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Non-damage Modal Parameter Variations on a 22 Story Reinforced Concrete Building

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ABSTRACT

The Chilean Construction Chamber Building has been instrumented with 12 accelerometers for ambient and seismic events since 1995. The structure is a 22 story reinforced concrete building structured with shear walls resting on gravely soils. More than 15 low level and moderate seismic events and several ambient vibration records have been recorded in the structure. One of the records is a continuous ambient record of 6 month. Area temperature, humidity, rainfall and wind velocity have been recorded together with local building vibrations. From these records the dynamic properties are identified using parametric and non parametric system identification techniques. Despite no damage has occurred the predominant modal frequency varies nearly 4% in average and damping also changes by more than 100% for earthquake events. For ambient vibrations frequency variations are in the order of 1%. The results give an initial indication of possible modal properties variations for non damaged typical reinforce concrete buildings.

INTRODUCTION

The Chilean Chamber of Construction is instrumented with a permanent network of 12 accelerometers connected to central recording system, Figure 1. Figure 2 presents the instrumentation layout and structure main characteristics. The instrumentation is able to record motions with amplitudes between 0.0001 up to 2 g in a bandwidth of 0.1 to 100 Hz. This network characteristic allows for the monitoring of ambient vibrations and strong seismic events. Since its installation in 1995 several earthquake records and ambient vibrations had been recorded in the building. During this time more than 15 minor and moderate events have been recorded. Table 1 show some of the events records and analyzed in this article.

Figure 1. Chilean Chamber of Construction

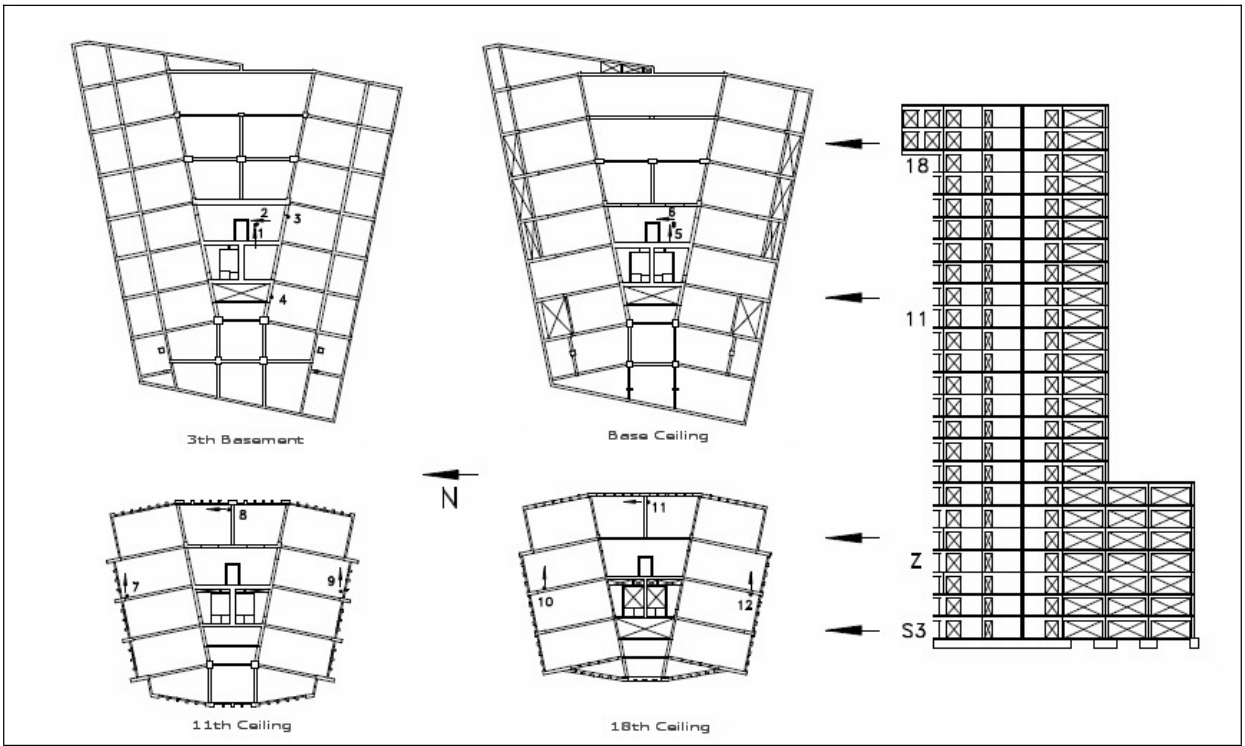

Figure 2. Sensor Location

Table 1. Earthquake Events

Event	Mag. Richter	Latitude	Longitude	Peak Ground Acceleration (g)	Max Structural Acceleration (g)
Jan24, 1997	5.3	33°28.1' S	70°47.1' W	0.064	0.140
April 20, 1997	5.3	33°59.7' S	70°28.0' W	0.022	0.050
Jun 19, 1997	5.1	33°09.4' S	70°18.1' W	0.013	0.040
Oct 14, 1997	6.8	30°44.5' S	71°19.7' W	0.024	0.080
Jan 12, 1998	5.9	31°18.8' S	71°25.1' W	0.009	0.046

MODAL PARAMETERS FROM EARTHQUAKE RECORDS

To identify the modal parameters of the structure a Multi-Input-Multi-Output (MIMO) modal minimization technique implemented by Li and Mau is used [1]. In this case only plane model identification is used, no torsional consideration or three dimensional behaviors are considered, [2]. Records from the third basement are considered as input. Output records from all floors are considered for each direction.

Initially average modal parameters were obtained by including the total duration of the strong motion record for the analysis. Table 2 show the variation of predominant parameters based. Variations are nevertheless relative minor compare with variations in input energy. Additionally no clear tendency is observed. In Figure 3 the relative good agreement of the model is observed from recorded and identify response [2].

If smaller analysis window are used for the MIMO identification, a more clear variation from the earthquake records with amplitude of motion is observe. Figure 4 present the variations of the first four translational predominant shapes of the structure, for the five earthquake records studied. A clear tendency to reduce the modal frequency is found with increasing amplitude response. Typical variations of frequency are in the order of 4%. For damping values this variation is stronger but a clear tendency is not found. Variations are on the order of 100% between windows.

Table 2. Modal Properties identify from Earthquake Records.										
Event	**24-01-1997**		**20-04-1997**		**19-06-1997**		**14-10-1997**		**12-01-1998**	
Richter Magnitude	5.3		5.3		5.1		6.8		5.9	
Predominant Frequency	Freq. Hz	β %	Freq. Hz	β %	Freq. Hz	β %	Freq. Hz	β %	Freq. Hz	β %
1	0.986	2.7	0.996	1.5	1.000	1.7	0.967	1.4	0.972	1.4
2	1.002	1.7	0.996	1.5	1.020	1.4	0.977	1.5	1.005	1.6
3	1.486	2.6	1.470	N/c	-	-	-	-	-	-
4	2.262	N/c	-	-	-	-	-	-	2.176	3.6
5	3.324	3.6	3.377	2.9	3.416	3.0	3.353	3.6	3.382	2.5
6	3.421	3.6	3.381	3.0	3.470	2.3	3.355	3.6	3.471	2.7
7	4.543	N/c	-	-	-	-	-	-	4.951	1.0
8	-	-	-	-	5.892	3.4	-	-	-	-
9	-	-	-	-	8.815	9.6	-	-	-	-
MIMO Relative Error (%)	38.0		24.0		26.3		27.1		20.4	
MIMO Absolute Error	1.75E5		2.83E4		1.59E4		2.82E5		2.20E4	

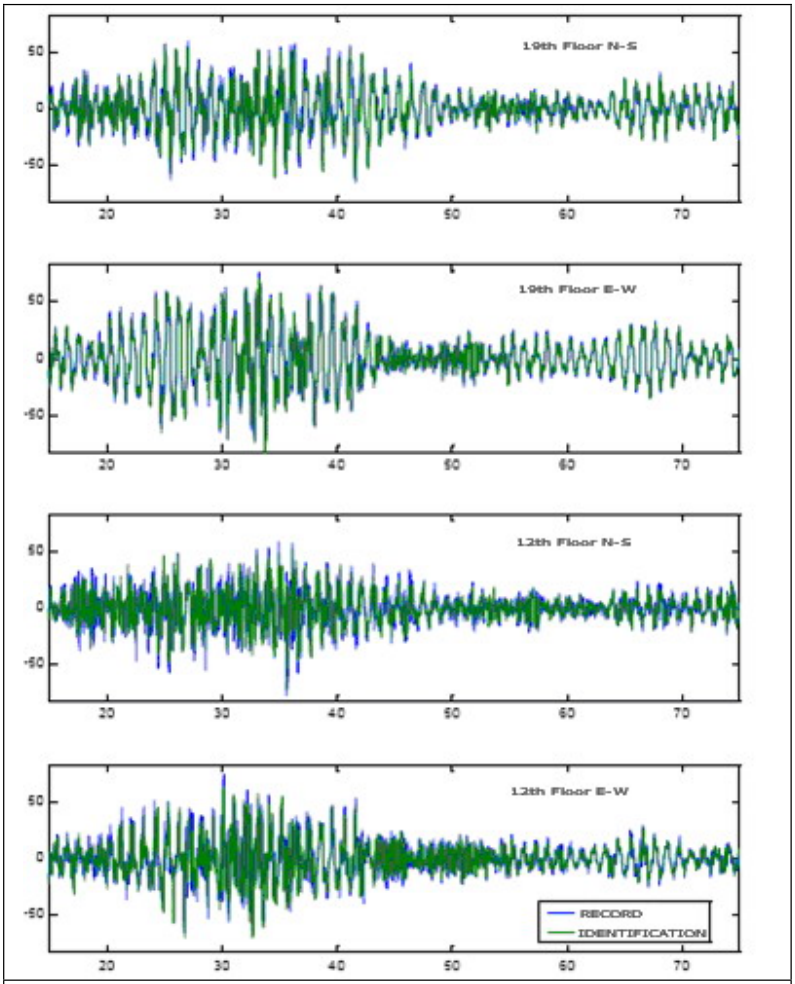

Figure 3. Adjusted model response to recorded values.

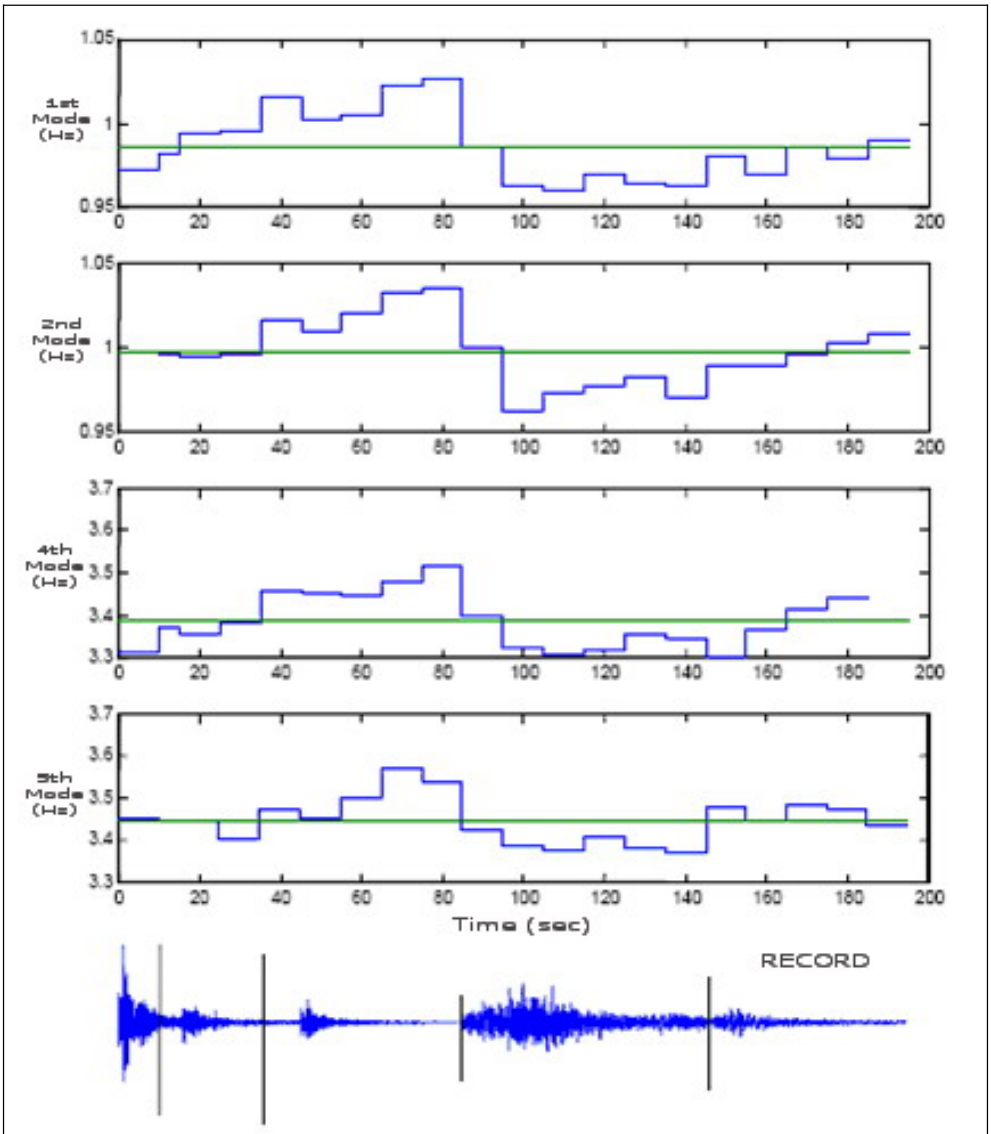

Figure 4. Variation on modal frequency for moving analysis window.

MODAL PARAMETERS FROM AMBIENT RECORDS

Several ambient vibration records have been obtained from the building. Several of them between earthquake events. One of the records is continuous for 6 month. This record includes the 12 channels which have been sampled at 100 Hz. Additionally weather conditions including temperature, humidity, rainfall, wind speed and wind direction have been monitor with a sampling rate of 15 minutes. Typical amplitude, weather condition records are shown in Figure 5 to 7.

In order to preliminary evaluate the influence of weather and modal properties two tests have been performed at the time of writing of this article.

Initially a 132 hour period, with strong temperature change is study to determined average predominant frequency, in each consecutive hour, Figure 6. A tendency to reduce predominant frequency is observed for increase in temperature. The frequency variations are very small, in the order of 1%.

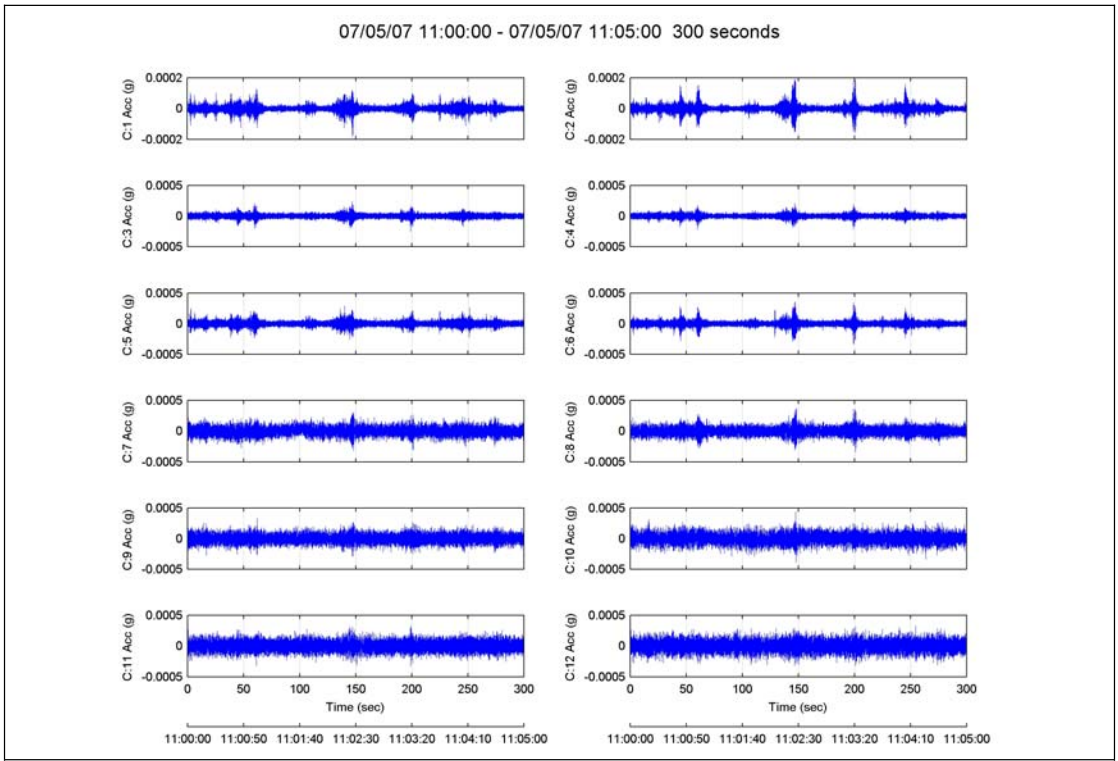

Figure 5. Ambient vibration

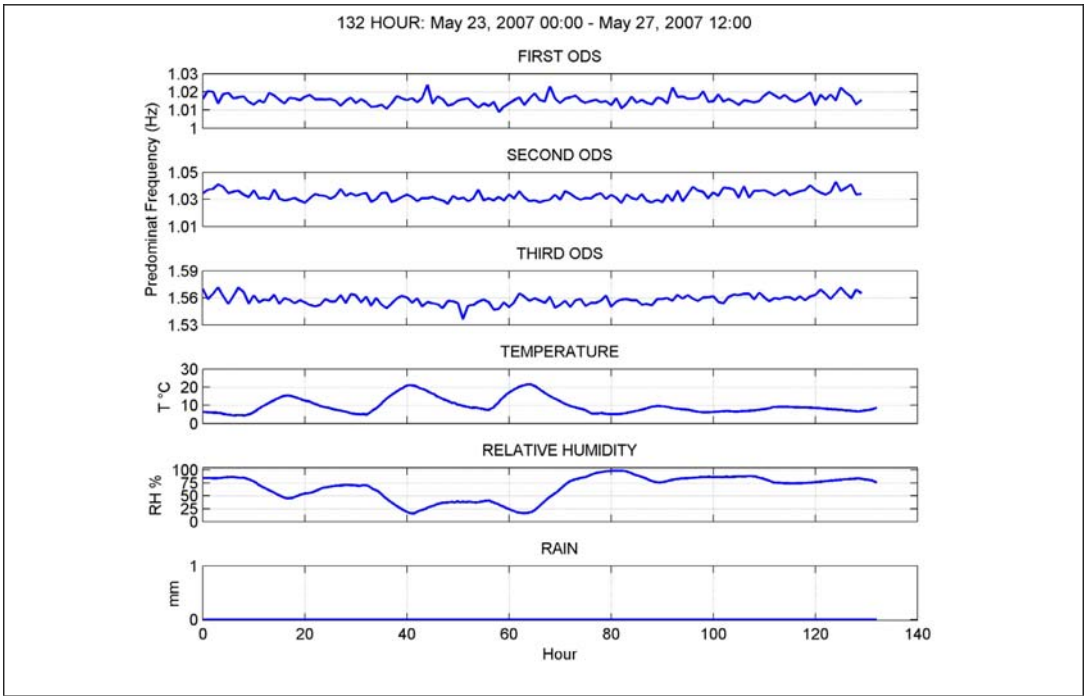

Figure 6. Modal Parameter Variations with Temperature in a single 132 hour period.

The effect of rain is observed in Figure 7. In this case a relative heavy rain occurred for a period of two day follow by several dry days. A tendency to increase predominant frequency is observed for increase rainfall. The frequency variations are very small again, in the order of 1%.

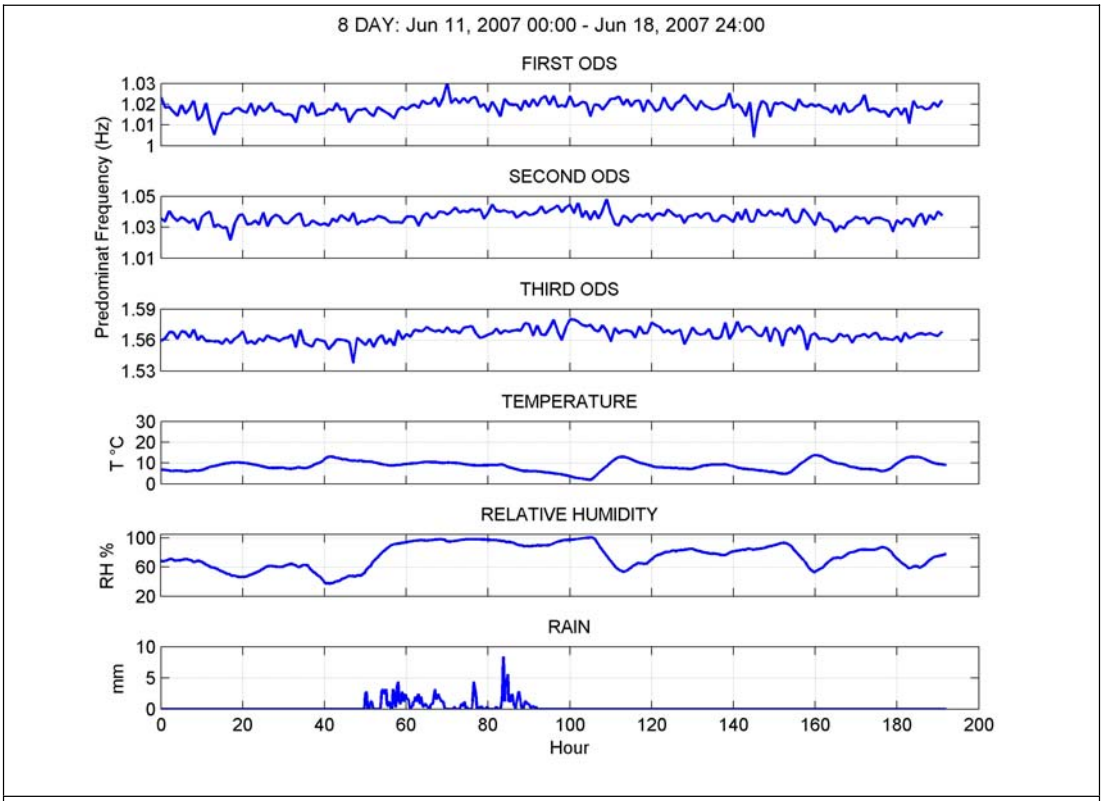

Figure 7. Modal Parameter Variations with Rain in an 8 day period.

CONCLUSIONS

The variation of modal parameters of a 22 story reinforced concrete shear wall building is determined using ambient vibration and earthquake records. Significant variations are found during earthquake response but the building sustains no damage. Variations in frequency for moderate events are close to 4%.

One important observation, already observed by other authors is that even for low ambient vibrations the structure exhibit predominant frequency variation that can be related to weather conditions. These variations nevertheless, in the cases studied so far, are close to 1%.

Additional studies are been carried out to evaluate more precisely the preliminary conclusion stated here.

AKNOLEDGEMENTS

The Civil Engineering Department of the University of Chile and the Chilean Council for Research and Technology, CONICYT Fondecyt Project # 1070319 supported this research paper.

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