

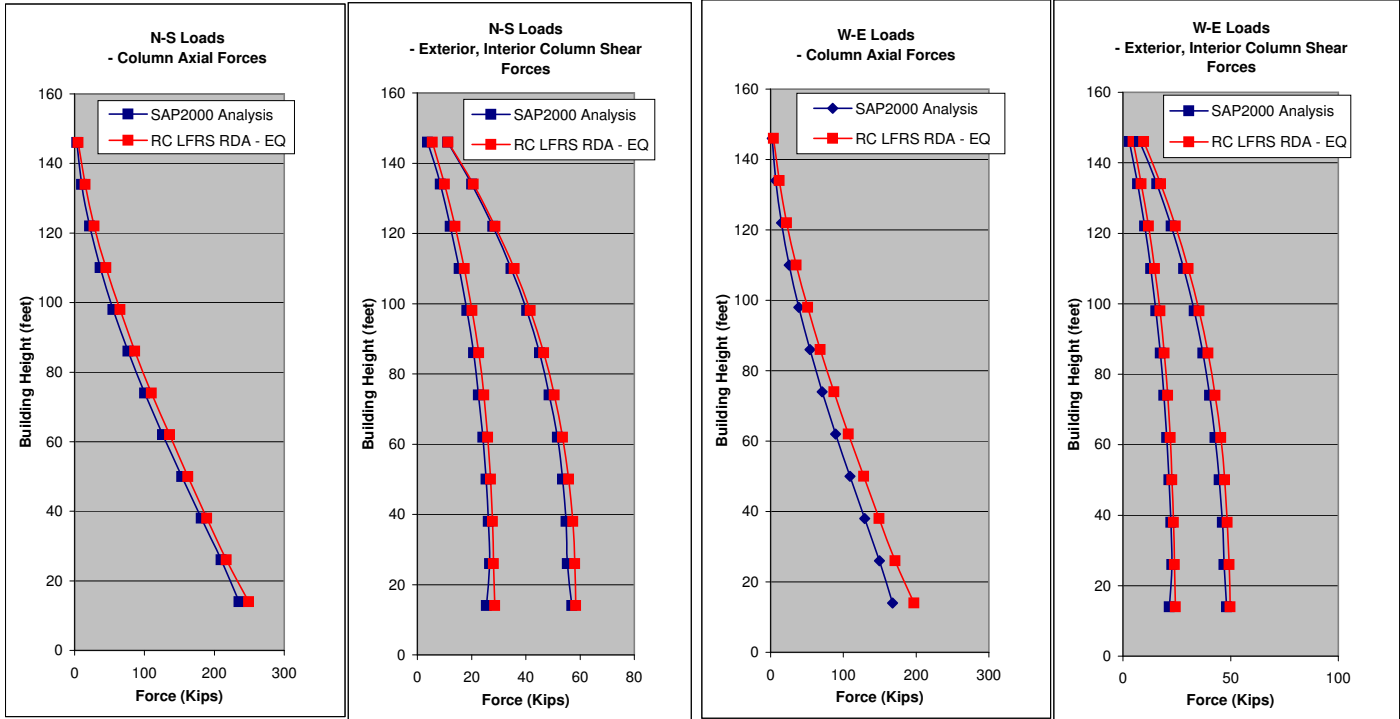
Project Sample 12 Story RC SMRF
 Job No.
 By AML
 Date 03/15/24
 Sheet ____ of ____

RC SMRF Seismic Forces and Displacements
 SAP2000 vs RC LFRS RDA - EQ Model
 Case 1 Study - Summary
 3/15/24

Company Name
 Company Address
 Company Tel/Fax
 Company Website

NBSD-Software.Com

RC SMRF SEISMIC FORCES AND DISPLACEMENTS AT FLOOR LEVELS
 SAP2000 2D FRAME MODEL VS RC LFRS RDA - EQ SOFTWARE TOOL
 CASE STUDY 1 - SAMPLE 12 STORY RC BUILDING



N- S Average Difference (all Floors) = 5.50 % (Shear) W- E Average Difference (all Floors) = 7.70 % (Shear)

Note: - SAP2000 results are for Shear (no Torsion) component of EQ loading, both loading directions.
 - RC LFRS RDA results include both Shear and Torsional components, each loading direction.

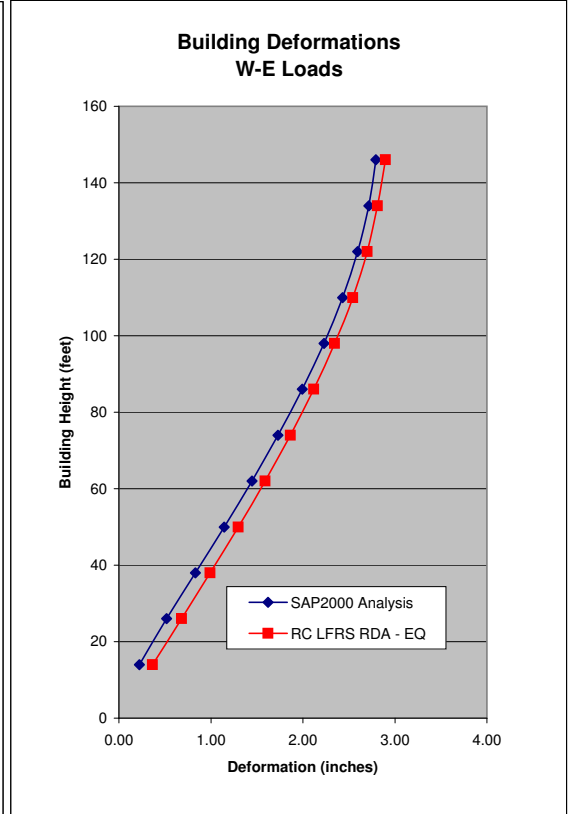
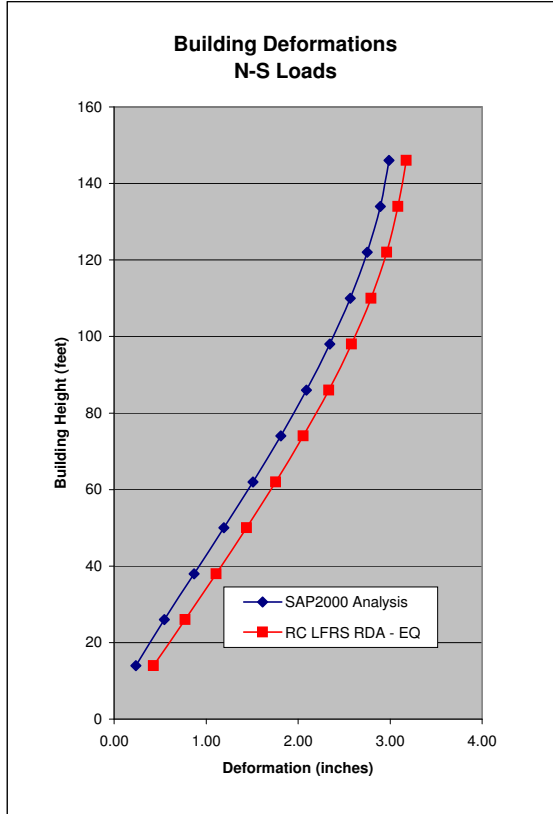
1. Seismic Forces

Floor Level	Story Weight, W _x (kips)	Floor Elevation, H _x (feet)	N - S Direction						W - E Direction					
			SAP2000 Analysis			RC LFRS RDA - EQ			SAP2000 Analysis			RC LFRS RDA - EQ		
			Axial Load (kips)	Exterior Column Shear (kips)	Interior Column Shear (kips)	Axial Load (kips)	Exterior Column Shear (kips)	Interior Column Shear (kips)	Axial Load (kips)	Exterior Column Shear (kips)	Interior Column Shear (kips)	Axial Load (kips)	Exterior Column Shear (kips)	Interior Column Shear (kips)
R	1,988	146.0	3.3	3.8	11.2	5.0	5.5	11.3	2.3	2.9	7.7	4.0	4.7	9.7
12	1,988	134.0	10.3	8.5	20.1	15.0	10.0	20.6	7.1	6.9	15.8	12.0	8.5	17.5
11	1,988	122.0	21.5	12.2	27.9	28.0	13.9	28.7	15.0	10.2	22.5	22.0	11.9	24.4
10	1,988	110.0	36.6	15.5	34.6	45.0	17.3	35.8	25.6	12.9	28.2	35.0	14.7	30.3
9	1,988	98.0	55.2	18.3	40.3	65.0	20.2	41.7	38.8	15.4	33.1	51.0	17.2	35.4
8	1,988	86.0	76.6	20.7	45.0	86.0	22.6	46.6	54.0	17.4	37.2	68.0	19.2	39.5
7	1,988	74.0	100.4	22.6	48.7	110.0	24.5	50.5	71.0	19.0	40.3	87.0	20.8	42.8
6	1,988	62.0	126.1	24.2	51.7	136.0	25.9	53.6	89.5	20.3	42.8	107.0	22.0	45.4
5	1,988	50.0	153.4	25.3	53.6	162.0	27.0	55.8	109.1	21.4	44.8	128.0	22.8	47.3
4	1,988	38.0	181.6	26.2	54.9	189.0	27.7	57.3	129.4	22.2	46.2	149.0	23.5	48.5
3	1,988	26.0	209.8	26.7	55.4	217.0	28.1	58.1	149.6	22.7	47.0	171.0	23.9	49.3
2	1,988	14.0	235.2	25.5	57.0	249.0	28.6	58.4	167.6	21.6	48.2	197.0	24.4	49.8

RC SMRF SEISMIC FORCES AND DISPLACEMENTS AT FLOOR LEVELS
SAP2000 2D FRAME MODEL VS RC LFRS RDA - EQ SOFTWARE TOOL
CASE STUDY 1 - SAMPLE 12 STORY RC BUILDING

N- S Average
 Difference (all Floors)
 = 5.30 %

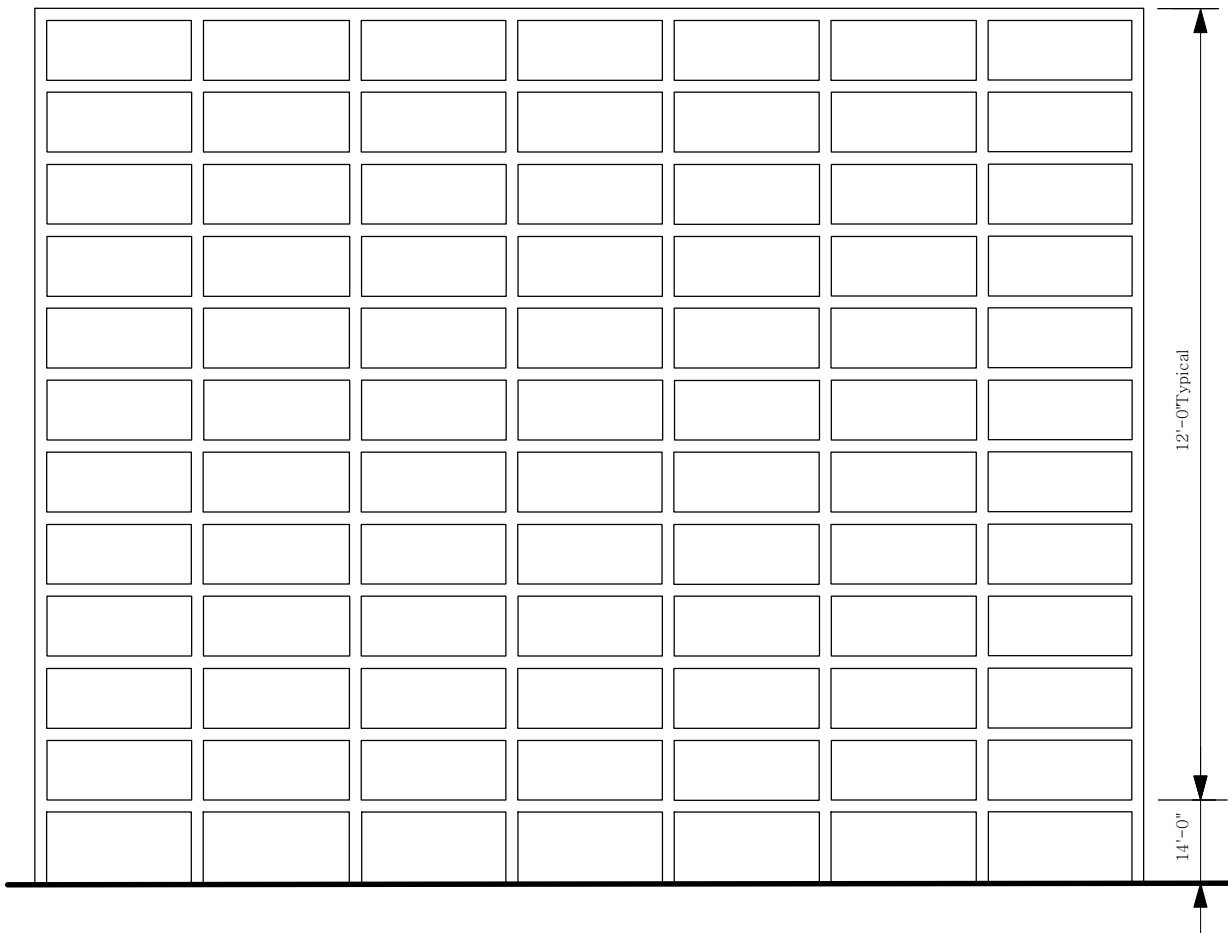
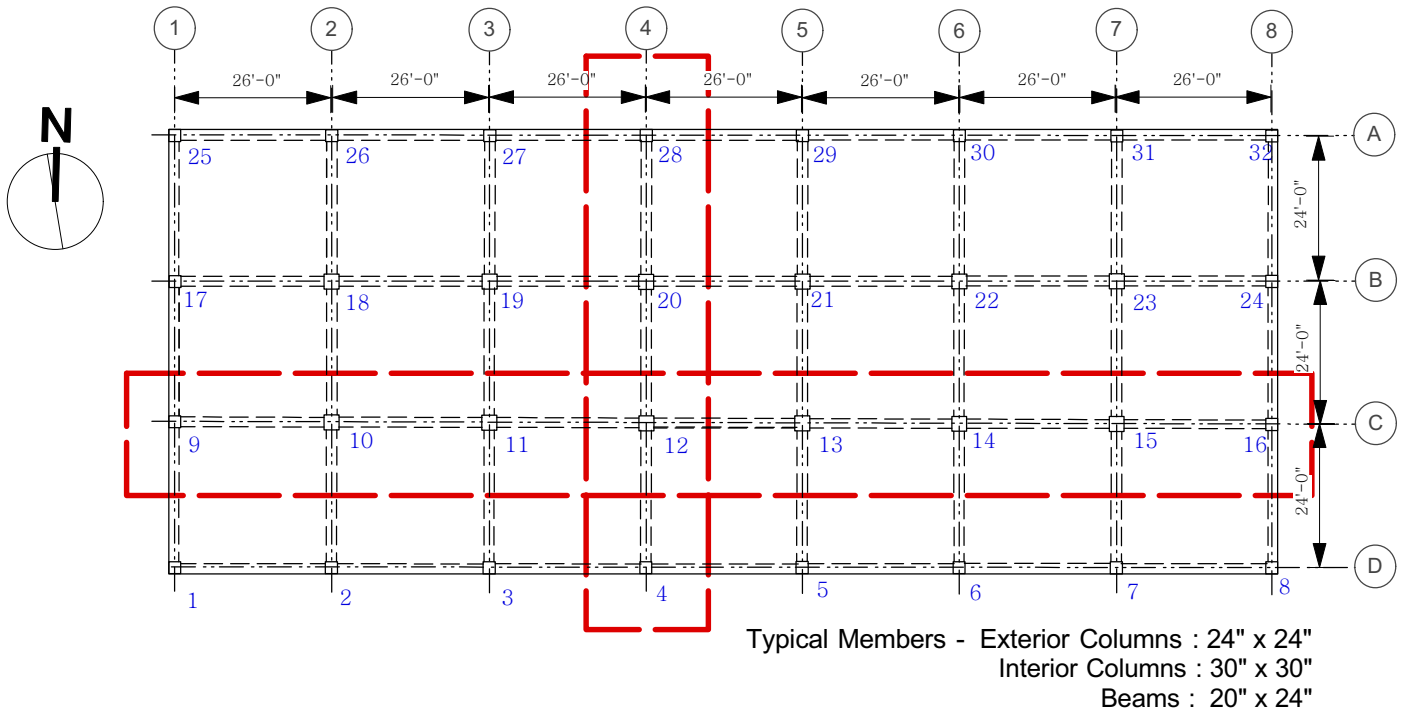
W- E Average
 Difference (all Floors)
 = 4.20 %



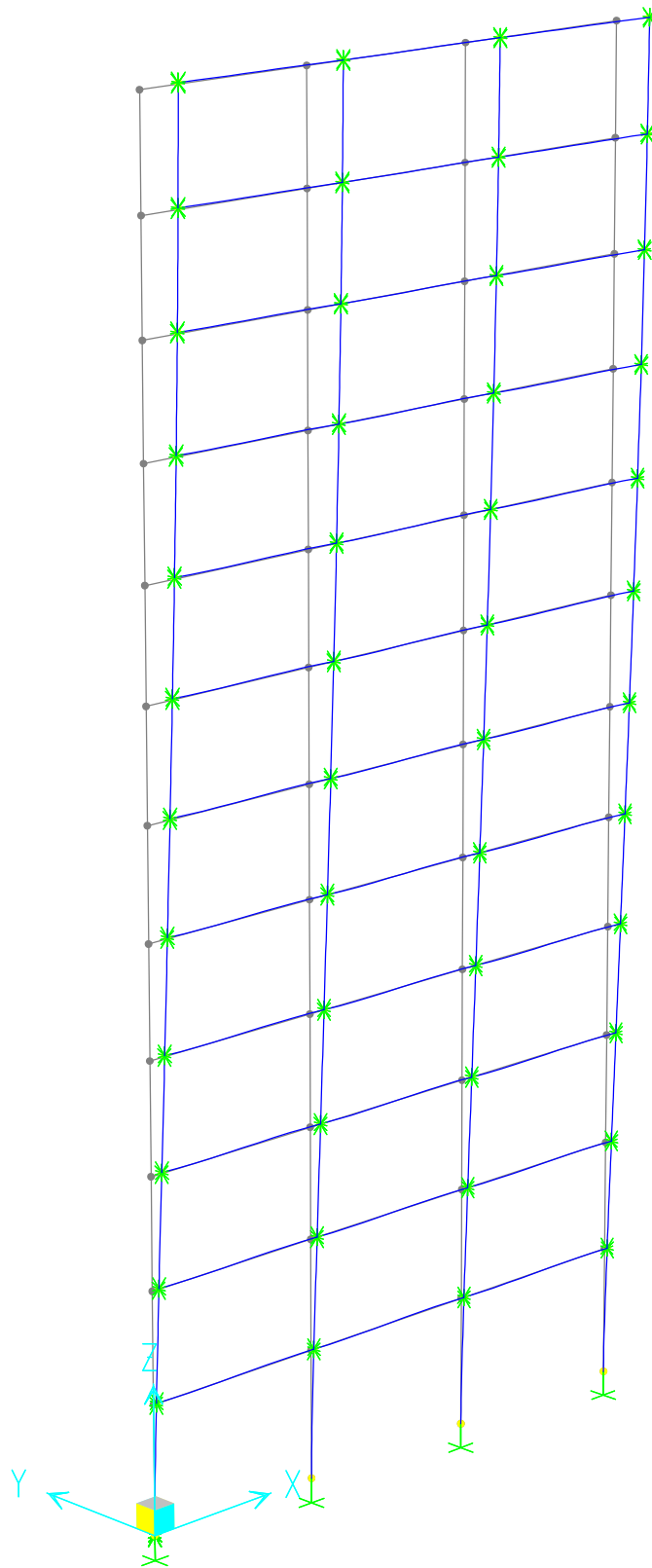
2. EQ Displacements

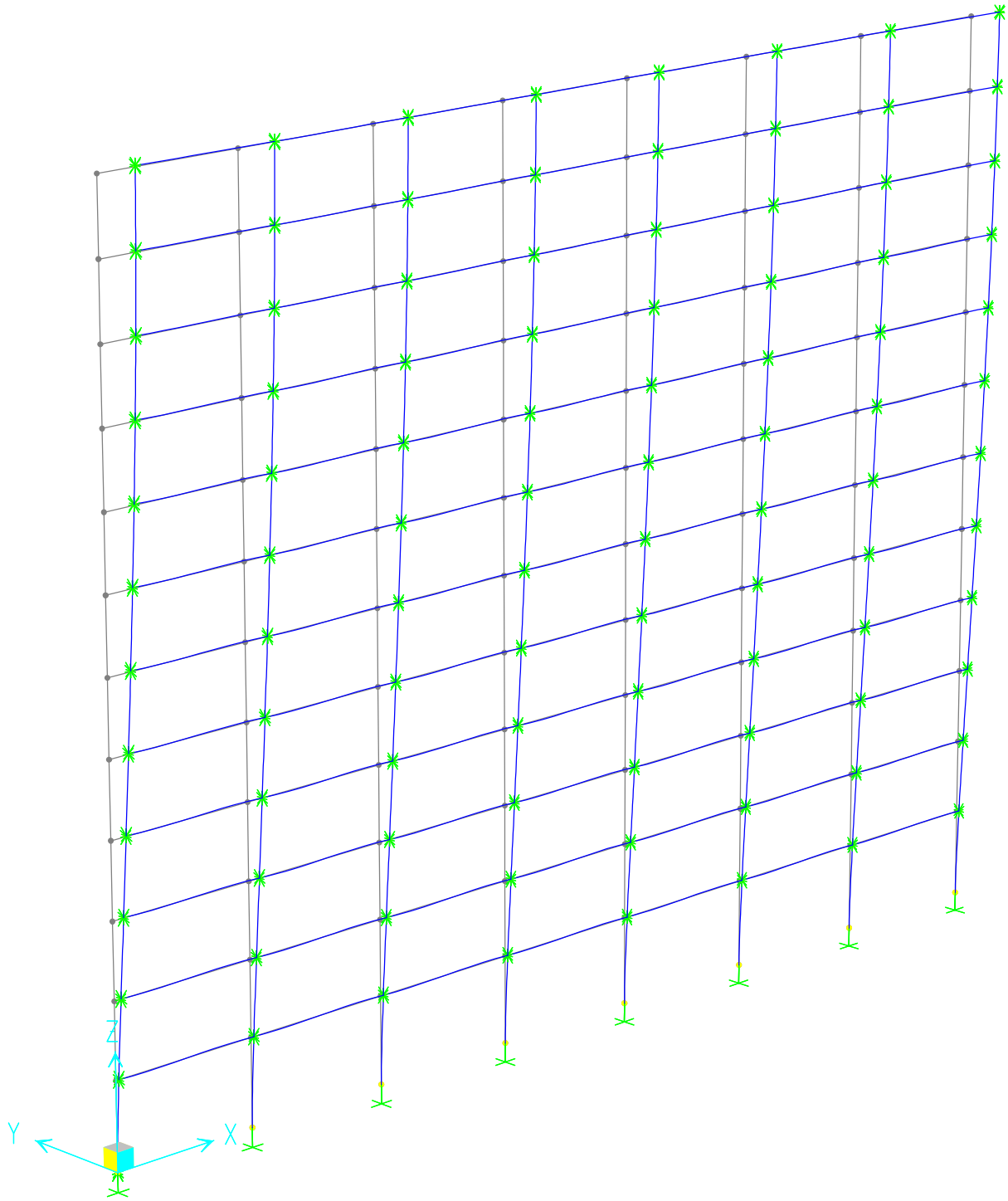
Floor Level	Story Weight, W _x (kips)	Floor Elevation, H _x (feet)	N- S Direction						W- E Direction					
			SAP2000 Analysis			RC LFRS RDA - EQ			SAP2000 Analysis			RC LFRS RDA - EQ		
			Building Deformation (inches)	Floor Deformation (inches)	Story Drift Ratio	Building Deformation (inches)	Floor Deformation (inches)	Story Drift Ratio	Building Deformation (inches)	Floor Deformation (inches)	Drift Ratio	Building Deformation (inches)	Floor Deformation (inches)	Story Drift Ratio
R	1,988	146.0	2.99	0.096	0.0007	3.18	0.091	0.0006	2.79	0.078	0.0005	2.90	0.085	0.0005
12	1,988	134.0	2.89	0.141	0.0010	3.09	0.122	0.0009	2.72	0.121	0.0008	2.81	0.113	0.0008
11	1,988	122.0	2.75	0.184	0.0013	2.96	0.171	0.0012	2.59	0.164	0.0011	2.70	0.157	0.0011
10	1,988	110.0	2.57	0.222	0.0015	2.79	0.212	0.0015	2.43	0.202	0.0014	2.54	0.195	0.0014
9	1,988	98.0	2.35	0.255	0.0018	2.58	0.247	0.0017	2.23	0.236	0.0016	2.35	0.227	0.0016
8	1,988	86.0	2.09	0.281	0.0020	2.33	0.276	0.0019	1.99	0.263	0.0018	2.12	0.254	0.0018
7	1,988	74.0	1.81	0.301	0.0021	2.06	0.299	0.0021	1.73	0.285	0.0020	1.87	0.275	0.0019
6	1,988	62.0	1.51	0.316	0.0022	1.76	0.317	0.0022	1.45	0.301	0.0021	1.59	0.291	0.0020
5	1,988	50.0	1.19	0.324	0.0023	1.44	0.330	0.0023	1.14	0.312	0.0022	1.30	0.306	0.0021
4	1,988	38.0	0.87	0.325	0.0023	1.11	0.339	0.0024	0.83	0.315	0.0022	0.99	0.312	0.0022
3	1,988	26.0	0.54	0.307	0.0021	0.77	0.344	0.0024	0.52	0.296	0.0021	0.68	0.316	0.0022
2	1,988	14.0	0.24	0.238	0.0014	0.43	0.428	0.0024	0.22	0.221	0.0013	0.37	0.365	0.0021

RC SMRF Seismic Forces and Displacements
 SAP2000 vs RC LFRS RDA - EQ Model
 Case 1 Study - Summary
 3/15/24



RC RDA CASE STUDIES - TYPICAL BUILDING CROSS SECTION AND ELEVATION





Project 12 Story RC SMRF Building
 Job No. 202140.20
 By AL
 Date 08/09/21
 Sheet _____ of _____

RC SMRF Seismic Forces and Displacements
 SAP2000 vs RC LFRS RDA - EQ Model
 Case 1 Study - Summary
 3/15/24

Company Name
 Company Address
 Company Tel/Fax
 Company Website

NBSD-Software.Com

CODE LEVEL SEISMIC FORCES AND SHEARS AT FLOOR LEVELS
ASCE 7-10 CHAPTER 12 - SEISMIC REQUIREMENTS FOR BUILDING STRUCTURES
CASE STUDY 1 - 12 STORY RC SMRF BUILDING

1. Seismic Parameter Data

$h_n = 146.0$ feet (Building Height)

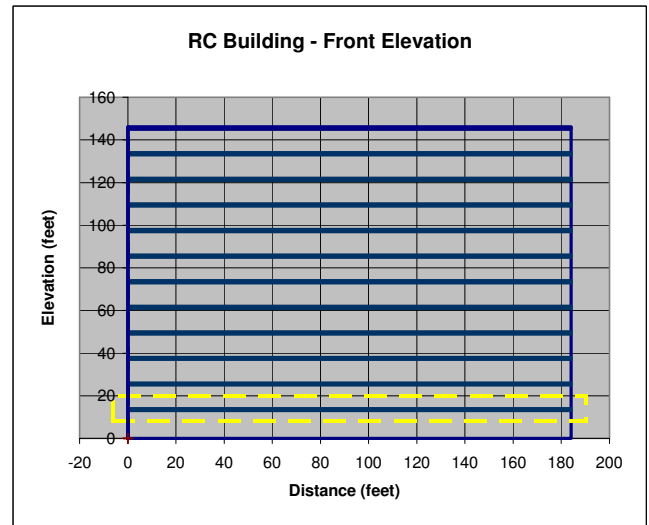
	N-S Direction	W-E Direction
LFRS	RC SMRF	RC SMRF
C_t	0.016	0.016
x	0.90	0.90

System	C_t	x
Steel MRF	0.028	0.80
Concrete MRF	0.016	0.90
EBF	0.030	0.75
All other systems	0.020	0.75

$T_a = C_t h_n^x$ (12.8-7)

T_a	1.42	1.42
R	8.0	8.0
K =	1.46	1.46
$C_S =$	0.055	0.055
$\rho =$	1.000	1.000

Seconds (Approximate Fundamental Period)
 Response Modification Factor (Table 12.2-1)
 (Exponent factor for Floor Levels - Sect 12.8.3)
 g's (Seismic Coefficient - Sect 12.8.1)
 Redundancy Factor (Section 12.3.4)



2. Vertical Distribution of Seismic Forces (Section 12.8.3)

Note: $F_x = \rho C_S W_x H_x^k$ for $\rho =$ Redundancy Factor each side
 $C_S =$ Seismic Coefficient each side
 $W_x H_x^k =$ Product each floor level, each side

Floor Level	Story Weight, W_x (kips)	Floor Elevation, H_x (feet)	N-S and E-W Directions						$W_x H_x^k$	Lateral Force, F_x (kips)	Story Shear, V_x (kips)	$F_x * h_x$ (kip-ft)	Over - turning Moment about Roof, M_{OTR} (kip-ft)	Over - turning Moment, M_{ot} (kip-ft)
			$W_x H_x^k$	Lateral Force, F_x (kips)	Story Shear, V_x (kips)	$F_x * h_x$ (kip-ft)	Over - turning Moment about Roof, M_{OTR} (kip-ft)	Over - turning Moment, M_{ot} (kip-ft)						
R	1,988	146.00	2,866,653	243	243	35,427	2,912	35,427						
12	1,988	134.00	2,529,346	214	457	28,689	8,393	64,117						
11	1,988	122.00	2,205,654	187	643	22,778	16,114	86,894						
10	1,988	110.00	1,896,285	161	804	17,657	25,762	104,551						
9	1,988	98.00	1,602,068	136	940	13,290	37,037	117,840						
8	1,988	86.00	1,323,982	112	1,052	9,638	49,657	127,479						
7	1,988	74.00	1,063,211	90	1,142	6,660	63,356	134,138						
6	1,988	62.00	821,229	70	1,211	4,310	77,890	138,448						
5	1,988	50.00	599,939	51	1,262	2,539	93,034	140,987						
4	1,988	38.00	401,924	34	1,296	1,293	108,585	142,280						
3	1,988	26.00	230,987	20	1,316	508	124,371	142,788						
2	1,988	14.00	93,580	8	1,323	111	142,899	142,899						

$\sum_{i=1}^n w_i h_i^k = 15,634,858$

$\sum_{i=1}^n w_i h_i^k = 0$

Weight = 23,850 kips

V = 1,323 kips

V = 0 kips

$M_{ot} = 142,899$ kip-ft

$M_{ot} = 0$ kip-ft

SUMMARY OF RDA RESULTS TO RC SHEAR ELEMENTS - LEVEL 2
 ASCE 7-10 SECTION 12.8 - EQUIVALENT LATERAL FORCE PROCEDURE - RIGID DIAPHRAGM ANALYSIS
 CASE STUDY 1 - 12 STORY RC SMRF BUILDING

Floor Level : 2

1. General Design Parameters

Story Shear - N-S Direction (Y) for Loading Direction = + (+/-)
 LFRS System: RC SMRF $V_s = 1,323$ kips (Story Shear)
 $C_s = 0.055$ g's (Seismic Coefficient)

Story Shear - W-E Direction (X) for Loading Direction = + (+/-)
 LFRS System: RC SMRF $V_s = 1,323$ kips (Story Shear)
 $C_s = 0.055$ g's (Seismic Coefficient)

Moment Frame Beams - N-S Direction (Y) **Moment Frame Beams - W-E Direction (X)**
 $b = 20.00$ inches $b = 20.00$ inches
 $d = 24.00$ inches $d = 24.00$ inches

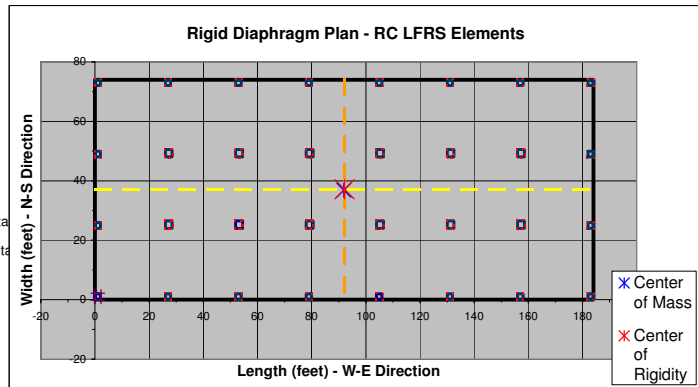
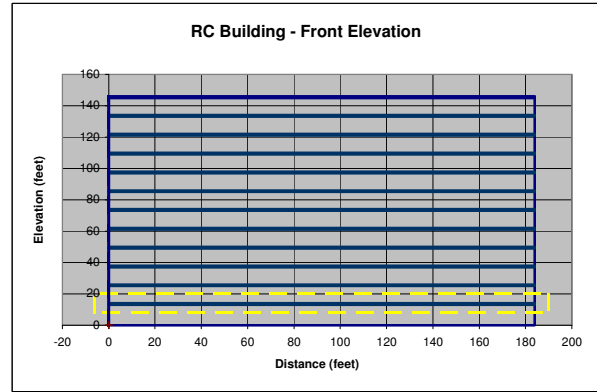
RC Diaphragm Dimensions						
Section	Length (feet)	Width (feet)	Thickness (inches)	x (feet)	y (feet)	Weight (kips)
1	184.00	74.00	12.00	-	-	1,906
2						
3						

for $\rho = 140$ pcf (Unit Weight)

Accidental Eccentricity (ASCE Section 12.8.4.2):

$e_{MIN} = 5.00$ % (accidental eccentricity)
 $e_{AX} = 3.70$ feet for $A_{XY} = 1.00$ (N-S Amplification of Accidental)
 $e_{AY} = 9.20$ feet $A_{XX} = 1.00$ (W-E Amplification of Accidental)

Material Data: $f'_c = 4.00$ Ksi (Compressive Strength - Concrete)
 $E_m =$ Ksi (Modulus of Rupture - Masonry)
 $E_c = 3,605$ ksi



2. RDA Load Distribution to RC Elements - Summary of Results

LFRS Direction	RC Element ID	RC Element Dimensions and Data										V _c (kips)	Deformation		Axial Forces from Overturning		
		RC LFRS		Dimensions				Coordinates		Stiffness			Total Drift Ratio	δ_{ns} (inches)	P _{WE} (Kips)	P _{NS} (Kips)	P _{OT} (Kips)
		Shear Wall	SMRF Column	H _{below} (feet)	H _{above} (feet)	L (feet)	t (inches)	x (feet)	y (feet)	K (kip/in)	Relative Stiffness						
N-S	1	x		14.00	12.00	2.00	24.0	0.00	0.00	75	1.00	30.6	0.0026	0.459		249	249
	2	x		14.00	12.00	2.00	24.0	26.00	0.00	75	1.00	29.9	0.0026	0.449		249	249
	3	x		14.00	12.00	2.00	24.0	52.00	0.00	75	1.00	29.2	0.0025	0.439		249	249
	4	x		14.00	12.00	2.00	24.0	78.00	0.00	75	1.00	28.6	0.0024	0.428		249	249
	5	x		14.00	12.00	2.00	24.0	104.00	0.00	75	1.00	27.9	0.0024	0.418		249	249
	6	x		14.00	12.00	2.00	24.0	130.00	0.00	75	1.00	27.2	0.0023	0.408		249	249
	7	x		14.00	12.00	2.00	24.0	156.00	0.00	75	1.00	26.5	0.0023	0.398		249	249
	8	x		14.00	12.00	2.00	24.0	182.00	0.00	75	1.00	25.8	0.0022	0.387		249	249
	9	x		14.00	12.00	2.00	24.0	0.00	24.00	131	1.75	53.2	0.0026	0.494			
	10	x		14.00	12.00	2.50	30.0	26.00	24.00	154	2.05	61.2	0.0025	0.439			
	11	x		14.00	12.00	2.50	30.0	52.00	24.00	154	2.05	59.8	0.0025	0.429			
	12	x		14.00	12.00	2.50	30.0	78.00	24.00	154	2.05	58.4	0.0024	0.419			
	13	x		14.00	12.00	2.50	30.0	104.00	24.00	154	2.05	57.0	0.0024	0.409			
	14	x		14.00	12.00	2.50	30.0	130.00	24.00	154	2.05	55.6	0.0023	0.399			
	15	x		14.00	12.00	2.50	30.0	156.00	24.00	154	2.05	54.2	0.0023	0.389			
	16	x		14.00	12.00	2.00	24.0	182.00	24.00	131	1.75	44.8	0.0022	0.417			
	17	x		14.00	12.00	2.00	24.0	0.00	48.00	131	1.75	53.2	0.0026	0.494			
	18	x		14.00	12.00	2.50	30.0	26.00	48.00	154	2.05	61.2	0.0025	0.439			
	19	x		14.00	12.00	2.50	30.0	52.00	48.00	154	2.05	59.8	0.0025	0.429			
	20	x		14.00	12.00	2.50	30.0	78.00	48.00	154	2.05	58.4	0.0024	0.419			
	21	x		14.00	12.00	2.50	30.0	104.00	48.00	154	2.05	57.0	0.0024	0.409			
	22	x		14.00	12.00	2.50	30.0	130.00	48.00	154	2.05	55.6	0.0023	0.399			
	23	x		14.00	12.00	2.50	30.0	156.00	48.00	154	2.05	54.2	0.0023	0.389			
	24	x		14.00	12.00	2.00	24.0	182.00	48.00	131	1.75	44.8	0.0022	0.417			
	25	x		14.00	12.00	2.00	24.0	0.00	72.00	75	1.00	30.6	0.0026	0.459		-247	-247
	26	x		14.00	12.00	2.00	24.0	26.00	72.00	75	1.00	29.9	0.0026	0.449		-247	-247
	27	x		14.00	12.00	2.00	24.0	52.00	72.00	75	1.00	29.2	0.0025	0.439		-247	-247
	28	x		14.00	12.00	2.00	24.0	78.00	72.00	75	1.00	28.6	0.0024	0.428		-247	-247
	29	x		14.00	12.00	2.00	24.0	104.00	72.00	75	1.00	27.9	0.0024	0.418		-247	-247
	30	x		14.00	12.00	2.00	24.0	130.00	72.00	75	1.00	27.2	0.0023	0.408		-247	-247
	31	x		14.00	12.00	2.00	24.0	156.00	72.00	75	1.00	26.5	0.0023	0.398		-247	-247
	32	x		14.00	12.00	2.00	24.0	182.00	72.00	75	1.00	25.8	0.0022	0.387		-247	-247

SUMMARY OF RDA RESULTS TO RC SHEAR ELEMENTS - LEVEL 2
 ASCE 7-10 SECTION 12.8 - EQUIVALENT LATERAL FORCE PROCEDURE - RIGID DIAPHRAGM ANALYSIS
 CASE STUDY 1 - 12 STORY RC SMRF BUILDING

Floor Level : 2

1. General Design Parameters

Story Shear - N-S Direction (Y) for Loading Direction = + (+/-)
 LFRS System: RC SMRF $V_s = 1,323$ kips (Story Shear)
 $C_s = 0.055$ g's (Seismic Coefficient)

Story Shear - W-E Direction (X) for Loading Direction = + (+/-)
 LFRS System: RC SMRF $V_s = 1,323$ kips (Story Shear)
 $C_s = 0.055$ g's (Seismic Coefficient)

Moment Frame Beams - N-S Direction (Y) **Moment Frame Beams - W-E Direction (X)**
 $b = 20.00$ inches $b = 20.00$ inches
 $d = 24.00$ inches $d = 24.00$ inches

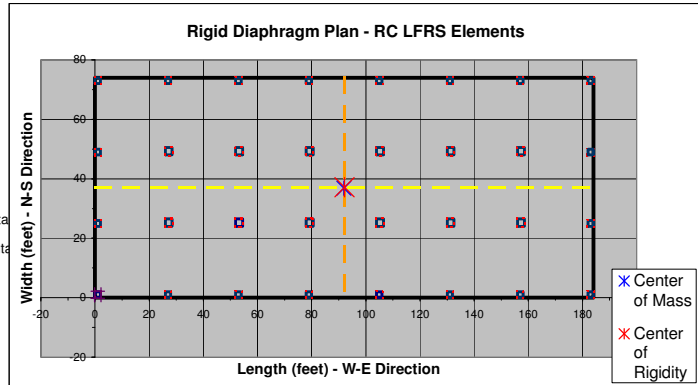
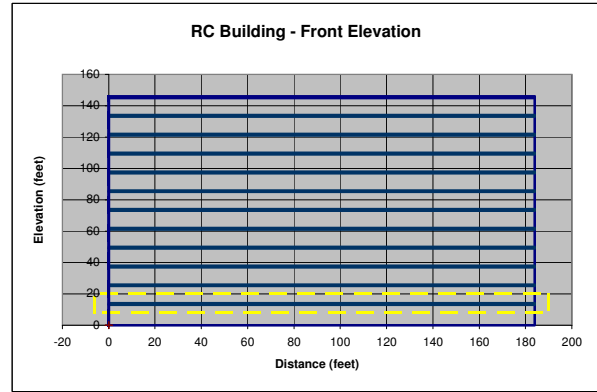
RC Diaphragm Dimensions						
Section	Length (feet)	Width (feet)	Thickness (inches)	x (feet)	y (feet)	Weight (kips)
1	184.00	74.00	12.00	-	-	1,906
2						
3						

for $\rho = 140$ pcf (Unit Weight)

Accidental Eccentricity (ASCE Section 12.8.4.2):

$e_{MIN} = 5.00$ % (accidental eccentricity)
 $e_{AX} = 3.70$ feet for $A_{XY} = 1.00$ (N-S Amplification of Accidental)
 $e_{AY} = 9.20$ feet $A_{XX} = 1.00$ (W-E Amplification of Accidental)

Material Data: $f'_c = 4.00$ Ksi (Compressive Strength - Concrete)
 $E_m =$ Ksi (Modulus of Rupture - Masonry)
 $E_c = 3,605$ ksi



2. RDA Load Distribution to RC Elements - Summary of Results

LFRS	RC	RC LFRS		RC Element Dimensions and Data								v	Deformation		Axial Forces from Overturning	
				Dimensions				Coordinates		Stiffness						
W-E	1	x		14.00	12.00	2.00	24.00	0.00	0.00	75	1.00	22.9	0.0020	0.343	197	197
	2	x		14.00	12.00	2.00	24.00	26.00	0.00	131	1.75	39.6	0.0019	0.368		
	3	x		14.00	12.00	2.00	24.00	52.00	0.00	131	1.75	39.6	0.0019	0.368		
	4	x		14.00	12.00	2.00	24.00	78.00	0.00	131	1.75	39.6	0.0019	0.368		
	5	x		14.00	12.00	2.00	24.00	104.00	0.00	131	1.75	39.6	0.0019	0.368		
	6	x		14.00	12.00	2.00	24.00	130.00	0.00	131	1.75	39.6	0.0019	0.368		
	7	x		14.00	12.00	2.00	24.00	156.00	0.00	131	1.75	39.6	0.0019	0.368		
	8	x		14.00	12.00	2.00	24.00	182.00	0.00	75	1.00	22.9	0.0020	0.343	-196	-196
	9	x		14.00	12.00	2.00	24.00	0.00	24.00	75	1.00	24.4	0.0021	0.365	197	197
	10	x		14.00	12.00	2.50	30.00	26.00	24.00	154	2.05	49.8	0.0021	0.358		
	11	x		14.00	12.00	2.50	30.00	52.00	24.00	154	2.05	49.8	0.0021	0.358		
	12	x		14.00	12.00	2.50	30.00	78.00	24.00	154	2.05	49.8	0.0021	0.358		
	13	x		14.00	12.00	2.50	30.00	104.00	24.00	154	2.05	49.8	0.0021	0.358		
	14	x		14.00	12.00	2.50	30.00	130.00	24.00	154	2.05	49.8	0.0021	0.358		
	15	x		14.00	12.00	2.50	30.00	156.00	24.00	154	2.05	49.8	0.0021	0.358		
	16	x		14.00	12.00	2.00	24.00	182.00	24.00	75	1.00	24.4	0.0021	0.365	-196	-196
	17	x		14.00	12.00	2.00	24.00	0.00	48.00	75	1.00	25.9	0.0022	0.388	197	197
	18	x		14.00	12.00	2.50	30.00	26.00	48.00	154	2.05	52.9	0.0022	0.380		
	19	x		14.00	12.00	2.50	30.00	52.00	48.00	154	2.05	52.9	0.0022	0.380		
	20	x		14.00	12.00	2.50	30.00	78.00	48.00	154	2.05	52.9	0.0022	0.380		
	21	x		14.00	12.00	2.50	30.00	104.00	48.00	154	2.05	52.9	0.0022	0.380		
	22	x		14.00	12.00	2.50	30.00	130.00	48.00	154	2.05	52.9	0.0022	0.380		
	23	x		14.00	12.00	2.50	30.00	156.00	48.00	154	2.05	52.9	0.0022	0.380		
	24	x		14.00	12.00	2.00	24.00	182.00	48.00	75	1.00	25.9	0.0022	0.388	-196	-196
	25	x		14.00	12.00	2.00	24.00	0.00	72.00	75	1.00	27.4	0.0023	0.410	197	197
	26	x		14.00	12.00	2.00	24.00	26.00	72.00	131	1.75	47.5	0.0023	0.442		
	27	x		14.00	12.00	2.00	24.00	52.00	72.00	131	1.75	47.5	0.0023	0.442		
	28	x		14.00	12.00	2.00	24.00	78.00	72.00	131	1.75	47.5	0.0023	0.442		
	29	x		14.00	12.00	2.00	24.00	104.00	72.00	131	1.75	47.5	0.0023	0.442		
	30	x		14.00	12.00	2.00	24.00	130.00	72.00	131	1.75	47.5	0.0023	0.442		
	31	x		14.00	12.00	2.00	24.00	156.00	72.00	131	1.75	47.5	0.0023	0.442		
	32	x		14.00	12.00	2.00	24.00	182.00	72.00	75	1.00	27.4	0.0023	0.410	-196	-196