Seismic Performance Assessment of Wheelchairs

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Introduction

This research studies factors dictates the overturning risk of a wheelchair during earthquakes.

As it is shown in Figure 1., at higher floors of a building, the earthquake response amplitude increases and closer to frequency of a single value at the building's natural frequency.

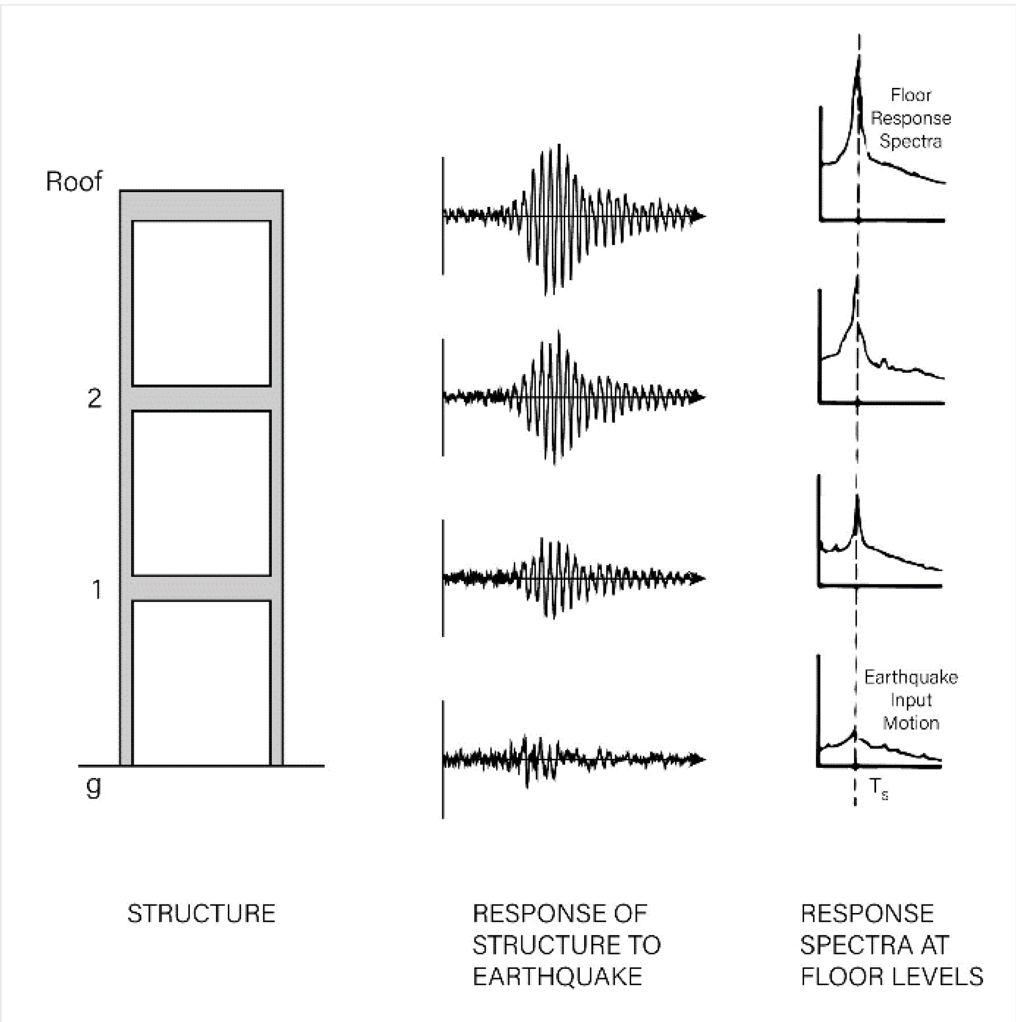

Fig.1 Building Floor Vibration Characteristics

The natural frequency is related to the total height of the building：

The total number of floors (N) can be multiplied by 0.1 to estimate the natural period (T) and the natural frequency of the building (f) as shown in equation *(1) &(2)*.

If there is a resonance effect with the wheelchair, it is very likely to have an overturning. As it is shown in Figure 2.

$$T = 0.1 \times N \quad \dots\dots (1)$$

$$f = \frac{1}{T} \quad \dots\dots (2)$$

T：Natural period of the building

N：Total number of floors

f：Natural frequency of the building

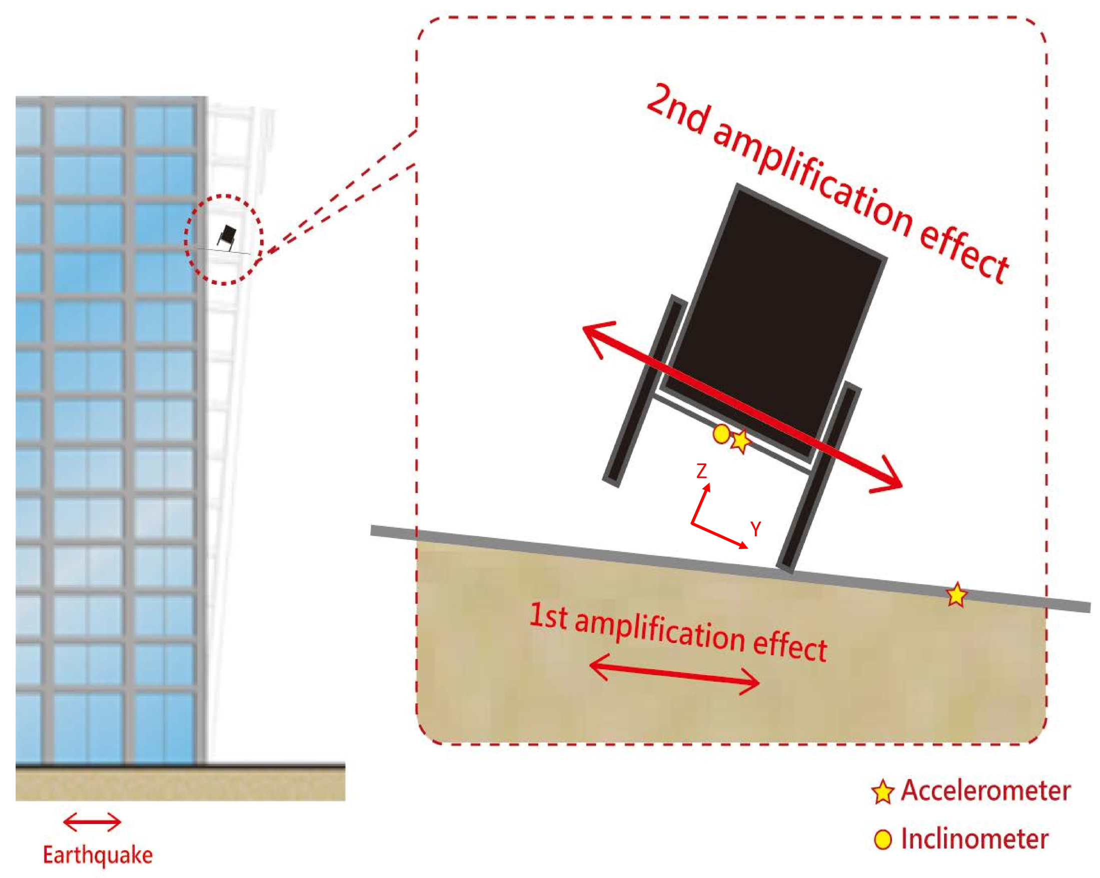

Fig.2 Second amplification effect

Results

Acceleration

Wheelchair vibration in earthquake includes Walking, Rocking, and Overturning, as shown in Figure 3. Collect the maximum acceleration of the wheelchair in every experiment as a line graph. The horizontal axis is the excitation frequency, the left vertical axis is the maximum acceleration of the wheelchair, and the corresponding reaction mode is marked on the right vertical axis. The line segments represent input accelerations of 300, 250, 200 and 150 gal from top to bottom. When the input amplitude is larger, the main reaction frequency of the wheelchair is lower. As input acceleration amplitude increases, it is more likely to stimulate various vibration modes of the wheelchair. In addition, the frequency of each mode is sorted from low to large: Overturning, Rocking, and Walking.

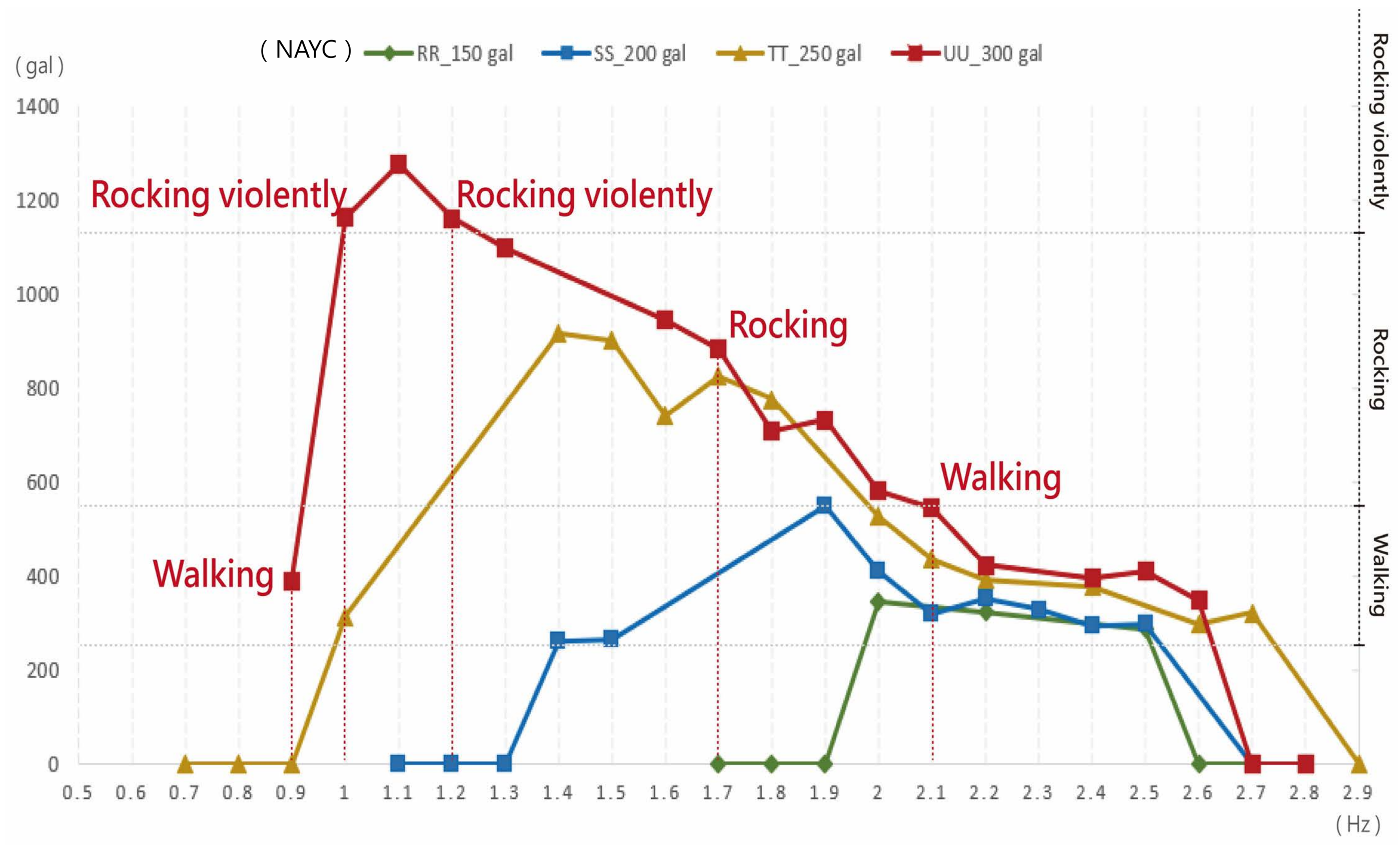

Fig.3 Maximum wheelchair acceleration in different sinusoidal amplitude (Y-dir)

Inclination

In addition, Figure 4. and Figure 5. are the inclinometer results of our actual measurement of two kinds of wheelchairs in different directions.

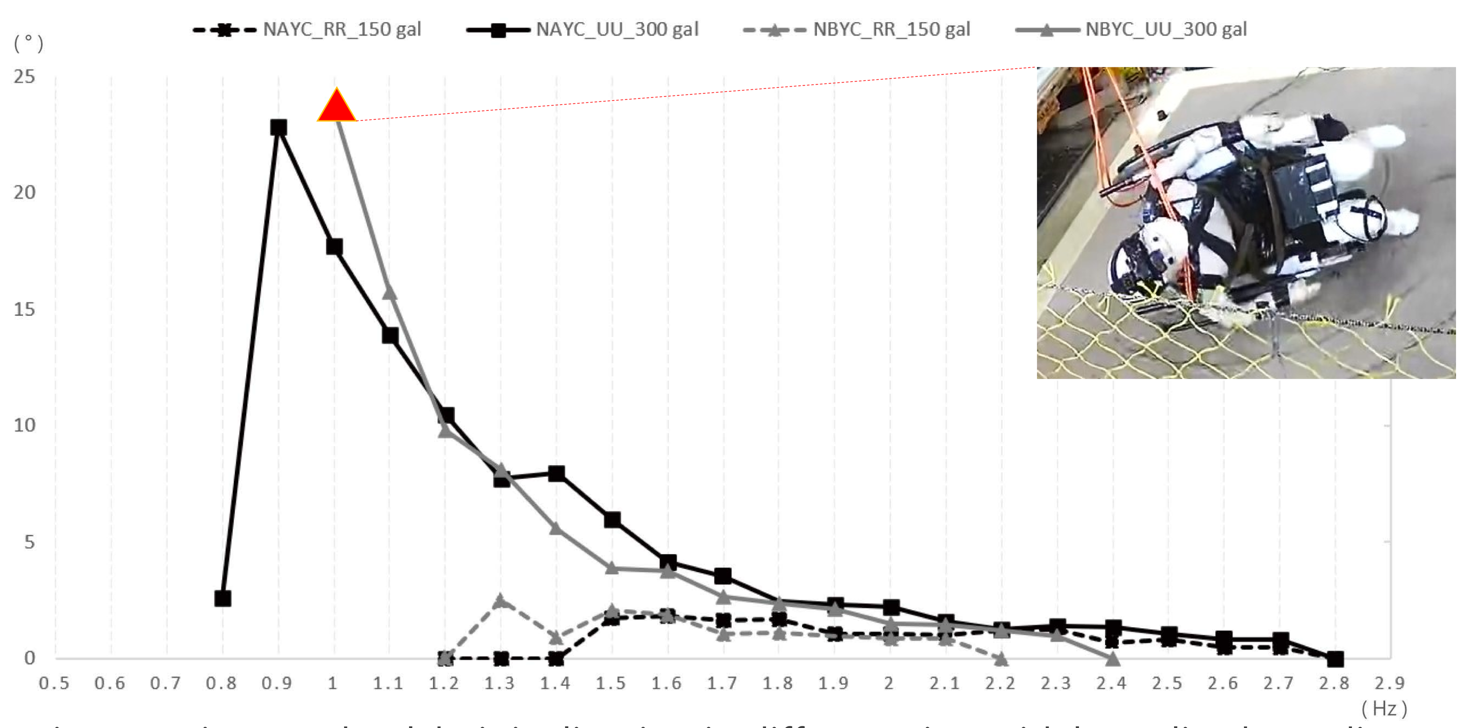

Fig.4 Maximum wheelchair inclination in different sinusoidal amplitude (Y-dir)

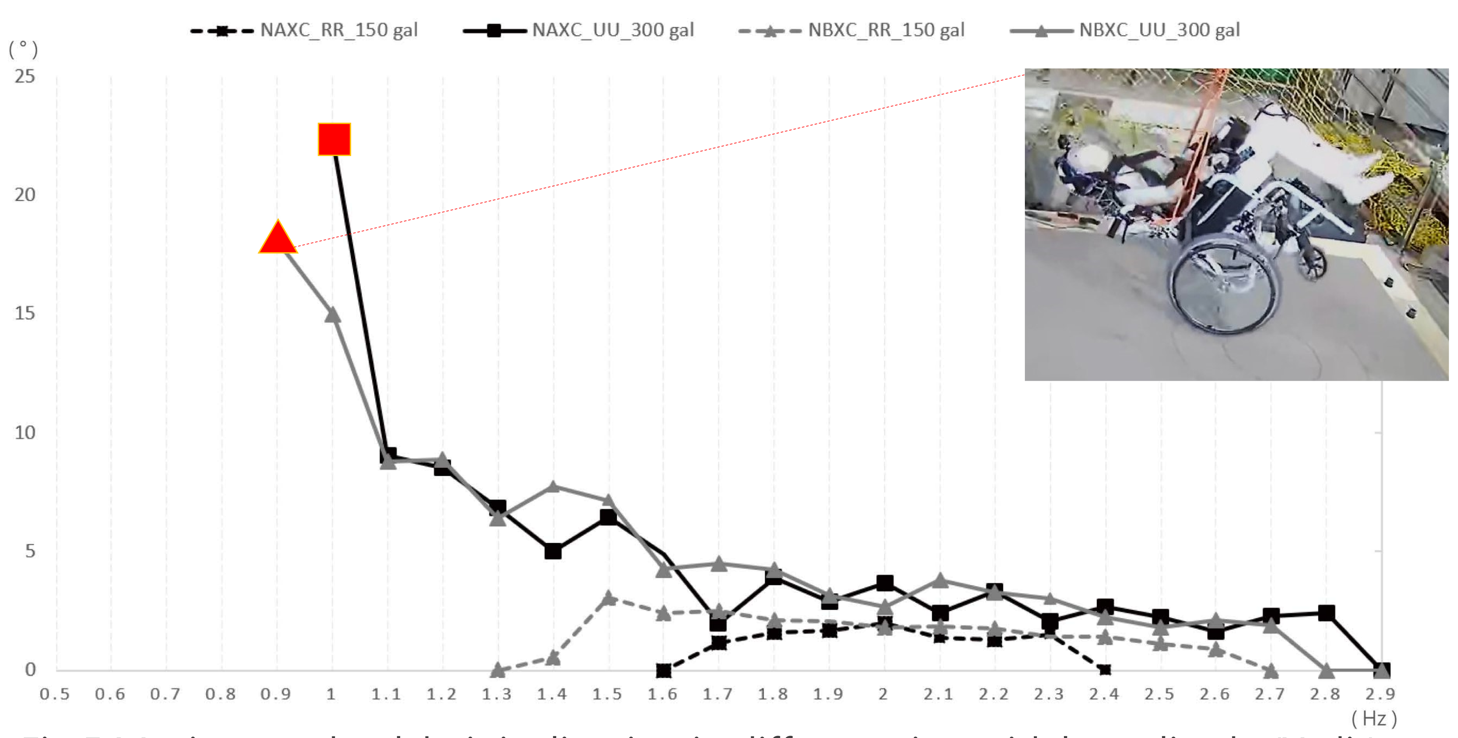

Fig.5 Maximum wheelchair inclination in different sinusoidal amplitude (X-dir)

Findings

High Risk Buildings

As shown in Table 1., findings from excitation of 300 gal include a high risk of wheel-chair overturning in buildings whose height range from 4 to 13-storeys, and the highest risk of wheel-chair overturning in buildings whose height is 9 to11-storeys.

Tbl.1 Wheelchair vibration response behavior in high risk buildings from 300 gal excitation

(Hz)

Freq.	Period	*10	Building height	
3.3	0.303	3.0	3 F	
3.2	0.313	3.1		
3.1	0.323	3.2		
3	0.333	3.3		
2.9	0.345	3.4		
2.8	0.357	3.6		
2.7	0.37	3.7		
2.6	0.385	3.8		
2.5	0.4	4.0	4 F	
2.4	0.417	4.2		
2.3	0.435	4.3		
2.2	0.455	4.5		
2.1	0.476	4.8		
2	0.5	5.0	5 F	
1.9	0.526	5.3		
1.8	0.556	5.6		
1.7	0.588	5.9	6 F	
1.6	0.625	6.3		
1.5	0.667	6.7		
1.4	0.714	7.1	7 F	
1.3	0.769	7.7		
1.2	0.833	8.3		
1.1	0.909	9.1	9 F	
1	1	10.0	10 F	
0.9	1.111	11.1	11 F	
0.8	1.25	12.5		
0.7	1.429	14.3		
0.6	1.667	16.7		
0.5	2	20.0	20 F	
0.4	2.5	25.0	25 F	super high-rise building
0.3	3.333	33.3		
0.2	5	50.0	50 F	
0.1	10	100.0	100 F	

Overturning & Violent rocking

Rocking

Walking

The scope of this study

Acknowledgements

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