also for the Bell Tower building, 9.49 Hz (J-SESAME software) and 9.17 Hz (four-spectral method) in NS direction and 7.17 Hz (J-SESAME software) and 7.16 Hz (four-spectral method) in EW direction. The results show that the frequencies obtained from the two methods are very close and are reliable methods for determining the vibration frequency of structures.

Some similar researches are Boukamp and Stephen (1966); The ambient and forced vibrations studies of the 60-stories Trans America building, Pakju (2012); determining dynamic characteristics of some concrete buildings in Tabriz city using measured micrometers, Morikawa et al (2013); dynamic behavior studies of two historical Armenian churches using measured micrometers.

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