GRAVITY RETAINING WALL TECHNICAL MANUAL
The user is responsible for the final design and use of the CornerStone® products. All drawings, illustrations, and text are accurate to the best of our knowledge but a qualified engineer shall do the analysis and structural design for all aspects of the segmental retaining wall project. The sole responsibility of the suitability of the products or information in this manual lies with the user.
STANDARD BLOCK

- **Height**: 24” (610mm)
- **Depth**: 24” (610mm)
- **Face Width**: 48” (1219mm)
- **Back Width**: 39” (991mm)
- **Weight**: 1345 lbs (621 Kgs)
- **Volume Voids**: 6.35 ft³ (0.180 m³)
- **Gravel Filled Weight**: 2150 lbs (975 Kgs)
- **Face Area**: 8 sq ft (0.745 m²)
- **Batter/Setback**: 4.5 deg

TOP BLOCK

- **Height**: 24” (610mm)
- **Depth**: 24” (610mm)
- **Face Width**: 48” (1219mm)
- **Back Width**: 39” (991mm)
- **Weight**: 1220 lbs (553 Kgs)
- **Volume Voids**: 6.35 ft³ (0.180 m³)
- **Gravel Filled Weight**: 2003 lbs (909 Kgs)
- **Face Area**: 8 sq ft (0.745 m²)
- **Batter/Setback**: 4.5 deg

BASE BLOCK

- **Height**: 24” (610mm)
- **Depth**: 24” (610mm)
- **Face Width**: 48” (1219mm)
- **Back Width**: 38” (991mm)
- **Weight**: 1325 lbs (602 Kgs)
- **Volume Voids**: 6.35 ft³ (0.180 m³)
- **Gravel Filled Weight**: 2130 lbs (966 Kgs)
- **Face Area**: 8 sq ft (0.745 m²)
- **Batter/Setback**: 4.5 deg

*Face Style Varies. Check with local producer. Weights and dimensions are nominal. Assumption: Concrete = 143 pcf (22.5 Kn/m³) / Aggregate = 110 pcf (5.267)
UNIT SPECIFICATIONS

STANDARD LEFT END CAP
- Height: 24" (610mm)
- Depth: 8" (203mm)
- Top Narrow Width: 48" (1219mm)
- Bottom Narrow Width: 39" (991mm)
- Weight: 340 lbs (154 Kgs)
- Face Area: 4.66 sq2 (0.434 m2)

STANDARD RIGHT END CAP
- Height: 24" (610mm)
- Depth: 8" (203mm)
- Top Narrow Width: 48" (1219mm)
- Bottom Narrow Width: 39" (991mm)
- Weight: 340 lbs (154 Kgs)
- Face Area: 4.66 sq2 (0.434 m2)

HALF HIGH LEFT END CAP
- Height: 12" (305mm)
- Depth: 9" (229mm)
- Top Narrow Width: 3" (76mm)
- Bottom Narrow Width: 4" (102mm)
- Weight: 170 lbs (77 Kgs)
- Face Area: 2.33 sq2 (0.217 m2)

HALF HIGH RIGHT END CAP
- Height: 12" (305mm)
- Depth: 9" (229mm)
- Top Narrow Width: 3" (76mm)
- Bottom Narrow Width: 4" (102mm)
- Weight: 170 lbs (77 Kgs)
- Face Area: 2.33 sq2 (0.217 m2)

*Face Style Varies. Check with local producer. Weights and dimensions are nominal.
Assumption: Concrete = 143 pcf (22.5 Kn/m3) / Aggregate 110 pcf (5.267)
48"(1219)
Height: 24" 610mm
Depth: 48" 1219mm
Face Width: 48" 1219mm
Back Width: 39" 991mm
Weight: 1920 lbs 870 Kgs
Volume Voids: 18.2 ft3 0.511m3
Gravel Filled Weight: 3925 lbs 1780kg

72"(1829)
Height: 24" 610mm
Depth: 72" 1829mm
Face Width: 48" 1219mm
Back Width: 39" 991mm
Weight: 2220 lbs 1006 Kgs
Volume Voids: 31.9 ft3 0.894m3
Gravel Filled Weight: 5732 lbs 2600 Kg

96"(2438)
Height: 24" 610mm
Depth: 96" 2438mm
Face Width: 48" 1219mm
Back Width: 39" 991mm
Weight: 2795 lbs 1267 Kgs
Volume Voids: 45.4 ft3 1.271m3
Gravel Filled Weight: 7789 lbs 3533 Kg

120"(3048)
Height: 24" 610mm
Depth: 120" 3048mm
Face Width: 48" 1219mm
Back Width: 39" 991mm
Weight: 3098 lbs 1405 Kgs
Volume Voids: 54.8 ft3 1.534m3
Gravel Filled Weight: 9126 lbs 4139 Kg

*Face Style Varies Check with local producer / Weights and dimmensions are nominal
Assumption: Concrete = 143 pcf (22.5 Kn/m3) / Aggregate 110 pcf (5.267)
Extender to MagnumStone block installation

After the MagnumStone block with the extender has been laid in its appropriate place the extender unit is slowly dropped into the back center hollow portion. Once connected the MagnumStone and extender will act as 1 unit and be secured with back fill materials and compaction.

Extender tongue to be dropped into slot

MagnumStone back center groove slot

Extender slowly dropped into place

Extender and MagnumStone Act as 1 unit once connected

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Extender to Extender Installation
MagnumStone extenders can be used in any combination of standard lengths. The design will be based on what is best suited for the soils and loads. MagnumStone engineering design software will allow the user to choose what is best suited for the project. Once a back fill is chosen the contractor can backfill and compact around the extender units. Typically a free draining material clean stone or approved material will be used.

Clean Stone between extenders and through hollow core or approved backfill materials
**Excavation**
Follow proper procedures for excavation cut lines and slopes etc. Consult your local Engineer for a proper design and soils testing / analysis.

**Base Preparation**
Follow proper procedures for excavation cut lines and slopes etc.

The width of the base leveling pad should be the depth of the block and or extender(s) on the first course plus 6” (152mm) front and back.

Example for a standard unit:
24” + 6”(front) + 6” (back) = 48” total

Material should be a 3/4” (20mm) road crush or equivalent.

The depth of the leveling pad should be minimum of 6” thick compacted to 95% standard proctor density.

Soil separating fabrics may be used between the sub-base and leveling pad.

**MagnumStone Block Installation**
All MagnumStone Units shall be installed and leveled front to back and side to side.
MagnumStone block and extender installation
Install the MagnumStone base block on the leveling pad. The base block should not have the lugs on the bottom. Ensure that the blocks are level front to back and side to side. Place the tongue of the extender block inside the groove of the MagnumStone block. If extender to extender blocks are required place them in the same manner as the previous ensuring that the blocks stay level and true.

Backfill MagnumStone blocks and extender units
Backfilling the MagnumStone blocks and extender units with a clear crush gravel (#57 Stone) slightly above the units. Run a plate vibratory compactor over the stones and units allowing them to settle in the hollow cores. Sweep any excess stones off the top of the units and blocks.
**Drainage**

- **Finish laying the MagnumStone Units and Extenders**
- **4" Perforated Drain Pipe**
  - Daylight front of wall min 35ft (11m)
- **Back Fill the Hollow cores and between extender units with clean stone or approved Backfill**
- **Install the drain gravel slightly above the units and compact with a plate vibratory compactor. Sweep access rock and debris off the blocks before installing the next course**

**MagnumStone Block and Extender Installation**

Every MagnumStone block and extender unit should be installed with proper care ensuring they are level and aligned

- **Lay the Next row on a running Bond pattern with the SecureLugs Connected in the hollow core below**
- **Complete the 2nd row installation ensuring everything is level**
Soil Separation Fabric
Install a soil separating fabric to separate the fines and compacted backfill material from the drainage aggregate. The filter fabric can be installed directly behind the MagnumStone extender units.

Filter fabric installed at the back of the extender units

Compact the approved backfill material behind the filter fabric

Filter fabric wrapped around clean gravel to stop fines from migrating

Compaction
Once the blocks have been placed and leveled compact the approved backfill materials.
**Installation**

Ensure that proper installation procedures and techniques are being used while installing each course. The blocks should be installed and levelled front to back and side to side.

- **Filter fabric placed behind extender units**
- **Approved compacted backfill**
- **Drainage Through Hollow Core**
- **Clean Stone or approved Backfill materials between extender units and inside hollow cores**
- **Filter Fabric**
- **MagnumStone Top Unit**
Typical Completed Cross Section

- Filter Fabric
- Approved backfill materials
- Filter Fabric at back of extenders
- Excavation
- Filter Fabric wrapped around wash rock to protect fines from migrating
- Clean Stone or approved Backfill materials between extender units and inside hollow cores
- Extender Units as designed by Engineer
- Compacted Base Material
- Drain Pipe
- Toe of Wall or Embedment
48” (1219) Extender Outside Corner
Corners in retaining walls are unavoidable. With the MagnumStone gravity system we have developed a solution that fits any situation.

72” (1829) Extender Outside Corner
- Follow proper procedures for excavation cut lines and slopes etc.
48" (1219) Extender Inside Corner

48"(1219) Extender & Base Block

48"(1219) Extender & Base Block in Middle of adjacent block

48"(1219) Extender & Standard Block in Middle of Adjacent Block

48"(1219) Extender & Standard Block

72" (1829) Extender Inside Corner

72"(1829) Extender & Base Block

72"(1829) Extender & Base Block in Middle of Adjacent Block

72"(1829) Extender & Standard Block in Middle of Adjacent Block

72"(1829) Extender & Standard Block
96" (2438) Extender Inside Corner

96"(2438) Extender & Base Block Placed in Middle of Adjacent Block

96"(2438) Extender & Base Block

96"(2438) Extender & Standard Block

96"(2438) Extender & Standard Block Placed in Middle of Adjacent Block

120" (3048mm) Extender Inside Corner

120"(3048) Extender & Base Block Placed in Middle of Adjacent Block

120"(3048) Extender & Base Block

120"(3048) Extender & Standard Block

120"(3048) Extender & Standard Block Placed in Middle of Adjacent Block
48" (1219) Inside Curve

48" (1219) Extender & Base Block

48" (1219) Extender & Standard Block

72" (1829mm) Inside Curve

72" (1829) Extender & Base Block

72" (1829) Extender & Standard Block
GravitY Retaining Wall Curves

96" (2438) Inside Curve

96"(2438) Extender & Base Block

96"(2438) Extender & Standard Block

120" (3048mm) Inside Curve

120"(3048) Extender & Base Block

120"(3048) Extender & Standard Block
48" (1219) Outside Curve

- 48"(1219) Extender & Base Block

72" (1829mm) Outside Curve

- 72"(1829) Extender & Base Block
- 48"(1219) Extender & Base Block

- 72"(1829) Extender & Standard Block
- 48"(1219) Extender & Standard Block
96" (2438) Outside Curve

- 96"(2438) Extender & Base Block
- 72"(1829) Extender & Base Block
- 72"(1829) Extender & Standard Block
- 96"(2438) Extender & Standard Block

120" (3048mm) Outside Curve

- 120"(3048) Extender & Base Block
- 96"(2438) Extender & Base Block
- 120"(3048) Extender & Standard Block
- 96"(2438) Extender & Standard Block
Note: Calculations are for preliminary use only and should not be used for construction without the review of a qualified professional.
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MagnumStone Wall Designer

In the following pages we have completed a sample design analysis using CornerStone Wall Designer engineering program.

http://magnumstone.com/magnumstone-wall-designer/

For preliminary design purposes we have used certain design assumptions...
Gravity Wall Analysis - Output

**REAwall**

*Version: 4.0.16099*

**SOIL PARAMETERS**
- Retained Soil: 34 deg 0 psf 120 pcf
- Foundation Soil: 34 deg 0 psf 120 pcf
- Leveling Pad: 40 deg 0 psf 130 pcf
  - Crushed Stone

**GEOMETRY**
- Design Height: 24.00 ft
- Wall Batter/Tilt: 4.77/0.00 deg
- Embedment: 0.50 ft
- Leveling Pad Depth: 0.50 ft
- Slope Angle: 0.0 deg
- Slope Length: 0.0 ft
- Slope Toe Offset: 0.0 ft
- Vertical on Single Depth

**FACTORs OF SAFETY**
- Sliding: 1.50
- Overturning: 1.50
- Bearing: 2.00

**RESULTS**
- FoS Sliding: 1.77 (lv/pd)
- FoS Overturning: 1.55
- Bearing: 5298.99

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CornerStone Analysis and Design 4.0.16099
Gravity Wall Analysis - Output

NOTES ON DESIGN UNITS

The wall section is designed on a ‘per unit width bases’ (lb/ft of wall or kN/m meter of wall). In the calculations the software shows lb/ft or kN/m, neglecting the unit width factor for simplicity.

The weights for the wall unit are shown as lbs / ft³ (kN / m³). For SRW design a 1 sf unit is typically 1 ft deep, 1.5 ft wide and 8 inches tall (or 1 ft³). Therefore a typical value of 120 pcf is shown. With larger units the unit weight will vary with the size of the unit. Say we have 4 ft wide unit, 1.5 ft tall and 24 inches deep with a tapered shape (sides narrow), built with 150 pcf concrete. We add up the concrete, the gravel fill and divide by the volume and the results may come out to 140 pcf, as shown in the table. The units with more gravel may have lower effective unit weights based on the calculations.

Hollow Units
Hollow units with gravel fill are treated differently in AASHTO. If the fill can fall out as the unit is lifted, then AASHTO only allows 80% of the weight of the fill to be used for eccentricity (overturning calculations). In the properties page for the units the weight of the concrete may be as low as 75 pcf. This is the effective unit weight of the concrete only (e.g. the weight of the concrete divided by the volume of the unit). The density of the concrete maybe 150 pcf, but not the effective weight including the volume of the void spaces used for gravel fill.

Rounding Errors
When doing hand calculations the values may vary from the values shown in the software. The program is designed using double precision values (64 bit precision: 14 decimal places). Over several calculations the results may differ from the single calculation the user is making, probably inputting one or two already rounded values.

Result Rounding
As noted above the software is based on double precision values. For example, using an NCMA design method an allowable factor of safety of 1.5 the software may calculate a value of 1.4999999999999, since this is less than 1.5, it would be false (NG), even though the results shown is 1.50 (results are rounded to 2 places on the screen). In the design check we round to 2 decimal places to check against the suggested value (1.499999999999 rounds to 1.50).

Given the precision of the calculation, this will provide a safe design even though the ‘absolute’ value is less than the minimum suggested.
Gravity Wall Analysis - Output

**DESIGN DATA**

**TARGET DESIGN VALUES (Factors of Safety)**
- Minimum Factor of Safety for the sliding along the base: \( FS_{sl} = 1.50 \)
- Minimum Factor of Safety for overturning about the toe: \( FS_{ot} = 1.50 \)
- Minimum Factor of Safety for bearing (foundation shear failure): \( FS_{br} = 2.00 \)

**MINIMUM DESIGN REQUIREMENTS**
- Minimum embedment depth: \( \text{Min}_\text{emb} = 0.50 \text{ ft} \)

**INPUT DATA**

**Geometry**
- Wall Geometry
  - Design Height, top of leveling pad to finished grade at top of wall: \( H = 24.00 \text{ ft} \)
  - Embedment, measured from top of leveling pad to finished grade: \( \text{emb} = 0.50 \text{ ft} \)
  - Leveling Pad Depth: \( \text{LP Thickness} = 0.50 \text{ ft} \)
  - Face Batter, measured from vertical: \( i = 4.77 \text{ deg} \)

**Slope Geometry**
- Slope Angle, measured from horizontal: \( \beta = 0.00 \text{ deg} \)
- Slope toe offset, measured from back of the face unit: \( \text{STL}_{\text{offset}} = 0.00 \text{ ft} \)
- Slope Length, measured from back of wall facing: \( \text{SL}_{\text{Length}} = 0.00 \text{ ft} \)

**NOTE:** If the slope toe is offset or the slope breaks within three times the wall height, a Coulomb Triai Wedge method of analysis is used.

**Surcharge Loading**
- Live Load, assumed transient loading (e.g. traffic): \( \text{LL} = 0.00 \text{ psf} \)
- Live Load Offset, measured from back face of wall: \( \text{LL}_{\text{offset}} = 0.00 \text{ ft} \)
- Live Load Width, assumed strip loading: \( \text{LL}_{\text{width}} = 100.00 \text{ ft} \)
- Dead Load, assumed permanent loading (e.g. buildings): \( \text{DL} = 0.00 \text{ psf} \)
- Dead Load Offset, measured from back face of wall: \( \text{DL}_{\text{offset}} = 0.00 \text{ ft} \)
- Dead Load Width, assumed strip loading: \( \text{DL}_{\text{width}} = 100.00 \text{ ft} \)

**Soil Parameters**

**Retained Zone**
- Angle of Internal Friction: \( \phi = 34.00 \text{ deg} \)
- Cohesion: \( \text{coh} = 0.00 \text{ psf} \)
- Moist Unit Weight: \( \gamma_m = 120.00 \text{ pcf} \)

**Foundation**
- Angle of Internal Friction: \( \phi = 34.00 \text{ deg} \)
- Cohesion: \( \text{coh} = 0.00 \text{ psf} \)
- Moist Unit Weight: \( \gamma_m = 120.00 \text{ pcf} \)
Gravity Wall Analysis - Output

**RETAINING WALL DESIGNER**

**STRUCTURAL PROPERTIES:**
N is the normal force [or factored normal load] on the base unit
The default leveling pad to base unit shear is 0.8 tan(\(\phi\)) or
may be the manufacturer supplied data. \(\phi\) is assumed to be 40 degrees for a stone leveling pad.

**Table of Values:**

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</table>
Gravity Wall Analysis - Output

FORCE DETAILS

The details below shown how the forces and moments are calculated for each force component. The values shown are not factored. All loads are based on a unit width (pFt / kN/m).

<table>
<thead>
<tr>
<th>Layer</th>
<th>Block Wt</th>
<th>X-Arm</th>
<th>Moment</th>
<th>Soil Fill Wt</th>
<th>X-Arm</th>
<th>Moment</th>
<th>Soil Wt</th>
<th>X-Arm</th>
<th>Moment</th>
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<tr>
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<td>560.00</td>
<td>2.80</td>
<td>1568.84</td>
<td>167.75</td>
<td>2.80</td>
<td>469.13</td>
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<td>247.00</td>
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<td>61.64</td>
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<tr>
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<td>3.00</td>
<td>3262.00</td>
<td>500.50</td>
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<td>1781.42</td>
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<td>500.50</td>
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<td>7</td>
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<td>3.18</td>
<td>5248.88</td>
<td>877.25</td>
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<td>3901.36</td>
<td>81.67</td>
<td>7.04</td>
<td>574.70</td>
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<td>3.02</td>
<td>5068.50</td>
<td>877.25</td>
<td>3.94</td>
<td>3454.96</td>
<td>81.67</td>
<td>7.19</td>
<td>1761.30</td>
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<tr>
<td>9</td>
<td>2240.00</td>
<td>3.73</td>
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<td>1248.50</td>
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<td>1509.75</td>
<td>5.76</td>
<td>8701.19</td>
<td>91.68</td>
<td>10.17</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Block Weight (Force v) = block: 6234 X-Arm = 3.27 ft
Soil Fill: 9276 pFt
Soils Block Weight (Force w) = 1796 pFt X-Arm = 3.70 ft

Active Earth Pressure Pa = 13078 pFt
Pa_h (Force H) = Pa cos(batter + δ) = 13078 x cos(14.4 + 25.5) = 10032 pFt
Pa_v (Force V) = Pa sin(batter + δ) = 13078 x sin(14.4 + 25.5) = 8390 pFt
Y-Arm = 8.00 ft
X-Arm = 7.95 ft

Passive Earth Pressures
Passive earth pressures are used for resistance of the Leveling Pad, but may be extended upward to assist with the resistance of the wall facing for walls that have deep embedments.

Passive Earth Pressure:
kp = 3.54
Pp = 159.17 pFt
Gravity Wall Analysis - Output

**CALCULATION RESULTS**

**OVERVIEW**
CornerStone calculates stability assuming the wall is a rigid body. Forces and moments are calculated about the base and the front toe of the wall. The base block width is used in the calculations. The concrete units and granular fill over the blocks are used as resisting forces.

**EARTH PRESSURES**
The method of analysis uses the Coulomb Earth Pressure equation (below) to calculate active earth pressures. Wall friction is assumed to act at the back of the wall face. The component of earth pressure is assumed to act perpendicular to the boundary surface. The effective δ angle is δ minus the wall batter at the back face. If the slope breaks within the failure zone, a trial wedge method of analysis is used.

**EXTERNAL EARTH PRESSURES**
- Effective δ angle (3/4 retained phi)
- Coefficient of active earth pressure

<table>
<thead>
<tr>
<th>External failure plane</th>
<th>Effective Angle from horizontal</th>
</tr>
</thead>
<tbody>
<tr>
<td>θ = 25.5 deg</td>
<td>Eff. Angle = 75.6 deg</td>
</tr>
</tbody>
</table>

ρ = 63 deg

\[ kp = \frac{1 + \sin(\phi)}{1 - \sin(\phi)} \]

\[ k_a = 0.378 \]

| W0: stone within units | W1: facing units | W2: stone over the tails | W6: Driving force Pa | W10: Driving Surcharge load Paq | W11: Driving Dead Load Surcharge Paqd |

**FORCES AND MOMENTS**
The program resolves all the geometry into simple geometric shapes to make checking easier. All x and y coordinates are referenced to a zero point at the front toe of the base block.

**UNFACTORED LOADS**

<table>
<thead>
<tr>
<th>Name</th>
<th>Factor y</th>
<th>Force (V)</th>
<th>Force (H)</th>
<th>X-len</th>
<th>Y-len</th>
<th>M0</th>
<th>M1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face Blocks(W1)</td>
<td>1.00</td>
<td>6234</td>
<td>3.27</td>
<td>--</td>
<td>--</td>
<td>20389</td>
<td></td>
</tr>
<tr>
<td>Soil Fill(W1)</td>
<td>1.00</td>
<td>9276</td>
<td>4.66</td>
<td>--</td>
<td>--</td>
<td>43177</td>
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</tr>
<tr>
<td>Soil Wedge(W2)</td>
<td>1.00</td>
<td>1798</td>
<td>3.70</td>
<td>--</td>
<td>--</td>
<td>66656</td>
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<tr>
<td>Lvl Pad(W18)</td>
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<td>666</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Pa h</td>
<td>1.00</td>
<td>8280</td>
<td>7.95</td>
<td>--</td>
<td>--</td>
<td>66650</td>
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<tr>
<td>Pa v</td>
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<td>82690</td>
<td>10032</td>
<td>--</td>
<td>--</td>
<td>80260</td>
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<tr>
<td>Sum V/H</td>
<td>1.00</td>
<td>26364</td>
<td>10032</td>
<td>--</td>
<td>Sum Mom 80260 136680</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: live load forces and moments are not included in SumV or Mr as live loads are not included as resisting forces.
Gravity Wall Analysis - Output

BASE SLIDING
Sliding at the base is checked at the block to leveling pad interface between the base block and the leveling pad. Sliding is also checked between the leveling pad and the foundation soils.

Forces Resisting sliding = W0 + W1 + W2 + Pav
9276 + 6234 + 1798 + 8390 = N = 25698 ppf

Resisting force at pad = W0 tan(slope1) + (W1 + W2 + Pav) tan(slope) + intercept x L
9276 x tan(36°) + 16422 x tan(33.9°) + 0.0 x 10.0 = RF1 = 17763
where L is the base block width

Friction angle is the lesser of the leveling pad and Fnd
Friction angle = 34.00 deg

N1 includes N (the leveling pad) + leveling pad (LP)
25698 + 666 = N1 = 26364 ppf

Passive resistance is calculated using kp = (1 + sin(34°)) / (1 - sin(34°))
kp = 3.54

Pressure at top of resisting trapezoid, d1 = 0.50
Fp1 = 212.23

Pressure at base of resisting trapezoid, d2 = 0.50
Fp2 = 212.23

Depth of trapezoid
Depth = 0.00
159.17

Resisting force at fnd = (N1 tan(phi) + c L) + Pp
26364 x tan(34°) + 0 x 10.3 + 159 = RF2 = 17942
where LP = lv pad thickness * 130pcf * (L + lv pad thickness/2)

Driving force is the horizontal component of Pav
10032
DF = 10032

FSsl = RF / DF
FSsl = 1.77 / 1.79

CornerStone Analysis and Design 4.0.16099
Gravity Wall Analysis - Output

OVERTURNING ABOUT THE TOE
   Overturning at the base is checked by assuming rotation about the front toe by the block mass and the soil
retained on the blocks. Allowable overturning can be defined by eccentricity (e/L). For concrete leveling pads
eccentricity is checked at the base of the pad.

Moments resisting eccentricity = M1 + M2 + MSoilInfill + MLvIPad + MPav
  20389 + 43177 + 6655 + 66659
  Mr =136880 ft-lbs

Moments causing eccentricity = MPah + MPq
  80260
  Mo =80260 ft-lbs

   e = L/2 - (Mr - Mo)/ N1
  e =10.00/2 - (136880 - 80260) /26364
  e =2.80
  e/L = 0.28

   FSot = Mr / Mo
  FSot =136880 / 80260
  FSot =1.71
Gravity Wall Analysis - Output

**ECCENTRICITY AND BEARING**

Eccentricity is the calculation of the distance of the resultant away from the centroid of mass. In wall design the eccentricity is used to calculate an effective footing width.

Calculation of Eccentricity

\[
\text{SumV} = (W1 + W2 + Pa_v) \\
\text{e} = \frac{L/2 - (\text{SumMr} - \text{SumMo})/\text{SumV}}{2} \\
\text{e} = 10.00/2 - (56621/25697.70) \\
e = 2.797 \text{ ft}
\]

Calculation of Bearing Pressures

\[
\text{Qult} = c * Nc + q * Nq + 0.5 * y * (B') * Ng
\]
where:

- \( Nc = 42.16 \)
- \( Nq = 22.44 \)
- \( Ng = 41.06 \)
- \( c = 0.00 \text{ psf} \)
- \( q = 120.00 \text{ psf} \)
- \( B' = B - 2e + \text{mpad} = 4.91 \text{ ft} \)
- \( \text{Gamma}(LP) = 130 \text{ psf} \)

Calculate Ultimate Bearing, Qult

\[
\text{Bearing Pressure} = \frac{(\text{SumVert} / B') + ((2B + \text{LP depth})/2 * \text{LP depth} * \text{gamma})}{2}
\]

\[
\text{Qult} = 15622 \text{ psf} \\
\text{sigma} = 5238.99 \text{ psf} \\
\text{Qult/sigma} = 2.95
\]