EXPERIMENTAL MODEL OF RC FRAME AND SHEAR WALL WITH STIFFNESS INTERRUPTION

1. Introduction

Reinforced concrete (RC) frames for buildings are popular to be combined with RC shear wall, and the RC shear wall can cover along the height of the frame in various portions. In this example, a set of experimental tests of RC frame – shear wall with four different coverages were modelled to show the accuracy of STERA_3D. The specimens were tested by Moehle and Sozen in 1980 [1] as a part of research grant report by University of Illinois at Urbana-Champaign, USA for National Science Foundation. Each specimen consists of two nine-story 2D frame with one shear wall in between. The dimension plan space of 915 mm with three bays and the total height of 914 mm. The design concrete strength was 38 MPa, with a yield stress of 399 MPa. The total weight on the specimens was 40.87 kN with 4.55 kN in each level.

The earthquake motions in this study were the scaled El Centro 1940 NS, compressed by a factor of 2.5 as stated in the report. For the modelling in STERA_3D, the input motions were the real motions recorded at the shaking table. The raw data of this experimental tests were retrieved from DataCenterHub repository [2]. There are four different specimens differentiated based on the shear wall coverage along the height, as shown in Table 1 below.

Table 1. Specimen of Moehle and Sozen

No	Abbreviation	Remarks
1	FNW	Only nine-story 2D frames with no wall.
2	FSW	Nine-story 2D frames with wall covering only the first floor.
3	FHW	Nine-story 2D frames with wall covering up to fourth floor.
4	FFW	Nine-story 2D frames with wall covering all levels.

2. Purpose of Study

The purpose of this study are as follows:

a. To model the RC frame with different shear wall coverage by performing numerical analysis of four specimens which experimentally tested with shaking table tests by Moehle and Sozen [1]
b. To verify the accuracy of analysis response by using STERA_3D [3] by comparing experiment responses and analysis responses in terms of displacement and acceleration.

3. Detail of Structure

a. Floor Plan (x-y view)

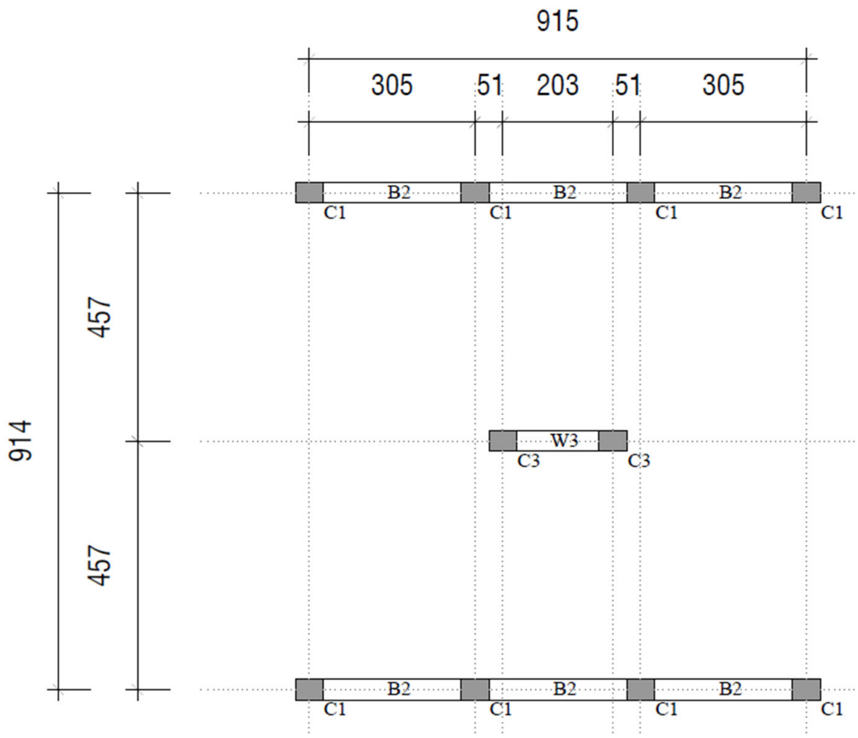


Figure 1. Plan view of 4th – 9th floor

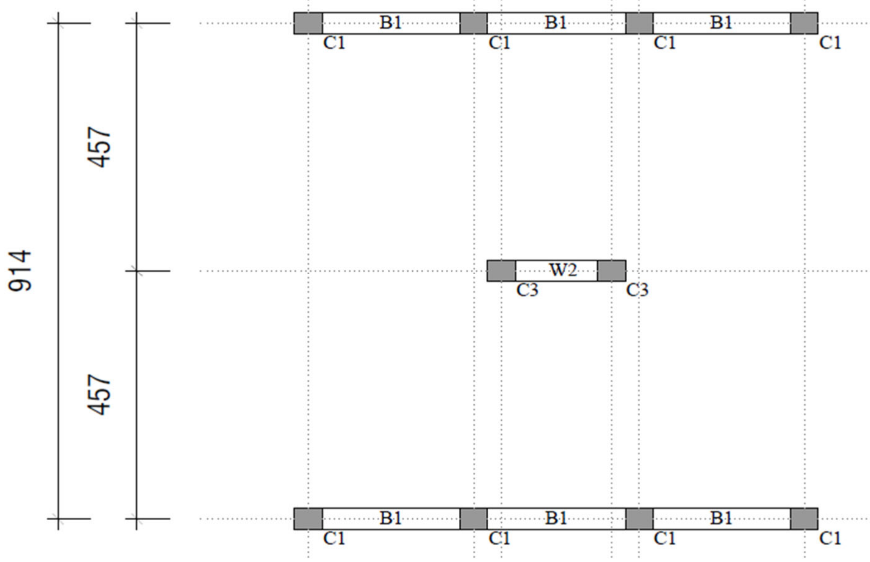


Figure 2. Plan view of 3rd floor

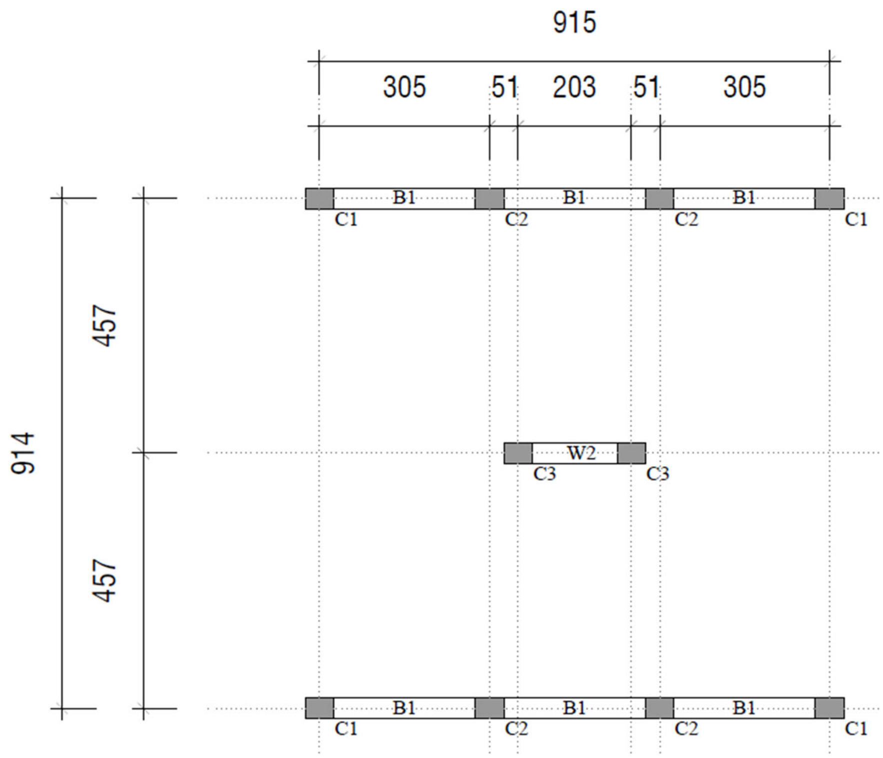


Figure 3. Plan view of 2nd floor

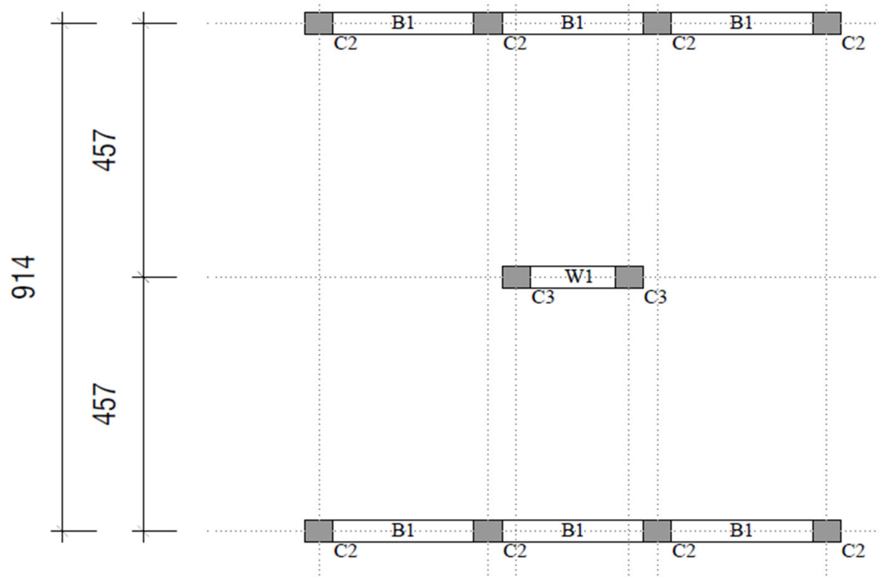
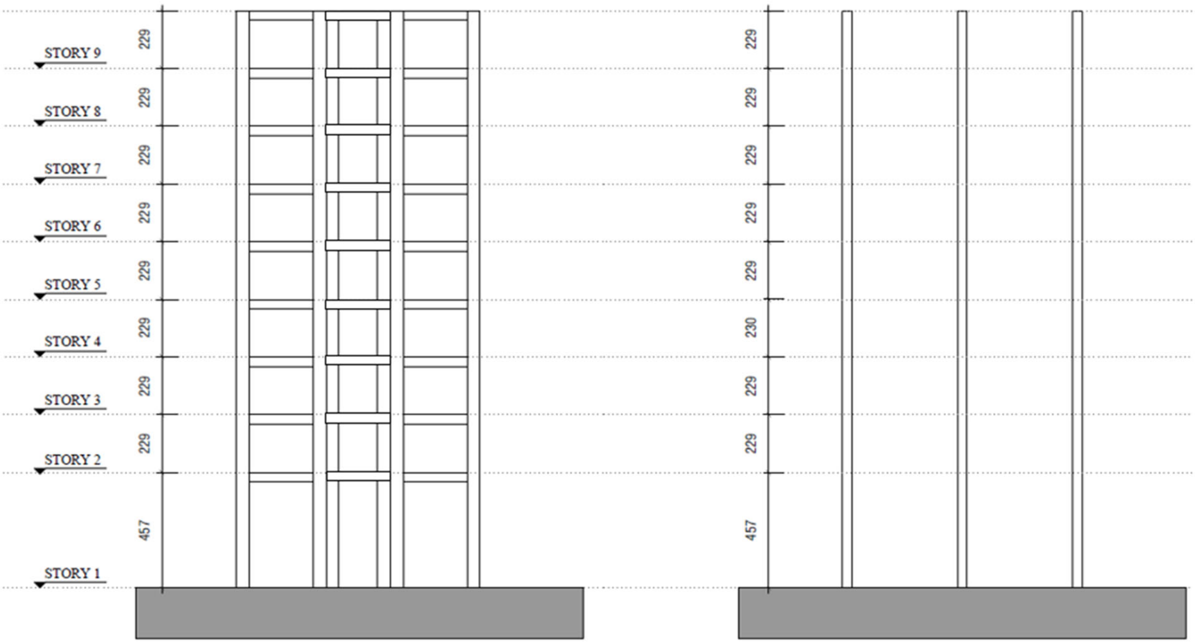


Figure 4. Plan view of 1st floor

b. Elevation (x-z view and y-z view)



(a) Front view (x-z view) (b) Side view (y-z view)

Figure 5. Elevation view of specimens

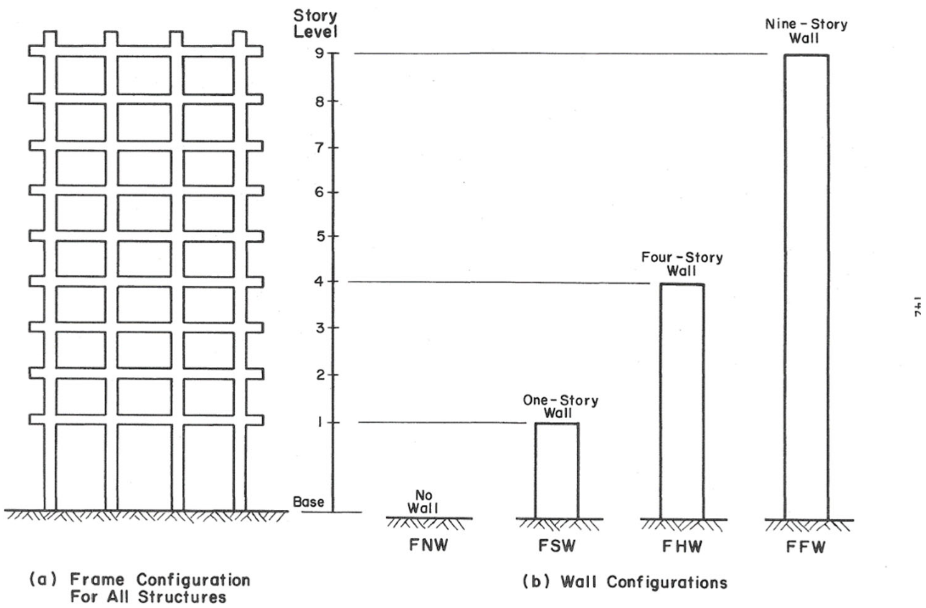
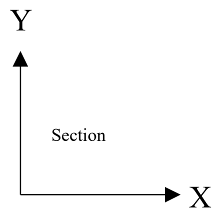
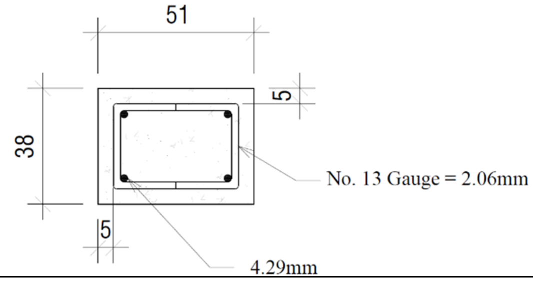
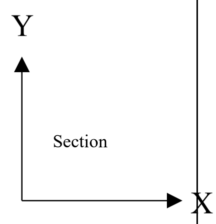
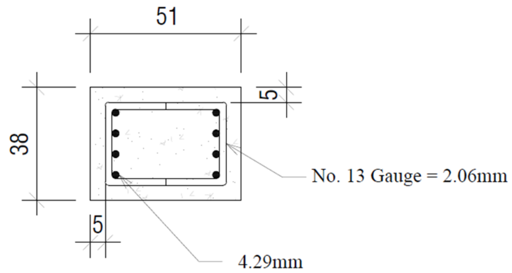
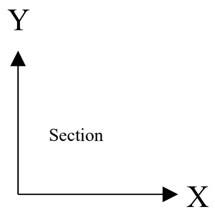
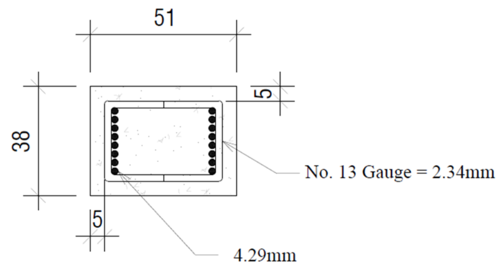


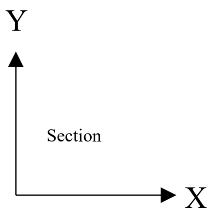
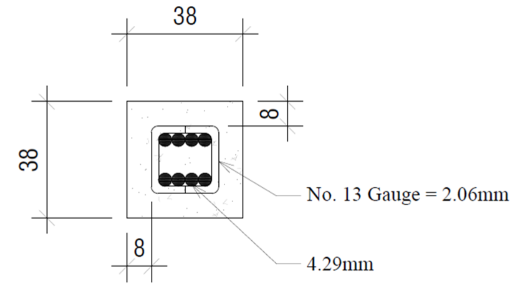
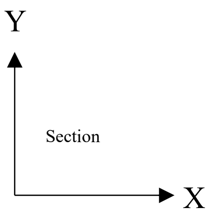
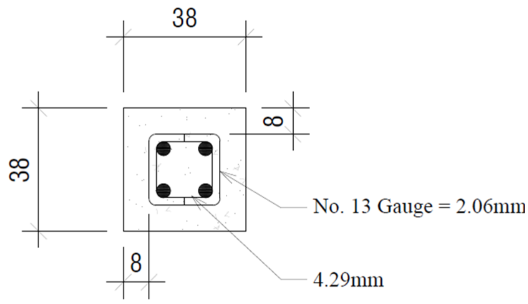
Figure 6. Elevation view of specimens [1]

c. Column List

<table>
<tr><td>Story</td><td></td><td>C1</td></tr>
<tr><td>See floor plan</td><td></td><td></td></tr>
<tr><td rowspan="3">F’c = 38 N/mm²</td><td>B x D</td><td>38 mm x 51 mm</td></tr>
<tr><td>Main bar</td><td>2 D 4.29 mm</td></tr>
<tr><td>Hoop</td><td>2 D 2.06 mm @ 10 mm</td></tr>
<tr><td></td><td></td><td>C2</td></tr>
<tr><td>See floor plan</td><td></td><td></td></tr>
<tr><td rowspan="3">F’c = 38 N/mm²</td><td>B x D</td><td>38 mm x 51 mm</td></tr>
<tr><td>Main bar</td><td>4 D 4.29 mm</td></tr>
<tr><td>Hoop</td><td>2 D 2.06 mm @ 10 mm</td></tr>
<tr><td></td><td></td><td>C3</td></tr>
<tr><td>See floor plan</td><td></td><td></td></tr>
<tr><td rowspan="3">F’c = 38 N/mm²</td><td>B x D</td><td>38 mm x 51 mm</td></tr>
<tr><td>Main bar</td><td>8 D 4.29 mm</td></tr>
<tr><td>Hoop</td><td>2 D 2.06 mm @ 10 mm</td></tr>
</table>

The tensile strength of main and shear reinforcement is 399 N/mm²

d. Beam List

Story		B1
See floor plan		
F'c = 38 N/mm²	B x D	38 mm x 38 mm
	Main bar	8 D 4.29 mm
	Hoop	2 D 2.06 mm @ 10 mm
		B2
See floor plan		
F'c = 38 N/mm²	B x D	38 mm x 38 mm
	Main bar	4 D 4.29 mm
	Hoop	2 D 2.06 mm @ 10 mm

The tensile strength of main and shear reinforcement is 399 N/mm²

e. Wall List

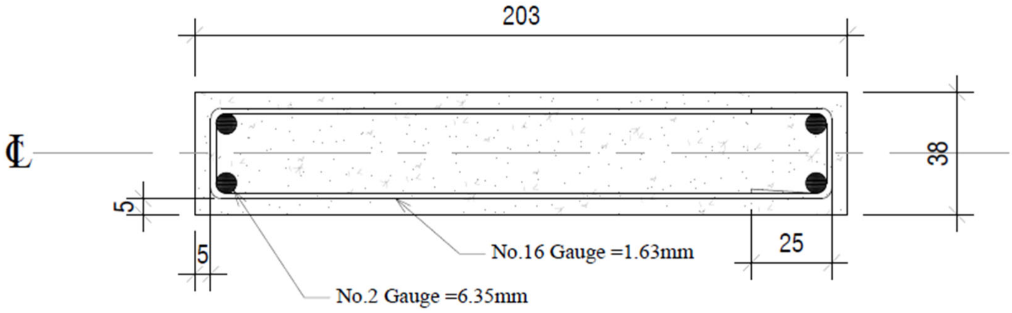


Figure 7. RC shear wall section

W1 = 2 D 6.35 mm @ 12.5 mm

W2 = 2 D 6.35 mm @ 25 mm

W3 = 2 D 6.35 mm @ 40 mm

F'c = 38 N/mm²

The tensile strength of main and shear reinforcement is 399 N/mm²

f. Structural Data

Plan Size			
Story	Height (mm)	Mass (kg)	Weight (kN)
9	229.000	455	4.55
8	229.000	454	4.54
7	229.000	457	4.57
6	229.000	455	4.55
5	229.000	456	4.56
4	229.000	456	4.56
3	229.000	453	4.53
2	229.000	456	4.56
1	457.000	451	4.51
total	2289.000	4093	40.93

g. Input Accelerations

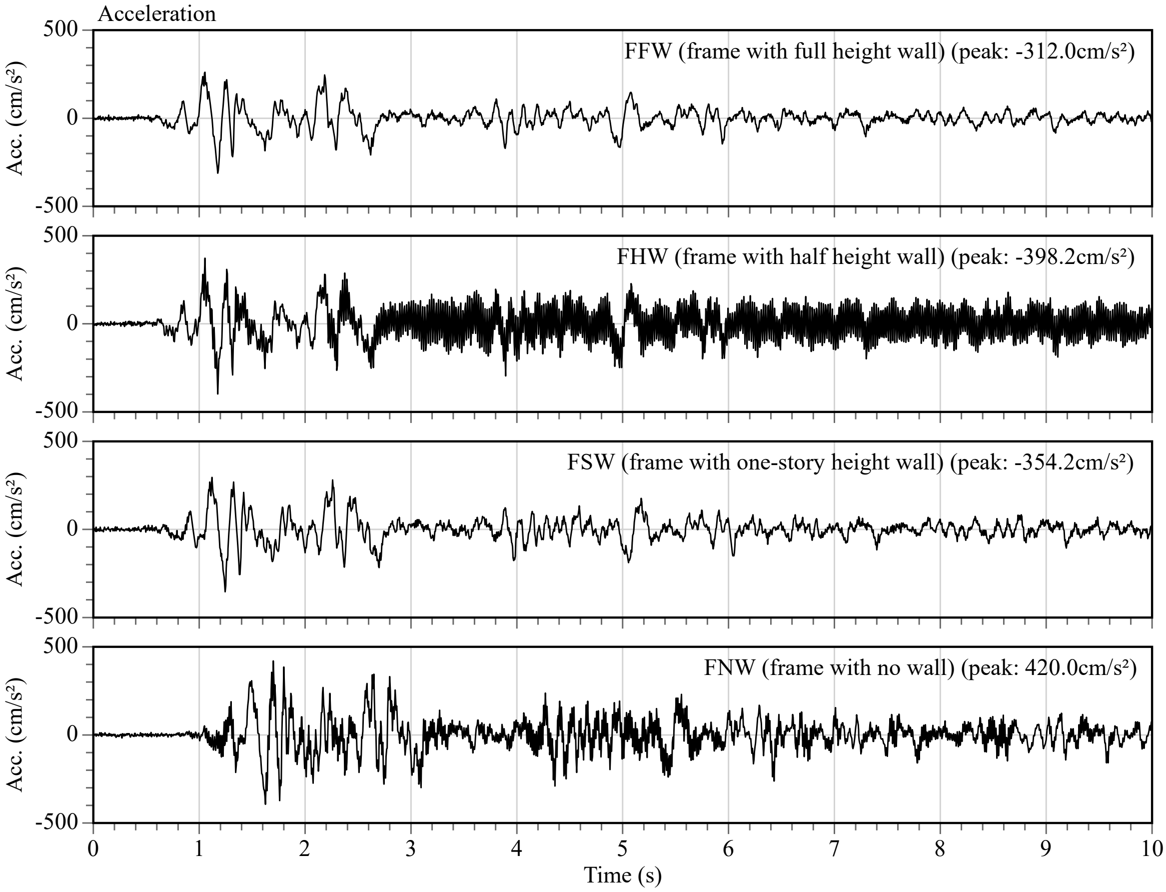


Figure 8. Four input ground motions for each specimen of Moehle and Sozen [1]

h. Comparison Results

1) Displacement Response of Experimental Test [1] and STERA 3D Analysis

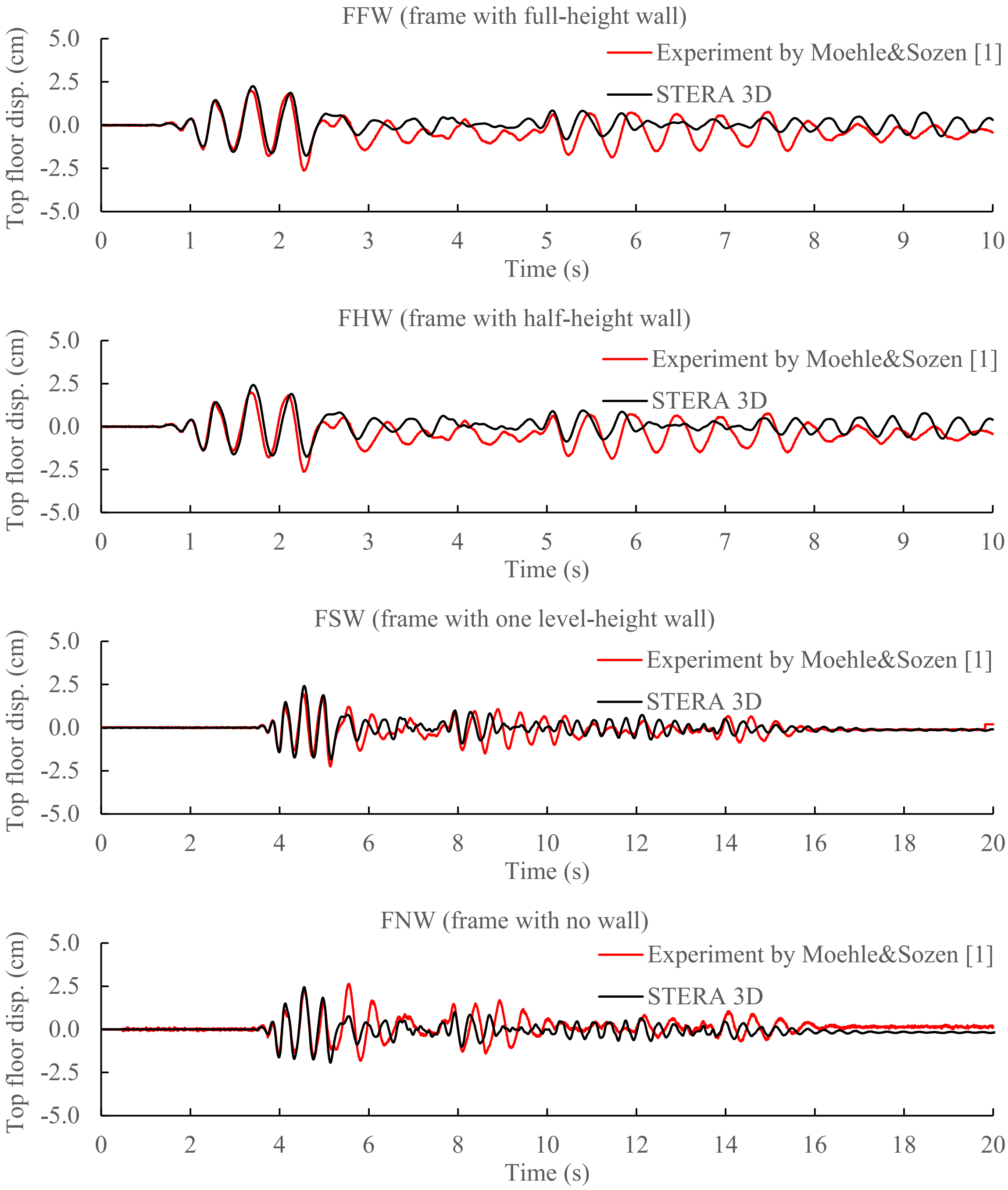


Figure 9. Displacement Response of Experimental Test [1] and STERA 3D Analysis

2) Acceleration Response of Experimental Test [1] and STERA 3D Analysis

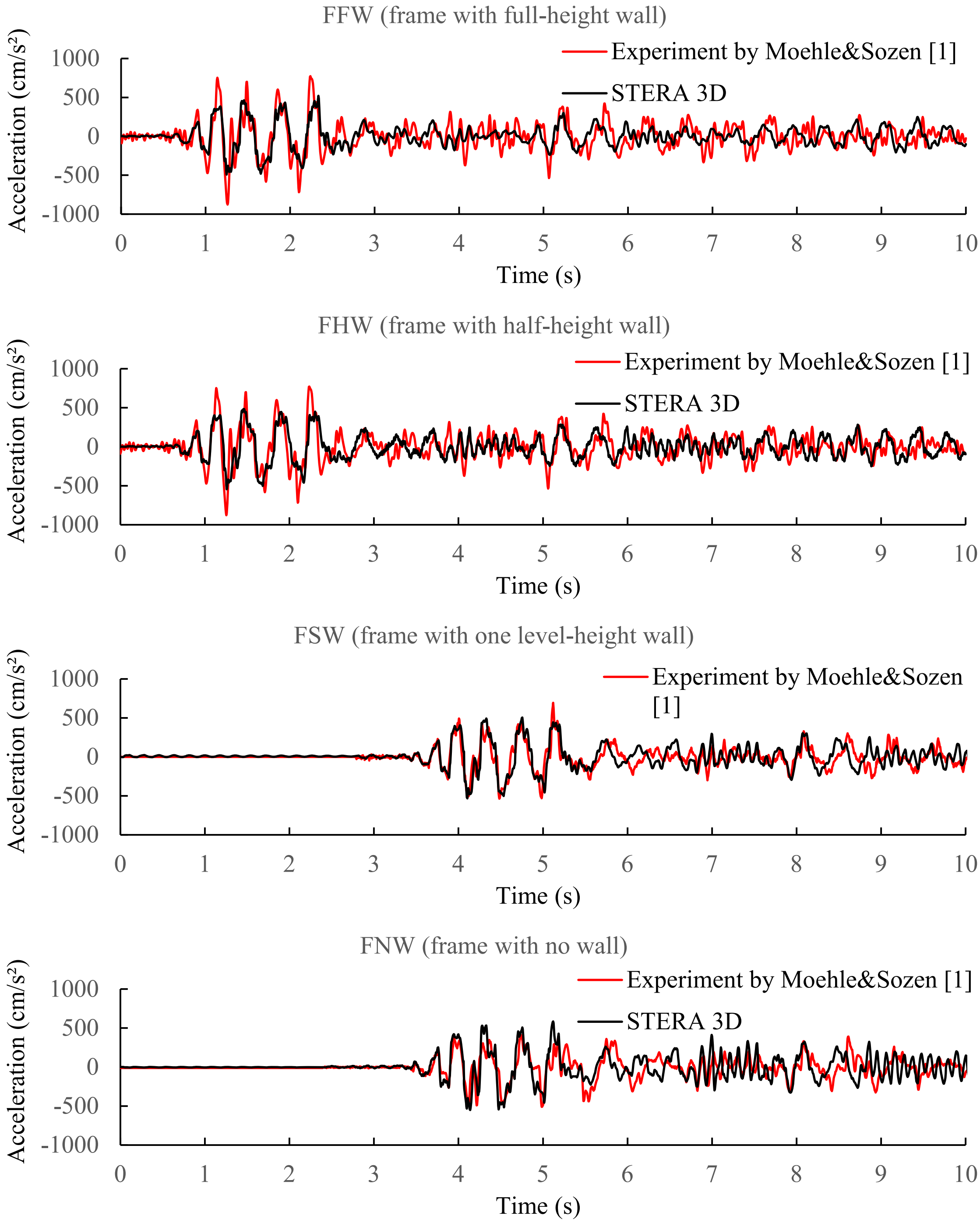


Figure 10. Acceleration Response of Experimental Test [1] and STERA 3D Analysis

4. STERA_3D Modelling

4.1. Naming rule of model:

Year_Specimen Owner_Model (in abbreviation)_detail.stera

No	Name	Remarks
1	1980_Moehle_FNW_no wall.stera	Only nine-story 2D frames with no wall.
2	1980_Moehle_FSW_1story wall.stera	Nine-story 2D frames with wall covering only the first floor.
3	1980_Moehle_FHW_4 story wall.stera	Nine-story 2D frames with wall covering up to fourth floor.
4	1980_Moehle_FFW_full wall.stera	Nine-story 2D frames with wall covering all levels.

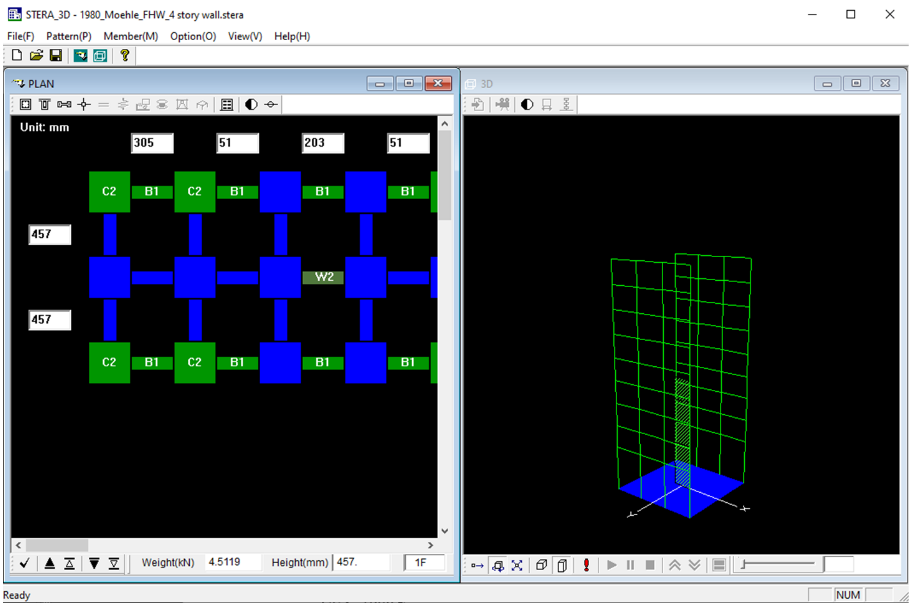
4.2. Naming rule of input motions:

Year_Specimen Owner_Model (in abbreviation)_detail.txt

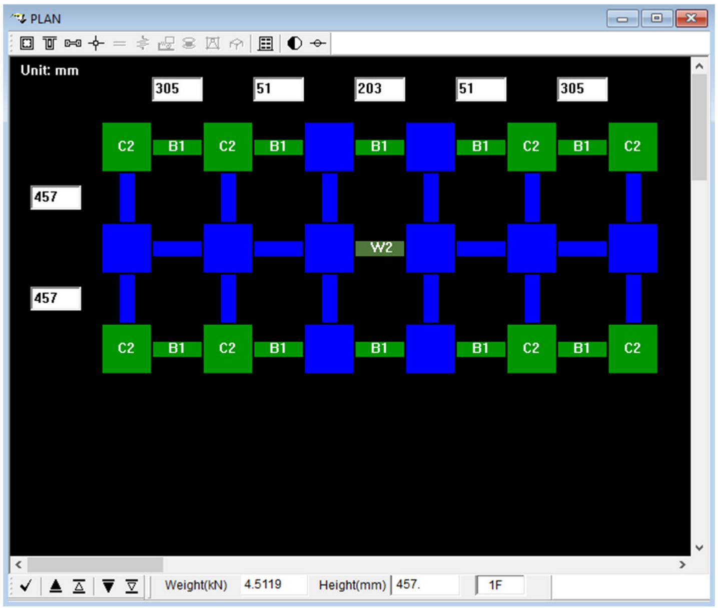
No	Name	Remarks
1	1980_Moehle_FNW_no wall.txt	Scaled 1940 El Centro NS
2	1980_Moehle_FSW_1story wall.txt	Scaled 1940 El Centro NS
3	1980_Moehle_FHW_4 story wall.txt	Scaled 1940 El Centro NS
4	1980_Moehle_FFW_full wall.txt	Scaled 1940 El Centro NS

4.3. STERA_3D model (for model FHW)

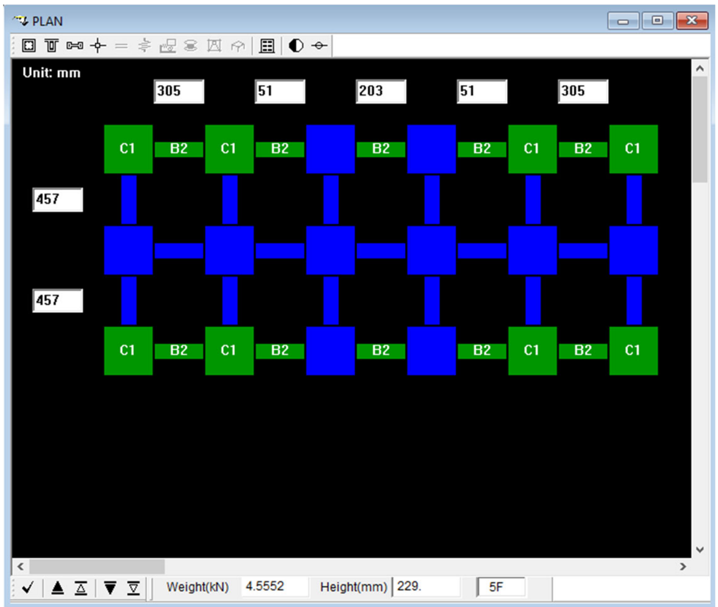
a. Overall view



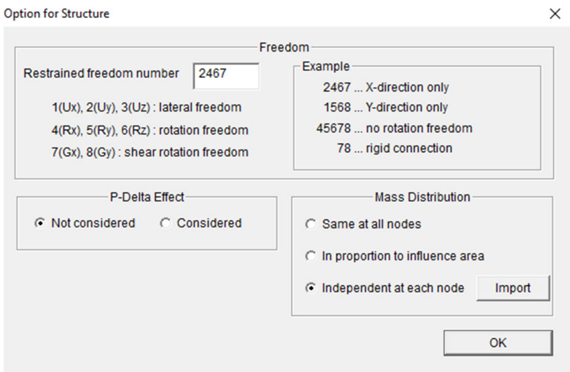
b. Plan for level 1



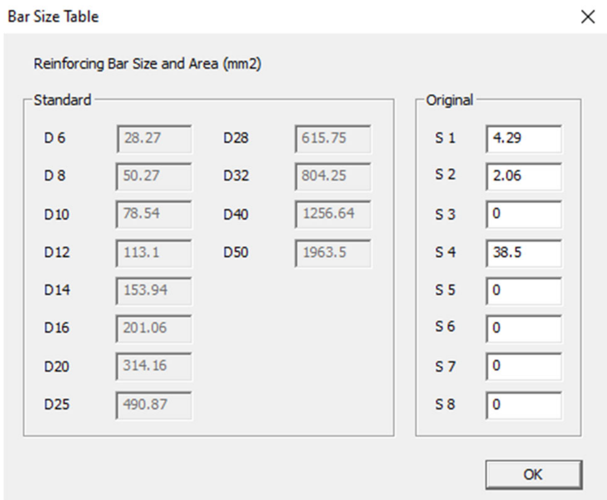
c. Plan for level 5



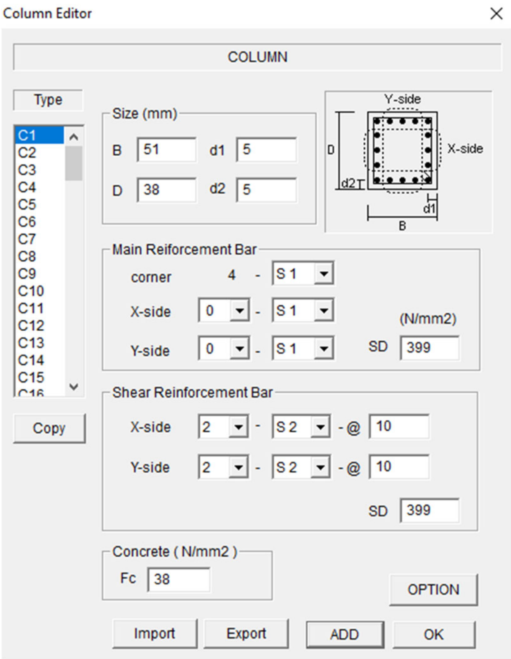
d. Restriction freedom for one directional analysis



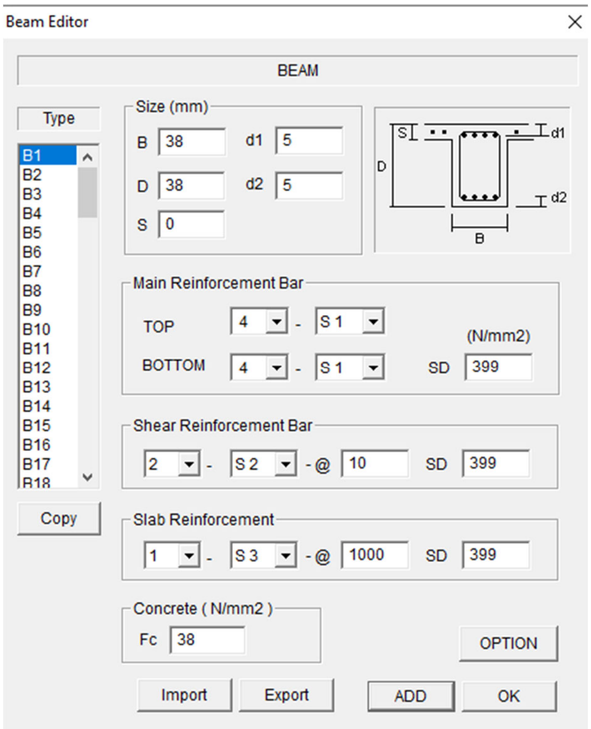
e. Definition of Custom Area Rebar



f. Definition of Column Member (C1)



g. Definition of Beam Member (B1)



5. References

1. Moehle, J.P., & Sozen, M. Experiment to study earthquake response of R/C structures with stiffness interruptions; National Science Foundation Report; University of Illinois at Urbana-Champaign: IL, USA, 1980.
2. Moehle, J., Sozen, M. Experiments to Study Earthquake Response of R/C Structures with Stiffness Interruptions (NEES-2011-1058). Available online: https://datacenterhub.org/deedsdv/publications/view/298 (accessed on 1 October 2020).
3. Saito, T. Structural Earthquake Response Analysis, STERA_3D Version 10.8. Available online: http://www.rc.ace.tut.ac.jp/saito/software-e.html (accessed on 1 October 2020).