Revision 3 Draft 4/21/2004

SUBSTANTIATING DATA FOR CRIPPLE WALL and SILL BOLTING

SEISMIC RETROFIT of ONE & TWO FAMILY DWELLINGS

The following calculations determine the seismic load demand to cripple walls and foundation sill plates for conditions commonly found in existing wood-framed residential buildings located in the San Francisco Bay Area. These demands are the basis for the cripple wall bracing and foundation sill anchorage requirements contained in the East Bay and Peninsula Chapter of ICC Seismic Retrofit Provisions. Certain assumptions are made in the calculation of these demand loads. They include:

1. Wood structural panels are used to brace the cripple walls, and the buildings are limited to a maximum of two stories. Therefore, the R factor used is 5.5. (2001 CBC Table 16-N)

2. The Redundancy Factor rho (ρ) = 1.0, because the cripple wall bracing lengths along each exterior wall in each axis are equal, or are nearly equal. (2001 CBC Sec.1630.1.1)

3. The Near Source Factor (Na) = 1.3, to account for buildings that are located between 4 and 10 kilometers of a Type A fault. This value is less than the maximum Na = 1.5 specified for locations 2 kilometer or less from a Type A fault, but is greater than the Na = 1.1 value permitted for buildings that are, 1) located on soil classified not greater than type SD, 2) are not defined by the code as being irregular, and 3) have rho = 1.0. (CBC Sec.1629.4.2 and Tables 16-L, 16-M, and 16-S)

4. New resisting elements are located at the building perimeter only, therefore, one-half of the total seismic load in each axis is resisted by each of two parallel perimeter wall lines.

5. No reduction from current code force levels is being taken, as is permitted by Section 301.3 of the Guidelines for Seismic Retrofit of Existing Buildings. (ICBO, 2001)

Certain assumptions are made with respect to the capacities of the new materials added to strengthen the buildings. They include:

1. Allowable stresses are increased by a factor of 1.33 for short term seismic loads, or are based on tabular values already adjusted for seismic loading (2001 CBC Table 23-II-I-1).

2. **For determining bolt capacities, foundation sill plates are considered to be tight grain Redwood. Based on observations, and some limited testing, the dowel bearing strength of this species is considered to be equivalent to Douglas Fir having a specific gravity of 0.50**. Bolt capacity is determined using one-half of the allowable double shear capacity for a sill plate twice the thickness of the actual 2x sill plate (2001 CBC Sec 2316.2 Item 24, amending 1991 NDS Sec. 8.3), and taking a 1.33 increase for duration of load. The resulting sill bolt capacities are **½” diameter = 820 pounds; 5/8” diameter = 1,170 pounds**.

3. Other wood members transmitting loads are assumed to be Douglas Fir and nails are assumed to be common wire diameter.

The buildings used to develop the seismic forces assume a rectangular building footprint where:

- For one-story buildings the footprint sizes are: 1) 30 feet by 40 feet (1,200 square feet)

2) 30 feet by 50 feet (1,500 square feet)
3) 36 feet by 56 feet (2,016 square feet)

- For two-story buildings the footprint sizes are: 1) 30 feet by 30 feet (1,800 square feet)
2) 30 feet by 40 feet (2,400 square feet)
3) 30 feet by 50 feet (3,000 square feet)

The following assumptions have also been made regarding the construction of the houses:

1. The floor to ceiling wall height is 8 feet.

2. The roof slope is 4:12, with gable ends occurring on the short (transverse) side, and two foot eave overhangs on all sides.

3. Four Cases of exterior and interior wall finish and roofing are considered.

A) Lightweight roofing (5 psf) of wood shake, wood shingle, or composition shingle, exterior wood sheathing or board finish, and ½" gypsum wallboard interior finish.

B) Lightweight roofing, exterior wood sheathing or board finish, and gypsum lath and plaster interior finish. This is considered the definition of "Light Construction"

C) Lightweight roofing, cement plaster (stucco) exterior finish, and gypsum lath and plaster interior finish.

D) Heavy roofing (11 psf) of concrete or clay tile, cement plaster (stucco) exterior finish, and gypsum lath and plaster interior finish. This is considered the definition of "Heavy Construction. Certain types of clay tile using mortar setting for the tile will exceed this unit weight and therefore should be excluded from using these prescriptive methods.

4. Interior partitions are framed with 2x4 studs at 16" o.c. with **either ½" gypsum wallboard (for 3A) or 3/8" gypsum lath and gypsum plaster (for 3B, 3C or 3D)** on each side. The lath and plaster is a heavier wall finish (4.5 psf) than standard ½" thick gypsum wallboard (2.2 psf). Ceilings below attics and below a second floor are assumed to be **either ½" gypsum wallboard (for 3A) or 3/8" gypsum lath and gypsum plaster (for 3B, 3C or 3D).**

5. The assumed layout of interior walls in a single story building is two in the long (longitudinal) direction and three cross walls in the short (transverse) direction. The assumed layout of interior partitions in a two-story building are two in the long direction and three in the short direction at the upper floor level, and one in the long direction and two in the short direction at the first floor level.

6. Exterior walls are framed with 2x4 studs at 16" o.c. **with either wood board or panel siding (for 3A or 3B), or cement plaster (stucco) exterior wall finishes (for 3C or 3D)**. The interior finish of exterior walls is assumed to be **either ½" gypsum wallboard (for 3A) or 3/8" gypsum lath and gypsum plaster (for 3B, 3C or 3D).** Attic gable end walls are assumed to be unfinished on the interior face.

7. The site is assumed to have no slope along an exterior wall line greater than 1:10 and cripple walls are limited to 4 feet in height at any point.

TABLE 3A - SUMMARY OF UNIT LOADS

The basic unit dead loads used to calculate the seismic loading demand for **Case 3A** are:

Roof/ceiling system: Light roofing and gypsum board ceiling finish. Light roofing is defined as wood shakes over spaced sheathing or wood shingles or composition shingles over solid sheathing. Vertical load adjustment for 4:12 roof slope = 1.054

Light roofing system:	5.0 psf
Rafters & ceiling framing:	2.5 psf
Gypsum wallboard:	2.2 psf
Miscellaneous:	0.8 psf
Light roof Total: 10.5 x 1.054 =	**11.0 psf**

Second floor/ceiling system: Gypsum wallboard is assumed to be the interior ceiling finish.

Carpet and fiber pad or finished wood flooring:	1.5 psf
7/8" thick wood subflooring:	2.5 psf
2 x 10 joists at 16" spacing:	2.5 psf
Gypsum wallboard:	2.2 psf
Second floor typical Total:	**8.7 psf (9.0 psf used)**

First floor system:

Carpet and fiber pad or finished wood flooring:	1.5 psf
7/8" thick wood subflooring:	2.5 psf
2 x 10 joists at 16" spacing:	2.5 psf
First floor Total:	**6.5 psf (7.0 psf used)**

Exterior walls: Wood siding or wood boards exterior finish and gypsum wallboard interior finish

7/8" wood board siding over building paper:	2.5 psf
2 x 4 studs at 16" spacing:	2.0 psf
Gypsum wallboard:	2.2 psf
Miscellaneous (insulation, piping, ducts, etc.):	1.0 psf
Exterior wall Total:	**7.7 psf[1] (8 psf used)**

[1] Attic gable wall weights are based on exterior finish and framing unit loads only.
Cripple wall weights are based on exterior finish and framing plus interior ½" plywood.

Interior partitions: Gypsum wallboard interior finish

2 x 4 studs at 16" spacing:	2.0 psf
Gypsum wallboard (2 sides):	4.4 psf
Miscellaneous:	1.0 psf
Interior partitions Total:	**7.4 psf (8 psf used)**

TABLE 3B - SUMMARY OF UNIT LOADS

The basic unit dead loads used to calculate the seismic loading demand for **Case 3B** are:

Roof/ceiling system: Light roofing and gypsum lath and plaster ceiling finish. Light roofing is defined as wood shakes over spaced sheathing or wood shingles or composition shingles over solid sheathing. Vertical load adjustment for 4:12 roof slope = 1.054

Light roofing system:	5.0 psf
Rafters & ceiling framing:	2.5 psf
Gypsum lath and plaster:	4.5 psf
Miscellaneous:	0.8 psf
Light roof Total: 12.8 x 1.054 =	**13.5 psf (14 psf used)**

Second floor/ceiling system: Gypsum lath and plaster interior ceiling finish.

Carpet and fiber pad or finished wood flooring:	1.5 psf
7/8" thick wood subflooring:	2.5 psf
2 x 10 joists at 16" spacing:	2.5 psf
Gypsum lath and plaster:	4.5 psf
Second floor typical Total:	**11.0 psf**

First floor system:

Carpet and fiber pad or finished wood flooring:	1.5 psf
7/8" thick wood subflooring:	2.5 psf
2 x 10 joists at 16" spacing:	2.5 psf
First floor Total:	**6.5 psf (7.0 psf used)**

Exterior walls: Wood siding or wood boards exterior finish and gypsum lath and plaster interior finish

7/8" wood board siding over building paper:	2.5 psf
2 x 4 studs at 16" spacing:	2.0 psf
Gypsum lath and plaster:	4.5 psf
Miscellaneous (insulation, piping, ducts, etc.):	1.0 psf
Exterior wall Total:	**10.0 psf**[1]

[1] Attic gable wall weights are based on exterior finish and framing unit loads only.
Cripple wall weights are based on exterior finish and framing plus interior ½" plywood.

Interior partitions: Gypsum lath and plaster is the interior finish

2 x 4 studs at 16" spacing:	2.0 psf
Gypsum lath and plaster (2 sides):	9.0 psf
Miscellaneous:	1.0 psf
Interior partitions Total:	**12.0 psf**

TABLE 3C - SUMMARY OF UNIT LOADS

The basic unit dead loads used to calculate the seismic loading demand for **Case 3C** are:

Roof/ceiling system: Light roofing and gypsum lath and plaster ceiling finish. Light roofing is defined as wood shakes over spaced sheathing or wood shingles or composition shingles over solid sheathing. Vertical load adjustment for 4:12 roof slope = 1.054

Light roofing system:	5.0 psf
Rafters & ceiling framing:	2.5 psf
Gypsum lath and plaster:	4.5 psf
Miscellaneous:	0.8 psf
Light roof Total: 12.8 x 1.054 =	**13.5 psf (14 psf used)**

Second floor/ceiling system: Gypsum lath and plaster interior ceiling finish.

Carpet and fiber pad or finished wood flooring:	1.5 psf
7/8" thick wood subflooring:	2.5 psf
2 x 10 joists at 16" spacing:	2.5 psf
Gypsum lath and plaster:	4.5 psf
Second floor typical Total:	**11.0 psf**

First floor system:

Carpet and fiber pad or finished wood flooring:	1.5 psf
7/8" thick wood subflooring:	2.5 psf
2 x 10 joists at 16" spacing:	2.5 psf
First floor Total:	**6.5 psf** (**7.0 psf used**)

Exterior walls: Cement plaster exterior finish and gypsum lath and plaster interior finish

1" exterior cement plaster (stucco):	10.0 psf
2 x 4 studs at 16" spacing:	2.0 psf
Gypsum lath and plaster:	4.5 psf
Miscellaneous (insulation, piping, ducts, etc.):	0.5 psf
Exterior wall Total:	**17.0 psf**[1]

[1] Attic gable wall weights are based on exterior finish and framing unit loads only.
Cripple wall weights are based on exterior finish and framing plus interior ½" plywood.

Interior partitions: Gypsum lath and plaster is the interior finish

2 x 4 studs at 16" spacing:	2.0 psf
Gypsum lath and plaster (2 sides):	9.0 psf
Miscellaneous:	1.0 psf
Interior partitions Total:	**12.0 psf**

TABLE 3D - SUMMARY OF UNIT LOADS

The basic unit dead loads used to calculate the seismic loading demand for **Case 3D** are:

Roof/ceiling system: Heavy roofing and gypsum lath and plaster ceiling finish. Heavy roofing is defined as concrete tile or clay tile at 11 psf maximum over solid sheathing. Vertical load adjustment for 4:12 roof slope = 1.054 **NOTE: Clay tile roofing set in mortar will exceed this limit and should be excluded from using this prescriptive method**

Heavy roofing system:	11.0 psf
Rafters & ceiling framing:	2.5 psf
Gypsum lath and plaster:	4.5 psf
Miscellaneous:	0.8 psf
Heavy roof Total: 18.8 x 1.054 =	**19.8 psf (20 psf used)**

Second floor/ceiling system: Gypsum lath and plaster interior ceiling finish.

Carpet and fiber pad or finished wood flooring:	1.5 psf
7/8" thick wood subflooring:	2.5 psf
2 x 10 joists at 16" spacing:	2.5 psf
Gypsum lath and plaster:	4.5 psf
Second floor typical Total:	**11.0 psf**

First floor system:

Carpet and fiber pad or finished wood flooring:	1.5 psf
7/8" thick wood subflooring:	2.5 psf
2 x 10 joists at 16" spacing:	2.5 psf
First floor Total:	**6.5 psf (7.0 psf used)**

Exterior walls: Cement plaster exterior finish and gypsum lath and plaster interior finish

1" cement plaster (stucco):	10.0 psf
2 x 4 studs at 16" spacing:	2.0 psf
Gypsum lath and plaster:	4.5 psf
Miscellaneous (insulation, piping, ducts, etc.):	0.5 psf
Exterior wall Total:	**17.0 psf**[1]

[1] Attic gable wall weights are based on exterior finish and framing unit loads only.
Cripple wall weights are based on exterior finish and framing plus interior ½" plywood.

Interior partitions: Gypsum lath and plaster is the interior finish

2 x 4 studs at 16" spacing:	2.0 psf
Gypsum lath and plaster (2 sides):	9.0 psf
Miscellaneous:	1.0 psf
Interior partitions Total:	**12.0 psf**

Case 3A One Story Demand / Capacity Calculations for 30' x 50' (1,500 Sq. Ft.)

Assume SD soil with Ca = 0.44; Na = 1.3; I = 1.00; and R = 5.5; Conversion to ASD force level: 1 / 1.4
Seismic V = 0.186 W (2001 CBC Equation 30-5)

Dead loads (W) tributary to cripple wall level for 1,500 square feet total floor area:

Roof/Ceiling: 11.0 psf (34' x 54') = 20.196 kips

First floor: 7 psf (30' x 50') = 10.50 kips

Exterior Walls:

1st Story walls: 8 psf (8') (30' x 2 + 50' x 2) = 10.24 kips
Gable end walls: 5 psf (5' x 30') 2 / 2 = 0.75 kips
Cripple walls: 6 psf (2') (30' x 2 + 50' x 2) 1.92 kips
12.91 kips

Interior walls: 8 psf (8') (29' x 3 + 49' x 2) = 11.84 kips

Sum W = 20.2 + 10.5 + 12.9 + 11.84 = 55.45 kips
Total V = (0.186) W = 10.313 kips
V to each cripple wall line = 10.313 / 2 = **5.16 kips**

Sill bolts needed in 2x sill along each exterior wall line:

5,156 pounds / 820 pounds/bolt = **7 – 1/2”bolts, or**
5,156 pounds / 1170 pounds/bolt = **5 - 5/8” bolts, or**
5,156 pounds / 1340 pounds per UFP10 = **4 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:

V to each wall line / unit capacity = lineal feet of shear wall based on 16” o.c. stud spacing
5,156 lbs / 380 plf = **14’-8”**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 5,156 pounds / 14.67 feet x 4.0 feet = 1,406 pounds
$_W$ dead load to panel = 11 psf (1’) + 7 psf (1.33’/2) + 5 psf (2.67’/2) + 8 psf (8’) + 6 psf (2’) = 98.3 plf
OTM = 1,406 pounds x 2 foot wall height = 2,813 lb-ft
RTM = 0.9 x 98.3 plf (6 foot tributary length)(4 foot /2 moment arm) = 1,062 lb-ft
OTM – RTM / panel length = (2,813 – 1,062) / 4 feet = **438 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4’-0” braced panel end studs

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 5,156 pounds / 14.67 feet x 4.0 feet = 1,406 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 8 psf (8’) + 6 psf (2’) = 186.5 plf
OTM = 1,406 pounds x 2 foot wall height = 2,813 lb-ft
RTM = 0.9 x 186.5 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,014 lb-ft
OTM – RTM / panel length = (2,813 – 2,014) / 4 feet = **200 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4’-0” braced panel end studs

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 5,156 pounds / 14.67 feet x 8.0 feet =2,812 pounds
$_W$ dead load to panel = 11 psf (1’) + 7 psf (1.33’/2) + 5psf (2.67’/2) + 8 psf (8’) + 6 psf (2’) = 98.3 plf
OTM = 2,812 pounds x 2 foot wall height = 5,625 lb-ft
RTM = 0.9 x 98.3 plf (10 foot tributary length)(8 foot /2 moment arm) = 3,439 lb-ft
OTM – RTM / panel length = (5,625 – 3,539) / 8 feet = **261 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8’-0” panel end studs

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along longitudinal wall:

V to 8 foot long panel = 5,156 pounds / 14.67 feet x 8.0 feet = 2,812 pounds

$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 8 psf (8’) + 6 psf (2’) = 186.5 plf
OTM = 2,812 pounds x 2 foot wall height = 5,625 lb-ft
RTM = 0.9 x 186.5 plf (10 foot tributary length)(8 foot /2 moment arm) = 6,714 lb-ft
OTM – RTM / panel length = (5,625 – 6,714) / 8 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 14’-8” foot continuous panel length along gable end wall:

V to 14’-8” long panel = 5,156 pounds
$_W$ dead load to panel = 11 psf (1’) + 7 psf (1.33’/2) + 5psf (2.67’/2) + 8 psf (8’) + 6 psf (2’) = 98.3 plf
OTM = 5,156 pounds x 2 foot wall height = 10,312 lb-ft
RTM = 0.9 x 98.3 plf (16’-8” tributary length)(14.67 feet /2 moment arm) = 10,817 lb-ft
OTM – RTM / panel length = (10,312 – 10,817) / 14.67 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 5,156 pounds / 14.67 feet x 8.0 feet = 2,813 pounds
$_W$ dead load to panel = 11 psf (1’) + 7 psf (1.33’/2) + 5psf (2.67’/2) + 8 psf (8’) + 6 psf (4’) = 110.3 plf
OTM = 2,813 pounds x 4 foot wall height = 11,250 lb-ft
RTM = 0.9 x 110.3 plf (10 foot tributary length)(8 foot) /2 moment arm) = 3,972 lb-ft
OTM – RTM / panel length = (11,250 – 3,972) / 8 feet = **910 pounds uplift**
Locate <u>two</u> new sill bolts with plate washer within 6 inches of each 8’-0” panel end studs (one each side)

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 5,156 pounds / 14.67 feet x 8.0 feet = 2,813 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 8 psf (8’) + 6 psf (4’) = 198.5 plf
OTM = 2,813 pounds x 4 foot wall height = 11,250 lb-ft
RTM = 0.9 x 198.5 plf (10 foot tributary length)(8 foot) /2 moment arm) = 7,146 lb-ft
OTM – RTM / panel length = (11,250 – 7,146) / 8 feet = **513 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8’-0” panel end studs

Overturning of 4 foot high cripple wall with 12 foot minumum panel length along gable end wall

V to 12 foot long panel = 5,156 pounds / 14.67 feet x 12.0 feet = 4,218 pounds
$_W$ dead load to panel = 11 psf (1’) + 7 psf (1.33’/2) + 5psf (2.67’/2) + 8 psf (8’) + 6 psf (4’) = 110.3 plf
OTM = 4,218 pounds x 4 feet wall height = 16,874 lb-ft
RTM = 0.9 x 110.3 plf (14 feet tributary length)(12 feet) /2 moment arm) = 8,341 lb-ft
OTM – RTM / panel length = (16,874 – 8,341) / 12 feet = **711 pounds uplift**
Locate <u>two</u> new sill bolts with plate washer within 6 inches of each braced 12’-0” panel end studs (one each side)

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along longitudinal wall

V to 12 foot long panel = 5,156 pounds / 14.67 feet x 12.0 feet = 4,218 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 8 psf (8’) + 6 psf (4’) = 198.5 plf
OTM = 4,218 pounds x 4 feet wall height = 16,874 lb-ft
RTM = 0.9 x 198.5 plf (14 feet tributary length)(12 feet) /2 moment arm) = 15,007 lb-ft
OTM – RTM / panel length = (16,874 – 15,007) / 12 feet = **155 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 12’-0” braced panel end studs

Overturning of 4 foot high cripple wall with 14’-8” foot continuous panel length along gable end wall:

V to 14’-8” long panel = 5,156 pounds
$_W$ dead load to panel = 11 psf (1’) + 7 psf (1.33’/2) + 5psf (2.67’/2) + 8 psf (8’) + 6 psf (4’) = 110.3 plf
OTM = 5,156 pounds x 4 foot wall height = 20,624 lb-ft

RTM = 0.9 x 110.3 plf (16’-8” tributary length)(14.67 feet /2 moment arm) = 12,137 lb-ft
OTM – RTM / panel length = (20,624 – 12,137) / 14.67 feet = **579 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of 14’-8” braced panel end studs

Overturning of 4 foot high cripple wall with 14’-8” foot continuous panel length along longitudinal wall:

V to 14’-8” long panel = 5,156 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 8 psf (8’) + 6 psf (4’) = 198.5 plf
OTM = 5,156 pounds x 4 foot wall height = 20,624 lb-ft
RTM = 0.9 x 198.5 plf (16’-8” tributary length)(14.67 feet /2 moment arm) = 21,835 lb-ft
OTM – RTM / panel length = (20,624 – 21,835) / 14.67 feet = **NO uplift**

Shear Transfer Along Each Wall Line
Connection between floor and top of cripple wall or foundation sill plate

V = 5,156 pounds / 450 pounds per connection = **12 L70 or A35, or**
V = 5,156 pounds / 585 pounds per connection = **9 L90 or H10R**

Transverse Wall Line = 30 feet = 172 plf
Longitudinal Wall Line = 50 feet = 103 plf

Case 3A One Story Demand / Capacity Calculations for 30’ x 40’ (1,200 Sq. Ft.)

Dead loads (W) tributary to cripple wall level:

Roof/Ceiling: 11 psf (34' x 44') = 16.456 kips

First floor: 7 psf (30 x 40') = 8.4 kips

Exterior Walls:

1st Story wall:	8 psf (8') (30' x 2 + 40' x 2) =	8.96 kips
Gable end walls:	5 psf (5' x 30') 2 / 2 =	0.75 kips
Cripple walls	6 psf (2') (30' x 2 + 40' x 2) =	1.68 kips
		11.39 kips

Interior walls: 8 psf (8') (30' x 3 + 40' x 2) = 10.88 kips

Sum W = 16.456 + 8.4 + 11.39 + 10.88 = 47.126 kips
Total V = (0.186) W = 8.765 kips

V to each cripple wall line = 8.765 / 2 = **4.38 kips**

Sill bolts needed in 2x sill along each exterior wall line:

4,383 pounds / 820 pounds/bolt = **6 – 1/2”bolts, or**
4,383 pounds/ 1,170 pounds/bolt = **4 - 5/8” bolts, or**
4,383 pounds/ 1,340 pounds/UFP10 = **4 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:

V to each wall line / unit capacity = lineal feet of shear wall based on 16” o.c. stud spacing
4,383 lbs / 380 plf = **12’-0”**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 4,383 pounds / 12 feet x 4.0 feet = 1,461 pounds
$_W$ dead load to panel = 11 psf (1’) + 7 psf (1.33’/2) = 5psf (2.67’/2) + 8 psf (8’) + 6 psf (2’) = 98.3 plf
OTM = 1,461 pounds x 2 foot wall height = 2,922 lb-ft
RTM = 0.9 x 98.3 plf (6 foot tributary length)(4 foot /2 moment arm) = 1,062 lb-ft
OTM – RTM / panel length = (2,922 – 1,062) / 4 feet = **465 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4’-0” braced panel

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 4,383 pounds / 12 feet x 4.0 feet = 1,461 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 8 psf (8’) + 6 psf (2’) = 186.5 plf
OTM = 1,461 pounds x 2 foot wall height = 2,922 lb-ft
RTM = 0.9 x 186.5 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,014 lb-ft
OTM – RTM / panel length = (2,922 – 2,014) / 4 feet = **227 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4’-0” braced panel

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 4,383 pounds / 12 feet x 8.0 feet = 2,922 pounds
$_W$ dead load to panel = 11 psf (1’) + 7 psf (1.33’/2) = 5psf (2.67’/2) + 8 psf (8’) + 6 psf (2’) = 98.3 plf
OTM = 2,922 pounds x 2 foot wall height = 5,844 lb-ft
RTM = 0.9 x 98.3 plf (10 foot tributary length)(8 foot /2 moment arm) = 3,540 lb-ft
OTM – RTM / panel length = (5,844 – 3,540) / 8 feet = **288 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 8’-0” braced panel

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along longitudinal wall:

V to 8 foot long panel = 4,383 pounds / 12 feet x 8.0 feet = 2,922 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 8 psf (8’) + 6 psf (2’) = 186.5 plf
OTM = 2,922 pounds x 2 foot wall height = 5,844 lb-ft
RTM = 0.9 x 186.5 plf (10 foot tributary length)(8 foot /2 moment arm) = 6,714 lb-ft
OTM – RTM / panel length = (5,844 – 6,714) / 8 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 12 foot continuous panel length along gable end wall:

V to 12 foot long panel = 4,383 pounds
$_W$ dead load to panel = 11 psf (1’) + 7 psf (1.33’/2) + 5psf (2.67’/2) + 8 psf (8’) + 6 psf (2’) = 98.3 plf
OTM = 4,383 pounds x 2 foot wall height = 8,766 lb-ft
RTM = 0.9 x 98.3 plf (14 foot tributary length)(12 feet /2 moment arm) = 7,434 lb-ft
OTM – RTM / panel length = (8,766 – 7,434) / 12 feet = **111 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 12’-0” braced panel

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 4,383 pounds / 12 feet x 8.0 feet = 2,922 pounds
$_W$ dead load to panel = 11 psf (1’) + 7 psf (1.33’/2) + 5psf (2.67’/2) + 8 psf (8’) + 6 psf (4’) = 110.3 plf
OTM = 2,922 pounds x 4 foot wall height = 11,688 lb-ft
RTM = 0.9 x 110.3 plf (10 foot tributary length)(8 foot) /2 moment arm) = 3,972 lb-ft
OTM – RTM / panel length = (11,688 – 3,972) / 8 feet = **965 pounds uplift**
Locate <u>two</u> new sill bolts with plate washer within 6 inches of each end stud of each 8’-0” panel (one each side)

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 4,383 pounds / 12 feet x 8.0 feet = 2,922 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 8 psf (8’) + 6 psf (4’) = 198.5 plf
OTM = 2,922 pounds x 4 foot wall height = 11,688 lb-ft
RTM = 0.9 x 198.5 plf (10 foot tributary length)(8 foot) /2 moment arm) = 7,146 lb-ft
OTM – RTM / panel length = (11,688 – 7,146) / 8 feet = **568 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each end stud at 8’-0” panels

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 4,383 pounds
$_W$ dead load to panel = 11 psf (1’) + 7 psf (1.33’/2) + 5psf (2.67’/2) + 8 psf (8’) + 6 psf (4’) = 110.3 plf
OTM = 4,383 pounds x 4 foot wall height = 17,532 lb-ft
RTM = 0.9 x 110.3 plf (14 foot tributary length)(12 foot) /2 moment arm) = 8,341 lb-ft
OTM – RTM / panel length = (17,532 – 8,341) / 12 feet = **766 pounds uplift**
Locate <u>two</u> new sill bolts with plate washer within 6 inches of each end stud of each 12’-0” panel (one each side)

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along longitudinal wall

V to 12 foot long panel = 4,383 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 8 psf (8’) + 6 psf (4’) = 198.5 plf
OTM = 4,383 pounds x 4 foot wall height = 17,532 lb-ft
RTM = 0.9 x 198.5 plf (14 foot tributary length)(12 foot) /2 moment arm) = 15,007 lb-ft
OTM – RTM / panel length = (17,532 – 15,007) / 12 feet = **210 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each end stud at 12’-0” panels

Shear Transfer Along Each Wall Line

Connection between floor and top of cripple wall or floor and foundation sill plate

V = 4,383 pounds / 450 pounds per connection = **10 L70 or A35; or**
V = 4,383 pounds / 585 pounds per connection = **8 L90 or H10R**

Transverse Wall Line = 30 feet = 146 plf
Longitudinal Wall Line = 40 feet = 110 plf

Case 3A One Story Demand / Capacity Calculations for 36’ x 56’ = 2,016 square feet

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Dead loads (W) tributary to cripple wall level:

Roof/Ceiling: 11 psf (40' x 60') = 26.40 kips

First floor: 7 psf (36 x 56') = 14.11 kips

Exterior Walls:

1st Story wall:	8 psf (8') (36' x 2 + 56' x 2) =	11.776 kips
Gable end walls:	5 psf (6' x 36') 2 / 2 =	1.08 kips
Cripple walls	6 psf (2') (36' x 2 + 56' x 2) =	2.21 kips
		15.064 kips

Interior wall: 8 psf (8') (35' x 3 + 55' x 2) = 13.76 kips

Sum W = 20.4 + 14.11 + 15.06 + 13.76 = 69.336 kips

Total V = (0.186) W = 12.90 kips

V to each cripple wall line = 12.90 / 2 = **6.45 kips**

Sill bolts needed in 2x sill along each exterior wall line:

6,448 pounds / 820 pounds/bolt = **8 – 1/2”bolts or**

6,448 pounds / 1170 pounds/bolt = **6 - 5/8” bolts, or**

6,448 pounds / 1340 pounds/bolt = **5 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:

V to each wall line / unit capacity = lineal feet of shear wall based on 16" o.c. stud spacing

6,448 lbs / 380 plf = **17'-4"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 6,448 pounds / 17.33 feet x 4.0 feet = 1,488 pounds
$_W$ dead load to panel = 11 psf (1') + 7 psf (1.33'/2) = 5 psf (2.67' /2) + 8 psf (8') + 6 psf (2') = 98.3 plf
OTM = 1,488 pounds x 2 foot wall height = 2,976 lb-ft
RTM = 0.9 x 98.3 plf (6 foot tributary length)(4 foot /2 moment arm) = 1,062 lb-ft
OTM – RTM / panel length = (2,976 – 1,062) / 4 feet = **478 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4'-0" braced panel

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 6,448 pounds / 17.33 feet x 4.0 feet = 1,488 pounds
$_W$ dead load to panel = 11 psf (9') + 7 psf (4') + 8 psf (8') + 6 psf (2') = 203 plf
OTM = 1,488 pounds x 2 foot wall height = 2,976 lb-ft
RTM = 0.9 x 203 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,192 lb-ft
OTM – RTM / panel length = (2,976 – 2,192) / 4 feet = **196 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4'-0" braced panel

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 6,448 pounds / 17.33 feet x 8.0 feet = 2,976 pounds
$_W$ dead load to panel = 11 psf (1') + 7 psf (1.33'/2) = 5psf (2.67'/2) + 8 psf (8') + 6 psf (2') = 98.3 plf
OTM = 2,976 pounds x 2 foot wall height = 5,952 lb-ft
RTM = 0.9 x 98.3 plf (10 foot tributary length)(8 foot /2 moment arm) = 3,540 lb-ft
OTM – RTM / panel length = (5,952 – 3,540) / 8 feet = **302 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 8'-0" braced panel

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along longitudinal wall:

V to 8 foot long panel = 6,448 pounds / 17.33 feet x 8.0 feet = 2,976 pounds
$_W$ dead load to panel = 11 psf (9) + 7 psf (4') + 8 psf (8') + 6 psf (2') = 203 plf
OTM = 2,976 pounds x 2 foot wall height = 5,952 lb-ft
RTM = 0.9 x 203 plf (10 foot tributary length)(8 foot /2 moment arm) = 7,308 lb-ft
OTM – RTM / panel length = (5,952 – 7,308) / 8 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 12 foot minimum panel length along gable end wall:

V to 12 foot long panel = 6,448 pounds /17.33 x 12.0 feet = 4,464 pounds
$_W$ dead load to panel = 11 psf (1') + 7 psf (1.33'/2) + 5 psf (2.67'/2) + 8 psf (8') + 6 psf (2') = 98.3 plf
OTM = 4,464 pounds x 2 foot wall height = 8,928 lb-ft
RTM = 0.9 x 98.3 plf (14 tributary length)(12 feet /2 moment arm) = 7,434 lb-ft
OTM – RTM / panel length = (8,928 – 7,434) / 12 feet = **125 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 12'-0" braced panel.

Overturning of 2 foot high cripple wall with 16 foot minimum panel length along gable end wall:

V to 16 foot long panel = 6,448 pounds / 17.33 x 16.0 feet = 5,952 pounds
$_W$ dead load to panel = 11 psf (1') + 7 psf (1.33'/2) + 5 psf (2.67'/2) + 8 psf (8') + 6 psf (2') = 98.3 plf
OTM = 5,952 pounds x 2 foot wall height = 11,904 lb-ft
RTM = 0.9 x 98.3 plf (18 feet tributary length)(16 feet /2 moment arm) = 12,744 lb-ft
OTM – RTM / panel length = (11,904 – 12,744) / 16 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 6,448 pounds / 17.33 feet x 8.0 feet = 2,976 pounds
$_W$ dead load to panel = 11 psf (1') + 7 psf (1.33'/2) + 5psf (2.67'/2) + 8 psf (8') + 6 psf (4') = 110.3 plf
OTM = 2,976 pounds x 4 foot wall height = 11,904 lb-ft
RTM = 0.9 x 110.3 plf (10 foot tributary length)(8 foot) /2 moment arm) = 3,972 lb-ft
OTM – RTM / panel length = (11,904 – 3,972) / 8 feet = **991 pounds uplift**
Locate <u>two</u> new sill bolts with plate washer within 6 inches of each end stud of each 8'-0" panel (one each side)

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 6,448 pounds / 17.33 feet x 8.0 feet = 2,976 pounds
$_W$ dead load to panel = 11 psf (9) + 7 psf (4') + 8 psf (8') + 6 psf (4') = 215 plf
OTM = 2,976 pounds x 4 foot wall height = 11,904 lb-ft
RTM = 0.9 x 215 plf (10 foot tributary length)(8 foot) /2 moment arm) = 7,740 lb-ft
OTM – RTM / panel length = (11,904 – 7,740) / 8 feet = **520 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each end stud at 8'-0" panels

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end walls

V to 12 foot long panel = 6,448 pounds / 17.33 feet x 12.0 feet = 4,464 pounds
$_W$ dead load to panel = 11 psf (1') + 7 psf (1.33'/2) + 5psf (2.67'/2) + 8 psf (8') + 6 psf (4') = 110.3 plf
OTM = 4,464 pounds x 4 foot wall height = 17,857 lb-ft
RTM = 0.9 x 110.3 plf (14 foot tributary length)(12 foot) /2 moment arm) = 8,341 lb-ft
OTM – RTM / panel length = (17,857 – 8,341) / 12 feet = **793 pounds uplift**
Locate <u>two</u> new sill bolts with plate washer within 6 inches of each end stud of each 12' panel (one each side)

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along longitudinal walls

V to 12 foot long panel = 6,448 pounds / 17.33 feet x 12.0 feet = 4,464 pounds
$_W$ dead load to panel = 11 psf (9) + 7 psf (4') + 8 psf (8') + 6 psf (4') = 215 plf
OTM = 4,464 pounds x 4 foot wall height = 17,857 lb-ft
RTM = 0.9 x 215 plf (14 foot tributary length)(12 foot) /2 moment arm) = 16,254 lb-ft
OTM – RTM / panel length = (17,857 – 16,254) / 12 feet = **133 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each end stud at 12'-0" panel

Overturning of 4 foot high cripple wall with 17'-4" foot continuous panel length along gable end walls

V to 17'-4" long panel = 6,448 pounds
$_W$ dead load to panel = 11 psf (1') + 7 psf (1.33'/2) + 5psf (2.67'/2) + 8 psf (8') + 6 psf (4') = 110.3 plf
OTM = 6,448 pounds x 4 foot wall height = 25,793 lb-ft
RTM = 0.9 x 110.3 plf (19'-4" tributary length)(17.33 feet) /2 moment arm) = 16,638 lb-ft
OTM – RTM / panel length = (25,793– 16,638) / 17.33 feet = **528 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each end stud of each 17'-4" panel

Overturning of 4 foot high cripple wall with 17'-4" foot continuous panel length along longitudinal wall

V to 17’-4” long panel = 6,448 pounds
$_W$ dead load to panel = 11 psf (9) + 7 psf (4’) + 8 psf (8’) + 6 psf (4’) = 215 plf
OTM = 6,448 pounds x 4 foot wall height = 25,793 lb-ft
RTM = 0.9 x 215 plf (19’-4” tributary length)(17.33 feet) /2 moment arm) = 32,422 lb-ft
OTM – RTM / panel length = (25,793 – 32,422) / 17.33 feet = **NO uplift**

Shear Transfer Along Each Wall Line

Connection between floor and top of cripple wall or floor and foundation sill plate

V = 6,448 pounds / 450 pounds per connection = **15 L70 or A35, or**
V = 6,448 pounds / 585 pounds per connection = **11 L90 or H10R**

Transverse Wall Line = 36 feet = 179 plf
Longitudinal Wall Line = 56 feet = 115 plf

Case 3B One Story Demand / Capacity Calculations for 30’ x 50’ (1,500 Sq. Ft.)

Assume SD soil with Ca = 0.44; Na = 1.3; I = 1.00; and R = 5.5; Conversion to ASD force level: 1 / 1.4
Seismic V = 0.186 W (2001 CBC Equation 30-5)

Dead loads (W) tributary to cripple wall level for 1,500 square feet total floor area:

Roof/Ceiling: 14 psf (34' x 54') = 25.704 kips

First floor: 7 psf (30' x 50') = 10.50 kips

Exterior Walls:

1st Story walls:	10 psf (8') (30' x 2 + 50' x 2) =	12.80 kips
Gable end walls:	5 psf (5' x 30') 2 / 2 =	0.75 kips
Cripple walls:	6 psf (2') (30' x 2 + 50' x 2)	<u>1.92 kips</u>
		15.47 kips

Interior walls: 12 psf (8') (29' x 3 + 49' x 2) = 17.76 kips

Sum W = 25.7 + 10.5 + 15.47 + 17.76 = 69.434 kips
Total V = (0.186) W = 12.915 kips
V to each cripple wall line = 12.915 / 2 = **6.46 kips**

Sill bolts needed in 2x sill along each exterior wall line:
6,457 pounds / 820 pounds/bolt = **8 – 1/2”bolts or**
6,457 pounds / 1170 pounds/bolt = **6 - 5/8” bolts**
6,457 pounds / 1340 pounds/UFP10 = **5 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of shear wall based on 16” o.c. stud spacing

6,457 lbs / 380 plf = **17'-4"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 6,457 pounds / 17.33 feet x 4.0 feet = 1,490 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) + 5psf (2.67'/2) + 10 psf (8') + 6 psf (2') = 117.3 plf
OTM = 1,490 pounds x 2 foot wall height = 2,980 lb-ft
RTM = 0.9 x 117.3 plf (6 foot tributary length)(4 foot /2 moment arm) = 1,267 lb-ft
OTM – RTM / panel length = (2,980 – 1,267) / 4 feet = **428 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4'-0" braced panel end studs

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 6,457 pounds / 17.33 feet x 4.0 feet = 1,490 pounds
$_W$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 10 psf (8') + 6 psf (2') = 225 plf
OTM = 1,490 pounds x 2 foot wall height = 2,980 lb-ft
RTM = 0.9 x 225 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,430 lb-ft
OTM – RTM / panel length = (2,980 – 2,430) / 4 feet = **139 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4'-0" braced panel end studs

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 6,457 pounds / 17.33 feet x 8.0 feet = 2,980 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) + 5psf (2.67'/2) + 10 psf (8') + 6 psf (2') = 117.3 plf
OTM = 2,980 pounds x 2 foot wall height = 5,961 lb-ft
RTM = 0.9 x 117.3 plf (10 foot tributary length)(8 foot /2 moment arm) = 4,224 lb-ft
OTM – RTM / panel length = (5,961 – 4,224) / 8 feet = **217 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8'-0" braced panel end studs

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along longitudinal wall:

V to 8 foot long panel = 6,457 pounds / 17.33 feet x 8.0 feet = 2,980 pounds
$_W$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 10 psf (8') + 6 psf (2') = 225 plf
OTM = 2,980 pounds x 2 foot wall height = 5,961 lb-ft
RTM = 0.9 x 225 plf (10 foot tributary length)(8 foot /2 moment arm) = 8,100 lb-ft
OTM – RTM / panel length = (5,961 – 8,100) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 12 foot minimum panel length along gable end wall:

V to 12 foot long panel = 6,457 pounds / 17.33 feet x 12.0 feet = 4,470 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) + 5 psf (2.67'/2) + 10 psf (8') + 6 psf (2') = 117.3 plf
OTM = 4,470 pounds x 2 foot wall height = 8,941 lb-ft
RTM = 0.9 x 117.3 plf (14 foot tributary length)(12 foot /2 moment arm) = 8,870 lb-ft
OTM – RTM / panel length = (8,941 – 8,870) / 12 feet = **6 pounds uplift (Neglect)**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 6,457 pounds / 17.33 feet x 8.0 feet = 2,980 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) + 5 psf (2.67'/2) + 10 psf (8') + 6 psf (4') = 129.3 plf
OTM = 2,980 pounds x 4 foot wall height = 11,921 lb-ft
RTM = 0.9 x 129.3 plf (10 foot tributary length)(8 foot) /2 moment arm) = 4,656 lb-ft
OTM – RTM / panel length = (11,921 – 4,656) / 8 feet = **908 pounds uplift**

Locate two new sill bolts with plate washer within 6 inches of each 8'-0" panel end studs (one each side)

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 6,457 pounds / 17.33 feet x 8.0 feet = 2,980 pounds
$_W$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 10 psf (8') + 6 psf (4') = 237 plf
OTM = 2,980 pounds x 4 foot wall height = 11,921 lb-ft
RTM = 0.9 x 237 plf (10 foot tributary length)(8 foot) /2 moment arm) = 8,532 lb-ft
OTM – RTM / panel length = (11,921 – 8,532) / 8 feet = **424 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8'-0" panel end studs

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 6,457 pounds / 17.33 feet x 12.0 feet = 4,470 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) + 5 psf (2.67'/2) + 10 psf (8') + 6 psf (4') = 129.3 plf
OTM = 4,470 pounds x 4 foot wall height = 17,882 lb-ft
RTM = 0.9 x 129.3 plf (14 foot tributary length)(12 foot) /2 moment arm) = 9,778 lb-ft
OTM – RTM / panel length = (17,882 – 9,778) / 12 feet = **675 pounds uplift**
Locate two new sill bolts with plate washer within 6 inches of each 12'-0" panel end studs (one each side)

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along longitudinal wall

V to 12 foot long panel = 6,457 pounds / 17.33 feet x 12.0 feet = 4,470 pounds
$_W$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 10 psf (8') + 6 psf (4') = 237 plf
OTM = 4,470 pounds x 4 foot wall height = 17,882 lb-ft
RTM = 0.9 x 237 plf (14 foot tributary length)(12 foot) /2 moment arm) = 17,917 lb-ft
OTM – RTM / panel length = (17,882 – 17,917) / 12 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 17'-4" foot minimum panel length along gable end wall

V to 17'-4" long panel = 6,457 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) + 5 psf (2.67'/2) + 10 psf (8') + 6 psf (4') = 129.3 plf
OTM = 6,457 pounds x 4 foot wall height = 25,829 lb-ft
RTM = 0.9 x 129.3 plf (19'-4" tributary length)(17.33 foot) /2 moment arm) = 19,503 lb-ft
OTM – RTM / panel length = (25,829 – 19,503) / 17.33 feet = **365 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 17'-4" panel end studs (one each side)

Shear Transfer Along Each Wall Line

Connection between floor and top of cripple wall or floor and foundation sill plate

V = 6,457 pounds / 450 pounds per connection = **15 L70 or A35, or**
V = 6,457 pounds / 585 pounds per connection = **11 L90 or H10R**

Transverse Wall Line = 30 feet = 215 plf
Longitudinal Wall Line = 50 feet = 129 plf

Case 3B One Story Demand / Capacity Calculations for 30' x 40' (1,200 Sq. Ft.)

Dead loads (W) tributary to cripple wall level:

Roof/Ceiling: 14 psf (34' x 44') = 20.944 kips

First floor: 7 psf (30 x 40') = 8.4 kips

Exterior Walls:

1st Story wall:	10 psf (8') (30' x 2 + 40' x 2) =	11.20 kips
Gable end walls:	5 psf (5' x 30') 2 / 2 =	0.75 kips
Cripple walls	6 psf (2') (30' x 2 + 40' x 2) =	1.68 kips
		13.63 kips

Interior walls: 12 psf (8') (30' x 3 + 40' x 2) = 16.32 kips

Sum W = 20.944 + 8.4 + 13.63 + 16.32 = 59.294 kips
Total V = (0.186) W = 11.028 kips
V to each cripple wall line = 11.028 / 2 = **5.51 kips**

Sill bolts needed in 2x sill along each exterior wall line:
5,514 pounds / 820 pounds/bolt = **7 – 1/2"bolts or**
5,514 pounds/ 1,170 pounds/bolt = **5 - 5/8" bolts**
5,514 pounds / 1,340 pounds/UFP10 = **5 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of shear wall based on 16" o.c. stud spacing
5,514 lbs / 380 plf = **14'-8"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 5,514 pounds / 14.67 feet x 4.0 feet = 1,504 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) = 5 psf (2.67'/2) + 10 psf (8') + 6 psf (2') = 117.3 plf
OTM = 1,504 pounds x 2 foot wall height = 3,008 lb-ft
RTM = 0.9 x 117.3 plf (6 foot tributary length)(4 foot /2 moment arm) = 1,267 lb-ft
OTM – RTM / panel length = (3,008 – 1,267) / 4 feet = **435 pounds uplift**

Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4’-0” braced panel

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 5,514 pounds / 14.67 feet x 4.0 feet = 1,504 pounds
$_W$ dead load to panel = 14 psf (7.5’) + 7 psf (4’) + 10 psf (8’) + 6 psf (2’) = 225 plf
OTM = 1,504 pounds x 2 foot wall height = 3,008 lb-ft
RTM = 0.9 x 225 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,430 lb-ft
OTM – RTM / panel length = (3,008 – 2,430) / 4 feet = **144 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4’-0” braced panel

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 5,514 pounds / 14.67 feet x 8.0 feet = 3,008 pounds
$_W$ dead load to panel = 14 psf (1’) + 7 psf (1.33’/2) = 5 psf (2.67’/2) + 10 psf (8’) + 6 psf (2’) = 117.3 plf
OTM = 3,008 pounds x 2 foot wall height = 6,016 lb-ft
RTM = 0.9 x 117.3 plf (10 foot tributary length)(8 foot /2 moment arm) = 4,224 lb-ft
OTM – RTM / panel length = (6,016 – 4,224) / 8 feet = **224 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 8’-0” braced panel

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along longitudinal wall:

V to 8 foot long panel = 5,514 pounds / 14.67 feet x 8.0 feet = 3,008 pounds
$_W$ dead load to panel = 14 psf (7.5’) + 7 psf (4’) + 10 psf (8’) + 6 psf (2’) = 225 plf
OTM = 3,008 pounds x 2 foot wall height = 6,016 lb-ft
RTM = 0.9 x 225 plf (10 foot tributary length)(8 foot /2 moment arm) = 8,100 lb-ft
OTM – RTM / panel length = (6,016 – 8,100) / 8 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 12 foot minimum panel length along gable end wall:

V to 12 foot long panel = 5,514 pounds /14.67 feet x 12.0 feet = 4,512 pounds
$_W$ dead load to panel = 14 psf (1’) + 7 psf (1.33’/2) = 5 psf (2.67’/2) + 10 psf (8’) + 6 psf (2’) = 117.3 plf
OTM = 4,512 pounds x 2 foot wall height = 9,023 lb-ft
RTM = 0.9 x 117.3 plf (14 feet tributary length)(12 feet /2 moment arm) = 8,870 lb-ft
OTM – RTM / panel length = (9,023 – 8,870) / 12 feet = **13 pounds uplift (Neglect)**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 5,514 pounds / 14.67 feet x 8.0 feet = 3,008 pounds
$_W$ dead load to panel = 14 psf (1’) + 7 psf (1.33’/2) + 5psf (2.67’/2) + 10 psf (8’) + 6 psf (4’) = 129.3 plf
OTM = 3,008 pounds x 4 foot wall height = 12,031 lb-ft
RTM = 0.9 x 129.3 plf (10 foot tributary length)(8 foot) /2 moment arm) = 4,656 lb-ft
OTM – RTM / panel length = (12,031 – 4,656) / 8 feet = **922 pounds uplift**
Locate <u>two</u> new sill bolts with plate washer within 6 inches of each 8’-0” panel end studs (one each side)

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 5,514 pounds / 14.67 feet x 8.0 feet = 3,008 pounds
$_W$ dead load to panel = 14 psf (7.5’) + 7 psf (4’) + 10 psf (8’) + 6 psf (4’) = 237 plf
OTM = 3,008 pounds x 4 foot wall height = 12,031 lb-ft

RTM = 0.9 x 237 plf (10 foot tributary length)(8 foot) /2 moment arm) = 8,532 lb-ft
OTM – RTM / panel length = (12,031 – 8,532) / 8 feet = **437 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8'-0" panel end studs

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 5,514 pounds / 14.67 feet x 12.0 feet = 4,512 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) + 5 psf (2.67'/2) + 10 psf (8') + 6 psf (4') = 129.3 plf
OTM = 4,512 pounds x 4 feet wall height = 18,047 lb-ft
RTM = 0.9 x 129.3 plf (14 feet tributary length)(12 feet) /2 moment arm) = 9,778 lb-ft
OTM – RTM / panel length = (18,047 – 9,778) / 12 feet = **689 pounds uplift**
Locate two new sill bolts with plate washer within 6 inches of each 12'-0" braced panel end studs (one each side)

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along longitudinal wall

V to 12 foot long panel = 5,514 pounds / 14.67 feet x 12.0 feet = 4,512 pounds
$_W$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 10 psf (8') + 6 psf (4') = 237 plf
OTM = 4,512 pounds x 4 feet wall height = 18,047 lb-ft
RTM = 0.9 x 237 plf (14 feet tributary length)(12 feet) /2 moment arm) = 17,917 lb-ft
OTM – RTM / panel length = (18,047 – 17,917) / 12 feet = **11 pounds uplift (Neglect)**

Overturning of 4 foot high cripple wall with 14'-8" foot continuous panel length along gable end wall:

V to 14'-8" long panel = 5,514 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) + 5 psf (2.67'/2) + 10 psf (8') + 6 psf (4') = 129.3 plf
OTM = 5,156 pounds x 4 foot wall height = 22,057 lb-ft
RTM = 0.9 x 129.3 plf (16'-8" tributary length)(14.67 feet /2 moment arm) = 14,223 lb-ft
OTM – RTM / panel length = (22,057 – 14,223) / 14.67 feet = **533 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of 14'-8" braced panel end studs

Overturning of 4 foot high cripple wall with 14'-8" foot continuous panel length along longitudinal wall:

V to 14'-8" long panel = 5,514 pounds
$_W$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 10 psf (8') + 6 psf (4') = 237 plf
OTM = 5,156 pounds x 4 foot wall height = 22,057 lb-ft
RTM = 0.9 x 237 plf (16'-8" tributary length)(14.67 feet /2 moment arm) = 26,070 lb-ft
OTM – RTM / panel length = (22,057 – 26,070) / 14.67 feet = **NO uplift**

Shear Transfer Along Each Wall Line
Connection between floor and top of cripple wall or floor and foundation sill plate

V = 5,514 pounds / 450 pounds per connection = **13 L70 or A35, or**
V = 5,514 pounds / 585 pounds per connection = **10 L90 or H10R**

Transverse Wall Line = 30 feet = 184 plf
Longitudinal Wall Line = 40 feet = 138 plf

Case 3B One Story Demand / Capacity Calculations for 36' x 56' = 2,016 square feet.

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Dead loads (W) tributary to cripple wall level:

Roof/Ceiling: 14 psf (40' x 60') = 33.60 kips

First floor: 7 psf (36 x 56') = 14.11 kips

Exterior Walls:

1st Story wall:	10 psf (8') (36' x 2 + 56' x 2) =	14.72 kips
Gable end walls:	5 psf (6' x 36') 2 / 2 =	1.08 kips
Cripple walls	6 psf (2') (36' x 2 + 56' x 2) =	2.21 kips
		18.008 kips

Interior wall: 12 psf (8') (35' x 3 + 55' x 2) = 20.64 kips

Sum W = 33.6 + 14.11 + 18.0 + 20.64 = 86.36 kips

Total V = (0.186) W = 16.063 kips

V to each cripple wall line = 16.063 / 2 = **8.03 kips**

Sill bolts needed in 2x sill along each exterior wall line:

8,032 pounds / 820 pounds/bolt = **10 – 1/2"bolts or**

8,032 pounds / 1170 pounds/bolt = **7 - 5/8" bolts**

8,032 pounds / 1340 pounds/UFP10 = **6 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:

V to each wall line / unit capacity = lineal feet of shear wall based on 16" o.c. stud spacing

8,032 lbs / 380 plf = **21'-4"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 8,032 pounds / 21.33 feet x 4.0 feet = 1,506 pounds

$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) = 5 psf (2.67' /2) + 10 psf (8') + 6 psf (2') = 117.3 plf

OTM = 1,506 pounds x 2 foot wall height = 3,012 lb-ft

RTM = 0.9 x 117.3 plf (6 foot tributary length)(4 foot /2 moment arm) = 1,267 lb-ft

OTM – RTM / panel length = (3,012 – 1,267) / 4 feet = **436 pounds uplift**

Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4'-0" braced panel

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 8,032 pounds / 21.33 feet x 4.0 feet = 1,506 pounds

$_W$ dead load to panel = 14 psf (9') + 7 psf (4') + 10 psf (8') + 6 psf (2') = 246 plf

OTM = 1,506 pounds x 2 foot wall height = 3,012 lb-ft

RTM = 0.9 x 246 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,657 lb-ft

OTM – RTM / panel length = (3,012 – 2,657) / 4 feet = **89 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4'-0" braced panel

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 8,032 pounds / 21.33 feet x 8.0 feet = 3,012 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) = 5 psf (2.67' /2) + 10 psf (8') + 6 psf (2') = 117.3 plf
OTM = 3,012 pounds x 2 foot wall height = 6,024 lb-ft
RTM = 0.9 x 117.3 plf (10 foot tributary length)(8 foot /2 moment arm) = 4,224 lb-ft
OTM – RTM / panel length = (6,024 – 4,224) / 8 feet = **225 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 8'-0" braced panel

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along longitudinal wall:

V to 8 foot long panel = 8,032 pounds / 21.33 feet x 8.0 feet = 3,012 pounds
$_W$ dead load to panel = 14 psf (9') + 7 psf (4') + 10 psf (8') + 6 psf (2') = 246 plf
OTM = 3,012 pounds x 2 foot wall height = 6,024 lb-ft
RTM = 0.9 x 246 plf (10 foot tributary length)(8 foot /2 moment arm) = 8,856 lb-ft
OTM – RTM / panel length = (6,024 – 8,856) / 8 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 12 foot continuous panel length along gable end wall:

V to 12 foot long panel = 8,032 pounds /21.33 x 12.0 feet = 4,518 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) = 5 psf (2.67' /2) + 10 psf (8') + 6 psf (2') = 117.3 plf
OTM = 4,518 pounds x 2 foot wall height = 9,035 lb-ft
RTM = 0.9 x 117.3 plf (14 tributary length)(12 feet /2 moment arm) = 8,870 lb-ft
OTM – RTM / panel length = (9,035 – 8,870) / 12 feet = **14 pounds uplift (Neglect)**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 8,032 pounds / 21.33 feet x 8.0 feet = 3,012 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) = 5 psf (2.67' /2) + 10 psf (8') + 6 psf (4') = 129.3 plf
OTM = 3,012 pounds x 4 foot wall height = 12,047 lb-ft
RTM = 0.9 x 129.3 plf (10 foot tributary length)(8 foot) /2 moment arm) = 4,656 lb-ft
OTM – RTM / panel length = (12,047 – 4,656) / 8 feet = **924 pounds uplift**
Locate two new sill bolts with plate washer within 6 inches of each end stud of each 8'-0" panel (one each side)

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 8,032 pounds / 21.33 feet x 8.0 feet = 3,012 pounds
$_W$ dead load to panel = 14 psf (9') + 7 psf (4') + 10 psf (8') + 6 psf (4') = 258 plf
OTM = 3,012 pounds x 4 foot wall height = 12,047 lb-ft
RTM = 0.9 x 258 plf (10 foot tributary length)(8 foot) /2 moment arm) = 9,288 lb-ft
OTM – RTM / panel length = (12,047 – 9,288) / 8 feet = **345 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each end stud at 8'-0" panels

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end walls

V to 12 foot long panel = 8,032 pounds / 21.33 feet x 12.0 feet = 4,518 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) = 5 psf (2.67' /2) + 10 psf (8') + 6 psf (4') = 129.3 plf
OTM = 4,518 pounds x 4 foot wall height = 18,071 lb-ft
RTM = 0.9 x 129.3 plf (14 foot tributary length)(12 foot) /2 moment arm) = 9,778 lb-ft
OTM – RTM / panel length = (18,071 – 9,778) / 12 feet = **691 pounds uplift**
Locate two new sill bolts with plate washer within 6 inches of each end stud of each 12' panel (one each side)

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along longitudinal walls

V to 12 foot long panel = 8,032 pounds / 17.33 feet x 12.0 feet = 4,518 pounds
$_W$ dead load to panel = 14 psf (9') + 7 psf (4') + 10 psf (8') + 6 psf (4') = 258 plf
OTM = 4,518 pounds x 4 foot wall height = 18,071 lb-ft
RTM = 0.9 x 258 plf (14 foot tributary length)(12 foot) /2 moment arm) = 19,505 lb-ft
OTM – RTM / panel length = (18,071 – 19,505) / 12 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 16 foot minimum panel length along gable end walls

V to 16 foot long panel = 8,032 pounds / 21.33 feet x 16.0 feet = 6,024 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) = 5 psf (2.67' /2) + 10 psf (8') + 6 psf (4') = 129.3 plf
OTM = 6,024 pounds x 4 foot wall height = 24,094 lb-ft
RTM = 0.9 x 129.3 plf (18 foot tributary length)(16 foot) /2 moment arm) = 16,762 lb-ft
OTM – RTM / panel length = (24,094 – 16,762) / 16 feet = **458 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each end stud of each 16' panel

Overturning of 4 foot high cripple wall with 21'-4" foot continuous panel length along gable end walls

V to 21'-4" long panel = 8,034 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) = 5 psf (2.67' /2) + 10 psf (8') + 6 psf (4') = 129.3 plf
OTM = 8,032 pounds x 4 foot wall height = 32,126 lb-ft
RTM = 0.9 x 129.3 plf (23'-4" tributary length)(21.33 foot) /2 moment arm) = 28,971 lb-ft
OTM – RTM / panel length = (32,126 – 28,971) / 21.33 feet = **148 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each end stud of each 21'-4" panel

Shear Transfer Along Each Wall Line
Connection between floor and top of cripple wall or floor and foundation sill plate

V = 8,032 pounds / 450 pounds per connection = **18 L70 or A35, or**
V = 8,032 pounds / 585 pounds per connection = **14 L90 or H10R**

Transverse Wall Line = 36 feet = 223 plf
Longitudinal Wall Line = 56 feet = 143 plf

Case 3C One Story Demand / Capacity Calculations for 30' x 50' (1,500 Sq. Ft.)

Assume SD soil with Ca = 0.44; Na = 1.3; I = 1.00; and R = 5.5; Conversion to ASD force level: 1 / 1.4
Seismic V = 0.186 W (2001 CBC Equation 30-5)

Dead loads (W) tributary to cripple wall level for 1,500 square feet total floor area:

Roof/Ceiling: 14 psf (34' x 54') = 25.704 kips

First floor: 7 psf (30' x 50') = 10.50 kips

Exterior Walls:

1st Story walls:	17 psf (8') (30' x 2 + 50' x 2) =	21.760 kips
Deduct for windows:	-7 psf (150 sq. ft)	<-1.05 kips>
Gable end walls:	12 psf (5' x 30') 2 / 2 =	1.80 kips
Cripple walls:	13.5 psf (2') (30' x 2 + 50' x 2)	4.320 kips
		26.830 kips

Interior walls: 12 psf (8') (29' x 3 + 49' x 2) = 17.76 kips

Sum W = 25.7 04+ 10.5 + 26.83 + 17.76 = 80.794 kips
Total V = (0.186) W = 15.028 kips
V to each cripple wall line = 15.0-28 / 2 = **7.51 kips**

Sill bolts needed in 2x sill along each exterior wall line:
7,514 pounds / 820 pounds/bolt = **10 – 1/2"bolts or**
7,514 pounds / 1170 pounds/bolt = **7 - 5/8" bolts**
7,514 pounds / 1340 pounds/UFP10 = **6 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of shear wall based on 16" o.c. stud spacing
7,514 lbs / 380 plf = **20'-0"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 7,514 pounds / 20 feet x 4.0 feet = 1,503 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) + 12 psf (2.67'/2) + 17 psf (8') + 13.5 psf (2') = 197.7 plf
OTM = 1,503 pounds x 2 foot wall height = 3,005 lb-ft
RTM = 0.9 x 197.7 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,135 lb-ft
OTM – RTM / panel length = (3,005 – 2,135) / 4 feet = **218 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4'-0" braced panel end studs

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 7,514 pounds / 20 feet x 4.0 feet = 1,503 pounds
$_W$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 17 psf (8') + 13.5 psf (2') = 296 plf
OTM = 1,503 pounds x 2 foot wall height = 3,005 lb-ft
RTM = 0.9 x 296 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,197 lb-ft
OTM – RTM / panel length = (3,005 – 3,197) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 7,514 pounds / 20 feet x 8.0 feet = 3,006 pounds
$_W$ dead load to panel = 14 psf (1’) + 7 psf (1.33’/2) + 12 psf (2.67’/2) + 17 psf (8’) + 13.5 psf (2’) = 197.7 plf
OTM = 3,006 pounds x 2 foot wall height = 6,011 lb-ft
RTM = 0.9 x 197.7 plf (10 foot tributary length)(8 foot /2 moment arm) = 7,116 lb-ft
OTM – RTM / panel length = (6,011 – 7,116) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 7,514 pounds / 20 feet x 8.0 feet = 3,006 pounds
$_W$ dead load to panel = 14 psf (1’) + 7 psf (1.33’/2) + 12 psf (2.67’/2) + 17 psf (8’) + 13.5 psf (4’) = 224.7 plf
OTM = 3,006 pounds x 4 foot wall height = 12,022 lb-ft
RTM = 0.9 x 224.7 plf (10 foot tributary length)(8 foot) /2 moment arm) = 8,089 lb-ft
OTM – RTM / panel length = (12,022 – 8,089) / 8 feet = **492 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8’-0” panel end studs

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 7,514 pounds / 20 feet x 8.0 feet = 3,006 pounds
$_W$ dead load to panel = 14 psf (7.5’) + 7 psf (4’) + 17 psf (8’) + 13.5 psf (4’) = 323 plf
OTM = 3,006 pounds x 4 foot wall height = 12,022 lb-ft
RTM = 0.9 x 323 plf (10 foot tributary length)(8 foot) /2 moment arm) = 11,628 lb-ft
OTM – RTM / panel length = (12,022 – 11,628) / 8 feet = **49 pounds uplift (Neglect)**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 7,514 pounds / 20 feet x 12.0 feet = 4,508 pounds
$_W$ dead load to panel = 14 psf (1’) + 7 psf (1.33’/2) + 12 psf (2.67’/2) + 17 psf (8’) + 13.5 psf (4’) = 224.7 plf
OTM = 4,508 pounds x 4 foot wall height = 18,033 lb-ft
RTM = 0.9 x 224.7 plf (14 foot tributary length)(12 foot) /2 moment arm) = 16,945 lb-ft
OTM – RTM / panel length = (18,033 – 16,985) / 12 feet = **87 pounds uplift (perhaps could Neglect)**
Locate one new sill bolt with plate washer within 6 inches of each 12’-0” panel end studs

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along longitudinal wall

V to 12 foot long panel = 7,514 pounds / 20 feet x 12.0 feet = 4,508 pounds
$_W$ dead load to panel = 14 psf (7.5’) + 7 psf (4’) + 17 psf (8’) + 13.5 psf (4’) = 323 plf
OTM = 4,508 pounds x 4 foot wall height = 18,033 lb-ft
RTM = 0.9 x 323 plf (14 foot tributary length)(12 foot) /2 moment arm) = 24,419 lb-ft
OTM – RTM / panel length = (18,033 – 24,419) / 12 feet = **NO uplift**

Shear Transfer Along Each Wall Line
Connection between floor and top of cripple wall or floor and foundation sill plate

V = 7,514 pounds / 450 pounds per connection = **17 L70 or A35, or**
V = 7,514 pounds / 585 pounds per connection = **13 L90 or H10R**

Transverse Wall Line = 30 feet = 250 plf
Longitudinal Wall Line = 50 feet = 150 plf

Case 3C One Story Demand / Capacity Calculations for 30' x 40' (1,200 Sq. Ft.)

Dead loads (W) tributary to cripple wall level:

Roof/Ceiling: 14 psf (34' x 44') = 20.944 kips

First floor: 7 psf (30 x 40') = 8.4 kips

Exterior Walls:

1st Story wall:	17 psf (8') (30' x 2 + 40' x 2) =	19.040 kips
Deduct for Windows:	-7 psf (130 sq. ft.)	<-0.91 kips>
Gable end walls:	12 psf (5' x 30') 2 / 2 =	1.80 kips
Cripple walls	13.5 psf (2') (30' x 2 + 40' x 2) =	3.78 kips
		23.71 kips

Interior walls: 12 psf (8') (30' x 3 + 40' x 2) = 16.32 kips

Sum W = 20.944 + 8.4 + 23.71 + 16.32 = 69.374 kips
Total V = (0.186) W = 12.904 kips
V to each cripple wall line = 12.904 / 2 = **6.45 kips**

Sill bolts needed in 2x sill along each exterior wall line:
6,452 pounds / 820 pounds/bolt = **8 – 1/2"bolts or**
6,452 pounds/ 1,170 pounds/bolt = **6 - 5/8" bolts**
6,452 pounds/ 1,340 pounds/UFP10 = **5 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of shear wall based on 16" o.c. stud spacing
6,452 lbs / 380 plf = **17'-4"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 6,452 pounds / 17.33 feet x 4.0 feet = 1,489 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) = 12 psf (2.67'/2) + 17 psf (8') + 13.5 psf (2') = 197.7 plf
OTM = 1,489 pounds x 2 foot wall height = 2,978 lb-ft
RTM = 0.9 x 197.7 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,135 lb-ft
OTM – RTM / panel length = (2,978 – 2,135) / 4 feet = **211 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4'-0" braced panel

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 6,452 pounds / 17.33 feet x 4.0 feet = 1,489 pounds
$_W$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 17 psf (8') + 13.5 psf (2') = 296 plf
OTM = 1,489 pounds x 2 foot wall height = 2,978 lb-ft
RTM = 0.9 x 296 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,197 lb-ft
OTM – RTM / panel length = (2,978 – 3,197) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 6,452 pounds / 17.33 feet x 8.0 feet = 2,978 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) = 12 psf (2.67'/2) + 17 psf (8') + 13.5 psf (2') = 197.7 plf
OTM = 1,978 pounds x 2 foot wall height = 5,955 lb-ft
RTM = 0.9 x 197.7 plf (10 foot tributary length)(8 foot /2 moment arm) = 7,116 lb-ft
OTM – RTM / panel length = (5,955 – 7,116) / 4 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 6,452 pounds / 17.33 feet x 8.0 feet = 2,978 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) + 12 psf (2.67'/2) + 17 psf (8') + 13.5 psf (4') = 224.7 plf
OTM = 2,978 pounds x 4 foot wall height = 11,911 lb-ft
RTM = 0.9 x 224.7 plf (10 foot tributary length)(8 foot) /2 moment arm) = 8,088 lb-ft
OTM – RTM / panel length = (11,911 – 8,088) / 8 feet = **478 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8'-0" panel end studs

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 6,452 pounds / 17.33 feet x 8.0 feet = 2,978 pounds
$_W$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 17 psf (8') + 13.5 psf (4') = 323 plf
OTM = 2,978 pounds x 4 foot wall height = 11,911 lb-ft
RTM = 0.9 x 323 plf (10 foot tributary length)(8 foot) /2 moment arm) = 11,628 lb-ft
OTM – RTM / panel length = (11,911 – 11,628) / 8 feet = **35 pounds uplift (Neglect)**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 6,452 pounds / 17.33 feet x 12.0 feet = 4,467 pounds
$_W$ dead load to panel = 14 psf (1') + 7 psf (1.33'/2) + 12 psf (2.67'/2) + 17 psf (8') + 13.5 psf (4') = 224.7 plf
OTM = 4,467 pounds x 4 foot wall height = 17,866 lb-ft
RTM = 0.9 x 224.7 plf (14 foot tributary length)(12 foot) /2 moment arm) = 16,985 lb-ft
OTM – RTM / panel length = (17,866 – 16,985) / 12 feet = **74 pounds uplift (perhaps could Neglect)**
Locate one new sill bolt with plate washer within 6 inches of each 12'-0" panel end studs

Shear Transfer Along Each Wall Line
Connection between floor and top of cripple wall or floor and foundation sill plate

V = 6,452 pounds / 450 pounds per connection = **15 L70 or A35, or**
V = 6,452 pounds / 585 pounds per connection = **11 L90 or H10R**

Transverse Wall Line = 30 feet = 215 plf
Longitudinal Wall Line = 40 feet = 161 plf

Case 3C One Story Demand / Capacity Calculations for 36' x 56' = 2,016 square feet.

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Dead loads (W) tributary to cripple wall level:

Roof/Ceiling: 14 psf (40' x 60') = 33.60 kips

First floor: 7 psf (36 x 56') = 14.112 kips

Exterior Walls:

1st Story wall:	17 psf (8') (36' x 2 + 56' x 2) =	25.024 kips
Deduct for windows	-7 psf (210 sq. ft.) =	<-1.470 kips>
Gable end walls:	12 psf (6' x 36') 2 / 2 =	2.592 kips
Cripple walls	13.5 psf (2') (36' x 2 + 56' x 2) =	<u>4.968 kips</u>
		31.114 kips

Interior wall: 12 psf (8') (35' x 3 + 55' x 2) = 20.64 kips

Sum W = 33.60 + 14.11 + 31.11 + 20.64 = 99.47 kips
Total V = (0.186) W = 18.501 kips
V to each cripple wall line = 18.501 / 2 = **9.25 kips**

Sill bolts needed in 2x sill along each exterior wall line:

9,250 pounds / 820 pounds/bolt = **12 – 1/2”bolts or**
9,250 pounds / 1170 pounds/bolt = **8 - 5/8” bolts**
9,250 pounds / 1340 pounds/UFP10 = **7 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:

V to each wall line / unit capacity = lineal feet of shear wall based on 16” o.c. stud spacing
9,250 lbs / 380 plf = **25’-4”**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 9,250 pounds / 25.33 feet x 4.0 feet = 1,461 pounds
$_W$ dead load to panel = 14 psf (1’) + 7 psf (1.33’/2) = 12 psf (2.67’ /2) + 17 psf (8’) + 13.5 psf (2’) = 197.7 plf
OTM = 1,461 pounds x 2 foot wall height = 2,921 lb-ft
RTM = 0.9 x 197.7 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,135 lb-ft
OTM – RTM / panel length = (2,921 – 2,135) / 4 feet = **197 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4’-0” braced panel

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 9,250 pounds / 25.33 feet x 4.0 feet = 1,461 pounds
$_W$ dead load to panel = 14 psf (9’) + 7 psf (4’) + 17 psf (8’) + 13.5 psf (2’) = 317 plf
OTM = 1,461 pounds x 2 foot wall height = 2,921 lb-ft
RTM = 0.9 x 317 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,424 lb-ft
OTM – RTM / panel length = (2,921 – 3,424) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 9,250 pounds / 25.33 feet x 8.0 feet = 2,921 pounds
$_W$ dead load to panel = 14 psf (1’) + 7 psf (1.33’/2) = 12 psf (2.67’ /2) + 17 psf (8’) + 13.5 psf (2’) = 197.7 plf
OTM = 2,921 pounds x 2 foot wall height = 5,842 lb-ft
RTM = 0.9 x 197.7 plf (10 foot tributary length)(8 foot /2 moment arm) = 7,116 lb-ft
OTM – RTM / panel length = (5,842 – 7,116) / 4 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 9,250 pounds / 25.33 feet x 8.0 feet = 2,921 pounds
$_W$ dead load to panel = 14 psf (1’) + 7 psf (1.33’/2) = 12 psf (2.67’ /2) + 17 psf (8’) + 13.5 psf (4’) = 224.7 plf

OTM = 2,921 pounds x 4 foot wall height = 11,685 lb-ft
RTM = 0.9 x 224.7 plf (10 foot tributary length)(8 foot) /2 moment arm) = 8,088 lb-ft
OTM – RTM / panel length = (11,685 – 8,088) / 8 feet = **450 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each end stud of each 8’-0” panel

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 9,250 pounds / 25.33 feet x 8.0 feet = 2,921 pounds
$_W$ dead load to panel = 14 psf (9’) + 7 psf (4’) + 17 psf (8’) + 13.5 psf (4’) = 344 plf
OTM = 2,921 pounds x 4 foot wall height = 11,685 lb-ft
RTM = 0.9 x 344 plf (10 foot tributary length)(8 foot) /2 moment arm) = 12,384 lb-ft
OTM – RTM / panel length = (11,685 – 12,384) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 9,250 pounds / 25.33 feet x 12.0 feet = 4,382 pounds
$_W$ dead load to panel = 14 psf (1’) + 7 psf (1.33’/2) = 12 psf (2.67’ /2) + 17 psf (8’) + 13.5 psf (4’) = 224.7 plf
OTM = 4,382 pounds x 4 foot wall height = 17,527 lb-ft
RTM = 0.9 x 224.7 plf (14 foot tributary length)(12 foot) /2 moment arm) = 16,985 lb-ft
OTM – RTM / panel length = (18,260 – 16,985) / 12 feet = **45 pounds uplift (Neglect)**

Shear Transfer Along Each Wall Line
Connection between floor and top of cripple wall or floor and foundation sill plate

V = 9,250 pounds / 450 pounds per connection = **21 L70 or A35, or**
V = 9,250 pounds / 585 pounds per connection = **16 L90 or H10R**

Transverse Wall Line = 36 feet = 257 plf
Longitudinal Wall Line = 56 feet = 165 plf

Case 3D One Story Demand / Capacity Calculations for 30’ x 50’ (1,500 Sq. Ft.)

Assume SD soil with Ca = 0.44; Na = 1.3; I = 1.00; and R = 5.5; Conversion to ASD force level: 1 / 1.4
Seismic V = 0.186 W (2001 CBC Equation 30-5)

Dead loads (W) tributary to cripple wall level for 1,500 square feet total floor area:

Roof/Ceiling: 20 psf (34' x 54') = 36.72 kips

First floor: 7 psf (30' x 50') = 10.50 kips

Exterior Walls:

1st Story walls:	17 psf (8') (30' x 2 + 50' x 2) =	21.760 kips
Deduct for windows:	-7 psf (150 sq. ft)	<-1.05 kips>
Gable end walls:	12 psf (5' x 30') 2 / 2 =	1.80 kips
Cripple walls:	13.5 psf (2') (30' x 2 + 50' x 2)	<u>4.320 kips</u>
		26.830 kips

Interior walls: 12 psf (8') (29' x 3 + 49' x 2) = 17.76 kips

Sum W = 36.72 + 10.5 + 26.83 + 17.76 = 91.81 kips
Total V = (0.186) W = 17.077 kips
V to each cripple wall line = 17.077 / 2 = **8.36 kips**

Sill bolts needed in 2x sill along each exterior wall line:
8,538 pounds / 820 pounds/bolt = **11 – 1/2"bolts or**
8,538 pounds / 1170 pounds/bolt = **8 - 5/8" bolts**
8,538 pounds / 1340 pounds/UFP10 = **7 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of shear wall based on 16" o.c. stud spacing
8,538 lbs / 380 plf = **22'-8"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 8,538 pounds / 22.67 feet x 4.0 feet = 1,507 pounds
$_W$ dead load to panel = 20 psf (1') + 7 psf (1.33'/2) + 12 psf (2.67'/2) + 17 psf (8') + 13.5 psf (2') = 203.67 plf
OTM = 1,507 pounds x 2 foot wall height = 3,014 lb-ft
RTM = 0.9 x 203.67 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,200 lb-ft
OTM – RTM / panel length = (3,014 – 2,200) / 4 feet = **203 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4'-0" braced panel end studs

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 8,538 pounds / 22.67 feet x 4.0 feet = 1,507 pounds
$_W$ dead load to panel = 20 psf (7.5') + 7 psf (4') + 17 psf (8') + 13.5 psf (2') = 341 plf
OTM = 1,507 pounds x 2 foot wall height = 3,014 lb-ft
RTM = 0.9 x 341 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,683 lb-ft
OTM – RTM / panel length = (3,014 – 3,683) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 8,538 pounds / 22.67 feet x 8.0 feet = 3,014 pounds
$_W$ dead load to panel = 20 psf (1') + 7 psf (1.33'/2) + 12 psf (2.67'/2) + 17 psf (8') + 13.5 psf (2') = 203.67 plf
OTM = 3,014 pounds x 2 foot wall height = 6,027 lb-ft
RTM = 0.9 x 203.7 plf (10 foot tributary length)(8 foot /2 moment arm) = 7,332 lb-ft
OTM – RTM / panel length = (6,027 – 7,332) / 8 feet = **No uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 8,538 pounds / 22.67 feet x 8.0 feet = 3,014 pounds
W dead load to panel = 20 psf (1') + 7 psf (1.33'/2) + 12 psf (2.67'/2) + 17 psf (8') + 13.5 psf (4') = 230.67 plf
OTM = 3,014 pounds x 4 foot wall height = 12,054 lb-ft
RTM = 0.9 x 230.7 plf (10 foot tributary length)(8 foot) /2 moment arm) = 8,304 lb-ft
OTM – RTM / panel length = (12,054 – 8,304) / 8 feet = **469 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8'-0" panel end studs

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 8,538 pounds / 22.67 feet x 8.0 feet = 3,014 pounds
W dead load to panel = 20 psf (7.5') + 7 psf (4') + 17 psf (8') + 13.5 psf (4') = 368 plf
OTM = 3,014 pounds x 4 foot wall height = 12,054 lb-ft
RTM = 0.9 x 368 plf (10 foot tributary length)(8 foot) /2 moment arm) = 13,248 lb-ft
OTM – RTM / panel length = (12,054 – 13,248) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 8,538 pounds / 22.67 feet x 12.0 feet = 4,520 pounds
W dead load to panel = 20 psf (1') + 7 psf (1.33'/2) + 12 psf (2.67'/2) + 17 psf (8') + 13.5 psf (4') = 230.67 plf
OTM = 4,520 pounds x 4 foot wall height = 18,081 lb-ft
RTM = 0.9 x 230.7 plf (14 foot tributary length)(12 foot) /2 moment arm) = 17,438 lb-ft
OTM – RTM / panel length = (18,081 – 17,438) / 12 feet = **53 pounds uplift (Neglect)**

Shear Transfer Along Each Wall Line

Connection between floor and top of cripple wall or floor and foundation sill plate

V = 8,538 pounds / 450 pounds per connection = **19 L70 or A35, or**
V = 8,538 pounds / 585 pounds per connection = **15 L90 or H10R**

Transverse Wall Line = 30 feet = 285 plf
Longitudinal Wall Line = 50 feet = 171 plf

Case 3D One Story Demand / Capacity Calculations for 30' x 40' (1,200 Sq. Ft.)

Dead loads (W) tributary to cripple wall level:

Roof/Ceiling: 20 psf (34' x 44') = 29.92 kips

First floor: 7 psf (30 x 40') = 8.4 kips

Exterior Walls:
1st Story wall: 17 psf (8') (30' x 2 + 40' x 2) = 19.040 kips
Deduct for Windows: -7 psf (130 sq. ft.) <-0.91 kips>

Gable end walls:	12 psf (5' x 30') 2 / 2 =	1.80 kips
Cripple walls	13.5 psf (2') (30' x 2 + 40' x 2) =	3.78 kips
		23.71 kips

Interior walls: 12 psf (8') (30' x 3 + 40' x 2) = 16.32 kips

Sum W = 29.92 + 8.4 + 23.71 + 16.32 = 78.35 kips
Total V = (0.186) W = 14.573 kips
V to each cripple wall line = 14.573 / 2 = **7.29 kips**

Sill bolts needed in 2x sill along each exterior wall line:
7,287 pounds / 820 pounds/bolt = **9 – 1/2”bolts or**
7,287 pounds/ 1,170 pounds/bolt = **7 - 5/8” bolts**
7,287 pounds/ 1,340 pounds/bolt = **6 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of shear wall based on 16” o.c. stud spacing
7,287 lbs / 380 plf = **20’-0”**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 7,287 pounds / 20 feet x 4.0 feet = 1,457 pounds
$_W$ dead load to panel = 20 psf (1’) + 7 psf (1.33’/2) = 12 psf (2.67’/2) + 17 psf (8’) + 13.5 psf (2’) = 203.67 plf
OTM = 1,457 pounds x 2 foot wall height = 2,915 lb-ft
RTM = 0.9 x 203.7 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,200 lb-ft
OTM – RTM / panel length = (2,915 – 2,200) / 4 feet = **178 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4’-0” braced panel

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 7,287 pounds / 20 feet x 4.0 feet = 1,457 pounds
$_W$ dead load to panel = 20 psf (7.5’) + 7 psf (4’) + 17 psf (8’) + 13.5 psf (2’) = 341 plf
OTM = 1,457 pounds x 2 foot wall height = 2,915 lb-ft
RTM = 0.9 x 341 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,683 lb-ft
OTM – RTM / panel length = (2,915 – 3,683) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 7,287 pounds / 20 feet x 8.0 feet = 2,915 pounds
$_W$ dead load to panel = 20 psf (1’) + 7 psf (1.33’/2) = 12 psf (2.67’/2) + 17 psf (8’) + 13.5 psf (2’) = 203.67 plf
OTM = 2,915 pounds x 2 foot wall height = 5,829 lb-ft
RTM = 0.9 x 203.7 plf (10 foot tributary length)(8 foot /2 moment arm) = 7,332 lb-ft
OTM – RTM / panel length = (5,829 – 7,332) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 7,287 pounds / 20 feet x 8.0 feet = 2,915 pounds
$_W$ dead load to panel = 20 psf (1’) + 7 psf (1.33’/2) = 12 psf (2.67’/2) + 17 psf (8’) + 13.5 psf (4’) = 230.67 plf

OTM = 2,915 pounds x 4 foot wall height = 11,658 lb-ft
RTM = 0.9 x 230.7 plf (10 foot tributary length)(8 foot /2 moment arm) = 8,304 lb-ft
OTM – RTM / panel length = (11,658 – 8,304) / 8 feet = **419 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 8'-0" braced panel

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall:

V to 8 foot long panel = 7,287 pounds / 20 feet x 8.0 feet = 2,915 pounds
$_W$ dead load to panel = 20 psf (7.5') + 7 psf (4') + 17 psf (8') + 13.5 psf (4') = 368 plf
OTM = 2,915 pounds x 4 foot wall height = 11,658 lb-ft
RTM = 0.9 x 368 plf (10 foot tributary length)(8 foot /2 moment arm) = 13,248 lb-ft
OTM – RTM / panel length = (11,658 – 13,248) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall:

V to 12 foot long panel = 7,287 pounds / 20 feet x 12.0 feet = 4,372 pounds
$_W$ dead load to panel = 20 psf (1') + 7 psf (1.33'/2) = 12 psf (2.67'/2) + 17 psf (8') + 13.5 psf (4') = 230.67 plf
OTM = 4,372 pounds x 4 foot wall height = 17,488 lb-ft
RTM = 0.9 x 230.7 plf (14 foot tributary length)(12 foot /2 moment arm) = 17,438 lb-ft
OTM – RTM / panel length = (17,488 – 17,438) / 12 feet = **4 pounds uplift (Neglect)**

Shear Transfer Along Each Wall Line
Connection between floor and top of cripple wall or floor and foundation sill plate

V = 7,287 pounds / 450 pounds per connection = **17 L70 or A35, or**
V = 7,287 pounds / 585 pounds per connection = **13 L90 or H10R**

Transverse Wall Line = 30 feet = 243 plf
Longitudinal Wall Line = 40 feet = 182 plf

Case 3D One Story Demand / Capacity Calculations for 36' x 56' = 2,016 square feet.

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Dead loads (W) tributary to cripple wall level:
Roof/Ceiling: 20 psf (40' x 60') = 48.00 kips

First floor: 7 psf (36 x 56') = 14.112 kips

Exterior Walls:

1st Story wall:	17 psf (8') (36' x 2 + 56' x 2) =	25.024 kips
Deduct for windows	-7 psf (210 sq. ft.) =	<-1.470 kips>
Gable end walls:	12 psf (6' x 36') 2 / 2 =	2.592 kips

Cripple walls 13.5 psf (2') (36' x 2 + 56' x 2) = 4.968 kips
31.114 kips

Interior wall: 12 psf (8') (35' x 3 + 55' x 2) = 20.64 kips

Sum W = 48.00 + 14.11 + 31.11 + 20.64 = 113.87 kips
Total V = (0.186) W = 21.179 kips
V to each cripple wall line = 21.179 / 2 = **10.59 kips**

Sill bolts needed in 2x sill along each exterior wall line:

10,590 pounds / 820 pounds/bolt = **13 – 1/2"bolts or**
10,590 pounds / 1170 pounds/bolt = **9 - 5/8" bolts**
10,590 pounds / 1340 pounds/UFP10 = **8 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:

V to each wall line / unit capacity = lineal feet of shear wall based on 16" o.c. stud spacing
10,590 lbs / 380 plf = **28'-0"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 10,590 pounds / 28 feet x 4.0 feet = 1,513 pounds
$_W$ dead load to panel = 20 psf (1') + 7 psf (1.33'/2) = 12 psf (2.67' /2) + 17 psf (8') + 13.5 psf (2') = 203.7 plf
OTM = 1,513 pounds x 2 foot wall height = 3,026 lb-ft
RTM = 0.9 x 203.7 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,200 lb-ft
OTM – RTM / panel length = (3,026 – 2,200) / 4 feet = **206 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of both end studs of each 4'-0" braced panel

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 10,590 pounds / 28 feet x 4.0 feet = 1,513 pounds
$_W$ dead load to panel = 20 psf (9') + 7 psf (4') + 17 psf (8') + 13.5 psf (2') = 371 plf
OTM = 1,512 pounds x 2 foot wall height = 3,026 lb-ft
RTM = 0.9 x 371 plf (6 foot tributary length)(4 foot /2 moment arm) = 4,007 lb-ft
OTM – RTM / panel length = (3,026 – 4,007) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 10,590 pounds / 28 feet x 8.0 feet = 3,026 pounds
$_W$ dead load to panel = 20 psf (1') + 7 psf (1.33'/2) = 12 psf (2.67' /2) + 17 psf (8') + 13.5 psf (2') = 203.7 plf
OTM = 3,026 pounds x 2 foot wall height = 6,051 lb-ft
RTM = 0.9 x 203.7 plf (10 foot tributary length)(8 foot /2 moment arm) = 7,332 lb-ft
OTM – RTM / panel length = (6,051 – 7,332) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 10,590 pounds / 28 feet x 8.0 feet = 3,026 pounds
$_W$ dead load to panel = 20 psf (1') + 7 psf (1.33'/2) = 12 psf (2.67' /2) + 17 psf (8') + 13.5 psf (4') = 230.7 plf
OTM = 3,026 pounds x 4 foot wall height = 12,103 lb-ft
RTM = 0.9 x 230.7 plf (10 foot tributary length)(8 foot /2 moment arm) = 8,304 lb-ft
OTM – RTM / panel length = (12,103 – 8,304) / 8 feet = **475 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8'-0" braced panel end studs

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall:

V to 8 foot long panel = 10,590 pounds / 28 feet x 8.0 feet = 3,026 pounds
$_W$ dead load to panel = 20 psf (9') + 7 psf (4') + 17 psf (8') + 13.5 psf (4') = 398 plf

OTM = 3,026 pounds x 4 foot wall height = 12,103 lb-ft
RTM = 0.9 x 398 plf (10 foot tributary length)(8 foot /2 moment arm) = 14,328 lb-ft
OTM – RTM / panel length = (12,103 – 14,328) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall:

V to 12 foot long panel = 10,590 pounds / 28 feet x 12.0 feet = 4,539 pounds
$_W$ dead load to panel = 20 psf (1') + 7 psf (1.33'/2) = 12 psf (2.67' /2) + 17 psf (8') + 13.5 psf (4') = 230.7 plf
OTM = 4,539 pounds x 4 foot wall height = 18,154 lb-ft
RTM = 0.9 x 230.7 plf (14 foot tributary length)(12 foot /2 moment arm) = 17,438 lb-ft
OTM – RTM / panel length = (18,154 – 17,438) / 12 feet = **60 pounds uplift (Perhaps could Neglect)**
Locate one new sill bolt with plate washer within 6 inches of each 12'-0" braced panel end studs

Overturning of 4 foot high cripple wall with 16 foot minimum panel length along gable end wall:

V to 16 foot long panel = 10,590 pounds / 28 feet x 16.0 feet = 6,051 pounds
$_W$ dead load to panel = 20 psf (1') + 7 psf (1.33'/2) = 12 psf (2.67' /2) + 17 psf (8') + 13.5 psf (4') = 230.7 plf
OTM = 6,051 pounds x 4 foot wall height = 24,206 lb-ft
RTM = 0.9 x 230.7 plf (18 foot tributary length)(16 foot /2 moment arm) = 29,894 lb-ft
OTM – RTM / panel length = (24,206 – 29,894) / 12 feet = **NO uplift**

Shear Transfer Along Each Wall Line
Connection between floor and top of cripple wall or floor and foundation sill plate

V = 10,590 pounds / 450 pounds per connection = **24 L70 or A35, or**
V = 10,590 pounds /585 pounds per connection = **18 L90 or 19 H10R**

Transverse Wall Line = 36 feet = 292 plf
Longitudinal Wall Line = 56 feet = 188 plf

Shear Transfer to Cripple Walls of One Story Buildings

Shear transfer capacity from the first floor into the cripple wall top plate from existing blocking or rim joist (along longitudinal wall lines), or end joist (along transverse wall lines) are determined below.

Along longitudinal walls, floor joists are assumed to be perpendicular and spaced at 16 inches o.c. If existing connections using 8d common toenails at 8 inches on center (two per joist space) exist between the rim joist or blocking, and the cripple wall top plate or foundation sill plate, that connection capacity would equal:
Per 16 inch joist space: 2 nails x 5/6 (for toenails) x 76 pounds (8d common nails) x 1.33 = 168 pounds
168 pounds x 12 / 16 feet = 126 plf capacity

This capacity does not count the two toenails normally connecting each joist to the cripple wall top plate. If only <u>one</u> of these toenails per joist are accounted for, the capacity along the longitudinal wall would equal:
Per 16 inch joist space x 1 nail x 76 pounds/nail x 5/6 x 1.33 = 84 pounds x 12 /16 = 63 plf
126 + 63 pounds 189 plf > 188 plf maximum demand at Case 3D (2000 sq. ft.)

Because toe nails can be difficult to observe and can be ineffective if the wood framing has split at the nails, existing nailing described above may be either absent or ineffective. Also, the current code prohibits the use of toe nails for shear transfer greater than 150 plf. Therefore, because this load path is essential, the shear transfer demand should be accommodated by adding sheet metal angles.

Along transverse walls, if existing 8d toe nailing at 6 inches o.c. is assumed it provides only 168 plf. The demand along the transverse walls exceeds this amount in all Cases except for Case 3A (1200 sq. ft) Therefore, adding sheet metal angles is necessary along transverse walls.

With respect to the ability of existing floor sheathing nailing to transfer shear into the top of the blocking or rim joist member the following analysis is provided:

Along the transverse walls where joists are assumed to be parallel to the wall, the ends of the floor sheathing boards should be nailed to that joist. Assuming 1x 6 straight sheathing with 2 - 8d nails each board, these wall lines should have 4 nails per foot assuming 6 inch wide boards. The capacity provided is 90 pounds per nail x 4 nails x 1.33 = 478 plf capacity. Therefore no supplemental connection between the upper edge of the rim or blocking, and the floor sheathing should be necessary for the maximum 292 plf transverse direction demand of Case 3D (2000 sq. ft.). If the floor sheathing is plywood a lower capacity should be assumed. The typical plywood edge nailing is 8d @ 6”o.c. which gives 76 pounds x 2 nails/ft. x 1.33 = 202 plf. Adding in the 16d sill plate nailing assumed at 16” o.c. through the sheathing to the end joist would add 141 pounds x (0.77 Cd) x 1.33 (12/16) = 109 plf, for a total of 311 plf. This still exceeds the maximum demand of 292 plf.

The longitudinal direction demand is a maximum of 188 plf for Case 3D (2000 sq. ft.). In this case 8d nails from the sheathing into the rim member should occur at 16 inches on center. This corresponds to each sheathing board being nailed to each rim member at the same spacing as the perpendicular joists. In addition, the first story wall sill plate should be nailed into the rim member with 20d (or perhaps larger nails) at 32 inches on center (one every other stud bay). The combined capacity for both types of nails is: 90 pounds x 1.33 x (12/16) + 170 pounds (0.705 Cd) x 1.33 (12 / 32) = 150 plf. This capacity is about 7 – 10% less than the demand for the Case 3C small and large footprint houses and ranges from 14 – 25% less than the demand for the Case 3D houses.

Conclusions about shear transfer from floor to cripple wall in One-Story Buildings:

1) No supplemental connection between the floor sheathing and the top edge of blocking or rim joist should be necessary in a one story condition, even though along longitudinal walls the assumed capacity is less than the demand in some Cases.

2) Sheet metal angles should be provided between the bottom edge of joists or blocking and the top plate or foundation sill plate.

Cripple Wall Top Plate used as a Collector in One Story Buildings

Where an existing cripple wall uses a single top plate, or has a double top plate constructed without a standard lap splice as required by the code (e.g., 4 foot lap with 8 –16d nails) these conditions may create a weak link in a top plate being used as a collector between widely spaced retrofit braced wall segments. The collector force along the longitudinal walls (where joists are assumed perpendicular) varies from 103 plf to 188 plf . For the case of the 2,016 sq. ft. building with a 56 foot long wall where a total of 28 feet of bracing is provided, if this bracing is located in two sections only at each end of the wall, the collector length will be one half of the distance between the two 14 foot long braced segments. For this case, the maximum force demand along this collector occurs where it connects to the braced sections of the cripple wall, and is determined below:

(56 feet - 28 feet) / 2 x 188 plf = **2,632 pounds**

The actual connection force will be proportionally less by 188 pounds per foot, where the butt joint occurs further away from the end of the braced panel and closer to the mid length of the wall. If braced panels are distributed along the length of the wall, rather than concentrated at the ends only, the splice connection force is also reduced, such that the maximum demand for this example is 188 plf times one-half the distance in feet between the braced wall ends. Where a top plate butt joint occurs within the length of a braced panel the sheathing nailing will also aid in providing a splice. However, the code does not permit using sheathing as a method of providing a collector splice, therefore wherever a top plate butt joint occurs it should be provided with a positive connection between the two pieces (2001 CBC Sec. 2315.5.2)

A splice connection for a 2,632 pound demand could to be made with bolts or nails. A bolted connection could be provided by installing a 4 – 1/2” bolts vertically through a single 2x top plate on each side of the butt joint, using a 16 inch long ¼ inch thick plate with bolts located 4 inches minimum from the butt joint and spaced 2.5 inches on center. An alternative splice could be made with an 18 gage strap nailed into the vertical face of the top plate having a total of 36 - 16d sinker nails. To prevent splitting, nails should be staggered and spaced not less than 1-½ inches apart. Commercially available straps with the necessary capacity would require that blocking be installed below the existing plate to allow for a second row of nails. The blocking would also need to be attached to the top plate with 16 – 10d common nails along the length of the strap.

For the 36 foot long transverse wall, the maximum collector force is 288 plf for the Case 3D (2000 sq. ft.) house, and its maximum length is (36’ – 28’) / 2 = 4.0 feet, therefore the force is 1,060 pounds. Along the transverse walls, the parallel end joist should be connected to the top plate as described above with L70 or equivalent angles, therefore a continuous joist should be able to act as the splice member for a single top plate IF the end butt joint of the top plate and end joint of the joist are offset, and the quantity of L70 angles on each side can provide the needed splice capacity. Where end joints in both the joist and a single top plate occur in close proximity, an additional splice connection of the top plate should be provided.

Conclusions about splices for single top plates of cripple walls.

The actual force at a splice of a single top plate in a cripple wall can vary greatly depending on the location of the splice with respect to the layout of the bracing panels along the wall. The code’s prescriptive double top plate splice for conventional construction provides a seismic tension capacity of 1,500 pounds and therefore a retrofit code should likely prescribe a similar capacity connection. This would most easily be provided by an 30 inch long 18 gage strap with 22 - 10d full length nails to provide that capacity, such as a Simpson LSTA or MSTA, nailed to the vertical face of the top plate.

Overturning Considerations for One-Story Buildings

The overturning calculations provided for each Case assume a lateral force within each braced panel that is directly proportional to its length as a fraction of the overall minimum length of bracing to be provided. For example if the total lateral load to a wall line is 7,600 pounds and the minimum bracing length is 20 feet, each 8 foot long panel section of bracing will be loaded with (7,600 / 20) x 8 = 3,040 pounds.

Dead load resistance to overturning is based on the unit weights for the various floor, roof and wall assembles assumed for each Case, and the tributary area supported by the cripple wall. **For roof loads tributary to a wall no roof overhang is assumed**. For the longitudinal walls the width of roof tributary to the exterior walls is 7’-6” for the 30 foot wide houses and 9 feet for the 36 foot wide house. These distances are based on one-quarter of the rafter span to the ridge, and are predicated on a purlin support being present at the halfway span of the rafter between the exterior wall and the roof ridge line. The width of first floor tributary to the longitudinal walls is 4 feet, based on an 8-foot span of floor joists to the first interior line of girders. Typically, the wall length resisting overturning is assumed to be 2 feet longer than the length of the braced wall panel. For example, a 4-foot long braced panel is assumed to engage 6 feet of tributary length for overturning resistance.

Because each individual braced wall length must be at least twice the cripple wall height, a maximum 4-foot height wall requires an 8-foot minimum bracing panel length. This requirement intends to reduce the uplift forces imposed by overturning. However, based on the calculations, net uplift will occur, particularly along the transverse gable end walls and even along the longitudinal (bearing) walls in the Cases having a lightweight roof.

Conclusions about uplift restraint for cripple walls of One-story house:

For 4”-0” tall walls having 8’-0” long braced panels, net uplift forces of up to 1000 pounds (ASD) are calculated to occur. In other cases the net uplift is 500 pounds or less. For these fairly small uplift forces, the use of foundation sill plate anchor bolts with plate washers could be utilized as restraint, based on the following.
For example a ½” diameter Kwik Bolt with 3-1/2” embed and 3-1/2” edge distance (20% redcution) has a tension capacity <u>without special inspection</u> of 700 pounds in 2000 psi concrete. Wedge-All anchors have smaller values of 532 pounds for ½” diameter <u>without special inspection</u> and assuming a 3-1/2 inch edge distance for 2000 psi concrete**. The minimum edge distances will require placing the bolts approximately 1 inch from the centerline of a 2x6 nominal sill plate. This would preclude the use of a flush cut sill method because the bolt would be too close to the edge of the cut face of the sill plate. A threaded rod installed with epoxy would be an alternative where an edge distance less than 3-1/2 inches is used.**

For uplifts between zero and 550 pounds, a single expansion anchor bolt with plate washer could be located within 6 inches of the stud at each braced panel segment. Plate washers in this case should be wider and thicker than the minimum 2 x 2 x 3/16 inch typical plate washer to provide the uplift resistance. On a 2x6 nominal sill plate with the anchor bolt offset from the center of the sill plate by 1 inch a 5 x 5 x 3/8 inch washer with a 2 inch long diagonal slot is recommended.

For uplifts between 550 and 1000 pounds, a pair of sill anchorage expansion anchor bolts with plate washers could be used to resist this uplift. One bolt could be located within 6 inches of each side of the stud at each end of each brace d panel segment. Alternatively, an FJA / FSA type strap nailed to the end stud and bolted into the face of the foundation stem wall could be used for forces up to 1000 pounds.

Case 3A Two Story Demand / Capacity for 30 ft x 40 ft (2,400 Sq. Ft.)

Assume SD soil with Ca = 0.44; Na = 1.3; I = 1.00; and R = 5.5; Conversion to ASD force level: 1 / 1.4
Seismic V = 0.186 W

Dead loads (W) tributary to cripple wall level for 30 x 40 two story = 2,400 square feet:

Roof/Ceiling: 11 psf (34' x 44') = 16.456 kips

Second Floor: 9 psf (30' x 40') = 10.80 kips First floor: 7 psf (30' x 40') = 8.40 kips

Exterior Walls:

1^{st} & 2^{nd} Story walls:	8 psf (16') (30' x 2 + 40' x 2) =	17.92 kips
Gable end walls:	5 psf (5' x 30') 2 / 2 =	0.75 kips
Cripple walls:	6 psf (2') (30' x 2 + 40' x 2) =	<u>1.68 kips</u>
		20.35 kips

Interior wall: 8 psf (8') (29' x 5 + 39' x 3) = 16.768 kips

Sum W = 16.46 + 10.8 + 8.4 + 20.35 + 16.77 = 72.77 kips
Total V = (0.186) W = 13.536 kips
V to each cripple wall line = 13.536 / 2 = **6.77 kips**

Number of sill bolts needed along any wall:

6,768 pounds / 820 pounds/bolt = **9 – 1/2” bolts**
6,768 pounds / 1170 pounds/bolt = **6 – 5/8” bolts**
6,768 pounds / 1340 pounds/UFP10 = **6 UFP10**

Length of cripple wall braced with 15/32” rated plywood sheathing w/ 8d @ 4" edge nailing:

V to each wall line / unit capacity = lineal feet of panel based on 16” stud spacing
6,768 pounds / 380 plf = **18’-8”**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 6,768 pounds / 18.67 feet x 4.0 feet = 1,450 pounds
$_W$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (2’) =168.3 plf
OTM = 1,450 pounds x 2 foot wall height = 2,900 lb-ft
RTM = 0.9 x 168.3 plf (6 foot tributary length)(4 foot /2 moment arm) = 1,818 lb-ft
OTM – RTM / panel length = (2,900 – 1,818) / 4 feet = **271 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4’-0” braced panel end studs

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 6,768 pounds / 18.67 feet x 4.0 feet = 1,450 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 9 psf (7.5’) + 8 psf (16’) + 6 psf (2’) = 318 plf
OTM = 1,450 pounds x 2 foot wall height = 2,900 lb-ft
RTM = 0.9 x 318 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,434 lb-ft
OTM – RTM / panel length = (2,900 – 3,434) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 6,768 pounds / 18.67 feet x 8.0 feet =2,900 pounds
$_W$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (2’) =168.3 plf
OTM = 2,900 pounds x 2 foot wall height = 5,801 lb-ft
RTM = 0.9 x 168.3 plf (10 foot tributary length)(8 foot /2 moment arm) = 6,060 lb-ft
OTM – RTM / panel length = (5,801 – 6,060) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 6,768 pounds / 18.67 feet x 8.0 feet = 2,900 pounds
$_W$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (4’) =180.3 plf
OTM = 2,900 pounds x 4 foot wall height = 11,602 lb-ft
RTM = 0.9 x 180.3 plf (10 foot tributary length)(8 foot) /2 moment arm) = 6,492 lb-ft
OTM – RTM / panel length = (11,602 – 6,492) / 8 feet = **639 pounds uplift**
Locate two new sill bolts with plate washer within 6 inches of each 8’-0” panel end studs (one each side)

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 6,768 pounds / 18.67 feet x 8.0 feet = 2,900 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 9 psf (7.5’) + 8 psf (16’) + 6 psf (4’) = 330 plf
OTM = 2,900 pounds x 4 foot wall height = 11,602 lb-ft
RTM = 0.9 x 330 plf (10 foot tributary length)(8 foot) /2 moment arm) = 11,880 lb-ft
OTM – RTM / panel length = (11,602 – 11,880) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 6,768 pounds / 18.67 feet x 12.0 feet = 4,351 pounds
$_W$ dead load to panel = 11 psf (1') + (9 psf +7 psf)(1.33'/2) + 5 psf (2.67'/2) + 8 psf (16') + 6 psf (4') =180.3 plf
OTM = 4,351 pounds x 4 feet wall height = 17,403 lb-ft
RTM = 0.9 x 180.3 plf (14 feet tributary length)(12 feet) /2 moment arm) = 13,633 lb-ft
OTM – RTM / panel length = (17,403 – 13,633) / 12 feet = **314 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 12'-0" braced panel end studs

Overturning of 4 foot high cripple wall with 16 foot minimum panel length along gable end wall

V to 12 foot long panel = 6,768 pounds / 18.67 feet x 16.0 feet = 5,801 pounds
$_W$ dead load to panel = 11 psf (1') + (9 psf +7 psf)(1.33'/2) + 5 psf (2.67'/2) + 8 psf (16') + 6 psf (4') =180.3 plf
OTM = 5,801 pounds x 4 feet wall height = 23,205 lb-ft
RTM = 0.9 x 180.3 plf (18 feet tributary length)(16 feet) /2 moment arm) = 23,371 lb-ft
OTM – RTM / panel length = (23,205 – 23,371) / 16 feet = **NO uplift**

Shear Transfer Along Each Wall Line

V = 6,768 pounds / 450 pounds per connection = **15 L70 or A35, or**
V = 6,768 pounds / 585 pounds per connection = **11 L90 or H10R**

Transverse Wall Line = 30 feet = 226 plf
Longitudinal Wall Line = 40 feet = 169 plf

Case 3A Two Story Demand / Capacity for 30 ft x 30 ft (1,800 Sq. Ft.)

Dead loads (W) tributary to cripple wall level for 1,800 square feet:

Roof/Ceiling: 11 psf (34' x 34') = 12.716 kips

Second Floor: 9 psf (30' x 30') = 8.10 kips   First floor: 7 psf (30' x 30') = 6.30 kips

Exterior Walls:

1st & 2nd Story walls:	8 psf (16') (30' x 2 + 30' x 2) =	15.36 kips
Gable end walls:	5 psf (5' x 30') 2 / 2 =	0.75 kips
Cripple walls:	6 psf (2') (30' x 2 + 30' x 2) =	1.44 kips
		17.55 kips

Interior wall: 8 psf (8') (29' x 5 + 29' x 3) = 14.848 kips

Sum W = 12.72 + 8.10 + 6.30 + 17.55 + 14.85 = 59.51 kips
Total V = (0.186) W = 11.070 kips
V to each cripple wall line = 11.070 / 2 = **5.535 kips**

Number of sill bolts needed along any wall:
5,535 pounds / 820 pounds/bolt = **7 – 1/2" bolts**
5,535 pounds / 1170 pounds/bolt = **5 – 5/8" bolts**
5,535 pounds / 1340 pounds/UFP10 = **5 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of panel based on 16 inch stud spacing

5,535 pounds / 380 plf **= 14’-8”**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 5,535 pounds / 14.67 feet x 4.0 feet = 1,510 pounds
$_W$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (2’) =168.3 plf
OTM = 1,510 pounds x 2 foot wall height = 3,019 lb-ft
RTM = 0.9 x 168.3 plf (6 foot tributary length)(4 foot /2 moment arm) = 1,818 lb-ft
OTM – RTM / panel length = (3,019 – 1,818) / 4 feet = **300 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4’-0” braced panel end studs

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 5,535 pounds / 14.67 feet x 4.0 feet = 1,510 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 9 psf (7.5’) + 8 psf (16’) + 6 psf (2’) = 318 plf
OTM = 1,510 pounds x 2 foot wall height = 3,019 lb-ft
RTM = 0.9 x 318 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,434 lb-ft
OTM – RTM / panel length = (3,019 – 3,434) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 5,535 pounds / 14.67 feet x 8.0 feet =3,019 pounds
$_W$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (2’) =168.3 plf
OTM = 3,019 pounds x 2 foot wall height = 6,038 lb-ft
RTM = 0.9 x 168.3 plf (10 foot tributary length)(8 foot /2 moment arm) = 6,060 lb-ft
OTM – RTM / panel length = (6,038 – 6,060) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 5,535 pounds / 14.67 feet x 8.0 feet = 3,019 pounds
$_W$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (4’) =180.3 plf
OTM = 3,019 pounds x 4 foot wall height = 12,076 lb-ft
RTM = 0.9 x 180.3 plf (10 foot tributary length)(8 foot) /2 moment arm) = 6,492 lb-ft
OTM – RTM / panel length = (12,076 – 6,492) / 8 feet = **698 pounds uplift**
Locate two new sill bolts with plate washer within 6 inches of each 8’-0” panel end studs (one each side)

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 5,535 pounds / 14.67 feet x 8.0 feet = 3,019 pounds
$_W$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 9 psf (7.5’) + 8 psf (16’) + 6 psf (4’) = 330 plf
OTM = 3,019 pounds x 4 foot wall height = 12,076 lb-ft
RTM = 0.9 x 330 plf (10 foot tributary length)(8 foot) /2 moment arm) = 11,880 lb-ft
OTM – RTM / panel length = (12,076 – 11,880) / 8 feet = **25 pounds uplift (Neglect)**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 5,535 pounds / 14.67 feet x 12.0 feet = 4,529 pounds
$_W$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (4’) =180.3 plf
OTM = 4,529 pounds x 4 feet wall height = 18,115 lb-ft
RTM = 0.9 x 180.3 plf (14 feet tributary length)(12 feet /2 moment arm) = 13,633 lb-ft
OTM – RTM / panel length = (18,115 – 13,633) / 12 feet = **373 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 12’-0” braced panel end studs

Overturning of 4 foot high cripple wall with 14’-8” continuous panel length along gable end wall

V to 14’-8” foot long panel = 5,535 pounds
$_W$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (4’) =180.3 plf
OTM = 5,535 pounds x 4 feet wall height = 22,140 lb-ft
RTM = 0.9 x 180.3 plf (16.67 feet tributary length)(14.67 feet /2 moment arm) = 19,837 lb-ft
OTM – RTM / panel length = (22,140 – 19,837) / 14.67 feet = **157 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 14’-8” braced panel end studs

Shear Transfer Along Each Wall Line

V = 5,535 pounds / 450 pounds per connection = **13 L70 or A35, or**
V = 5,535 pounds / 585 pounds per connection = **10 L90 or H10R**

Transverse Wall Line = 30 feet = 185 plf
Longitudinal Wall Line = 30 feet = 185 plf

Case 3A Two Story Demand / Capacity for 30’ x 50’ = 3,000 square feet

Dead loads (W) tributary to cripple wall level for 3,000 square feet:

Roof/Ceiling: 11 psf (34' x 54') = 20.196 kips

Second Floor: 9 psf (30' x 50') = 13.50 kips First floor: 7 psf (30' x 50') = 10.50 kips

Exterior Walls:

1st & 2nd Story walls:	8 psf (16') (30' x 2 + 50' x 2) =	20.48 kips
Gable end walls:	5 psf (5' x 30') 2 / 2 =	0.75 kips
Cripple walls:	6 psf (2') (30' x 2 + 50' x 2) =	1.92 kips
		23.15 kips

Interior wall: 8 psf (8') (29' x 5 + 49' x 3) = 18.688 kips

Sum W = 20.20 + 13.50 + 10.50 + 23.15 + 18.69 = 86.03 kips
Total V = (0.186) W = 16.002 kips
V to each cripple wall line = 16.002 / 2 = **8.00 kips**

Number of sill bolts needed along any wall:
8,001 pounds / 820 pounds/bolt = **10 – 1/2” bolts**
8,001 pounds / 1170 pounds/bolt = **7 – 5/8” bolts**
8,001 pounds / 1340 pounds/UFP10 = **6 UFP10**

Length of cripple wall braced with 15/32” rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of panel based on 16 inch stud spacing
8,001 pounds / 380 plf **= 21’-4”**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 8,001 pounds / 21.33 feet x 4.0 feet = 1,500 pounds
$_{W}$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (2’) =168.3 plf
OTM = 1,500 pounds x 2 foot wall height = 3,000 lb-ft
RTM = 0.9 x 168.3 plf (6 foot tributary length)(4 foot /2 moment arm) = 1,818 lb-ft
OTM – RTM / panel length = (3,000 – 1,818) / 4 feet = **296 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4’-0” braced panel end studs

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 8,001 pounds / 21.33 feet x 4.0 feet = 1,500 pounds
$_{W}$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 9 psf (7.5’) + 8 psf (16’) + 6 psf (2’) = 318 plf
OTM = 1,500 pounds x 2 foot wall height = 3,000 lb-ft
RTM = 0.9 x 318 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,434 lb-ft
OTM – RTM / panel length = (3,000 – 3,434) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 8,001 pounds / 21.33 feet x 8.0 feet =3,000 pounds
$_{W}$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (2’) =168.3 plf
OTM = 3,000 pounds x 2 foot wall height = 6,001 lb-ft
RTM = 0.9 x 168.3 plf (10 foot tributary length)(8 foot /2 moment arm) = 6,060 lb-ft
OTM – RTM / panel length = (6,001 – 6,060) / 8 feet = **NO uplift**
Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 8,001 pounds / 21.33 feet x 8.0 feet = 3,000 pounds
$_{W}$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (4’) =180.3 plf
OTM = 3,000 pounds x 4 foot wall height = 12,002 lb-ft
RTM = 0.9 x 180.3 plf (10 foot tributary length)(8 foot) /2 moment arm) = 6,492 lb-ft
OTM – RTM / panel length = (12,002 – 6,492) / 8 feet = **689 pounds uplift**
Locate two new sill bolts with plate washer within 6 inches of each 8’-0” panel end studs (one each side)

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 8,001 pounds / 21.33 feet x 8.0 feet = 3,000 pounds
$_{W}$ dead load to panel = 11 psf (7.5’) + 7 psf (4’) + 9 psf (7.5’) + 8 psf (16’) + 6 psf (4’) = 330 plf
OTM = 3,000 pounds x 4 foot wall height = 12,002 lb-ft
RTM = 0.9 x 330 plf (10 foot tributary length)(8 foot) /2 moment arm) = 11,880 lb-ft
OTM – RTM / panel length = (12,002 – 11,880) / 8 feet = **15 pounds uplift (Neglect)**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 8,001 pounds / 21.33 feet x 12.0 feet = 4,501 pounds
$_{W}$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (4’) =180.3 plf
OTM = 4,501 pounds x 4 feet wall height = 18,002 lb-ft
RTM = 0.9 x 180.3 plf (14 feet tributary length)(12 feet) /2 moment arm) = 13,633 lb-ft
OTM – RTM / panel length = (18,002 – 13,633) / 12 feet = **364 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 12’-0” braced panel end studs

Overturning of 4 foot high cripple wall with 16 foot minimum panel length along gable end wall

V to 12 foot long panel = 8,001 pounds / 21.33 feet x 16.0 feet = 6,001 pounds
$_{W}$ dead load to panel = 11 psf (1’) + (9 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 8 psf (16’) + 6 psf (4’) =180.3 plf
OTM = 6,001 pounds x 4 feet wall height = 24,003 lb-ft
RTM = 0.9 x 180.3 plf (18 feet tributary length)(16 feet) /2 moment arm) = 23,371 lb-ft

OTM – RTM / panel length = (24,003 – 23,271) / 16 feet = **40 pounds uplift (Neglect)**

Shear Transfer Along Each Wall Line

V = 8,001 pounds / 450 pounds per connection = **18 L70 or A35, or**
V = 8,001 pounds / 585 pounds per connection = **14 L90 or H10R**

Transverse Wall Line = 30 feet = 267 plf
Longitudinal Wall Line = 50 feet = 160 plf

Case 3B Two Story Demand / Capacity for 30 ft x 40 ft (2,400 Sq. Ft.)

Assume SD soil with Ca = 0.44; Na = 1.3; I = 1.00; and R = 5.5; Conversion to ASD force level: 1 / 1.4
Seismic V = 0.186 W

Dead loads (W) tributary to cripple wall level for 30 x 40 two story = 2,400 square feet:

Roof/Ceiling: 14 psf (34' x 44') = 20.944 kips

Second Floor: 11 psf (30' x 40') = 13.20 kips First floor: 7 psf (30' x 40') = 8.40 kips

Exterior Walls:

1st & 2nd Story walls:	10 psf (16') (30' x 2 + 40' x 2) =	22.40 kips
Gable end walls:	5 psf (5' x 30') 2 / 2 =	0.75 kips
Cripple walls:	6 psf (2') (30' x 2 + 40' x 2) =	1.68 kips
		24.83 kips

Interior wall: 12 psf (8') (29' x 5 + 39' x 3) = 25.152 kips

Sum W = 20.94 + 13.2 + 8.4 + 24.83 + 25.15 = 92.53 kips
Total V = (0.186) W = 17.210 kips
V to each cripple wall line = 17.210 / 2 = **8.60 kips**

Number of sill bolts needed along any wall:
8,605 pounds / 820 pounds/bolt = **11 – 1/2” bolts**
8,605 pounds / 1170 pounds/bolt = **8 – 5/8” bolts**
8,605 pounds / 1340 pounds/UFP10 = **7 UFP10**

Length of cripple wall braced with 15/32” rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of panel based on 16” stud spacing
8,605 pounds / 380 plf = **22’-8”**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 8,605 pounds / 22.67 feet x 4.0 feet = 1,519 pounds
$_W$ dead load to panel = 14 psf (1’) + (11 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 10 psf (16’) + 6 psf (2’) =204.7
OTM = 1,519 pounds x 2 foot wall height = 3,037 lb-ft
RTM = 0.9 x 204.7 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,210 lb-ft
OTM – RTM / panel length = (3,037 – 2,210) / 4 feet = **207 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4’-0” braced panel end studs

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 8,605 pounds / 22.67 feet x 4.0 feet = 1,519 pounds
$_W$ dead load to panel = 14 psf (7.5’) + 7 psf (4’) + 11 psf (7.5’) + 10 psf (16’) + 6 psf (2’) = 387.5 plf
OTM = 1,519 pounds x 2 foot wall height = 3,037 lb-ft
RTM = 0.9 x 387.5 plf (6 foot tributary length)(4 foot /2 moment arm) = 4,185 lb-ft
OTM – RTM / panel length = (3,037 – 4,185) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 8,605 pounds / 22.67 feet x 8.0 feet = 3,037 pounds
$_W$ dead load to panel = 14 psf (1’) + (11 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 10 psf (16’) + 6 psf (2’) =204.7
OTM = 3,037 pounds x 2 foot wall height = 6,074 lb-ft
RTM = 0.9 x 204.7 plf (10 foot tributary length)(8 foot /2 moment arm) = 7,368 lb-ft
OTM – RTM / panel length = (6,074 – 7,368) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 8,605 pounds / 22.67 feet x 8.0 feet = 3,037 pounds
$_W$ dead load to panel = 14 psf (1’) + (11 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 10 psf (16’) + 6 psf (4’) =216.7
OTM = 3,037 pounds x 4 foot wall height = 12,148 lb-ft
RTM = 0.9 x 216.7 plf (10 foot tributary length)(8 foot) /2 moment arm) = 7,800 lb-ft
OTM – RTM / panel length = (12,148 – 7,800) / 8 feet = **544 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8’-0” panel end studs

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 8,605 pounds / 22.67 feet x 8.0 feet = 3,037 pounds
$_W$ dead load to panel = 14 psf (7.5’) + 7 psf (4’) + 11 psf (7.5’) + 10 psf (16’) + 6 psf (4’) = 399.5 plf
OTM = 3,037 pounds x 4 foot wall height = 12,148 lb-ft
RTM = 0.9 x 399.5 plf (10 foot tributary length)(8 foot) /2 moment arm) = 14,382 lb-ft
OTM – RTM / panel length = (12,148 – 14,382) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 8,605 pounds / 22.67 feet x 12.0 feet = 4,556 pounds
$_W$ dead load to panel = 14 psf (1’) + (11 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 10 psf (16’) + 6 psf (4’) =216.7
OTM = 4,556 pounds x 4 feet wall height = 18,222 lb-ft
RTM = 0.9 x 216.7 plf (14 feet tributary length)(12 feet) /2 moment arm) = 16,380 lb-ft
OTM – RTM / panel length = (18,222 – 16,380) / 12 feet = **153 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 12’-0” braced panel end studs

Overturning of 4 foot high cripple wall with 16 foot minimum panel length along gable end wall

V to 12 foot long panel = 8,605 pounds / 22.67 feet x 16.0 feet = 6,074 pounds
$_W$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) + 5 psf (2.67'/2) + 10 psf (16') + 6 psf (4') =216.7
OTM = 6,074 pounds x 4 feet wall height = 24,296 lb-ft
RTM = 0.9 x 216.7 plf (18 feet tributary length)(16 feet) /2 moment arm) = 28,080 lb-ft
OTM – RTM / panel length = (24,296 – 28,080) / 16 feet = **NO uplift**

Shear Transfer Along Each Wall Line

V = 8,605 pounds / 450 pounds per connection = **20 L70 or A35, or**
V = 8,605 pounds / 585 pounds per connection = **15 L90 or H10R**

Transverse Wall Line = 30 feet = 287 plf
Longitudinal Wall Line = 40 feet = 215 plf

Case 3B Two Story Demand / Capacity for 30 ft x 30 ft (1,800 Sq. Ft.)

Dead loads (W) tributary to cripple wall level for 1,800 square feet:

Roof/Ceiling: 14psf (34' x 34') = 16.184 kips

Second Floor: 11 psf (30' x 30') = 9.90 kips   First floor: 7 psf (30' x 30') = 6.30 kips

Exterior Walls:

1st & 2nd Story walls:	10 psf (16') (30' x 2 + 30' x 2) =	19.20 kips
Gable end walls:	5 psf (5' x 30') 2 / 2 =	0.75 kips
Cripple walls:	6 psf (2') (30' x 2 + 30' x 2) =	1.44 kips
		21.39 kips

Interior wall: 12 psf (8') (29' x 5 + 29' x 3) = 22.272 kips

Sum W = 16.18 + 9.90 + 6.30 + 21.39 + 22.27 = 76.05 kips
Total V = (0.186) W = 14.145 kips
V to each cripple wall line = 14.145 / 2 = **7.07 kips**

Number of sill bolts needed along any wall:
7,072 pounds / 820 pounds/bolt = **9 – 1/2" bolts**
7,072 pounds / 1170 pounds/bolt = **7 – 5/8" bolts**
7,072 pounds / 1340 pounds/UFP10 = **6 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of panel based on 16 inch stud spacing
7,072 pounds / 380 plf **= 18'-8"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 7,072 pounds / 18.67 feet x 4.0 feet = 1,515 pounds
$_W$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) + 5 psf (2.67'/2) + 10 psf (16') + 6 psf (2') = 204.7
OTM = 1,515 pounds x 2 foot wall height = 3,031 lb-ft
RTM = 0.9 x 204.7 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,210 lb-ft

OTM – RTM / panel length = (3,031 – 2,210) / 4 feet = **205 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4'-0" braced panel end studs

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 7,072 pounds / 18.67 feet x 4.0 feet = 1,515 pounds
$_W$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 11 psf (7.5') + 10 psf (16') + 6 psf (2') = 387.5 plf
OTM = 1,515 pounds x 2 foot wall height = 3,031 lb-ft
RTM = 0.9 x 387.5 plf (6 foot tributary length)(4 foot /2 moment arm) = 4,185 lb-ft
OTM – RTM / panel length = (3,031 – 4,185) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 7,072 pounds / 18.67 feet x 8.0 feet = 3,031 pounds
$_W$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) + 5 psf (2.67'/2) + 10 psf (16') + 6 psf (2') = 204.7
OTM = 3,031 pounds x 2 foot wall height = 6,062 lb-ft
RTM = 0.9 x 204.7 plf (10 foot tributary length)(8 foot /2 moment arm) = 7,368 lb-ft
OTM – RTM / panel length = (6,062 – 7,368) / 8 feet = **NO uplift**
Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 7,072 pounds / 18.67 feet x 8.0 feet = 3,031 pounds
$_W$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) + 5 psf (2.67'/2) + 10 psf (16') + 6 psf (4') = 216.7
OTM = 3,031 pounds x 4 foot wall height = 12,123 lb-ft
RTM = 0.9 x 216.7 plf (10 foot tributary length)(8 foot) /2 moment arm) = 7,800 lb-ft
OTM – RTM / panel length = (12,123 – 7,800) / 8 feet = **540 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8'-0" panel end studs

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 7,072 pounds / 18.67 feet x 8.0 feet = 3,031 pounds
$_W$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 11 psf (7.5') + 10 psf (16') + 6 psf (4') = 399.5 plf
OTM = 3,031 pounds x 4 foot wall height = 12,123 lb-ft
RTM = 0.9 x 399.5 plf (10 foot tributary length)(8 foot) /2 moment arm) = 14,382 lb-ft
OTM – RTM / panel length = (12,123 – 14,382) / 8 feet = **No uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 7,072 pounds / 18.67 feet x 12.0 feet = 4,546 pounds
$_W$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) + 5 psf (2.67'/2) + 10 psf (16') + 6 psf (4') = 216.7
OTM = 4,546 pounds x 4 feet wall height = 18,185 lb-ft
RTM = 0.9 x 216.7 plf (14 feet tributary length)(12 feet) /2 moment arm) = 16,380 lb-ft
OTM – RTM / panel length = (18,185 – 16,380) / 12 feet = **150 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 12'-0" braced panel end studs

Overturning of 4 foot high cripple wall with 16 foot minimum panel length along gable end wall

V to 12 foot long panel = 7,072 pounds / 18.67 feet x 16.0 feet = 6,062 pounds
$_W$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) + 5 psf (2.67'/2) + 10 psf (16') + 6 psf (4') = 216.7
OTM = 6,062 pounds x 4 feet wall height = 24,247 lb-ft
RTM = 0.9 x 216.7 plf (18 feet tributary length)(16 feet) /2 moment arm) = 28,080 lb-ft
OTM – RTM / panel length = (24,247 – 28,080) / 16 feet = **NO uplift**

Shear Transfer Along Each Wall Line

V = 7,072 pounds / 450 pounds per connection = **16 L70 or A35, or**
V = 7,072 pounds / 585 pounds per connection = **12 L90 or 13 H10R**

Transverse Wall Line = 30 feet = 236 plf
Longitudinal Wall Line = 30 feet = 236 plf

Case 3B Two Story Demand / Capacity for 30’ x 50’ = 3,000 square feet

Dead loads (W) tributary to cripple wall level for 3,000 square feet:

Roof/Ceiling: 14 psf (34' x 54') = 25.704 kips

Second Floor: 11 psf (30' x 50') = 16.50 kips   First floor: 7 psf (30' x 50') = 10.50 kips

Exterior Walls:
1st & 2nd Story walls: 10 psf (16') (30' x 2 + 50' x 2) = 25.60 kips
Gable end walls: 5 psf (5' x 30') 2 / 2 = 0.75 kips
Cripple walls: 6 psf (2') (30' x 2 + 50' x 2) = <u>1.92 kips</u>
28.27 kips
Interior wall: 12 psf (8') (29' x 5 + 49' x 3) = 28.032 kips

Sum W = 25.70 + 16.50 + 10.50 + 28.27 + 28.03 = 109.01 kips
Total V = (0.186) W = 20.275 kips
V to each cripple wall line = 20.275 / 2 = **10.14 kips**

Number of sill bolts needed along any wall:
10,138 pounds / 820 pounds/bolt = **13 – 1/2” bolts**
10,138 pounds / 1170 pounds/bolt = **9 – 5/8” bolts**
10,138 pounds / 1340 pounds/UFP10 = **8 UFP10**

Length of cripple wall braced with 15/32” rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of panel based on 16 inch stud spacing
10,138 pounds / 380 plf **= 26’-8” or for 10d @ 4”** 10,138 pounds / 460 plf **= 22’-8”**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:
Using 10d @ 4” edge nailing
V to 4 foot long panel = 10,138 pounds / 22.67 feet x 4.0 feet = 1,789 pounds
$_{W}$ dead load to panel = 14 psf (1’) + (11 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 10 psf (16’) + 6 psf (2’) = 204.7
OTM = 1,789 pounds x 2 foot wall height = 3,578 lb-ft
RTM = 0.9 x 204.7 plf (6 foot tributary length)(4 foot /2 moment arm) = 2,210 lb-ft
OTM – RTM / panel length = (3,578 – 2,210) / 4 feet = **342 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 4’-0” braced panel end studs

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 10,138 pounds / 22.67 feet x 4.0 feet = 1,789 pounds
$_W$ dead load to panel = 14 psf (7.5’) + 7 psf (4’) + 11 psf (7.5’) + 10 psf (16’) + 6 psf (2’) = 387.5 plf
OTM = 1,789 pounds x 2 foot wall height = 3,578 lb-ft
RTM = 0.9 x 387.5 plf (6 foot tributary length)(4 foot /2 moment arm) = 4,185 lb-ft
OTM – RTM / panel length = (3,578 – 4,185) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 8 foot minimum panel length along gable end wall:

V to 8 foot long panel = 10,138 pounds / 22.67 feet x 8.0 feet = 3,578 pounds
$_W$ dead load to panel = 14 psf (1’) + (11 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 10 psf (16’) + 6 psf (2’) = 204.7
OTM = 3,578 pounds x 2 foot wall height = 7,156 lb-ft
RTM = 0.9 x 204.7 plf (10 foot tributary length)(8 foot /2 moment arm) = 7,368 lb-ft
OTM – RTM / panel length = (7,156 – 7,368) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 10,138 pounds / 22.67 feet x 8.0 feet = 3,578 pounds
$_W$ dead load to panel = 14 psf (1’) + (11 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 10 psf (16’) + 6 psf (4’) = 216.7
OTM = 3,578 pounds x 4 foot wall height = 14,312 lb-ft
RTM = 0.9 x 216.7 plf (10 foot tributary length)(8 foot) /2 moment arm) = 7,800 lb-ft
OTM – RTM / panel length = (14,312 – 7,800) / 8 feet = **814 pounds uplift**
Locate two new sill bolts with plate washer within 6 inches of each 8’-0” panel end studs (one each side)

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 10,138 pounds / 22.67 feet x 8.0 feet = 3,578 pounds
$_W$ dead load to panel = 14 psf (7.5’) + 7 psf (4’) + 11 psf (7.5’) + 10 psf (16’) + 6 psf (4’) = 399.5 plf
OTM = 3,578 pounds x 4 foot wall height = 14,312 lb-ft
RTM = 0.9 x 399.5 plf (10 foot tributary length)(8 foot) /2 moment arm) = 14,382 lb-ft
OTM – RTM / panel length = (14,312 – 14,382) / 8 feet = **No uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 10,138 pounds / 22.67 feet x 12.0 feet = 5,367 pounds
$_W$ dead load to panel = 14 psf (1’) + (11 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 10 psf (16’) + 6 psf (4’) = 216.7
OTM = 5,367 pounds x 4 feet wall height = 21,469 lb-ft
RTM = 0.9 x 216.7 plf (14 feet tributary length)(12 feet) /2 moment arm) = 16,380 lb-ft
OTM – RTM / panel length = (21,469 – 16,380) / 12 feet = **424 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each braced panel end studs

Overturning of 4 foot high cripple wall with 16 foot minimum panel length along gable end wall

V to 12 foot long panel = 10,138 pounds / 22.67 feet x 12.0 feet = 7,156 pounds
$_W$ dead load to panel = 14 psf (1’) + (11 psf +7 psf)(1.33’/2) + 5 psf (2.67’/2) + 10 psf (16’) + 6 psf (4’) = 216.7
OTM = 7,156 pounds x 4 feet wall height = 28,625 lb-ft
RTM = 0.9 x 216.7 plf (18 feet tributary length)(16 feet) /2 moment arm) = 28,080 lb-ft
OTM – RTM / panel length = (28,625 – 28,080) / 16 feet = **34 pounds uplift (Neglect)**

Shear Transfer Along Each Wall Line

V = 10,138 pounds / 450 pounds per connection = **23 L70 or A35, or**
V = 10,138 pounds / 585 pounds per connection = **17 L90 or 18 H10R**

Transverse Wall Line = 30 feet = 338 plf
Longitudinal Wall Line = 50 feet = 203 plf

Case 3C Two Story Demand / Capacity for 30 ft x 40 ft (2,400 Sq. Ft.)

Assume SD soil with Ca = 0.44; Na = 1.3; I = 1.00; and R = 5.5; Conversion to ASD force level: 1 / 1.4
Seismic V = 0.186 W

Dead loads (W) tributary to cripple wall level for 30 x 40 two story = 2,400 square feet:

Roof/Ceiling: 14 psf (34' x 44') = 20.944 kips

Second Floor: 11 psf (30' x 40') = 13.20 kips First floor: 7 psf (30' x 40') = 8.40 kips

Exterior Walls:

1st & 2nd Story walls:	17 psf (16') (30' x 2 + 40' x 2) =	38.08 kips
Deduct for windows:	-7 psf (240 sq. ft.) =	<-1.68> kips
Gable end walls:	12 psf (5' x 30') 2 / 2 =	1.80 kips
Cripple walls:	13.5 psf (2') (30' x 2 + 40' x 2) =	3.78 kips
		41.98 kips

Interior wall: 12 psf (8') (29' x 5 + 39' x 3) = 25.152 kips

Sum W = 20.94 + 13.2 + 8.4 + 41.98 + 25.15 = 109.68 kips
Total V = (0.186) W = 20.40 kips
V to each cripple wall line = 20.40 / 2 = **10.20 kips**

Number of sill bolts needed along any wall:
10,200 pounds / 820 pounds/bolt = **13 – 1/2" bolts**
10,200 pounds / 1170 pounds/bolt = **9 – 5/8" bolts**
10,200 pounds / 1340 pounds/UFP10 = **8 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of panel based on 16" stud spacing
10,200 pounds / 380 plf = **28'-0" or for 10d @ 4"** 10,200 / 460 **= 22'-8"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:
Using 10d @ 4" edge nailing
V to 4 foot long panel = 10,200 pounds / 22.67 feet x 4.0 feet = 1,800 pounds

$_{W}$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (2')= 341
OTM = 1,800 pounds x 2 foot wall height = 3,600 lb-ft
RTM = 0.9 x 341 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,683 lb-ft
OTM – RTM / panel length = (3,600 – 3,683) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 10,200 pounds / 22.67 feet x 4.0 feet = 1,800 pounds
$_{W}$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 11 psf (7.5') + 17 psf (16') + 13.5 psf (2') = 514.5 plf
OTM = 1,800 pounds x 2 foot wall height = 3,600 lb-ft
RTM = 0.9 x 514.5 plf (6 foot tributary length)(4 foot /2 moment arm) = 5,557 lb-ft
OTM – RTM / panel length = (3,600 – 5,557) / 4 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 10,200 pounds / 22.67 feet x 8.0 feet = 3,600 pounds
$_{W}$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (4')= 368
OTM = 3,600 pounds x 4 foot wall height = 14,400 lb-ft
RTM = 0.9 x 368 plf (10 foot tributary length)(8 foot) /2 moment arm) = 13,248 lb-ft
OTM – RTM / panel length = (14,400 – 13,248) / 8 feet = **144 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8'-0" panel end studs

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 10,200 pounds / 22.67 feet x 8.0 feet = 3,600 pounds
$_{W}$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 11 psf (7.5') + 17 psf (16') + 13.5 psf (4') = 541.5 plf
OTM = 3,600 pounds x 4 foot wall height = 14,400 lb-ft
RTM = 0.9 x 541.5 plf (10 foot tributary length)(8 foot) /2 moment arm) = 19,494 lb-ft
OTM – RTM / panel length = (14,400 – 19,494) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 10,200 pounds / 22.67 feet x 12.0 feet = 5,400 pounds
$_{W}$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (4')= 368
OTM = 5,400 pounds x 4 feet wall height = 21,600 lb-ft
RTM = 0.9 x 368 plf (14 feet tributary length)(12 feet) /2 moment arm) = 27,821 lb-ft
OTM – RTM / panel length = (21,600 – 27,821) / 12 feet = **NO uplift**

Shear Transfer Along Each Wall Line

V = 10,200 pounds / 450 pounds per connection = **23 L70 or A35, or**
V = 10,200 pounds / 450 pounds per connection = **17 L90 or 18 H10R**

Transverse Wall Line = 30 feet = 340 plf
Longitudinal Wall Line = 40 feet = 255 plf

Case 3C Two Story Demand / Capacity for 30 ft x 30 ft (1,800 Sq. Ft.)

Dead loads (W) tributary to cripple wall level for 1,800 square feet:

Roof/Ceiling: 14psf (34' x 34') = 16.184 kips

Second Floor: 11 psf (30' x 30') = 9.90 kips   First floor: 7 psf (30' x 30') = 6.30 kips

Exterior Walls:

1st & 2nd Story walls:	17 psf (16') (30' x 2 + 30' x 2) = 32.64 kips	
Deduct for windows-7 psf (200 sq. ft.) =		<-1.40> kips
Gable end walls:	12 psf (5' x 30') 2 / 2 =	1.80 kips
Cripple walls:	13.5 psf (2') (30' x 2 + 30' x 2) =	3.24 kips
		36.28 kips

Interior wall: 12 psf (8') (29' x 5 + 29' x 3) = 22.272 kips

Sum W = 16.18 + 9.90 + 6.30 + 36.28 + 22.27 = 90.94 kips
Total V = (0.186) W = 16.914 kips
V to each cripple wall line = 16.914 / 2 = **8.46 kips**

Number of sill bolts needed along any wall:
8,457 pounds / 820 pounds/bolt = **11 – 1/2" bolts**
8,457 pounds / 1170 pounds/bolt = **8 – 5/8" bolts**
8,457 pounds / 1340 pounds/UFP10 = **7 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of panel based on 16 inch stud spacing
8,457 pounds / 380 plf = **22'-8"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 8,457 pounds / 22.67 feet x 4.0 feet = 1,492 pounds

$_W$ dead load to panel = 14 psf (1’) + (11 psf +7 psf)(1.33’/2) +12 psf (2.67’/2)+17 psf (16’)+ 13.5 psf (2’)= 341
OTM = 1,492 pounds x 2 foot wall height = 2,985 lb-ft
RTM = 0.9 x 341 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,683 lb-ft
OTM – RTM / panel length = (2,985 – 3,683) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 8,457 pounds / 22.67 feet x 4.0 feet = 1,492 pounds
$_W$ dead load to panel = 14 psf (7.5’) + 7 psf (4’) + 11 psf (7.5’) + 17 psf (16’) + 13.5 psf (2’) = 514.5 plf
OTM = 1,492 pounds x 2 foot wall height = 2,985 lb-ft
RTM = 0.9 x 514.5 plf (6 foot tributary length)(4 foot /2 moment arm) = 5,557 lb-ft
OTM – RTM / panel length = (2,985 – 5,557) / 4 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 8,457 pounds / 22.67 feet x 8.0 feet = 2,985 pounds
$_W$ dead load to panel = 14 psf (1’) + (11 psf +7 psf)(1.33’/2) +12 psf (2.67’/2)+17 psf (16’)+ 13.5 psf (4’)= 368
OTM = 2,985 pounds x 4 foot wall height = 11,939 lb-ft
RTM = 0.9 x 368 plf (10 foot tributary length)(8 foot) /2 moment arm) = 13,248 lb-ft
OTM – RTM / panel length = (11,939 – 13,248) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 8,457 pounds / 22.67 feet x 8.0 feet = 2,985 pounds
$_W$ dead load to panel = 14 psf (7.5’) + 7 psf (4’) + 11 psf (7.5’) + 17 psf (16’) + 13.5 psf (4’) = 541.5 plf
OTM = 2,985 pounds x 4 foot wall height = 11,939 lb-ft
RTM = 0.9 x 541.5 plf (10 foot tributary length)(8 foot) /2 moment arm) = 19,494 lb-ft
OTM – RTM / panel length = (11,939 – 19,494) / 8 feet = **NO uplift**

Shear Transfer Along Each Wall Line

V = 8,457 pounds / 450 pounds per connection = **19 L70 or A35, or**
V = 8,457 pounds / 585 pounds per connection = **15 L90 or H10R**

Transverse Wall Line = 30 feet = 282 plf
Longitudinal Wall Line = 30 feet = 282 plf

Case 3C Two Story Demand / Capacity for 30’ x 50’ = 3,000 square feet

Dead loads (W) tributary to cripple wall level for 3,000 square feet:

Roof/Ceiling: 14 psf (34' x 54') = 25.704 kips

Second Floor: 11 psf (30' x 50') = 16.50 kips   First floor: 7 psf (30' x 50') = 10.50 kips

Exterior Walls:

1^{st} & 2^{nd} Story walls:	17 psf (16') (30' x 2 + 50' x 2) =	43.52 kips
Deduct for Windows:	-7 psf (300 sq. ft.) =	<-2.10> kips
Gable end walls:	12 psf (5' x 30') 2 / 2 =	1.80 kips
Cripple walls:	13.5 psf (2') (30' x 2 + 50' x 2) =	4.32 kips
		47.54 kips

Interior wall: 12 psf (8') (29' x 5 + 49' x 3) = 28.032 kips

Sum W = 25.70 + 16.50 + 10.50 + 47.54 + 28.03 = 128.28 kips
Total V = (0.186) W = 23.86 kips
V to each cripple wall line = 23.86 / 2 = **11.93 kips**

Number of sill bolts needed along any wall:
11,930 pounds / 820 pounds/bolt = **15 – 1/2” bolts**
11,930 pounds / 1170 pounds/bolt = **11 – 5/8” bolts**
11,930 pounds / 1340 pounds/UFP10 = **9 UFP10**

Length of cripple wall braced with 15/32” rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of panel based on 16 inch stud spacing

11,930 pounds / 380 plf **= 31'- 4"NG!! Must use 10d @ 4"** 11,930 pounds / 460 plf **= 26'-8"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:
Using 10d @ 4" edge nailing

V to 4 foot long panel = 11,930 pounds / 26.67 feet x 4.0 feet = 1,790 pounds
$_{W}$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (2')= 341
OTM = 1,790 pounds x 2 foot wall height = 3,579 lb-ft
RTM = 0.9 x 341 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,683 lb-ft
OTM – RTM / panel length = (3,579 – 3,683) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 11,930 pounds / 26.67 feet x 4.0 feet = 1,790 pounds
$_{W}$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 11 psf (7.5') + 17 psf (16') + 13.5 psf (2') = 514.5 plf
OTM = 1,790 pounds x 2 foot wall height = 3,579 lb-ft
RTM = 0.9 x 514.5 plf (6 foot tributary length)(4 foot /2 moment arm) = 5,557 lb-ft
OTM – RTM / panel length = (3,579 – 5,557) / 4 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 11,930 pounds / 26.67 feet x 8.0 feet = 3,579 pounds
$_{W}$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (4')= 368
OTM = 3,579 pounds x 4 foot wall height = 14,316 lb-ft
RTM = 0.9 x 368 plf (10 foot tributary length)(8 foot) /2 moment arm) = 13,248 lb-ft
OTM – RTM / panel length = (14,316 – 13,248) / 8 feet = **134 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8'-0" panel end studs

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 11,930 pounds / 26.67 feet x 8.0 feet = 3,579 pounds
$_{W}$ dead load to panel = 14 psf (7.5') + 7 psf (4') + 11 psf (7.5') + 17 psf (16') + 13.5 psf (4') = 541.5 plf
OTM = 3,579 pounds x 4 foot wall height = 14,316 lb-ft
RTM = 0.9 x 541.5 plf (10 foot tributary length)(8 foot) /2 moment arm) = 19,494 lb-ft
OTM – RTM / panel length = (14,316 – 19,494) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 11,930 pounds / 26.67 feet x 12.0 feet = 5,369 pounds
$_{W}$ dead load to panel = 14 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (4')= 368
OTM = 5,369 pounds x 4 feet wall height = 21,474 lb-ft
RTM = 0.9 x 368 plf (14 feet tributary length)(12 feet) /2 moment arm) = 27,821 lb-ft
OTM – RTM / panel length = (21,474 – 27,821) / 12 feet = **NO uplift**

Shear Transfer Along Each Wall Line

V = 11,390 pounds / 450 pounds per connection = **27 L70 or A35; or**

V = 11,390 pounds / 585 pounds per connection = **19 L90, or 20 H10R**

Transverse Wall Line = 30 feet = 398 plf
Longitudinal Wall Line = 50 feet = 239 plf

Case 3D Two Story Demand / Capacity for 30 ft x 40 ft (2,400 Sq. Ft.)

Assume SD soil with Ca = 0.44; Na = 1.3; I = 1.00; and R = 5.5; Conversion to ASD force level: 1 / 1.4
Seismic V = 0.186 W

Dead loads (W) tributary to cripple wall level for 30 x 40 two story = 2,400 square feet:

Roof/Ceiling: 20 psf (34' x 44') = 29.92 kips

Second Floor: 11 psf (30' x 40') = 13.20 kips First floor: 7 psf (30' x 40') = 8.40 kips

Exterior Walls:

1^{st} & 2^{nd} Story walls:	17 psf (16') (30' x 2 + 40' x 2) =	38.08 kips
Deduct for windows:	-7 psf (240 sq. ft.) =	<-1.68> kips
Gable end walls:	12 psf (5' x 30') 2 / 2 =	1.80 kips
Cripple walls:	13.5 psf (2') (30' x 2 + 40' x 2) =	3.78 kips
		41.98 kips

Interior wall: 12 psf (8') (29' x 5 + 39' x 3) = 25.152 kips

Sum W = 29.92 + 13.2 + 8.4 + 41.98 + 25.15 = 118.65 kips
Total V = (0.186) W = 22.07 kips
V to each cripple wall line = 22.07 / 2 = **11.035 kips**

Number of sill bolts needed along any wall:

11,035 pounds / 820 pounds/bolt = **14 – 1/2" bolts**
11,035 pounds / 1170 pounds/bolt = **10 – 5/8" bolts**
11,035 pounds / 1340 pounds/UFP10 = **9 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of panel based on 16" stud spacing
11,035 pounds / 380 plf = **29'-4"** **or for 10d @ 4"** 11,035 / 460 **= 24'-0"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:
Using 10d @ 4" edge nailing
V to 4 foot long panel = 11,035 pounds / 24 feet x 4.0 feet = 1,839 pounds
$_W$ dead load to panel = 20 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (2')= 347
OTM = 1,839 pounds x 2 foot wall height = 3,678 lb-ft
RTM = 0.9 x 347 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,748 lb-ft
OTM – RTM / panel length = (3,678 – 3,748) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 11,035 pounds / 24 feet x 4.0 feet = 1,839 pounds
$_W$ dead load to panel = 20 psf (7.5') + 7 psf (4') + 11 psf (7.5') + 17 psf (16') + 13.5 psf (2') = 559.5 plf
OTM = 1,839 pounds x 2 foot wall height = 3,678 lb-ft
RTM = 0.9 x 559.5 plf (6 foot tributary length)(4 foot /2 moment arm) = 6,043 lb-ft
OTM – RTM / panel length = (3,678 – 6,043) / 4 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 11,035 pounds / 24 feet x 8.0 feet = 3,678 pounds
$_W$ dead load to panel = 20 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (4')= 374
OTM = 3,678 pounds x 4 foot wall height = 14,713 lb-ft
RTM = 0.9 x 374 plf (10 foot tributary length)(8 foot) /2 moment arm) = 13,464 lb-ft
OTM – RTM / panel length = (14,713 – 13,464) / 8 feet = **156 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8'-0" panel end studs

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 11,035 pounds / 24 feet x 8.0 feet = 3,678 pounds
$_W$ dead load to panel = 20 psf (7.5') + 7 psf (4') + 11 psf (7.5') + 17 psf (16') + 13.5 psf (4') = 586.5 plf
OTM = 3,678 pounds x 4 foot wall height = 14,713 lb-ft
RTM = 0.9 x 586.5 plf (10 foot tributary length)(8 foot) /2 moment arm) = 21,114 lb-ft
OTM – RTM / panel length = (14,713 – 21,114) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 11,035 pounds / 24 feet x 12.0 feet = 5,518 pounds
$_W$ dead load to panel = 20 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (4')= 374
OTM = 5,418 pounds x 4 feet wall height = 22,070 lb-ft
RTM = 0.9 x 374 plf (14 feet tributary length)(12 feet) /2 moment arm) = 28,274 lb-ft
OTM – RTM / panel length = (22,070 – 28,274) / 12 feet = **NO uplift**

Shear Transfer Along Each Wall Line

V = 11,035 pounds / 450 pounds per connection = **25 L70 or A35, or**
V = 11,035 pounds / 450 pounds per connection = **19 L90 or H10R**

Transverse Wall Line = 30 feet = 368 plf
Longitudinal Wall Line = 40 feet = 276 plf

Case 3D Two Story Demand / Capacity for 30 ft x 30 ft (1,800 Sq. Ft.)

Dead loads (W) tributary to cripple wall level for 1,800 square feet:

Roof/Ceiling: 20 psf (34' x 34') = 23.12 kips

Second Floor: 11 psf (30' x 30') = 9.90 kips   First floor: 7 psf (30' x 30') = 6.30 kips

Exterior Walls:

1st & 2nd Story walls:	17 psf (16') (30' x 2 + 30' x 2) = 32.64 kips	
Deduct for windows-7 psf (200 sq. ft.) =		<-1.40> kips
Gable end walls:	12 psf (5' x 30') 2 / 2 =	1.80 kips
Cripple walls:	13.5 psf (2') (30' x 2 + 30' x 2) =	3.24 kips
		36.28 kips

Interior wall: 12 psf (8') (29' x 5 + 29' x 3) = 22.272 kips

Sum W = 23.12 + 9.90 + 6.30 + 36.28 + 22.27 = 97.87 kips
Total V = (0.186) W = 18.204 kips
V to each cripple wall line = 18.204 / 2 = **9.10 kips**

Number of sill bolts needed along any wall:

9,102 pounds / 820 pounds/bolt = **12 – 1/2" bolts**
9,102 pounds / 1170 pounds/bolt = **8 – 5/8" bolts**
9,102 pounds / 1340 pounds/UFP10 = **7 UFP10**

Length of cripple wall braced with 15/32" rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of panel based on 16 inch stud spacing
9,102 pounds / 380 plf = **24'-0"**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:

V to 4 foot long panel = 9,102 pounds / 24 feet x 4.0 feet = 1,517 pounds
$_W$ dead load to panel = 20 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (2')= 347
OTM = 1,517 pounds x 2 foot wall height = 3,034 lb-ft
RTM = 0.9 x 347 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,748 lb-ft
OTM – RTM / panel length = (3,034 – 3,748) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 9,102 pounds / 24 feet x 4.0 feet = 1,517 pounds
$_W$ dead load to panel = 20 psf (7.5') + 7 psf (4') + 11 psf (7.5') + 17 psf (16') + 13.5 psf (2') = 559.5 plf
OTM = 1,517 pounds x 2 foot wall height = 3,034 lb-ft
RTM = 0.9 x 559.5 plf (6 foot tributary length)(4 foot /2 moment arm) = 6,043 lb-ft
OTM – RTM / panel length = (3,034 – 6,043) / 4 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 9,102 pounds / 24 feet x 8.0 feet = 3,034 pounds
$_W$ dead load to panel = 20 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (4')= 374
OTM = 3,034 pounds x 4 foot wall height = 12,136 lb-ft
RTM = 0.9 x 374 plf (10 foot tributary length)(8 foot) /2 moment arm) = 13,464 lb-ft
OTM – RTM / panel length = (12,136 – 13,464) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 9,102 pounds / 24 feet x 8.0 feet = 3,034 pounds
$_W$ dead load to panel = 20 psf (7.5') + 7 psf (4') + 11 psf (7.5') + 17 psf (16') + 13.5 psf (4') = 586.5 plf
OTM = 3,034 pounds x 4 foot wall height = 12,136 lb-ft
RTM = 0.9 x 586.5 plf (10 foot tributary length)(8 foot) /2 moment arm) = 21,114 lb-ft
OTM – RTM / panel length = (12,136 – 19,494) / 8 feet = **NO uplift**

Shear Transfer Along Each Wall Line

V = 9,102 pounds / 450 pounds per connection = **21 L70 or A35, or**
V = 9,102 pounds / 585 pounds per connection = **16 L90 or H10R**

Transverse Wall Line = 30 feet = 303 plf

Longitudinal Wall Line = 30 feet = 303 plf

Case 3D Two Story Demand / Capacity for 30’ x 50’ = 3,000 square feet

Dead loads (W) tributary to cripple wall level for 3,000 square feet:

Roof/Ceiling: 20 psf (34' x 54') = 36.72 kips

Second Floor: 11 psf (30' x 50') = 16.50 kips First floor: 7 psf (30' x 50') = 10.50 kips

Exterior Walls:

1^{st} & 2^{nd} Story walls:	17 psf (16') (30' x 2 + 50' x 2) =	43.52 kips
Deduct for Windows:	-7 psf (300 sq. ft.) =	<-2.10> kips
Gable end walls:	12 psf (5' x 30') 2 / 2 =	1.80 kips
Cripple walls:	13.5 psf (2') (30' x 2 + 50' x 2) =	4.32 kips
		47.54 kips

Interior wall: 12 psf (8') (29' x 5 + 49' x 3) = 28.032 kips

Sum W = 36.72 + 16.50 + 10.50 + 47.54 + 28.03 = 139.29 kips
Total V = (0.186) W = 25.91 kips
V to each cripple wall line = 25.91 / 2 = **12.95 kips**

Number of sill bolts needed along any wall:
12,954 pounds / 820 pounds/bolt = **16 – 1/2” bolts**
12,954 pounds / 1170 pounds/bolt = **12 – 5/8” bolts**
12,954 pounds / 1340 pounds/UFP10 = **10 UFP10**

Length of cripple wall braced with 15/32” rated plywood sheathing w/ 8d @ 4" edge nailing:
V to each wall line / unit capacity = lineal feet of panel based on 16 inch stud spacing
12,954 pounds / 380 plf = 34’-0” NG!! **Must use 10d @ 4”** 12,954 pounds / 460 plf = **28’-8”**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along gable end wall:
Using 10d @ 4” edge nailing
V to 4 foot long panel = 12,954 pounds / 28.67 feet x 4.0 feet = 1,808 pounds
$_W$ dead load to panel = 20 psf (1’) + (11 psf +7 psf)(1.33’/2) +12 psf (2.67’/2)+17 psf (16’)+ 13.5 psf (2’)= 347
OTM = 1,808 pounds x 2 foot wall height = 3,615 lb-ft
RTM = 0.9 x 347 plf (6 foot tributary length)(4 foot /2 moment arm) = 3,748 lb-ft
OTM – RTM / panel length = (3,615 – 3,748) / 4 feet = **NO uplift**

Overturning of 2 foot high cripple wall with 4 foot minimum panel length along longitudinal wall:

V to 4 foot long panel = 12,954 pounds / 28.67 feet x 4.0 feet = 1,808 pounds
$_W$ dead load to panel = 20 psf (7.5’) + 7 psf (4’) + 11 psf (7.5’) + 17 psf (16’) + 13.5 psf (2’) = 559.5 plf
OTM = 1,808 pounds x 2 foot wall height = 3,615 lb-ft
RTM = 0.9 x 559.5 plf (6 foot tributary length)(4 foot /2 moment arm) = 6,043 lb-ft
OTM – RTM / panel length = (3,615 – 6,043) / 4 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along gable end wall

V to 8 foot long panel = 12,954 pounds / 28.67 feet x 8.0 feet = 3,615 pounds
$_W$ dead load to panel = 20 psf (1’) + (11 psf +7 psf)(1.33’/2) +12 psf (2.67’/2)+17 psf (16’)+ 13.5 psf (4’)= 374
OTM = 3,615 pounds x 4 foot wall height = 14,460 lb-ft
RTM = 0.9 x 374 plf (10 foot tributary length)(8 foot) /2 moment arm) = 13,464 lb-ft
OTM – RTM / panel length = (14,460 – 13,464) / 8 feet = **125 pounds uplift**
Locate one new sill bolt with plate washer within 6 inches of each 8’-0” panel end studs

Overturning of 4 foot high cripple wall with 8 foot minimum panel length along longitudinal wall

V to 8 foot long panel = 12,954 pounds / 28.67 feet x 8.0 feet = 3,615 pounds
$_W$ dead load to panel = 20 psf (7.5’) + 7 psf (4’) + 11 psf (7.5’) + 17 psf (16’) + 13.5 psf (4’) = 586.5 plf
OTM = 3,615 pounds x 4 foot wall height = 14,460 lb-ft
RTM = 0.9 x 586.5 plf (10 foot tributary length)(8 foot) /2 moment arm) = 21,114 lb-ft
OTM – RTM / panel length = (14,460 – 19,494) / 8 feet = **NO uplift**

Overturning of 4 foot high cripple wall with 12 foot minimum panel length along gable end wall

V to 12 foot long panel = 12,954 pounds / 28.67 feet x 12.0 feet = 5,423 pounds
$_W$ dead load to panel = 20 psf (1') + (11 psf +7 psf)(1.33'/2) +12 psf (2.67'/2)+17 psf (16')+ 13.5 psf (4')= 374
OTM = 5,423 pounds x 4 feet wall height = 21,690 lb-ft
RTM = 0.9 x 374 plf (14 feet tributary length)(12 feet) /2 moment arm) = 28,274 lb-ft
OTM – RTM / panel length = (21,690 – 28,274) / 12 feet = **NO uplift**

Shear Transfer Along Each Wall Line

V = 12,954 pounds / 450 pounds per connection = **29 L70 or A35; or**
V = 12,954 pounds / 585 pounds per connection = **22 L90, or 23 H10R**

Transverse Wall Line = 30 feet = 432 plf
Longitudinal Wall Line = 50 feet = 259 plf

Shear Transfer to Cripple Walls of Two-Story Buildings

Shear transfer capacity from the first floor into the cripple wall top plate from existing blocking or rim joist (along longitudinal wall lines), or end joist (along transverse wall lines) are determined below.

Along longitudinal walls, floor joists are assumed to be perpendicular and spaced at 16 inches o.c. If existing connections using 8d common toenails at 8 inches on center (two per joist space) exist between the rim joist or blocking, and the cripple wall top plate or foundation sill plate, that connection capacity would equal:
Per 16 inch joist space: 2 nails x 5/6 (for toenails) x 76 pounds (8d common nails) x 1.33 = 168 pounds
168 pounds x 12 / 16 feet = 126 plf capacity

This capacity does not count the two toenails normally connecting each joist to the cripple wall top plate. If only <u>one</u> of these toenails per joist are accounted for, the capacity along the longitudinal wall would equal:
Per 16 inch joist space x 1 nail x 76 pounds/nail x 5/6 x 1.33 = 84 pounds x 12 /16 = 63 plf

126 + 63 pounds = 189 plf > 185 plf maximum demand at Case 3A. All other cases exceed 189 plf.

Because toe nails can be difficult to observe and can be ineffective if the wood framing has split at the nails, existing nailing described above may be either absent or ineffective. Also, the current code prohibits the use of toe nails for shear transfer greater than 150 plf. Therefore, because this load path is essential, the shear transfer demand should be accommodated by adding sheet metal angles.

Along transverse walls, if existing 8d toe nailing at 6 inches o.c. is assumed it provides only 168 plf. The demand along the transverse walls exceeds this amount in all two-story Cases and sizes of buildings. Therefore, adding sheet metal angles definitely is necessary along transverse walls.

With respect to the ability of existing floor sheathing nailing to transfer shear into the top of the blocking or rim joist member the following analysis is provided:

Along the transverse walls where joists are assumed to be parallel to the wall, the ends of the floor sheathing boards should be nailed to that joist. Assuming 1x 6 straight sheathing with 2 - 8d nails each board, these wall lines should have 4 nails per foot assuming 6 inch wide boards. The capacity provided is 90 pounds per nail x 4 nails x 1.33 = 478 plf capacity. This ignores any contribution of sill plate nailing into the end joist. **Therefore when straight sheathing is installed no supplemental connection between the upper edge of the end joist and the floor sheathing should be necessary for the maximum 432 plf transverse direction demand of Case 3D (3000 sq. ft.)**. If the floor sheathing is plywood a lower capacity should be assumed. The typical plywood edge nailing is 8d @ 6"o.c. which gives 76 pounds x 2 nails/ft. x 1.33 = 202 plf. Adding in the 16d sill plate nailing assumed at 16" o.c. through the sheathing to the end joist would add 141 pounds x (0.77 Cd) x 1.33 (12/16) = 109 plf for a total of 311 plf . This is sufficient for all configurations except for Case 3B (3000 sq.ft.), Case 3C (2400 and 3000 sq. ft.) and Case 3D (2400 sq. ft. and 3000 sq. ft.). The overstress for Case 3B is 9%, for Case 3C 9% and 28%, and for Case 3D, 18% and 39% respectively. **Therefore in two-story buildings with plywood sheathed first floors, a supplemental connection along the transverse walls may be prudent**.

The longitudinal direction demand is a maximum of 303 plf for Case 3D (1800 sq. ft.). In this case 8d nails from the sheathing into the rim member should occur at 16 inches on center. This corresponds to each sheathing board being nailed to each rim member at the same spacing as the perpendicular joists. In addition, the first story wall sill plate should be nailed into the rim member with 20d (or perhaps larger nails) at 32 inches on center (one every other stud bay). The combined capacity for both types of nails is: 90 pounds x 1.33 x (12/16) + 170 pounds x (0.76 Cd) x 1.33 (12 / 32) = 154 plf. This capacity is less than the demand in all cases and sizes of buildings**. Therefore a supplemental connection between the rim member and the floor sheathing, or between the joists and the top plate or foundation sill plate is definitely necessary along longitudinal walls**.

Conclusions about shear transfer from floor to cripple wall in Two-Story Buildings:

1) **Along Transverse Walls, where joists are parallel, no supplemental connection between the floor sheathing and the top edge of the end joist should be necessary in a two-story condition having a wood board straight sheathed flooring.**
2) **Along Transverse Walls, a supplemental connection should be provided when plywood floor sheathing is used.**
3) **Along Longitudinal Walls where joists are perpendicular, a supplemental connection is necessary at the top edge of the blocking or rim joist, or between the joist and the top plate or foundation sill plate for two-story buildings.**
4) **In all Cases and building sizes sheet metal angles should be provided between the bottom edge of joists or blocking and the top plate of the cripple wall or foundation sill plate,**

Cripple Wall Top Plate used as a Collector in Two-Story Buildings

Where an existing cripple wall uses a single top plate, or has a double top plate constructed without a standard lap splice as required by the code (e.g., 4 foot lap with 8 –16d nails) these conditions may create a weak link in a top plate being used as a collector between widely spaced retrofit braced wall segments. The collector force along the longitudinal walls (where joists are assumed perpendicular) varies from 103 plf to 188 plf . For the Case 3A of the 3,000 sq. ft. building with a 56 foot long wall where a total of 21-4" feet of bracing is provided, if this bracing is located in two sections only at each end of the wall, the collector length will be one half of the distance between the two braced segments. For this case, the maximum force demand along this collector occurs where it connects to the braced sections of the cripple wall, and is determined below:

(56 feet – 21.33 feet) / 2 x 160 plf = **2,773 pounds**

The actual connection force will be proportionally less by 160 pounds per foot, where the butt joint occurs further away from the end of the braced panel and closer to the mid length of the wall. If braced panels are distributed along the length of the wall, rather than concentrated at the ends only, the splice connection force is also reduced, such that the maximum demand for this example is 160 plf times one-half the distance in feet between the braced wall ends. Where a top plate butt joint occurs within the length of a braced panel the sheathing nailing will also aid in providing a splice. However, the code does not permit using sheathing as a method of providing a collector splice, therefore wherever a top plate butt joint occurs it should be provided with a positive connection between the two pieces (2001 CBC Sec. 2315.5.2)

A splice connection for a 2,773 pound demand could to be made with bolts or nails. A bolted connection could be provided by installing a 4 – 1/2" bolts vertically through a single 2x top plate on each side of the butt joint, using a 16 inch long ¼ inch thick plate with bolts located 4 inches minimum from the butt joint and spaced 2.5 inches on center. An alternative splice could be made with an 18 gage strap nailed into the vertical face of the top plate having a total of 36 - 16d sinker nails. To prevent splitting, nails should be staggered and spaced not less than 1-½ inches apart. Commercially available straps with the necessary capacity would require that blocking be installed below the existing plate to allow for a second row of nails. The blocking would also need to be attached to the top plate with 16 – 10d common nails along the length of the strap.

For the 36 foot long transverse wall, the maximum collector force is 267 plf for the Case 3A (3000 sq. ft.) house, and its maximum length is (30' – 21.33') / 2 = 4.33 feet, therefore the force is 1,157 pounds. Along the transverse walls, the parallel end joist should be connected to the top plate as described above with L70 or equivalent angles, therefore a continuous joist should be able to act as the splice member for a single top plate IF the end butt joint of the top plate and end joint of the joist are offset, and the quantity of L70 angles on each side can provide the needed splice capacity. Where end joints in both the joist and a single top plate occur in close proximity, an additional splice connection of the top plate should be provided.

Conclusions about splices for single top plates of cripple walls.

The actual force at a splice of a single top plate in a cripple wall can vary greatly depending on the location of the splice with respect to the layout of the bracing panels along the wall. The code's prescriptive double top plate splice for conventional construction provides a seismic tension capacity of 1,500 pounds and therefore a retrofit code should likely prescribe a similar capacity connection. This would most easily be provided by an 30 inch long 18 gage strap with 22 - 10d full length nails to provide that capacity, such as a Simpson LSTA or MSTA, nailed to the vertical face of the top plate.

Overturning Considerations for Two-Story Buildings

The overturning calculations for each Case assume a lateral force within each braced panel segment that is directly proportional to its length, as a fraction of the overall length of bracing provided. For example if the calculated lateral load to a wall line is 7,600 pounds and the total bracing length provided is 20 feet, each 8 foot long panel section of bracing has a lateral load of (7,600 / 20) x 8 = 3,040 pounds.

Dead load resistance to overturning is based on the unit weights for the various floor, roof and wall assembles assumed for each Case, and the tributary area supported by the cripple wall. **For roof loads, no roof overhang is assumed**. For the longitudinal walls the width of roof tributary to the exterior walls is assumed to be one-quarter of the rafter span to the ridge based on a purlin being present at the halfway point between the exterior wall and the ridge line. The width of first floor tributary to the longitudinal walls is 4 feet, based on an 8-foot span of floor joists to the first interior line of girders. The width of the second floor tributary to the longitudinal walls is 7'-6" based on one-half of the span to the center of the 30 foot wide buildings. Where an interior first story bearing wall is closer to the exterior wall than the center of the building width, this assumption will overestimate tributary weight from the second floor, but the second floor weight contribution is only 21% of the total resistance for Cases 3A and 3B and reduces to only 15% in Case 3D. **Typically, the wall length resisting overturning is assumed to be 2 feet longer than the length of the braced wall panel. For example, a 4-foot long braced panel is assumed to engage 6 feet of tributary wall length for overturning resistance**.

Because each individual braced wall length must be at least twice the cripple wall height, a maximum 4-foot height wall requires an 8-foot minimum bracing panel length. This requirement intends to reduce the uplift forces imposed by overturning. However, based on the calculations, net uplift still occurs along the transverse gable end walls, but uplift does not occur along the longitudinal walls for any of the two-story conditions.

Conclusions about uplift restraint for cripple walls of Two-story house:

For 4”-0” tall walls having 8’-0” long braced panels using 15/32” sheathing with 8d @ 4” edge nailing, net uplift forces ranging from 815 to 540 pounds (ASD) are calculated to occur along gable end walls for Cases 3A and 3B. In Cases 3C and 3D along gable end walls, the range is 160 to zero. For these fairly small uplift forces, the use of foundation sill plate anchor bolts with plate washers could be utilized as restraint, based on the following.

For example a ½” diameter Kwik Bolt with 3-1/2” embed and 3-1/2” edge distance (20% reduction) has a tension capacity without special inspection of 700 pounds in 2000 psi concrete. Wedge-All anchors have smaller values of 532 pounds for ½” diameter without special inspection and assuming a 3-1/2 inch edge distance in 2000 psi concrete**. The minimum 3-1/2 inch edge distance will require placing the bolts approximately 1 inch from the centerline of a 2x6 nominal sill plate. This would preclude the use of a flush cut sill method because the bolt would be too close to the edge of the cut face of the sill plate. A threaded rod installed with epoxy would be an alternative where an edge distance less than 3-1/2 inches is used.**

For uplifts between zero and 550 pounds, a single expansion anchor bolt with plate washer could be located within 4 inches of the end studs of each braced panel segment. Plate washers in this case should be wider and thicker than the current minimum 2 x 2 x 3/16 inch plate washer to provide uplift resistance. On a 2x6 nominal sill plate with the anchor bolt offset from the center of the sill plate by 1 inch a 5 x 5 x 3/8 inch washer with a 2 inch long diagonal slot is recommended.

For uplifts between 550 and 1000 pounds, a pair of expansion anchor bolts with plate washers could be used to resist this uplift. Each bolt could be located within 4 inches of the end studs of each braced panel segment. Alternatively, an FJA / FSA type strap nailed to the end stud and bolted into the face of the foundation stem wall could be used for forces up to 1000 pounds.

DRAFT TABLE A-1
BRACING, BOLTING AND SHEAR TRANSFER REQUIREMENTS FOR ONE-STORY HOUSES
Using 15/32-inch rated plywood sheathing with 8d @ 4” o.c.
10d @ 4” nailing is not used in order to reduce overturning demands

Total Floor Area (sq.ft.)	Case ID	Bracing Length 8d @ 4”nailing	No. of Sill Bolts along each wall line 5/8”∅	½”∅	No. of L70 or A35 angles along each wall line	Shear Transfer Force along each wall (plf) Trans	Long
1,200 [A]	3A	12’-0”	4	6	10	146	110
1,200 [A]	3B	14’-8”	5	7	13	184	138
1,200 [A]	3C	17’-4”	6	8	15	215	161
1,200 [A]	3D	20’-0”	7	9	17	243	182
1,500 [B]	3A	14’-8”	5	7	12	172	103
1,500 [B]	3B	17’-4”	6	8	15	215	129
1,500 [B]	3C	20’-0”	7	10	17	250	150
1,500 [B]	3D	22’-8”	8	11	19	285	171
2,000 [C]	3A	17’-4”	6	8	15	179	115
2,000 [C]	3B	21’-4”	7	10	18	223	143
2,000 [C]	3C	25’-4”	8	12	21	257	165
2,000 [C]	3D	28’-0”	9	13	24	292	188

[A] Footprint is 30 feet x 40 feet

[B] Footprint is 30 feet x 50 feet
[C] Footprint is 36 feet x 56 feet

DRAFT TABLE A-2

BRACING, BOLTING AND SHEAR TRANSFER REQUIREMENTS FOR TWO-STORY HOUSES
Using 15/32-inch rated sheathing with either 8d or 10d @ 4" o.c.
10d @ 4" is used where 8d nailing results in too little capacity OR
when calculated length exceeds 85% of the total assumed maximum length of the wall

Total Floor Area (sq.ft.)	Case ID	Bracing Length 8d @ 4" nailing	Bracing Length 10d @ 4 nailing	No. of Sill Bolts along each wall line 5/8"∅	No. of Sill Bolts along each wall line ½"∅	No. of L70 or A35 angles along each wall line	Shear Transfer Force along each wall (plf) Trans	Shear Transfer Force along each wall (plf) Long
1,800 [A]	3A	14'-8"	N/A	5	7	13	185	185
1,800 [A]	3B	18'-8"	N/A	7	9	16	236	236
1,800 [A]	3C	22'-8"	N/A	8	11	19	282	282
1,800 [A]	3D	24'-0"	N/A	8	12	21	303	303
2,400 [B]	3A	18'-8"	N/A	6	9	15	226	169
2,400 [B]	3B	22'-8"	N/A	8	11	20	287	215
2,400 [B]	3C	26'-8"	22'-8"	9	13	23	340	255
2,400 [B]	3D	29'-4"	24'-0"	10	14	25	368	276
3,000 [C]	3A	21'-4"	N/A	7	10	18	267	160
3,000 [C]	3B	26'-8"	22'-8"	9	13	23	338	203
3,000 [C]	3C	N/A	26'-8"	11	15	27	398	239
3,000 [C]	3D	N/A	28'-8"	12	16	29	432	259

[A] Footprint is 30 feet x 30 feet
[B] Footprint is 30 feet x 40 feet
[C] Footprint is 30 feet x 50 feet

Locations and quantity of extra foundation sill bolts needed for uplift adjacent to braced panel end studs based on the overturning calculations following each Case and building size

DRAFT TABLE B-1

BRACED WALL LENGTHS REQUIRING EXTRA SILL BOLTS FOR UPLIFT AT ONE-STORY
USING 15/32" RATED SHEATHING w/ 8d @ 4" o.c. EDGE NAILING ONLY
2 Bolts or FJA for net uplift ≥ 550 ≤ 1000 pounds 1 Bolt for net uplift < 550 pounds

Total Floor Area	Case ID	Cripple Wall Height	Number of Extra Sill Bolts Needed for Uplift at Ends of Braced Panel									
			4'-0"		8'-0"		12'-0"		16'-0"		20'-0"	
			Trans	Long	Trans	Long	Trans	Long	Trans	Long	Trans	Long
1,200	3A	2'-0"	1	1	1	0	1	0	N/A	N/A	N/A	N/A
1,200	3A	4'-0"	N/A	N/A	2	1	2	1	N/A	N/A	N/A	N/A
1,200	3B	2'-0"	1	1	1	0	0	0	0	0	N/A	N/A
1,200	3B	4'-0"	N/A	N/A	2	1	2	0	1[A]	0[A]	N/A	N/A
1,200	3C	2'-0"	1	0	0	0	0	0	0	0	N/A	N/A
1,200	3C	4'-0	N/A	N/A	1	0	1	0	0	0	N/A	N/A
1,200	3D	2'-0"	1	0	0	0	0	0	0	0	0	0
1,200	3D	4'-0"	N/A	N/A	1	0	0	0	0	0	0	0
1,500	3A	2'-0"	1	1	1	0	0	0	0[A]	0[A]	N/A	N/A

1,500	3A	4'-0"	N/A	N/A	2	1	2	1	1[A]	0[A]	N/A	N/A
1,500	3B	2'-0"	1	1	1	0	0	0	0	0	0[B]	0[B]
1,500	3B	4'-0"	N/A	N/A	2	1	2	0	1	0	1[B]	0[B]
1,500	3C	2'-0"	1	0	0	0	0	0	0	0	0	0
1,500	3C	4'-0"	N/A	N/A	1	0	1	0	0	0	0	0
1,500	3D	2'-0"	1	0	0	0	0	0	0	0	0	0
1,500	3D	4'-0"	N/A	N/A	1	0	0	0	0	0	0	0
2,000	3A	2'-0"	1	1	1	0	1	0	0	0	0[B]	0[B]
2,000	3A	4'-0"	N/A	N/A	2	1	2	1	2	0	1[B]	0[B]
2,000	3B	2'-0"	1	1	1	0	0	0	0	0	0	0
2,000	3B	4'-0"	N/A	N/A	2	1	2	0	1	0	1[C]	0
2,000	3C	2'-0"	1	0	0	0	0	0	0	0	0	0
2,000	3C	4-0"	N/A	N/A	1	0	0	0	0	0	0	0
2,000	3D	2'-0"	0	0	0	0	0	0	0	0	0	0
2,000	3D	4'-0"	N/A	N/A	1	0	1	0	0	0	0	0

[A] Maximum braced length considered is 14'-8"
[B] Maximum braced length considered is 17'-4"
[C] One extra bolt also required at maximum considered braced length of 21'-4"

Locations and quantity of extra foundation sill bolts needed for uplift adjacent to braced panel end studs based on the overturning calculations following each Case and building size

DRAFT TABLE B-2

BRACED WALL LENGTHS REQUIRING EXTRA SILL BOLTS FOR UPLIFT AT TWO-STORY 15/32" RATED SHEATHING w/ 8d @ 4" o.c. EDGE NAILING[A]
2 Bolts or FJA for net uplift ≥ 550 ≤ 1000 pounds 1 Bolt for net uplift < 550 pounds

Total Floor Area	Case ID	Cripple Wall Height	Number of Extra Sill Bolts Needed for Uplift at Ends of Braced Panel									
			4'-0"		8'-0"		12'-0"		16'-0"		20'-0"	
			Trans	Long	Trans	Long	Trans	Long	Trans	Long	Trans	Long
1,800	3A	2'-0"	1	0	0	0	0	0	0[B]	0[B]	N/A	N/A
1,800	3A	4'-0"	N/A	N/A	2	0	1	0	1[B]	0[B]	N/A	N/A
1,800	3B	2'-0"	1	0	0	0	0	0	0	0	N/A	N/A
1,800	3B	4'-0"	N/A	N/A	1	0	1	0	0	0	N/A	N/A
1,800	3C	2'-0"	0	0	0	0	0	0	0	0	0	0
1,800	3C	4'-0	N/A	N/A	0	0	0	0	0	0	0	0
1,800	3D	2'-0"	0	0	0	0	0	0	0	0	0	0
1,800	3D	4'-0"	N/A	N/A	0	0	0	0	0	0	0	0
2,400	3A	2'-0"	1	0	0	0	0	0	0	0	N/A	N/A
2,400	3A	4'-0"	N/A	N/A	2	0	1	0	0	0	N/A	N/A
2,400	3B	2'-0"	1	0	0	0	0	0	0	0	0	0

2,400	3B	4'-0"	N/A	N/A	1	0	1	0	0	0	0	0
2,400	3C[A]	2'-0"	0	0	0	0	0	0	0	0	0	0
2,400	3C[A]	4'-0"	N/A	N/A	1	0	0	0	0	0	0	0
2,400	3D[A]	2'-0"	0	0	0	0	0	0	0	0	0	0
2,400	3D[A]	4'-0"	N/A	N/A	1	0	0	0	0	0	0	0
3,000	3A	2'-0"	1	0	0	0	0	0	0	0	0	0
3,000	3A	4'-0"	N/A	N/A	2	0	1	0	0	0	0	0
3,000	3B[A]	2'-0"	1	0	0	0	0	0	0	0	0	0
3,000	3B[A]	4'-0"	N/A	N/A	2	0	1	0	0	0	0	0
3,000	3C[A]	2'-0"	0	0	0	0	0	0	0	0	0	0
3,000	3C[A]	4-0"	N/A	N/A	1	0	0	0	0	0	0	0
3,000	3D[A]	2'-0"	0	0	0	0	0	0	0	0	0	0
3,000	3D[A]	4'-0"	N/A	N/A	1	0	0	0	0	0	0	0

[A] Specific Cases and sizes using 10d @ 4" edge nailing are indicated by this footnote
[B] Maximum braced length considered is 14'-8"

DRAFT TABLE C-1
High Capacity Single Segment Length Bracing for 1,200 Sq. Ft. One-Story Buildings
Using 15/32" Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing

<table>
<tr><th rowspan="2">Total Floor Area (sq. ft.)</th><th rowspan="2">Case ID</th><th rowspan="2">Bracing Length</th><th rowspan="2">Cripple Wall Height</th><th rowspan="2">Tie-down Required at Each End of Braced Panel</th><th colspan="2">Tie-down Force (lbs.)</th></tr>
<tr><th>Trans</th><th>Long</th></tr>
<tr><td>1,200</td><td>3A</td><td>6'-8"</td><td>2'-0"</td><td>2 bolts w/ PW</td><td>931</td><td>588</td></tr>
<tr><td></td><td></td><td>6'-8'</td><td>2'-8"</td><td>PHD2</td><td>1,354</td><td>1,010</td></tr>
<tr><td></td><td></td><td>6'-8"</td><td>3'-4"</td><td>PHD2</td><td>1,777</td><td>1,433</td></tr>
<tr><td></td><td></td><td>6'-8"</td><td>4'-0"</td><td>PHD2</td><td>2,200</td><td>1,856</td></tr>
<tr><td>1,200</td><td>3B</td><td>9'-4"</td><td>2'-0'</td><td>2 bolts w/ PW | None</td><td>583</td><td>34</td></tr>
<tr><td></td><td></td><td>9'-4"</td><td>2'-8"</td><td>2 bolts w/PW | 1 bolt w/PW</td><td>957</td><td>408</td></tr>
<tr><td></td><td></td><td>9'-4"</td><td>3'-4"</td><td>PHD2 | 2 bolts w/PW</td><td>1,330</td><td>781</td></tr>
<tr><td></td><td></td><td>9'-4"</td><td>4'-0"</td><td>PHD2</td><td>1,703</td><td>1,154</td></tr>
<tr><td>1,200</td><td>3C</td><td>10'-8"</td><td>2'-0"</td><td>1 bolt w/PW | None</td><td>83</td><td>0</td></tr>
<tr><td></td><td></td><td>10'-8"</td><td>2'-8"</td><td>1 bolt w/PW | None</td><td>435</td><td>0</td></tr>
<tr><td></td><td></td><td>10'-8"</td><td>3'-4"</td><td>2 bolts w/PW | 1 bolt w/PW</td><td>787</td><td>226</td></tr>
<tr><td></td><td></td><td>10'-8"</td><td>4'-0"</td><td>PHD2 | 2 bolts w/PW</td><td>1,139</td><td>578</td></tr>
<tr><td>1,200</td><td>3D</td><td>12'-0"</td><td>2'-0"</td><td>None</td><td>0</td><td>0</td></tr>
<tr><td></td><td></td><td>12'-0"</td><td>2'-8"</td><td>1 bolt w/PW | None</td><td>280</td><td>0</td></tr>
<tr><td></td><td></td><td>12'-0"</td><td>3'-4"</td><td>2 bolts w/ PW | None</td><td>628</td><td>0</td></tr>
<tr><td></td><td></td><td>12'-0"</td><td>4'-0"</td><td>2 bolts w/PW | 1 bolt w/PW</td><td>976</td><td>111</td></tr>
</table>

DRAFT TABLE C-2

High Capacity Single Segment Length Bracing for 1,500 Sq. Ft. One-Story Buildings
Using 15/32" Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing

Total Floor Area (sq. ft.)	Case ID	Bracing Length	Cripple Wall Height	Tie-down Required at Each End of Braced Panel	Tie-down Force (lbs.) Trans	Long
1,500	3A	8'-0"	2'-0"	2 bolts w/PW | 1 bolt w/PW	847	450
		8'-0"	2'-8"	PHD2 | 2 bolts w/PW	1,258	862
		8'-0"	3'-4"	PHD2	1,670	1,273
		8'-0"	4'-0"	PHD2	2,082	1,685
1,500	3B	10'-8"	2'-0'	1 bolt w/ PW | None	542	0
		10'-8"	2'-8"	2 bolts w/PW | 1 bolt w/PW	923	309
		10'-8"	3'-4"	PHD2 | 2 bolts w/PW	1,303	690
		10'-8"	4'-0"	PHD2	1,684	1,070
1,500	3C	12'-0"	2'-0"	None	7	0
		12'-0"	2'-8"	1 bolt w/PW | None	368	0
		12'-0"	3'-4"	2 bolts w/PW | 1 bolt w/PW	729	109
		12'-0"	4'-0"	PHD2 | 1 bolt w/PW	1,089	470
1,500	3D	13'-4"	2'-0"	None	0	0
		13'-4"	2'-8"	1 bolt w/PW | None	240	0
		13'-4"	3'-4"	2 bolts w/ PW | None	605	0
		13'-4"	4'-0"	2 bolts w/PW | None	970	22

DRAFT TABLE C-3
High Capacity Single Segment Length Bracing for 2,000 Sq. Ft. One-Story Buildings
Using 15/32" Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing

Total Floor Area (sq. ft.)	Case ID	Bracing Length	Cripple Wall Height	Tie-down Required at Each End of Braced Panel	Tie-down Force (lbs.) Trans	Long
2,000	3A	10'-8"	2'-0"	2 bolts w/PW | 1 bolt w/PW	649	52
		10'-8"	2'-8"	PHD2 | 1 bolt w/PW	1,029	404
		10'-8"	3'-4"	PHD2 | 2 bolts w/PW	1,409	755
		10'-8"	4'-0"	PHD2	1,789	1,107
2,000	3B	12'-0"	2'-0'	2 bolts w/ PW | None	600	0
		12'-0"	2'-8"	PHD2 |1 bolt w/PW	1,020	210
		12'-0"	3'-4"	PHD2 | 2 bolts w/PW	1,442	631
		12'-0"	4'-0"	PHD2	1,863	1,052
2,000	3C	14'-8"	2'-0"	None	0	0
		14'-8"	2'-8"	1 bolt w/PW | None	132	0
		14'-8"	3'-4"	1 bolt w/PW | None	485	0
		14'-8"	4'-0"	2 bolts w/PW | None	838	0
2,000	3D	16'-0"	2'-0"	None	0	0
		16'-0"	2'-8"	1 bolt w/PW | None	42	0
		16'-0"	3'-4"	1 bolt w/ PW | None	411	0
		16'-0"	4'-0"	2 bolts w/PW | None	779	0

DRAFT TABLE C-4
High Capacity Single Segment Length Bracing for 1,800 Sq. Ft. Two-Story Buildings
Using 15/32" Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing

Total Floor Area (sq. ft.)	Case ID	Bracing Length	Cripple Wall Height	Tie-down Required at Each End of Braced Panel		Tie-down Force (lbs.)	
						Trans	Long
1,800	3A	9’-4”	2’-0”	1 bolt w/PW	None	328	0
		9’-4”	2’-8”	2 bolts w/PW	None	703	0
		9’-4”	3’-4”	PHD2	1 bolt w/PW	1,077	314
		9’-4”	4’-0”	PHD2	2 bolts w/PW	1,452	689
1,800	3B	10’-8”	2’-0’	1 bolt w/PW	None	159	0
		10’-8”	2’-8”	1 bolt w/PW	None	579	0
		10’-8”	3’-4”	2 bolts w/PW	None	998	0
		10’-8”	4’-0”	PHD2	1 bolt w/PW	1,417	375
1,800	3C	13’-4”	2’-0”	None		0	0
		13’-4”	2’-8”	None		0	0
		13’-4”	3’-4”	None		0	0
		13’-4”	4’-0”	None		0	0
1,800	3D	14’-8”	2’-0”	None		0	0
		14’-8”	2’-8”	None		0	0
		14’-8”	3’-4”	None		0	0
		14’-8”	4’-0”	None		0	0

DRAFT TABLE C-5
High Capacity Single Segment Length Bracing for 2,400 Sq. Ft. Two-Story Buildings
Using 15/32” Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing

Total Floor Area (sq. ft.)	Case ID	Bracing Length	Cripple Wall Height	Tie-down Required at Each End of Braced Panel		Tie-down Force (lbs.)	
						Trans	Long
2,400	3A	10’-8’	2’-0”	1 bolt w/PW	None	310	0
		10’-8”	2’-8”	2 bolts w/PW	None	710	0
		10’-8”	3’-4”	PHD2	1 bolt w/PW	1,110	257
		10’-8”	4’-0”	PHD2	2 bolts w/PW	1,510	657
2,400	3B	13’-4”	2’-0’	None		0	0
		13’-4”	2’-8”	1 bolt w/PW	None	281	0
		13’-4”	3’-4”	2 bolts w/PW	None	684	0
		13’-4”	4’-0”	PHD2	None	1,087	0
2,400	3C	16’-0”	2’-0”	None		0	0
		16’-0”	2’-8”	None		0	0
		16’-0”	3’-4”	None		0	0
		16’-0”	4’-0”	None		0	0
2,400	3D	17’-4”	2’-0”	None		0	0
		17’-4”	2’-8”	None		0	0
		17’-4”	3’-4”	None		0	0
		17’-4”	4’-0”	None		0	0

DRAFT TABLE C-6
High Capacity Single Segment Length Bracing for 3,000 Sq. Ft. Two-Story Buildings
Using 15/32” Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing

Total Floor Area (sq. ft.)	Case ID	Bracing Length	Cripple Wall Height	Tie-down Required at Each End of Braced Panel		Tie-down Force (lbs.)	
						Trans	Long

3,000	3A	12’-0”	2’-0”	1 bolt w/PW	None	273	0
		12’-0”	2’-8”	2 bolts w/PW	None	692	0
		12’-0”	3’-4”	PHD2	1 bolt w/PW	1,112	169
		12’-0”	4’-0”	PHD2	2 bolts w/PW	1,531	588
3,000	3B	16’-0”	2’-0’	None		0	0
		16’-0”	2’-8”	None		0	0
		16’-0”	3’-4”	1 bolt w/PW	None	390	0
		16’-0”	4’-0”	2 bolts w/PW	None	780	0
3,000	3C	18’-8”	2’-0”	None		0	0
		18’-8”	2’-8”	None		0	0
		18’-8”	3’-4”	None		0	0
		18’-8”	4’-0”	None		0	0
3,000	3D	20’-0”	2’-0”	None		0	0
		20’-0”	2’-8”	None		0	0
		20’-0”	3’-4”	None		0	0
		20’-0”	4’-0”	None		0	0

DRAFT TABLE D-1
High Capacity Multi-Segment Bracing for 1,200 Sq. Ft. One-Story Buildings
Using 15/32” Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing
All panels lengths used in this table comply with a minimum 1:2 height-to-width ratio

Total Floor Area (sq. ft.)	Case ID	Bracing Length	Cripple Wall Height	Tie-down Required at Each End of Braced Panel		Tie-down Force (lbs.) Trans	Long
1,200	3A	2 @ 4’-0”	2’-0”	2 bolts w/PW	2 bolts w/PW	830	592
1,200	3A	8’-0”min	>2’-0”	See Table C-1			
1,200	3B	1 @ 4’-0”	2’-0”	2 bolts w/PW	2 bolts w/PW	865	574
		1 @ 5’-4”	2’-0”	2 bolts w/PW	1 bolt w/PW	794	439
1,200	3B	2 @ 5’-4”	2’-8”	2 bolts w/PW	2 bolts w/PW	884	623
1,200	3B	9’-4”min	>2’-8”	See Table C-1			
1,200	3C	1 @ 4’-0”	2’-0”	2 bolts w/PW	2 bolts w/PW	875	610
		1 @ 6’-8”	2’-0”	2 bolts w/PW	1 bolt w/PW	638	268
1,200	3C	2 @ 5’-4”	2’-8”	PHD2	2 bolts w/PW	1,197	872
1,200	3C	2 @ 6-8”	3’-4”	PHD2	2 bolts w/PW	1,037	654
1,200	3C	10’-8”min	>3’-4”	See Table C-1			
1,200	3D	1 @ 4’-0”	2’-0”	2 bolts w/PW	1 bolt w/PW	665	294
		1 @ 8’-0”	2’-0”	1 bolt w/PW	None	298	0
1,200	3D	1 @ 5’-4”	2’-8”	2 bolts w/PW	1 bolt w/PW	918	464
		1 @ 6’-8”	2’-8”	2 bolts w/PW	1 bolt w/PW	790	254
1,200	3D	2 @ 6’-8”	3’-4”	PHD2	2 bolts w/PW	1,160	624
1,200	3D	12’-0”min	>3’-4”	See Table C-1			

DRAFT TABLE D-2

High Capacity Multi-Segment Bracing for 1,500 Sq. Ft. One-Story Buildings

Using 15/32” Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing

All panels lengths used in this table comply with a minimum 1:2 height-to-width ratio

Total Floor Area (sq. ft.)	Case ID	Bracing Length	Cripple Wall Height	Tie-down Required at Each End of Braced Panel	Tie-down Force (lbs.) Trans	Long
1,500	3A	2 @ 4’-0”	2’-0”	PHD2 | 2 bolts w/PW	1,024	785
1,500	3A	2 @ 5’-4”	2’-8”	2 bolts w/PW | 2 bolts w/PW	951	660
1,500	3A	1 @ 8’-0”	>2’-8”	See Table C-2		
1,500	3B	1 @ 4’-0”	2’-0”	2 bolts w/PW | 2 bolts w/PW	894	603
		1 @ 6’-8”	2’-0”	2 bolts w/PW | 1 bolt w/PW	753	333
1,500	3B	2 @ 5’-4”	2’-8”	PHD2 | 2 bolts w/PW	1,214	859
1,500	3B	2 @ 6’-8”	3’-4”	PHD2 | 2 bolts w/PW	1,125	706
1,500	3B	10’-8”min	>3’-4”	See Table C-2		
1,500	3C	3 @ 4’-0”	2’-0”	2 bolts w/PW | 1 bolt w/PW	719	453
1,500	3C	1 @ 4’-0”	2’-0”	2 bolts w/PW | 1 bolt w/PW	719	453
		1 @ 8’-0”	2’-0”	1 bolt w/PW | None	363	0
1,500	3C	1 @ 5’-4”	2’-8”	2 bolts w/PW | 2 bolts w/PW	988	663
		1 @ 6’-8”	2’-8”	2 bolts w/PW | 1 bolt w/PW	864	480
1,500	3C	2 @ 6’-8”	3’-4”	PHD2 | 2 bolts w/PW	1,037	564
1,500	3C	12’-0”min	>3’-4”	See Table C-2		
1,500	3D	1 @ 4’-0”	2’-0”	2 bolts w/PW | 1 bolt w/PW	731	433
		1 @ 9’-4”	2’-0”	1 bolt w/PW | None	242	0
1,500	3D	2 @ 4’-0”	2’-0’	2 bolts w/PW | 1 bolt w/PW	731	433
		1 @ 5’-4”	2’-0”	2 bolts w/PW | 1 bolt w/PW	609	245
1,500	3D	3 @ 5’-4”	2’-8”	2 bolts w/PW | 1 bolt w/PW	721	268
1,500	3D	2 @ 6’-8”	3’-4”	PHD2 | 2 bolts w/PW	1,270	840
1,500	3D	13’-4”min	>3’-4”	See Table C-2		

DRAFT TABLE D-3

High Capacity Multi-Segment Bracing for 2,000 Sq. Ft. One-Story Buildings

Using 15/32" Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing

All panels lengths used in this table comply with a minimum 1:2 height-to-width ratio

Total Floor Area (sq. ft.)	Case ID	Bracing Length	Cripple Wall Height	Tie-down Required at Each End of Braced Panel	Tie-down Force (lbs.) Trans	Tie-down Force (lbs.) Long
2,000	3A	3 @ 4'-0"	2'-0"	2 bolts w/PW | 1 bolt w/PW	809	527
2,000	3A	1 @ 4'-0"	2'-0"	2 bolts w/PW | 2 bolts w/PW	944	661
		1 @ 6'-8"	2'-0"	2 bolts w/PW | 1 bolt w/PW	826	417
2,000	3A	2 @ 5'-4"	2'-8"	PHD2 | 2 bolts w/PW	1,274	929
2,000	3A	2 @ 6'-8"	3'-4"	PHD2 | 2 bolts w/PW	1,197	789
2,000	3A	10'-8"min	>3'-4"	See Table C-3		
2,000	3B	3 @ 4'-0"	2'-0"	PHD2 | 2 bolts w/PW	1,022	675
2,000	3B	1 @ 4'-0"	2'-0"	PHD2 | 2 bolts w/PW	1,022	675
		1 @ 8'-0"	2'-0"	2 bolts w/PW | 1 bolt w/PW	811	232
2,000	3B	1 @ 4'-0"	2'-0"	2 bolts w/PW | 1 bolt w/PW	778	431
		2 @ 5'-4"	2'-0"	2 bolts w/PW | 1 bolt w/PW	708	283
2,000	3B	3 @ 5'-4"	2'-8"	2 bolts w/PW | 1 bolt w/PW	938	514
2,000	3B	2 @ 6'-8"	3'-4"	PHD2	1,519	1,017
2,000	3B	12'-0"min	>3'-4"	See Table C-3		
2,000	3C	4 @ 4'-0"	2'-0"	2 bolts w/PW | 1 bolt w/PW	623	300
2,000	3C	1 @ 4'-0"	2'-0"	2 bolts w/PW | 1 bolt w/PW	728	405
		2 @ 5'-4"	2'-0"	2 bolts w/PW | 1 bolt w/PW	609	215
2,000	3C	1 @ 4'-0"	2'-0"	2 bolts w/PW | 1 bolt w/PW	623	300
		1 @ 5'-4"	2'-0"	1 bolt w/PW | 1 bolt w/PW	504	110
		1 @ 6'-8"	2'-0"	1 bolt w/ PW | None	385	0
2,000	3C	2 @ 5'-4"	2'-8"	2 bolts w/PW | 1 bolt w/PW	741	347
		1 @ 6'-8"	2'-8"	2 bolts w/PW | 1 bolt w/PW	617	152
2,000	3C	2 @ 6'-8"	3'-4"	PHD2	1,471	1,006
2,000	3C	14'-8"min	>3'-4"	See Table C-3		

2,000	3D	4 @ 4’-0”	2’-0”	2 bolts w/PW | 1 bolt w/PW	774	322
2,000	3D	1 @ 4’-0”	2’-0”	2 bolts w/PW | 1 bolt w/PW	774	322
		1 @ 5’-4”	2’-0”	2 bolts w/PW | 1 bolt w/PW	652	100
		1 @ 6’-8”	2’-0”	1 bolt w/ PW | None	529	0
2,000	3D	3 @ 5’-4”	2’-8”	PHD2 | 1 bolt w/PW	1,063	511
2,000	3D	2 @ 5’-4”	2’-8”	2 bolts w/PW | 1 bolt w/PW	927	375
		1 @ 6’-8”	2’-8”	2 bolts w/PW | 1 bolt w/PW	800	147
2,000	3D	3 @ 6’-8”	3’-4”	2 bolts w/PW | 1 bolt w/PW	901	248
2,000	3D	2 @ 8’-0”	4’-0”	1 bolt w/ PW | None	433	0
2,000	3D	16’-0”min		See Table C-3		

DRAFT TABLE D-4
High Capacity Multi-Segment Bracing for 1,800 Sq. Ft. Two-Story Buildings
Using 15/32” Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing
All panels lengths used in this table comply with a minimum 1:2 height-to-width ratio

Total Floor Area (sq. ft.)	Case ID	Bracing Length	Cripple Wall Height	Tie-down Required at Each End of Braced Panel	Tie-down Force (lbs.) Trans	Tie-down Force (lbs.) Long
1,800	3A	1 @ 4’-0”	2’-0”	2 bolts w/PW | 1 bolt w/PW	732	327
		1 @ 5’-4”	2’-0”	2 bolts w/PW | 1 bolt w/PW	631	137
1,800	3A	2 @ 5’-4”	2’-8”	2 bolts w/PW | 1 bolt w/PW	815	321
1,800	3A	9’-4” min	>2’-8”	See Table C-4		
1,800	3B	1 @ 4’-0”	2’-0”	2 bolts w/PW | 1 bolt w/PW	773	280
		1 @ 6’-8”	2’-0”	1 bolt w/PW | None	528	0
1,800	3B	2 @ 5’-4”	2’-8”	PHD2 | 1 bolt w/PW	1,079	476
1,800	3B	2 @ 6’-8”	3’-4”	2 bolts w/PW | 1 bolt w/PW	939	226
1,800	3B	10’-8”min	>3’-4”	See Table C-4		
1,800	3C	2 @ 4’-0”	2’-0”	1 bolt w/PW | None	348	0
		1 @ 5’-4”	2’-0”	1 bolt w/PW | None	143	0
1,800	3C	3 @ 5’-4”	2’-8”	1 bolt w/PW | None	255	0
1,800	3C	2 @ 6’-8”	3’-4”	2 bolts w/PW | None	714	38
1,800	3C	2 @ 8’-0”	4’-0”	1 bolt w/PW | None	458	0
1,800	3C	13’-4”min		See Table C-4		
1,800	3D	4 @ 4’-0”	2’-0”	1 bolt w/PW | None	201	0
1,800	3D	1 @ 4’-0”	2’-0”	1 bolt w/PW | None	304	0
		2 @ 5’-4”	2’-0”	1 bolt w/PW | None	96	0
1,800	3D	3 @ 5’-4”	2’-8”	1 bolt w/PW | None	342	0
1,800	3D	1 @ 6’-8”	3’-4”	2 bolts w/PW | None	645	0
		1 @ 8’-0”	3’-4”	1 bolt w/PW | None	426	0
1,800	3D	2 @ 8’-0”	4’-0”	2 bolts w/PW | None	593	0
1,800	3D	14’-8”min		See Table C-4		

DRAFT TABLE D-5

High Capacity Multi-Segment Bracing for 2,400 Sq. Ft. Two-Story Buildings

Using 15/32" Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing

All panels lengths used in this table comply with a minimum 1:2 height-to-width ratio

Total Floor Area (sq. ft.)	Case ID	Bracing Length	Cripple Wall Height	Tie-down Required at Each End of Braced Panel	Tie-down Force (lbs.) Trans	Tie-down Force (lbs.) Long
2,400	3A	3 @ 4'-0"	2'-0"	2 bolts w/PW | 1 bolt w/PW	674	269
2,400	3A	1 @ 4'-0"	2'-0"	2 bolts w/PW | 1 bolt w/PW	815	410
		1 @ 6'-8"	2'-0"	2 bolts w/PW | None	613	29
2,400	3A	2 @ 5'-4"	2'-8"	PHD2 | 2 bolts w/PW	1,123	629
2,400	3A	2 @ 6'-8"	3'-4"	PHD2 | 1 bolt w/PW	1,004	421
2,400	3A	10'-8"min	>3'-4"	See Table C-5		
2,400	3B	4 @ 4'-0"	2'-0"	1 bolt w/PW | None	523	29
2,400	3B	2 @ 4'-0"	2'-0"	2 bolts w/PW | 1 bolt w/PW	738	245
		1 @ 5'-4"	2'-0"	2 bolts w/PW | None	615	12
2,400	3B	3 @ 5'-4"	2'-8"	2 bolts w/PW | 1 bolt w/PW	746	142
2,400	3B	2 @ 6'-8"	3'-4"	PHD2 | 2 bolts w/PW	1,322	999
2,400	3B	2 @ 8'-0"	4'-0"	PHD2 | 1 bolt w/PW	1,176	354
2,400	3B	13'-4"min		See Table C-5		
2,400	3C	4 @ 4'-0"	2'-0"	1 bolt w/PW | None	354	0
2,400	3C	1 @ 4'-0"	2'-0"	1 bolt w/PW | None	354	0
		1 @ 5'-4"	2'-0"	1 bolt w/PW | None	150	0
		1 @ 6'-8"	2'-0"	None	0	0
2,400	3C	3 @ 5'-4"	2'-8"	1 bolt w/PW | None	545	0
2,400	3C	3 @ 6'-8"	3'-4"	1 bolt w/PW | None	300	0
2,400	3C	2 @ 8'-0"	4'-0"	2 bolts w/PW | 1 bolt w/PW	894	113
2,400	3C	16'-0"min		See Table C-5		
2,400	3D	5 @ 4'-0"	2'-0"	1 bolt w/PW | None	167	0
2,400	3D	1 @ 4'-0"	2'-0"	1 bolt w/PW | None	336	0
		1 @ 5'-4"	2'-0"	1 bolt w/PW | None	128	0
		1 @ 8'-0"	2'-0"	None	0	0
2,400	3D	1 @ 5'-4"	2'-8"	1 bolt w/PW | None	402	0
		2 @ 6'-8"	2'-8"	1 bolt w/PW | None	188	0

2,400	3D	3 @ 6’-8”	3’-4”	1 bolt w/PW	None	416	0
2,400	3D	1 @ 8’-0”	4’-0”	2 bolts w/PW	None	864	0
		1 @ 9’-4”	4’-0”	2 bolts w/PW	None	639	0
2,400	3D	17’-4”min		See Table C-5			

DRAFT TABLE D-6
High Capacity Multi-Segment Bracing for 3,000 Sq. Ft. Two-Story Buildings
Using 15/32” Structural I Plywood w/ 10d @ 3 inch o.c. edge nailing
All panels lengths used in this table comply with a minimum 1:2 height-to-width ratio

Total Floor Area (sq. ft.)	Case ID	Bracing Length	Cripple Wall Height	Tie-down Required at Each End of Braced Panel		Tie-down Force (lbs.)	
						Trans	Long
3,000	3A	3 @ 4’-0”	2’-0”	2 bolts w/PW	1 bolt w/PW	879	475
3,000	3A	1 @ 4’-0”	2’-0”	2 bolts w/PW	1 bolt w/PW	637	232
		2 @ 5’-4”	2’-0”	1 bolt w/PW	None	536	42
3,000	3A	1 @ 5’-4”	2’-8”	PHD2	2 bolts w/PW	1,209	715
		1 @ 6’-8”	2’-8”	PHD2	1 bolt w/PW	1,106	522
3,000	3A	3 @ 5’-4”	2’-8”	2 bolts w/PW	1 bolt w/PW	765	271
3,000	3A	2 @ 6’-8”	3’-4”	PHD2	2 bolts w/PW	1,313	729
3,000	3A	2 @ 8’-0”	4’-0”	PHD2	1 bolt w/PW	1,189	515
3,000	3A	12’-0”min		See Table C-6			
3,000	3B	4 @ 4’-0”	2’-0”	2 bolts w/PW	1 bolt w/PW	715	221
3,000	3B	1 @ 4’-0”	2’-0”	2 bolts w/PW	1 bolt w/PW	617	124
		2 @ 6’-8”	2’-0”	1 bolt w/PW	None	372	0
3,000	3B	3 @ 5’-4”	2’-8”	PHD2	1 bolt w/PW	1001	398
3,000	3B	3 @ 6’-8”	3’-4”	2 bolts w/PW	1 bolt w/PW	768	147
3,000	3B	2 @ 8’-0”	4’-0”	PHD2	2 bolts w/PW	1,560	737
3,000	3B	16’-0”min		See Table C-6			
3,000	3C	5 @ 4’-0”	2’-0”	1 bolt w/PW	None	272	0
3,000	3C	1 @ 4’-0”	2’-0”	1 bolt w/PW	None	358	0
		1 @ 6’-8”	2’-0”	1 bolt w/PW	None	0	0
		1 @ 8’-0”	2’-0”	None		0	0
3,000	3C	1 @ 4’-0”	2’-0”	1 bolt w/PW	None	272	0
		3 @ 5’-4”	2’-0”	1 bolt w/PW	None	68	0
3,000	3C	4 @ 5’-4”	2’-8”			336	0
3,000	3C	3 @ 6’-8”	3’-4”	1 bolt w/PW	None	588	0
3,000	3C	3 @ 8’-0”	4’-0”	2 bolts w/PW	1 bolt w/PW	332	0
3,000	3C	18’-8”min		See Table C-5			
3,000	3D	5 @ 4’-0”	2’-0”	1 bolt w/PW	None	359	0
3,000	3D	1 @ 4’-0”	2’-0”	1 bolt w/PW	None	359	0
		3 @ 5’-4”	2’-0”	1 bolt w/PW	None	150	0

3,000	3D	4 @ 5’-4”	2’-8”	1 bolt w/PW	None	444	0
3,000	3D	3 @ 5’-4”	2’-8”	1 bolt w/PW	None	349	0
		1 @ 6’-8”	2’-8”	1 bolt w/PW	None	136	0
3,000	3D	3 @ 6’-8”	3’-4”	2 bolts w/PW	None	736	0
3,000	3D	2 @ 6’-8”	3’-4”	2 bolts w/PW	None	600	0
		1 @ 8’-0”	3’-4”	1 bolt w/PW	None	382	0
3,000	3D	1 @ 8’-0”	4’-0”	2 bolts w/PW	None	908	0
		1 @ 12-0”	4’-0”	1 bolt w/PW	None	235	0
3,000	3D	20-0”min		See Table C-5			