ENGINEERING

The Engineering section presents information necessary for design of Stone Strong retaining walls in a gravity configuration. This information includes design methodologies and example calculations for traditional allowable stress method as well as LRFD (Load and Resistance Factor Design) procedures. Information is also provided on computerized analysis methods.

The design methodologies presented conform substantially to AASHTO specifications (Standard Specification for Highway Bridges - 2002, or LRFD Bridge Specifications - 2007). The allowable stress methodology has undergone rigorous evaluation through the HITEC review process and was judged to be in conformance with the AASHTO standard.

This section includes the following documents:

- Gravity Wall Height Tables
  - Typical
  - Typical (metric)
  - AASHTO
  - AASHTO (metric)
  - LRFD
  - LRFD (metric)
  - Vertical Face
  - Vertical Face (metric)
- Gravity Wall Design Methodology
- Example Calculation (no tail extension)
- Example Calculation (w/ tail extension)
- LRFD Design Methodology
- LRFD Example Calc (no tail extension)
- LRFD Example Calc (w/ tail extension)
- Calculation Spreadsheet User Notes
- Calculation Spreadsheet Example Calculation

Stone Strong recommends that site specific design be performed by a licensed Professional Engineer who is familiar with the site conditions. Global stability should be evaluated separately by the designer considering the site specific soil and ground water conditions.

Calculation Spreadsheet

None of the commercially available software packages will accommodate analysis of “stepped module” configurations (modular units of different width). Stone Strong has developed a powerful spreadsheet application for Microsoft Excel that will analyze stepped modules in a gravity configuration. The spreadsheet follows the design methodologies listed above, and includes options for allowable stress analysis, LRFD analysis, and metric versions of both cases. The file is compatible with Excel versions 97-2003 and later. The spreadsheet is extremely versatile and provides many design and analysis options.

In order to solve complex slope and surcharge geometry including tiered walls, a trial wedge analysis method is utilized. This routine automatically iterates to evaluate the critical failure geometry and the associated load on the wall system. This feature is unique to available analysis software currently available.

Geogrid Reinforced Walls

There are commercially available software packages with well documented methodologies that can be used for design of geogrid reinforced walls (e.g. MSEW & SRWall). These programs require test data to define the interface shear properties of the precast modular units and the connection properties between the synthetic geogrid and the precast modular facing. Test data for these properties are included in subsequent sections of this manual.

STONE STRONG systems

Stone Strong
Gravity Height Calculations

5/28/10

24SF & 6SF units only

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	150 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	9.0 ft.	7.5 ft.	9.0 ft.	7.5 ft.
Sand, ϕ = 30°	10.5 ft.	7.5 ft.	10.5 ft.	7.5 ft.
Sand/Gravel, ϕ = 34°	12.0 ft.	10.5 ft.	10.5 ft.	10.5 ft.
Crushed Stone, ϕ = 38°	13.5 ft.	12.0 ft.	12.0 ft.	12.0 ft.

Table based on minimum recommneded safety factors:

Overturning FS=1.5 Sliding FS=1.5 Bearing FS=2.0

Seismic safety factors reduced by 25%

clay soil includes 150 psf cohesion in foundation soil

unit weight 120 pcf for clay, 125 pcf for all other soils

24-62 base unit

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	150 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	12.0 ft.	9.0 ft.	12.0 ft.	9.0 ft.
Sand, ϕ = 30°	13.5 ft.	10.5 ft.	13.5 ft.	10.5 ft.
Sand/Gravel, ϕ = 34°	15.0 ft.	13.5 ft.	15.0 ft.	13.5 ft.
Crushed Stone, ϕ = 38°	18.0 ft.	15.0 ft.	16.5 ft.	16.5 ft.

24-ME (12" extenstion) base unit

Level	Level	Level	3H:1V
0 psf	150 psf	0 psf	0 psf
0g	0g	0.15g	0g
12.0 ft.	9.0 ft.	12.0 ft.	9.0 ft.
13.5 ft.	10.5 ft.	13.5 ft.	10.5 ft.
15.0 ft.	13.5 ft.	15.0 ft.	13.5 ft.
16.5 ft.	15.0 ft.	16.5 ft.	15.0 ft.

24-86 & 24-62 base units

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	150 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	13.5 ft.	12.0 ft.	13.5 ft.	10.5 ft.
Sand, ϕ = 30°	16.5 ft.	13.5 ft.	16.5 ft.	12.0 ft.
Sand/Gravel, ϕ = 34°	19.5 ft.	16.5 ft.	19.5 ft.	16.5 ft.
Crushed Stone, ϕ = 38°	22.5 ft.	19.5 ft.	21.0 ft.	19.5 ft.

24" CIP tail extension

Level	Level	Level	3H:1V
0 psf	150 psf	0 psf	0 psf
0g	0g	0.15g	0g
13.5 ft.	10.5 ft.	13.5 ft.	9.0 ft.
15.0 ft.	12.0 ft.	15.0 ft.	10.5 ft.
18.0 ft.	15.0 ft.	18.0 ft.	15.0 ft.
19.5 ft.	16.5 ft.	19.5 ft.	18.0 ft.

STONE STRONG systems

Stone Strong
Gravity Height Calculations
AASHTO

5/28/10

24SF & 6SF units only

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	250 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	7.5 ft.	4.5 ft.	7.5 ft.	6.0 ft.
Sand, ϕ = 30°	9.0 ft.	6.0 ft.	7.5 ft.	7.5 ft.
Sand/Gravel, ϕ = 34°	10.5 ft.	7.5 ft.	9.0 ft.	9.0 ft.
Crushed Stone, ϕ = 38°	10.5 ft.	7.5 ft.	9.0 ft.	10.5 ft.

Table based on AASHTO safety factors:

Overturning FS=2.0 Sliding FS=1.5 Bearing FS=3.0

Seismic safety factors reduced by 25%

clay soil includes 150 psf cohesion in foundation soil

unit weight 120 pcf for clay, 125 pcf for all other soils

24-62 base unit

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	250 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	10.5 ft.	7.5 ft.	10.5 ft.	9.0 ft.
Sand, ϕ = 30°	12.0 ft.	7.5 ft.	10.5 ft.	10.5 ft.
Sand/Gravel, ϕ = 34°	13.5 ft.	9.0 ft.	12.0 ft.	10.5 ft.
Crushed Stone, ϕ = 38°	15.0 ft.	10.5 ft.	13.5 ft.	13.5 ft.

24-ME (12" extenstion) base unit

Level	Level	Level	3H:1V
0 psf	250 psf	0 psf	0 psf
0g	0g	0.15g	0g
10.5 ft.	7.5 ft.	9.0 ft.	9.0 ft.
10.5 ft.	7.5 ft.	10.5 ft.	9.0 ft.
12.0 ft.	9.0 ft.	10.5 ft.	10.5 ft.
13.5 ft.	10.5 ft.	12.0 ft.	12.0 ft.

24-86 & 24-62 base units

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	250 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	10.5 ft.	10.5 ft.	13.5 ft.	10.5 ft.
Sand, ϕ = 30°	12.0 ft.	12.0 ft.	15.0 ft.	12.0 ft.
Sand/Gravel, ϕ = 34°	16.5 ft.	13.5 ft.	15.0 ft.	15.0 ft.
Crushed Stone, ϕ = 38°	18.0 ft.	13.5 ft.	16.5 ft.	16.5 ft.

24" CIP tail extension

Level	Level	Level	3H:1V
0 psf	250 psf	0 psf	0 psf
0g	0g	0.15g	0g
12.0 ft.	9.0 ft.	12.0 ft.	10.5 ft.
13.5 ft.	10.5 ft.	12.0 ft.	12.0 ft.
15.0 ft.	12.0 ft.	13.5 ft.	13.5 ft.
16.5 ft.	13.5 ft.	15.0 ft.	15.0 ft.

STONE STRONG systems

Stone Strong
Gravity Height Calculations
AASHTO - LRFD

5/28/10

24SF & 6SF units only

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	250 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	7.5 ft.	3.0 ft.	7.5 ft.	6.0 ft.
Sand, ϕ = 30°	7.5 ft.	4.5 ft.	7.5 ft.	7.5 ft.
Sand/Gravel, ϕ = 34°	9.0 ft.	4.5 ft.	9.0 ft.	7.5 ft.
Crushed Stone, ϕ = 38°	10.5 ft.	6.0 ft.	10.5 ft.	9.0 ft.

Table based on AASHTO load and resistance factors

clay soil includes 150 psf cohesion in foundation soil

unit weight 120 pcf for clay, 125 pcf for all other soils

24-62 base unit

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	250 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	10.5 ft.	6.0 ft.	10.5 ft.	7.5 ft.
Sand, ϕ = 30°	10.5 ft.	6.0 ft.	10.5 ft.	9.0 ft.
Sand/Gravel, ϕ = 34°	12.0 ft.	7.5 ft.	12.0 ft.	10.5 ft.
Crushed Stone, ϕ = 38°	13.5 ft.	9.0 ft.	13.5 ft.	12.0 ft.

24-ME (12" extenstion) base unit

Level	Level	Level	3H:1V
0 psf	250 psf	0 psf	0 psf
0g	0g	0.15g	0g
9.0 ft.	6.0 ft.	9.0 ft.	7.5 ft.
10.5 ft.	6.0 ft.	10.5 ft.	9.0 ft.
12.0 ft.	7.5 ft.	12.0 ft.	10.5 ft.
13.5 ft.	9.0 ft.	13.5 ft.	12.0 ft.

24-86 & 24-62 base units

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	250 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	13.5 ft.	9.0 ft.	13.5 ft.	10.5 ft.
Sand, ϕ = 30°	13.5 ft.	9.0 ft.	13.5 ft.	12.0 ft.
Sand/Gravel, ϕ = 34°	16.5 ft.	12.0 ft.	16.5 ft.	15.0 ft.
Crushed Stone, ϕ = 38°	18.0 ft.	13.5 ft.	18.0 ft.	16.5 ft.

24" CIP tail extension

Level	Level	Level	3H:1V
0 psf	250 psf	0 psf	0 psf
0g	0g	0.15g	0g
12.0 ft.	9.0 ft.	12.0 ft.	9.0 ft.
13.5 ft.	9.0 ft.	13.5 ft.	10.5 ft.
15.0 ft.	12.0 ft.	15.0 ft.	13.5 ft.
16.5 ft.	13.5 ft.	16.5 ft.	15.0 ft.

STONE STRONG systems

Stone Strong
Gravity Height Calculations
Vertical Face

5/28/10

24SF & 6SF units only

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	150 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	9.0 ft.	6.0 ft.	9.0 ft.	7.5 ft.
Sand, ϕ = 30°	9.0 ft.	7.5 ft.	9.0 ft.	7.5 ft.
Sand/Gravel, ϕ = 34°	10.5 ft.	7.5 ft.	10.5 ft.	9.0 ft.
Crushed Stone, ϕ = 38°	12.0 ft.	9.0 ft.	10.5 ft.	10.5 ft.

Table based on minimum recommneded safety factors:

Overturning FS=1.5 Sliding FS=1.5 Bearing FS=2.0

Seismic safety factors reduced by 25%

clay soil includes 150 psf cohesion in foundation soil

unit weight 120 pcf for clay, 125 pcf for all other soils

recess and face adjusted for zero setback

24-62 base unit

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	150 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	12.0 ft.	9.0 ft.	12.0 ft.	9.0 ft.
Sand, ϕ = 30°	12.0 ft.	10.5 ft.	12.0 ft.	9.0 ft.
Sand/Gravel, ϕ = 34°	13.5 ft.	12.0 ft.	13.5 ft.	12.0 ft.
Crushed Stone, ϕ = 38°	15.0 ft.	13.5 ft.	15.0 ft.	13.5 ft.

24-ME (12" extenstion) base unit

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	150 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	12.0 ft.	9.0 ft.	10.5 ft.	9.0 ft.
Sand, ϕ = 30°	12.0 ft.	10.5 ft.	12.0 ft.	9.0 ft.
Sand/Gravel, ϕ = 34°	13.5 ft.	12.0 ft.	13.5 ft.	12.0 ft.
Crushed Stone, ϕ = 38°	15.0 ft.	13.5 ft.	13.5 ft.	13.5 ft.

24-86 & 24-62 base units

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	150 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	13.5 ft.	12.0 ft.	13.5 ft.	10.5 ft.
Sand, ϕ = 30°	16.5 ft.	13.5 ft.	16.5 ft.	12.0 ft.
Sand/Gravel, ϕ = 34°	18.0 ft.	15.0 ft.	18.0 ft.	16.5 ft.
Crushed Stone, ϕ = 38°	19.5 ft.	16.5 ft.	19.5 ft.	18.0 ft.

24" CIP tail extension

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 psf	150 psf	0 psf	0 psf
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	13.5 ft.	10.5 ft.	13.5 ft.	9.0 ft.
Sand, ϕ = 30°	15.0 ft.	12.0 ft.	13.5 ft.	12.0 ft.
Sand/Gravel, ϕ = 34°	16.5 ft.	13.5 ft.	15.0 ft.	15.0 ft.
Crushed Stone, ϕ = 38°	18.0 ft.	15.0 ft.	16.5 ft.	16.5 ft.

STONE STRONG systems

Stone Strong
Gravity Height Calculations
(metric)

5/28/10

24SF & 6SF units only

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 kPa	7.2 kPa	0 kPa	0 kPa
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	2.7 m	2.3 m	2.7 m	2.3 m
Sand, ϕ = 30°	3.2 m	2.3 m	3.2 m	2.3 m
Sand/Gravel, ϕ = 34°	3.7 m	2.7 m	3.7 m	3.2 m
Crushed Stone, ϕ = 38°	4.1 m	3.2 m	4.1 m	3.7 m

Table based on minimum recommneded safety factors:

Overturning FS=1.5 Sliding FS=1.5 Bearing FS=2.0

Seismic safety factors reduced by 25%

clay soil includes 7.5 kPa cohesion in foundation soil

unit weight 19 kN/m^3 for clay, 20 kN/m^3 for all other soils

24-62 base unit

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 kPa	7.2 kPa	0 kPa	0 kPa
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	3.7 m	2.7 m	3.7 m	2.7 m
Sand, ϕ = 30°	4.1 m	3.2 m	4.1 m	3.2 m
Sand/Gravel, ϕ = 34°	4.6 m	4.1 m	4.6 m	4.1 m
Crushed Stone, ϕ = 38°	5.0 m	4.6 m	5.0 m	4.6 m

24-ME (305 mm extenstion) base unit

Level	Level	Level	3H:1V
0 kPa	7.2 kPa	0 kPa	0 kPa
0g	0g	0.15g	0g
3.7 m	2.7 m	3.7 m	2.7 m
4.1 m	3.2 m	4.1 m	2.7 m
4.6 m	3.7 m	4.6 m	3.7 m
5.0 m	4.1 m	5.0 m	4.6 m

24-86 & 24-62 base units

Soil Type / Backfill Slope	Level	Level	Level	3H:1V
Surcharge	0 kPa	7.2 kPa	0 kPa	0 kPa
Seismic PGA	0g	0g	0.15g	0g
Clay, ϕ = 26°	4.6 m	3.7 m	4.6 m	3.2 m
Sand, ϕ = 30°	5.0 m	4.1 m	5.0 m	3.7 m
Sand/Gravel, ϕ = 34°	5.9 m	5.0 m	5.9 m	5.0 m
Crushed Stone, ϕ = 38°	6.9 m	5.9 m	6.9 m	5.9 m

610 mm CIP tail extension

Level	Level	Level	3H:1V
0 kPa	7.2 kPa	0 kPa	0 kPa
0g	0g	0.15g	0g
4.1 m	3.2 m	4.1 m	3.2 m
4.6 m	4.2 m	4.6 m	3.6 m
5.5 m	4.6 m	5.5 m	4.6 m
5.9 m	5.5 m	5.9 m	5.5 m

STONE STRONG systems

Stone Strong
Gravity Height Calculations
AASHTO (metric)

5/28/10

24SF & 6SF units only

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 12 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	2.3 m	1.4 m	2.3 m	1.8 m
Sand, ϕ = 30°	2.7 m	1.8 m	2.7 m	2.3 m
Sand/Gravel, ϕ = 34°	2.7 m	1.8 m	2.7 m	2.7 m
Crushed Stone, ϕ = 38°	3.2 m	2.3 m	3.2 m	3.2 m

Table based on AASHTO safety factors:

Overturning FS=2.0 Sliding FS=1.5 Bearing FS=3.0

Seismic safety factors reduced by 25%

clay soil includes 7.5 kPa cohesion in foundation soil

unit weight 19 kN/m^3 for clay, 20 kN/m^3 for all other soils

24-62 base unit

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 12 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	3.2 m	2.3 m	3.2 m	2.7 m
Sand, ϕ = 30°	3.2 m	2.3 m	3.2 m	3.2 m
Sand/Gravel, ϕ = 34°	3.7 m	2.7 m	3.7 m	3.2 m
Crushed Stone, ϕ = 38°	4.1 m	3.2 m	4.1 m	3.7 m

24-ME (12" extenstion) base unit

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 12 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	3.2 m	2.3 m	3.2 m	2.7 m
Sand, ϕ = 30°	3.2 m	2.3 m	3.2 m	2.7 m
Sand/Gravel, ϕ = 34°	3.7 m	2.7 m	3.7 m	3.2 m
Crushed Stone, ϕ = 38°	4.1 m	3.2 m	4.1 m	3.7 m

24-86 & 24-62 base units

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 12 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	4.1 m	3.2 m	4.1 m	3.2 m
Sand, ϕ = 30°	4.6 m	3.2 m	4.6 m	3.7 m
Sand/Gravel, ϕ = 34°	5.0 m	4.1 m	5.0 m	4.6 m
Crushed Stone, ϕ = 38°	5.5 m	4.1 m	5.5 m	5.0 m

24" CIP tail extension

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 12 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	3.7 m	2.7 m	3.7 m	3.2 m
Sand, ϕ = 30°	4.1 m	3.2 m	4.1 m	3.7 m
Sand/Gravel, ϕ = 34°	4.6 m	3.7 m	4.6 m	4.1 m
Crushed Stone, ϕ = 38°	5.0 m	4.1 m	5.0 m	4.6 m

STONE STRONG systems

Stone Strong
Gravity Height Calculations
AASHTO - LRFD (metric)

5/28/10

24SF & 6SF units only

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 12 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	1.8 m	0.9 m	1.8 m	1.4 m
Sand, ϕ = 30°	2.3 m	0.9 m	2.3 m	1.8 m
Sand/Gravel, ϕ = 34°	2.7 m	1.4 m	2.7 m	2.3 m
Crushed Stone, ϕ = 38°	3.2 m	1.8 m	3.2 m	2.7 m

Table based on AASHTO load and resistance factors

clay soil includes 7.5 kPa cohesion in foundation soil

unit weight 19 kN/m^3 for clay, 20 kN/m^3 for all other soils

24-62 base unit

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 12 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	2.7 m	1.8 m	2.7 m	2.3 m
Sand, ϕ = 30°	3.2 m	1.8 m	3.2 m	2.7 m
Sand/Gravel, ϕ = 34°	3.7 m	2.3 m	3.7 m	3.2 m
Crushed Stone, ϕ = 38°	4.1 m	2.7 m	4.1 m	3.7 m

24-ME (12" extenstion) base unit

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 12 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	2.7 m	1.4 m	2.7 m	2.1 m
Sand, ϕ = 30°	3.2 m	1.8 m	3.2 m	2.7 m
Sand/Gravel, ϕ = 34°	3.7 m	2.3 m	3.7 m	3.2 m
Crushed Stone, ϕ = 38°	4.1 m	2.7 m	4.1 m	3.7 m

24-86 & 24-62 base units

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 12 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	4.1 m	2.3 m	4.1 m	3.2 m
Sand, ϕ = 30°	4.1 m	2.7 m	4.1 m	3.7 m
Sand/Gravel, ϕ = 34°	4.6 m	3.7 m	4.6 m	4.1 m
Crushed Stone, ϕ = 38°	5.0 m	3.7 m	5.0 m	5.0 m

24" CIP tail extension

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 12 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	3.7 m	1.8 m	3.7 m	2.3 m
Sand, ϕ = 30°	3.7 m	2.7 m	3.7 m	3.2 m
Sand/Gravel, ϕ = 34°	4.1 m	3.2 m	4.1 m	3.7 m
Crushed Stone, ϕ = 38°	4.6 m	3.7 m	4.6 m	4.1 m

STONE STRONG systems

Stone Strong
Gravity Height Calculations
Vertical Face (metric)

5/28/10

24SF & 6SF units only

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 7.2 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	2.7 m	1.8 m	2.7 m	2.3 m
Sand, ϕ = 30°	2.7 m	2.3 m	2.7 m	2.3 m
Sand/Gravel, ϕ = 34°	3.2 m	2.3 m	3.2 m	2.7 m
Crushed Stone, ϕ = 38°	3.2 m	2.7 m	3.2 m	3.2 m

Table based on minimum recommneded safety factors:

Overturning FS=1.5 Sliding FS=1.5 Bearing FS=2.0

Seismic safety factors reduced by 25%

clay soil includes 7.5 kPa cohesion in foundation soil

unit weight 19 kN/m^3 for clay, 20 kN/m^3 for all other soils

recess and face adjusted for zero setback

24-62 base unit

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 7.2 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	3.7 m	2.7 m	3.7 m	2.7 m
Sand, ϕ = 30°	3.7 m	3.2 m	3.7 m	2.7 m
Sand/Gravel, ϕ = 34°	4.1 m	3.7 m	4.1 m	3.7 m
Crushed Stone, ϕ = 38°	4.6 m	4.1 m	4.6 m	4.1 m

24-ME (12" extenstion) base unit

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 7.2 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	3.2 m	2.7 m	3.2 m	2.7 m
Sand, ϕ = 30°	3.7 m	3.2 m	3.7 m	2.7 m
Sand/Gravel, ϕ = 34°	4.1 m	3.2 m	4.1 m	3.7 m
Crushed Stone, ϕ = 38°	4.6 m	3.7 m	4.6 m	4.1 m

24-86 & 24-62 base units

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 7.2 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	4.6 m	3.7 m	4.6 m	3.2 m
Sand, ϕ = 30°	5.0 m	4.1 m	5.0 m	3.7 m
Sand/Gravel, ϕ = 34°	5.5 m	5.0 m	5.5 m	5.0 m
Crushed Stone, ϕ = 38°	5.9 m	5.5 m	5.9 m	5.5 m

24" CIP tail extension

Soil Type / Backfill Slope / Surcharge / Seismic PGA	Level 0 kPa 0g	Level 7.2 kPa 0g	Level 0 kPa 0.15g	3H:1V 0 kPa 0g
Clay, ϕ = 26°	4.1 m	3.2 m	4.1 m	3.2 m
Sand, ϕ = 30°	4.1 m	3.7 m	4.1 m	3.2 m
Sand/Gravel, ϕ = 34°	5.0 m	4.1 m	5.0 m	4.6 m
Crushed Stone, ϕ = 38°	5.0 m	4.6 m	5.0 m	5.0 m