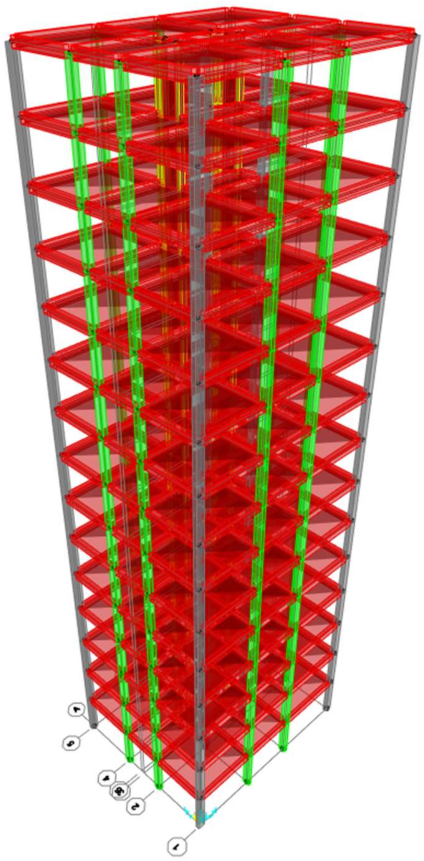
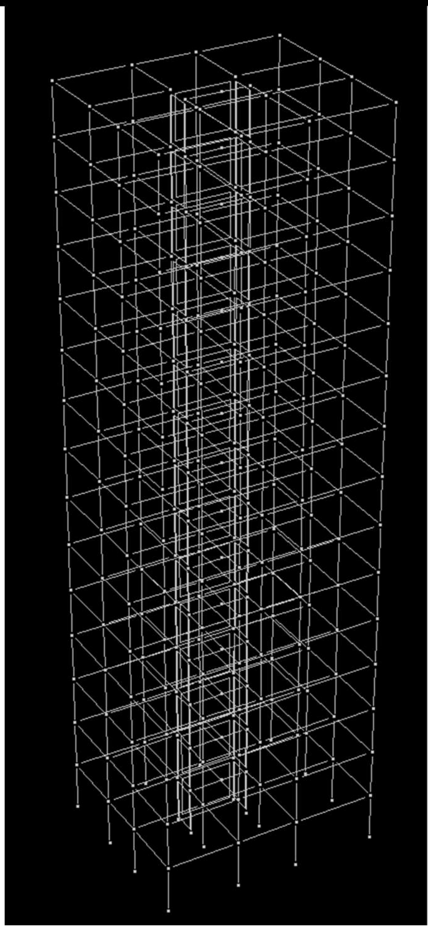
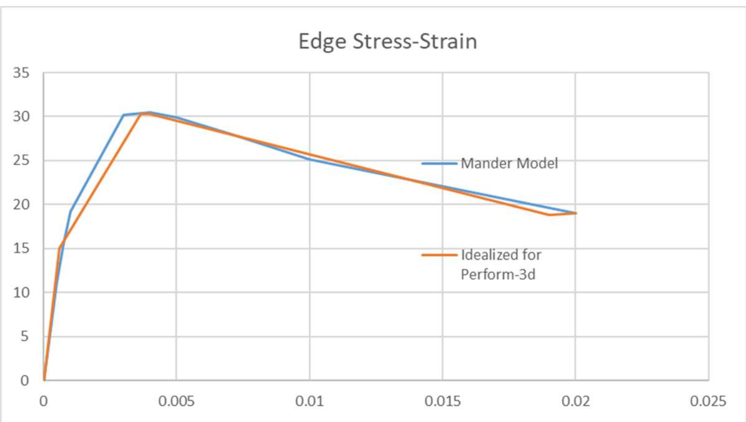
STRUCTURAL APPRAISAL REPORT OF BURAK'S BUILDING





With Performance Based Design Methodology



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İSTANBUL

2020

I declare that all material in this project is my own work and does not involve plagiarism.

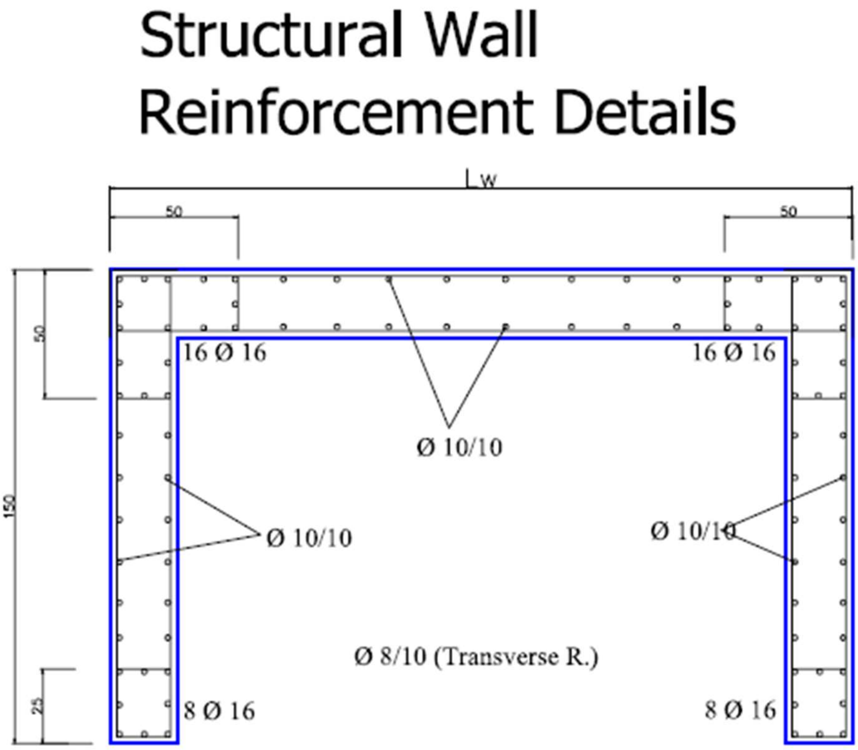
Burak AYYILMAZ

Table of Contents

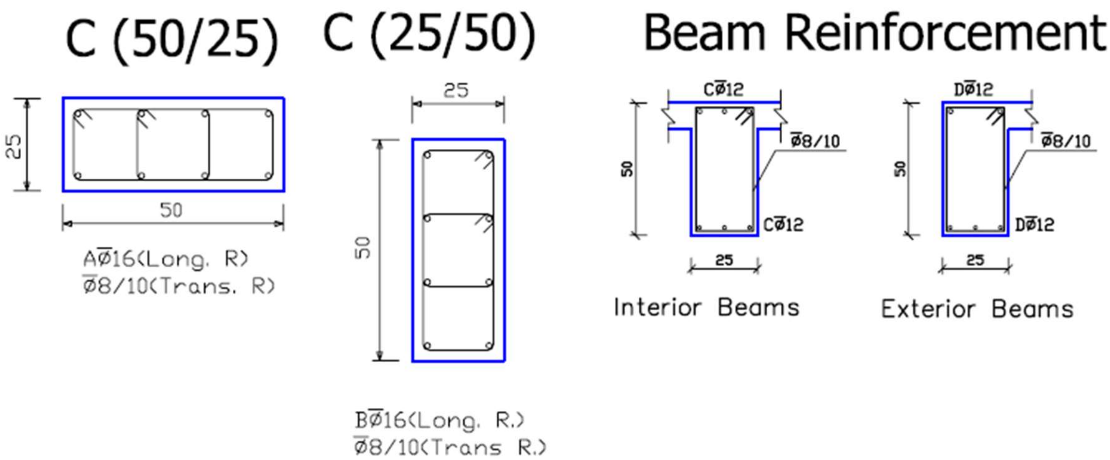
1 Introduction

Building Information

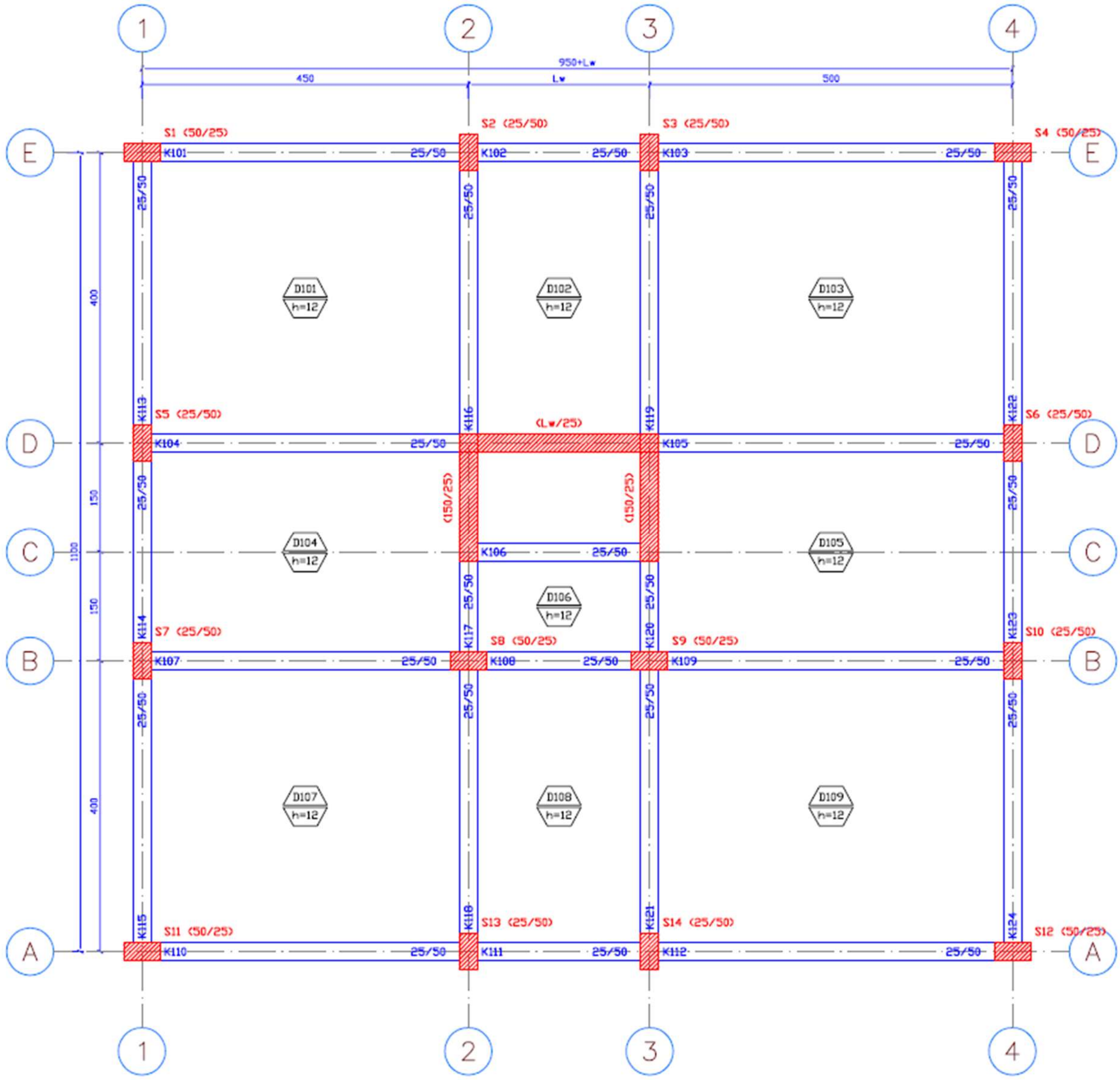
Shear wall detail;



Beam and column member details;



Story plan;



1
2
3
4
950+Lw
450
Lw
500
E
D
C
B
A
400
150
150
400
1100
S1 (50/25)
S2 (25/50)
S3 (25/50)
S4 (50/25)
S5 (25/50)
S6 (25/50)
S7 (25/50)
S8 (50/25)
S9 (50/25)
S10 (25/50)
S11 (50/25)
S12 (50/25)
S13 (25/50)
S14 (25/50)
(Lw/25)
(150/25)
(150/25)
K101
K102
K103
K104
K105
K106
K107
K108
K109
K110
K111
K112
K113
K114
K115
K116
K117
K118
K119
K120
K121
K122
K123
K124
25/50
D101
D102
D103
D104
D105
D106
D107
D108
D109
h=12

Data;

Number of Story	15m
L_w	3.75m
A	10
B	8
C, D	3

Materials

Tablo 5.1. Beklenen (Ortalama) Malzeme Dayanımları

Beton	$f_{ce} = 1.3 f_{ck}$
Donatı çeliği	$f_{ye} = 1.2 f_{yk}$
Yapı çeliği (S235)	$f_{ye} = 1.5 f_{yk}$
Yapı çeliği (S275)	$f_{ye} = 1.3 f_{yk}$
Yapı çeliği (S355)	$f_{ye} = 1.1 f_{yk}$
Yapı çeliği (S460)	$f_{ye} = 1.1 f_{yk}$

In analyses, expected material strength of steel and concrete were used. Except shear strength calculation, characteristic strength values used for shear capacity of members.

Loads

Considered loads for analyses are structure self-weight, superimposed dead load and live load. For calculating self-weight of structure, density of concrete taken as 25 kN/m^3. Respectively superimposed DL and live load were taken as 2.5 kN/m^2 and 2 kN/m^2. For cracking analysis, SW and SDL taken as normally but live-load reduced with multiplier 0.3.

2 Component Section Property Calculations and Damage Limits

Dead Load Analysis

		Member Name													
		S	S	S	S	S	S	S	S	S	S	S	S	S	S
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Storey	1	-877	-1167	-1216	-942	-982	-999	-1042	-1075	-927	-1027	-776	-875	-914	-851
	2	-827	-1087	-1132	-887	-910	-897	-933	-996	-856	-950	-726	-801	-836	-797
	3	-774	-1007	-1048	-830	-839	-807	-838	-919	-787	-874	-675	-731	-763	-742
	4	-720	-928	-964	-772	-769	-724	-751	-843	-719	-801	-624	-664	-692	-686
	5	-664	-848	-881	-712	-700	-649	-672	-768	-654	-729	-572	-600	-625	-630
	6	-606	-769	-798	-650	-633	-578	-599	-695	-590	-658	-520	-539	-560	-573
	7	-548	-690	-716	-588	-566	-512	-530	-622	-527	-589	-467	-479	-498	-516
	8	-488	-611	-634	-524	-501	-449	-464	-551	-466	-521	-415	-422	-438	-458
	9	-428	-533	-553	-459	-436	-389	-402	-480	-406	-454	-362	-366	-380	-400
	10	-367	-456	-473	-394	-372	-330	-341	-410	-346	-387	-310	-311	-323	-343
	11	-305	-379	-393	-327	-309	-274	-283	-340	-287	-321	-257	-258	-268	-285
	12	-243	-303	-314	-261	-246	-218	-225	-271	-228	-256	-205	-205	-213	-227
	13	-180	-227	-235	-194	-183	-164	-170	-202	-171	-191	-152	-153	-160	-169
	14	-118	-151	-157	-127	-121	-110	-114	-134	-113	-126	-100	-101	-105	-110
	15	-54	-75	-79	-59	-60	-58	-61	-66	-56	-62	-47	-51	-54	-52
	Section Type	C1	C2	C2	C1	C2	C1	C1	C2	C2	C2	C1	C2	C2	C1

	Story	Mean Axial Load (kN)
C1 Type Member	1,2,3,4	-812.4
	5,6,7	-588.1
	8,9,10	-406.9
	11,12,13,14,15	-171.6

	Story	Mean Axial Load (kN)
C2 Type Member	1,2,3,4,5	-872.6
	6,7,8	-586.3
	9,10,11,12	-352.3
	13,14,15	-126.3

Interaction Surface Analysis

Yield moments of members were determined by interaction surface analysis. XTract section analysis program was used. Maximum steel and minimum concrete strains were determined according to code for concrete 0.0035 and for steel 0.01.

5.3.1.5 – Betonarme plastik mafsal kesitlerinin *etkin akma momentleri*'nin tanımlanmasına ilişkin koşullar aşağıda **(a)**, **(b)**, **(c)**'de verilmiştir:

(a) Malzeme dayanımları **5.4.1.5**'e göre alınacaktır.

(b) Etkin akma momentinin hesabında betonun basınç birim şekildeğiştirmesi 0.0035, donatı çeliğinin birim şekildeğiştirmesi ise 0.01 alınabilir.

(c) Etkin akma momentinin hesabında düşey yüklerden meydana gelen eksenel kuvvetler dikkate alınacaktır.

		Zero Moment.		Balanced Condition		Zero Axial
		Pc(kN)	Pt(kN)	P(kN)	M(kNm)	M(kNm)
C1	3-3	3998	530.9	1641	274.9	115.1
	2-2	3998	530.9	1574	132.1	53.56
C2	2-2	3871	424.7	1619	122.9	44.09
	3-3	3871	424.7	1646	265.5	93.03
B	3-3	-	-	-	-	39.95

Cracked Section Analysis

For C1 type elements;

	Effective Stiffness Modifiers		Effective Inertia	
Storey	3-3	2-2	3-3	2-2
1,2,3,4	0.26	0.30	6.647E-04	1.940E-04
5,6,7	0.24	0.27	6.158E-04	1.733E-04
8,9,10	0.22	0.24	5.617E-04	1.578E-04
11,12,13,14,15	0.18	0.20	4.739E-04	1.323E-04

For C2 type elements

	Effective Stiffness Modifiers		Effective Inertia	
Story	3-3	2-2	3-3	2-2
1,2,3,4,5	0.25	0.27	6.447E-04	1.727E-04
6,7,8	0.22	0.25	5.736E-04	1.619E-04
9,10,11,12	0.20	0.22	5.103E-04	1.453E-04
13,14,15	0.15	0.20	4.033E-04	1.292E-04

For Beam type elements

Member	Effective Inertia	Effective Stiffness Modifiers
K101,K104,K107,K110	2.30059E-04	0.09
K103,K105,K109,K112	2.428E-04	0.09
K115,K118,K121,K124, K113,K116,K119,K122	2.153E-04	0.08
K102,K106,K108,K111	2.071E-04	0.08
K114,K123	1.782E-04	0.07
K117,K120	9.379E-05	0.04

Damage Strains

Strain limits of column and beam elements;

C1 Damage States					
B	250	S	100	mm	
H	500	b0	200	sb	0.750
d	25	h0	450	sh	0.889
d_transversal	8	h_#_Tr	4	SH6	0.713
a	50.27	b_#_Tr	2	Alfa	0.475
d_longitudinal	16	ai_B	100	Omega	0.022
Fce	26	ai_H	150.0	Ult	0.009
Fye	264	ph_H	0.004468		
		ph_B	0.005027		
		Sınırlı Hasar	Kontrollü Hasar	Göçme Öncesi	
C1	Concrete Strain	0.0025	0.0070	0.0094	
	Steel Strain	0.0075	0.036	0.048	

C2 Damage States					
B	250	S	100	mm	
H	500	b0	200	sb	0.750
d	25	h0	450	sh	0.889
d_transversal	8	h_#_Tr	3	SH6	0.588
a	50.27	b_#_Tr	2	Alfa	0.392
d_longitudinal	16	ai_B	100	Omega	0.013
Fce	26	ai_H	225.0	Ult	0.008
Fye	264	ph_H	0.003351		
		ph_B	0.005027		
		Sınırlı Hasar	Kontrollü Hasar	Göçme Öncesi	
C2	Concrete Strain	0.0025	0.0061	0.0081	
	Steel Strain	0.0075	0.036	0.048	

B Damage States					
B	250	S	100	mm	
H	500	b0	192	sb	0.740
d	25	h0	442	sh	0.887
d_transversal	8	h_#_Tr	4	SH6	0.820
a	50.27	b_#_Tr	2	Alfa	0.538
d_longitudinal	16	ai_B	96	Omega	0.025
Fce	26	ai_H	110.5	Ult	0.010
Fye	264	ph_H	0.0045		
		ph_B	0.0052		
		Sınırlı Hasar	Kontrollü Hasar	Göçme Öncesi	
B	Concrete Strain	0.0025	0.0074	0.0098	
	Steel Strain	0.0075	0.036	0.048	

Strain limits of Shear Wall;

SW Free_Boun Damage States					
B	250	S	100	mm	
H	250	b0	200	sb	0.750
d	25	h0	200	sh	0.750
d_transversal	8	h_#_Tr	3	SH6	0.750
a	50.27	b_#_Tr	2	Alfa	0.422
d_longitudinal	16	ai_B	100	Omega	0.022
Fce	26	ai_H	100.0	Ult	0.009
Fye	264	ph_H	0.0075		
		ph_B	0.005027		
		Sınırlı Hasar	Kontrollü Hasar	Göçme Öncesi	
SW_Free	Concrete Strain	0.0025	0.0070	0.0094	
	Steel Strain	0.0075	0.036	0.048	

SW Int_Boun Damage States					
B	250	S	100	mm	
H	500	b0	225	sb	0.778
d	25	h0	475	sh	0.895
d_transversal	8	h_#_Tr	4	SH6	0.726
a	50.27	b_#_Tr	2	Alfa	0.505
d_longitudinal	16	ai_B	112.5	Omega	0.022
Fce	26	ai_H	158.3	Ult	0.009
Fye	264	ph_H	0.004233		
		ph_B	0.004468		
		Sınırlı Hasar	Kontrollü Hasar	Göçme Öncesi	
SW_Int	Concrete Strain	0.0025	0.0070	0.0094	
	Steel Strain	0.0075	0.036	0.048	

Plastic Rotation Limits

	C1 Type Members					
	Göçme öncesi		Sınırlı Hasar		Yield Rotation	
Storey	3-3	2-2	3-3	2-2	3-3	2-2
1,2,3,4	0.012	0.016	0.009	0.012	0.0052	0.0031
5,6,7	0.014	0.022	0.010	0.017	0.0050	0.0030
8,9,10	0.015	0.036	0.012	0.027	0.0049	0.0030
11,12,13,14,15	0.025	0.036	0.019	0.027	0.0048	0.0030

	C2 Type Members					
	Göçme Öncesi		Sınırlı Hasar		Yield Rotation	
Storey	3-3	2-2	3-3	2-2	3-3	2-2
1,2,3,4,5	0.008	0.013	0.00615	0.009	0.00605	0.0032
6,7,8	0.012	0.018	0.009	0.013	0.0057	0.0031
9,10,11,12	0.019	0.028	0.014	0.021	0.0054	0.0030
13,14,15	0.023	0.036	0.018	0.027	0.0051	0.0030

B Type Elements			
Member	Göçme Öncesi	Sınırlı Hasar	Yield Rotation
K101,K104,K107,K110	0.036	0.027	0.0052
K103,K105,K109,K112	0.036	0.027	0.0055
K115,K118,K121,K124, K113,K116,K119,K122	0.035	0.027	0.0049
K102,K106,K108,K111	0.035	0.027	0.0048
K114,K123	0.035	0.026	0.0045
K117,K120	0.032	0.024	0.0043

Shear Strength Limits of Components

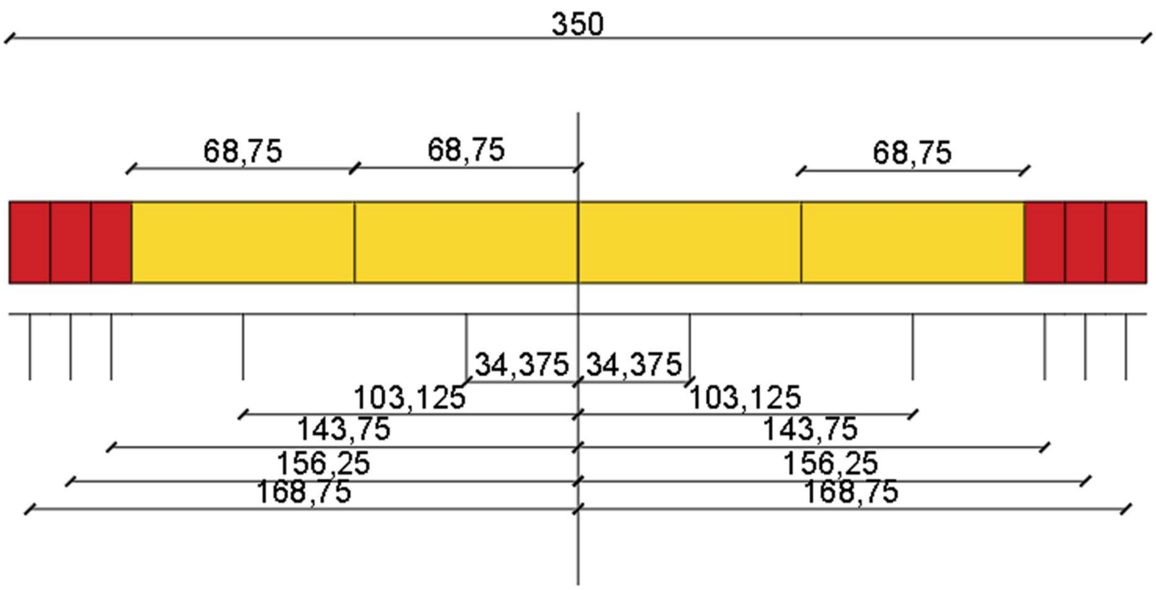
Shear strength limits;

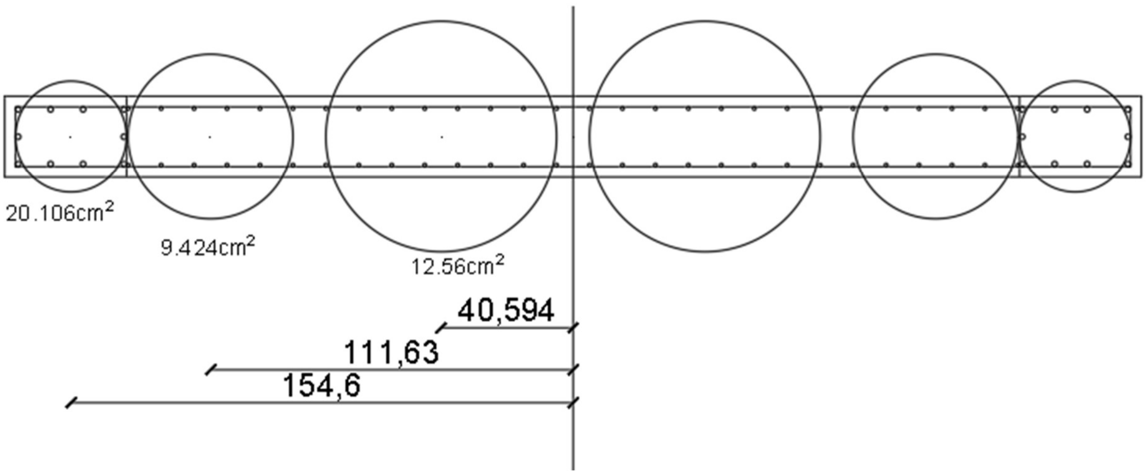
Member	d(mm)	b(mm)	Diam.(mm)	#of bars	S(mm)	Fy(Mpa)	Fc(Mpa)	Vreinforcement (kN)	Vconcrete(kN)	Vtotal(kN)
C1_2-2	450	250	8	2	100	220	20	99.5	117	216.5
C1_3-3	200	450	8	4	100	220	20	88.5	93.6	182.1
C2_2-2	450	250	8	2	100	220	20	99.5	117	216.5
C2_3-3	200	450	8	4	100	220	20	88.5	93.6	182.1
Beam	450	250	8	2	100	220	20	99.5	117	216.5
Shear Wall Long_Axis	3650	250	8	2	100	220	20	807.3	949	1756.3
Shear Wall Short_Axis	1400	250	8	2	100	220	20	619.3	728	1347.3

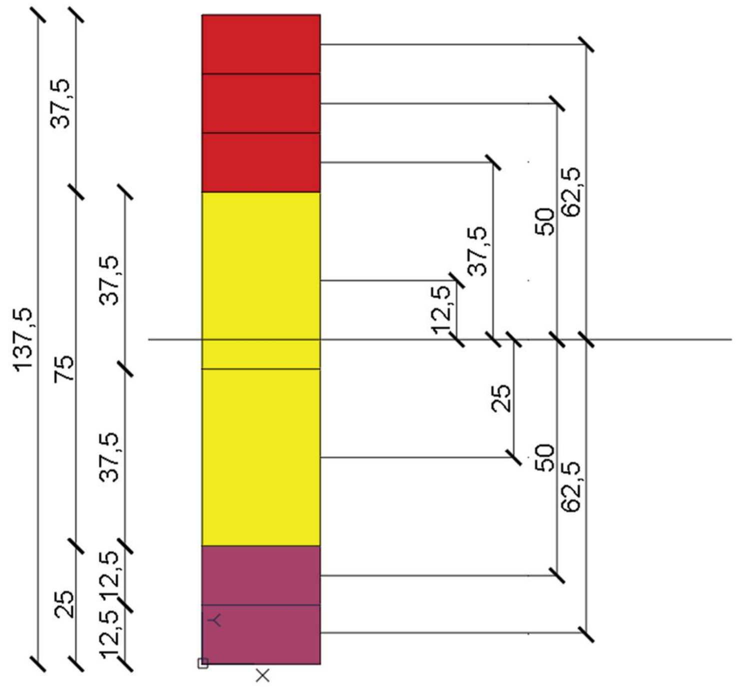
3 Mathematical Model of Structure

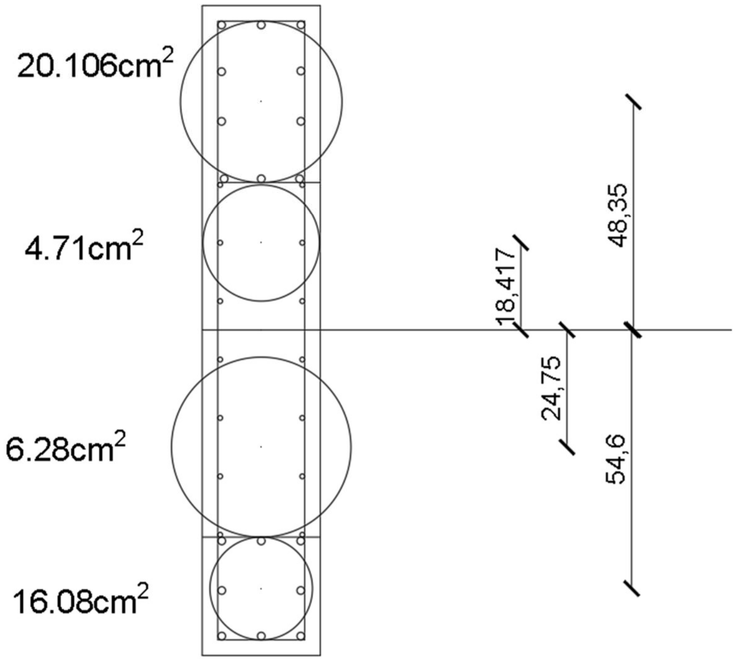
Idealization of Shear Wall

Because of its shape, shear wall has been modelled with two part. Some losses occurred intersection part but not important for accuracy of model.

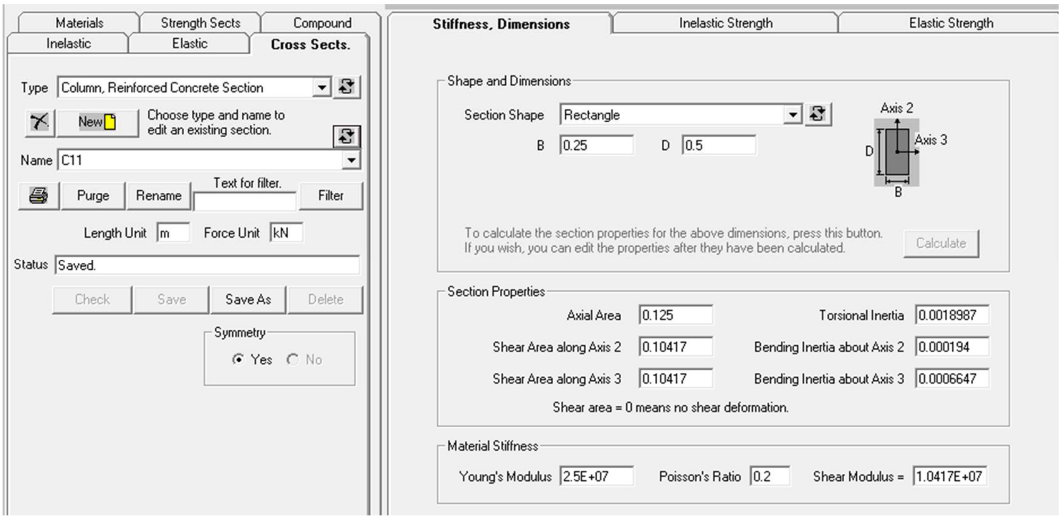




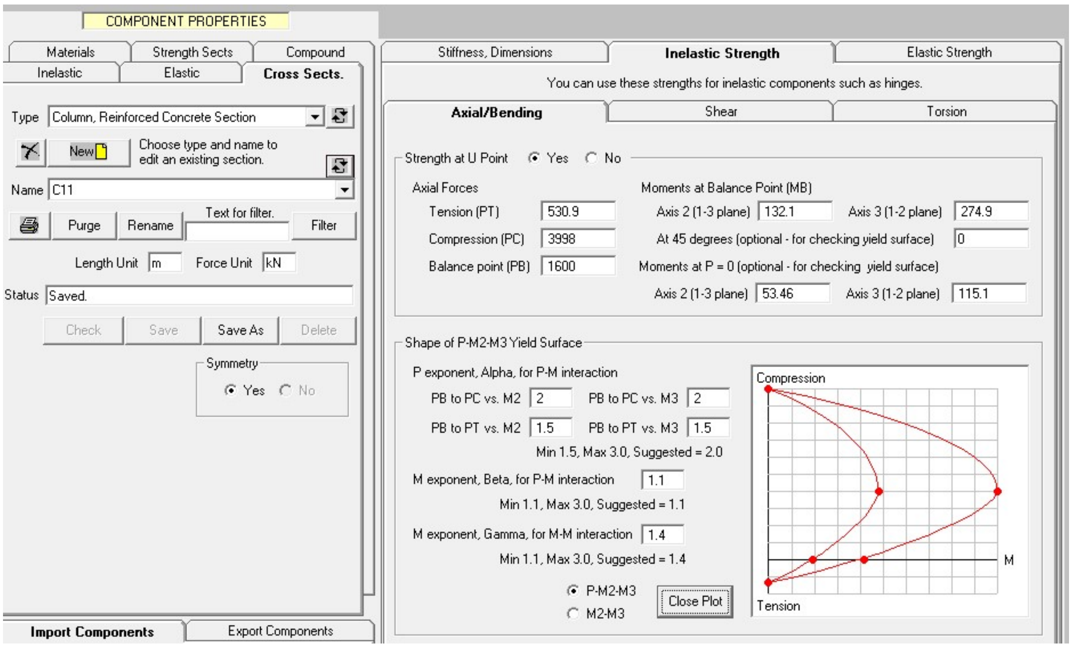

137,5
37,5
75
25
37,5
37,5
12,5
12,5
12,5
37,5
50
62,5
25
50
62,5


20.106cm^2
4.71cm^2
6.28cm^2
16.08cm^2
48,35
18,417
24,75
54,6

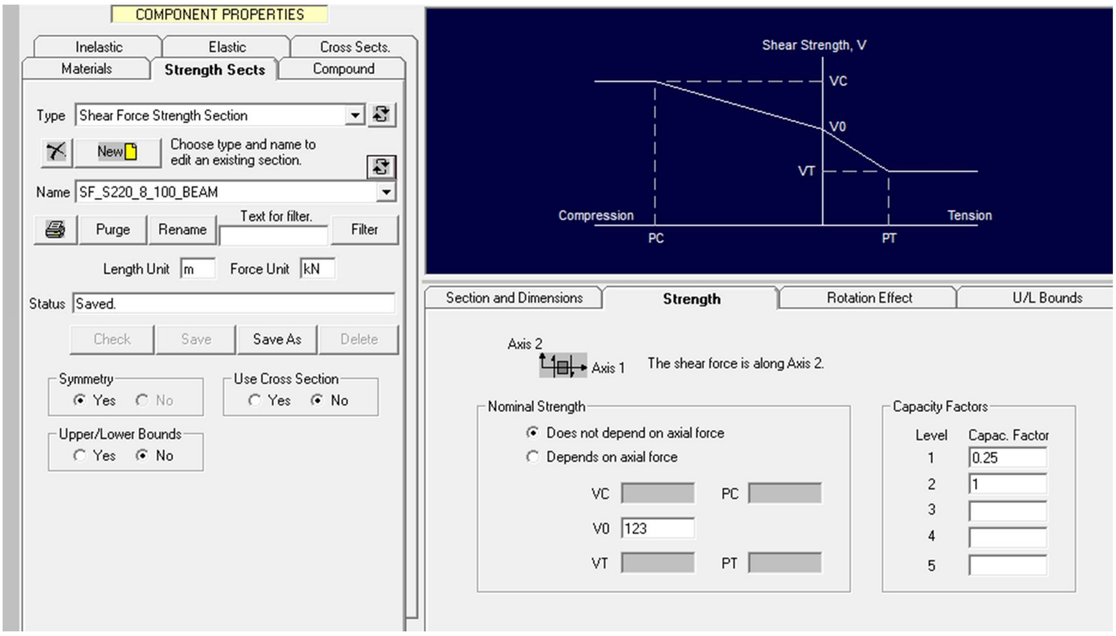
Perform-3d Model Information



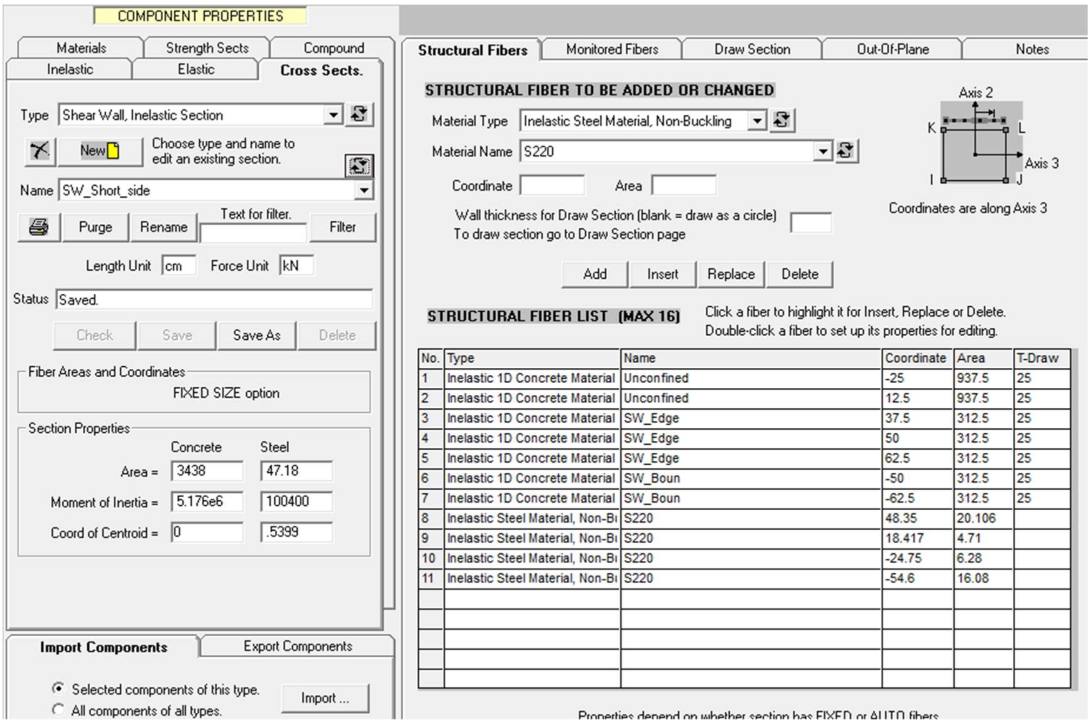
All beams and columns are modelled with its effective section property



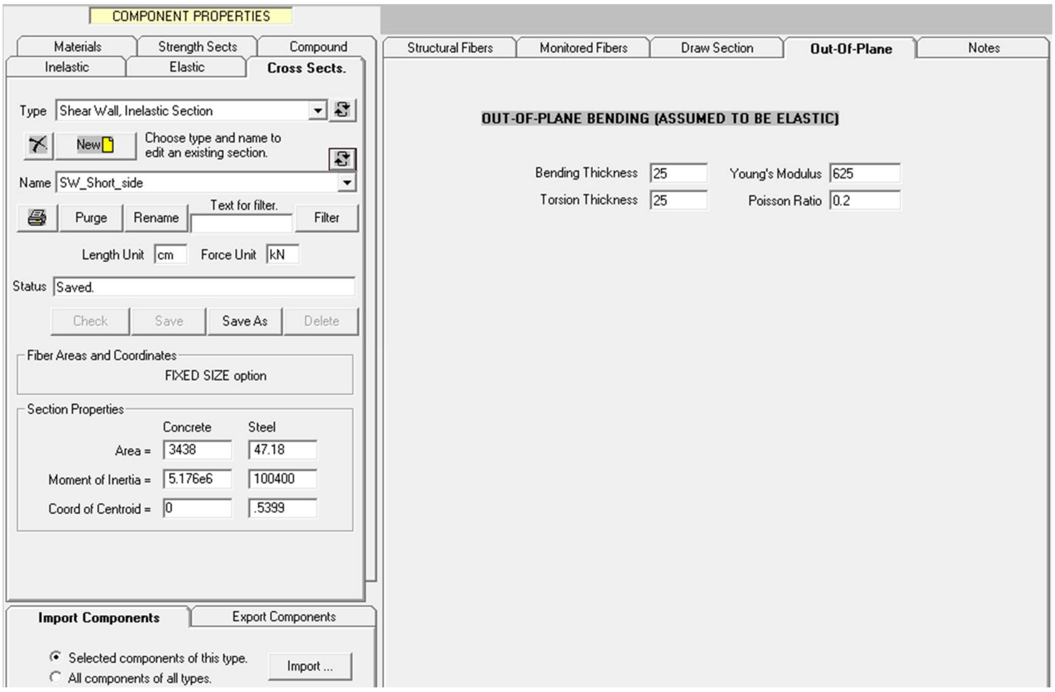
Interaction diagram of columns are modelled with basic properties, controlled and calibrated.

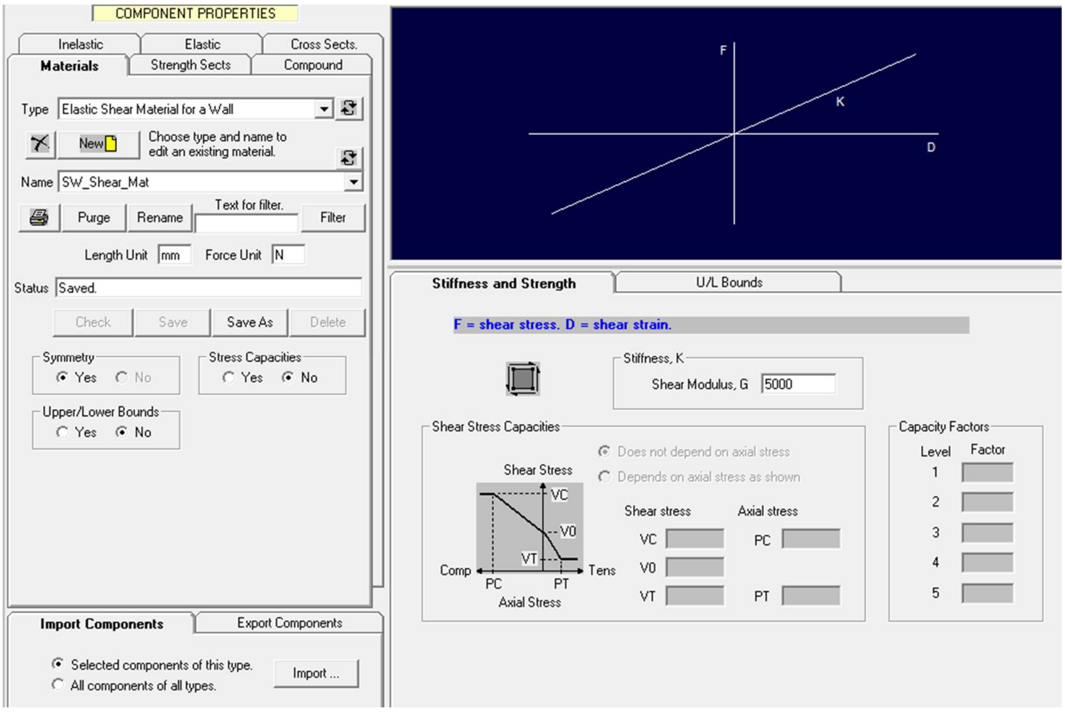


For obtaining damage type, strength sections are assigned to beams and columns. Capacity factor 0.25 is concrete cracking force, 1.00 is total collapse force according to code.

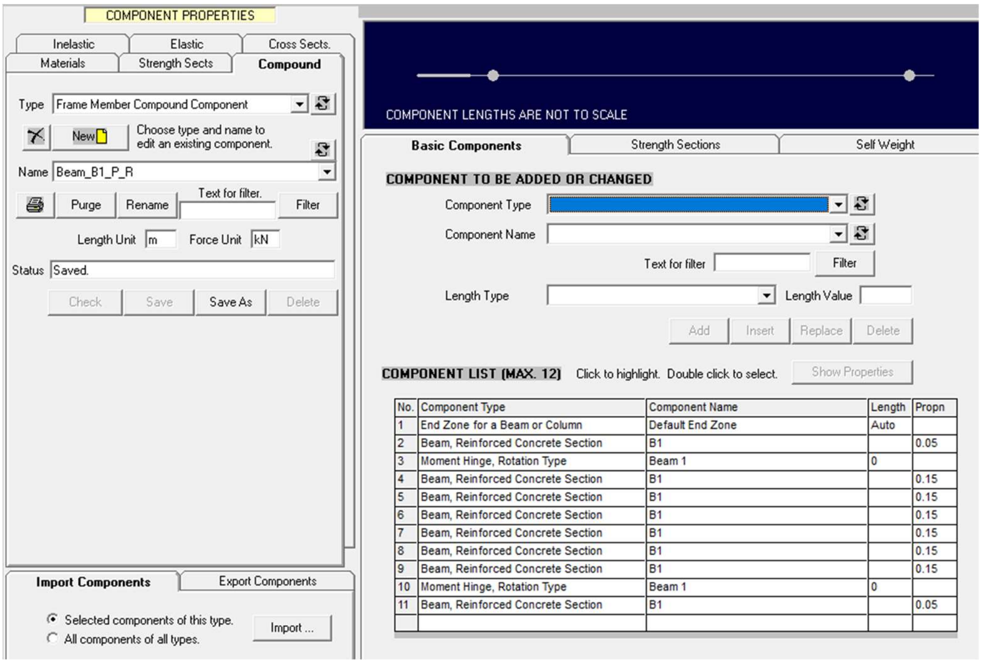


Shear wall are modelled with fiber elements.

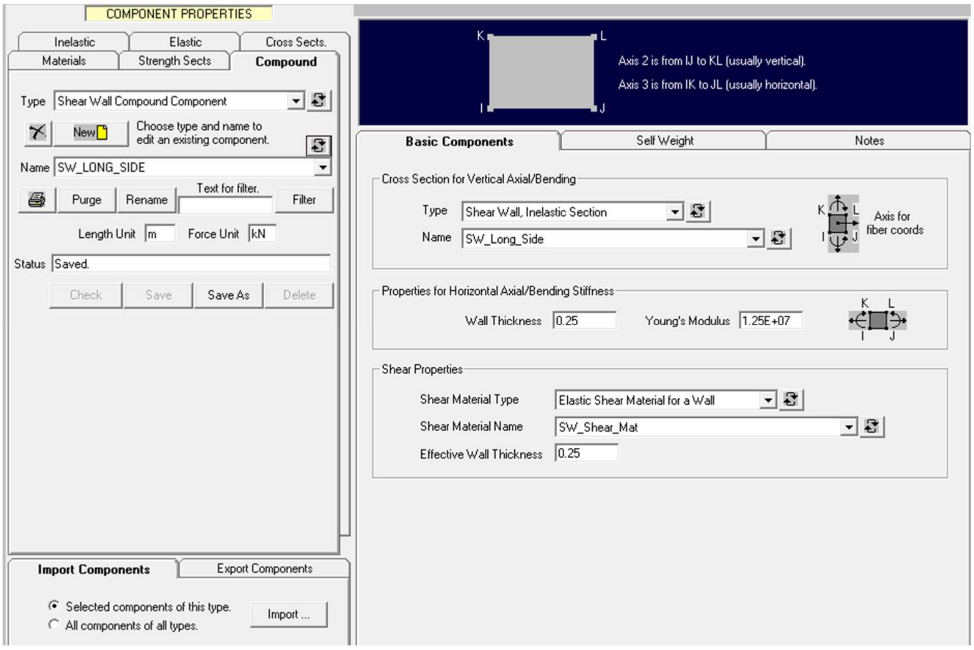




Shear wall effective stiffness behavior is given by modulus reduction.



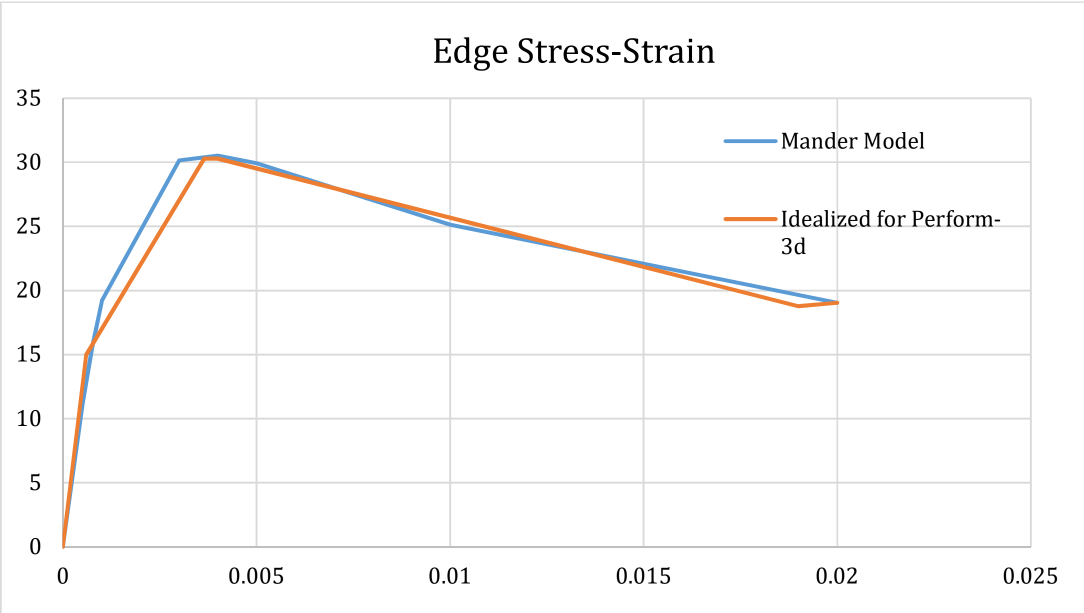
Beam and column compounds.

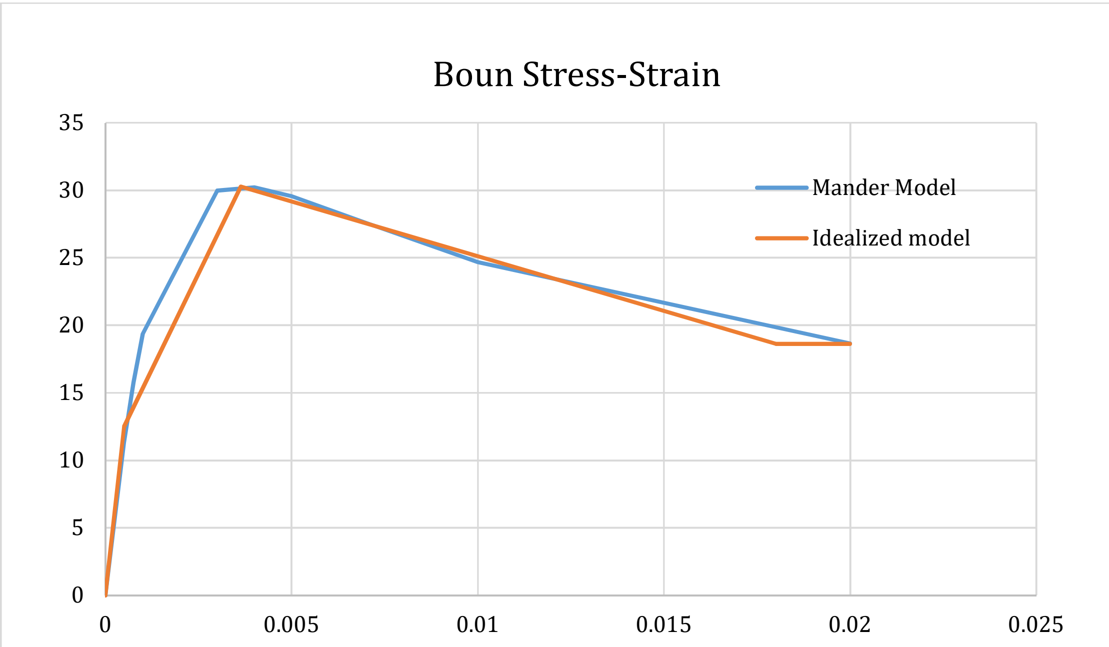


Shear wall compound.

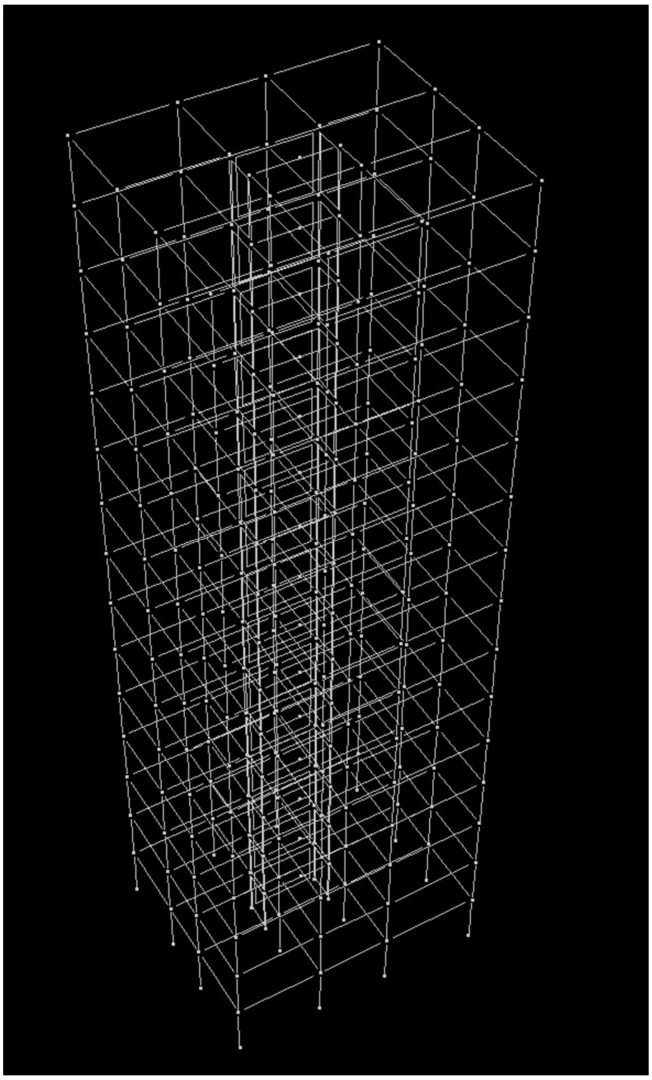
Material Models

Limitations of perform-3d, allows trilinear model of materials usually. For this reason, Mander confined model were idealized truly.

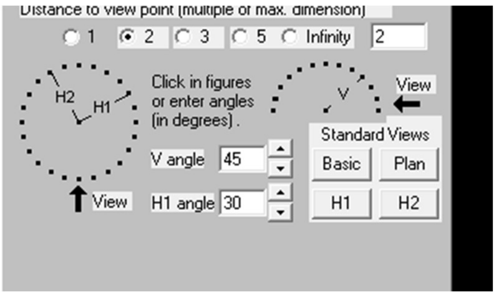




Building structural model;



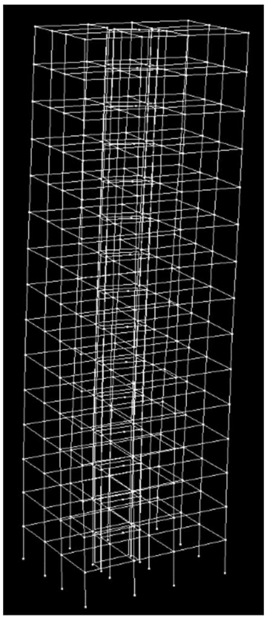
Directions;



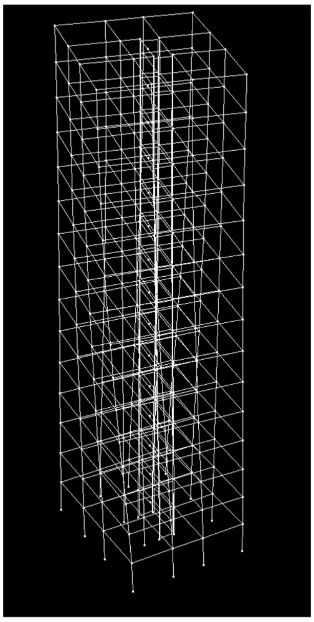
4 Dynamic Properties, Model Verification of Structure and Earthquake Records

Mod Shapes and Period Information

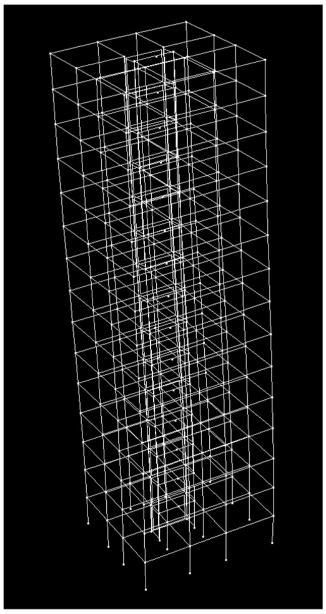
First three mod shape of structure is given below.



First Mode



Second Mode



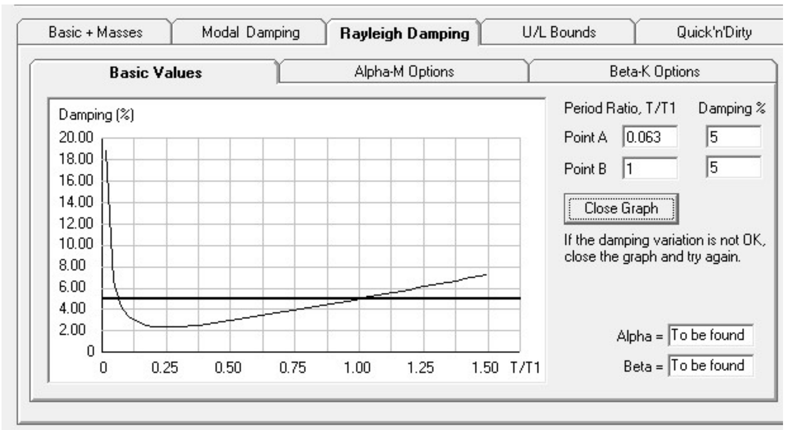
Third Mode

First three mode of structure were compared with SAP200 for model verification. The results is common with perform. Perform-3d model is accepted.

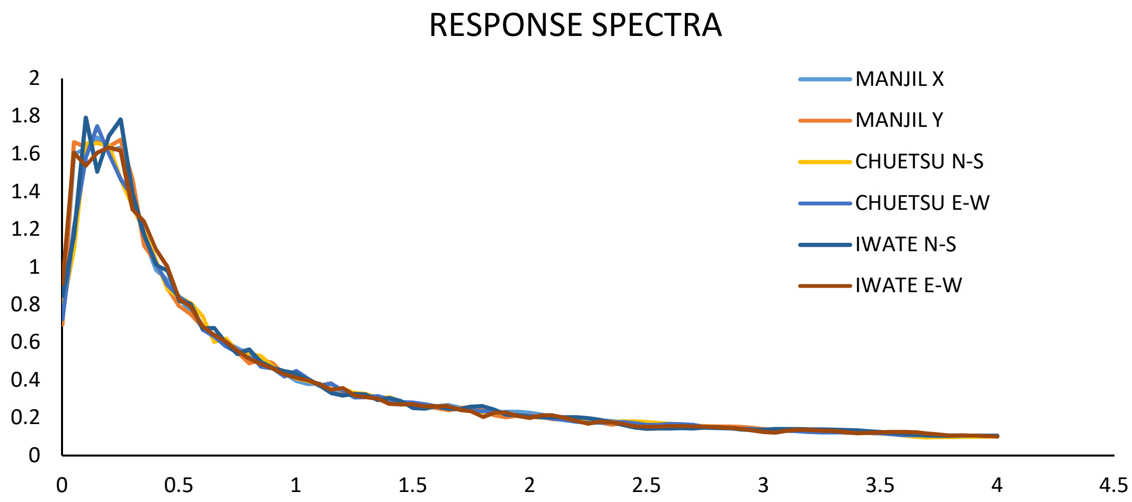
Mode	SAP2000	Perform-3d
1.	3.705	3.798
2.	3.52	3.485
3.	2.034	2.129

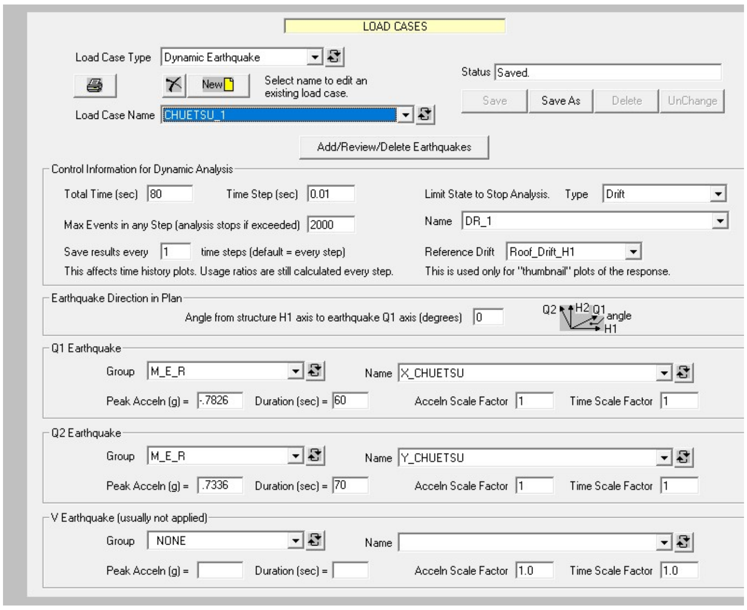
Damping Properties

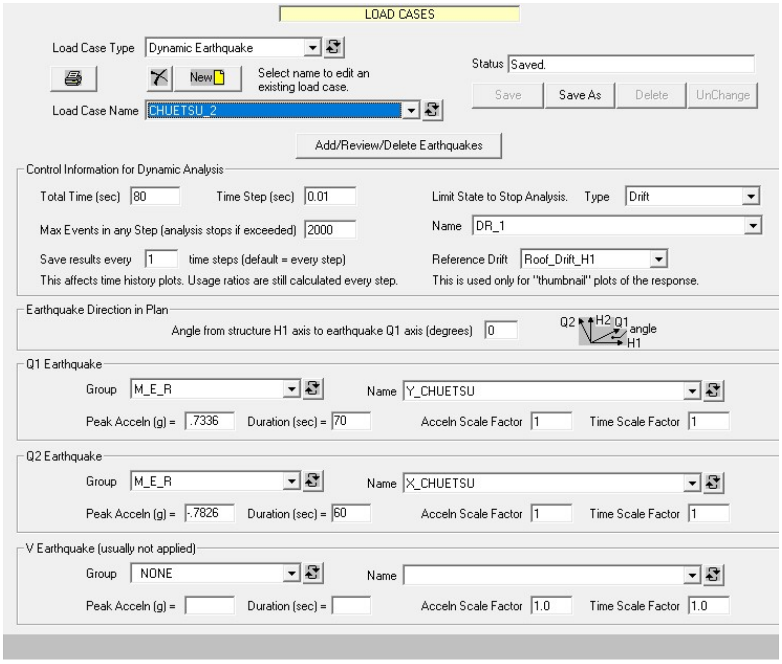
Rayleigh damping model is used for conducting analyses.



Response Spectra of the Records





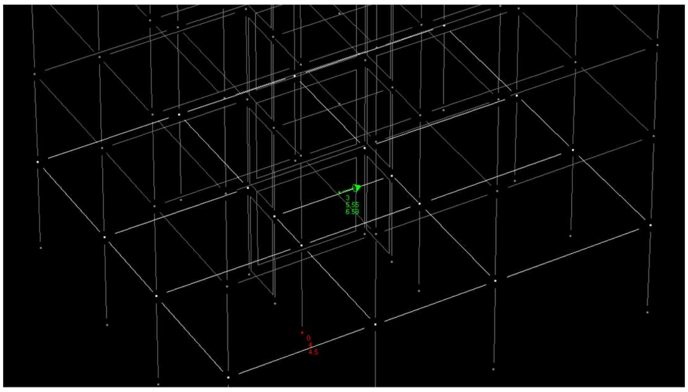


As one see, record directions are changed.

5 Control of Relative Story Drift Ratios

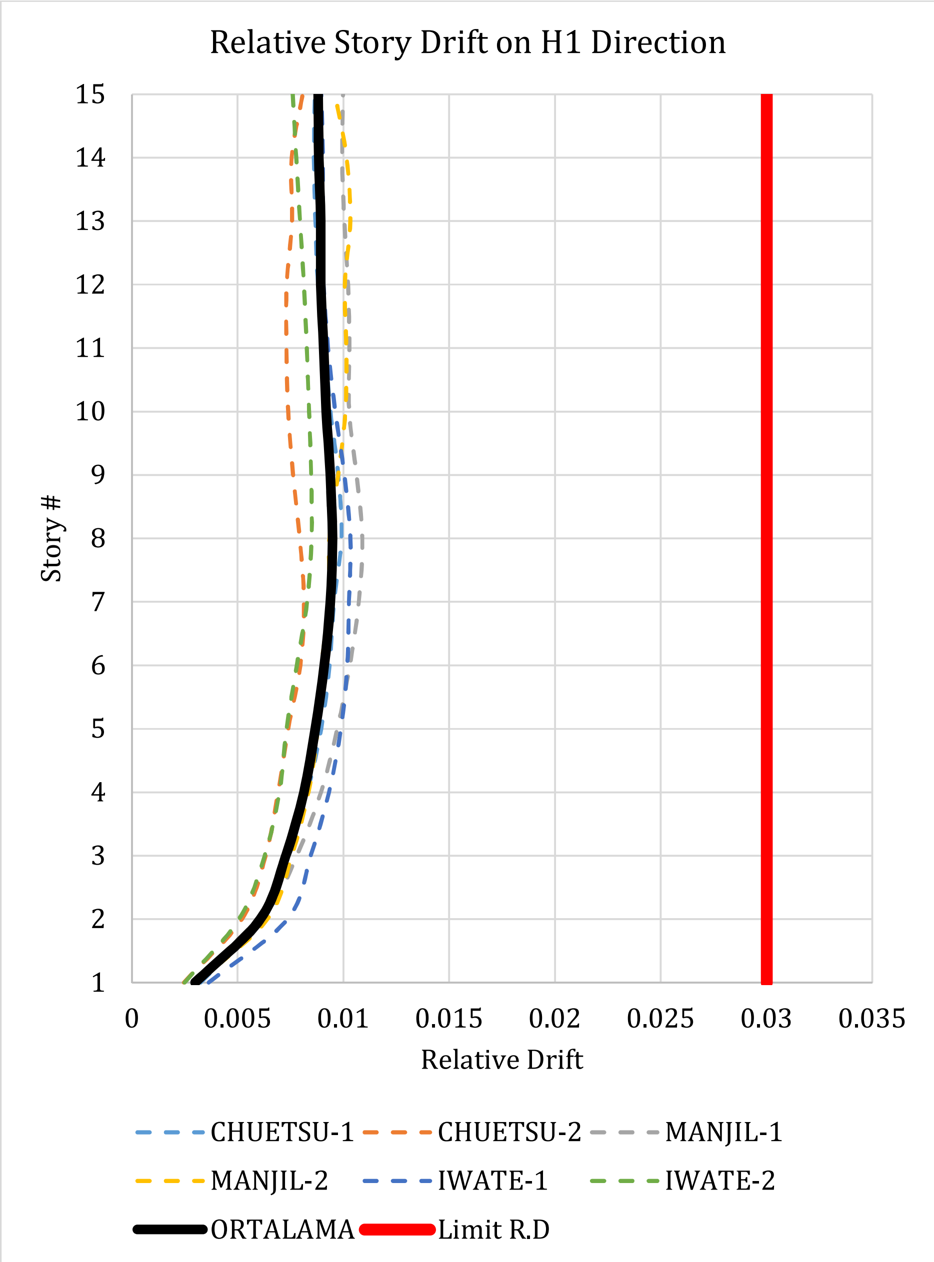
Control Nodes

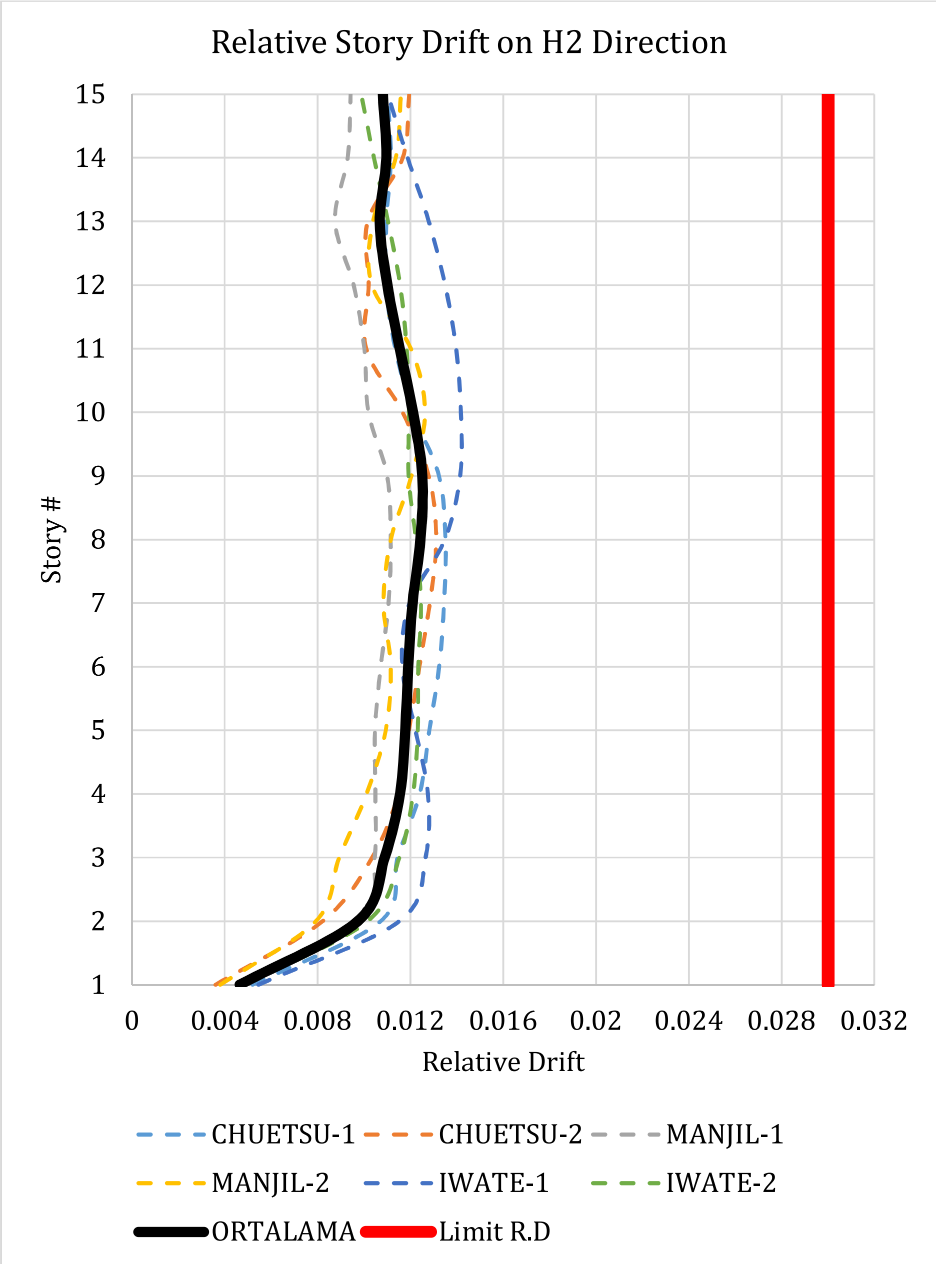
Center of gravity of story were determined as a control node for 15 stories.



Limit Story Drift Ratio

Limit story drift ratio is taken from TBSC. Limit R.S.D is taken as 0.03 for average of each records. 0.045 for one record.

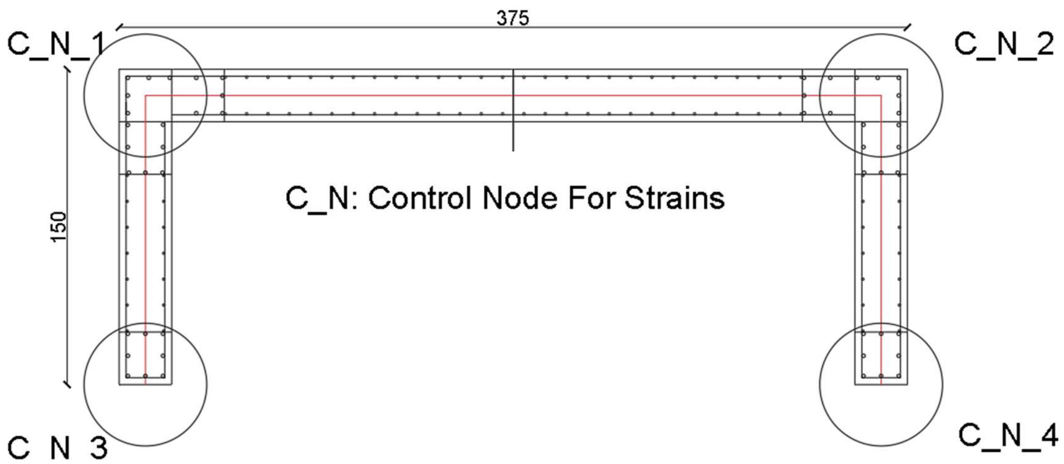

Relative Story Drift on H1 Direction
Story #
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
Relative Drift
CHUETSU-1
CHUETSU-2
MANJIL-1
MANJIL-2
IWATE-1
IWATE-2
ORTALAMA
Limit R.D

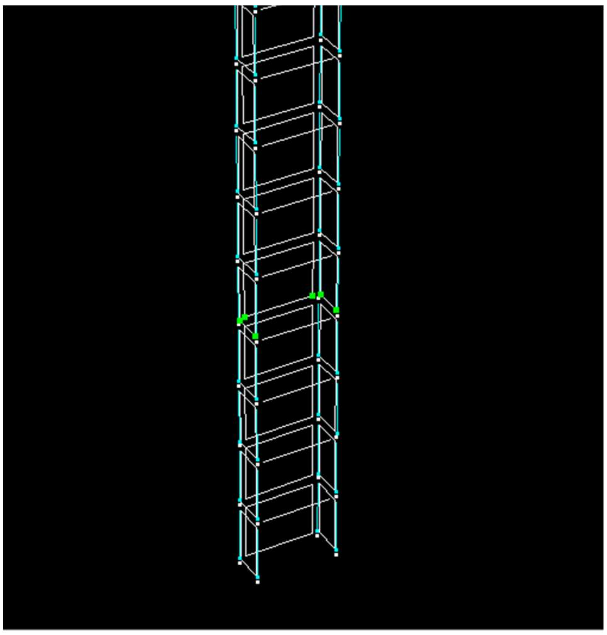

Relative Story Drift on H2 Direction
Story #
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.004
0.008
0.012
0.016
0.02
0.024
0.028
0.032
Relative Drift
CHUETSU-1
CHUETSU-2
MANJIL-1
MANJIL-2
IWATE-1
IWATE-2
ORTALAMA
Limit R.D

6 Strains and Shear Strength Control of Shear Wall

Control Nodes

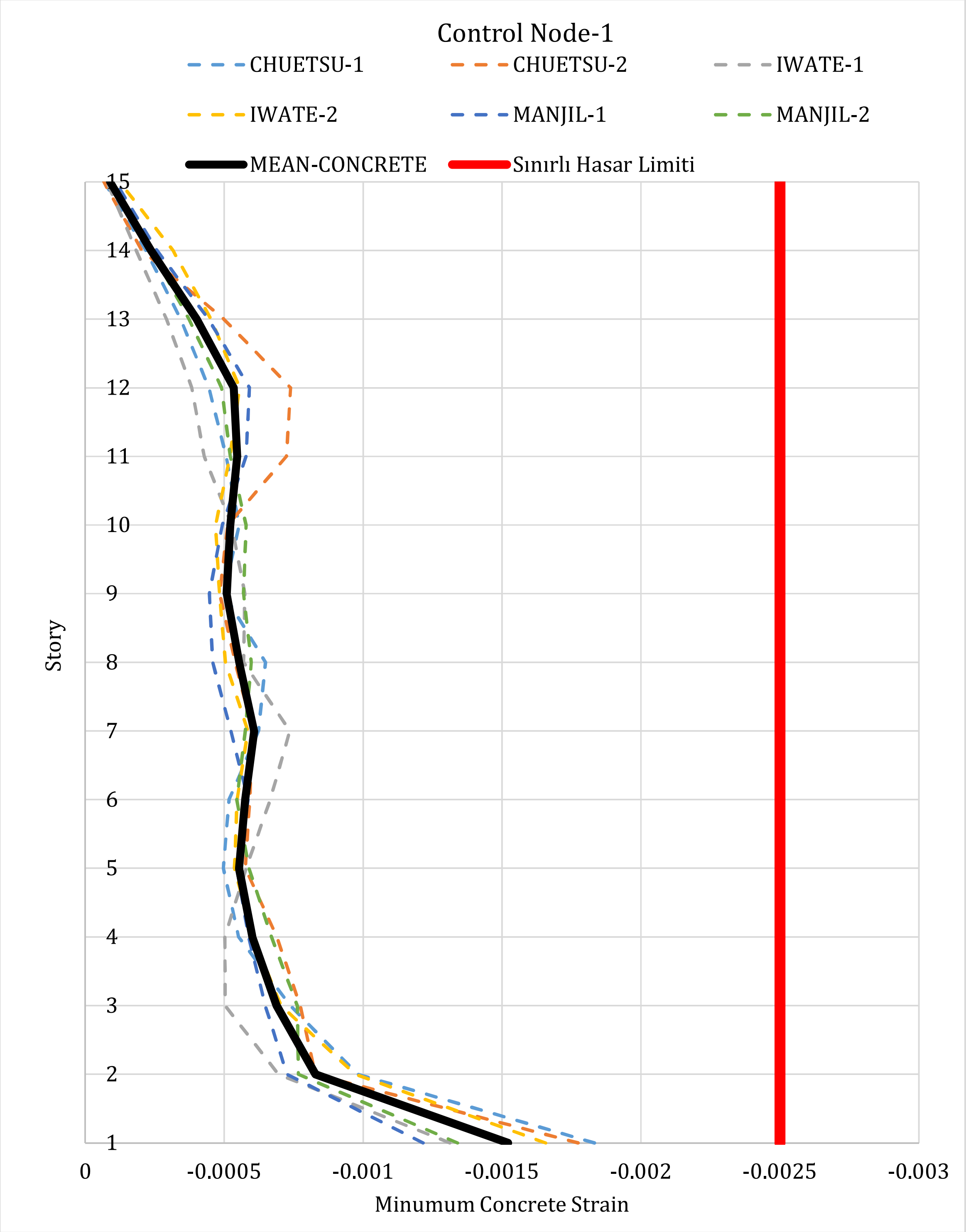
For calculating envelope strains, control nodes were chosen most critical points. Strain gage elements were assigned for measure the strain.

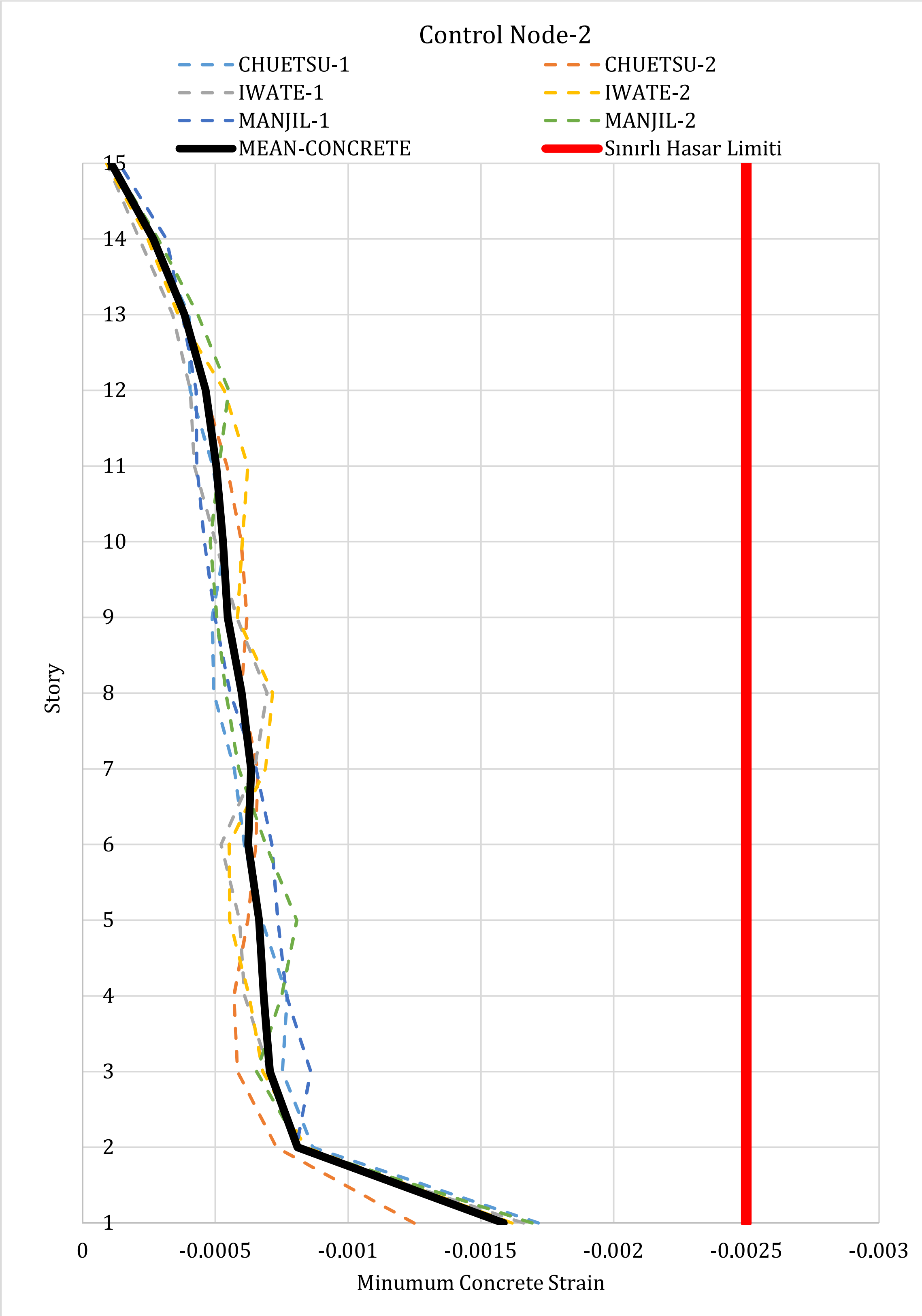




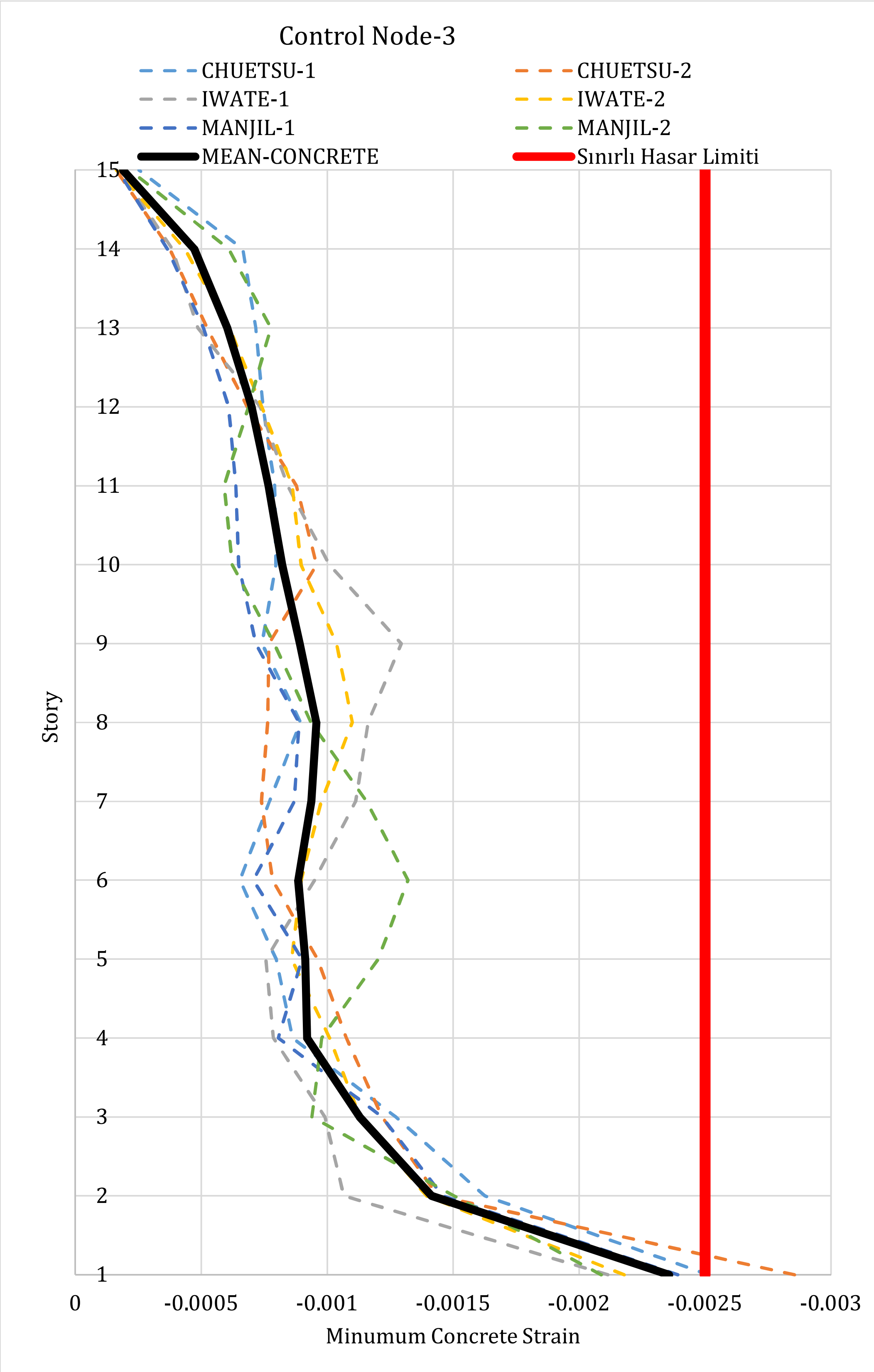
Structure section elements were assigned to the shear wall for determining the shear forces.

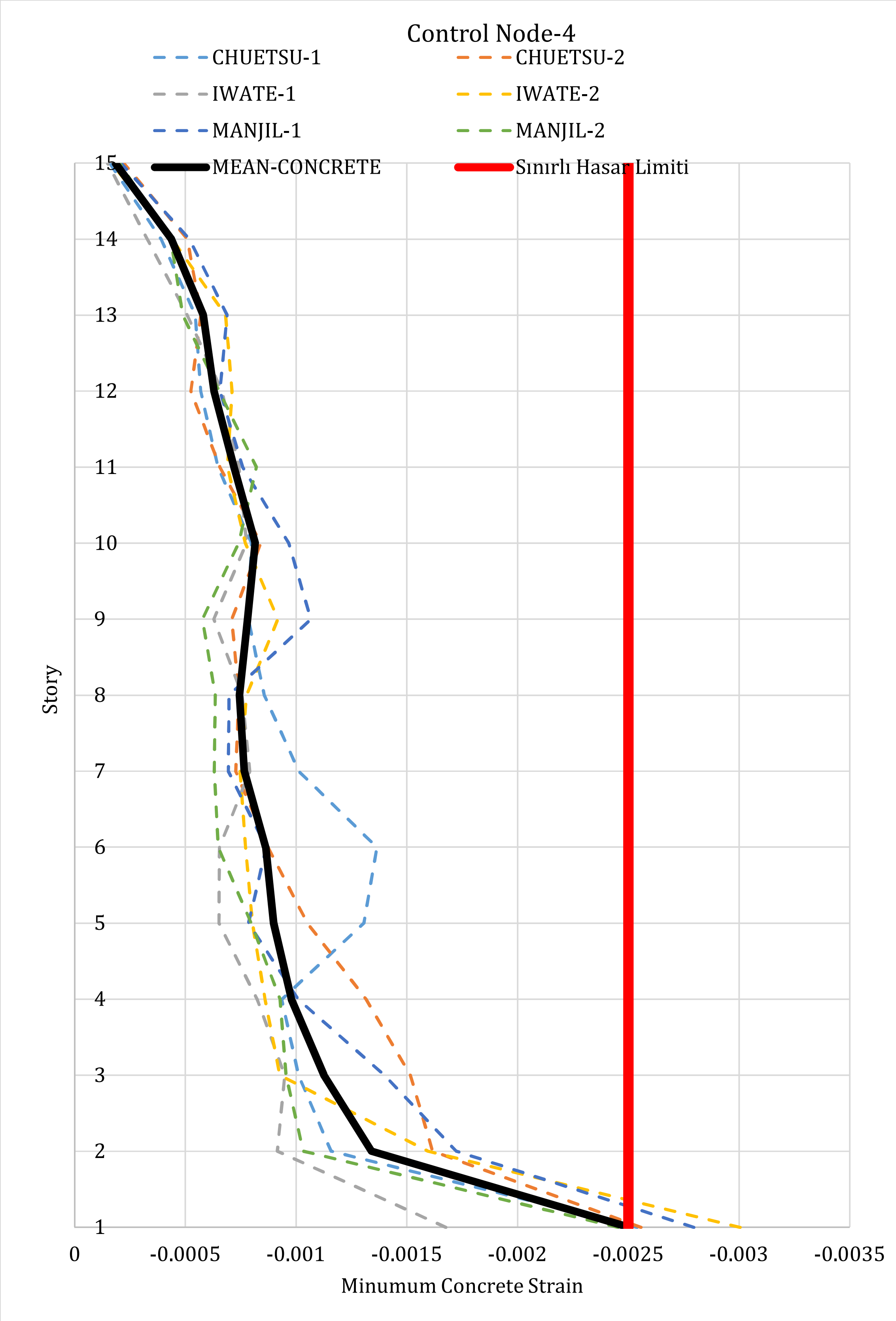
Minimum Concrete Strains of Control Nodes



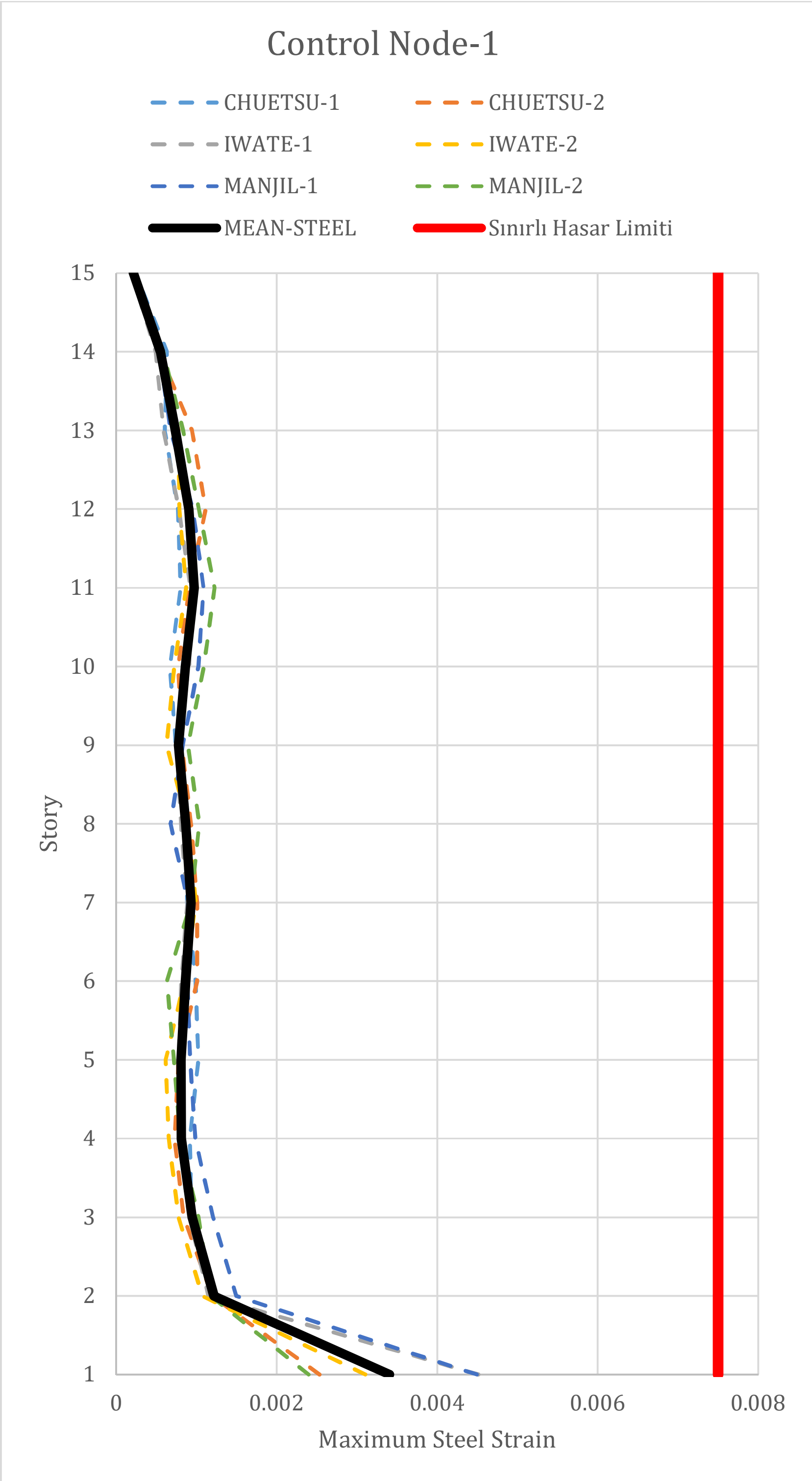


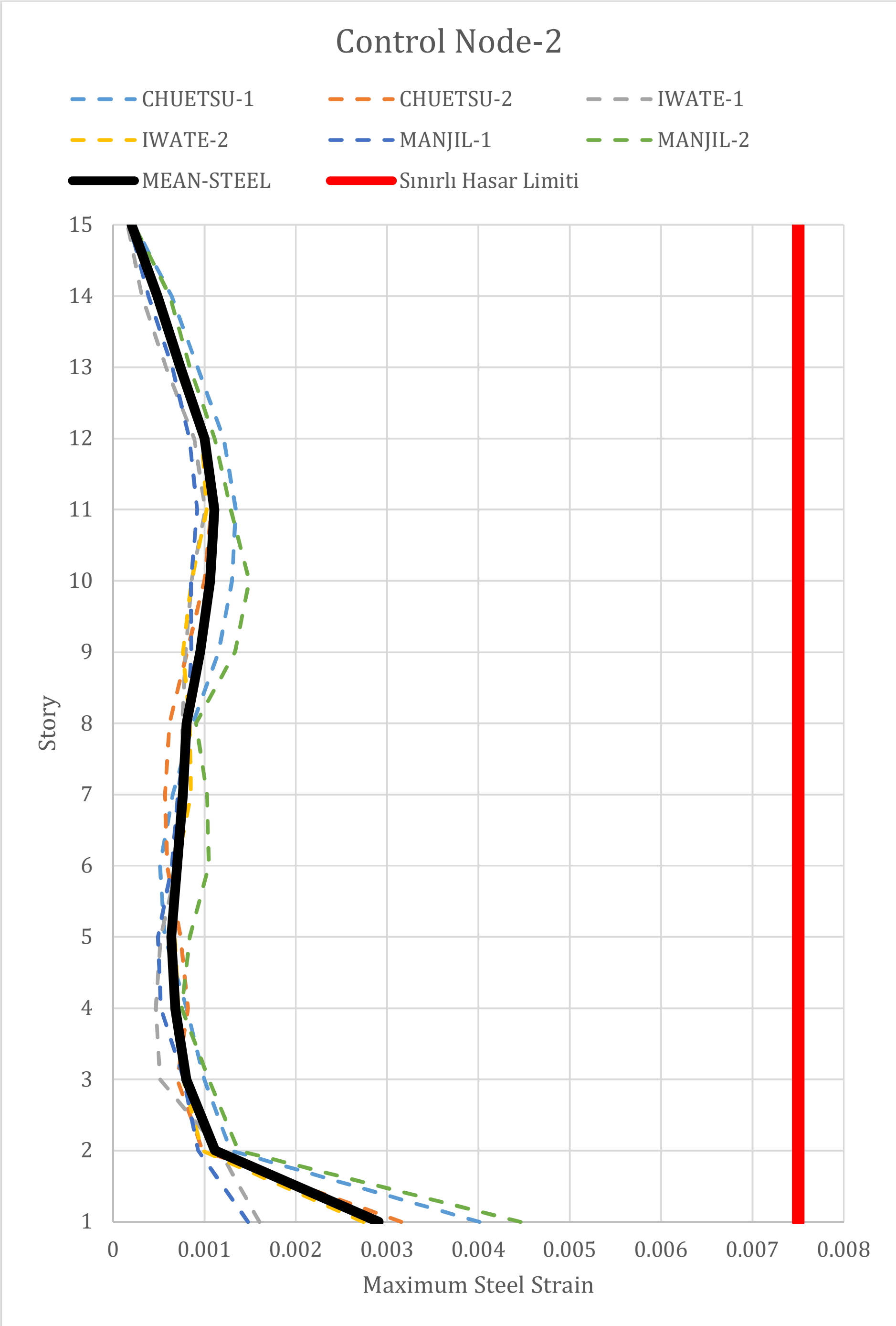
Control Node-2
CHUETSU-1
CHUETSU-2
IWATE-1
IWATE-2
MANJIL-1
MANJIL-2
MEAN-CONCRETE
Sınırlı Hasar Limiti
Story
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-0.0005
-0.001
-0.0015
-0.002
-0.0025
-0.003
Minumum Concrete Strain

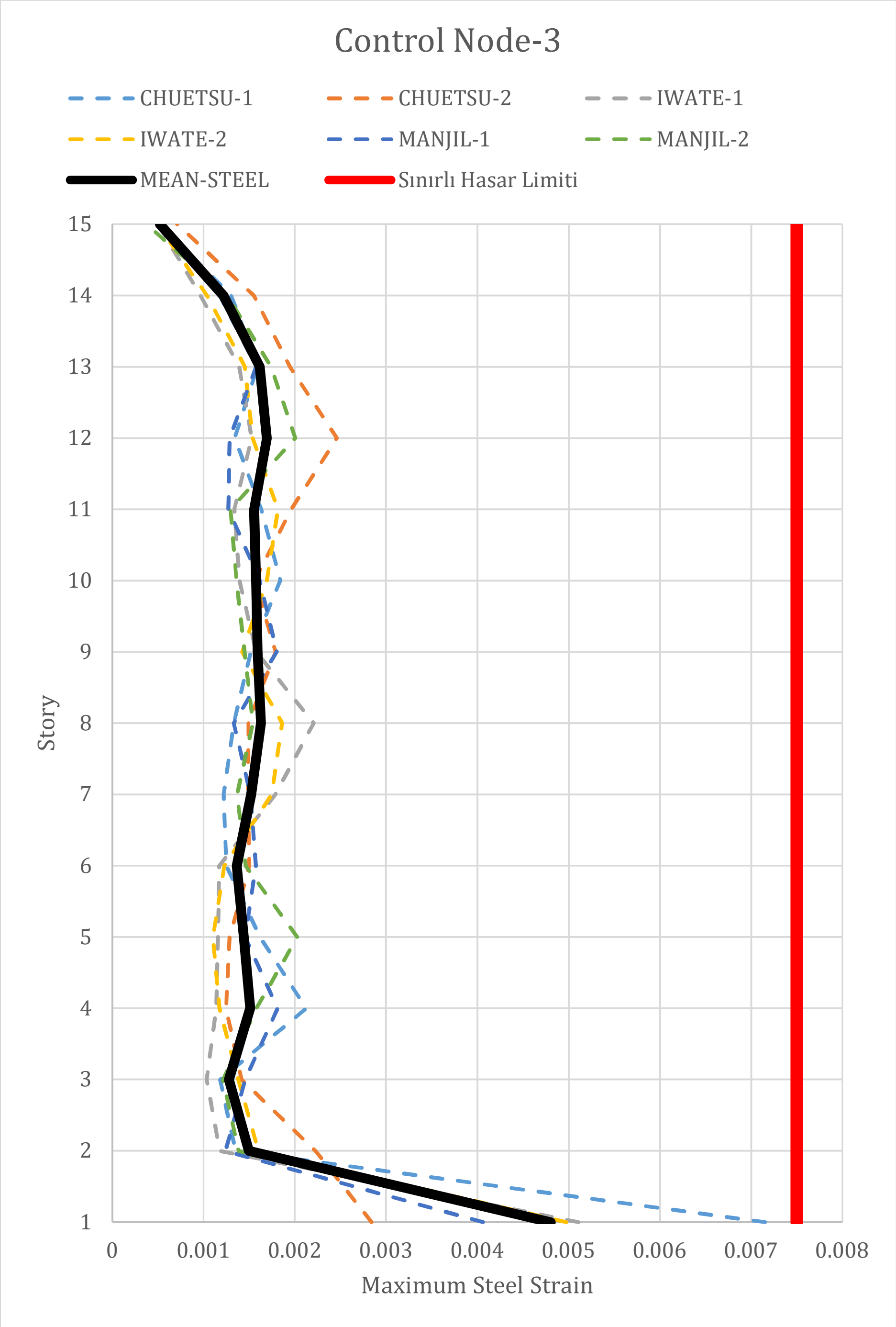

Control Node-3
CHUETSU-1
CHUETSU-2
IWATE-1
IWATE-2
MANJIL-1
MANJIL-2
MEAN-CONCRETE
Sınırlı Hasar Limiti
Story
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-0.0005
-0.001
-0.0015
-0.002
-0.0025
-0.003
Minumum Concrete Strain


Control Node-4
CHUETSU-1
CHUETSU-2
IWATE-1
IWATE-2
MANJIL-1
MANJIL-2
MEAN-CONCRETE
Sınırlı Hasar Limiti
Story
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-0.0005
-0.001
-0.0015
-0.002
-0.0025
-0.003
-0.0035
Minumum Concrete Strain

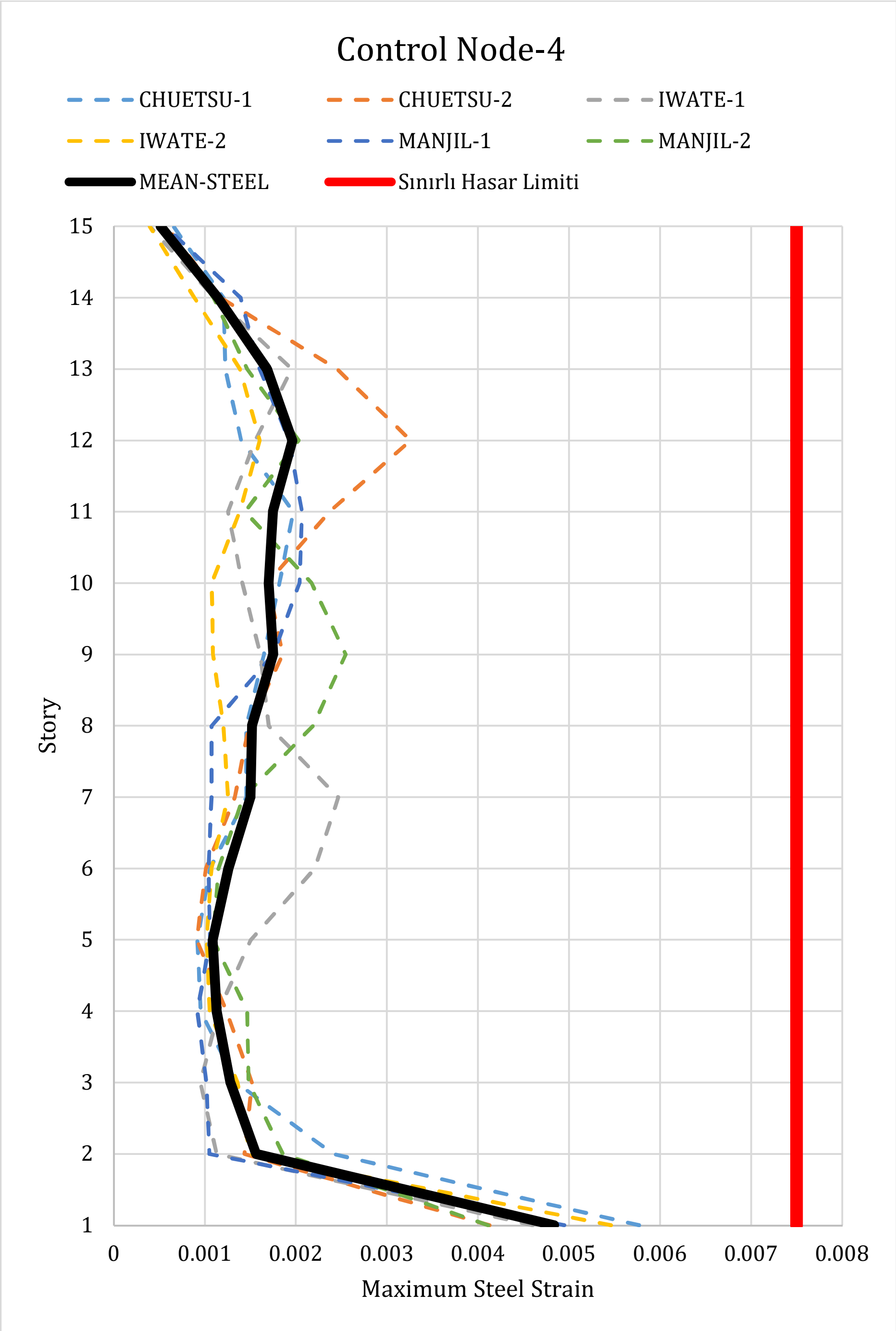
Maximum Steel Strain



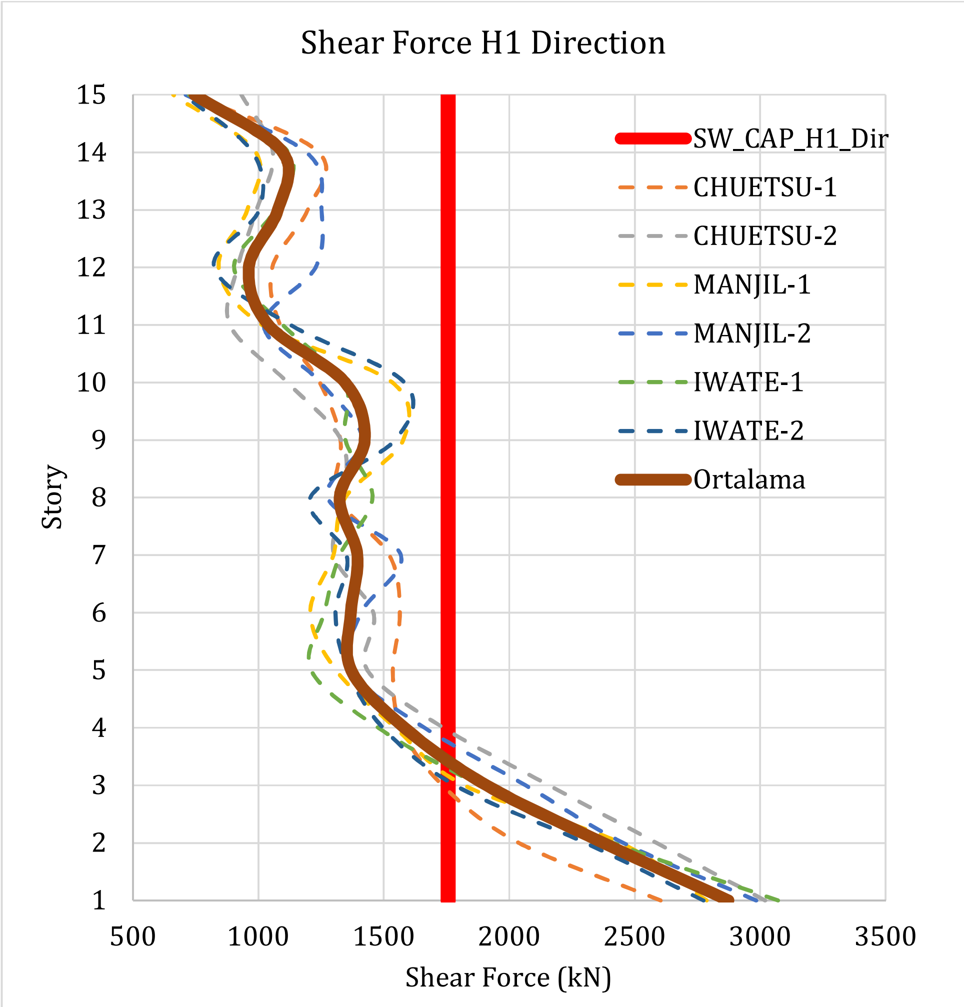

Control Node-2
CHUETSU-1
CHUETSU-2
IWATE-1
IWATE-2
MANJIL-1
MANJIL-2
MEAN-STEEL
Sınırlı Hasar Limiti
Story
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
Maximum Steel Strain

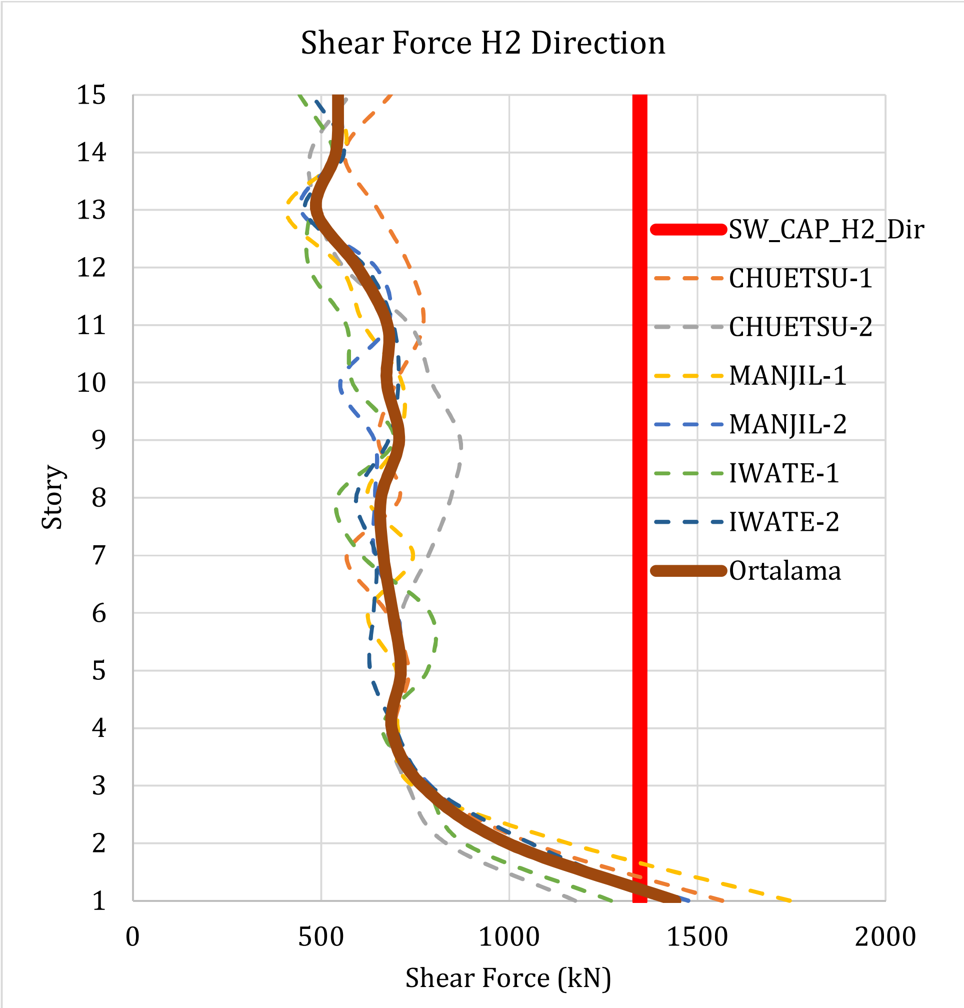


Control Node-3
CHUETSU-1
CHUETSU-2
IWATE-1
IWATE-2
MANJIL-1
MANJIL-2
MEAN-STEEL
Sınırlı Hasar Limiti
Story
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
Maximum Steel Strain


Control Node-4
CHUETSU-1
CHUETSU-2
IWATE-1
IWATE-2
MANJIL-1
MANJIL-2
MEAN-STEEL
Sınırlı Hasar Limiti
Story
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
Maximum Steel Strain

Shear Strength Control of Shear Wall




Shear Force H2 Direction
Story
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
500
1000
1500
2000
Shear Force (kN)
SW_CAP_H2_Dir
CHUETSU-1
CHUETSU-2
MANJIL-1
MANJIL-2
IWATE-1
IWATE-2
Ortalama

7 Damage Characterization

Structural Components Expected to be Damaged

Damage characteristic of structure will evaluate with two components, shear wall and frame system. Performance level will be determined by forces such as shear and flexural. Also relative story drift ratio will be controlled.

Shear Wall

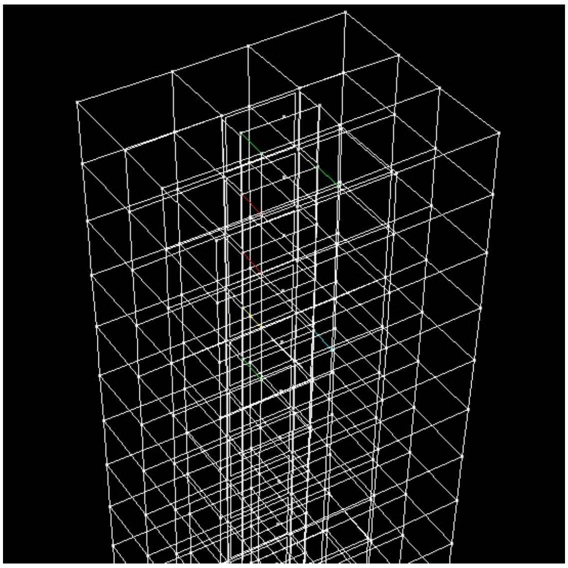
As we see, Shear wall can take damage due to forces shear and flexural.

Average minimum concrete strains are lower than the sınırlı hasar capacity

Average maximum steel strains are lower than the sınırlı hasar capacity

Average shear forces are higher than the shear capacity.

Frame System



Flexural damages of the frame system are not pass sınırlı hasar limit state for 6 NTHA.

Results of analyses are shown that shear damage will not occur.

Story Drift Ratio

Relative story drift ratios are lower than the code criteria.

8 Executive Report

Structural Reliability

The BURAK' building is not safe for seismic performance because of shear failure. Retrofitting is required for preventing shear collapses.

	Shear Damage	Flexural Damage
Frame System	No Damage	Sınırlı Hasar
Shear Wall	**Collapse**	Sınırlı Hasar

Recommendations

FRP material can be used for retrofitting process.