

**Simpson Strong-Tie
Strong Frame[®] Selector
User Manual for V5.0**

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TABLE OF CONTENTS

1. OVERVIEW 3

2. GETTING STARTED 3

3. DESIGN CRITERIA 4

4. GEOMETRY 6

 4.1 Geometry for 1-story SMF frames:6

 4.2 Geometry for Multibay x Multistory frames:8

5. VERTICAL LOAD 9

6. LOAD COMBINATIONS 12

7. ANALYSIS 14

8. SIGN CONVENTIONS 14

9. MEMBER FORCES 15

10. SMF MEMBER DESIGN 16

11. SMF CONNECTION DESIGN 16

12. ANCHORAGE SOLUTIONS 17

 12.1 Design Information17

 12.2 Anchorage Solution Types17

13. FRAME PDF OUTPUT 20

14. FEMA P-807 OUTPUT 22

15. ANCHORAGE PDF OUTPUT 23

16. DRAW FRAME 25

17. ADDITIONAL HELP OR QUESTIONS 25

1. OVERVIEW

The Simpson Strong Frame[®] Moment Frame Selector (Strong Frame Selector) is a program that will help the Designer in selecting an appropriate frame for their given geometry and loading. Only minimum input geometries are required for the software to select an appropriate frame for the available space.

An easy-to-use input screen and drop down menus make it simple for the Designer to input lateral and gravity loads. Both wind and seismic loads can be entered and the Strong Frame Selector will determine possible frame sizes that meet the Designer's input requirements. Uniform, partial uniform, as well as point loads can be placed anywhere along the span of the beam.

Once a frame size has been selected, anchorage design is as easy as picking the foundation type, concrete strength, concrete service condition (Cracked or Uncracked), grade of anchor rod and Seismic Design Category.

The PDF output is in a concise format that contains all the important design information.

2. GETTING STARTED

Open the software by clicking on the Strong Frame Selector icon. Enter the required Job name, Frame ID and user information on the top of the screen. Select from "Select a Frame to Add" drop down button to add either One Story SMF frame to design or add Multistory x Multibay SMF frame input to send to Simpson Strong-Tie for analysis and design. After entering all the Design Criteria and *Search* has been performed, the frame can then be added to the "*Configured Frames*" list. From here select *Save* or *Save As* to save the file to the desired location.



3. DESIGN CRITERIA

Following is a list of the input variables under the *Design Criteria* window on the Frame Design Tab:

Design Code: IBC 2009, IBC 2012, IBC 2015, IBC 2018 and FEMA P-807 (SMF only). Load combinations will be used for the analysis and design from the selected code. When designing for FEMA P-807, connection capacity forces are used for design.

Seismic Load R-Value: This is the R-Value the base shear or frame lateral load calculated is based on; this is not the R-Value for Frame Design (see below). If the base shear is calculated based on plywood shear wall, then the Seismic Load R-Value to select here is 6.5.

ASD Seismic Load: Enter ASD seismic lateral load (lbs) resisted by the moment frame. This value should include any shear value from stories above. For any overturning forces imposed on top of the beam, see *ASD Point Load* section below. This seismic value must correspond to the *Seismic Load R-Value* entered above. For 2-story SMF frames, there will be two ASD Seismic Loads, one at the mid-level beam (B1) and another at the top-level beam (B2). Please note, these are the story forces (portion of seismic force induced to the specific level, ASCE 7 Section 12.8.3), not the story shear (cumulated story forces from stories above). Also, ASD Seismic Loads are to be calculated assuming *Redundancy Factor* =1.0 and *Importance Factor* =1.0. See redundancy factor and importance factor sections below.

V_{pr} Frame Load (LRFD): Enter ultimate load (lbs) required to be resisted by the moment frame. This value is the ultimate value the frame can deliver. This option is only available for FEMA P-807 design under one story SMF frames.

Seismic Drift Limit: The Designer has five drift limits to choose from: No Limit, 0.010 hx, 0.015 hx, 0.020 hx and 0.025 hx, where hx is the story height. See ASCE 7 Table 12.12-1 for selecting the appropriate seismic drift limit.

Seismic S_{DS} value: Short period response acceleration value per ASCE 7 Equation 11.4-3

Importance Factor: Factor assigned to structure according to its Occupancy Category (ASCE7-05) or Risk Category (ASCE 7-10); please refer to ASCE 7 Section 11.5. Importance Factor is used for calculating story drift per ASCE 7 Section 12.8.6. If *ASD Seismic Load* entered above was not calculated using 1.0, then user shall modify this Importance Factor to reflect that of the *ASD Seismic Load*, see ASCE 7 Section 12.8 (i.e. if I=1.25 for ASD seismic load calculation, the select I=1.25).

Frame Design R-Value: R- Value to which the moment frame is to be designed (ASCE 7 Table 12.2-1) up to R=8.0 for steel SMF. If the frame is used with another lateral system in the same line, the smaller R shall be used (i.e. R=6.5 if the SMF is used in conjunction with a wood plywood shearwall system). C_d associated with the selected Frame Design R-Value will be used for story drift determinations per ASCE 7 Section 12.8.6.

Omega Factor: System Overstrength Factor from Table 12.2-1 of ASCE 7. This factor should correspond to *Frame Design R-Value* for the seismic force-resisting system. Per footnote g of Table 12.2-1, Omega Factor is permitted to be reduced by subtracting ½ for structures with flexible diaphragms.

Redundancy Factor: 1 or 1.3 per ASCE 7 Section 12.3.4.

ASD Wind Load: Enter ASD wind lateral load resisted by the moment frame. This value should include any shear value from stories above. Please note wind maps given in IBC 2012 are at strength level; to convert to ASD level, multiply the wind load by a factor of 0.6. For any overturning forces imposed on top of the beam, see **ASD Point Load** section below.

Wind Drift Limit: There are 6 wind drift limits the Designer can choose from. They are: No limit, $h_x/175$, $h_x/250$, $h_x/300$, $h_x/350$, $h_x/400$; default is set to No limit. The Designer must verify appropriate drift limit for their design requirements. Load combinations used for wind drift check for IBC 2009 are:

20	$D + 0.75 W + 0.75 L + 0.75 L_r$
21	$D - 0.75 W + 0.75 L + 0.75 L_r$
22	$D + 0.75 W + 0.75 L + 0.75 S$
23	$D - 0.75 W + 0.75 L + 0.75 S$
24	$D + 0.75 W + 0.75 L + 0.75 R$
25	$D - 0.75 W + 0.75 L + 0.75 R$

And IBC 2012/IBC 2015/IBC 2018 are:

20	$D + 0.45 W + 0.75 L + 0.75 L_r$
21	$D - 0.45 W + 0.75 L + 0.75 L_r$
22	$D + 0.45 W + 0.75 L + 0.75 S$
23	$D - 0.45 W + 0.75 L + 0.75 S$
24	$D + 0.45 W + 0.75 L + 0.75 R$
25	$D - 0.45 W + 0.75 L + 0.75 R$

Note that these combinations are slightly different than proposed by ASCE 7-05 Chapter C, Appendix C: $D + 0.5L + 0.7W$, and ASCE 7-10 Commentary Appendix C: $D + 0.5L + W_a$, where W_a is the wind load based on serviceability wind speeds.

Beam Deflection Limits: For longer frames, beam deflection can become significant depending on the loading magnitude. There are three beam deflection limits the Designer can select, they are as follows:

Live load: $L/180$, $L/240$, $L/360$ [Default], $L/480$ and $L/600$

Dead + Live Load: $L/120$, $L/180$, $L/240$ [Default], $L/360$

Snow or Wind Load: $L/120$, $L/240$, $L/360$ [Default], and $L/480$

Simply Supported Beam: $L/120$, $L/240$, $L/300$ and $L/360$ [Default]

The Designer must verify beam deflection limits based on construction and loading type. Refer to IBC 2009 or IBC 2012/IBC 2015/IBC 2018 Table 1604.3 for appropriate beam deflection limits. For Simpson Strong-Tie SMF, a deflection limit of $L/360$ is suggested for the Live Load and

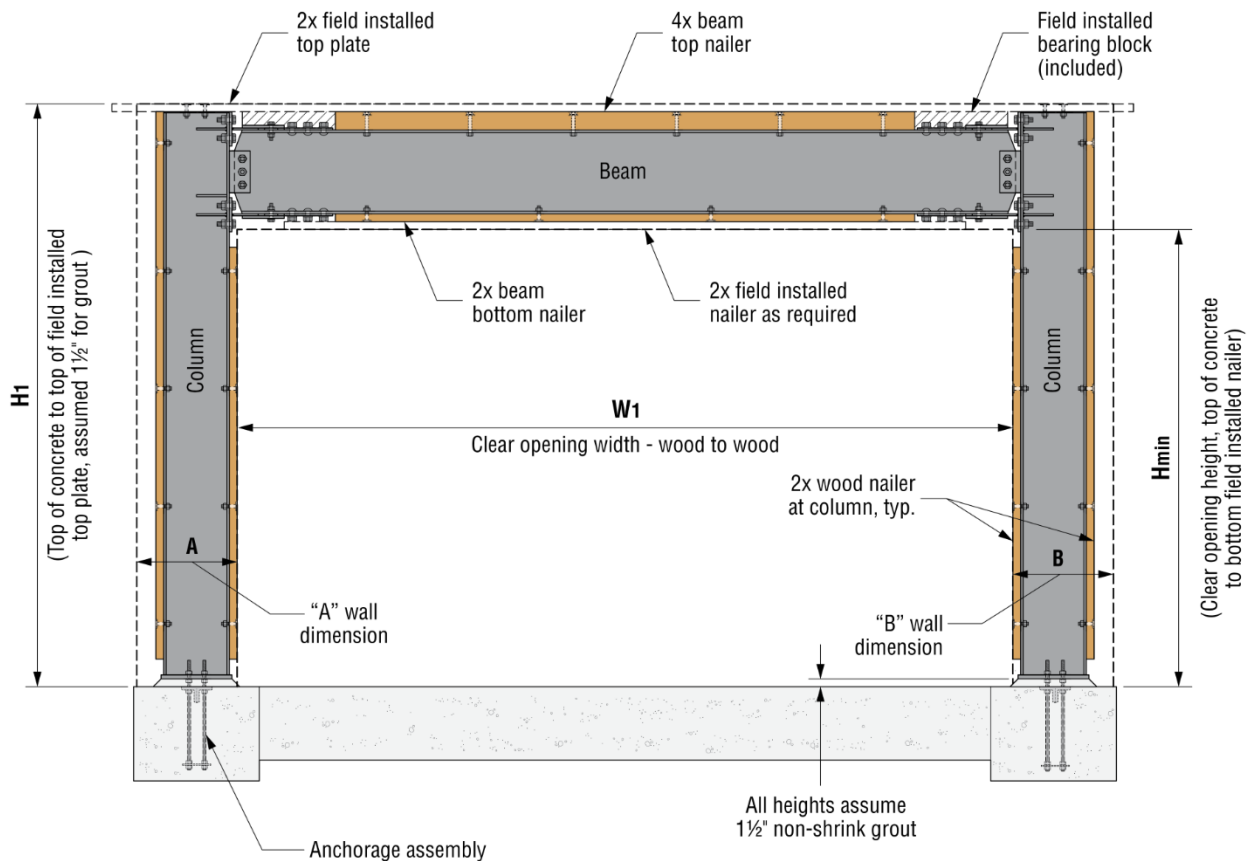
Dead+Live Load as well as for the simply supported beam cases to limit beam end rotations. See Simpson Strong-Tie Design Procedure Step 2 ESR-2802 for more information.

Base Fixity: Frames can be design with pinned or fixed base columns. Please note, when fixed base is selected, Simpson Strong-Tie provides the fix base design following the AISC Seismic Design manual embedded column base approach. In addition with embedded column base design, the base of the column may see yielding in addition to the Yield-Links at the beam to column connection. In order to have the correct column length, the designer will need to provide the correct grade beam depth from his/her design and input into fields of “*Slab Depth*” and “*Grade Beam Depth*”. Please note, Grade beam width and depth required for embedment depth will be calculated by the Strong Frame Selector software. However actual grade beam design (width/depth/reinforcing etc.) with consideration to soil properties will need to be provided by the Designer.

4. GEOMETRY

4.1 Geometry for 1-story SMF frames:

Following is a list of input variables under the Geometry Section:



W₁ is the clear opening width from the inside face of 2x wood nailers for each column.

H1 is the dimension from top of concrete to top of the field installed top plate. The dimension includes 1-1/2" for field-installed 2x top plate and 1-1/2" for non-shrink grout under the base plate.

Hmin is the clear opening height from top of concrete to the bottom face of the beam bottom nailer. Dimensional difference between H1 and Hmin is used by the Strong Frame Selector to calculate possible beam sizes.

For garage front applications where the steel frame bears on top of a concrete curb and the clear opening height is measured from the top of the concrete slab to the bottom of the steel beam nailer, Hmin should be adjusted to exclude the curb height.

Uneven Col and H02 are the check box and input height the user need to provide for frames with uneven left and right columns for the frame (i.e. at sloped sites). Please note H02 is the positive offset height of right column with reference to the left column.

A Wall Dimension is the space available for the left column. It is dimensioned from the interior face of the inside nailer of the left column to the edge of the next opening/end of wall.

B Wall Dimension is the space available for the right column. It is dimensioned from the interior face of the inside nailer of the right column to the edge of next opening/end of wall. The minimum of A and B wall dimensions is used by the Strong Frame Selector to calculate possible column sizes.

Column dimensions including wood nailers are 9" for C8, 13.5" for C10, 15.5" for C12, 17.125" for C14, 19.5" for C16 and 21.125" for C18 SMF columns. For example, when 14" is entered for both A and B wall dimensions, only frames using the C8 and C10 columns will be shown on the list of possible SMF solutions.

For 1-story SMF frames, Minimum and Maximum **WI** dimensions allowed are 6'-0" (72") and 30'-0" (360"). Minimum and Maximum **H1** dimensions allowed are 6'-0" (72") and 26'-0" (312").

4.2 Geometry for Multibay x Multistory frames:

Design Criteria (Multibay x Multistories)

Design Code: **IBC 2012**

Seismic Lateral Demand

Seismic Load R Value: **6.5**

ASD Seismic Load (Level 2): **0**

ASD Seismic Load (Level 3): **0**

Seismic Design Parameter Demand

Seismic Drift Limit: **0.025 hx**

Seismic S_{DS} Value: **1**

Importance Factor, I: **1.0**

Frame Design R Value: **6.5**

Omega Factor: **2.5**

Redundancy Factor: **1.0**

Wind Lateral Demands

ASD Wind Load (Level 2): **0**

ASD Wind Load (Level 3): **0**

Wind Drift Limit: **No limit**

Multibay-MultiStory

No. of Bays: **3** No. of Stories: **2**

Column Location: **Centerline-to-Centerline** Height To: **Top of Dbl Top Plate**

Floor Depth Geometry: Level 2: **6.00"** Level 3: **6.00"** Level 4: **6.00"** Level 5: **6.00"**

Uneven Column Height at Base?: **No** Base Fixity: **Pinned Base**

Beam Depth Restriction: **No** Column Depth Restriction: **No**

Note: Please click on beam for loading input Legend

Seismic and Wind Input parameters on the left of the input panel are similar to the 1-story x 1-bay frames. The parameters below are applicable to multistory x multibay frames only:

No. of Bays: Input the number of bays desired for the design frame

No. of Stories: Input the number of stories desired for the design frame

Column Location: Select how to locate the horizontal spacing of columns. Either centerline-to-centerline or clear distance to column wood nailers

Height To: Select how to locate vertical dimension of the frames. Either to top of the double top plates or to top of the beam nailer (see Figure below)

Floor Depth Geometry: Input height of floor system (i.e. joist depth) including thickness of plywood floor sheathing

Uneven Column Height at Base: Select Yes or No for uneven column heights (column offset from top of concrete). If “Yes” is selected, then input column offset also. Base of left column is used as the reference (i.e. it’s offset is equal to 0”)

Base Fixity: Select “Pinned” or “Fixed” base design for the frame

Beam Depth restriction: Select “Yes” or “No” to restrict the beam depth for the frame design. If “Yes” is selected, then the choice of different beam depths is shown as well as the option to select “Yes” or “No” for beam top and bottom nailers.

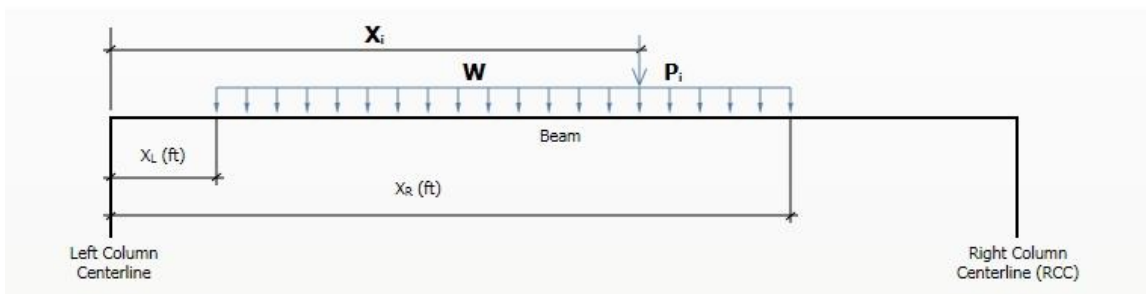
Column Depth Restriction: Select “Yes” or “No” to restrict the column depth for the frame design. If “Yes” is selected, then the choice of different column depths is shown as well as the option to select “Yes” or “No” for column nailers.

Beam Gravity Loads: Please click on the beam members to bring up input screen. See Section 5 below for load input.

5. VERTICAL LOAD

Vertical loads are input in the **Load Distribution** window located under the **Design Criteria** window. Sign convention for loading is positive in the gravity direction, and negative for uplift. Uniform loads are in pounds per linear foot and may be the full width of the frame or may be partial uniform loads. 7 basic load cases can be entered into the Strong Frame Selector software as follows: Dead Load (D), Live Load (L), Roof Live Load (L_r), Snow (S), Rain (R), Wind (W) and Seismic (E).

The loading is represented graphically by the following diagram:



ASD Uniform Loads: The Designer can input uniform loads for Dead Load (D), Live Load (L), Roof Live Load (L_r), Snow (S) Load, Rain (R) and Wind (W) load. Partial uniform loads can start and end anywhere within the beam span. The dimensions X_L and X_R are the distance from the centerline of the left column to the start and end of the partial uniform load, respectively. Strong Frame Selector will ignore any loads past the end of the beam. Click on “To RCC” to load the beam to the Right Column Centerline. For Snow loads, the designer is required to select the Snow Load Factor (f_2 in IBC) that corresponds to the roof configuration (see IBC Section 1605.2).

ASD Uniform Loads: (Negative value for uplift)

	Load (plf)	X _L (ft)	X _R (ft)			Load (plf)	X _L (ft)	X _R (ft)	
W _{DL1}	0	0	9.67	<input checked="" type="checkbox"/> To RCC	W _{L1}	0	0	9.67	<input checked="" type="checkbox"/> To RCC
W _{DL2}	0	0	9.67	<input checked="" type="checkbox"/> To RCC	W _{LL1}	0	0	9.67	<input checked="" type="checkbox"/> To RCC
W _{DL3}	0	0	9.67	<input checked="" type="checkbox"/> To RCC	W _{LL2}	0	0	9.67	<input checked="" type="checkbox"/> To RCC
Rain Load	0	0	9.67	<input checked="" type="checkbox"/> To RCC	Snow Load	0	0	9.67	<input checked="" type="checkbox"/> To RCC
Wind	0	0	9.67	<input checked="" type="checkbox"/> To RCC	Snow Load Factor	0.2			

ASD Point Loads: Up to 8 point loads can be entered for each of the 7 basic load cases. Point loads are specified in (lbs) followed by the distance from the centerline of the left column. Click on “At RCC” to apply the point load at the Right Column Centerline. For Seismic point reactions the Designer must increase the seismic point loads with the appropriate Ω_0 value per ASCE Section 12.3.3.3.

ASD Point Load on top of Beam: (Negative value for uplift)

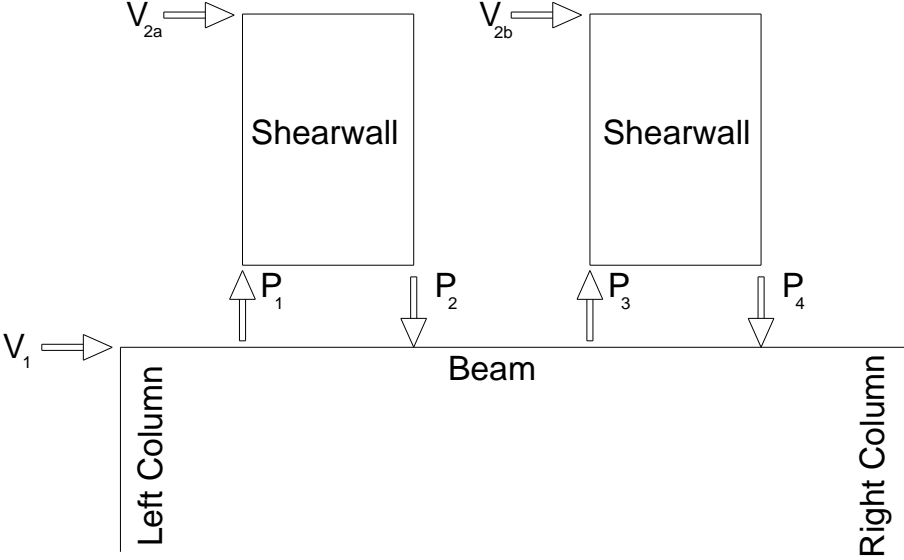
8

Reset

	DL	LL	RLL	Snow	Rain	Wind	Seismic *	X _i	
P ₁ (lbs)	0	0	0	0	0	0	0	X ₁ (ft)	0 <input type="checkbox"/> At RCC
P ₂ (lbs)	0	0	0	0	0	0	0	X ₂ (ft)	0 <input type="checkbox"/> At RCC
P ₃ (lbs)	0	0	0	0	0	0	0	X ₃ (ft)	0 <input type="checkbox"/> At RCC
P ₄ (lbs)	0	0	0	0	0	0	0	X ₄ (ft)	0 <input type="checkbox"/> At RCC
P ₅ (lbs)	0	0	0	0	0	0	0	X ₅ (ft)	0 <input type="checkbox"/> At RCC
P ₆ (lbs)	0	0	0	0	0	0	0	X ₆ (ft)	0 <input type="checkbox"/> At RCC
P ₇ (lbs)	0	0	0	0	0	0	0	X ₇ (ft)	0 <input type="checkbox"/> At RCC
P ₈ (lbs)	0	0	0	0	0	0	0	X ₈ (ft)	0 <input type="checkbox"/> At RCC

* Designer to apply overstrength factor as applicable.

Point loads due to Wind or Seismic from shearwall reactions above the moment frame must be consistent with the direction of the lateral load. For example, P₁ and P₃ in the figure below shall be entered with a negative value for uplift. The selector software will switch the direction of P₁ and P₃ to positive and P₂ and P₄ to negative and V₁ to negative through load combinations so the Designer does not have to do two designs by switching the load directions. See **Load Combinations** Section below for more information regarding load combination and direction of lateral loads.



6. LOAD COMBINATIONS

The seven basic load cases defined above (D, L, Lr, R, S, W, and E) are used for combining loads Per IBC 2009, IBC 2012, IBC 2015 and IBC 2018. The basic load cases and load combinations are summarized in the tables below. The major difference between IBC 2009 and IBC 2012/IBC 2015/IBC 2018 load combinations are the combinations involving wind loads. For IBC 2012/IBC 2015/IBC 2018, wind loads are at strength level, whereas for IBC 2009, wind loads are at serviceability level.

Combo	IBC 2009 Load Combinations	IBC 2012 Load Combinations	
1	D	D	Nominal Loads
2	L	L	
3	Lr	Lr	
4	S	S	
5	R	R	
6	W	W	
7	E	E	
8	D	D	ASD Load Combinations
9	D+ L	D+ L	
10	D + Lr	D + Lr	
11	D + S	D + S	
12	D + R	D + R	
13	D + 0.75 L+ 0.75 Lr	D + 0.75 L+ 0.75 Lr	
14	D + 0.75 L+ 0.75 S	D + 0.75 L+ 0.75 S	
15	D + 0.75 L+ 0.75 R	D + 0.75 L+ 0.75 R	
16	D + 1 W	D + 0.6 W	
17	D - 1 W	D - 0.6 W	
18	$(1.0 + 0.14 S_{DS}) D + 0.7 E * \rho$	$(1.0 + 0.14 S_{DS}) D + 0.7 E * \rho$	
19	$(1.0 + 0.14 S_{DS}) D - 0.7 E * \rho$	$(1.0 + 0.14 S_{DS}) D - 0.7 E * \rho$	
20	D + 0.75 W + 0.75 L+ 0.75 Lr	D + 0.45 W + 0.75 L+ 0.75 Lr	
21	D - 0.75 W + 0.75 L+ 0.75 Lr	D - 0.45 W + 0.75 L+ 0.75 Lr	
22	D + 0.75 W + 0.75 L+ 0.75 S	D + 0.45 W + 0.75 L+ 0.75 S	
23	D - 0.75 W + 0.75 L+ 0.75 S	D - 0.45 W + 0.75 L+ 0.75 S	
24	D + 0.75 W + 0.75 L+ 0.75 R	D + 0.45 W + 0.75 L+ 0.75 R	
25	D - 0.75 W + 0.75 L+ 0.75 R	D - 0.45 W + 0.75 L+ 0.75 R	
26	$(1.0 + 0.105 S_{DS}) D + 0.525 E * \rho + 0.75 L + 0.75 Lr$	$(1.0 + 0.105 S_{DS}) D + 0.525 E * \rho + 0.75 L + 0.75 Lr$	
27	$(1.0 + 0.105 S_{DS}) D - 0.525 E * \rho + 0.75 L + 0.75 Lr$	$(1.0 + 0.105 S_{DS}) D - 0.525 E * \rho + 0.75 L + 0.75 Lr$	
28	$(1.0 + 0.105 S_{DS}) D + 0.525 E * \rho + 0.75 L + 0.75 S$	$(1.0 + 0.105 S_{DS}) D + 0.525 E * \rho + 0.75 L + 0.75 S$	
29	$(1.0 + 0.105 S_{DS}) D - 0.525 E * \rho + 0.75 L + 0.75 S$	$(1.0 + 0.105 S_{DS}) D - 0.525 E * \rho + 0.75 L + 0.75 S$	
30	$(1.0 + 0.105 S_{DS}) D + 0.525 E * \rho + 0.75 L + 0.75 R$	$(1.0 + 0.105 S_{DS}) D + 0.525 E * \rho + 0.75 L + 0.75 R$	
31	$(1.0 + 0.105 S_{DS}) D - 0.525 E * \rho + 0.75 L + 0.75 R$	$(1.0 + 0.105 S_{DS}) D - 0.525 E * \rho + 0.75 L + 0.75 R$	
32	0.6 D + 1 W	0.6 D + 0.6 W	
33	0.6 D - 1 W	0.6 D - 0.6 W	
34	$(0.6 - 0.14 S_{DS}) D + 0.7 E * \rho$	$(0.6 - 0.14 S_{DS}) D + 0.7 E * \rho$	
35	$(0.6 - 0.14 S_{DS}) D - 0.7 E * \rho$	$(0.6 - 0.14 S_{DS}) D - 0.7 E * \rho$	

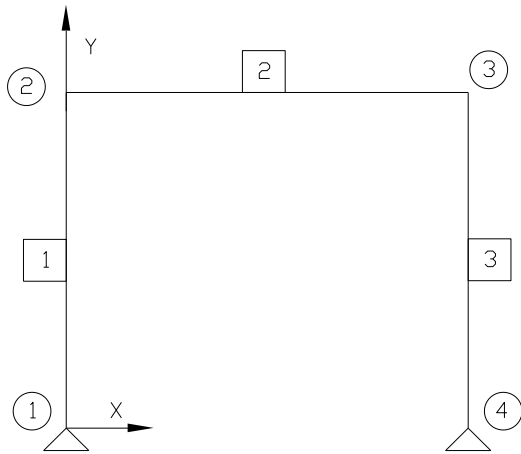
Combo	IBC 2009 Load Combinations	IBC 2012 Load Combinations	
36	1.4 D	1.4 D	LRFD Load Combinations
37	1.2 D + 1.6 L + 0.5 Lr	1.2 D + 1.6 L + 0.5 Lr	
38	1.2 D + 1.6 L + 0.5 S	1.2 D + 1.6 L + 0.5 S	
39	1.2 D + 1.6 L + 0.5 R	1.2 D + 1.6 L + 0.5 R	
40	1.2 D + 1.6 Lr + 0.5 L	1.2 D + 1.6 Lr + 0.5 L	
41	1.2 D + 1.6 Lr + 0.8 W	1.2 D + 1.6 Lr + 0.5 W	
42	1.2 D + 1.6 Lr - 0.8 W	1.2 D + 1.6 Lr - 0.5 W	
43	1.2 D + 1.6 S + 0.5 L	1.2 D + 1.6 S + 0.5 L	
44	1.2 D + 1.6 S + 0.8 W	1.2 D + 1.6 S + 0.5 W	
45	1.2 D + 1.6 S - 0.8 W	1.2 D + 1.6 S - 0.5 W	
46	1.2 D + 1.6 R + 0.5 L	1.2 D + 1.6 R + 0.5 L	
47	1.2 D + 1.6 R + 0.8 W	1.2 D + 1.6 R + 0.5 W	
48	1.2 D + 1.6 R - 0.8 W	1.2 D + 1.6 R - 0.5 W	
49	1.2 D + 1.6 W + 0.5 L + 0.5 Lr	1.2 D + 1 W + 0.5 L + 0.5 Lr	
50	1.2 D - 1.6 W + 0.5 L + 0.5 Lr	1.2 D - 1 W + 0.5 L + 0.5 Lr	
51	1.2 D + 1.6 W + 0.5 L + 0.5 S	1.2 D + 1 W + 0.5 L + 0.5 S	
52	1.2 D - 1.6 W + 0.5 L + 0.5 S	1.2 D - 1 W + 0.5 L + 0.5 S	
53	1.2 D + 1.6 W + 0.5 L + 0.5 R	1.2 D + 1 W + 0.5 L + 0.5 R	
54	1.2 D - 1.6 W + 0.5 L + 0.5 R	1.2 D - 1 W + 0.5 L + 0.5 R	
55	$(1.2 + 0.2 S_{DS})D + E^*p + 0.5 L + f2^*S$	$(1.2 + 0.2 S_{DS})D + E^*p + 0.5 L + f2^*S$	
56	$(1.2 + 0.2 S_{DS})D - E^*p + 0.5 L + f2^*S$	$(1.2 + 0.2 S_{DS})D - E^*p + 0.5 L + f2^*S$	
57	0.9 D + 1.6 W	0.9 D + 1 W	
58	0.9 D - 1.6 W	0.9 D - 1 W	
59	$(0.9 - 0.2 S_{DS}) D + E^*p$	$(0.9 - 0.2 S_{DS}) D + E^*p$	
60	$(0.9 - 0.2 S_{DS}) D - E^*p$	$(0.9 - 0.2 S_{DS}) D - E^*p$	
61	$(1.2 + 0.2 S_{DS})D + \Omega E + 0.5L + f2^*S$	$(1.2 + 0.2 S_{DS})D + \Omega E + 0.5L + f2^*S$	
62	$(1.2 + 0.2 S_{DS})D - \Omega E + 0.5L + f2^*S$	$(1.2 + 0.2 S_{DS})D - \Omega E + 0.5L + f2^*S$	
63	$(0.9 - 0.2 S_{DS}) D + \Omega E$	$(0.9 - 0.2 S_{DS}) D + \Omega E$	
64	$(0.9 - 0.2 S_{DS}) D - \Omega E$	$(0.9 - 0.2 S_{DS}) D - \Omega E$	

For gravity load combination from 8 to 60, a minimum lateral load, $N_i = \text{maximum [75 lbs, } 0.2 \times \text{maximum (wind or seismic)]}$ is added to the gravity combinations. This is similar to the 0.002 Y_i requirement by AISC 360. Load combinations 61 to 64 are used for the base plate design as required by AISC 341-05 Section 8.5 and AISC 341-10/14 Section D.6. Load combinations 61 to 64 are also used for anchorage design per ACI 318-11 Section D.3.3.4.3 option d (ACI 318-14, Chapter 17 Section 17.2.3.4.3 option d). For SMF, minimum of the mechanism and Omega Combo (LCM 61-64) are used for frame member design. Maximum tension and shear is taken as the lesser of the Ω_o combinations reactions and the tension/shear forces the frame can delivered (i.e. assuming plastic hinges to form at each end of the beam). For uneven and fixed based frames, demand forces are from the Ω_o / overstrength combinations only.

For FEMA P-807, load combination used is similar to 61-64. Instead of $\Omega_o E$, the capacity of the moment connections/frame is used. The design forces from these modified load combinations will be used for the member design, base plate design and anchorage design. FEMA P-807 is only applicable to even column pinned base frames in the Strong Frame Designer. Contact Simpson Strong-Tie for any other configurations.

7. ANALYSIS

Analysis for the Simpson Strong Frame Selector Software is based on the stiffness method. For each element (beam and columns), a stiffness matrix is determined and then assembled into a combined global stiffness matrix. For the SMF PR connections, stiffness for the links is captured at each end of the beam with a rotational spring. After applying boundary conditions, the Strong Frame Selector solves for the overall displacement matrix. From the displacement matrix, member end forces are determined for each of the elements.



The stiffness matrix for each element is based on centerline to centerline dimensions with the Euler-Bernoulli beam model (Shear deformations included). Both large ($P-\Delta$) and small ($P-\delta$) P-Delta are accounted for in the analysis and design by the use of the geometry stiffness matrix method for $P-\Delta$ and AISC B1 factor for $P-\delta$.

Member internal forces are determined by sub-dividing each element into 100 segments. Shear, axial, moment as well as deflection are calculated along the 101 points for each element.

The analysis method satisfies the AISC Effective Length Method with a General Second Order Elastic Analysis, where unreduced stiffness used for elements in analysis, but a K value is calculated for design. In addition, Notional Loads are applied to the gravity load combinations as required.

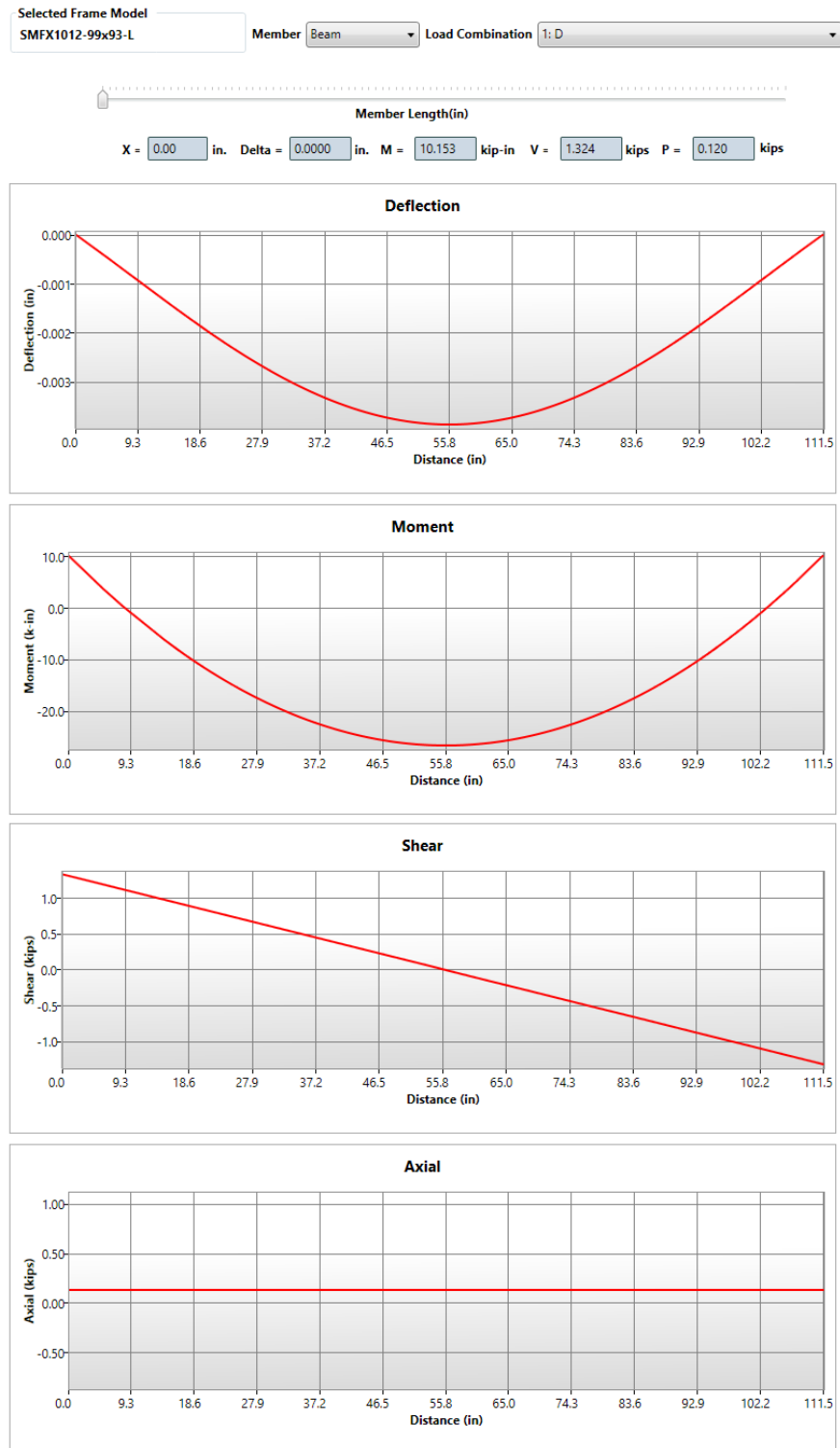
8. SIGN CONVENTIONS

Default coordinate system is the 2D Cartesian coordinate system with x-axis being in the horizontal direction and y-axis being in the vertical direction. Positive y-direction is up (uniform and point loads as defined in the previous section follows the same convention, except a negative sign is automatically added to the user input values for point and uniform loads so Designers do not have to type in the (-) sign for gravity loading).

Output member moment is positive value on the tension side and negative on the compression side. Positive column reaction axial values indicate compression where as negative axial reaction values indicate tension. For beam deflection in the y-axis, negative values indicate beam is deflecting down (gravity direction), where as positive values indicate beam is deflecting up.

9. MEMBER FORCES

Graphical display of the member forces (Moment, Shear and Axial) along with member deflection can be viewed by clicking on the “**Member Forces**” button just below the list of “**Possible Solutions**”. Designers can select the **Member** (Beam or Columns), **Load Combination** and the slide the tool bar along the length of the element to view numerical output for deflection, moment, shear and axial load along the 101 output points.



10. SMF MEMBER DESIGN

In addition to Load Combinations 36 to 60, beam and columns are designed for frame mechanism forces, assuming links at both ends of the beam are at their probable maximum rupture strength. Beam is designed and tested as unbraced from column to column. There are no requirements for stability bracing of the beams or at the Yield-Link locations. Columns are designed so bracing is only required near the beam top flange level of the beam.

Member design is in accordance with the ANSI/AISC 360, *Specification for Structural Steel Buildings*. Design for beam and column flexure is in accordance with sections F.1 thru F.5. In addition, since columns are designed so bracing is only required near the beam top flange level, column flexure design modifies $M_p = S_x F_y$ instead of $Z_x F_y$ so columns can remain essentially elastic per the Simpson Strong Tie SMF Design procedure in AISC 358-16.

Sections E.3, E.4 and E.7 are used for beam and column compression design. Combined flexural and axial design for beam and columns are in accordance with Chapter H. Member design for shear is in accordance with Chapter G. The maximum demand-to-capacity ratio (DCR) for all member design under code forces is 1.01. Maximum DCR for capacity and omega load combination is 1.03.

11. SMF CONNECTION DESIGN

Similar to the member design, moment connections at each end of the beam are designed for frame mechanism forces, assuming links at both ends of the beam are at their probable maximum rupture strength. Connection design capacity is calculated per AISC 360 Chapter J. The maximum demand-to-capacity ratio (DCR) for connection design under code combinations is limited to 1.01, whereas DCR for connections under capacity design and omega load combinations is limited to 1.03.

Base plate capacities are calculated based on AISC Design Guide #1 and Design Guide #16. Compression and bearing capacities are calculated per DG#1. Base plate tension capacity assuming two-way bending is calculated using Design Guide #16.

12. ANCHORAGE SOLUTIONS

12.1 Design Information

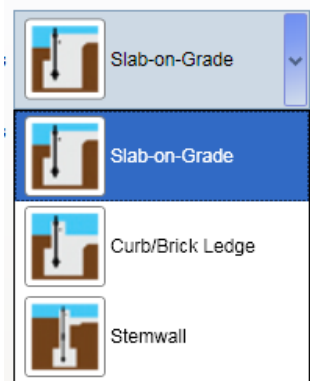
Tension anchorage solutions are based on ACI 318 Appendix D/Chapter 17. Tension capacity is taken as minimum of 1) Anchor rod strength in tension [N_{sa}], 2) Anchor breakout strength [N_{cbg}] and 3) Anchor pullout strength [N_{pn}]. Strength reduction factors in tension are based on 1) Seismic Design Category [$\phi_{seismic}=0.75$] and 2) Crack/Un-cracked Concrete [$\phi_{conc}=0.7$]. Please note, when either IBC 2009 or IBC 2012 is selected, instead of applying the strength reduction factor of 0.4 to the capacity side, load combinations including Ω_o is used on the demand side to calculate the maximum tension force per ACI 318-11 Section D3.3.4.3 option (d) and ACI 318-14, Chapter 17 Section 17.2.3.4.3 option (d). Please note, for even column pinned base conditions, the strong frame also considered the maximum load the system can delivered and design the anchorage for the less of the omega load and the max load the system can deliver.

Shear capacity for the MFSL anchor solution type is based on AISC Design Guide #1. Shear capacity for MFAB anchor solution type is based on ACI 318 Chapter 10. Design shear strength for both solutions types included a 0.8 reduction factor for built-up grout pad.

The program will calculate anchor bolt shear and tension interaction above the concrete. However, anchorage designs are based on embedment for tension into the foundation, while shear design is based on resistance within the curb or slab. For other conditions, the Designer must consider shear and tension interaction of the concrete failure surfaces. Please note, the selector program only calculates the requirement of the anchorage, footing design as a whole is the responsibility of the Designer.

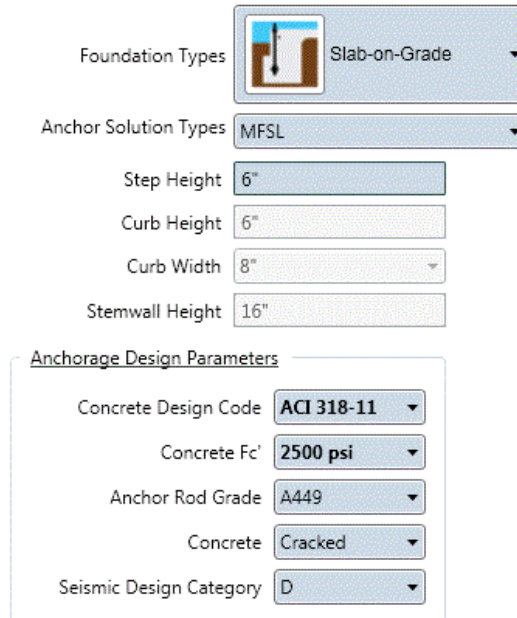
12.2 Anchorage Solution Types

After a frame model has been designed and selected, the Designer can click on the **Anchorage Design** button to start the Anchorage Design. The Designer can chose anchorage solutions based on **Foundation Type**. The three foundation types are described below and are selected from a drop down menu:



For ***Slab-on-Grade Foundation Types***, there are two solutions the Designer can choose from; they are ***MFSL*** and ***MFAB with Hairpins***.

Input fields required for the MFSL and MFAB with Hairpins are:



The screenshot shows the following input fields:

- Foundation Types:** Slab-on-Grade (with a diagram icon)
- Anchor Solution Types:** MFSL
- Step Height:** 6"
- Curb Height:** 6"
- Curb Width:** 8"
- Stemwall Height:** 16"
- Anchorage Design Parameters:**
 - Concrete Design Code:** ACI 318-11
 - Concrete f_c' :** 2500 psi
 - Anchor Rod Grade:** A449
 - Concrete:** Cracked
 - Seismic Design Category:** D

Step Height: Height from top of concrete footing to top of concrete slab. This dimension is used for determining the length of anchor rod required for anchorage.

Concrete Design Code: The latest ACI 318 code is used for anchorage design.

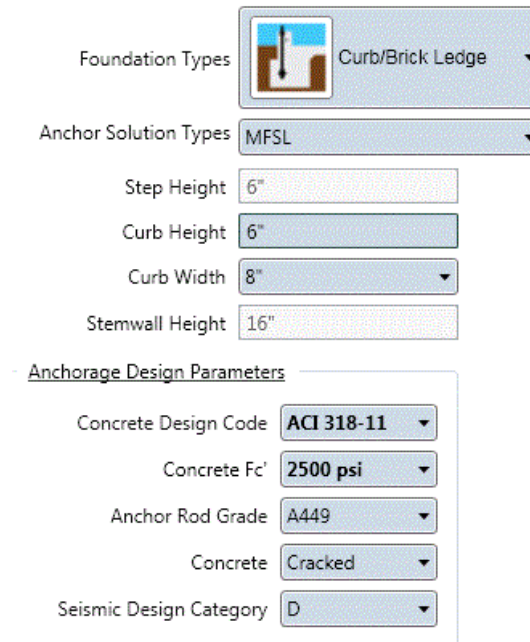
Concrete Strength (f_c'): The Designer can choose 2500 psi, 3000 psi, 4000 psi or 4500 psi as the concrete compressive strength. The concrete compressive strength is used for determining the anchorage tension and shear capacities.


Anchor Rod Grade: Two anchor rod grades are available to the Designer, either F1554 Gr. 36 or A449. Anchorage solution using A449 include "HS" in their designation to denote high strength.

Concrete (service condition): The Designer can choose either Cracked or Uncracked as the service concrete condition. See ACI 318 appendix D/Chapter 17 for the different reductions factors associated with Cracked or Uncracked concrete.

Seismic Design Category: The Designer can select the Seismic Design Category based on the specific project. This is used to determine additional requirements for Seismic Design.

For ***Curb/Brick Ledge Foundation Types***, two solutions are available for the Designer. They are ***MFSL*** and ***MFAB with Ties***. Input fields for these solutions are similar to the Slab-on-Grade solutions, except ***Curb Height*** is required instead of ***Step Height***. One additional input is the ***Curb Width***. Under this drop down box, the Designer can choose either an 8-in, 10-in or 12-in wide concrete curb.



Foundation Types  Curb/Brick Ledge ▾

Anchor Solution Types MFSL ▾

Step Height 6"

Curb Height 6"

Curb Width 8" ▾

Stemwall Height 16"

Anchorage Design Parameters

Concrete Design Code ACI 318-11 ▾

Concrete Fc' 2500 psi ▾

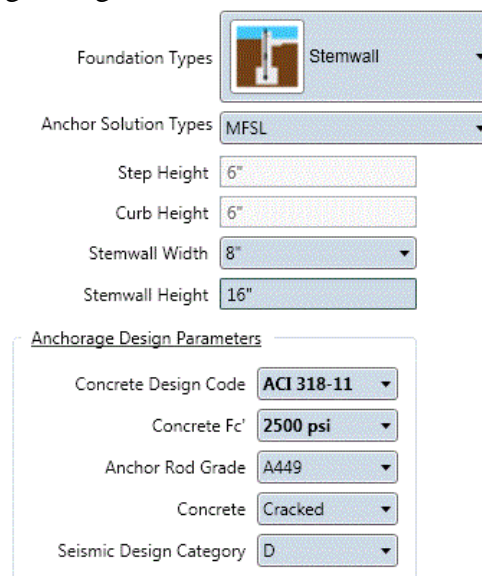
Anchor Rod Grade A449 ▾


Concrete Cracked ▾

Seismic Design Category D ▾

If small end distances are required/desired, the ***MFAB with Ties*** is the best option.

For ***Stemwall Foundation Types***, only the ***MFSL*** solution is available to the Designer. This solution requires the Designer design wall reinforcing to transfer forces from the base of the column down to the foundation. Capacity of the anchor rods, shear lug, hairpin, ties and concrete are included in the solution PDF output. Anchorage force demands are also summarized in the solution so the Designer can perform their own anchorage design.



Foundation Types  Stemwall ▾

Anchor Solution Types MFSL ▾

Step Height 6"

Curb Height 6"

Stemwall Width 8" ▾

Stemwall Height 16"

Anchorage Design Parameters

Concrete Design Code ACI 318-11 ▾

Concrete Fc' 2500 psi ▾

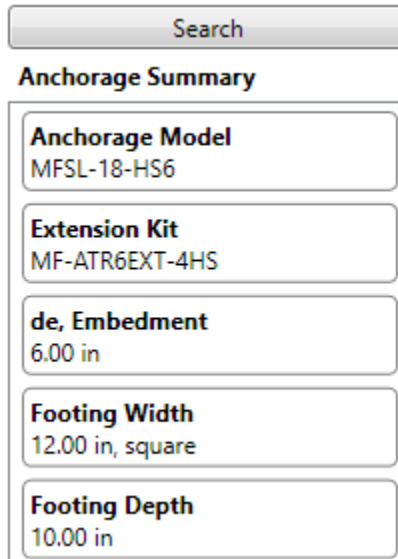
Anchor Rod Grade A449 ▾

Concrete Cracked ▾

Seismic Design Category D ▾

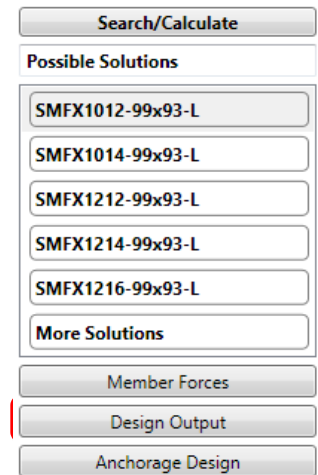
Extension Kits:

When the standard anchorage solution lengths are not long enough, the Strong Frame Selector Software will output a recommended extension solution. Standard extension lengths are 3’-0” long. If extension lengths are longer than 3’-0”, then the Selector software will output the total length of extension rod required.

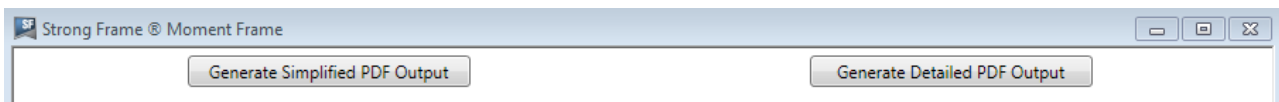


13. FRAME PDF OUTPUT

Once the list of *Possible Solutions* appears after the frame analysis/design, the Designer has the option to generate a *Design Output* in PDF format. This PDF file contains a summary of the design input parameters entered by the Designer as well as the loading information. Demand capacity ratios are presented for the frame design followed by the governing design forces. Frame design information is also summarized with all the relevant frame geometry dimensions. Note that the final W1 and W2 dimensions depend on the foundation anchorage solution. The Designer must refer to the Anchorage output for the final W1 and W2 dimensions where additional end distances might be required for anchorage design.



There are two options for PDF output: “Simplified” or “Detailed”. When Simplified output [Default] is selected, the program will only output the basic information. If a full detailed design package is desired, then close the “Simplified” output and click on “Generate Detailed PDF Output”.



For the detailed output, the PDF file will include the Design Summary described above followed by member properties, frame analysis geometries, member nodal displacements, beam forces, column forces, beam member design, column member design from all the LRFD design load combinations as well as column reaction forces for the 7 basic load cases and governing ASD and LRFD load combinations. Summarized ASD foundation forces for both left and right column can be used by the Designer in their foundation design.

Foundation Forces (ASD):

Left Column (Node 1) Reactions:

Load Cases	Shear (kips)	Axial (kips)
D	0.01	0.37
L	0.00	0.00
Lr	0.00	0.00
S	0.00	0.00
R	0.00	0.00
W	0.00	0.00
0.7E	-2.50	-3.80

Load Combination	Max Shear (kips)	Axial with Max Shear (kips)
19	2.52	4.23

Load Combination	Min Shear (kips)	Axial with Min Shear (kips)
34	-2.50	-3.63

Load Combination	Shear with Max Tension (kips)	Max Tension (kips)
34	-2.50	-3.63

Load Combination	Shear with Max Compression (kips)	Max Compression (kips)
19	2.52	4.23

Right Column (Node 4) Reactions:

Load Cases	Shear (kips)	Axial (kips)
D	-0.01	0.37
L	0.00	0.00
Lr	0.00	0.00
S	0.00	0.00
R	0.00	0.00
W	0.00	0.00
0.7E	-2.50	3.80

Load Combination	Max Shear (kips)	Axial with Max Shear (kips)
35	2.49	-3.63

Load Combination	Min Shear (kips)	Axial with Min Shear (kips)
18	-2.51	4.23

Load Combination	Shear with Max Tension (kips)	Max Tension (kips)
35	2.49	-3.63

Load Combination	Shear with Max Compression (kips)	Max Compression (kips)
18	2.51	4.23

Foundation Forces (LRFD), Load Combination 36-60 :

Left Column (Node 1) Reactions:

Load Combination	Max Shear (kips)	Axial with Max Shear (kips)
56	3.60	5.96

Load Combination	Min Shear (kips)	Axial with Min Shear (kips)
59	-3.57	-5.17

Load Combination	Shear with Max Tension (kips)	Max Tension (kips)
59	-3.57	-5.17

Load Combination	Shear with Max Compression (kips)	Max Compression (kips)
56	3.60	5.96

Right Column (Node 4) Reactions:

Load Combination	Max Shear (kips)	Axial with Max Shear (kips)
60	3.56	-5.17

Load Combination	Min Shear (kips)	Axial with Min Shear (kips)
55	-3.59	5.96

Load Combination	Shear with Max Tension (kips)	Max Tension (kips)
60	3.56	-5.17

Load Combination	Shear with Max Compression (kips)	Max Compression (kips)
55	-3.59	5.96

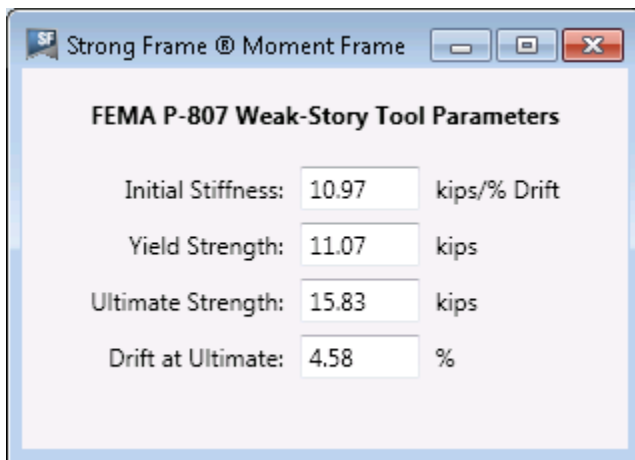
14. FEMA P-807 OUTPUT

Once all geometry has been entered and **Search** is pushed to perform the analysis and design. An extra button **FEMA P807 Parameter** will appear under the **Anchorage Design** button. When user selects the frame, four parameters used by the FEMA P-807 Weak-Story Tool will be presented in a separate window.

Please note for the four parameters presented no gravity load other than the frame weight has been considered. If the frame also resists gravity loads, please fill out the worksheet (link below) and e-mail or contact Simpson Strong-Tie for assistance.

<https://www.strongtie.com/products/lateral-systems/strong-frame-moment-frames/special-moment/special-custom-frame-worksheets?source=sfnay>

Once we receive your worksheet, we'll generate pushover curves for your specific frame with gravity loads included.



FEMA P-807 Weak-Story Tool Parameters		
Initial Stiffness:	10.97	kips/% Drift
Yield Strength:	11.07	kips
Ultimate Strength:	15.83	kips
Drift at Ultimate:	4.58	%



Search

Possible Solutions

- SMFX1012-151x97-X1.25
- SMFX1012-151x97-X1.50
- SMFX1012-151x97-X1.75
- SMFX1012-151x97-X2.00
- SMFX1212-151x97-X1.25

More Solutions

Member Forces

Design Output

Anchorage Design

FEMA P807 Parameters

15. ANCHORAGE PDF OUTPUT

Similar to the Frame PDF output, anchorage design output can be generated by clicking on the **Design Output** button in the Anchorage Design tab. The anchorage design PDF file summarizes the anchorage model, footing width and footing depth required for anchorage as well as end distance required from the centerline of the nearest anchor bolt to the edge/end of concrete.

Anchorage Design For:

Job Name:
 Date: 7/17/2020
 Strong Frame® Selector 4.8.0.0

Engineer:
 Frame ID:
 Frame Model: SMFX1012-99x93-L

Foundation Type: Slab-on-Grade

Anchorage Model: MFSL-18-HS6
 Anchorage Grade: A449, Diameter: 0.750"
 Extension Kit: Not Required
 Step Height: 6"
 Min. Edge Distance: 2.125" , Embedment, d_e : 7.00"

Anchorage Design Details: MFSL

Anchorage SQ Footing Width, W : 22.00"
 Anchorage Footing Depth, D : 11.00"
 Concrete Code: ACI 318-14 Concrete f_c' : 2500 psi
 Concrete: Cracked SDC: D

Left Column:

End Distance: 5.250" (Additional studs are not required)

Right Column:

End Distance: 5.250" (Additional studs are not required)

Final Frame W1 and W2 Dimensions (Including Additional End Distance where required for Anchorages):

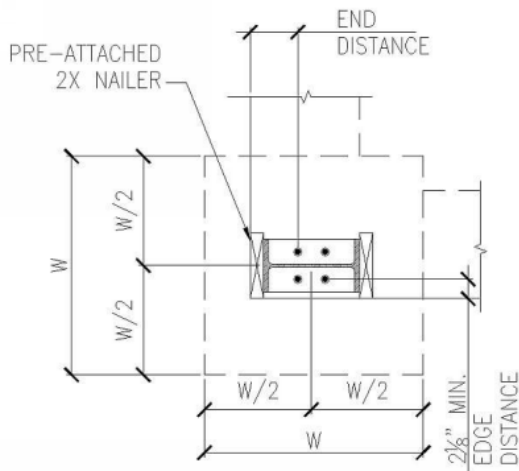
W1: 8'-2"

W1 Final: 8'-2"

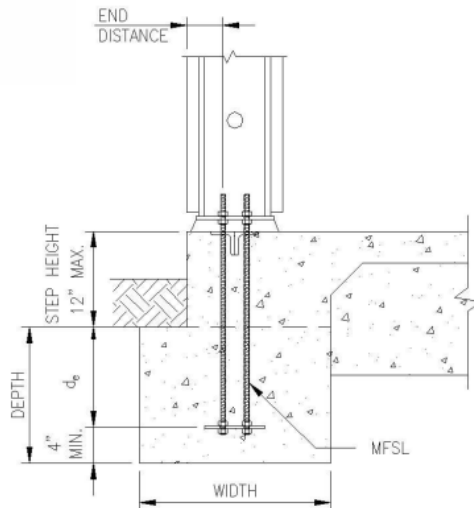
W2: 10'-5"

W2 Final: 10'-5"

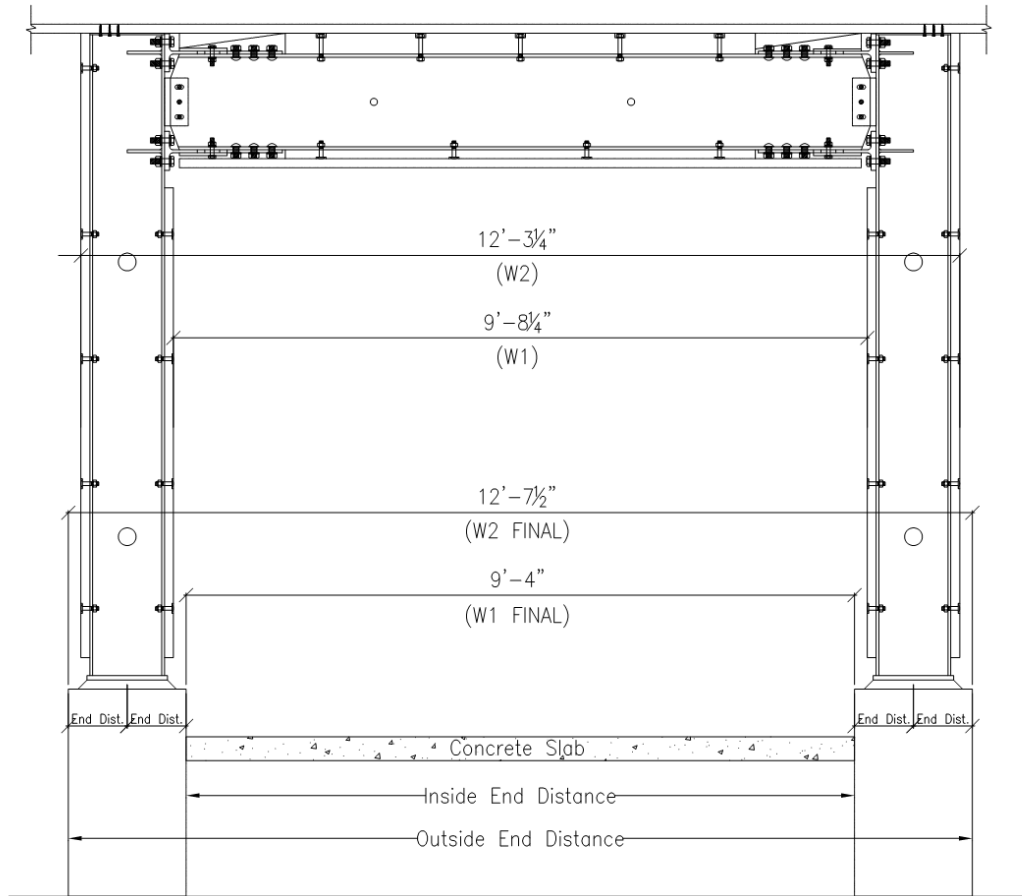
Plan View:



Section View:



Please note the W1, W1 Final, W2 and W2 Final dimensions. The W1 Final and W2 Final dimensions (see graphic on next page) included the additional end distance required for shear anchorage capacity.



W1 Final and W2 Final Dimensions

16. DRAW FRAME

In addition to PDF outputs, Users can also generate an AutoCAD elevation. The elevation is drawn to scale so Users can simply insert the frame elevation into their drawing. Please send you Strong Frame input file to strongframe@strongtie.com for assistance in generating the CAD elevation.

17. ADDITIONAL HELP OR QUESTIONS

If information beyond what is provided in this document is needed, or frames that are not covered by the Strong Frame Selector Software (i.e. frame design using other members form the AISC Manual) contact Simpson Strong-Tie at (800) 999-5099 or strongframe@strongtie.com