# **Advanced Application 2**

Seismic Design for Reinforced Concrete Building

# Seismic Design for Reinforced Concrete Building

# **Overview**

This example problem is meant to demonstrate the design of a Reinforced Concrete building structure subjected to floor loads, wind loads and seismic loads.

# Description

Seismic Design Data

- Dual system (special reinforced concrete structural walls with special moment frame) in the transverse direction
- Special moment frame in the longitudinal direction
- Assigned to a high seismic zone

# Methodology

- Response spectrum analysis
- P-Delta analysis

# Model



Figure 1 : Reinforced Concrete Building Model



Figure 2 : Typical Floor Plan



Figure 3 : Longitudinal Section

# **Design Procedure**

## 1. Material & Section Properties Input

## Material

- Concrete fc' = 4,000 psi
- Reinforcement fy = 60,000 psi

#### Section

- Edge columns  $24 \times 24$  in.
- Interior columns 30×30 in.
- Beams 20×24 in.
- Walls 18 in. (In-plane & Out-of-plane)

Properties	
Material   Section   Thickness	
ID Name Type Standard DB 1 Gra <u>Concr ASTM( Gra</u> Properties	Add
Properties Material Section Thickness D Name 1 Edge Column 2 Interior Column 3 Room Material Section Thickness ID Type Thickness(ft) Offset Add.,	s Type Shape Add User SB Modify User SB Delete Section Data
I Value 1,50000 No Modily Delete Copy Impor Renum	Section ID 1 Name Edge Column © User © DB AISC10(US) Sect, Name Built-Up Section Get Data from Single Angle DB Name AISC10(US) Sect, Name H 24 in B 24 in
	Consider Shear Deformation, Consider Warping Effect(7th DOF) Offset : Center-Center Change Offset Show Calculation Results OK Cancel Apply
	Show Calculation Results, OK Cancel Apply

Figure 4 : Material & Section Properties Input

## 2. Create Model

Units : Length > ft

Set UCS to X-Y Plane Origin : 0, 0, 16 Change View Direction > (on)

Historia Add
Grid Name $= 2F$
X-Grid Lines Add
Relative > (on)
'7@26' ОК
Y-Grid Lines
Relative > (on)
'3@22' ОК
Add/Modify Grid Lines
Define Grids OK

III E Line Grid, Line Grid Snap (toggle on)

Define Grids-(Model View)	
Point Grid Line Grid	
Current Grid : None Add Delete Modify	odify Grid Lines
OK Apply Close	Grid Lines     Y-Grid Lines       26     22       26     22       26     22       26     22       156     26       182     26       182     26       Add     Modify       Del     Del       Add     Modify       Del     Del
Grid	d Lines
	O Absolute      e Relative
	Lines : 7@26
	Example : $-5,0, -3,5, 4, 6@3$ ( Ex : 5@3 results in 5 grid lines at the spacing of 3 )
C	OK Cancel

Figure 5 : Create Grid Lines

	Gen 2015 - [C:WUsersWu	ser#Desktop#Release renewal	Gen#Tutorial Manual	#Tuturial#App 2. Seismi	c Design for RC Building¥	FSeismic-RC_1 *] - [Model ]	View]	. 0 %
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Tree Menu # X Menu Tables Group Works Papart	4 🔯 Model View ×							Þ
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Section : 3     I : Edge Column								Ø
2 : Interior Column 3 : Beam								
								2
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								0
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								-
								-
	+							
	Message Window							* ×
								*
Tree Menu Task Pane	Command Message	Analysis Message /						

Figure 5 : Grid Lines in X-Y Plane

## **Generate Floor Plan**

🖆 Hidden, 🎤 Node Number, 💀 Element Number (toggle on)

Create Elements

Element Type = General Beam / Tapered Beam

Section Name = 3 : Beam

Draw Elements as shown (Refer Figure 6)



Figure 6 : Floor Plan

### **Generate Columns**

Change to GCS

Select All

t Extrude Element

Node  $\rightarrow$  Line Element

Reverse I-J > (on)

Element Type = Beam

Material = 1 : Grade C4000

Section = 1 : Edge column

 $d_x, d_y, d_z = 0, 0, -16$ 

Apply



Figure 7 : Generate Columns

## **Change Properties of Interior Columns**

Work > Properties > Section : 1 : Edge column = Active

Display > Property > Property Name > (on)

Isometric View (Refer Figure 8)

Top View > Select Window > Select Interior Columns

Work > Properties > Section = 2 : Interior column Drag & Drop (Refer Figure 9)



Figure 8 : Inactivate Beams



Figure 9 : "Drag & Drop" Interior Column Properties

## **Generate Walls**

••••••	
Hidden (toggle off) ;	Node Number (toggle on)
Display > Property > Property	V Name > (off)
Select Window (Refer Figure	10)
> Active	
Create Elements	
Element Type : Wall	
Membrane > (on)	
Wall ID > Auto Inc. > 1	
Material Name > 1:Grade C4000	
Thickness > 1:1.5000	
Intersect Node > (on)	

Nodal Connectivity > 50, 42, 10, 18 (Refer ) on Figure 11)

Select Single > Wall Element 1

Translate Element > Copy

Equal Distance  $(d_x, d_y, d_z) > 130, 0, 0$  Apply

Wall ID Increment = 1  $\bigcirc$ K



Figure 10 : Location of Wall Element



Figure 11 : Nodal Connectivity of Wall Element



Figure 12 : Generation of Wall Element

## **Building Generation**

Select All

Structure > Building > Control Data > Building Generation

Number of Copies = 11

Distance(Global Z) = 12 Add Apply



Figure 13 : Building Generation

## **Generate Story Data**

 $Structure > Building > Control \ Data > Story$ 

Auto Generate Story Data,...

OK

Close

ft				
Module Name	Story Name	Level(ft)	Height(ft)	Floor Diaphragm
Base Dese	Roof	148.00	0.00	Consider
Base	12F	136.00	12.00	Consider
Base	10F	124.00	12.00	Consider
Base	9F	100.00	12.00	Consider
Base	8F	88.00	12.00	Consider
Base	7F	76.00	12.00	Consider
Base	6F	64.00	12.00	Consider
Base	5F	52.00	12.00	Consider
Base	4F	40.00	12.00	Consider
Base	3F	28.00	12.00	Consider
Base	2F	16.00	12.00	Consider
Rase	1F Colomia	0.00	16.00	Do not consider
	Autom	atic Constantion of Sta		
	Unse	elected List	ory Data Selected List	
		elected List	Selected List	t Level Height
		eluce eneration of sto	yry Data Selected List No Name 1 1F 2 2F 3 3F 4 4F 5 5F 6 6F 7 7F 8 8F 9 9F 10 10F 11 11F 12 12F 13 Rect	Level Height 0 16 16 12 28 12 40 12 52 12 64 12 76 12 88 12 100 12 112 12 124 12 136 12 36 12 36 12

Figure 14 : Generation of Story Data

## 3. Boundary Conditions Input

The lower ends of the columns are assumed fixed.

```
Boundary > Supports > Define Supports
D - All > (on)
R - All > (on)
Select Window
```



Figure 15 : Boundary Supports

## 4. Loading Data Input

Load > Static Load > Create Load Cases > Static Load Cases

- Dead Load
- Live Load
- Wind Load (X-direction)
- Wind Load (Y-direction)
- Earthquake Load (X-direction, Eccentricity direction-Positive)
- Earthquake Load (X-direction, Eccentricity direction-Negative)
- Earthquake Load (Y-direction, Eccentricity direction-Positive)
- Earthquake Load (Y-direction, Eccentricity direction-Negative)

St	atic Lo	oad Cas	ses			x
	Nar Typ Des	me pe scriptior	: <mark>EVN</mark> : Earthquak n : Earthquak	e (E) e Load in Y-dir (-ve Ecc)	▲dd Modify Delete	
		No	Name	Туре	Description	<u> </u>
		1	DL	Dead Load (D)	Dead Load	
		2	LL	Live Load (L)	Live Load	
		3	WX	Wind Load on Structure (W)	Wind Load in X-direction	
		4	WY	Wind Load on Structure (W)	Wind Load in Y-direction	
		5	EXP	Earthquake (E)	Earthquake Load in X-dir (+ve Ecc	
		6	EXN	Earthquake (E)	Earthquake Load in X-dir (-ve Ecc)	
		7	EYP	Earthquake (E)	Earthquake Load in Y-dir (+ve Ec	Ξ
		8	EYN	Earthquake (E)	Earthquake Load in Y-dir (-ve Ecc	
	*					
	•				Þ	-
					Close	

Figure 16 : Loading Data Input

## Self Weight

 $Load > Static \ Loads > Structure \ Loads / Masses > Self \ Weight$ 

Z = -1 Add

Node Element Boundary Mass Load
Self weight
Load Case Name
DL •
Load Group Name
Default
Self Weight Factor
Wgt.Z ∳ Wgt.Y
Y The Y
X
× 0
Ŷ Ū
Z O
Lood Coco, X, X, Z, Group
DL 0 0 -1 Default
Operation
Indany Detete
Close

Figure 17 : Self Weight Load

### Floor Load

Load > Initial Forces/Misc. > Assign Floor Loads > Define Floor Load Type

- Name > Typical Floor : DL = -30 psf, LL = -75 psf Add
- Name > Roof Level : DL = -10 psf, LL = -20 psf Add

Load > Initial Forces/Misc. > Assign Floor Loads > Assign Floor Load

- Load Type > Typical Floor
- Two Way Distribution
- Copy Floor Load > (on)
- Axis > z (on)
- Distance > 10@12
- Assign Nodes Defining Loading Area > (1, 8, 32, 25)

Similarly, assign floor load at roof level :

- Load Type > Roof Level
- Copy Floor Load > (off)
- Assign Nodes Defining Loading Area > (386, 387, 417, 410)



Figure 18 : Assign Floor Loads



Figure 19 : Floor Load Distribution

## Wind Loads

Load > Static Loads > Lateral > Wind Loads

- Load Case Name > WX
- Wind Load Code > IBC2012 (ASCE7-10)
- Alternate Method > (on)
- Basic Wind Speed > 85 mile/h
- Exposure Category > B
- Scale Factor in Global X > 1
- Scale Factor in Global Y > 0

Apply

- Load Case Name > WY
- Scale Factor in Global X > 0
- Scale Factor in Global Y > 1



Clo	se	

Add/Modify Wind Load Specification
Load Case Name : WX Wind Load Code : IBC2012(ASCE7-10) Description :
Alternate Method     Directional Procedure Wind Load Parameters Basic Wind Speed :     85     mails 4
Exposure Category : B
Mean Roof Height : 0 ft
Topographic Effects 🛄
Net Pressure Coefficient (Cnet)
Windward 0.73 Leeward -0.51
Wind Eccentricity X-Dir, (Wx) : ◯ Positive ◯ Negative ◉ None Y-Dir, (Wy) : ◯ Positive ◯ Negative ◉ None
Wind Load Direction Factor (Scale Factor)
X-Dir, 1 Y-Dir, 0 Z-Rot, 0
Additional Wind Loads (Unit:Ibf,ft)
Story AddX AddY AddRZ Add
-
Wind Load Profile OK Cancel Apply



Figure 20 : Input Wind Loads

## **Convert Model Weight & Loads to Masses**

Structure > Type > Structure Type

- Structure Type > 3-D (on)
- Convert Self-weight into Masses (on)
- Convert to X, Y (on)
- Gravity Acceleration > 32.1719 (ft/sec<sup>2</sup>)
- -

Structure Type
Structure Type ③ 3-D
Mass Control Parameter © Lumped Mass Consider Off-diagonal Masses Considering Rotational Rigid Body Mode for Modal Participation Factor Consistent Mass Convert Mass Convert Self-weight into Masses Convert to X, Y, Z © Convert to X, Y Convert to Z
Gravity Acceleration : 32,1719 ft/sec* Initial Temperature : 0 [F] Align Top of Beam Section with Floor (X-Y Plane) for Panel Zone Effect / Display Align Top of Slab(Plate) Section with Floor (X-Y Plane) for Display
OK Cancel

Figure 21 : Convert Model Weight to Masses

Load > Static Loads > Structure Loads/Masses > Nodal Masses > Loads to Masses

- Mass Direction > X, Y (on)
- Load Type for Converting > *All* (on)
- Gravity > 32.1719 (ft/sec<sup>2</sup>)
- Load Case > DL
- Scale Factor > 1
- Load Case > LL
- Scale Factor > 0.25

Loads to Masses
Mass Direction
Load Type for Converting V Nodal Load Beam Load Floor Load V Pressure (Hydrostatic) Gravity : 32,17191€ ft/sec <sup>2</sup> Load Case / Factor
Scale Factor : 0.25
LoadCase Scale Add DL 1 LL 0,25 Modify
Delete Remove Load to Mass Data
OK Cancel

Figure 22 : Covert Model Loads to Masses

### **Static Seismic Loads**

Load > Static Loads > Lateral > Seismic Loads

- Add
- Load Case Name > EXP
- Seismic Load Code > IBC2012 (ASCE7-10)
- Seismic Design Category > E
- Site Class > C
- Ss = 1.0
- S1 = 0.3
- Importance Factor (I) = 1
- Period (Code) > X-Dir. = 1.2; Y-Dir. = 0
- Response Modification Coef. (R) > X-Dir. = 8 (Special moment frame),

Y-Dir. = 8 (Dual system: special reinforced concrete structural walls with special moment frame)

- Scale Factor in Global X = 1
- Scale Factor in Global Y = 0
- Accidental Eccentricity in X-direction > Positive (on)
- Accidental Eccentricity in Y-direction > Positive (on)

Apply

- Load Case Name > EXN
- Period (Code) > X-Dir. = 1.2 ; Y-Dir. = 0
- Scale Factor in Global X = 1
- Scale Factor in Global Y = 0
- Accidental Eccentricity in X-direction > Negative (on)
- Accidental Eccentricity in Y-direction > Negative (on)

Apply

- Load Case Name > EYP
- Period (Code) > X-Dir. = 0; Y-Dir. = 1.2
- Scale Factor in Global X = 0
- Scale Factor in Global Y = 1
- Accidental Eccentricity in X-direction > Positive (on)
- Accidental Eccentricity in Y-direction > Positive (on)

Apply

- Load Case Name > EYN
- Period (Code) > X-Dir. = 0 ; Y-Dir. = 1.2
- Scale Factor in Global X = 0
- Scale Factor in Global Y = 1
- Accidental Eccentricity in X-direction > Negative (on)
- Accidental Eccentricity in Y-direction > Negative (on)



atic Seismic Loac	ls		×	Add/Modify Seismic Load Specification
Load Case EXP EXN EYP EYN	Code Name IBC2012(ASCE7-10) IBC2012(ASCE7-10) IBC2012(ASCE7-10) IBC2012(ASCE7-10)	Description	Add Modify Delete	Load Case Name : EXP  Seismic Load Code : IBC2012(ASCE7-10;  Code : BC2012(ASCE7-10;  Seismic Load Parameters Design Spectral Response Acceleration Site Class C
•	III	•	Close	Ss         I         ▼         Fa         1,00000         Sds         0,666677         g           S1         0,3         ▼         Fv         1,50000         Sd1         0,30000         g           Period Coef, (Cu)         1,40000         TL         4         sec
				Risk Category       Importance 1         Seis, Design Category : Sds D Sd1 D => D         Structural Parameters         X-Dir, Y-Dir,         Analytical Period :         0         0         Analytical Period :         1.2         Fundamental Period :         1.2         Response Modification         Response Modification         Seismic Load Direction Factor (Scale Factor)         X-Direction :         Y-Direction :         Y-Direction :         Y-Direction :         Accidental Eccentricity         X-Direction (Ex) :         Positive         None         Y-Direction (Ex) :         Positive </td

Figure 23 : Input Static Seismic Loads

### **Response Spectrum Load**

Load > Seismic > Response Spectrum Data > Response Spectrum Functions Add

**Design Spectrum** 

- Design Spectrum > IBC2012 (ASCE7-10)
- Site Class > C
- Ss = 1.0
- S1 = 0.3
- 0K



Close



Figure 24 : Response Spectrum Loads

Load > Response Spectrum Analysis Data > Response Spectrum Load Cases

- Load Case Name > RX
- Direction > X-Y
- Excitation Angle = 0 (deg.)
- Scale Factor (I/R) > 1/8 = 0.125
- Period Modification Factor = 1
- Function Name (Damping Ratio) > IBC2012(ASCE7-10) (0.05) > (on)
- Interpolation of Spectral Data > Linear (on)
- Accidental Eccentricity > (on)
- Modal Combination Type > SRSS

Add

- Load Case Name > RY
- Excitation Angle = 90 (deg.)
- Modal Combination Type > SRSS

Close

Response Spectrum Load Cases	
Spectrum Load Case	
Load Case Name: RX	
Direction : X-Y -	Modal Combination Control
Auto-Search Angle	Modal Combination Type
Major Ortho	● SRSS ─ CQC ─ ABS ─ Linear
Excitation Angle : 0 🚔 [deg]	Add signs(+,-) to the Results
Scale Factor : 0,125	Along the Major Mode Direction
Period Modification Factor :	Along the Absolute Maximum Value
	Select Mode Shapes
Modal Combination Control	Mode Use Mode Shape Factor
Spectrum Functions	1         ✓         1.0000           2         ✓         1.0000
Function Name (Damping Ratio)	3 <u>V</u> 1.0000 4 V 1.0000
▼IBC2012(ASCE7-10) (0,05)	5 V 1.0000 6 V 1.0000
	7 1.0000
	9 V 1.0000
Apply Damping Method	10 2 1.0000
Damping Method,	
Correction by Damping Ratio	
Interpolation of Spectral Data	Check All Check None
💿 Linear 🛛 🔘 Logarithm	OK Cancel
Accidental Eccentricity	
Description :	
LoadCase Direction Scale	
BX X-Y 0,125	
RY X-Y 0,125	
Operations	
Add Modify Delete	
Eigenvalue Analysis Control	

Figure 25 : Response Spectrum Analysis

## 5. Analysis

Analysis > P-Delta Analysis Control

- Number of Iterations = 5
- Convergence Tolerance = 1e-005
- P-Delta Combination > Load Case > DL ; Scale Factor > 1
- P-Delta Combination > Load Case > LL ; Scale Factor = 0.25

OK	

Analysis > Eigenvalue Analysis Control

- Type of Analysis > Eigen Vectors (on) > Subspace Iteration (on)
- Number of Frequencies = 10
- Number of Iterations = 20
- Subspace Dimension = 0
- Convergence Tolerance = 1e-010

	OK
- 1	011

#### Perform Analysis

lype of Analysis Eigen Vectors Subspace Iteration Clanczos	Ritz Vectors
Eigen Vectors          Number of Frequencies :       10         Frequency range of interest         Search From :       0         To :       1600	Eigenvalue Control Parameters Number of Iterations : 20  Subspace Dimension : 1  Convergence Tolerance : 1e-010
Remove Eigenvalue Analysis Data	OK Cancel

P-Delta Analysis Col	itroi	
Control Parame Number of Iterat Convergence To	ters ions : plerance:	5 📑 1e-005
P-Delta Combin Load Case : L Scale Factor :	ation - 0,25	•
Load Case DL LL	Scale 1 0,25	Add
Bernove P-De	Ita Analu	Delete
		Cancel

Figure 27 : P-Delta and Eigenvalue Analysis Control

## 6. Design Input Results > Combinations Concrete Design > Auto Generation

OK ]

- -
- Option > Add (on) Design Code > ACI318-11 -
- -Scale Up Factor = 1.48; RX Add
- -Scale Up Factor = 1 ; RY Add
- Bi-directional combined **Bi-directional combination** needs to be investigated, but
- omitted in this tutorial. Ì

				-						actor I	
+	No	Name	Active	lype	Description			oadCase	Fa	4 4000	
4	2	CLCB1	Stren	Add	1.4D 1.2D + 1.6l	-   -	¢ DL	(51)		1.4000	
+	3	cLCB3	Stren	Add	1.2D + 1.6WX + 1.0L						
	4	cLCB4	Stren	Add	1.2D + 1.6WY + 1.0L						
+	5	cLCB5	Stren	Add	1.2D - 1.6WX + 1.0L						
+	6	CLCB6	Stren	Add	1.2D - 1.6WY + 1.0L						
╈	8	cl CB8	Stren	Add	1.2D + 1.0EXP + 1.0E						
	9	cLCB9	Stren	Add	1.2D + 1.0EYP + 1.0L						
	10	cLCB10	Stren	Add	1.2D + 1.0EYN + 1.0L						
+	11	CLCB11	Stren	Add	1.2D - 1.0EXP + 1.0L						
╈	12	cLCB12	Stren	Add	1.2D - 1.0EXN + 1.0L						
	14	cLCB14	Stren	Add	1.2D - 1.0EYN + 1.0L						
	15	cLCB15	Stren	Add	1.2D + 1.0(1.48)(RX(RS)+RX(E						
-	16	cLCB16	Stren	Add	1.2D + 1.0(1.48)(RX(RS)-RX(ES						
+	1/	cLCB17	Stren	Add	1.20 + 1.0(1.0)(RY(RS)+RY(ES)						
+	19	cLCB19	Stren	Add	1.2D - 1.0(1.48)(RX(RS)+RX(ES						
	20	cLCB20	Stren	Add	1.2D - 1.0(1.48)(RX(RS)-RX(ES)						
	21	cLCB21	Stren	Add	1.2D - 1.0(1.0)(RY(RS)+RY(ES) -						
					matil eneration of Load Combinations						ISE
					matil eneration of Load Combinations     prion     Add Replace     Code Selection     Steel © Concrete SRC     Footing Design Code : ACI318-11      Scale Up of Response Spectrum Load Cases     Scale Up Factor : 1     Rx     Factor Load Case     Add     Add						ISE
					Mad Case     Add     Add Case     Add	×					ISE
					matil eneration of Load Combinations  Dation  Add Replace  Code Selection Steel Selection Scale Up of Response Spectrum Load Cases Scale Up Factor:  Factor Load Case I.400 RX I.000 RY Delete Wind Load Factor  Strength-level Selsmic Load Factor	×					ISE
					matic eneration of Load Combinations  Total Concrete  Steel  Steel  Concrete  Steel  Steel Steel  Steel  St	×					ISE
					matil eneration of Load Combinations  International Content of Control	×					ISE
					matil eneration of Load Combinations     add Replace	×					ISE
					matil eneration of Load Combinations  Dation  Add Replace  Dod Selection Steel Footing Besign Code : ACI318-11  Scale Up of Response Spectrum Load Casee Scale Up Factor : RX  Factor Load Case I.480 RX I.000 RY Delete Mnd Load Factor Strength-level Service-level Seismic Load Factor Strength-level Service-level Seismic Load Factor Strength-level Service-level Consider Lateral Soil Pressure Factor Load Factor : UP Manipulation Construction Stage Load Case ST only Construction Stage Load Case ST only C Son V ST+CS Consider Othogonal Effect SetLoad Cases for Orthogonal Effect SetLoad Cases SetLoad Cases SetLoad Cases SetLoad Case SetLoad Case SetLoad Cases SetLoad Cases SetLoad Case Se	× –					ISE
					matil eneration of Load Combinations  matil eneration of Load Combinations  Content	×					se
					matil eneration of Load Combinations Add Replace Add Replace Code Steelection Steel © Concrete SRC Footina Design Code : ACI318-11  Scale Up of Response Spectrum Load Cases Scale Up Factor : 1 Factor Load Case I,480 RAV Delete Mind Load Factor Strength-level © Service-level Consider Lateral Soil Pressure Factor Load Factor : 0.9 Strength-level © Service-level Consider Lateral Soil Pressure Factor Load Factor : 0.9 Strength-level © Service-level Consider Lateral Soil Pressure Factor Load Factor : 0.9 Strength-level © Service-level Consider Lateral Soil Pressure Factor Load Factor : 0.9 Strength-level © Service-level Consider Consuder Lateral Soil Pressure Factor Load Factor : 0.9 Strength-level © Sonly © ST-CS Consider Orthogonal Effect Set Load Case ST Only © S Only © ST-CS Consider Othogonal Effect Set Load Case ST Only © SO Nule SRSS(Square-Root-of-Sum-of-Squares) Senerate Additional Seismic Load For Vertical Seismic Load For Vertical Seismic Load	×					se
					matil eneration of Load Combinations         Dation         Add         Replace         Code Selection         Steel         Code Selection         Steel         Code Concrete         Steel         Concrete         Steel         Code Selection         Scale Up Factor:         Factor         Code Selection         I.480 FRX         I.000 RY         Delete         Mind Load Factor         © Strength-level         © Strength-level         © Strength-level         © Strength-level         © Strength-level         © Construction Stage Load Case         St Strength-level         © Construction Stage Load Case         St Stalt Load Cases for Orthogonal Effect         Staltic Load Cases for Orthogonal Effect         Staltic Load Cases for Orthogonal Effect         Staltic Load Combinations         © Strongth         © Strongth Case         Stractic Load         Staltic Load Cases for Orthogonal Effect         Strength-level         Strength-level         © Strongth         Strongth <td>×</td> <td></td> <td></td> <td></td> <td></td> <td>se</td>	×					se
					matix       eneration of Load Combinations         Option       Add         Add       Replace         Odd Selection       Steel         Steel       Concrete       SRC         Footina       Steel       Steel         Design Code :       ACI318-11       •         Scale Up of Response Spectrum Load Cases       Scale Up Factor :       Nat         Factor       Load Case       Add         I.400 RX       Modify       Delete         Wind Load Factor       Service-level       Service-level         Sistength-level       Service-level         Consider Lateral Soil Pressure Factor       Load Factor       Strength-level         Consider Load Case       ST Only       CS Only       ST CS Niv         St Story       CS Nonganal Effect       Set Load Cases       ST Only       ST ONLY       Stresses         S TO Niv       CS Only       CS Only       ST Vertical Seismic Load       Stresses       Stresses       Stresses         S To Social Seismic Load       Setses       ST Only       CS Only       Stresses         S To Construction Stage Load Case       ST Social Seismic Load       Stresses       Stresses         S To Social Selsemic Load       Setses						

Compare RX (RY) with EX (EY)

### RX (RY):

Results > Tables > Result Tables > Story > Story Shear (Response Spectrum Analysis)-Spectrum Load Cases > RX(RS) (on) & RY(RS) (on)

- Shear Force (Without Spring)



Figure 29 : Story Shear (Response Spectrum Analysis)

```
EX (EY):
Load > Static Loads > Lateral > Seismic Loads
Load Case > EXP > Modify > Seismic Load Profile
- Story Shear (on)
```

Similarly, select Load Cases EXN, EYP & EYN



Figure 30 : Story Shear (Static Seismic Loads)

Design > General > General Design Parameter > Definition of Frame

- X-direction > Unbraced | Sway (on)
- Y-direction > Braced | Non-Sway (on)
- Design Type > 3-D

OK

- Auto Calculate Effective Length Factors > (on)

Y-Direction of Frame ○ Unbraced   Sway	Definition of Frame X-Direction of Frame	⊚ Unbraced   Sway ⊙ Braced   Non-sway
Design Type	Y-Direction of Frame	© Unbraced   Sway ๏ Braced   Non-sway
<ul> <li>● 3-D</li> <li>○ X-Z Plane</li> <li>○ Y-Z Plane</li> <li>○ X-Y Plane</li> </ul>	Design Type	
	⊚ 3-D ⊘ Y-Z Plane	© X-Z Plane © X-Y Plane
☑ Auto Calculate Effective Length Factors	🔽 Auto Calculate Effec	ctive Length Factors

Figure 31 : Definition of Frame

Design > General > General Design Parameter > Modify Live Load Reduction Factor General Tab

- Option > Add/Replace (on)
- Applied Components > Axial Force (on)
- Top View > Select Window 🛐
- Interior columns: Reduction Factor = 0.56
- Edge column: Reduction Factor = 0.69

Apply

- Corner column: Reduction Factor = 0.88



Figure 32 : Modify Live Load Reduction Factor

-	Unbraced Length (L, Lb)	
-	Option > Add/Replace (on)	
-	Unbraced Length > $Ly=0$ ; $Lx=0$	
-	Laterally Unbraced Length > Do not consider (on)	
-	Select All 🕟	
	Apply	
-	Equivalent Moment Correction Factor (Cm)	
-	Option > Add/Replace (on)	
-	Moment Factor > Calculate by Program (on)	
-	Select All ()	
	Apply	
	Close	
	General Steel Concrete SRC	
	Unbraced Length(L,Lb)	General Steel Concrete SRC
	Option	Equivalent Moment Correction 👻
	Add/Replace O Delete	Option
	Unbraced Length	Add/Replace
	Ly : 0 ft	Moment Factor
	Lz : 0 ft	Cmy: 0
	Laterally Unbraced Length	Cmz: 0
		Calculate by Program
	Do not consider	Apply Close
	Apply Close	

Figure 34 : Equivalent Moment Correction Factor

Figure 33 : Unbraced Length

Design > Design > RC Design > Design Code

- Design Code > ACI318-11 \_
- Apply Special Provisions for Seismic Design > (on) \_
- \_ Select Frame Type > Special Moment Frames (on)

OK	
----	--

oncrete Design Code	
oncice besign code	U
Design Code : ACI318-11	•
Apply Special Provisions for Se	ismic Design
Select Frame Type	
Special Moment Frames	
Intermediate Moment Frames	
Ordinary Moment Frames	
Shear Wall Type	
🔄 Special RC Structural Wall	
Boundary Element Method	
© c ≥ lw/600(su/hw)     Definition American Filler	
Important Factor (le)	(Ctor (Cd) 4,50 ₹
fr $\geq 0.2$ frk	1,20 +
Shear for Design	
	Update by Code
R*Vc(a1+SUM(Mpr)/L>max(Ve1	.Ve2)/2) , R = 0
Method	
MMA(VET, VEZ) O MIN(VET, V	782) 🕒 Vel 🔘 Vez
Ve1 , Vg + a1+SUM(Mpr)/L	,a1= 1
Ve2 , Vg + a2*Veq	, a2 = 1
Member Types to be excluded i	n Seismic Desian
☑ Sub-Beam ☑ Can	tilever
☑ Underground Beam/Column	
Moment Redistribution Factor for E	Beam : 1

Figure 35 : Concrete Design Code

pdate By C	ode	
OK		
	Strength Reduction Factors	<b>—</b>
	Design Code : ACI318-11	Update By Code
	Strength Reduction Factors	
	For Tensile Control (phi_t)	: 0,9
	For Compressive Control	
	- Member with Spiral Reinforcement (phi_c1)	; 0,75
	<ul> <li>Other Reinforced Member (phi_c2)</li> </ul>	: 0,65
	For Shear and Torsion (phi_v)	: 0,75
	ОК	Close

Design > Design > RC Design > Strength Reduction Factors U 

Figure 36 : Strength Reduction Factors

Design > Design > RC Design > Design Criteria for Rebars (Refer Figure 37)

Design Criteria for Rebars
For Beam Design         Main Rebar       :       :       :       Rebar         Stirrups       :       ##       •       Arrangement :       2 •         Side Bar       :       ##       •       Image: Consider Spacing Limit for Main Rebark         dT :       0       ft       dB :       0       ft         Doubly Rebar       /> Consider Spacing Limit for Main Rebark       >       Spliced Bars :       None @ 50% © 100%
For Column Design Main Rebar : #8 Pebar Ties/Spirals : #4 Arrangement : V: 2 do : 0 ft Z: 2 Ø Consider Spacing Limit for Main Rebar Spliced Bars : None @ 50% 100%
For Brace Design Main Rebar : #7 Ties/Spirals : do : 0 tt Z: 2 → Consider Spacing Limit for Main Rebar Spliced Bars : ◎ None @ 50% ○ 100%
For Shear Wall Design Vertical Rebar : #5 End Rebar From : #5 Boundary Element Rebar : #3 Boundary Element Rebar Space : (0,656167979) ft de : 0 ft dw : 0 ft Input Additional Wall Data
OK Close

Figure 37 : Design Criteria for Rebars

Design > Design > RC Design > Modify Concrete Materials

Select material ID #1 **Rebar Selection** 

- Code > ASTM (RC) -
- Grade of Main Rebar > Grade 60 \_
- Grade of Sub-Rebar > Grade 40 \_

Modify	
Close	
ĺ	Modify Concrete Materials
	Material List
	ID Name fc fck R Chk Lambda Main-bar Sub-bar
	1 Grade C4000 576000 X 1 Grade 60 Grade 40
	Concrete Material Selection
	Code : ASTM(RC)  Grade : Grade C4000
	Specified Compressive Strength (fc1fck) : 576000 lbf/ft2
	🗖 Light Weight Concrete Factor (Lambda) 💠 1
	Rebar Selection
	Code : ASTM(RC) -
	Grade of Main Rebar : Grade 60 - Fy : 8640000 Ibf/ft2
	Grade of Sub-Rebar : Grade 40 - Fys : 5760000 lbf/ft2
	Modify Close
	Modify Close

Figure 38 : Modify Concrete Materials

## 7. Design Output

ACI318-11	RC-B	eam D	esign F	lesult Dial	og													×
Code : /	ACI31	8-11		U	nit : I	bf , t	ft	Prim	ary Sorting Opt	ion								
Sorted b	у 🔍 I () Г	vlembe Propert	er Sy					© SE	ECT (© MEM	1B								
MEMB	05	Sec	tion	fc		NZ	10			D(1)								
SECT	L	Bc	Нс	fy	S	Mu	B	AsTop	Rebar	Mu	B	AsBot	Rebar	Vu	B	AsV	Stirrup	
Span		bf	hf	fys														
1		Be	am	576000	1	190744	11	0.0143	3-#8	95372.1	11	0.0100	3-#7	36939.1	22	0.0048	2-#3 @3.5"	
3		1.666	2.000	8640000	М	52798.6	31	0.0053	3-#7	75014.7	7	0.0073	3-#7	20641.1	22	0.0021	2-#3 @8.5"	
26.000		0.000	0.000	5760000	J	190747	7	0.0143	3-#8	95373.3	7	0.0100	3-#7	37598.6	22	0.0049	2-#3 @3.5"	
2		Be	am	576000	1	187267	11	0.0140	3-#8	93633.7	11	0.0100	3-#7	37436.0	22	0.0048	2-#3 @3.5"	
3		1.666	2.000	8640000	М	46927.1	31	0.0053	3-#7	61537.9	11	0.0060	3-#7	20478.5	22	0.0021	2-#3 @8.5"	
26.000		0.000	0.000	5760000	J	183335	7	0.0137	3-#8	91667.7	7	0.0100	3-#7	37101.6	22	0.0048	2-#3 @3.5"	
3		Be	am	576000	1	185767	11	0.0139	3-#8	92883.7	11	0.0100	3-#7	37274.5	22	0.0048	2-#3 @3.5"	
3		1.666	2.000	8640000	М	46888.9	31	0.0053	3-#7	60711.8	11	0.0059	3-#7	20317.0	22	0.0000	2-#3 @10"	
26.000		0.000	0.000	5760000	J	185589	7	0.0139	3-#8	92794.4	7	0.0100	3-#7	37263.1	22	0.0048	2-#3 @3.5"	
4	ACI38-11       Unit: bf       t       Primary Sorting Option         0 by       Member Property         WB       SE       Section       fc       PO       N(r)       LC       Nmu       B       Astrop       Rebar       Mu       B       AsBot       Rebar       Vu       LC       AsV       Stirrup       Ninv       Stirrup       Ninv       B       AsTop       Rebar       Mu       B       AsBot       Rebar       Vu       LC       AsV       Stirrup       Ninv       Stirrup       Stirrup       Stirrup       Ninv       Stirrup       Ninv       Stirrup       Ninv       Stirrup       Ninv       Stirrup       Ninv       Stirrup       Stirrup																	
3		1.666	2.000	8640000	М	46867.6	27	0.0053	3-#7	60586.8	7	0.0059	3-#7	20311.3	42	0.0000	2-#3 @10"	
26.000		0.000	0.000	5760000	J	185708	7	0.0139	3-#8	92854.0	7	0.0100	3-#7	37268.8	22	0.0048	2-#3 @3.5"	
5		Be	am	576000	1	185589	11	0.0139	3-#8	92794.4	11	0.0100	3-#7	37263.1	22	0.0048	2-#3 @3.5"	
3		1.666	2.000	8640000	М	46888.9	27	0.0053	3-#7	60711.8	7	0.0059	3-#7	20317.0	22	0.0000	2-#3 @10"	
26.000		0.000	0.000	5760000	J	185767	7	0.0139	3-#8	92883.7	7	0.0100	3-#7	37274.5	22	0.0048	2-#3 @3.5"	-
				570000		400002	44	0.0197	0 40	01667 7	44	0.0100	9 47	27404 6	1 22	0 0040	່ າ#າ @ລາ <b>ະ</b> "	
Conn	ect M		/iew					Resu	It View Option									
Sele	ct All		Jnsele	ct All	He-	calculatio	on	All	© 0K ⊚ N	IG								
Grap	hic		Detai	I ] [	Sumn	nary]	<<											
Ontion	for D	otail Pi	rint Po	eition .		ndate Bel	har	Conv	Table									
Epd		i Mia		onuori od I				Copy	14010									
End End	· .	j iviiū,		nu 5,		Close												

 $Design > Design > RC \ Design > Concrete \ Code \ Design > Beam \ Design$ 

Sorted by > Member (on) >>

Figure 39 : Concrete Beam Design

Design > Design > RC Design > Concrete Code Design > Column Design Sorted by > Member (on)

A	CI318-11	RC-C	olumn	Desigr	n Result D	ialog									×				
	Code : A	CI31	3-11		U	nit : Ibf	, f	t	Primar	y Sorting	Option								
	Sorted b	y 🍳	Memb	er					© SEC	1 💿 T	/EMB								
		0	Prope	rty															
	MEMB	SE	Section		Section		Section		fc	fy	LC	Pu	Mc	Act	V Pobor	Vu	Ac H	H Pabar	*
	SECT	L	Bc	Hc	Height	fys	В	Rat-P	Rat-M	ABL .	V-IXebai	Rat-V	A9-11	Hitebal					
	51		Edge (	Column	576000	8640000	12	542993	147130	0.0420	0 2 #0	50859.7	0.0005	2 #4 @2"	1				
	1		2.000	2.000	16.000	5760000	12	0.488	0.494	0.0435	0-3-#0	0.254	0.0025	2-#4 @2					
	52		Edge (	Column	576000	8640000		542993	147130	0.0439	8.3.#8	50859.7	0.0025	2.#4 @2"					
	1	1	2.000	2.000	16.000	5760000	000 °	0.488	0.494	0.0455	0-0-#0	0.254	0.0025	2444 @2					
	53		Edge (	Column	576000	8640000	8640000 5760000 2		75824.6	0.0439	8-3-#8	57319.9	0.0025	2.#4 @2"					
	1	· ·	2.000	2.000	16.000	5760000			0.516	0.0459	0-0-#0	0.283	0.0025	2-111 @2					
	54	Г	Edge (	Column	576000	8640000	8640000 5760000 2		83716.0	0.0439	8-3-#8	58285.8	0.0025	2.#4 @2"					
	1		2.000	2.000	16.000	5760000			0.552	0.0433		0.284							
	55		Edge (	Column	576000	8640000 5760000 2	756133	84844.4	0.0439	8-3-#8	58424.1	0.0025	2-#4 @2"						
	1		2.000	2.000	16.000		0.628	0.560			0.285								
	56	Г	Edge (	Column	576000	8640000 2		756133	84844.4	0.0439	8-3-#8	58424.1	0.0025	2-#4 @2"					
	1		2.000	2.000	16.000	5760000	-	0.628	0.560	0.0400		0.285							
	57		Edge (	Column	576000	8640000	2	746092	83716.0	0.0439	8-3-#8	58285.8	0.0025	2.#4 @2"					
	1		2.000	2.000	16.000	5760000	-	0.619	0.552	0.0400		0.284		2444 @2					
	58	Г	Edge (	Column	576000	8640000	2	678827	75824.6	0.0439	8.3.#8	57319.9	0.0025	2_#4_@2"					
	1	1	2.000	2.000	16.000	5760000	-	0.564	0.516	0.0400	0-0-#0	0.283							
	59		Edge (	Column	576000	8640000	12	658369	152728	0.0430	83#8	54341.7	0.0025	2 #4 @2"					
	1	· · ·	2.000	2.000	16.000	5760000		0.566	0.568	0.0100	00.00	0.268	0.0020	2.01 @2					
	60		Interio	or Colu	576000	8640000	14	826023	111747	0.0658	12.4.#8	112738	0.0116	2.#4 @15"					
	2	1	2.500	2.500	16.000	5760000		0.442	0.397	0.0000	12-4-80	0.522	0.0110	2444 @1.0	-				
	Conn	ect M	Indel V	liew															
	Selec	+ All		nseler	t All	Be-calc	ulatio	n	Hesuit	view Up	ion								
	00100			00100					) All	© 0K	© NG								
	Graph	пс		Detail,		summary		<<											
	Draw PM Curve Update Rebar Close Copy Table																		

Figure 40 : Concrete Column Design

Design > Design > RC Design > Concrete Code Design > Wall Design Sorted by > Wall ID + Story (on) SEL (Select) > WID (Wall ID) = 1 ; Story = 1F Graphic

Code : Sorted	: ACI31 by 🧕	8-11 (Met Wall ID +	thod 1) Story	Unit :	lbf , Sort Resi	ft ult		rimary S ) WID ((	orting Op Story	tion –			
WID	SE	Wall ID (*	Mark	fc	fv	Ratio		Mc	Vu	As-V	V-Rebar	End-Rebar	Т
Ston	Πĩ.	Iw	HTw	hw	fvs	Rat-V	Pu	I CB	I CB	As-H	H-Rebar	Barlaver	10
1		wM	0001	576000	8640000	0.277		1.0E+07	298038	0.0043	#5 @12"	Not Use	4
1E		22 000	16 000	1 5000	1 5000 5760000		1325372	34	30	0.0037	#5 @13"	Double	
2		wM	002	576000	8640000	0 277		1 0E+07	298038	0.0043	#5 @12"	NotUse	1.
1F		22,000	16.000	1.5000	0 5760000 0.386	1325372	29	29	0.0037	#5 @13"	Double	-1*	
1		wM	0001	576000	8640000	0.320		0.00000	264277	0.0032	#5 @16"	Not Use	11
2F		22 000	12 000	1 5000	5760000	0.301	2792400	2	30	0.0037	#5 @13"	Double	
2	_	wM	0002	576000	8640000	0.320		0.00000	264277	0.0032	#5 @16"	Not Use	
2F		22,000	12.000	1.5000	5760000	0.301	2792400	2	29	0.0037	#5 @13"	Double	1
1	-	wM	0001	576000	8640000	0.291		0.00000	243169	0.0032	#5 @16"	Not Use	1
3F		22,000	12.000	1.5000	5760000	0.246	2542547	2	30	0.0037	#5 @13"	Double	
2		wM	0002	576000	8640000	0.291		0.00000	243169	0.0032	#5 @16"	Not Use	
3F		22.000	12.000	1.5000	5760000	0.246	2542547	2	29	0.0037	#5 @13"	Double	
1		wM	0001	576000	8640000	0.262		0.00000	221542	0.0032	#5 @16"	Not Use	1
4F		22.000 wMi 22.000	12.000	1.5000	5760000	0.216	2288378	2	30	0.0037	#5 @13"	Double	
2		22.000 12.000 wM0002		576000	8640000	0.262		0.00000	221542	0.0032	#5 @16"	Not Use	
4F		22.000	12.000	1.5000	5760000	0.216	2288378	2	29	0.0037	#5 @13"	Double	1
1		wM	0001	576000	8640000	0.233		0.00000	199433	0.0032	#5 @16"	Not Use	1
5F		22.000	12.000	1.5000	5760000	0.197	2030659	2	30	0.0037	#5 @13"	Double	
2	-	wM	0002	576000	8640000	0.233		0.00000	199433	0.0032	#5 @16"	Not Use	
5F		22.000	12.000	1.5000	5760000	0.197	2030659	2	29	0.0037	#5 @13"	Double	1.
Cor Se Graw	inect N lest All aphic PM C	lodel Viev Ur	w nselect A Detail Update	l Su Su Rebar	Re-calcul ummary Cl	lation . C< lose		esult Vie All 🔿 opy Tabl	w Option OK OI	NG	·		-

Figure 41 : Concrete Wall Design



Figure 42 : Typical Output of Concrete Wall Design