

# MagnumStone™

by CORNERSTONE®

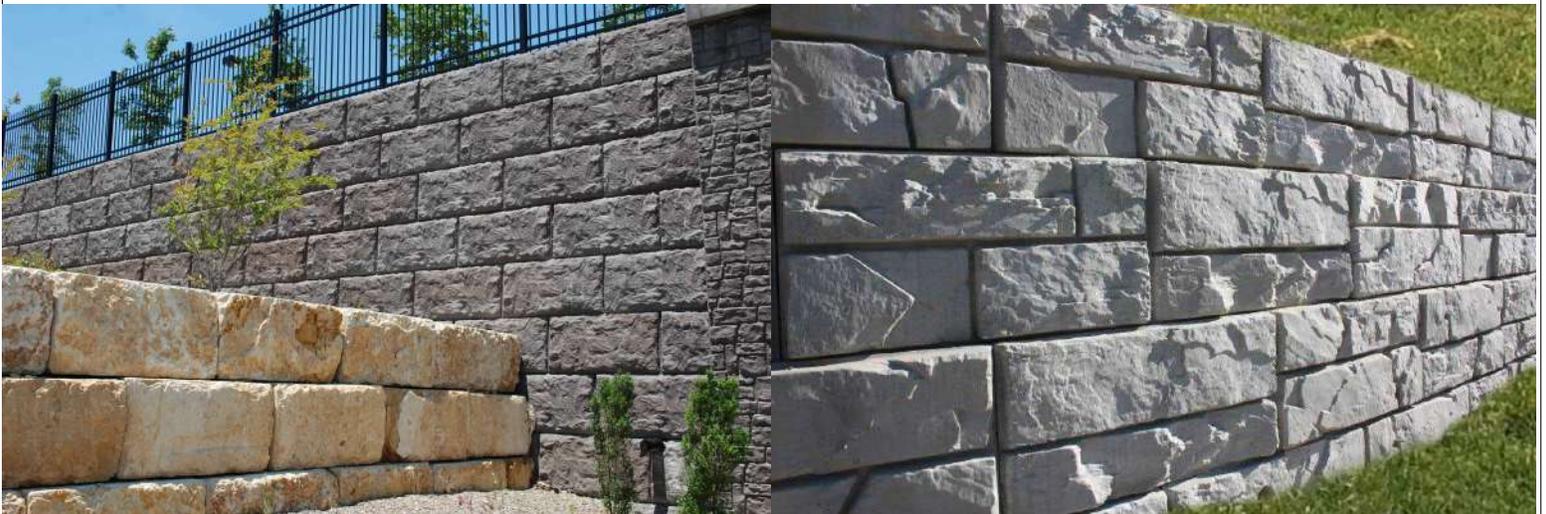


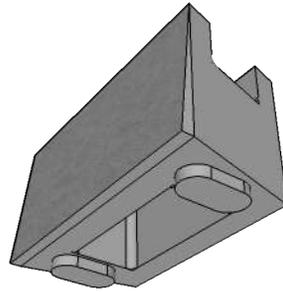
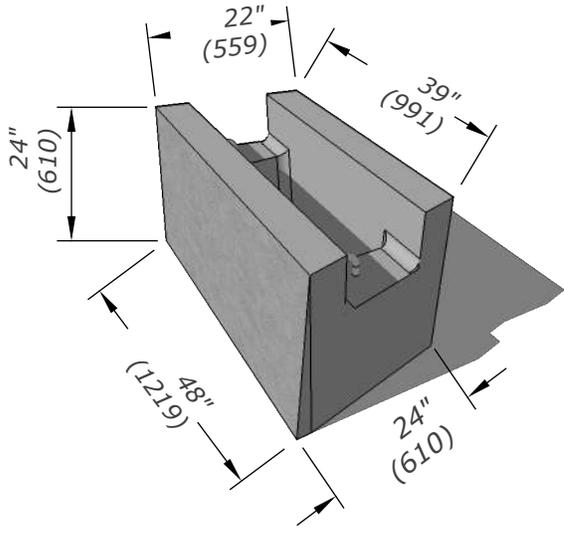
## GRAVITY RETAINING WALL TECHNICAL MANUAL

# MagnumStone™

by CORNERSTONE®

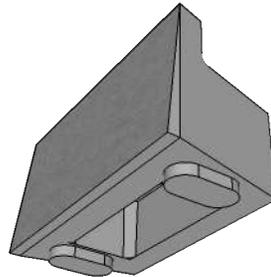
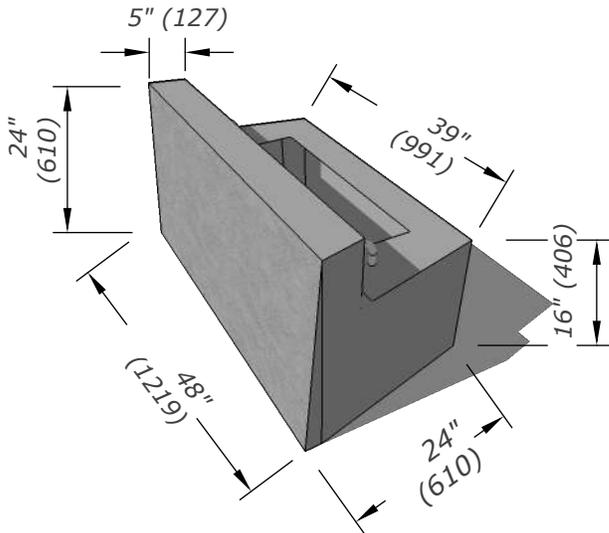
The user is responsible for the final design and use of the CornerStone® products. All drawings, illustrations, and text are accurate to the best of our knowledge but a qualified engineer shall do the analysis and structural design for all aspects of the segmental retaining wall project. The sole responsibility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





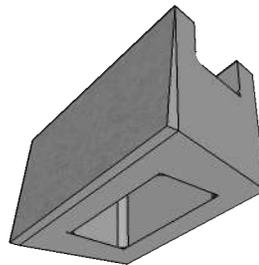
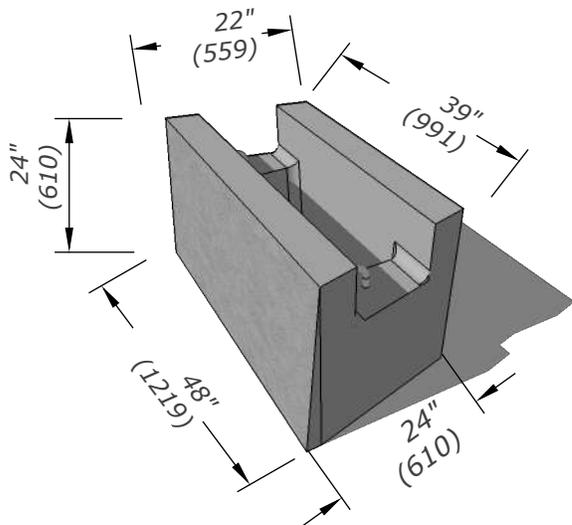
## STANDARD BLOCK

Height	24"	610mm
Depth	24"	610mm
Face Width	48"	1219mm
Back Width	39"	991mm
Weight	1345 lbs	621 Kgs
Volume Voids	6.35 ft <sup>3</sup>	0.180 m <sup>3</sup>
Gravel Filled Weight	2150 lbs	975 Kgs
Face Area	8 sq ft	0.745 m <sup>2</sup>
Batter/Setback	4.5 deg	



## TOP BLOCK

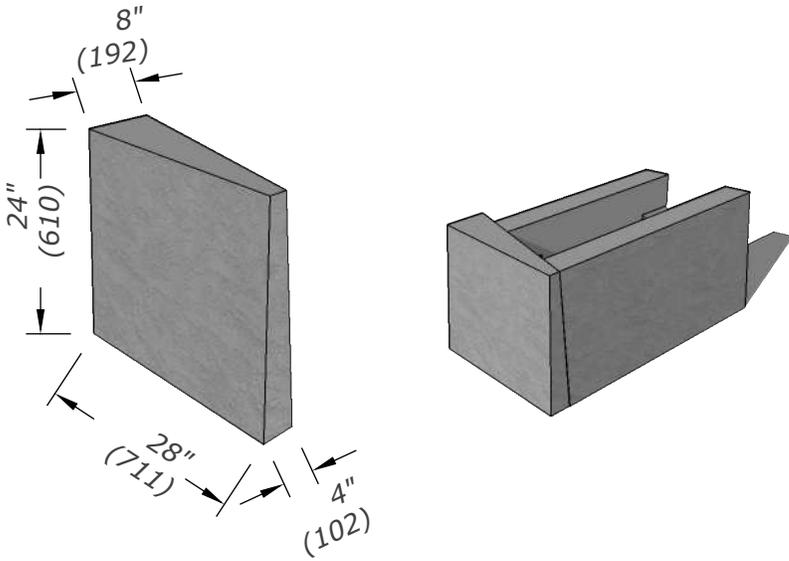
Height	24"	610mm
Depth	24"	610mm
Face Width	48"	1219mm
Back Width	39"	991mm
Weight	1220 lbs	553 Kgs
Volume Voids	6.35ft <sup>3</sup>	0.180 m <sup>3</sup>
Gravel Filled Weight	2003 lbs	909 Kgs
Face Area	8 sq ft	0.745 m <sup>2</sup>
Batter/Setback	4.5 deg	



## BASE BLOCK

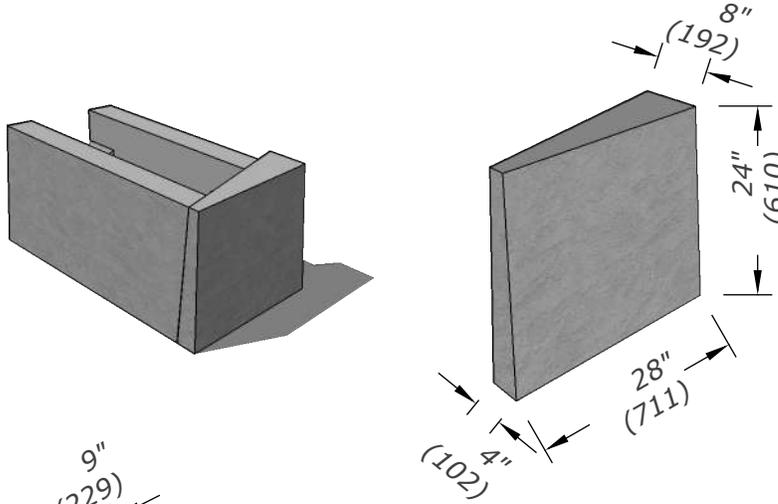
Height	24"	610mm
Depth	24"	610mm
Face Width	48"	1219mm
Back Width	38"	991mm
Weight	1325 lbs	602 Kgs
Volume Voids	6.35 ft <sup>3</sup>	0.180 m <sup>3</sup>
Gravel Filled Weight	2130 lbs	966 Kgs
Face Area	8 sq ft	0.745 m <sup>2</sup>
Batter/Setback	4.5 deg	

\*Face Style Varies. Check with local producer / Weights and dimensions are nominal  
Assumption: Concrete = 143 pcf (22.5 Kn/m<sup>3</sup>) / Aggregate 110 pcf (5.267)



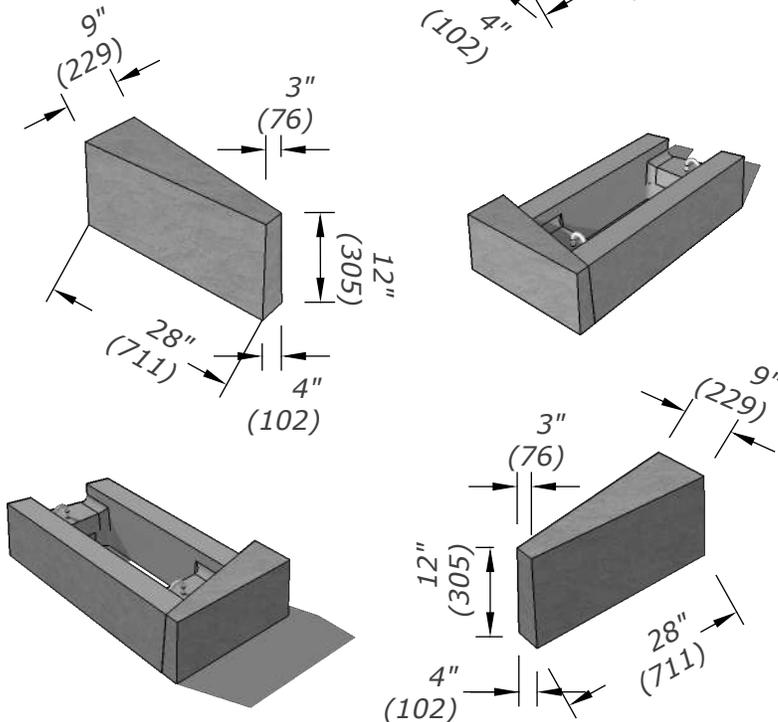
**STANDARD LEFT END CAP**

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



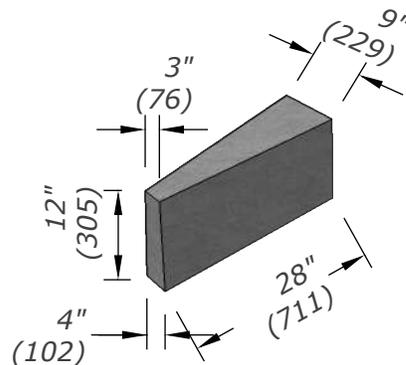
**STANDARD RIGHT END CAP**

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**

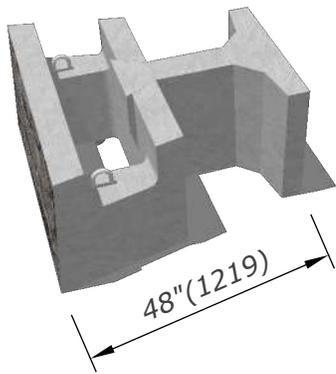
Height	12"	305mm
Depth	9"	229mm
Top Narrow Width	3"	76mm
Bottom Narrow Width	4"	102mm
Weight	170 lbs	77 Kgs
Face Area	2.33 sq2	0.217 m2



**HALF HIGH RIGHT END CAP**

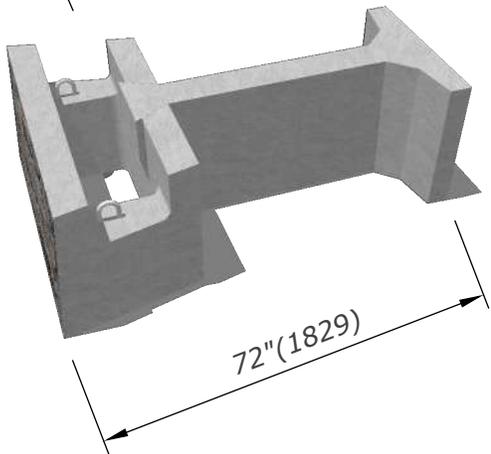
Height	12"	305mm
Depth	9"	229mm
Top Narrow Width	3"	76mm
Bottom Narrow Width	4"	102mm
Weight	170 lbs	77 Kgs
Face Area	2.33 sq2	0.217 m2

\*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)



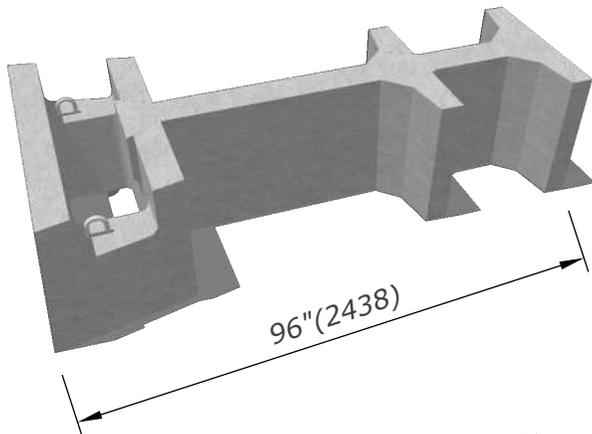
**48"(1219)**

Height	24"	610mm
Depth	48"	1219mm
Face Width	48"	1219mm
Back Width	39"	991mm
Weight	1920 lbs	870 Kgs
Volume Voids	18.2 ft <sup>3</sup>	0.511m <sup>3</sup>
Gravel Filled Weight	3925 lbs	1780kg



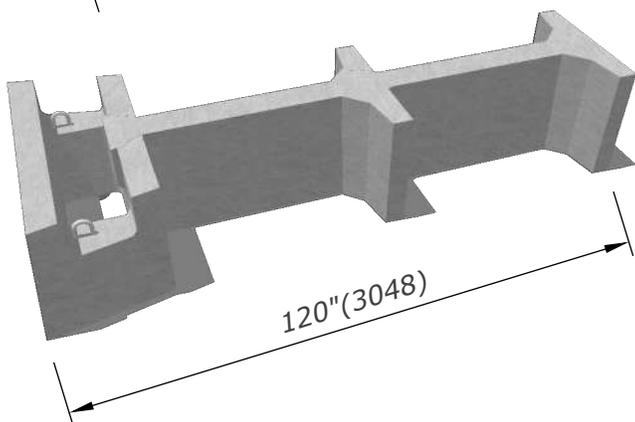
**72"(1829)**

Height	24"	610mm
Depth	72"	1829mm
Face Width	48"	1219mm
Back Width	39"	991mm
Weight	2220 lbs	1006 Kgs
Volume Voids	31.9 ft <sup>3</sup>	0.894m <sup>3</sup>
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 ft <sup>3</sup>	1.271m <sup>3</sup>
Gravel Filled Weight	7789 lbs	3533 Kg



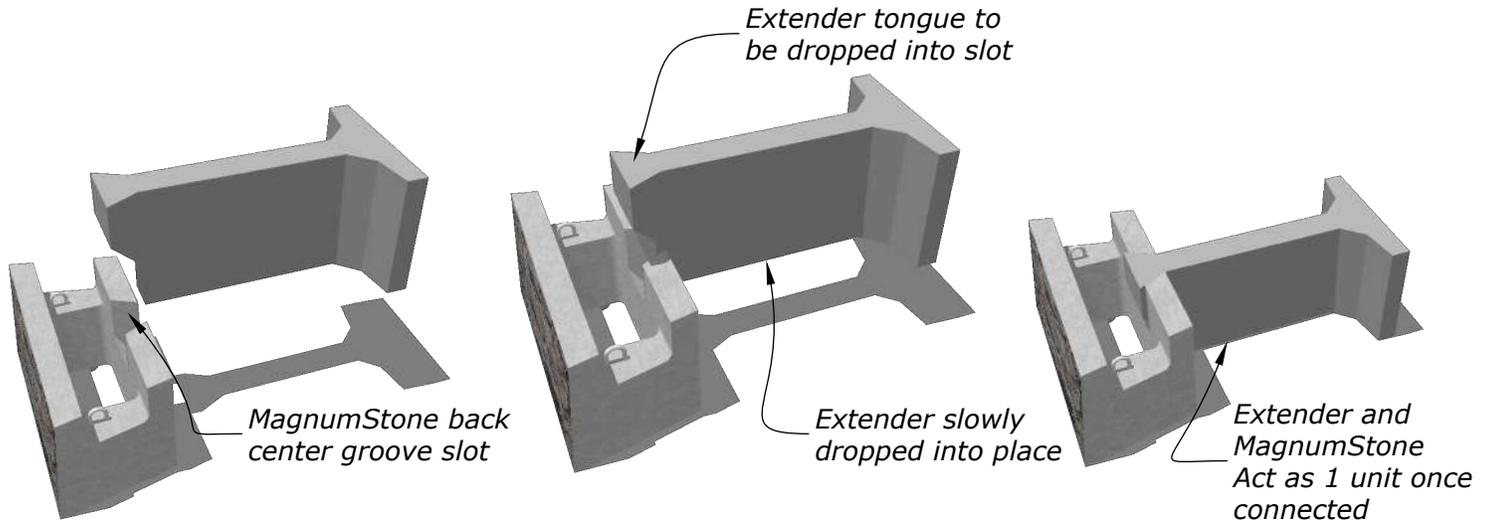
**120"(3048)**

Height	24"	610mm
Depth	120"	3048mm
Face Width	48"	1219mm
Back Width	39"	991mm
Weight	3098 lbs	1405 Kgs
Volume Voids	54.8 ft <sup>3</sup>	1.534m <sup>3</sup>
Gravel Filled Weight	9126 lbs	4139 Kg

\*Face Style Varies. Check with local producer / Weights and dimensions are nominal  
Assumption: Concrete = 143 pcf (22.5 Kn/m<sup>3</sup>) / Aggregate 110 pcf (5.267)

### Extender to MagnumStone block installation

After the MagnumStone block with the extender has been laid in it's 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.

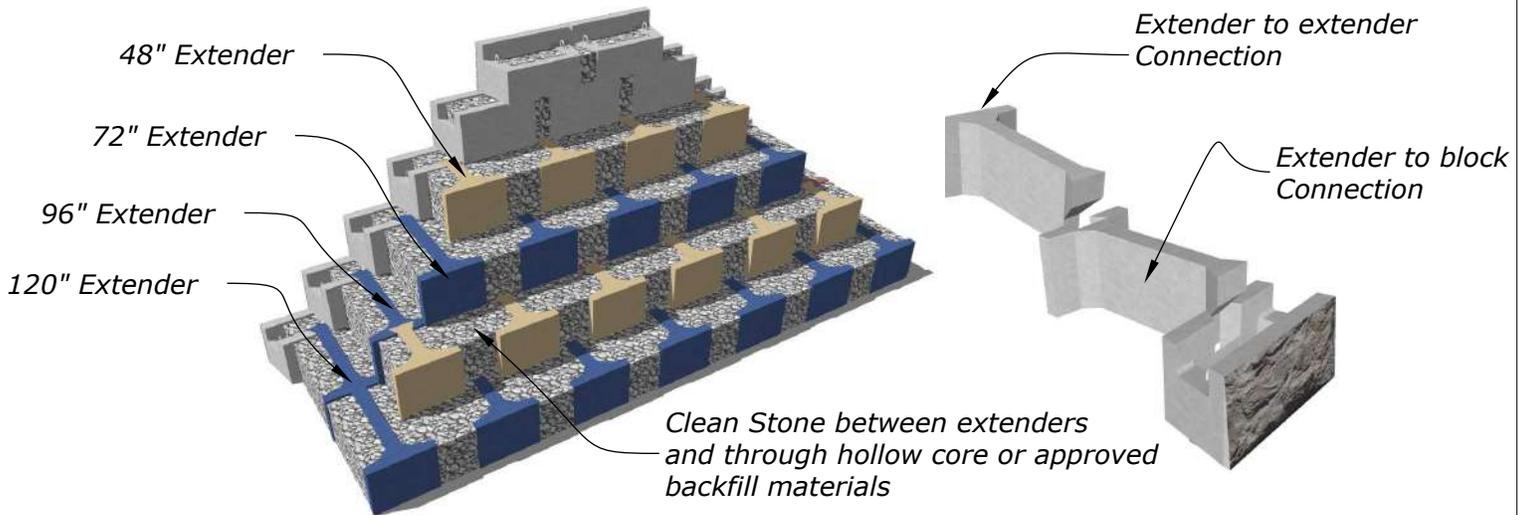


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**Extender to Extender Installation**

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.

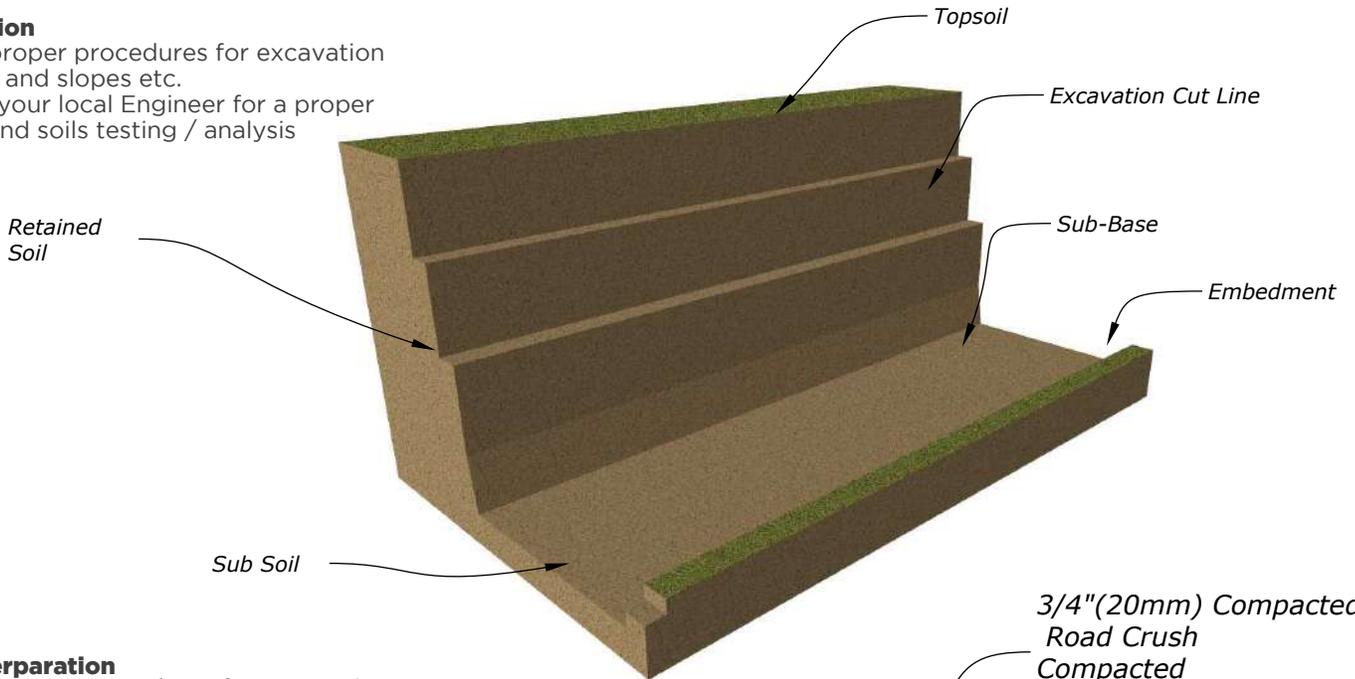
Once a back fill is chosen the contractor can backfill and compact around the extender units. Typically a free draining material clean stone or approved material will be used.



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**Excavation**

Follow proper procedures for excavation cut lines and slopes etc.  
Consult your local Engineer for a proper design and soils testing / analysis



**Base Perparation**

Follow proper procedures for excavation cut lines and slopes etc.

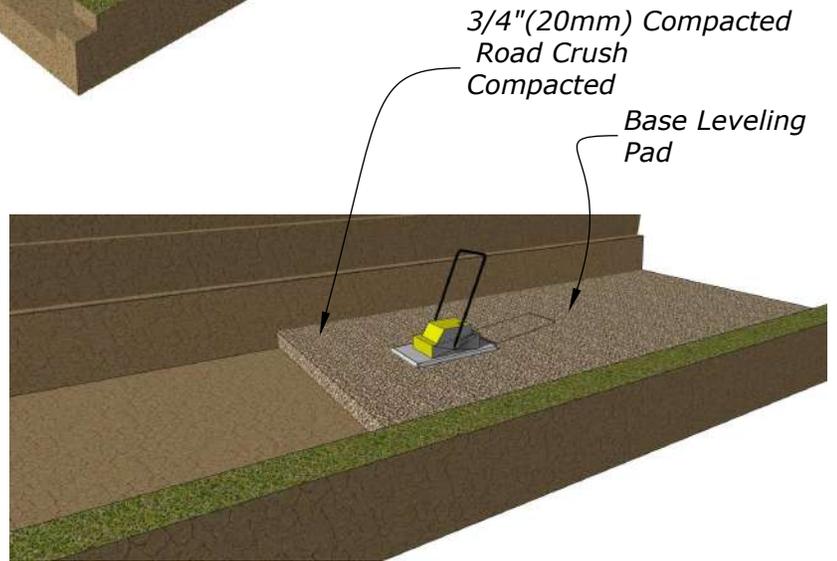
The width of the base leveling pad should be the depth of the block and or extender(s) on the first course plus 6" (152mm) front and back.

example for a standard unit  
24" + 6"(front) + 6" (back)  
= 48" total

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

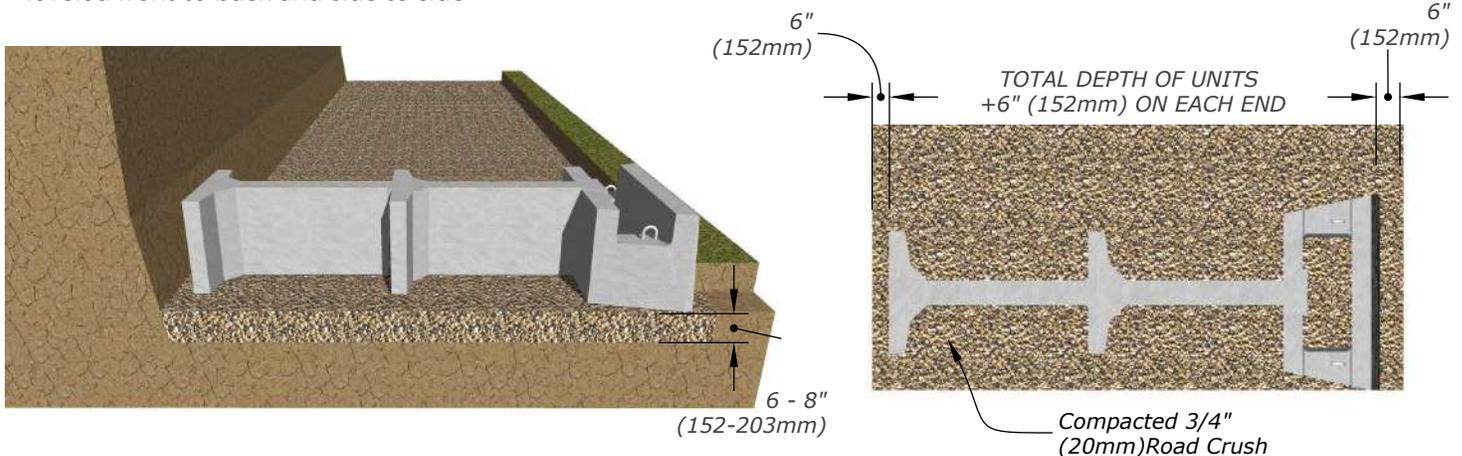
The depth of the leveling pad should be minimum of 6" thick compacted to 95% standard proctor density.

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**

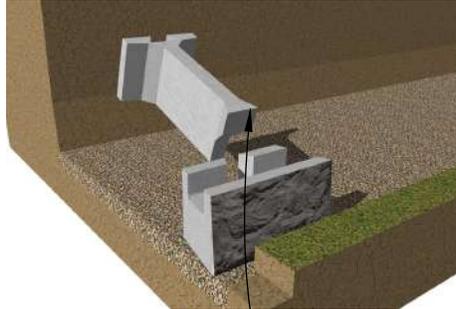
Install the MagnumStone base block on the leveling pad. The base block should not have the lugs on the bottom. Ensure that the blocks are level front to back and side to side.

Place the tongue of the extender block inside the groove of the MagnumStone block

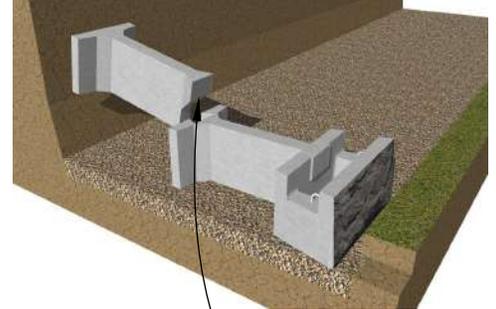
If extender blocks are required place them in the same manner as the previous ensuring that the blocks stay level and true.



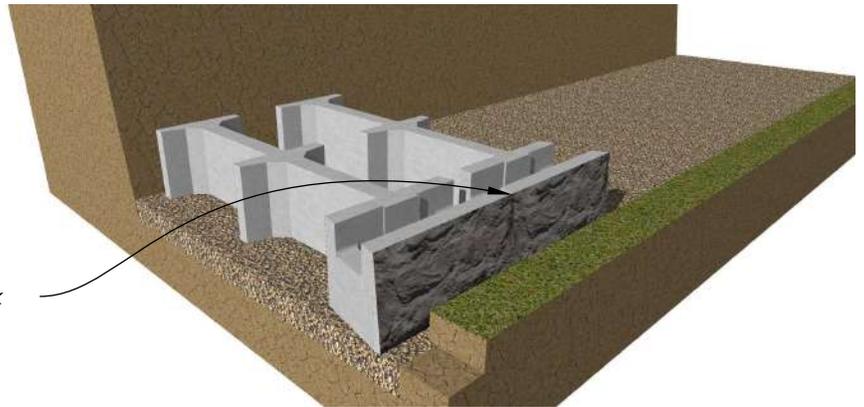
*MagnumStone Groove Slot*



*Extender tongue inserted into groove slot*



*Extender to Extender groove and tongue connection*



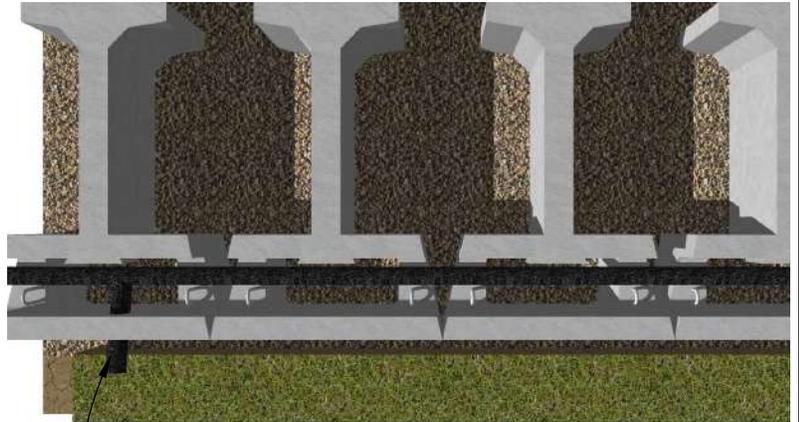
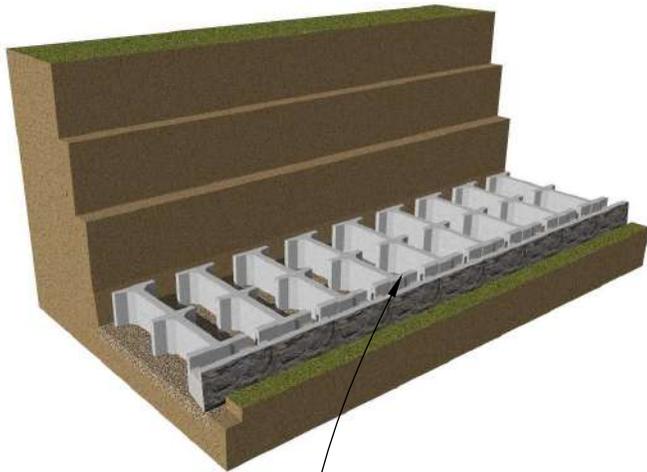
*Place the next row of blocks level and aligned front to back and side to side*

**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**

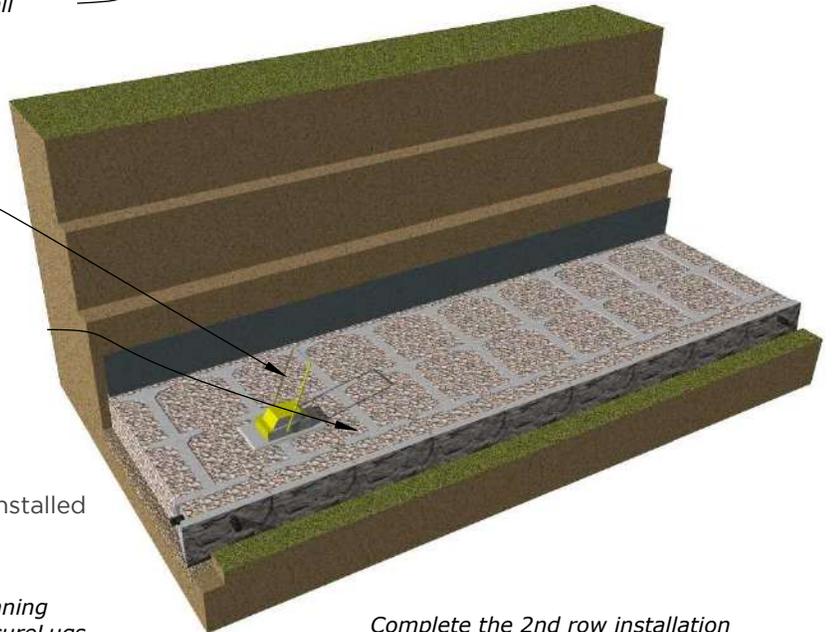


*Finish laying the  
MagnumStone Units  
and Extenders*

*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  
the units and compact with a plate vibratory  
compactor. Sweep access rock and debris  
off the blocks before installing the next course*

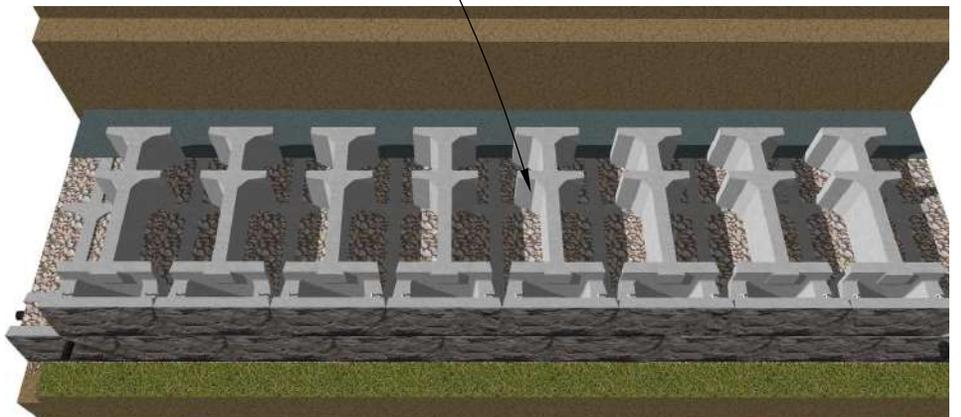
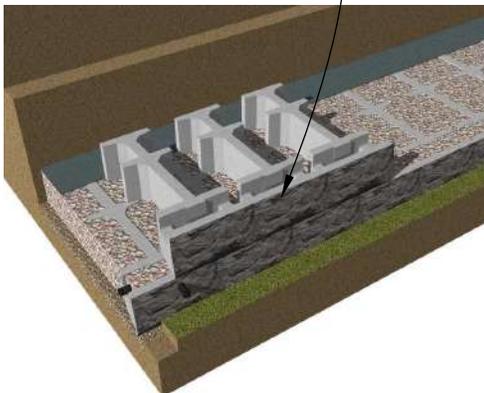


**MagnumStone Block and Extender Installation**

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*

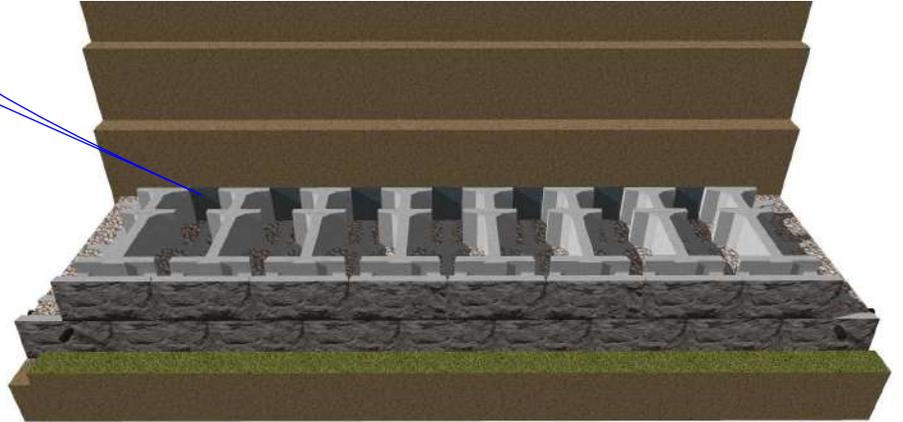
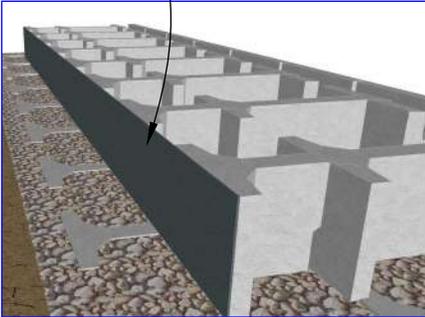
*Complete the 2nd row installation  
ensuring everything is level*



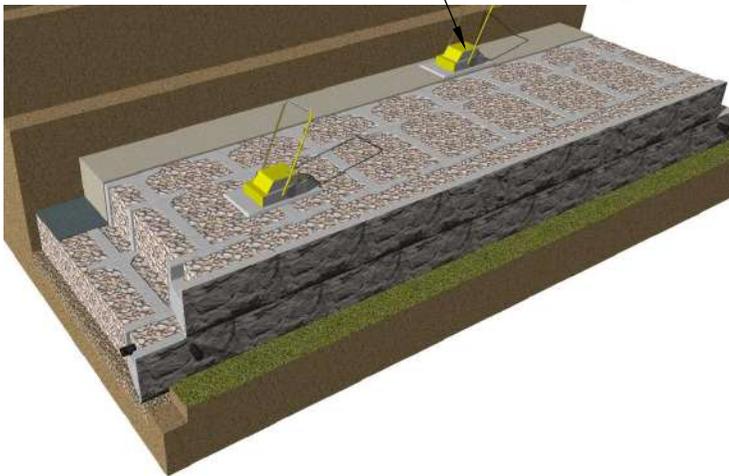
**Soil Separation Fabric**

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.

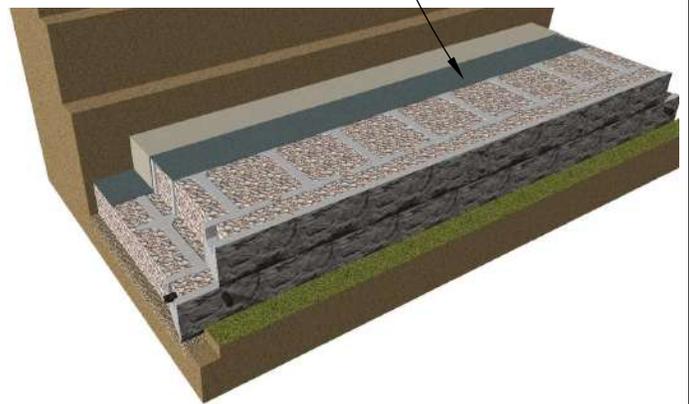
*Filter fabric installed at the back of the extender units*



*Compact the approved backfill material behind the filter fabric*



*Filter fabric wrapped around clean gravel to stop fines from migrating*



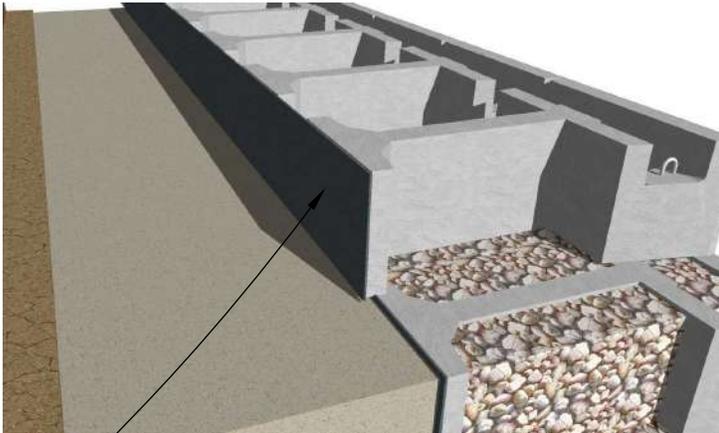
**Compaction**

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

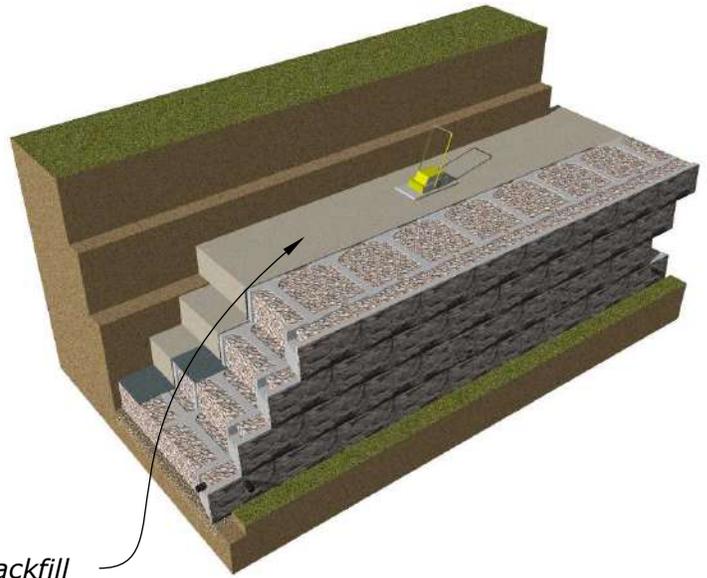


**Installation**

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.

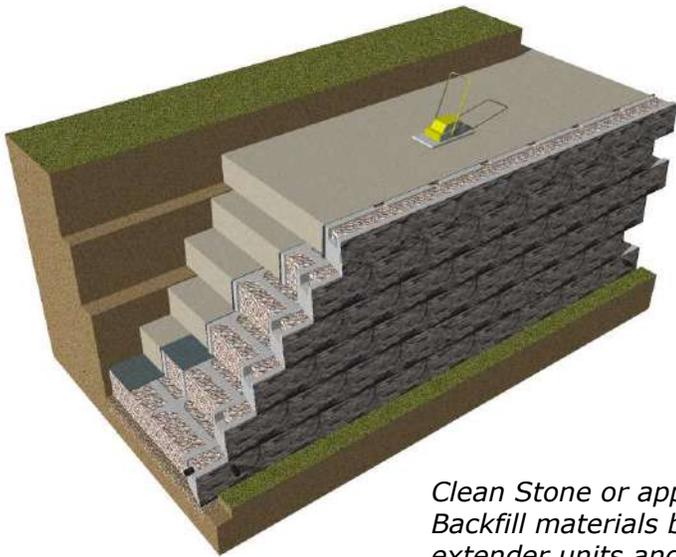


*Filter fabric placed behind extender units*

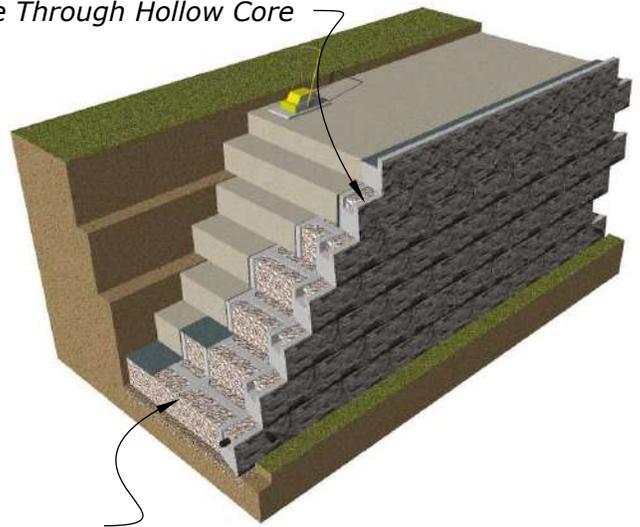


*Approved compacted backfill*

*Drainage Through Hollow Core*

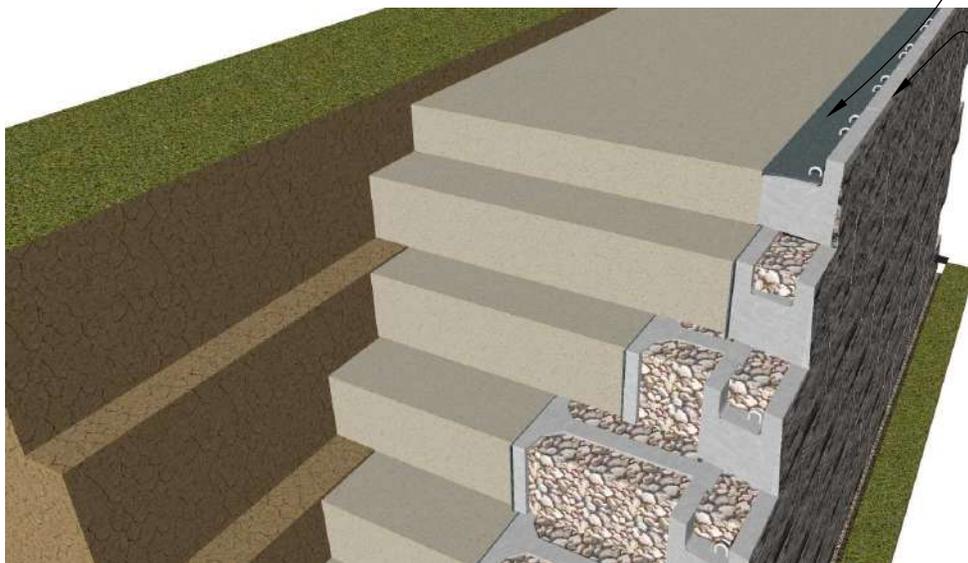


*Clean Stone or approved Backfill materials between extender units and inside hollow cores*

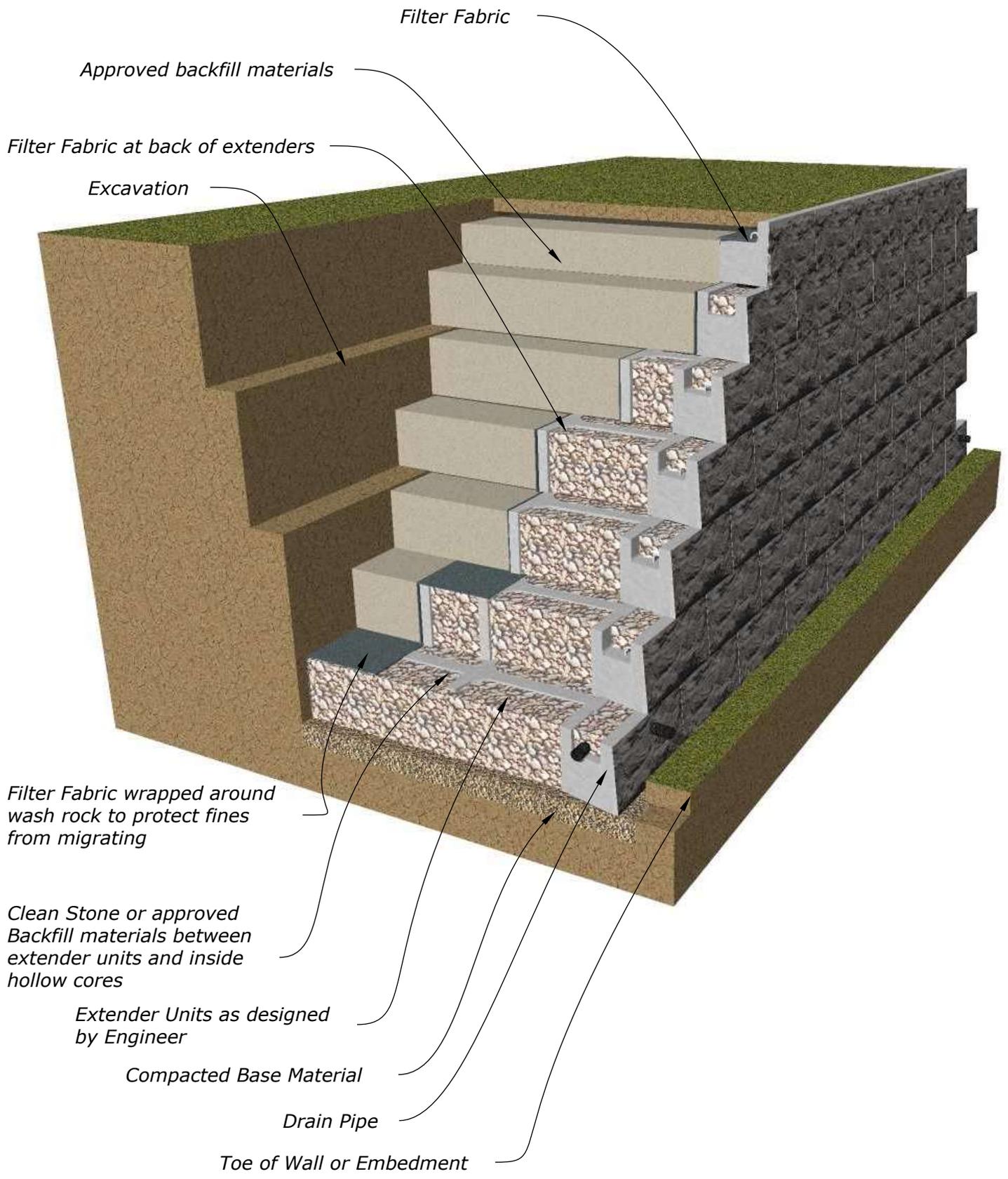


*Filter Fabric*

*MagnumStone Top Unit*



**Typical Completed Cross Section**

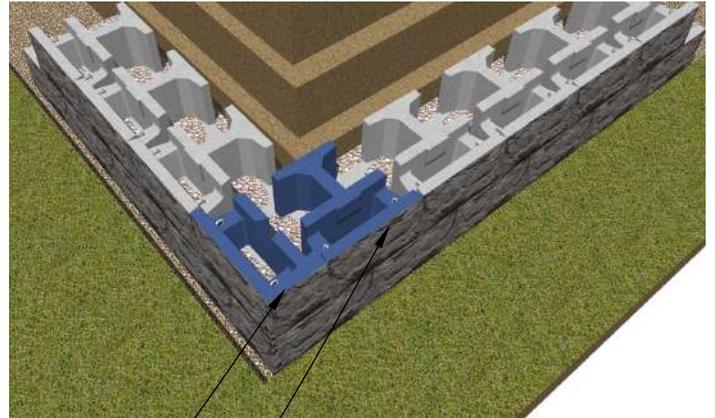
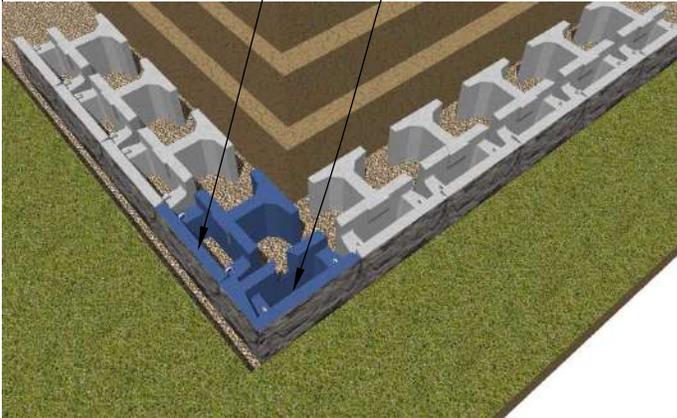


**48" (1219) Extender Outside Corner**

Corners in retaining walls are unavoidable. With the MagnumStone gravity system we have developed a solution that fits any situation.

48" (1219) Extender & Base Block

Corner / End Cap Base Block



Standard Corner / End Cap

48" (1219) Extender & Standard Block

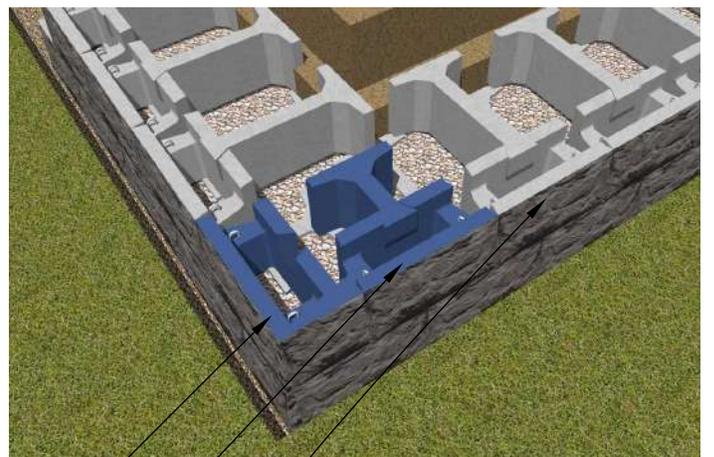
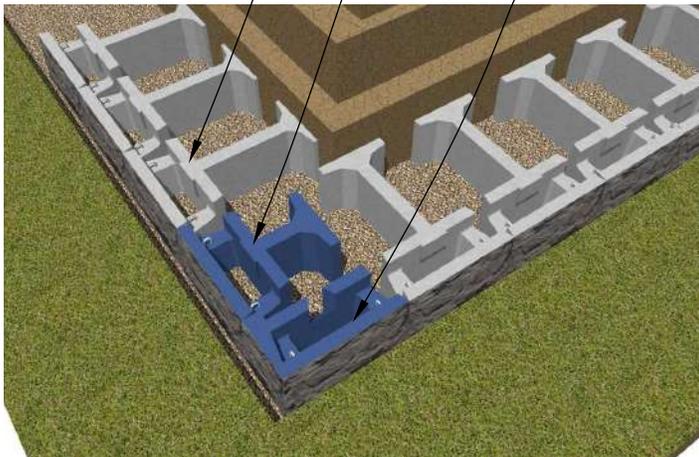
**72" (1829) Extender Outside Corner**

- Follow proper procedures for excavation cut lines and slopes etc.

72" (1829) Extender & Base Block

48"(1219) Extender & Base Block

Corner / End Cap Base Block



Standard Corner / End Cap

48"(1219) Extender & Standard Block

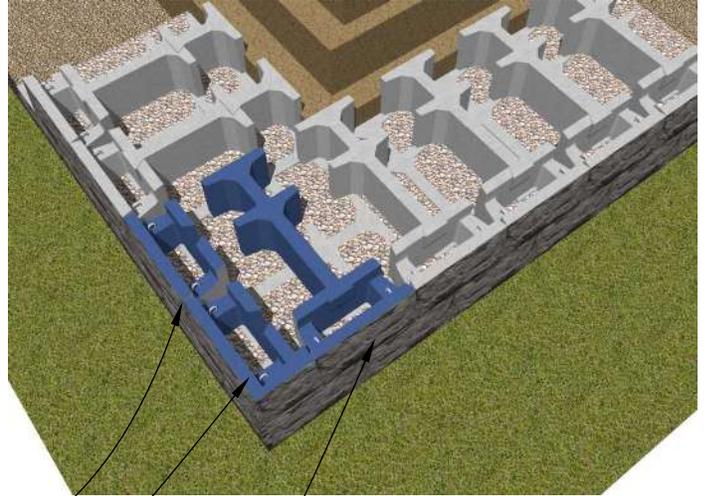
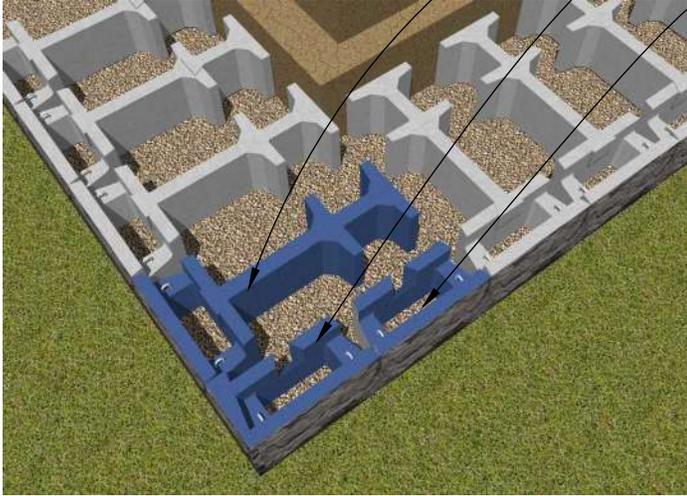
72"(1829) Extender & Standard Block

**96" (2438) Extender Outside Corner**

96" (2438)

Corner End Cap Base Block

Standard Base Block



Standard Block

Standard Corner End Cap

96" (2438) extender

**120" (3048mm) Extender Outside Corner**

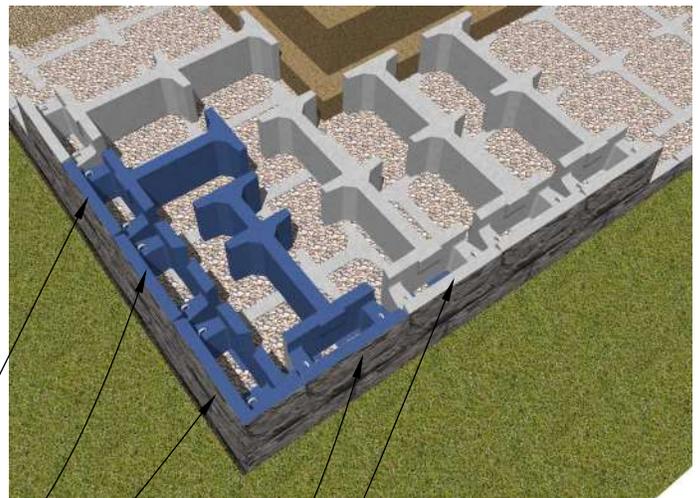
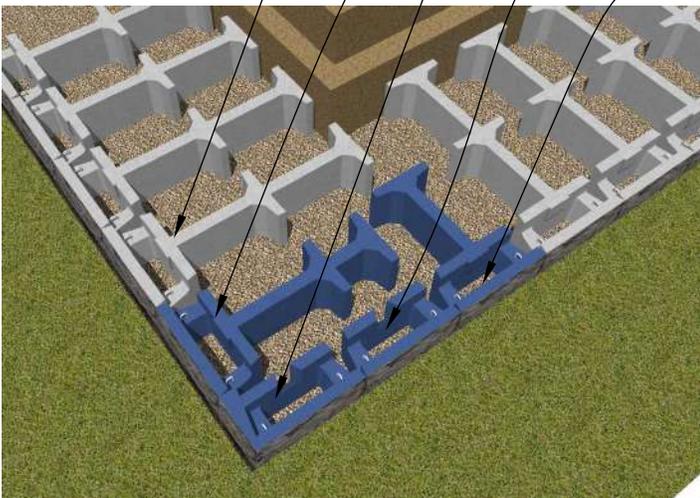
120" (3048) Extender Base Block

96"(2438) Extender

Corner End Cap Base Block

Standard Base Blocks

72"(1829) Extender



72"(1829) Extender

Standard Block

Standard Corner End Cap

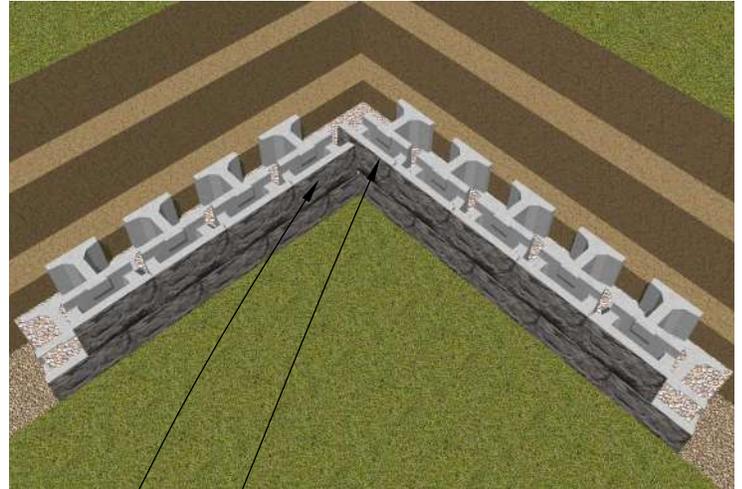
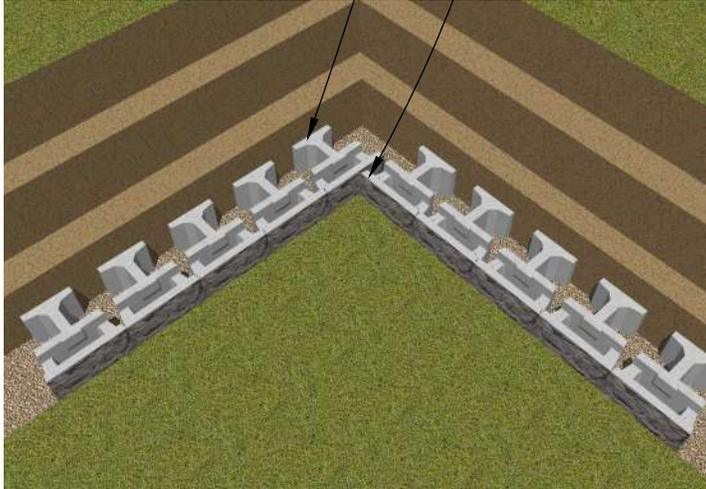
96"(2438) Extender

120"(3048) Extender

**48" (1219) Extender Inside Corner**

*48"(1219) Extender & Base Block*

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



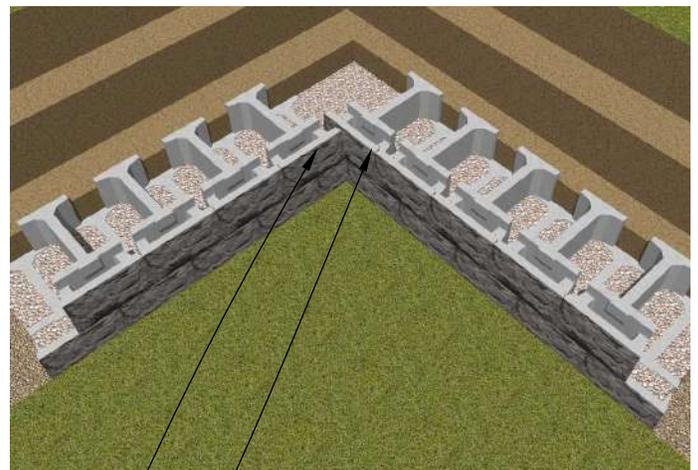
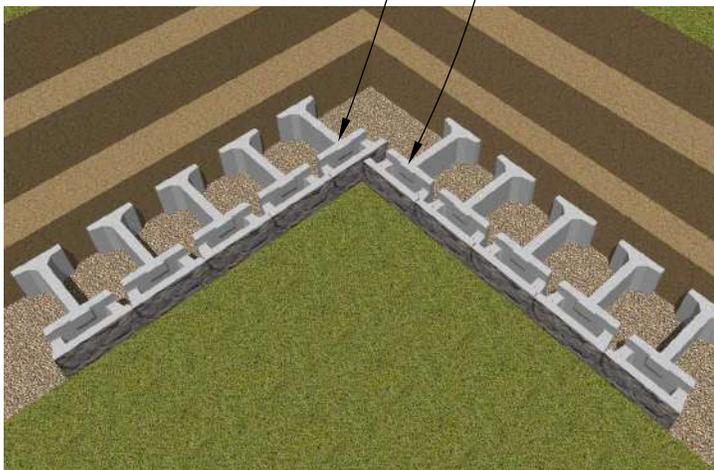
*48"(1219) Extender & Standard Block  
in Middle of Adjacent Block*

*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*



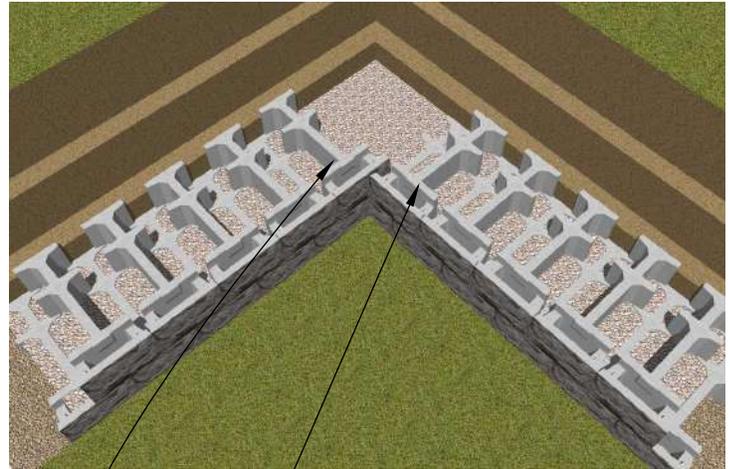
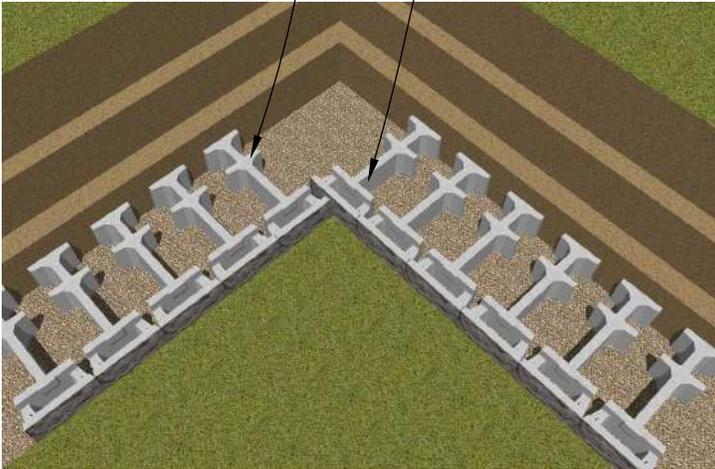
*72"(1829) Extender & Standard Block  
in Middle of Adjacent Block*

*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



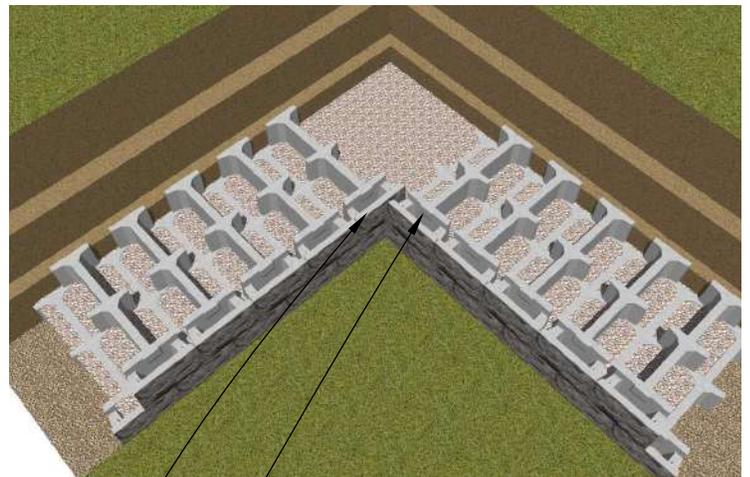
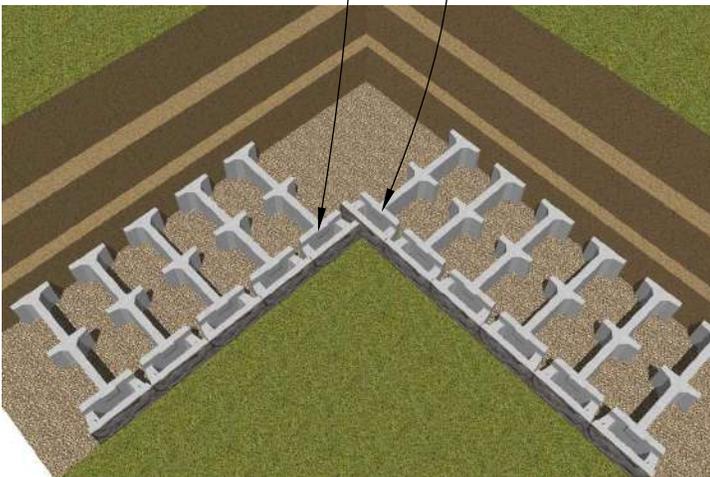
96"(2438) Extender & Standard Block

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

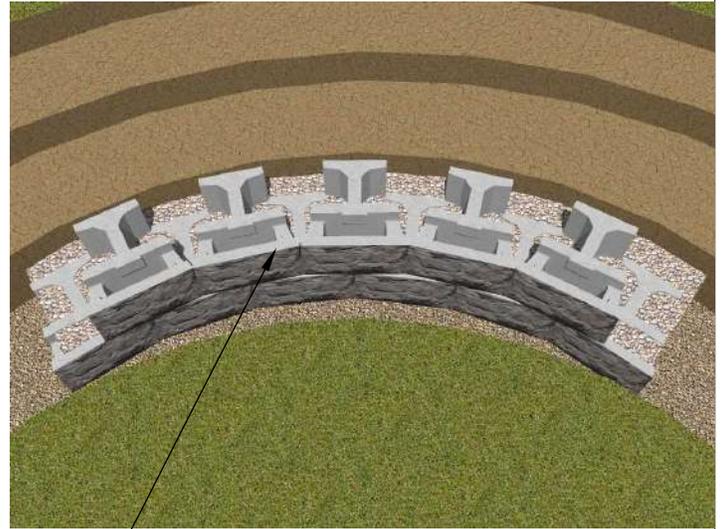


120"(3048) Extender & Standard Block

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

**48" (1219) Inside Curve**

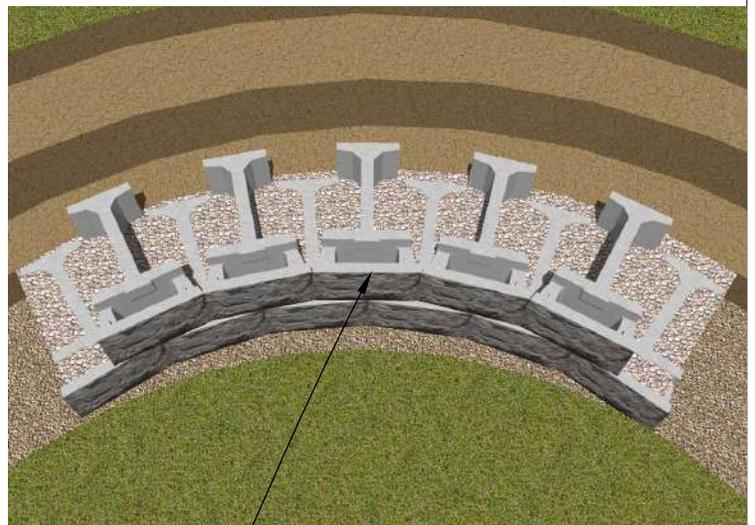
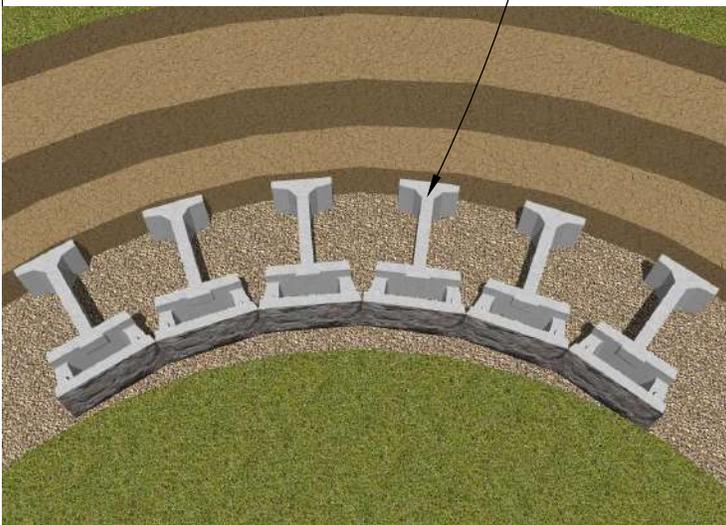
*48"(1219) Extender & Base Block*



*48"(1219) Extender & Standard Block*

**72" (1829mm) Inside Curve**

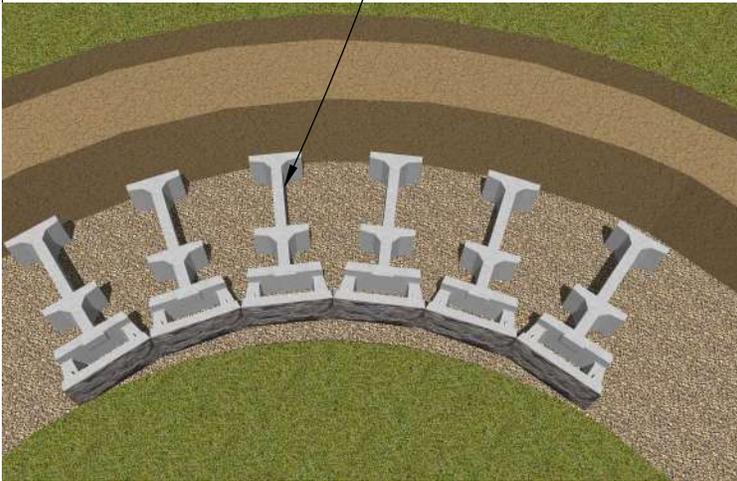
*72"(1829) Extender & Base Block*



*72"(1829) Extender & Standard Block*

**96" (2438) Inside Curve**

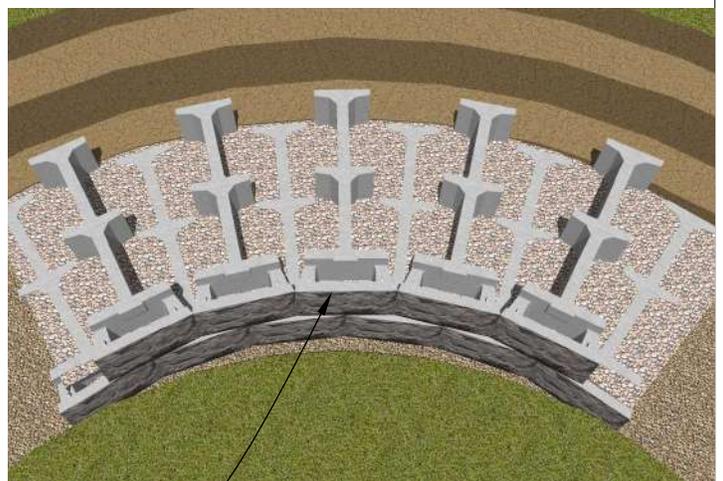
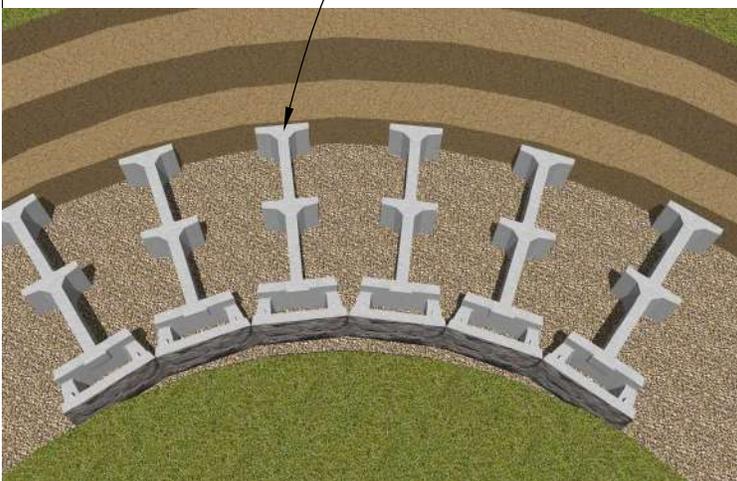
*96"(2438) Extender & Base Block*



*96"(2438) Extender & Standard Block*

**120" (3048mm) Inside Curve**

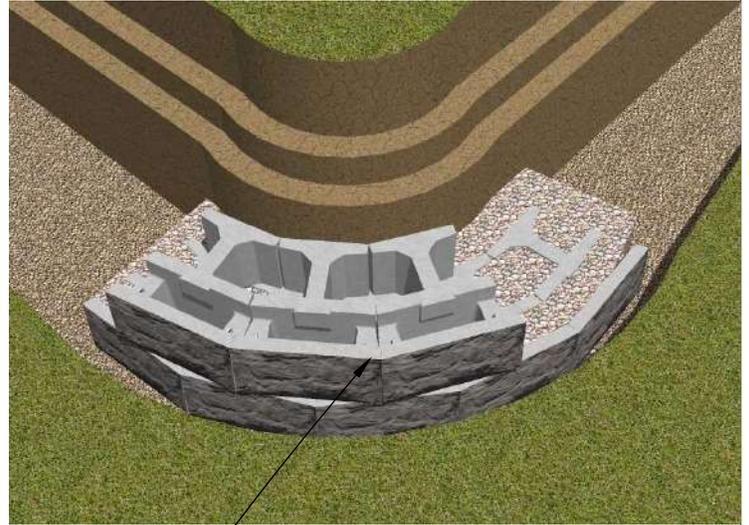
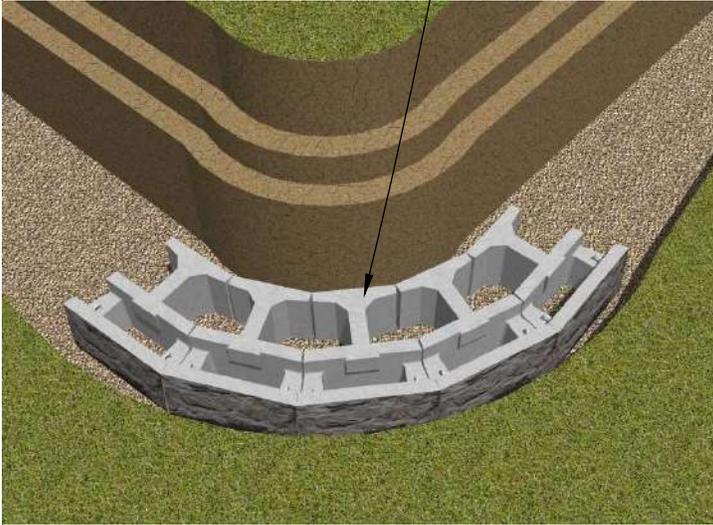
*120"(3048) Extender & Base Block*



*120"(3048) Extender & Standard Block*

**48" (1219) Outside Curve**

*48"(1219) Extender & Base Block*

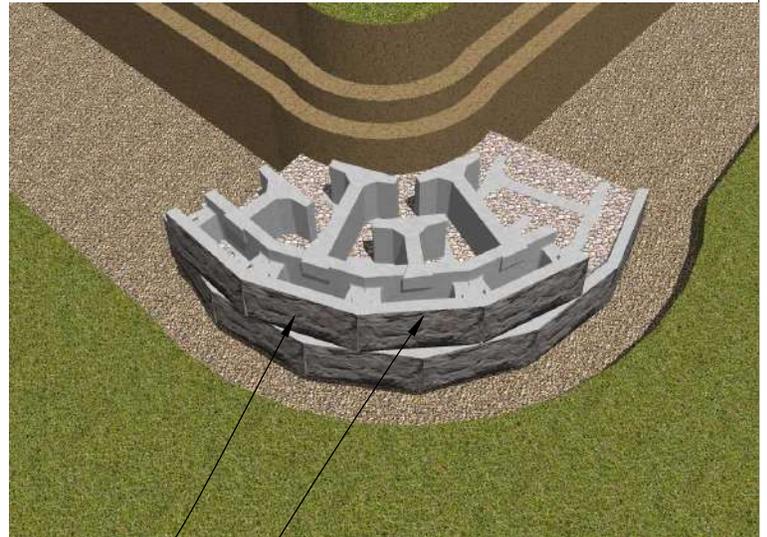
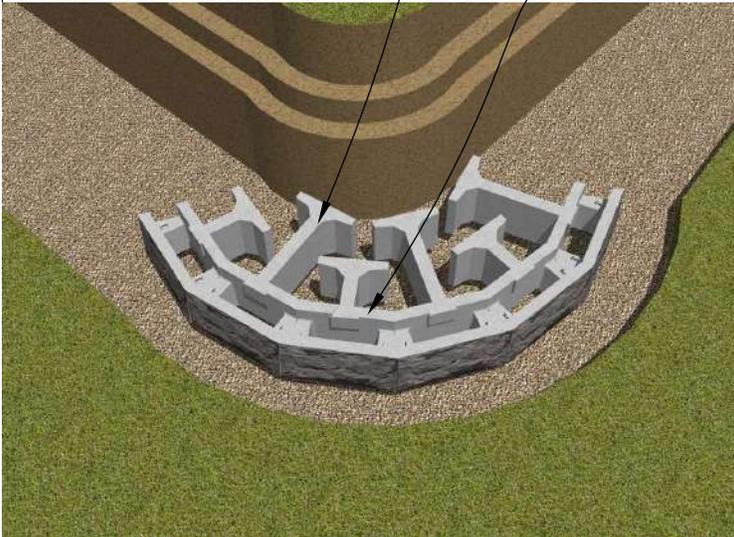


*48"(1219) Extender & Standard Block*

**72" (1829mm) Outside Curve**

*72"(1829) Extender & Base Block*

*48"(1219) Extender & Base Block*



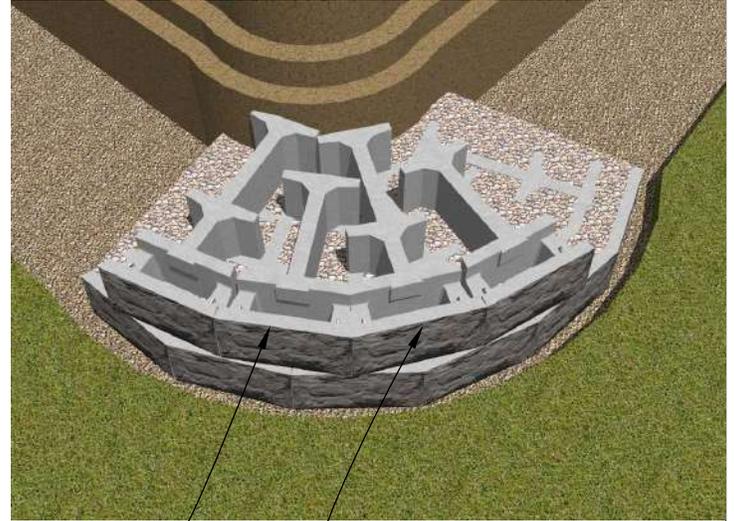
*72"(1829) Extender & Standard Block*

*48"(1219) Extender & Standard Block*

**96" (2438) Outside Curve**

96"(2438) Extender & Base Block

72"(1829) Extender & Base Block



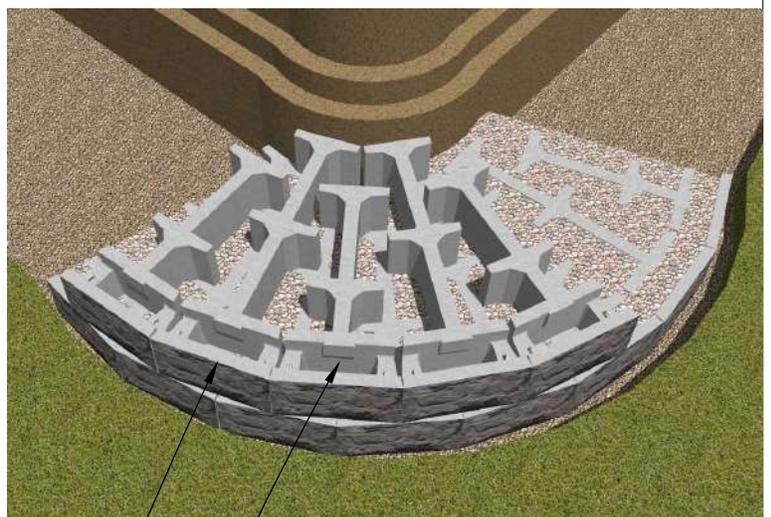
72"(1829) Extender & Standard Block

96"(2438) Extender & Standard Block

**120" (3048mm) Outside Curve**

120"(3048) Extender & Base Block

96"(2438) Extender & Base Block

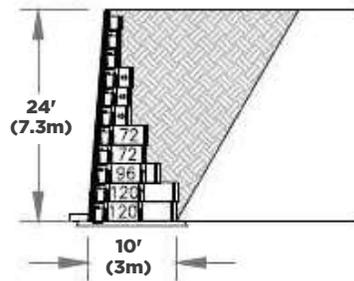
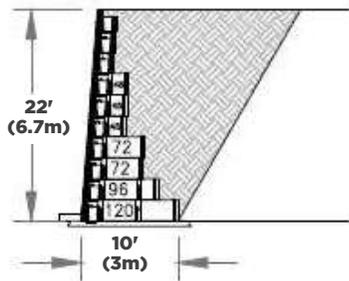
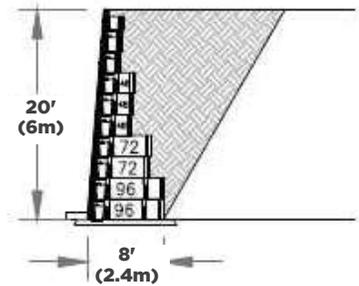
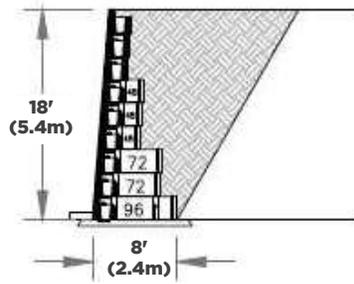
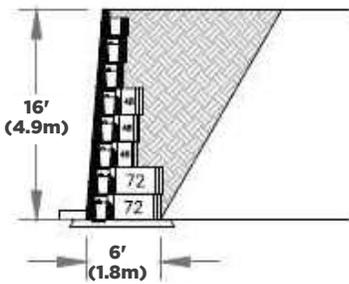
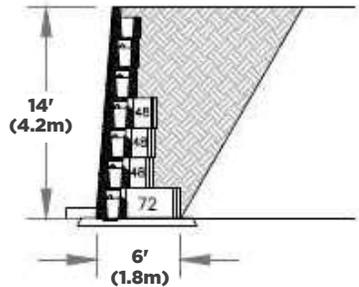
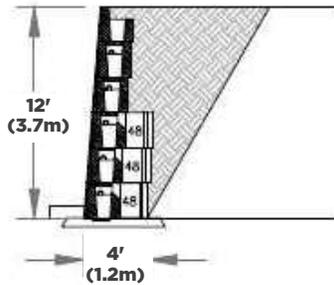
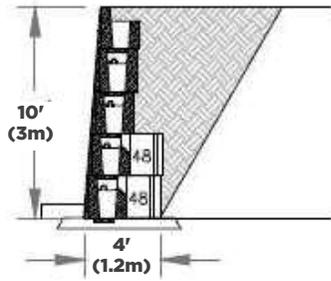
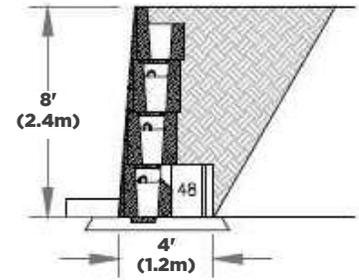
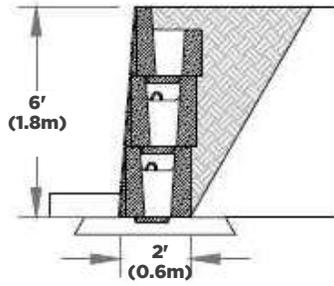


120"(3048) Extender & Standard Block

96"(2438) Extender & Standard Block

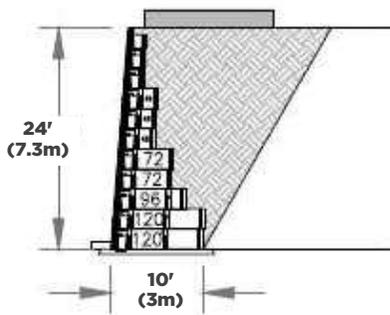
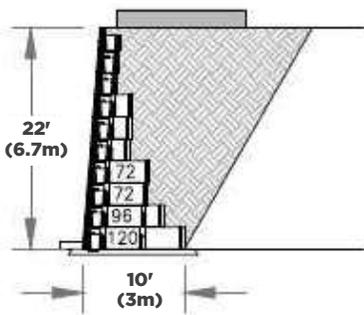
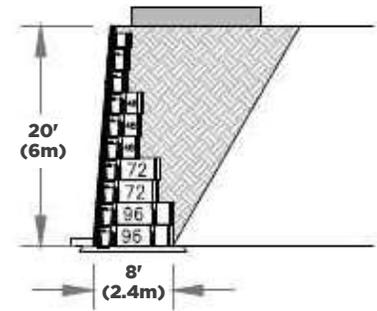
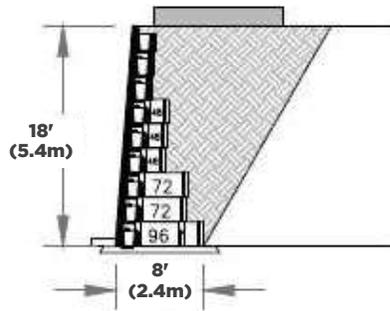
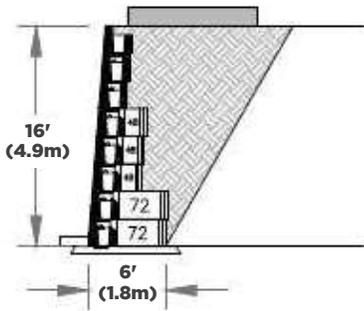
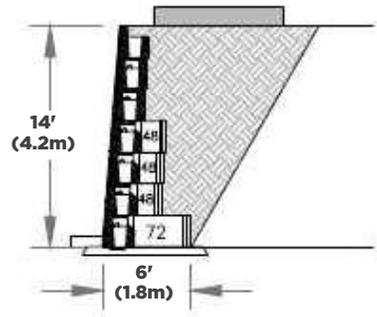
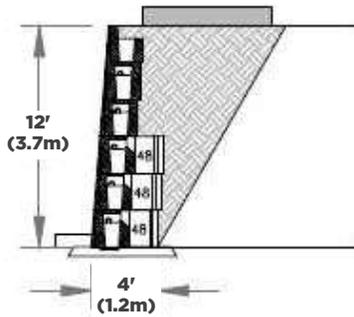
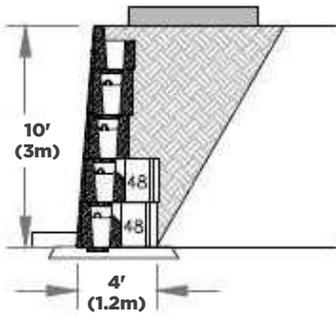
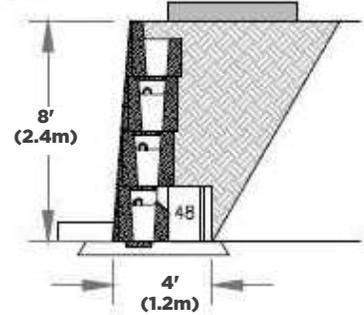
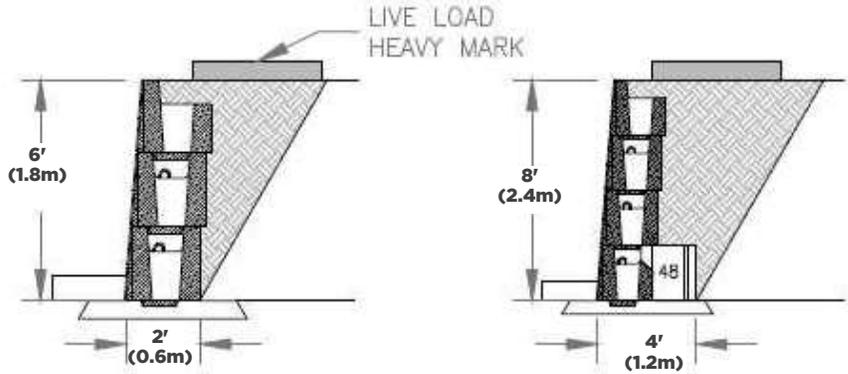
<b>Slope Angle</b>	0 Degrees
<b>Live Load</b>	0 PSF
<b>Retained Soil</b>	34 Degrees
<b>Unit Refill</b>	Crushed Gravel

Note: Calculations are for preliminary use only and should not be used for construction without the review of a qualified professional.



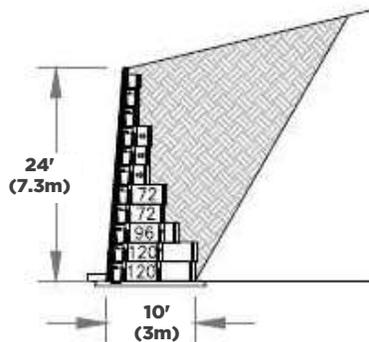
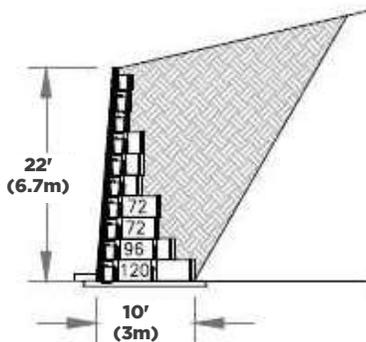
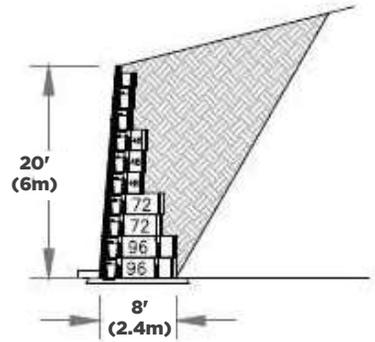
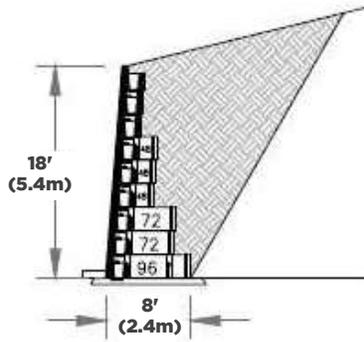
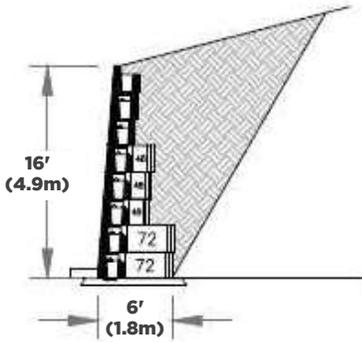
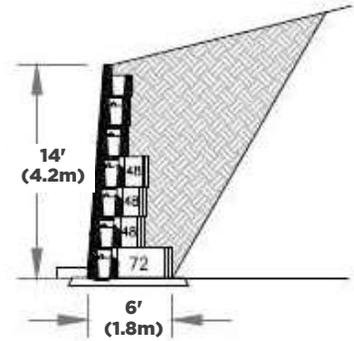
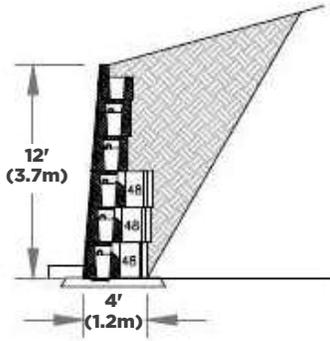
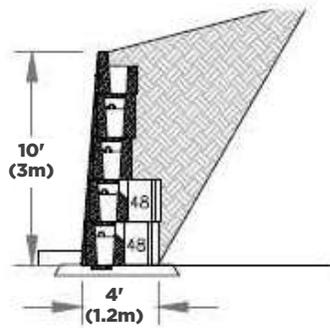
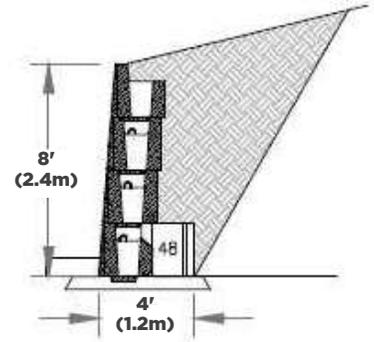
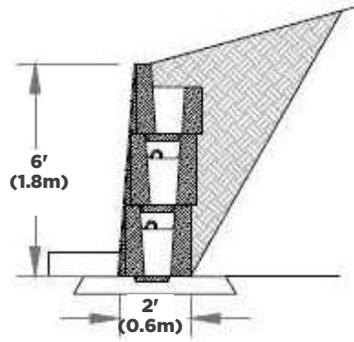
<b>Slope Angle</b>	0 Degrees
<b>Live Load</b>	250 PSF
<b>Retained Soil</b>	34 Degrees
<b>Unit Refill</b>	Crushed Gravel

Note: Calculations are for preliminary use only and should not be used for construction without the review of a qualified professional.



<b>Slope Angle</b>	20 Degrees
<b>Live Load</b>	0 PSF
<b>Retained Soil</b>	34 Degrees
<b>Unit Refill</b>	Crushed Gravel

Note: Calculations are for preliminary use only and should not be used for construction without the review of a qualified professional.



## 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

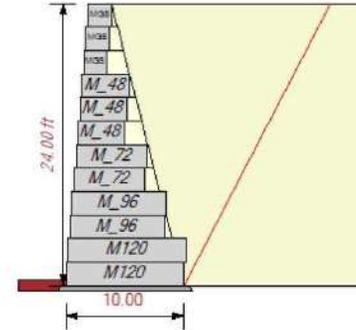
Name	Elev [dpth]	ka	Pa	Paq	Paqd	(PaC)	PaT	FSsk(M Pd)	FoS OT	%DH
MGS	22.00[2.00]	0.222	53	0	0	0	53	100.00	13.29	100%
MGS	20.00[4.00]	0.222	213	0	0	0	213	57.79	3.63	50%
MGS	18.00[6.00]	0.222	480	0	0	0	480	25.38	1.76	33%
M_48	16.00[8.00]	0.341	1310	0	0	0	1310	20.92	2.62	50%
M_48	14.00[10.00]	0.314	1884	0	0	0	1884	12.04	1.96	40%
M_48	12.00[12.00]	0.297	2565	0	0	0	2565	8.82	1.55	33%
M_72	10.00[14.00]	0.355	4176	0	0	0	4176	9.57	1.83	43%
M_72	8.00[16.00]	0.336	5157	0	0	0	5157	7.89	1.56	38%
M_96	6.00[18.00]	0.350	7302	0	0	0	7302	7.43	1.85	44%
M_96	4.00[20.00]	0.361	8661	0	0	0	8661	6.35	1.84	40%
M120	2.00[22.00]	0.396	11500	0	0	0	11500	6.28	1.89	45%
M120	0.00[24.00]	0.378	13078	0	0	0	13078	1.77 (1.79)	1.71	42%

**Gravity Wall Analysis - Output**



**REAWall**  
Version: 4.0.16099

Project: Sample Project  
 Location: Site Location  
 Designer: xxx  
 Date: 4/29/2016  
 Section: Section 1  
 Design Method: NCMA\_09\_3rd\_Ed  
 Design Unit: MagnumStone



SOIL PARAMETERS	$\phi$	coh	$\gamma$
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	Live Load:	0 psf
Wall Batter/Tilt:	4.77/ 0.00 deg	Live Load Offset:	0.00 ft
Embedment:	0.50 ft	Live Load Width:	100 ft
Leveling Pad Depth:	0.50 ft	Dead Load:	0 psf
Slope Angle:	0.0 deg	Dead Load Offset:	0.0 ft
Slope Length:	0.0 ft	Dead Load Width:	100 ft
Slope Toe Offset:	0.0 ft	Leveling Pad Width:	11.00 ft
Vertical $\delta$ on Single Depth			

**FACTORS OF SAFETY**

Sliding:	1.50	Overtuning:	1.50
Bearing:	2.00		

**RESULTS**

FoS Sliding:	1.77 (1/1pd)	FoS Overtuning:	1.55
Bearing:	5298.99	FoS Bearing:	2.95

Name	Elev.[dpth]	ka	Pa	Paq	Paqd	(PaC)	PaT	FSS/(M Pd)	FoS OT	%D/H
MGS	22.00[2.00]	0.222	53	0	0	0	53	100.00	13.29	100%
MGS	20.00[4.00]	0.222	213	0	0	0	213	57.79	3.63	50%
MGS	18.00[6.00]	0.222	480	0	0	0	480	25.38	1.75	33%
M_48	16.00[8.00]	0.341	1310	0	0	0	1310	20.92	2.62	50%
M_48	14.00[10.00]	0.314	1884	0	0	0	1884	12.04	1.95	40%
M_48	12.00[12.00]	0.297	2565	0	0	0	2565	8.82	1.55	33%
M_72	10.00[14.00]	0.355	4176	0	0	0	4176	9.57	1.83	43%
M_72	8.00[16.00]	0.336	5157	0	0	0	5157	7.69	1.56	38%
M_96	6.00[18.00]	0.380	7382	0	0	0	7382	7.48	1.85	44%
M_96	4.00[20.00]	0.361	8661	0	0	0	8661	6.35	1.64	40%
M120	2.00[22.00]	0.396	11500	0	0	0	11500	6.28	1.89	45%
M120	0.00[24.00]	0.378	13078	0	0	0	13078	1.77 (1.79)	1.71	42%

**Gravity Wall Analysis - Output****NOTES ON DESIGN UNITS**

The wall section is designed on a 'per unit width bases' (lb/ft/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 / ft<sup>3</sup> (kN / m<sup>3</sup>). For SRW design a 1 sf unit is typically 1 ft deep, 1.5 ft wide and 8 inches tall (or 1 ft<sup>3</sup>). 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 1.4999999999999999, 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 (1.4999999999999999 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	FSsl =1.50
Minimum Factor of Safety for overturning about the toe	FSot =1.50
Minimum Factor of Safety for bearing (foundation shear failure)	FSbr =2.00

MINIMUM DESIGN REQUIREMENTS

Minimum embedment depth	Min_emb =0.50 ft
-------------------------	------------------

INPUT DATA

Geometry

Wall Geometry

Design Height, top of leveling pad to finished grade at top of wall	H =24.00 ft
Embedment, measured from top of leveling pad to finished grade	emb =0.50 ft
Leveling Pad Depth	LP Thickness =0.50 ft
Face Batter, measured from vertical	i =4.77 deg

Slope Geometry

Slope Angle, measured from horizontal	$\beta$ =0.00 deg
Slope toe offset, measured from back of the face unit	STL_offset =0.00 ft
Slope Length, measured from back of wall facing	SL_Length =0.00 ft

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

Surcharge Loading

Live Load, assumed transient loading (e.g. traffic)	LL = 0.00 psf
Live Load Offset, measured from back face of wall	LL_offset =0.00 ft
Live Load Width, assumed strip loading	LL_width = 100.00 ft
Dead Load, assumed permanent loading (e.g. buildings)	DL = 0.00 psf
Dead Load Offset, measured from back face of wall	DL_offset =0.00 ft
Dead Load Width, assumed strip loading	DL_width = 100.00 ft

Soil Parameters

Retained Zone

Angle of Internal Friction	$\phi$ = 34.00 deg
Cohesion	coh =0.00 psf
Moist Unit Weight	gamma =120.00 pcf

Foundation

Angle of Internal Friction	$\phi$ = 34.00 deg
Cohesion	coh =0.00 psf
Moist Unit Weight	gamma =120.00 pcf

**Gravity Wall Analysis - Output**



RETAINING WALL UNITS

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:

Unit	Ht (in)	Width (in)	Depth (in)	Concr_Vol (cf/ft)	Concr_Density (pcf)	CG (in)
Cap Block	6.00	48.00	24.00	1.00	140.00	12.00, 3.00
Cap Block	6.00	48.00	24.00	1.00	140.00	12.00, 3.00
Top Cap 12in	12.00	48.00	24.00	1.13	140.00	10.63, 6.00
Top Cap 24in	24.00	48.00	24.00	2.32	140.00	10.63, 12.00
Standard	24.00	48.00	24.00	2.32	140.00	10.63, 12.00
MAG_48	24.00	48.00	48.00	3.29	140.00	19.05, 12.00
Mag_72	24.00	48.00	72.00	3.79	140.00	27.26, 12.00
Mag_96	24.00	48.00	96.00	4.78	140.00	37.76, 12.00
Mag_120	24.00	48.00	120.00	5.28	140.00	48.65, 12.00
Mag_144	24.00	48.00	144.00	6.23	140.00	61.45, 12.00
Mag_168	24.00	48.00	168.00	6.68	140.00	69.28, 12.00

Unit	Aggr_Vol (cf)	Aggr_Density (pcf)	Aggr_CG (in)	Equiv_Density (pcf)	Equiv_CG (in)
Cap Block	0.00	110.00	12.00, 6.00	140.00	12.00
Cap Block	0.00	110.00	12.00, 6.00	140.00	12.00
Top Cap 12in	0.75	110.00	12.00, 12.00	120.00	11.10
Top Cap 24in	1.53	110.00	12.00, 12.00	123.23	11.10
Standard	1.53	110.00	11.53, 12.00	123.23	10.94
MAG_48	4.55	110.00	26.69, 12.00	120.14	23.03
Mag_72	7.98	110.00	39.25, 12.00	117.32	34.73
Mag_96	11.35	110.00	52.90, 12.00	119.83	47.62
Mag_120	13.73	110.00	69.16, 12.00	112.43	62.42
Mag_144	13.73	110.00	69.16, 12.00	99.22	66.34
Mag_168	13.73	110.00	69.16, 12.00	87.29	69.21



**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  $\delta$  angle is  $\delta$  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 $\delta$ angle (3/4 retained $\phi$ )	$\delta = 25.5$ deg
Coefficient of active earth pressure	$k_a = 0.378$
External failure plane	$\rho = 63$ deg
Effective Angle from horizontal	Eff. Angle = 75.60 deg
Coefficient of passive earth pressure: $k_p = (1 + \sin(\phi)) / (1 - \sin(\phi))$	$k_p = 3.54$

- W0: stone within units
- W1: facing units
- W2: stone over the tails
- W9: Driving force Pa
- W10: Driving Surcharge load Paq
- W11: Driving Dead Load Surcharge Paqd

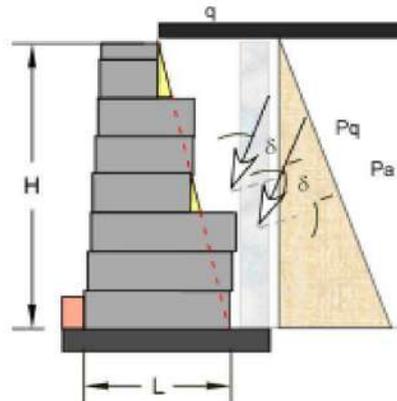
FORCES AND MOMENTS

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

Name	Factor $\gamma$	Force (V)	Force (H)	X-len	Y-len	Mo	Mr
Face Blocks(W1)	1.00	6234	--	3.27	--	--	20389
Soil Fill(W0)	1.00	9276	--	4.65	--	--	43177
Soil Wedge(W2)	1.00	1798	--	3.70	--	--	6655
LvIPad(W18)	1.00	666	--	--	--	--	--
Pa_h	1.00	--	10032	--	8.00	80260	--
Pa_v	1.00	8390	--	7.95	--	--	66659
Sum V / H	1.00	26364	10032			Sum Mom	80260 136880

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 =  $W0 \tan(\text{slope}1) + (W1 + W2 + Pav) \tan(\text{slope}) + \text{intercept} \times L$   
 [slope 1 is the friction between the unit fill and the leveling pad,  $\tan(36.0)$ ]  
 $9276 \times \tan(36) + 16422 \times \tan(33.9) + 0.0 \times 10.0$   
 where L is the base block width

$Rf1 = 17763$

Friction angle is the lesser of the leveling pad and  $Fnd$   
 $N1$  includes  $N$  (the leveling pad) + leveling pad (LP)  
 $25698 + 666$

$\phi = 34.00$  deg

$N1 = 26364$  ppf

Passive resistance is calculated using  $kp = (1 + \sin(34)) / (1 - \sin(34))$   
 Pressure at top of resisting trapezoid,  $d1 = 0.50$   
 Pressure at base of resisting trapezoid,  $d2 = 0.50$   
 Depth of trapezoid  
 $Pp = (Fp1 + Fp2) / 2 \times \text{depth}$

$kp = 3.54$

$Fp1 = 212.23$

$Fp2 = 212.23$

depth = 0.00

$159.17$

Resisting force at  $fnd = (N1 \tan(\phi) + cL) + Pp$   
 $26364 \times \tan(34) + 0 \times 10.3 + 159$   
 where LP =  $lv$  pad thickness \* 130pcf \*  $(L + lv \text{ pad thickness} / 2)$

$Rf2 = 17942$

Driving force is the horizontal component of  $Pah$   
 $10032$

$Df = 10032$

$FSsl = Rf / Df$

$FSsl = 1.77 / 1.79$

**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 + MLvlPad + 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

$$\text{SumV} = (W1 + W2 + Pa\_v)$$

$$e = L/2 - (\text{SumMr} - \text{SumMo})/(\text{SumV})$$

$$e = 10.00/2 - (56621 / 25697.70)$$

$$e = 2.797 \text{ ft}$$

Calculation of Bearing Pressures

$$\text{Qult} = c * Nc + q * Nq + 0.5 * \gamma * (B') * Ng$$

where:

$$Nc = 42.16$$

$$Nq = 29.44$$

$$Ng = 41.06$$

$$c = 0.00 \text{ psf}$$

$$q = 120.00 \text{ psf}$$

$$B' = B - 2e + |\text{lpad}| = 4.91 \text{ ft}$$

$$\text{Gamma(LP)} = 130 \text{ pcf}$$

Calculate Ultimate Bearing, Qult

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

Calculated Factors of Safety for Bearing

$$\text{Qult} = 15622 \text{ psf}$$

$$\text{sigma} = 5298.99 \text{ psf}$$

$$\text{Qult/sigma} = 2.95$$