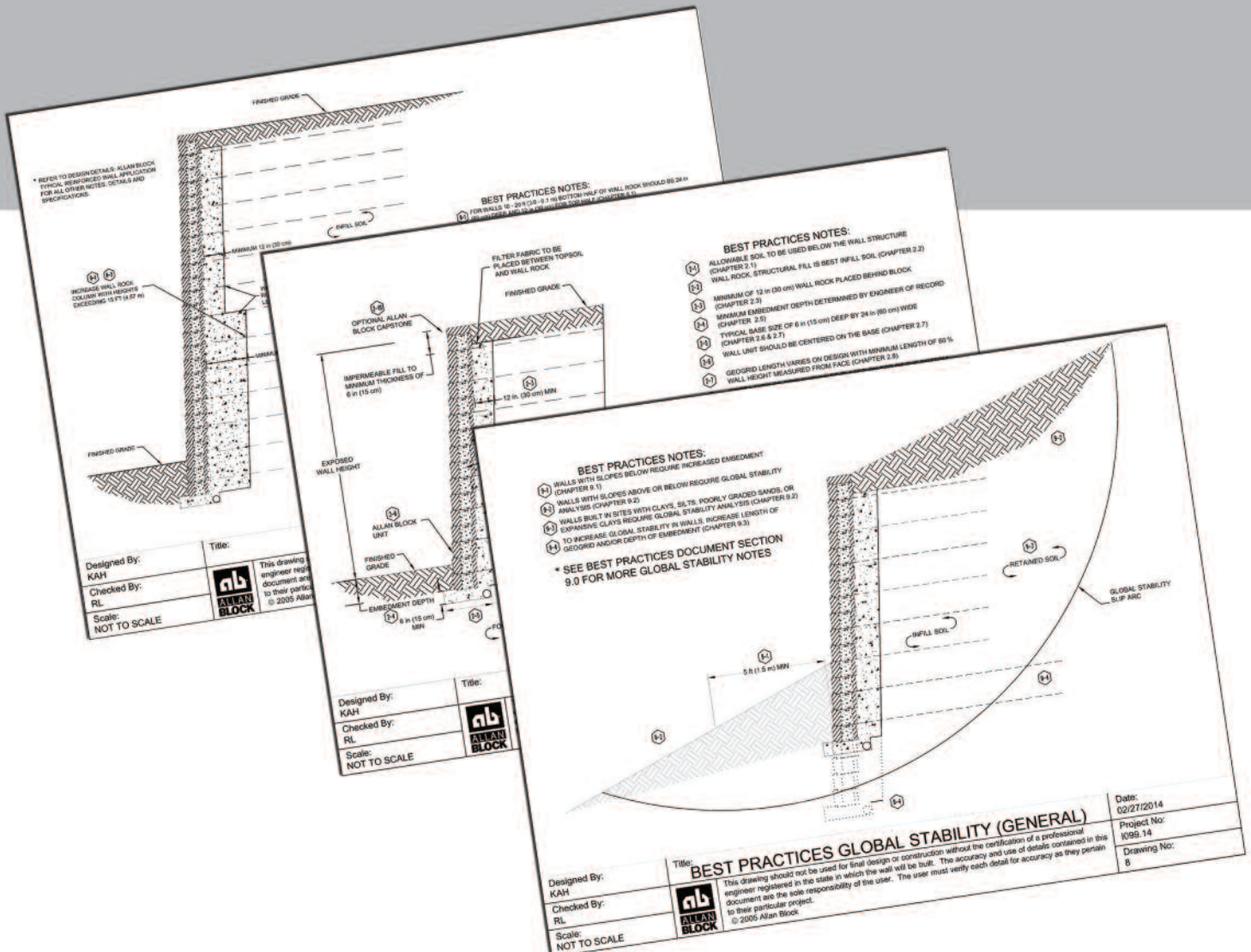


Best Practices for SRW Design



Best Practices for Allan Block Segmental Retaining Wall Design For Residential and Commercial Applications

The intent of this document is to communicate the best practices for design of Segmental Retaining Walls (SRW) as determined by Allan Block Corporation based on 25 plus years of research, design and field experience. This is not meant to be a final authority as each project has their own set of unique situations. The local engineer of record must use their best engineering judgment to account for those situations that present themselves and provide a safe and efficient design for the customer. At no time does the contractor or local building official have the authority to override the approved plans and specifications provided from the local engineer of record. It is the recommendation of Allan Block Corporation that the local engineer of record work for and be paid by the project owner. It has been determined that the local engineer of record should be the Project Site Civil Engineer as they are best suited to take responsibility for the design, and how it affects the site, whether they do the design in-house or use an outside consultant to do the design for the project. The Project Site Civil Engineer has control of several of the overall aspects of the project and therefore is most able to properly handle the integration and communication required to ensure the performance of the wall complies with the needs of the site. For wall design applications that are outside of the experience level of the Project Site Civil Engineer a wall designer with the appropriate knowledge and experience should be contracted with by the Project Site Civil Engineer. It is recommended that the wall contractor not be responsible for securing the engineering.

How to use this document:

The Best Practice document contains drawings (Part 1) highlighting details associated with typical issues that may be present on any given project. Notes expanding on each topic are contained in the chapters that follow. Please refer to the Table of Contents Part 2 – Best Practice Considerations for a list of topics contained in this document.

To find the most up-to-date information available, visit allanblock.com.

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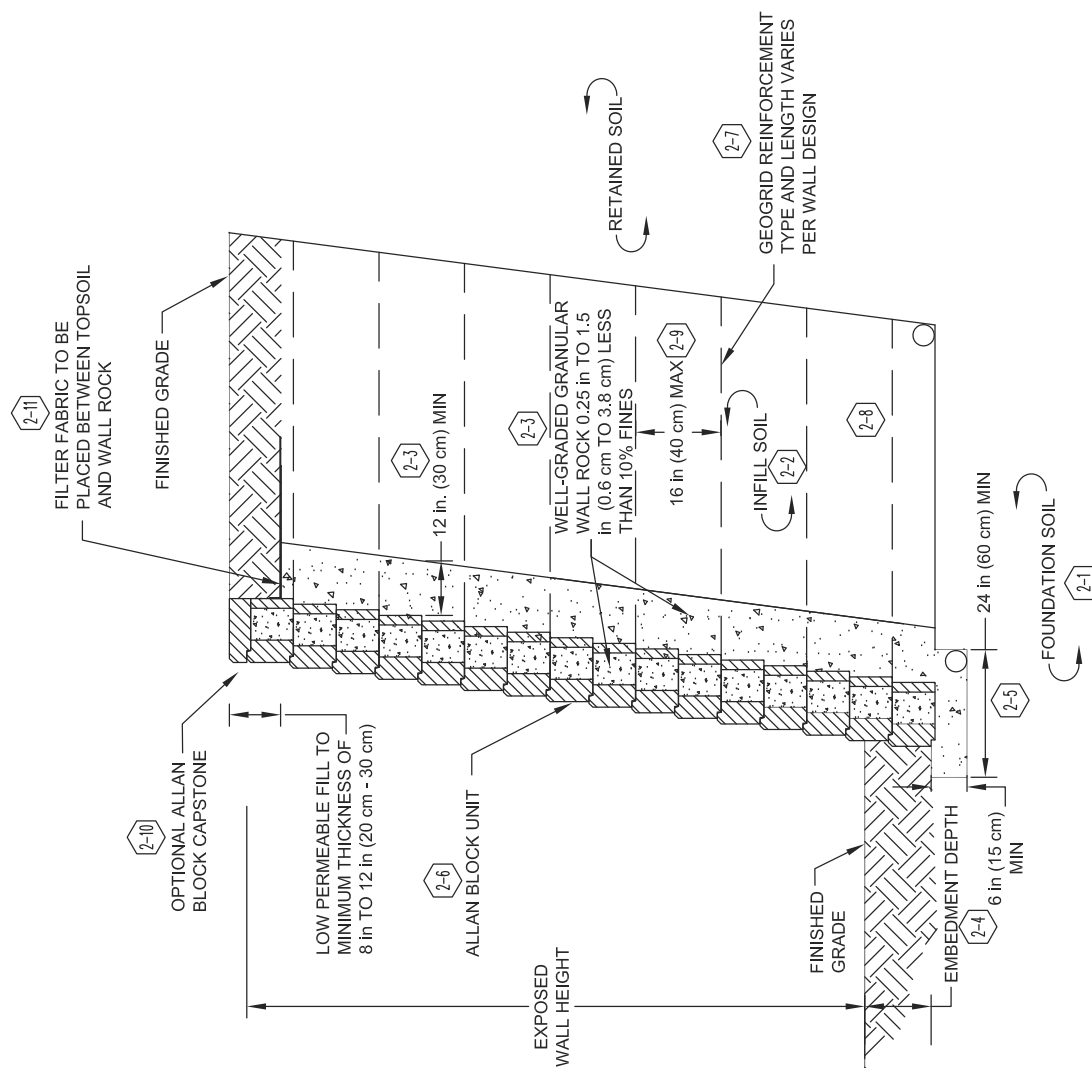
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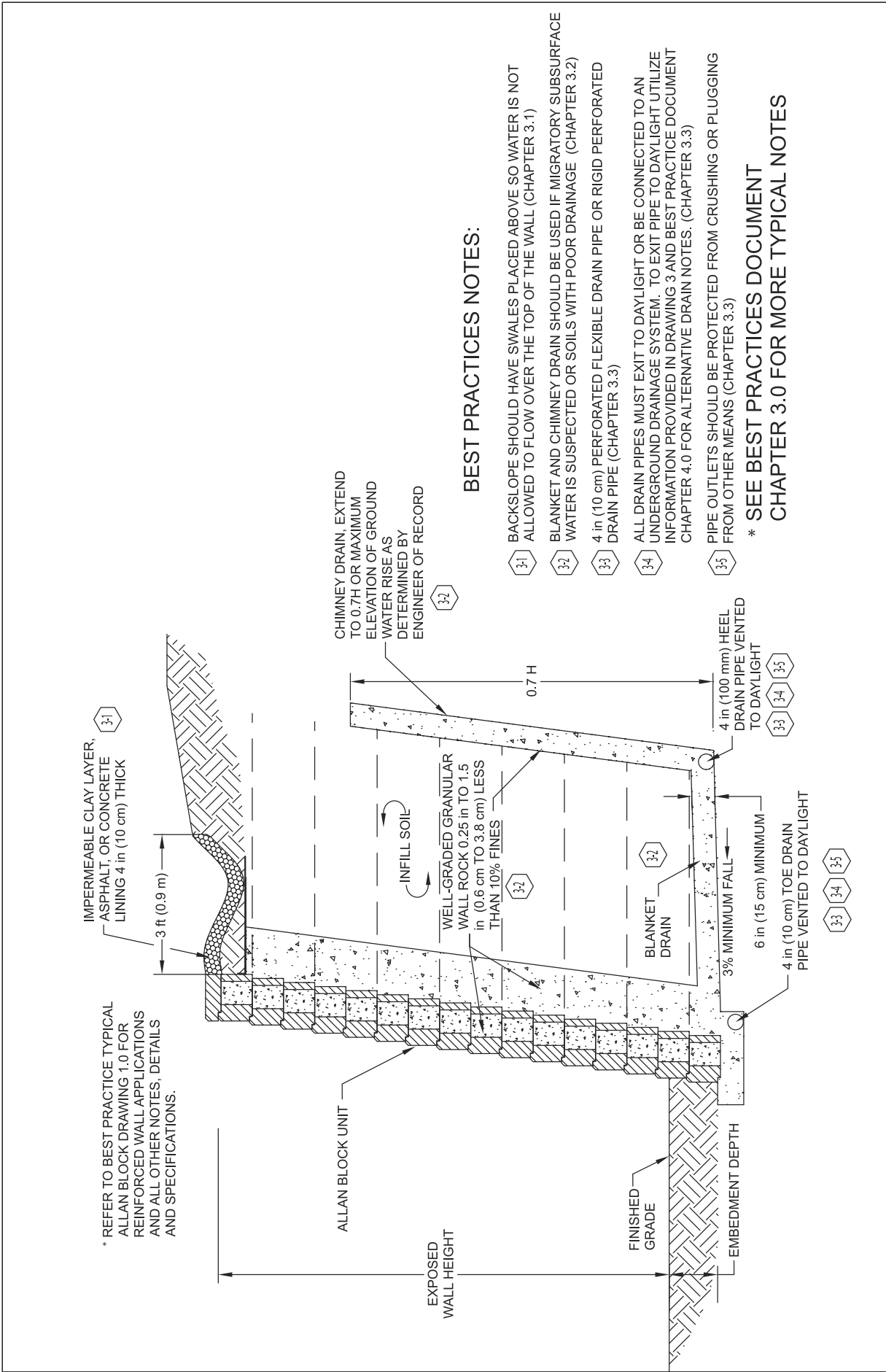
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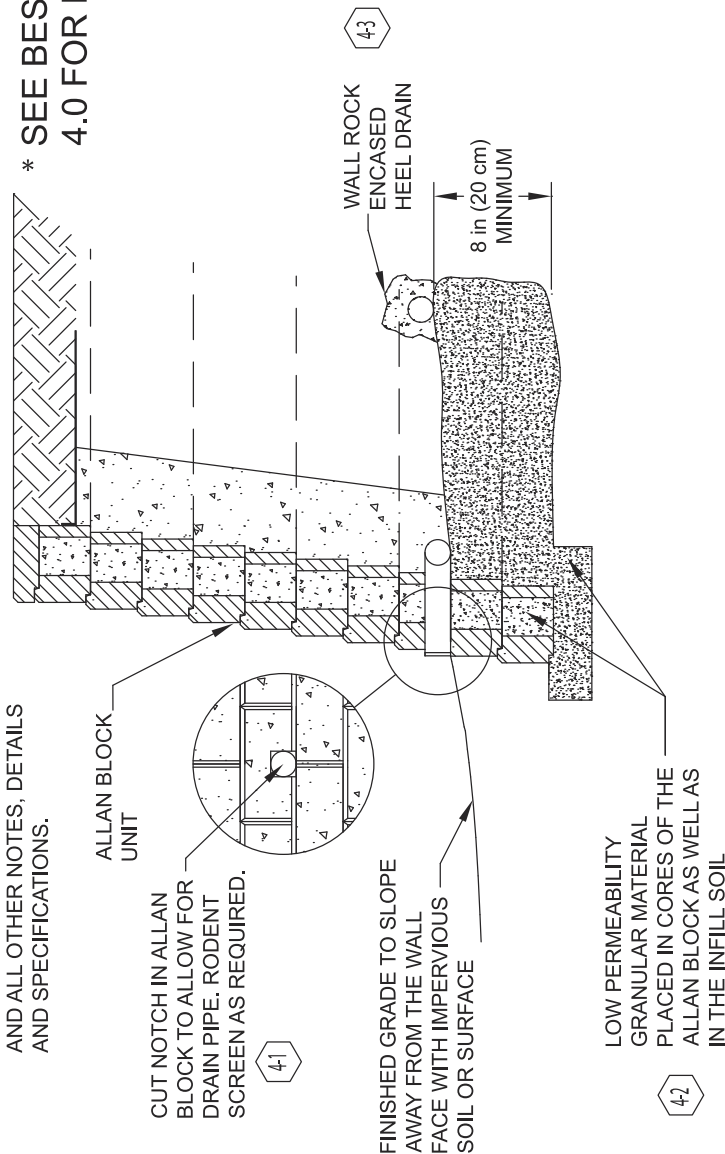
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4-2 LOW PERMEABILITY GRANULAR SOILS SHOULD BE PLACED TO CREATE A SHELF INSIDE THE MASS (CHAPTER 4.1)

4-3 1 ft³/ft (0.3 m³/m) OF ADDITIONAL WALL ROCK SHOULD BE PLACED AROUND HEEL DRAIN WHEN INFILL MATERIAL USED IS FINE GRAINED COHESIVE SOILS HAVING A PLASTICITY INDEX (PI) OF > 6 & LL > 30 (CHAPTER 4.2)

* REFER TO BEST PRACTICE TYPICAL ALLAN BLOCK DRAWING 1.0 FOR REINFORCED WALL APPLICATIONS AND ALL OTHER NOTES, DETAILS AND SPECIFICATIONS.

* SEE BEST PRACTICES DOCUMENT CHAPTER 4.0 FOR MORE ALTERNATIVE DRAIN NOTES



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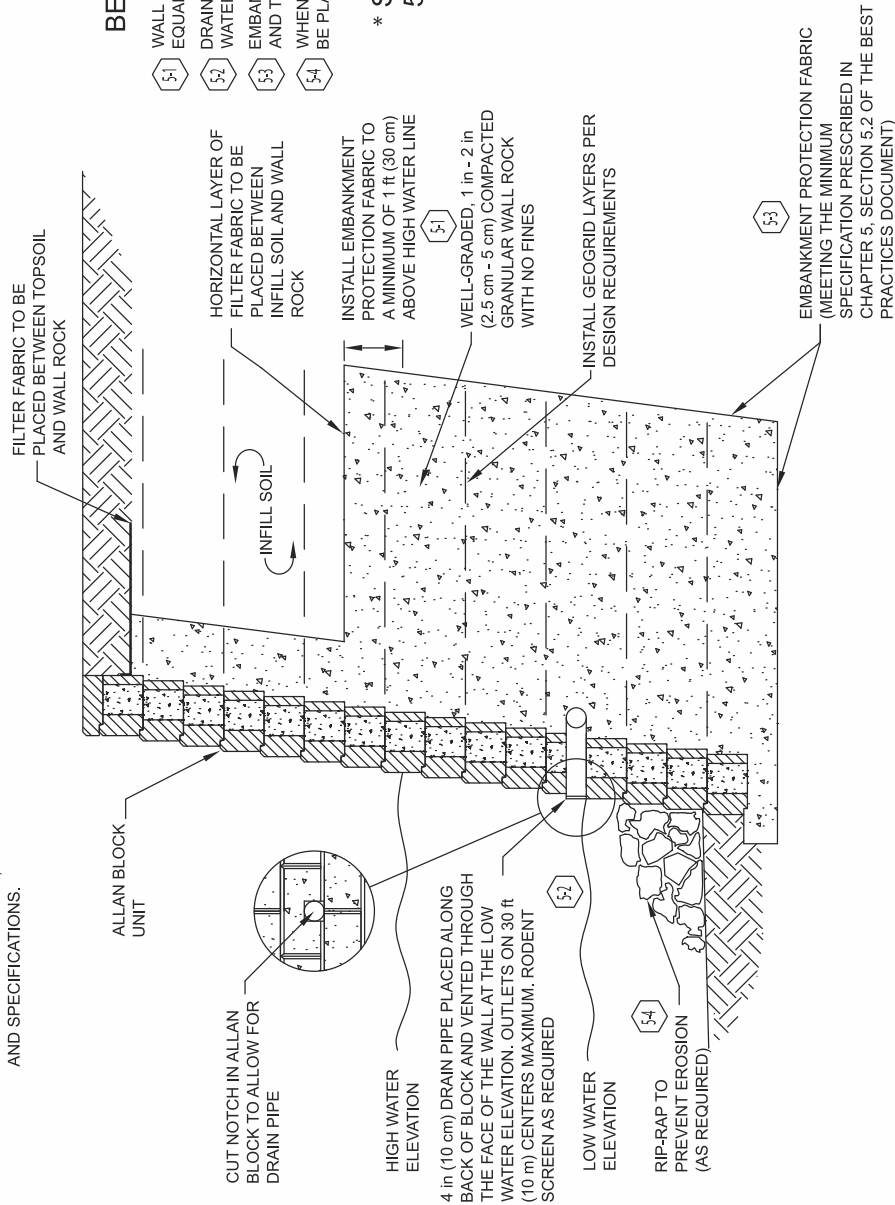
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BEST PRACTICES NOTES:

- 51 WALL ROCK PLACED TO THE LIMITS OF THE GEOGRID UP TO A HEIGHT EQUAL TO 12 in (30 cm) HIGHER THAN ANY WATER SOURCE (CHAPTER 5.1)
- 52 DRAIN PIPE RAISED TO THE LOW WATER ELEVATION TO AID IN EVACUATION OF WATER DURING WATER FLUCTUATION (CHAPTER 5.2)
- 53 EMBANKMENT PROTECTION FABRIC SHOULD BE USED UNDER THE INFILL MASS AND TO A HEIGHT OF 12 in (30 cm) HIGHER THAN HIGH WATER MARK (CHAPTER 5.2)
- 54 WHEN MOVING WATER IS DETERMINED, RIP-RAP IN FRONT OF THE WALL SHOULD BE PLACED TO PROTECT THE WALL FROM SCOUR EFFECTS (CHAPTER 5.2)

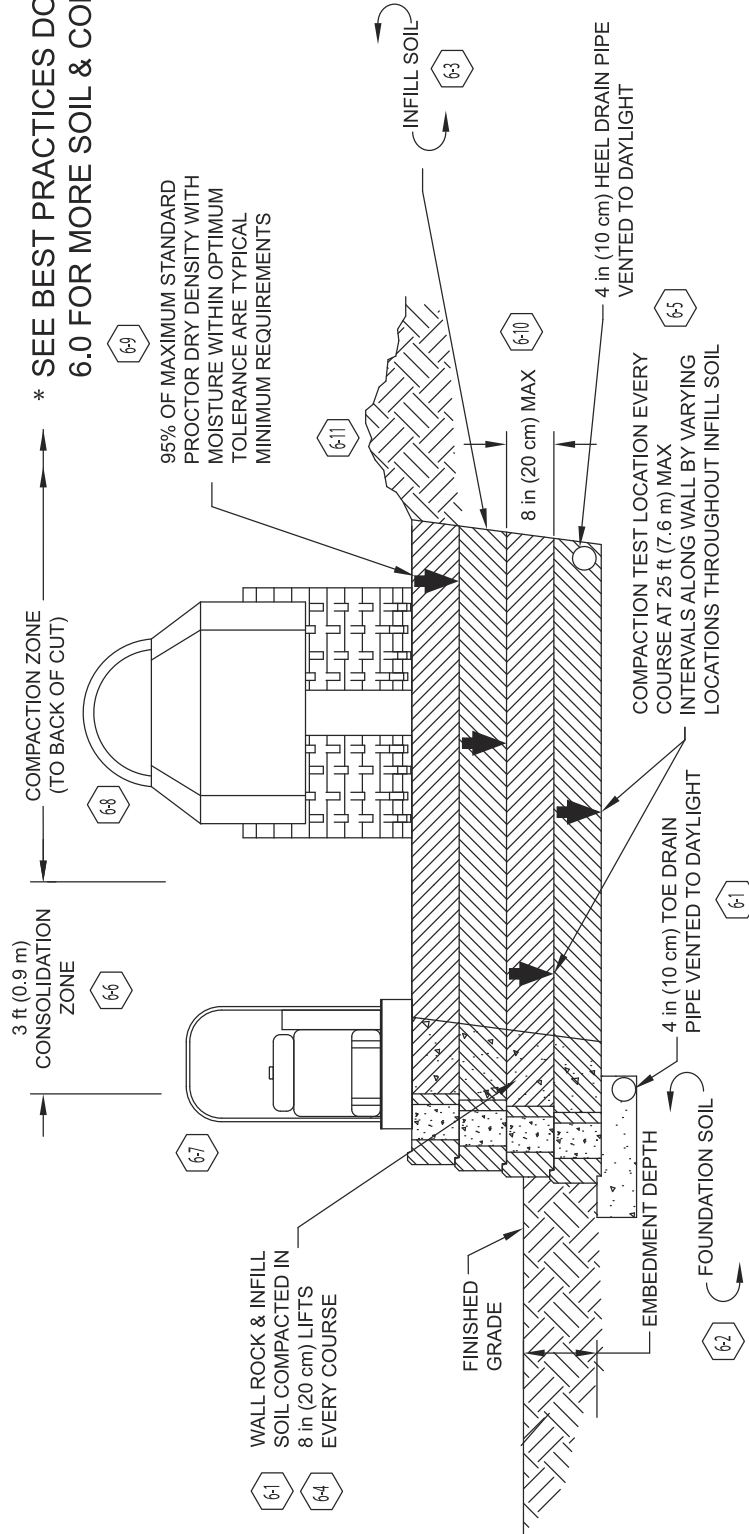
* SEE BEST PRACTICES DOCUMENT CHAPTER 5.0 FOR MORE WATER APPLICATION NOTES


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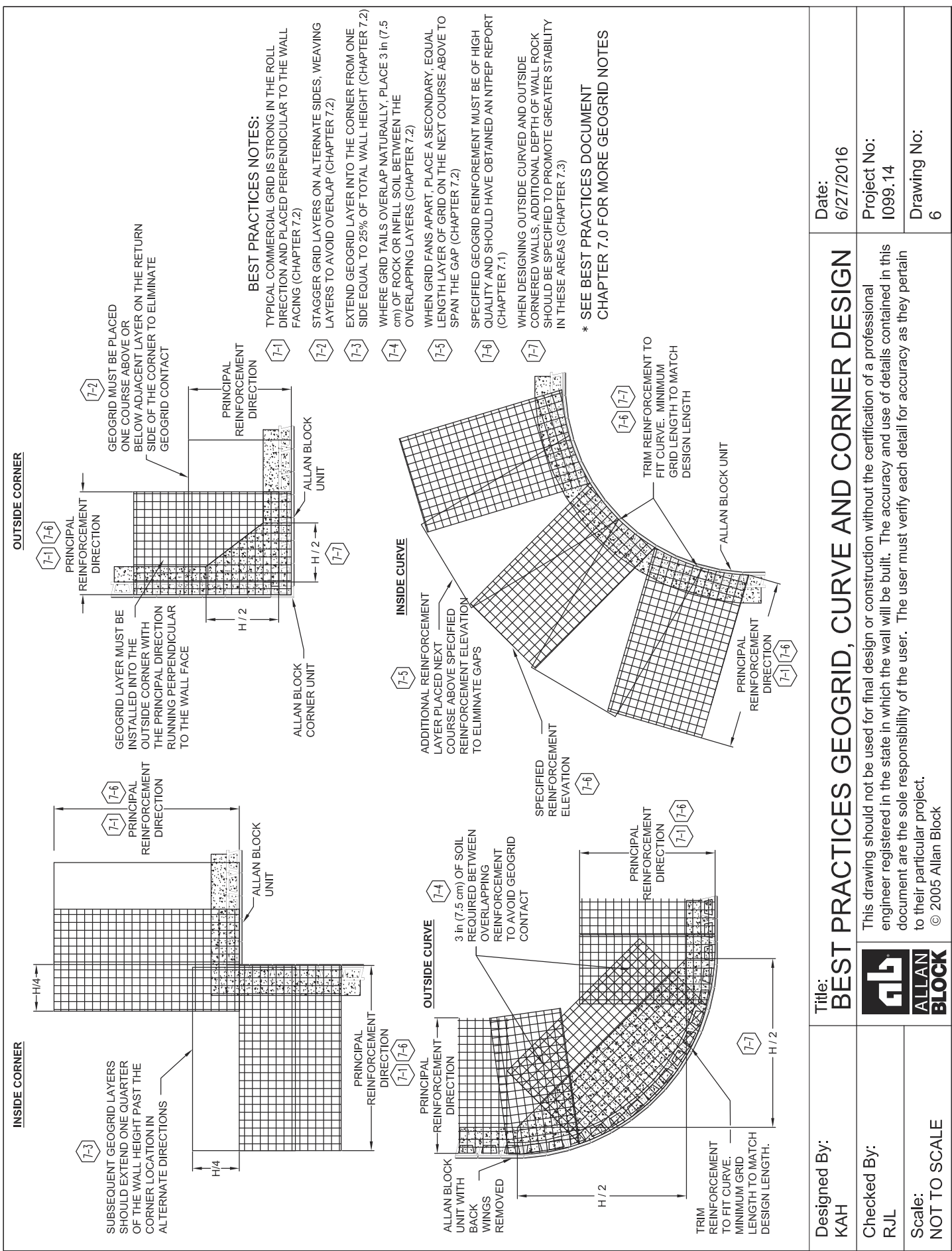
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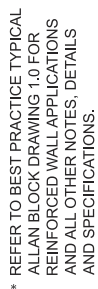
- 6-1 UNDERSTANDING SITE SOILS AND PROPER MINIMUM SOIL PARAMETERS FOR INFILL SOIL AS WELL AS PROPER DRAINAGE REQUIREMENTS ARE ESSENTIAL TO DESIGNING AND CONSTRUCTING A WALL PROPERLY. (CHAPTERS 6.1, 6.2, 6.3, 6.4, AND 6.5)
- 6-2 ALLOWABLE SOILS TO BE USED BELOW THE WALL STRUCTURE FACE (CHAPTER 6.2)
- 6-3 ALLOWABLE SOILS TO BE USED IN REINFORCED MASS (CHAPTER 6.3)
- 6-4 WALL ROCK COLUMN SIZE OF MATERIAL USED (CHAPTER 6.4)
- 6-5 TESTING FREQUENCY SHOULD BE SET TO REACH PROPER COMPACTION REQUIREMENTS (CHAPTER 6.6)
- 6-6 HAND OPERATED PLATE COMPACTOR ONLY TO BE USED IN THE CONSOLIDATION ZONE (CHAPTER 6.7)
- 6-7 COMPACTION OF SECOND COURSE AND ABOVE WILL BEGIN BY RUNNING THE PLATE COMPACTOR DIRECTLY ON THE BLOCK FACING (CHAPTER 6.7)
- 6-8 HEAVY COMPACTION EQUIPMENT MAY BE USED BEHIND THE CONSOLIDATION ZONE (CHAPTER 6.7)
- 6-9 TYPICAL DENSITY TESTING SHOULD FOLLOW ENGINEER OF RECORDS SPECIFICATIONS (CHAPTER 6.7 & 6.9)
- 6-10 MAXIMUM FILL AND COMPACTION LIFTS OF 8 in (20 cm) WITH NO EXCEPTIONS (CHAPTER 6.8)
- 6-11 IMPLEMENT TEMPORARY BERM OR GRADE THE BACKFILL AT DAY'S END TO AVOID WATER ACCUMULATION BEHIND THE WALL (CHAPTER 6.11)

* SEE BEST PRACTICES DOCUMENT CHAPTER 6.0 FOR MORE SOIL & COMPACTION NOTES



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- 8-1 FOR WALLS 10'-20 ft (3.0 - 6.1 m) BOTTOM HALF OF WALL ROCK SHOULD BE 24 in (60 cm) DEEP AND 12 in (30 cm) FOR TOP HALF (CHAPTER 8.2)
- 8-2 FOR WALLS OVER 20 ft (6.1 m) TALL, THE BOTTOM HALF OF WALL ROCK IS 36 in (90 cm) DEEP AND THE TOP HALF OF WALL ROCK IS DIVIDED IN TWO WITH 24 in (60 cm) AND 12 in (30 cm) DEEP COLUMNS (CHAPTER 8.2)
- 8-3 SELECT/STRUCTURAL FILL SHOULD BE USED FOR A MINIMUM OF 1/3 THE HEIGHT OF WALL TO EXTEND TO THE ENTIRE LENGTH OF THE REINFORCEMENT (CHAPTER 8.2)
- 8-4 WALL UNIT SHOULD BE CENTERED ON THE BASE AND HAVE AN AVERAGE, FRONT BACK, DEPTH OF AT LEAST 10 in (25 cm) (CHAPTER 8.7)

* SEE BEST PRACTICES DOCUMENT
CHAPTER 8.0 FOR MORE TALL WALL NOTES

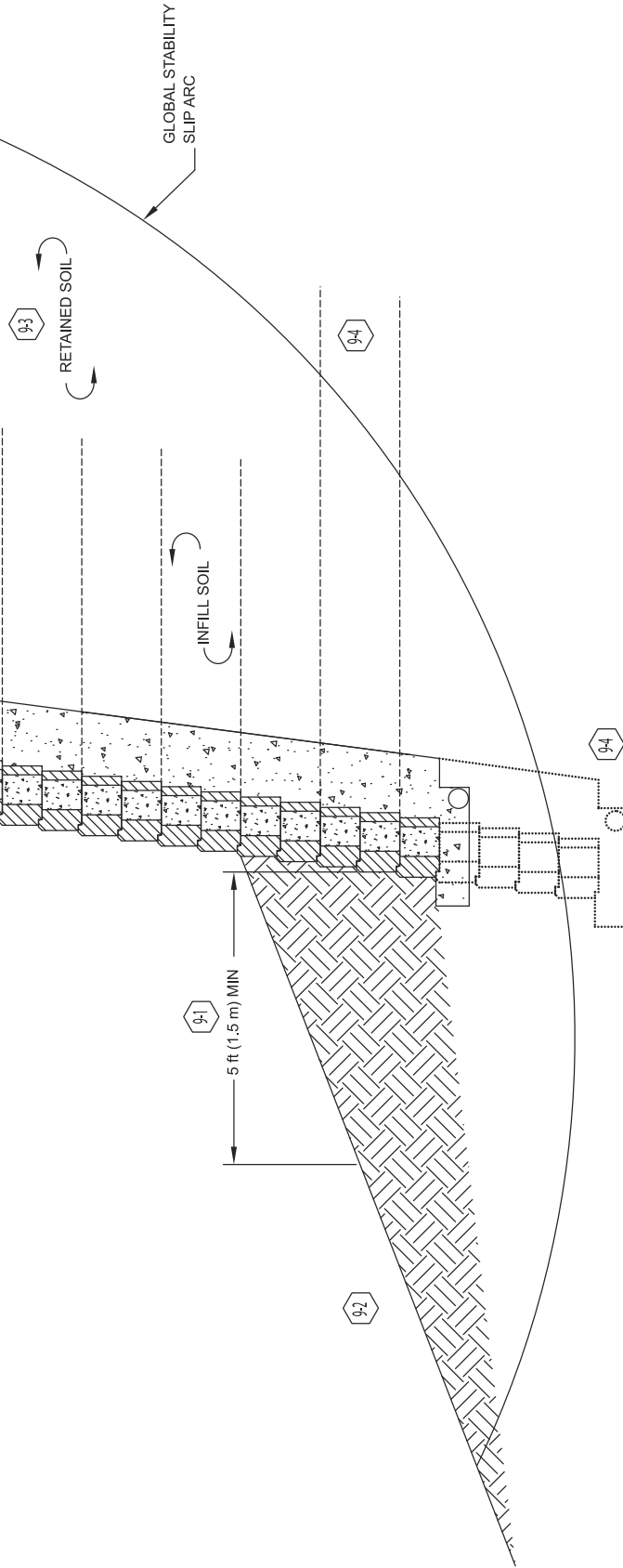


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BEST PRACTICES NOTES:

- 9-1 WALLS WITH SLOPES BELOW REQUIRE INCREASED EMBEDMENT (CHAPTER 9.1)
- 9-2 WALLS WITH SLOPES ABOVE OR BELOW REQUIRE GLOBAL STABILITY ANALYSIS (CHAPTER 9.2)
- 9-3 WALLS BUILT IN SITES WITH CLAYS, SILTS, POORLY GRADED SANDS, OR EXPANSIVE CLAYS REQUIRE GLOBAL STABILITY ANALYSIS (CHAPTER 9.2)
- 9-4 TO INCREASE GLOBAL STABILITY IN WALLS, INCREASE LENGTH OF GEOGRID AND/OR DEPTH OF EMBEDMENT (CHAPTER 9.3)

* SEE BEST PRACTICES DOCUMENT SECTION 9.0 FOR MORE GLOBAL STABILITY NOTES



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BEST PRACTICES GLOBAL STABILITY (GENERAL)



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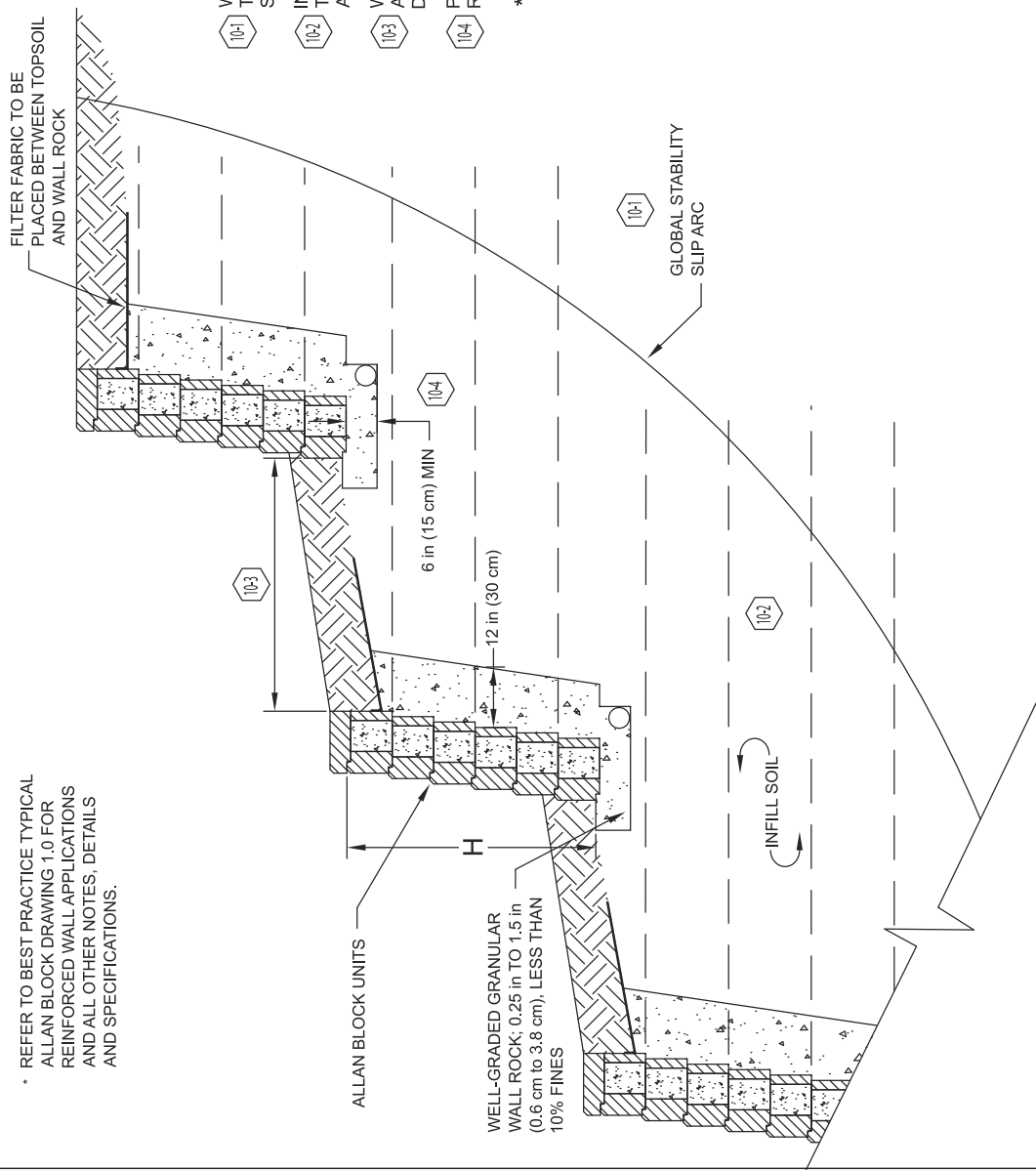
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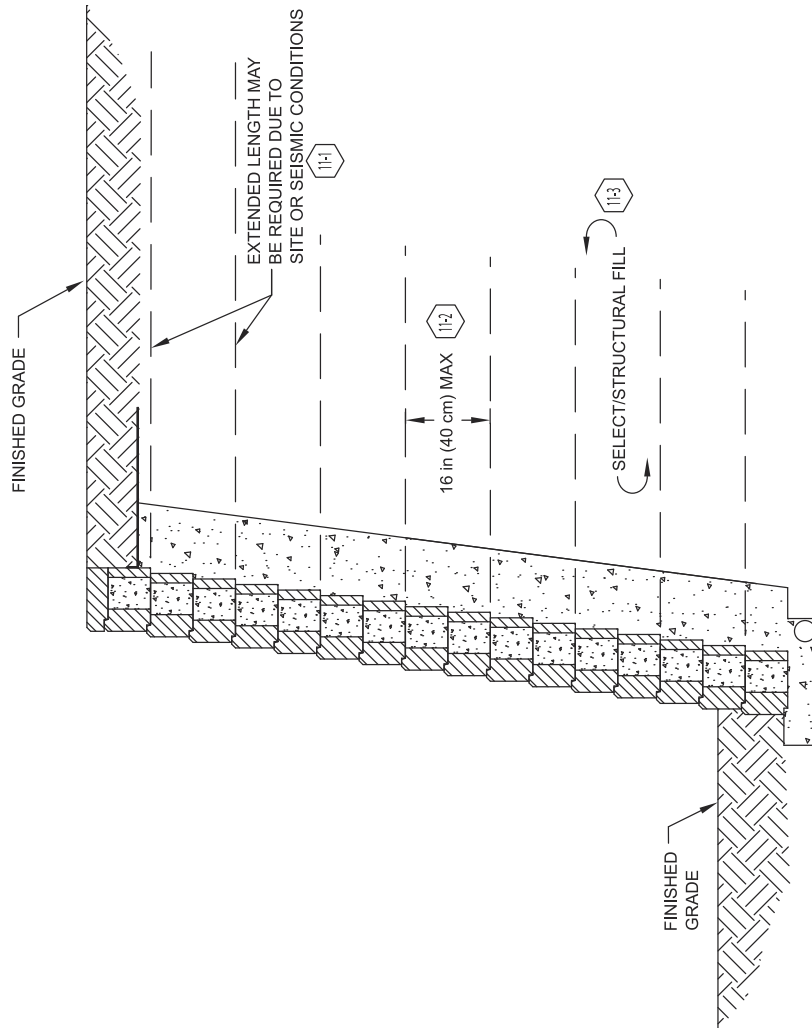


BEST PRACTICES NOTES:

- 10-1 WHENEVER WALLS ARE CONSTRUCTED IN A TERRACED ARRANGEMENT, THE DESIGN MUST CONSIDER THE OVERALL GLOBAL STABILITY OF THE STRUCTURE (CHAPTER 10.1)
- 10-2 IN A TERRACED STRUCTURE GEOGRID LENGTHS FOR THE BOTTOM TERRACE ARE TYPICALLY 60% (MIN) OF THE ENTIRE HEIGHT. A GLOBAL ANALYSIS WILL DICTATE OVERALL GEOGRID LENGTHS (CHAPTER 10.1)
- 10-3 WALLS CLOSER THAN 2H HORIZONTALLY SHOULD BE EVALUATED AS AN ADDED SURCHARGE TO THE TERRACE BELOW AND MAY NEED TO BE DESIGNED FOR (CHAPTER 10.1)
- 10-4 PROPER COMPACTION IS NECESSARY FOR FOUNDATION SOILS AND WALL ROCK BELOW EACH TERRACE TO LIMIT SETTLEMENT (CHAPTER 10.1)

* SEE BEST PRACTICES DOCUMENT CHAPTER 10.0 FOR MORE TERRACE WALL NOTES

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BEST PRACTICES NOTES:

- 11:1 TYPICALLY THE TOP LAYER(S) OF GEOGRID WILL BE EXTENDED TO ROUGHLY 90% OR MORE (MIN EXTENSION OF 3 ft (0.9 m)) OF THE TOTAL WALL HEIGHT TO SATISFY SEISMIC DESIGN REQUIREMENTS (CHAPTER 11.1)
- 11:2 TWO COURSE (16 in (40 cm)) MAXIMUM SPACING IS RECOMMENDED IN ALL DESIGNED WALLS (CHAPTER 11.1)
- 11:3 USING SELECT BACKFILL WILL REDUCE THE EFFECTS OF THE DYNAMIC LOADING (CHAPTER 11.1)

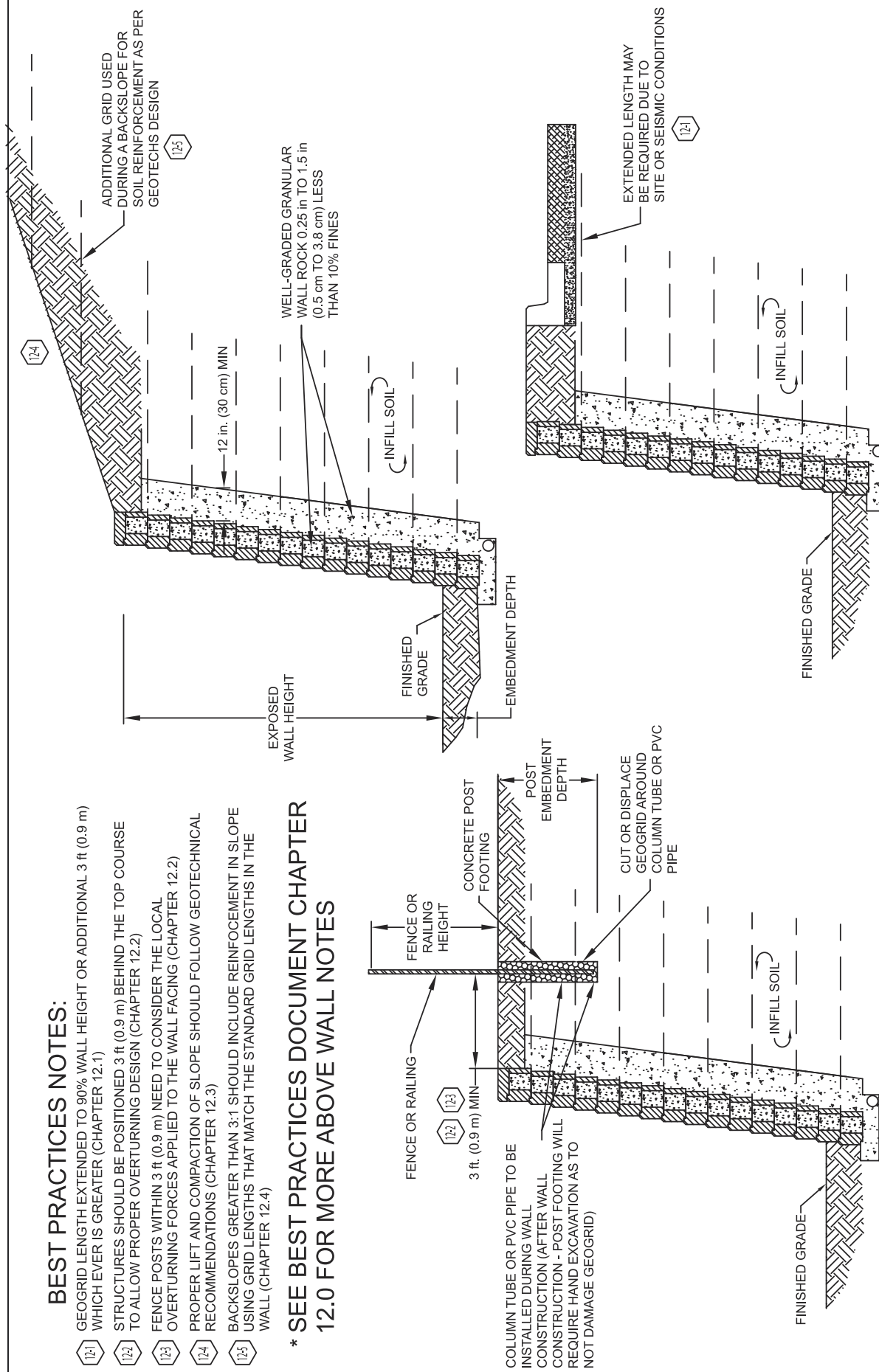
* SEE BEST PRACTICES DOCUMENT
CHAPTER 11.0 FOR MORE SEISMIC NOTES

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BEST PRACTICES NOTES:

- 12.1 GEOGRID LENGTH EXTENDED TO 90% WALL HEIGHT OR ADDITIONAL 3 ft (0.9 m) WHICH EVER IS GREATER (CHAPTER 12.1)
- 12.2 STRUCTURES SHOULD BE POSITIONED 3 ft (0.9 m) BEHIND THE TOP COURSE TO ALLOW PROPER OVERTURNING DESIGN (CHAPTER 12.2)
- 12.3 FENCE POSTS WITHIN 3 ft (0.9 m) NEED TO CONSIDER THE LOCAL OVERTURNING FORCES APPLIED TO THE WALL FACING (CHAPTER 12.2)
- 12.4 PROPER LIFT AND COMPACTION OF SLOPE SHOULD FOLLOW GEOTECHNICAL RECOMMENDATIONS (CHAPTER 12.3)
- 12.5 BACKSLOPES GREATER THAN 3:1 SHOULD INCLUDE REINFORCEMENT IN SLOPE USING GRID LENGTHS THAT MATCH THE STANDARD GRID LENGTHS IN THE WALL (CHAPTER 12.4)

*** SEE BEST PRACTICES DOCUMENT CHAPTER 12.0 FOR MORE ABOVE WALL NOTES**



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BEST PRACTICES ABOVE WALL CONSIDERATIONS



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Best Practices for Allan Block Segmental Retaining Wall Design For Residential and Commercial Applications



AB Spec Book

This is a comprehensive guide and design details for SRW walls. Includes Allan Block specifications, ASTM standards and AUTOCAD drawings.



AB Engineering Manual

This technical specification manual will allow a wall designer to source and reference specific information for use in developing project document.



AB Commercial Manual

A complete installation guide for building Allan Block segmental retaining walls. Includes detailed information, photos, graphic and charts from start to finish.



Seismic Testing Book

Manual details seismic testing information on the Allan Block products completed along with Columbia University in 2003. Includes results, photos and drawings in regards to Allan Block's Rock Lock connection.

Best Practices for Allan Block Segmental Retaining Wall Design For Residential and Commercial Applications

1.0 Design Guidelines and Pre-Construction Considerations

Design Guidelines Item

(For this document the term owner refers to the property owner or their designated representative)

- 1.1) Meeting with owner to fully understand the basic needs for the site.
 - a) What is the general use of the site? Know what the site will be used for commercial, residential, public, etc.
 - b) Knowing the site use will often dictate design loading, design methodology and level of effort required to complete the project so proper bidding can be provided.
 - c) Identify miscellaneous items such as drop structures, light standards, building foundations and property lines that may encroach into the geogrid zone.
 - d) Engineer should determine if as-built documents will be required at the end of the project. If so, provisions should be set in place to document changes during construction.
- 1.2) Determining when engineering is required.
 - a) Local codes and municipalities will have minimum height requirements set for walls that require engineering. However, height is not the only factor that should be considered. Engineering should be required for walls of any height that have any of the special considerations within this manual such as but not limited to the following: poor soils, multiple terrace arrangements, steep slopes above or below, high seismic loading, roadway surcharges, etc.
- 1.3) Make sure the site plans call out locations of all existing and proposed utilities.
 - a) Have a process in place to verify location of existing utilities.
 - b) Avoid placing utilities, especially storm sewer, sanitary sewer, water, landscape irrigation, and gas lines within the reinforced zone of segmental walls. If no other alternatives exist, provisions should be set in place for future maintenance.
- 1.4) Determine wall layout, wall heights, conditions above and below the wall, as well as live and dead loads (locations and levels).
 - a) Wall layout should be approved by the owner.
 - b) Utilize the Wall Design Checklist in the Allan Block Spec Book.
- 1.5) Obtain a thorough geotechnical report in the area where the wall will be located.
 - a) Geotechnical report should be available to all parties doing design work and should be an all-encompassing document covering all aspects of the site such as the following:
 - i.) Soil strength – preferably the tested friction angle of the on-site soils
 - ii.) Clear description of on-site soils
 - iii.) Gradation of soils
 - iv.) Groundwater conditions
 - v.) Settlement
 - vi.) Soil unit weights

Best Practices for Allan Block Segmental Retaining Wall Design For Residential and Commercial Applications

vii.) Plasticity Index (PI) and Liquid Limit (LL)

viii.) Site specific seismic coefficients

ix.) Global stability recommendations

- b) The geotechnical investigation and report should be paid for by the owner.
- c) If no other guidance has been provided, a geotechnical investigation should include soil borings with sampling and logs at an interval of not more than 100 ft (30 m) along the centerline of the proposed retaining wall(s) and at 150 ft (46 m) along the back of the reinforced soil zone.

- 1.6) Understanding the site soils as well as the soils used in the infill zone is essential to understanding how the retaining wall will function. One of the economic advantages to an SRW system is that site soils can usually be used in the infill zone provided they are of a certain quality and surface and groundwater conditions at the site are controlled by recommendations given in Chapters 3.0 – 5.0.

While cohesionless, free graining materials (less than 10% fines and or PI less than 6 and LL less than 30) are preferred, soils with low plastic fines (i.e. SC with PI less than 20 and LL less than 40) may be used for lower height SRW construction provided the following additional design criteria are implemented:

- a) Proper internal drainage is installed including wall rock in and behind the facing and blanket and chimney drains to keep the infill mass dry, see Chapters 3.0 – 5.0.
- b) In areas where frost heaves are possible, only soils with low to moderate frost heave potential shall be utilized. Verify parameters with geotech. Expanding the depth of wall rock behind the facing can help reduce the effects of frost heaves. See Chapter 6, Section 6.4 for information on the wall rock column.
- c) The cohesive shear strength parameter (c), for the reinforced fill, is ignored for internal and external stability analysis. Cohesion values are allowed in the foundation and global stability analysis. However, it is recommended that no more than 10% of the tested/reported values should be used due to the unpredictability of cohesive soils.
- d) The final design is checked by a qualified geotechnical engineer to ensure that the use of cohesive soils does not result in unacceptable time-dependent movement of the SRW system.
- e) High plastic or organic soils including MH, CH, OH, OL and PT are not recommended for any segmental retaining wall construction as their use can cause excessive settling over time and or excessive internal stress to build up causing internal lateral forces to occur. See Chapter 8 for more information on tall walls.

- 1.7) Visit the site to ensure that the site plans adequately capture the important details of the site.
- a) Site drainage
 - b) Surface water – lakes, rivers, ponds or detention basins, etc.
 - c) Slopes above or below
 - d) Make determination that site soils appear to be similar to what is indicated in the geotechnical report.
 - e) Proposed locations of structures, roadways and other surcharges.

- 1.8) Consider temporary construction loads and future snow and/or storage loads.
- a) Will construction loading govern design over final loading conditions?

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- b) Snow loads are not only vertical but snowplows can provide lateral loading.
- c) Consider reinforced barriers to prevent the lateral loads.
- d) Magnitude of load will range depending on condition.

- 1.9) Establish scope of responsibility and required design methodology of project with owner including seismic design requirements.
- a) The owner should understand the limits of design responsibility. The SRW Engineer Suggested Roles as provided in Section 3, Roles and Responsibilities in the National Concrete Masonry Association (NCMA) Design Manual are as follows:
 - i.) Design of SRW for structural stability including external stability (sliding and overturning), internal stability, internal compound stability and facial stability.
 - ii.) Determination of the maximum unreinforced height of SRW.
 - iii.) Design of geogrid layout for taller walls requiring soil reinforcement.
 - iv.) Determination of minimum embedment of wall (except in the case of scour depth or erosion control issues, which should be determined by site civil engineer).
 - v.) Specification and/or approval of wall unit, geogrid reinforcement, drainage material within wall structure, and reinforced soil properties.
 - vi.) Determination of what structures can or cannot be placed within reinforced soil zone and wall face, and detailing for SRWs to accommodate acceptable structures.
 - vii.) Under the direction of geotechnical engineer, assist in the coordination of slope stability evaluation around and through the SRW and the design of the geogrid in reinforced SRWs to address slope stability in vicinity of SRW, as needed.
 - viii.) If contracted to and notified, construction observation of the overall wall structure installation and review of SRW material submittals (generally on a time and materials basis, separate from the wall design contract).
 - b) Unless other arrangements have been made between the owner and the wall design engineer, the wall design engineer is responsible for the area in and around the wall known as the Design Envelope – Figure 1-1. This Design Envelope is defined as follows: The horizontal distance, measured from the toe of the wall, is the greater of twice the height of the wall ($2H$) or, the height of the projection from the tail of the reinforcement layers to the surface (H_e) plus a distance equal to the length of the reinforcement (L). The vertical height is the height of the wall facing, measured from the top of the base to the top of the top facing unit (H).
 - c) Agree upon the design method to be used, Allan Block, NCMA, AASHTO or FHWA. For information about the Coulomb Design Methodology see the Allan Block Spec Book. A complete step by step description can be found in the AB Engineering Manual.
- 1.10) Retaining wall design calculations should follow good engineering judgment and or standard design methodologies such as Allan Block, NCMA, AASHTO or FHWA. All methodologies should follow

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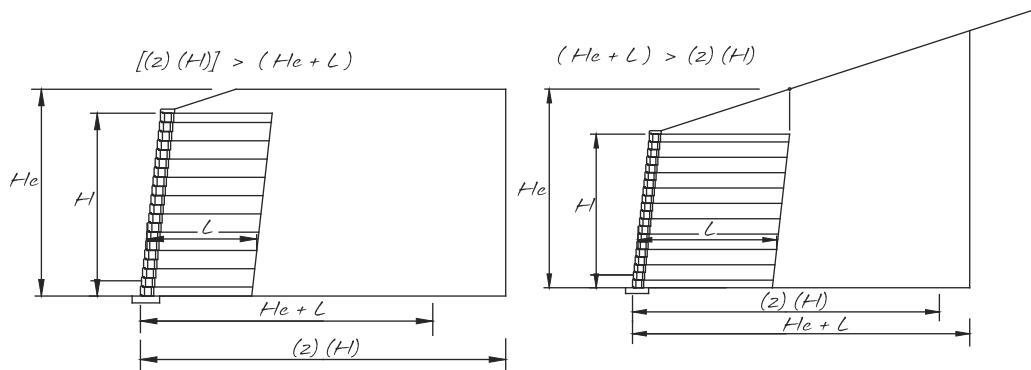


Figure 1-1: Design Envelope

standard minimum design safety factors.

- | | |
|--------------------------------|--|
| a) Sliding | Minimum Safety Factor > 1.5 |
| b) Overturning | Minimum Safety Factor > 2.0 |
| c) Bearing | Minimum Safety Factor > 2.0 |
| d) Grid Overstress | Minimum Safety Factor > 1.5 |
| e) Pullout from Soil | Minimum Safety Factor > 1.5 |
| f) Pullout from Block | Minimum Safety Factor > 1.5 |
| g) Internal Compound Stability | Minimum Safety Factor > 1.3 |
| h) Global | Minimum Safety Factor > 1.3 |
| i) Seismic | Minimum Safety Factor > 75% of static or 1.1 minimum |

For a thorough discussion and design methodology of each, see the Allan Block Engineering Manual.

- 1.11) All standard design methodologies listed in Section 1.9.c above use a coherent gravity mass design theory for stability calculations. A coherent gravity mass is made up of the wall facing and layers of geogrid reinforcement placed horizontally through properly compacted soils. The geogrid length, strength and horizontal spacing between layers are key to calculating the internal stability of the mass. Much independent testing has been performed on the mass as a whole and on the individual parts of the system. None more so than the connection between the geogrid and the wall facing. More information on the actual connection test method can be found in ASTM D 6638. It has been determined that walls constructed using 60% minimum lengths of grid and a two course (16 in (40 cm)) maximum vertical spacing builds a high quality reinforced mass that easily distribute the calculated internal pressures. Testing has also proven that actual internal forces within a properly constructed reinforced mass are much less than the theoretical design loads based on active earth pressure calculations. Internal Compound Stability (ICS) calculations provide an analysis from a global stability perspective within the design envelope defined in Section 1.9b above.
- 1.12) Require that Contractors must be trained and certified by local manufacturer or equivalent accredited organization.
- Allan Block and NCMA have certification programs that are accredited. Identify when advanced certification levels are appropriate based on complexity and criticality of project application.
 - Require contractors to provide a list of projects they have completed.

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- 1.13) Manufactured product specifications and associated test results.
- Call for block requirements and testing per ASTM C 1372, Table 1.
 - Specify allowable height deviations between adjacent units. To provide best quality units for construction reasons, a height tolerance between adjacent units should not exceed 0.125 in (3mm) for walls over 10 ft (3.0 m) in height.
 - Identify when freeze thaw resistance requirements are appropriate per ASTM C 1262.
 - Geogrids should have "Mill Reports" or other proper documentation, See Chapter 7 for more information.
 - Block producer's QA/QC manual.

Strength and Absorption Requirements (ASTM)

Minimum Required Net Average Compressive Strength, psi (MPa)		
Average of 3 units 3000 (20.7)		Individual Unit 2500 (17.2)
Maximum Water Absorption Requirements, lb/ft ³ (kg/m ³)		
<u>Light Weight</u>	<u>Medium Weight</u>	<u>Normal Weight</u>
18 (288)	15 (240)	13 (208)
Weight Classification Oven-Dry Density of Concrete lb/ft ³ (kg/m ³)		
<u>Light Weight</u>	<u>Medium Weight</u>	<u>Normal Weight</u>
Less than 105 (1680)	105 (1680) to less than 125 (2000)	125 (2000) or more

Table 1: ASTM Requirements

- 1.14) Freeze Thaw Durability: Like all concrete products, dry-cast concrete SRW units are susceptible to freeze-thaw degradation with exposure to de-icing salts and cold temperature. This is a concern in northern tier states or countries that use deicing salts. Based on good performance experience by several agencies, ASTM C1372, or equivalent governing standard or public authority, Standard Specification for Segmental Retaining Wall Units should be used as a model, except that, to increase durability, the compressive strength for the units should be increased to a minimum of 4,000 psi (28 MPa) unless local requirements dictate higher levels. Also, maximum water absorption should be reduced and requirements for freeze-thaw testing increased.
- Require a current passing ASTM C 1262 or equivalent governing standard or public authority, test report from material supplier in northern or cold weather climates. See Figure 1-2 for Freeze Thaw Durability Criteria and Regional Map to define the appropriate zone and requirements for the project.
 - Avoid using SRW products for steps or walkways where de-icing salts will be used. Use SRW as the base material with a concrete or stone slab step cover.
 - Where runoff may flow over or on to the wall, provide a collection basin and either pipe the water around the wall or provide an extended shoot where the saline water does not flow down the wall.
 - Where de-icing chemicals land on a SRW retaining wall, consider a more durable capping unit. Durability concerns occur where there are saturated conditions in repeated freezing and thawing conditions.
 - In areas where SRW's are exposed to repeated exposure from snow removal equipment, consider sealants or water repelling chemicals periodically applied to the walls (silane and siloxane compounds).
 - Units selected for a project should be tested for compressive strength, density, and absorption. The tested compressive strength and density should equal or exceed the values reported at the project initiation and the absorption should be less than or equal to the absorption previously reported. If these conditions are met, the durability of the units delivered to the project would be expected to be equivalent to or better than the units previously evaluated for durability through ASTM C1262 testing. If the compressive strength is more than 5% less than that previously reported, the density is more than 2% less than that previously reported, or the absorption is more than 5% greater (relative) than that previously reported, than additional units should

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Durability Standards for Segmental Retaining Wall Units

In northern climates that are considered to be more arid, the environment that creates freeze thaw durability issues may not be present. The Local Engineer of Record needs to evaluate if continued wetting of the blocks creates an environment where durability concerns are warranted. Proven field performance may be used at the discretion of the Local Engineer of Record in lieu of specific freeze/thaw testing.

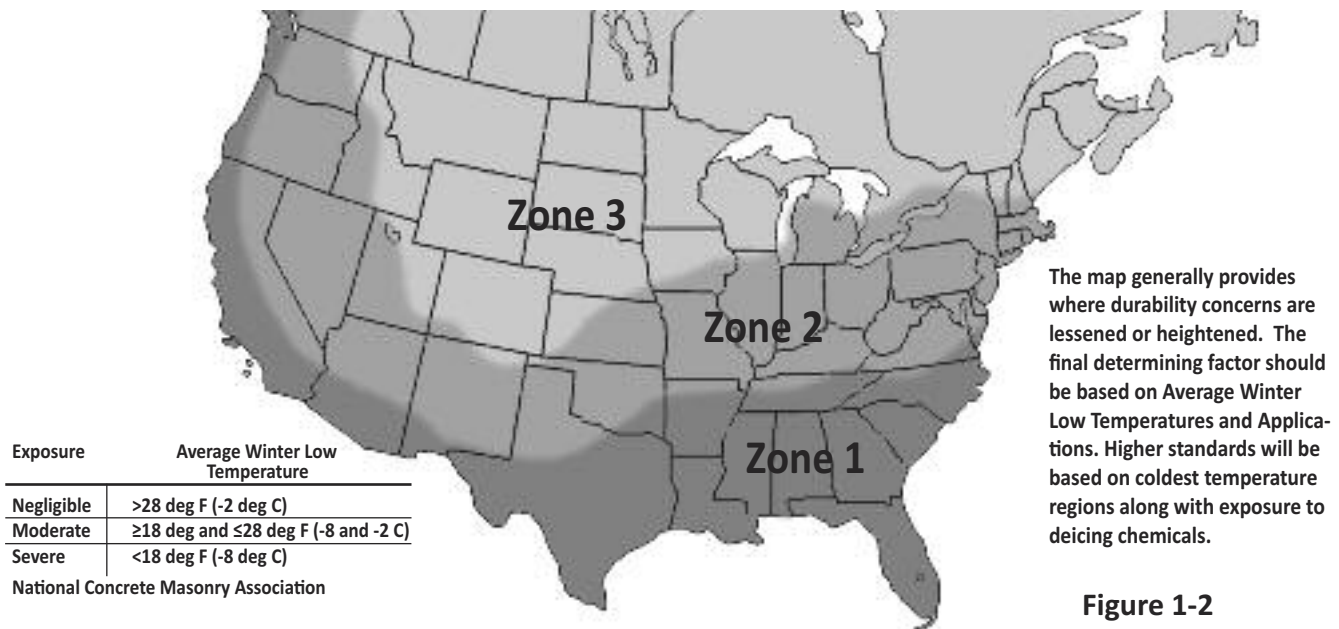


Figure 1-2

Exposure/Temperature Conditions	Minimum Compressive Strength ³	Minimum Freeze-Thaw Durability Criteria
Negligible	Per design specs	No freeze-thaw testing required
Where units will NOT be exposed to De-Icing Salts:		
Moderate ¹ Severe ¹	28 MPa (4000 psi) (min)	Less than 1% weight loss after 100 cycles for 5 of 5 specimens OR less than 1.5% weight loss after 150 cycles for 4 of 5 specimens. Tested using ASTM C1262 in tap water
Where units will be exposed to De-Icing Salts:		
Moderate ²	28 MPa (4000 psi) (min)	Less than 1% weight loss after 20 cycles for 5 of 5 specimens OR less than 1.5% weight loss after 30 cycles for 4 of 5 specimens. Tested using ASTM C1262 in 3% saline solution
Severe ²	40 MPa (5800 psi) (min)	Less than 1% weight loss after 40 cycles for 5 of 5 specimens OR less than 1.5% weight loss after 50 cycles for 4 of 5 specimens. Tested using ASTM C1262 in 3% saline solution

¹ Exposure to de-icing salts is unlikely or unplanned, but may include occasional exposure. Average de-icing salt contact would be one or less exposure per year during the design life of the SRW.

² Exposure to de-icing salts is likely or expected.

³ Compressive strength is a historical minimum guide to what has been found to provide units that pass weight loss requirements when tested to ASTM C1262. Actual Minimum Compressive Strength should be established based on results when testing to ASTM C 1262 and found to be in compliance with minimum requirements of ASTM C 1372, from the plant supplying the product.

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be sampled and tested for freeze/thaw durability (either in water or saline, as appropriate) and verified in compliance with the project specifications.

- 1.15) Requirement for a pre-construction meeting with all parties associated with the project to approve design and best practice requirements.
 - a) A pre-construction meeting should be held with all parties attending so the entire construction plan can be discussed from start to finish and any issues can be worked out with a plan in place to move forward successfully.
 - b) All parties are all of those that will be working on or around the wall site including but not limited to the owner, architect, site civil, geotech, wall designer, general contractor, excavation contractor, wall builder, Allan Block supplier representative, railing or fence installer, local utility representative, inspectors (private and government as appropriate) etc.
 - c) Language can be placed in the project specifications requiring a pre-construction meeting.
 - d) Reference the AB Construction and Inspection Checklist in the AB Spec Book as a good agenda for the meeting.
 - e) Meeting topics shall include, but not be limited to: contractor qualifications, schedule and phasing of wall construction and inspection, coordination with other on-site construction activities, responsibilities of parties, and source, quality, and acceptance of materials.
- 1.16) Include in the scope of the project three additional site visits.
 - a) The first at the beginning of the project to reinforce the need for the contractor to comply with the specifications in the approved design and to answer any questions.
 - b) The second visit would be a random site inspection to ensure that the work methods are in agreement with the approved plans and to answer any questions.
 - c) The third visit to be at the conclusion of the project to verify that the details above and below the wall structure have been completed as required. Additional inspections are available at the request of the owner based on a preset rate schedule. A written summary will be provided to the owner at the conclusion of the project for each visit made to the site.
- 1.17) A typical construction drawing submittal should include but is not limited to the following items (Size and complexity of project may lessen or increase this list):
 - a) Front wall profile view which depicts the location of geogrid reinforcement, elevation of top and bottom of wall and finished grade at bottom and top of wall.
 - b) Wall station data with corresponding elevation for exposed grade at top and bottom of wall (i.e. profile data).
 - c) Panel section markers depicting locations of design sections.
 - d) Design sections showing:
 - i.) Geogrid locations, type and length
 - ii.) Thickness of wall rock material and infill depth
 - iii.) Any surcharges
 - iv.) Any required drain locations
 - v.) Block type
 - vi.) Base size

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- e) Wall plan view depicting proper wall orientation should be provided. However, layout of walls should be done using the site plans provided by the owner based on survey information.
 - f) Any required specialized or standard details that will provide guidance to the contractor, such as design specifications, form work above, at the ends, or in front of the wall structure.
 - g) Detailed information and assumed on-site soil conditions, reinforced fill requirements, soil and compaction testing, site visits from the local engineer of record, and documentation requirements before, during, and after construction.
 - h) Contractor training and certification requirements.
 - i) Expected water conditions above and below grade.
- 1.18) For the bidding process, the owner is recommended to provide the following to ensure accurate and comparable bids between contractors.
- a) The owner should provide a complete design for all walls, unless the project is a negotiated design/build contract on the front end. If design/build is used, the owner should ensure that a complete design is submitted and construction verification is validated by an engineering firm working directly for the owner.
 - b) A complete bid package including items listed in Section 1.17, a complete geotechnical report including items listed in Section 1.5.
 - c) Any other information or details about the site and final requirements that are pertinent to the completion of the project.
- 1.19) Provide detailed requirements for onsite inspection to ensure that specifications are complied with during construction. The testing and inspection firm needs to evaluate conditions prior to construction and then to document the construction process. This includes, but is not limited to:
- a) Confirmation that the foundation soils are suitable for support of the structure.
 - b) Confirmation that the retained soils are as defined in the wall design.
 - c) Verify the reinforced soils comply with the material specified in the wall design.
 - d) Confirm reinforcement material is that specified in the wall design.
 - e) Verify the wall unit is that specified in the wall design.
 - f) Document the construction process, verifying the wall is constructed in general accordance to the plans and specification.
 - g) Perform the required soil testing in order to evaluate/validate that the soil placed meets the specified gradation, shear strengths, weight, Atterberg limits and compaction requirements.
 - h) A detailed construction log should be used with sign offs at incremental levels by the responsible parties.

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2.0 Typical Wall Construction

- 2.1) Contractors must inspect all materials upon delivery to the site to assure proper material has been received. Contractor must protect all materials from damage or contamination prior to use within the wall (ASTM C1372). Utilize Allan Block Product Standards in the Allan Block Spec Book.
- a) No substitutions in geogrid or SRW units should be allowed.
 - b) Any changes in specified materials should be evaluated and approved by the SRW Designer and may require redesign.
- 2.2) Allowable soil to be used below the wall structure face.
- a) Geotechnical report should include parameters and recommendations for sub-soils.
 - b) If poor soils are encountered during construction, consult with owner and geotech for removal and replacement recommendation.
 - c) Utilize Section 3.1 Foundation Soils in the Allan Block Spec Book.
 - i.) Foundation soils to be inspected by the on-site soils engineer to ensure they meet or exceed design soil parameters.
 - ii) Over excavated areas shall be filled with compactable material approved by the on-site soils engineer.
- 2.3) Allowable soil to be used in the reinforced mass.
- a) Best soil is wall rock or select/structural fill with less than 10% fines, to the limits of the geogrid lengths.
 - b) If site soils are allowed by the geotechnical engineer; on-site soils engineer to verify they meet the minimum requirements set forth in the soils report, and they are in compliance with the soil properties used in the design process.
 - c) Utilize Section 1 Part 2.3 Infill Soils in the Allan Block Spec Book.
 - i) Unsuitable soils for backfill (heavy clays or organic soils) shall not be used.
 - ii) Poorly graded sands, expansive clays and/or soils with a PI greater than 20 or a LL greater than 40 should not be used in wall construction.
 - iii) Fine grained cohesive soils with a friction angle of less than 31 degrees with a PI ranging between 6 and 20 and LL from 30 to 40, may be used in wall construction, but additional backfilling, compaction and water management efforts, such as blanket drains and chimney drains are required.
 - iv) Soils with a PI of less than 6 and LL less than 30 are generally considered granular and can be used as infill material.
 - d) The suggested gradation requirements for the reinforced (infill) soils in SRW's are:
- 2.4) Wall rock column size and material used.
- a) The wall rock column is typically 12 in (30 cm) deep directly behind the wall facing and consists of material summarized in Section 1 Part 2.2 in the Allan Block Spec Book.
 - i) Material must be well-graded compactible aggregate, 0.25 - 1.5 in, (0.6 – 3.8 cm) with no more than 10% passing the #200 sieve. (ASTM D422).
 - b) At the top of the wall, above the wall rock column it is common to place a horizontal layer of landscape fabric

Sieve Size	% Passing
1 in (24 mm)	100 - 75
No. 4 (4.75 mm)	100 - 20
No. 40 (0.425 mm)	0 - 60
No. 200 (0.075 mm)	0 - 35

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to protect the wall rock from being infiltrated by the topsoil placed to finish the wall. Topsoil is defined as low permeable soils ranging from 8 - 12 in. (20 – 30 cm) to minimize infiltration of surface water into the reinforced mass.

- c) When designing curved and radius wall segments the designer should provide details to the installer for wall rock placement.
 - i) For inside curved and inside cornered walls, the minimum wall rock specified should follow Section 6.4 (paragraph a) and Section 8.2 for Tall Wall applications.
 - ii) For outside curved and outside cornered walls, additional depth of wall rock should be specified to promote greater stability in these areas. Additional depth of wall rock is dependent on the total height of the wall and should be a minimum of $H/2$ as detailed in Drawing No. 6 in the front of this document.

2.5) Soil parameter verification.

- a) On-site soils engineer to verify and document that soils meet those specified in the soils report and wall design.
- b) Minimum infill soils to meet requirements outlined in Section 1, Part 2.3 in the AB Spec Book: USCS Soil types (GP, GW, SW, SP, GP-GM and SP-SM) are ideal select/structural fill, with PI less than 6 and LL less than 30, but if soils with friction angle less than 31 degrees are to be used (PI of less than 20 and LL of less than 40) special installation and drainage details and specifications are required, see Chapter 1, Section 1.6 and Chapter 6 for more information.

2.6) Wall embedment depth should be determined by the wall design engineer based on typical industry standard and specific site requirements.

- a) A commonly used embedment depth calculation for walls with level ground below is 1 in (2.5 cm) of depth per foot (30 cm) of wall height, with a typical minimum of 6 in (15 cm) for commercial projects.
- b) For walls with slopes above or below see Chapter 9.0 Global Stability – General.

2.7) Base trench verification and compaction requirements.

- a) Typical depth of the trench is based on a minimum 6 in (15 cm) deep compacted wall rock base and buried block depth equal to 1 in (2.5 cm) of depth per foot (30 cm) of wall height, with a typical minimum of 6 in (15 cm) for commercial projects.
- b) Design methodology used may require deeper wall trenches as would slopes below.
- c) Base trench to be compacted to the level specified in the geotechnical report and inspected by the on-site soils engineer prior to any base material being placed.

2.8) Imported base material, size of base, compaction requirements of base and location of the base course unit on the base material.

- a) Typical base material used is consistent with wall rock. For more information on wall rock see Chapter 2.0, Section 2.4.
- b) 6 in (15 cm) deep by 24 in (60 cm) wide (or 12 in (30 cm) wider than the block depth) is the typical minimum base size. A larger base may be required for poor foundation soils in order to meet minimum bearing factors of safety.

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- c) Poor soils should be removed and replaced, unless the engineer provides guidance based on the application.
- d) Wall unit is typically centered on the base.
- e) For deeper facing units such as AB Fieldstone with the Long Anchoring unit, the typical base width would be 36 in (90 cm).
- f) For walls with deeper than typical minimum sized base, it is common to add a continuous longitudinal layer of geogrid, 3 in (7.5 cm) to 6 in (15 cm) above the bottom of the trench. This geogrid provides additional stability to the compacted base and helps to span lesser quality soils.

2.9) Minimum grid lengths.

- a) 60% of total wall height measured from the top of the base to the top of the top wall block. Example – 10 ft (3 m) wall, 6 ft (1.8 m) minimum long grids. Grid lengths are measured from the face of the wall.

2.10) Typical location of initial layer of grid.

- a) The first layer of geogrid should be placed on top of the base course of block and every other course from that point, Figure 7-1.

2.11) Maximum suggested grid spacing.

- a) 16 in (40 cm) maximum spacing provides the best overall performance of the reinforced structure.

2.12) Minimum Wall Facing Depth.

- a) The recommendations contained within this guide, including those for geogrid spacing and length as discussed in 2.9 – 2.11 above, are based on the use of a facing unit that has an average (front to back) depth of at least 10 in. (25 cm). The 10 in. (25 cm) minimum depth of facing unit is recommended because SRW units of this depth or greater have a proven performance record while in service over many decades. This recommendation also recognizes that as the unit depth decreases, so does the stability of the facing, particularly overturning resistance during construction or while in service.

2.13) For walls using the manufacturer's optional capping system or approved equal:

- a) Capping system shall be secured in place using a high quality flexible exterior grade masonry sealant, Figure 2-1.

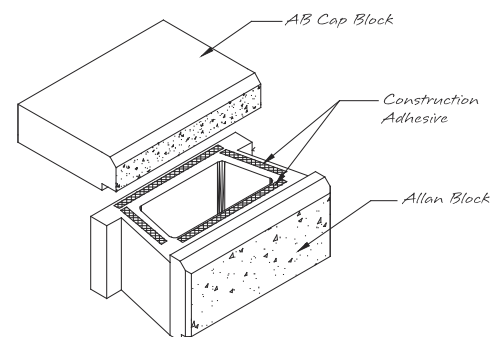


Figure 2-1: Cap Adhesive

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3.0 Water Management – Typical

- 3.1) Identify localized water sources such as storm drains and drop structures. Consult with Project Site Civil Engineer to ensure that water will not be introduced into the reinforced mass. Consider excess irrigation or natural groundwater sources.
- a) Utilize Water Management Section 3 in the Allan Block Spec Book.
 - i) Surface drainage
 - (1) Must drain away from the top and bottom of the wall.
 - (2) Slopes above walls should have swales placed above so water is not allowed to flow over the top of the wall.
 - (3) During construction, Surface water must not be allowed to pond or be trapped in the area above the wall or at the toe of the wall. Surface water must be directed away from partially constructed walls at the end of each day's construction.
 - (4) Provisions, such as check valves, to prevent flooding from broken lines or heads must be put in place to stop over irrigation above walls.
 - b) Additional wall rock should be added around all storm drains and drop structures to aid in draining any areas of the pipe that may leak.
 - c) If there are any utilities within the reinforcement zone, place gravel around them to generate good compaction levels.

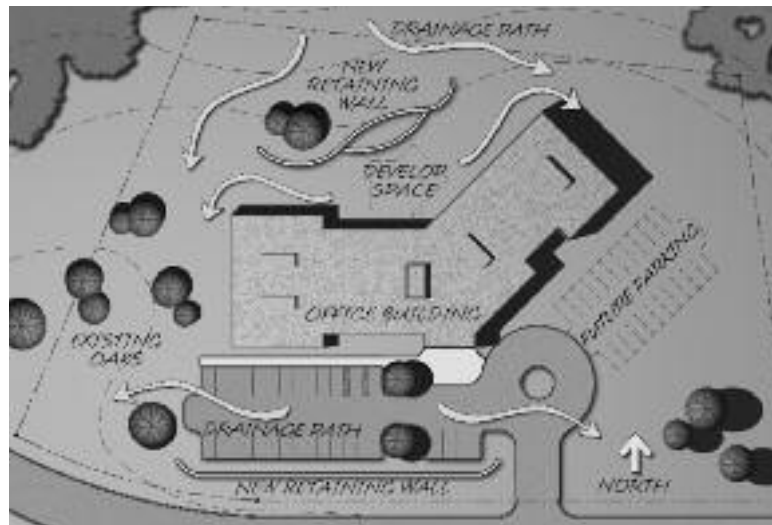


Figure 3-1: Surface Water Management

- 3.2) Use a combination of blanket and chimney drains.
- a) If site soils are used that do not have granular characteristics a chimney and blanket drain should be considered to ensure the infill mass stays as dry as possible. Unless otherwise directed by the geotechnical engineer, a blanket and chimney drain should be used when infill soils have a less than 30 degree friction angle when determined without the use of cohesion.
 - b) If migrating subsurface water is on the site a chimney and blanket drain should be used.

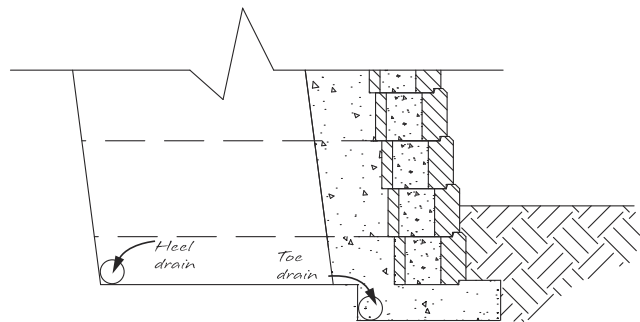
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- c) See Allan Block Chimney and Blanket Drain detail (Drawing No. 2.0).
 - d) Drain material to be consistent with wall rock material. For more information on wall rock material see Chapter 2.0 Typical Wall Construction.
 - e) Manufactured chimney and blanket drains to be approved by the geotechnical and/or the local engineer of record prior to use.
- 3.3) Location, type, and venting of drain pipes.
- a) Utilize Water Management Sections 1.4 and 1.5 in the Allan Block Spec Book.
 - b) 4 in (10 cm) perforated flexible drain pipe or rigid perforated pipes are recommended.
 - c) When a rigid perforated pipe is used, it should be placed with holes down.
 - d) All drain pipes must exit to daylight or be connected to an underground drainage system. Use Allan Block detail Alternate Drain (Drawing No. 3.0) for examples of venting to daylight.
 - i) It is recommended that a minimum 1% gradient be maintained on the placement of the pipe with outlets on 50 ft (15 m) centers, or 100 ft (30 m) centers if the pipe is crowned between the outlets.
 - ii) It is recommended that all pipe outlets be configured to be protected from crushing or plugging from other means.
- 3.4) Above grade water management plan and finishing of the compacted soil mass.
- a) Surface water that cannot be diverted from the wall must be collected with surface drainage swales and drained laterally in order to disperse the water around the wall structure. Construction of a typical swale system shall be in accordance with Drawing No. 2.0. See also Chapter 12 for further discussion on above wall considerations.

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4.0 Water Management – Alternate Drain

- 4.1) Location, type, and venting of drain pipes.
- a) When the drain pipe must be raised to accommodate outlets through the wall face.
 - i) Low permeable granular soils should be used to create a shelf inside the mass, level to the height of the finished grade outside the wall to prevent water from ponding below grade. See Allan Block Design Detail – Alternate Drain in the AB Spec Book or at allanblock.com.
- 4.2) A heel drain should be specified for sites whenever grid is used or where migrating water from behind the mass is possible.
- a) The purpose of the heel drain is to pick up any water that migrates from behind the retaining wall structure at the cut, and route the water away from the reinforced mass during construction and for incidental water for the life of the structure.
 - b) The piping used at the back of the reinforced mass shall have a one percent minimum gradient over the length, but it is not critical for it to be positioned at the very bottom of the cut.
 - c) The heel drain should be vented at 100 ft (30 m) intervals along the entire length of the wall and should not be tied into the toe drain system.
 - d) The pipe may be a rigid pipe with holes at the bottom or a corrugated perforated flexible pipe.
 - e) For infill soils with a high percentage of sand and/or gravel the heel drain pipe does not need to be surrounded by wall rock. When working with soils containing fine grained cohesive soils having a PI of greater than 6 and LL of 30 or greater, 1 ft³ (.03 m³) of wall rock is required around the pipe for each 1 ft (30 cm) of pipe length.



*Drains must be vented to daylight or connected to a storm sewer system.
All drain pipes must be protected from migration of fine material.
Refer to approved plans for construction details.*

Figure 4-1: Typical Drain with Heel Drain

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5.0 Water Application

- 5.1) Below grade water management plan for water application walls.
- a) When more than incidental groundwater is known to move through the retained soils.
 - i) The wall rock should be placed to the limits of the geogrid lengths up to a height equal to 12 in (30 cm) higher than any water source.
- 5.2) When a wall is constructed to be a water application such as in a lake, stream or detention basin.
- a) The wall rock should be placed to the limits of the geogrid lengths up to a height equal to 12 in (30 cm) higher than the determined high water mark. If the high water mark is unknown, the entire infill zone should be constructed with wall rock.
 - b) The drain pipe should be raised to the low water elevation to aid in the evacuation of water from the reinforced mass as water level fluctuates.
 - c) Embankment protection fabric should be used under the infill mass and up the back of the infill mass to a height of 12 in (30 cm) higher than the determined high water mark.
 - i.) Embankment protection fabric is used to stabilize rip rap and foundation soils in water applications and to separate infill materials from the retained soils. This fabric should permit the passage of fines to preclude clogging of the material. Embankment protection fabric shall be a high strength polypropylene monofilament material designed to meet or exceed typical NTPEP specifications; stabilized against ultraviolet (UV) degradation and typically meets or exceeds the values in Table 2.
 - d) For walls having moving water or wave action, natural or manufactured rip-rap in front of the wall to protect the toe of the wall from scour effects is recommended.

Mechanical Property	Determination Method
Tensile Strength = 225 lbs/in (39.4 kN/m)	ASTM D-4595
Puncture Strength = 950 lbs (4228 N)	ASTM D-6241
Apparent Opening Size (AOS) = U.S. Sieve #70 (0.212 mm)	ASTM D-4751
Trapezoidal Tear = 100 lbs (445 N)	ASTM D-4533
Percent Open Area = 4%	COE-02215
Permeability = 0.01 cm/sec	ASTM D-4491

**Table 2: Embankment Protection
Fabric Specifications**

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6.0 Soil & Compaction

- 6.1) Understanding the site soils as well as the soils used in the infill zone is essential to understanding how the retaining wall will function. One of the economic advantages to an SRW system is that site soils can usually be used in the infill zone provided they are of a certain quality and surface and groundwater conditions at the site are controlled by recommendations given in Chapters 3.0 – 5.0.

While cohesionless, free graining materials (less than 10% fines and or PI less than 6 and LL less than 30) are preferred, soils with low plastic fines (i.e. SC with PI less than 20 and LL less than 40) may be used for lower height SRW construction provided the following additional design criteria are implemented:

- a) Proper internal drainage is installed including wall rock in and behind the facing and blanket and chimney drains to keep the infill mass dry, see Chapters 3.0 – 5.0.
- b) In areas where frost heaves are possible, only soils with low to moderate frost heave potential shall be utilized. Verify parameters with geotech. Expanding the depth of wall rock behind the facing can help reduce the effects of frost heaves. See Chapter 6, Section 6.4 for information on the wall rock column.
- c) The cohesive shear strength parameter (c), for the reinforced fill, is ignored for internal and external stability analysis. Cohesion values are allowed in the foundation and global stability analysis. However, it is recommended that no more than 10% of the tested/reported values should be used due to the unpredictability of cohesive soils.
- d) The final design is checked by a qualified geotechnical engineer to ensure that the use of cohesive soils does not result in unacceptable time-dependent movement of the SRW system.
- e) High plastic or organic soils including MH, CH, OH, OL and PT are not recommended for any segmental retaining wall construction as their use can cause excessive settling over time and or excessive internal stress to build up causing internal lateral forces to occur. See Chapter 8 for more information on tall walls.

- 6.2) Allowable soil to be used below the wall structure face.

- a) Geotechnical report should include parameters and recommendations for sub-soils.
- b) If poor soils are encountered during construction, consult with owner and geotech for removal and replacement recommendation.
- c) Utilize Section 3.1 Foundation Soils in the Allan Block Spec Book.
 - i) Foundation soils to be inspected by the on-site soils engineer to ensure they meet or exceed design soil parameters.
 - ii) Over excavated areas shall be filled with compactable material approved by the on-site soils engineer.

- 6.3) Allowable soil to be used in the reinforced mass.

- a) Best soil is wall rock or select/structural fill with less than 10% fines, to the limits of the geogrid lengths.
- b) If site soils are allowed by the geotechnical engineer; on-site soils engineer to verify they meet the minimum requirements set forth in the soils report, and they are in compliance with the soil properties used in the design process.
- c) Utilize Section 1 Part 2.3 Infill Soils in the Allan Block Spec Book.
 - i) Unsuitable soils for backfill (heavy clays or organic soils) shall not be used.
 - ii) Poorly graded sands, expansive clays and/or soils with a PI greater than 20 or a LL greater than 40

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should not be used in wall construction.

- iii) Fine grained cohesive soils with a friction angle of less than 31 degrees with a PI ranging between 6 and 20 and LL from 30 to 40, may be used in wall construction, but additional backfilling, compaction and water management efforts, such as blanket drains and chimney drains are required.
- iv) Soils with a PI of less than 6 and LL less than 30 are generally considered granular and can be used as infill material.
- d) The suggested gradation requirements for the reinforce (infill) soils in SRW's are:

Sieve Size	% Passing
1 in (24 mm)	100 - 75
No. 4 (4.75 mm)	100 - 20
No. 40 (0.425 mm)	0 - 60
No. 200 (0.075 mm)	0 - 35

6.4) Wall rock column size and material used

- a) The wall rock column is typically 12 in (30 cm) deep directly behind the wall facing and consists of material summarized in Section 1 Part 2.2 in the Allan Block Spec Book.
 - i) Material must be well-graded compactible aggregate, 0.25 - 1.5 in, (0.6 – 3.8 cm) with no more than 10% passing the #200 sieve. (ASTM D422).
- b) At the top of the wall, above the wall rock column it is common to place a horizontal layer of landscape fabric to protect the wall rock from being infiltrated by the topsoil placed to finish the wall. Topsoil is defined as low permeable soils ranging from 8 - 12 in. (20 – 30 cm) to minimize infiltration of surface water into the reinforced mass.
- c) When designing curved and radius wall segments the designer should provide details to the installer for wall rock placement.
 - i) For inside curved and inside cornered walls, the minimum wall rock specified should follow Section 6.4 (paragraph a) and Section 8.2 for Tall Wall applications.
 - ii) For outside curved and outside cornered walls, additional depth of wall rock should be specified to promote greater stability in these areas. Additional depth of wall rock is dependent on the total height of the wall and should be a minimum of H/2 as detailed in Drawing No. 6 in the front of this document.

6.5) Soil parameter verification

- a) On-site soils engineer to verify and document that soils meet those specified in the soils report and wall design.
- b) Minimum infill soils to meet requirements outlined in Section 1 Part 2.3 in the AB Spec Book: USCS Soil types (GP, GW, SW, SP, GP-GM and SP-SM) are ideal select/structural fill, with PI less than 6 and LL less than 30, but if soils with friction angle less than 31 degrees are to be used (PI of less than 20 and LL of less than 40) special installation and drainage details and specifications are required, see Chapter 6, Section 6.1.

6.6) Establish inspection and testing requirements in advance of providing a design. The professional in charge of this work must be retained by the owner.

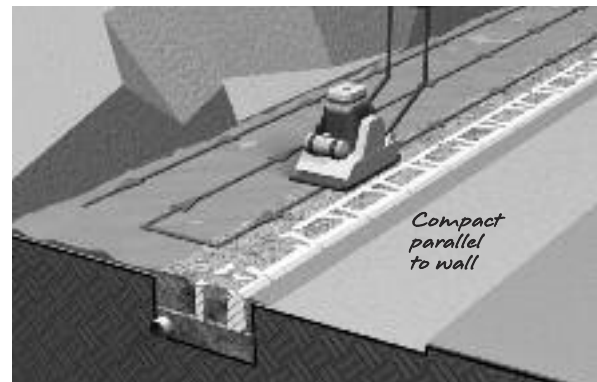
- a) Size and scope of project will require different levels of testing and inspection.
- b) An independent testing firm should be hired by the owner to provide services.

Best Practices for Allan Block Segmental Retaining Wall Design For Residential and Commercial Applications

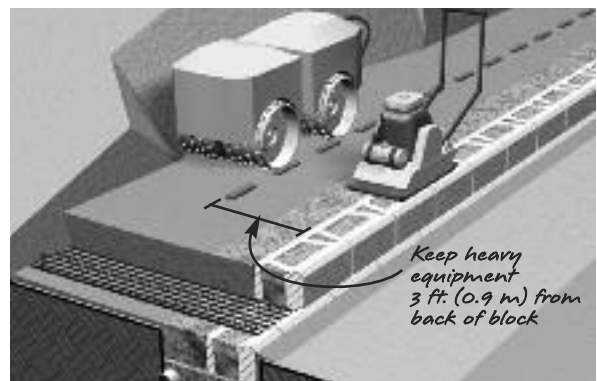
- c) Independent firm to keep inspection log and provide written reports at predetermined intervals to the owner.
- d) Testing frequency should be set to establish a proper compaction protocol to consistently achieve the minimum compaction requirements set by the design requirements. If full time inspection and testing at 8 in (20 cm) lifts is not provided, then the following testing frequency should be followed:
 - i) One test for every 8 in (20 cm) of vertical fill placed and compacted, for every 25 lineal ft (7.6 m) of retaining wall length, starting on the first course of block.
 - ii) Vary compaction test locations to cover the entire area of reinforced zone; including the area compacted by the hand-operated compaction equipment.
 - iii) Once protocol is deemed acceptable, testing can be conducted randomly at locations and frequencies determined by the on-site soils engineer.
- e) Slopes above the wall must be compacted and checked in a similar manner.

6.7) Compaction requirements on wall rock and facing unit.

- a) Hand operated plate compactor to be used behind the base course within the 3 ft (0.9 m) wide consolidation zone with a minimum of two passes, Figure 6-1.
- b) Compaction of second course and above will begin by running the plate compactor **directly on top of the block facing** and then compacting in parallel paths from the wall face until the entire consolidation zone has been compacted, Figure 6-2.
- c) Utilize Section 1 Part 3.4 E in the Allan Block Spec Book.
 - i) Final compaction requirements in the consolidation zone shall be established by the engineer of record, typically 95% of Standard Proctor.
 - ii) A minimum of two passes of the plate compactor are required with maximum lifts of 8 in. (20 cm).
 - iii) Expansive or fine-grained soils may require additional compaction passes and/or specific compaction equipment such as a sheepsfoot roller.
 - iv) Maximum lifts of 4 in. (10 cm) may be required to achieve adequate compaction within the consolidation zone.
 - v) Employ methods using lightweight compaction equipment that will not disrupt the stability, alignment or batter of the wall.
 - vi) Install each subsequent course in like manner. Repeat procedure to the extent of wall height.



**Figure 6-1: Compaction Path
First Course**



**Figure 6-2: Compaction Path
Second Course and Above**

6.8) Block and infill soil placed in 8 in (20 cm) lifts maximum.

- a) Industry Standard from Allan Block Corporation, NCMA, AASHTO, FHWA, etc.

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- 6.9) Compaction requirements for all soils in areas in, above and behind the reinforced mass.
- a) Typical minimum requirements are: 95% of maximum Standard Proctor dry density (ASTM D698) with a moisture content control of +1% to -3% of optimum. Section 13.5.3, NCMA Design Manual.
- 6.10) Compaction testing locations and frequencies. Documentation of on-site soil testing.
- a) See Section 6.6.
- 6.11) Water Management during construction.
- a) Utilize Section 3 Part 1.1 Surface Drainage in the Allan Block Spec Book.
 - i) At the end of each day's construction and at final completion, grade the backfill to avoid water accumulation behind the wall or in the reinforced zone.
- 6.12) For walls with step ups in the base course, extra care should be given to properly compact the base material at the end of each course to add greater stability to the next course, Figure 6-3.
- 6.13) For a walls with steps built into the wall, additional compaction requirements and wall rock should be included into the project specs, Figure 6-4.
- a) A minimum of 6 in (15 cm) of wall rock base material shall be installed beneath each tread block, treating each course as a wall base course.
 - b) Minimum compaction requirements for standard wall construction shall be followed. See Section 6.7.

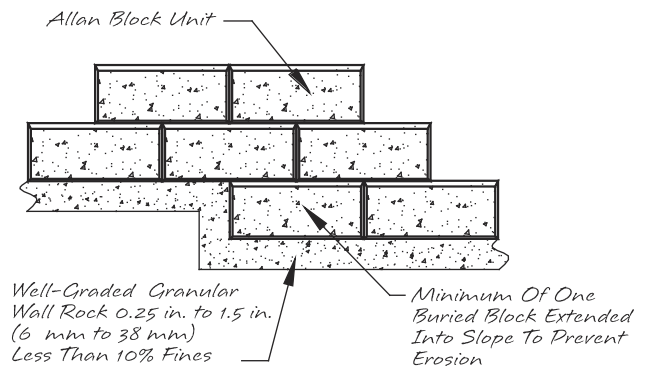


Figure 6-3: Step Up Detail

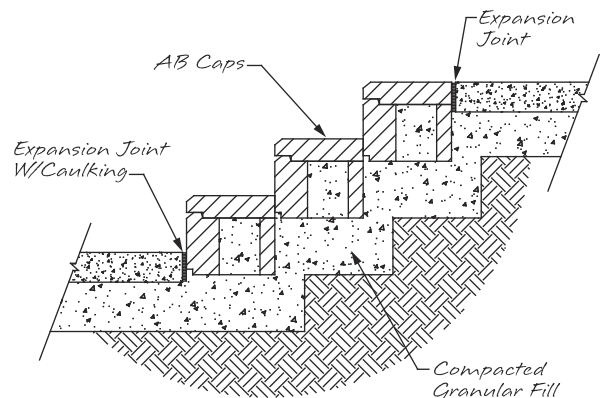


Figure 6-4: Stair Detail

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7.0 Geogrid Reinforcement Requirements, Corner and Radius Design Practices

- 7.1) Certification to ensure proper materials for the geogrid reinforcement. Most geogrids used for soil reinforcement are manufactured from polyester fiber. To ensure a high quality product, use a geosynthetic reinforcement that has obtained an NTPEP Report.
- There are many different international manufacturers that are supplying geogrid reinforcement, and they are not all equal. It is important to understand what influences the durability of the geogrid and the U.S. Federal Highway Administration identified three key factors:
 - Soils that have a pH of 10 or more represent an environment that could potentially degrade the geogrid faster especially in the presence of sufficient water.
 - Polyester molecular weight – the size of the polymer molecule has a significant influence on the chemical durability.
 - Polyester carboxyl end group (CEG) – grids are less susceptible to degradation when they have fewer CEG in their molecular structure.
 - Establish minimum requirements when using polyester geogrids. NCMA adopted the guidelines that the FHWA set for geogrid reinforcement. All polyester geogrids submitted for approval must be made of polyester fiber that meets the following specifications:
 - Molecular weight greater than 25,000 g/mol
 - Carboxyl End Group less than 30 mmol/Kg
 - The certification, obtained from the geogrid manufacturer, must originate from the actual manufacturer of the fiber to show conformance with the specification.
 - Designer must consider soils that have a pH of 10 or more represent an environment that could potentially degrade the geogrid faster especially in the presence of sufficient water and may require additional design criteria.
- 7.2) Proper orientation of grid and placement
- Typical commercial geogrid is strong in the roll direction and should be placed in sheets perpendicular to the wall facing.
 - Utilize Section 2 – Part 3.3 Geogrid Installation in the Allan Block Spec Book.
 - Cut geogrid to designed embedment length and place on top of the Allan Block units to the back edge of the raised front lip or within 1 in (2.5 cm) of the retaining wall face when using AB Fieldstone.
 - Extend away from wall approximately 3% above horizontal on compacted infill soils.
 - For straight walls, placement of adjacent sheets of geogrid should be side-by-side without any overlap. For walls with corners or curves the following are the best practice method of placement:
 - For outside corners, to avoid overlapping grid layers, grids should be stagger by one course on either side of the corner, weaving the strong direction from bottom to top of wall. See Allan Block standard detail 10 in Allan Block Spec Book.

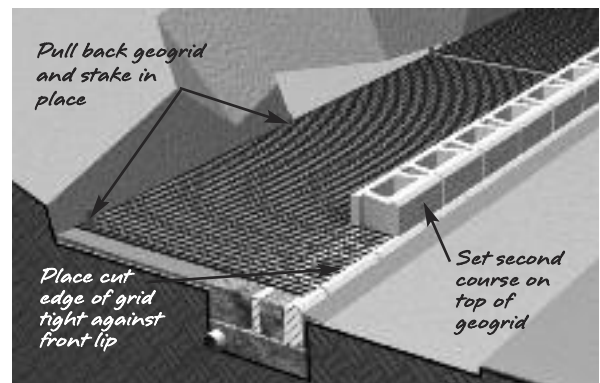


Figure 7-1: Grid Location

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- ii) For inside corner, extend the geogrid layer into the corner from one side a distance equal to 25% of the total wall height. Alternate extended geogrid layer from side to side per course to create a geogrid weave as wall is built. See Allan Block standard detail 9 in Allan Block Spec Book.
- iii) For outside curves, where grid tails overlap naturally, place roughly 3 in (7.5 cm) of wall rock or infill soil between the overlapping layers. See Allan Block standard detail 12 in Allan Block Spec Book.
- iv) For inside curves, where grid layers fan apart, place a secondary, equal length, layer of grid on the next course above the fanned gap. See Allan Block standard detail 11 in Allan Block Spec Book.

7.3) Wall rock design for corners and curved walls.

- a) When designing curved and radius wall segments the designer should provide details to the installer for wall rock placement.
 - i) For inside curved and inside cornered walls, the minimum wall rock specified should follow Section 6.4 (paragraph a) and Section 8.2 for Tall Wall applications.
 - ii) For outside curved and outside cornered walls, additional depth of wall rock should be specified to promote greater stability in these areas. Additional depth of wall rock is dependent on the total height of the wall and should be a minimum of $H/2$ as detailed in Drawing No. 6 in the front of this document.

Best Practices for Allan Block Segmental Retaining Wall Design For Residential and Commercial Applications

8.0 Tall Wall Considerations

- 8.1) Tall Wall Considerations are to be employed with structures rising to a height of between 10 – 15 ft (3 – 4.6 m), depending on the application and the discretion of the wall design engineer. A 10 ft (3 m) high wall structure with a slope or structure above would be considered as a tall wall, while the same wall height constructed with a level condition above the wall without any additional surcharge may not require consideration as a tall wall.

Several factors may change a typical design when structures reach these defined higher levels such as the depth of wall rock, increased design parameters, enhanced structural fill and global stability analysis requirements.

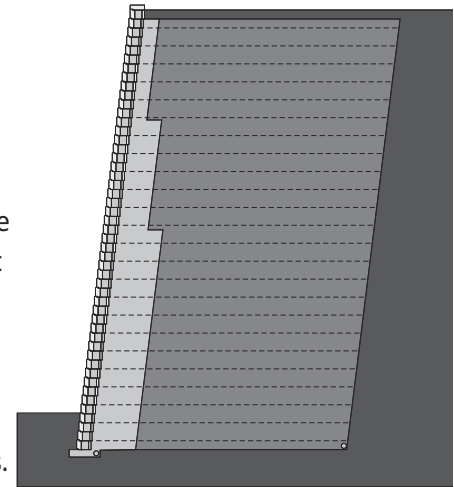


Figure 8-1: Variable Wall Rock Thickness

- 8.2) Wall rock depth behind the block and material used.
- Site conditions and wall height should make the engineer consider expanding the depth and or size of material used.
 - Typical wall rock depth will vary with wall height, if select/structural fill is not utilized in the reinforced mass, Figure 8-1.
 - For walls up to 10 - 15 ft (3 - 4.6 m) as discussed in section 8.1, 12 in (30 cm) typical depth top to bottom.
 - For walls from 10 - 20 ft (3 - 6.1 m) tall, the bottom half is suggested to be increased to 24 in (60 cm) deep and the top half to be the typical depth of 12 in (30 cm) deep.
 - For walls over 20 ft (6.1 m) tall, the bottom half is suggested to be increased to 36 in (90 cm) deep and the top half is divided in two with a 24 in (60 cm) deep column and a 12 in (30 cm) deep column at the top.
- 8.3) For tall walls the engineer should increase design parameters of compaction and wall rock usage.
- Select/structural fill should be specified for the minimum bottom 1/3 to 1/2 of the reinforced fill. An Internal Compound Stability (ICS) analysis can aid the designer to determine if greater select/structural fill heights are required. The use of additional select/structural fill should extend to the entire length of the reinforcement. This fill material should have a PI of less than 6 for walls up to 20 ft (6.1 m) and for taller walls the material should have a PI of zero. An example of what type of fill should be considered for this area would be compactable sands or gravels.
 - The engineer must carefully review the site geometry and structures above and below the wall to adequately plan for the use of the land placed into service by the retaining wall structure.
 - Provide detailed requirements for onsite inspection to ensure that detailed specifications are complied with during construction. This includes, but is not limited to:
 - Confirmation of the foundation soils
 - Confirmation of the retained soils
 - Verify the imported materials
 - Confirm reinforcement material
 - Verify the block
 - Validate soil placement and compaction.

(1) A single test/confirmation for each of the items listed would not be considered adequate. A de-

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tailed construction log should be used with sign offs at incremental levels by the responsible parties.

- d) Consider how much potential settlement will impact structures above the reinforced soil mass. Consider increasing compaction requirements from 95% of standard proctor to 98% to minimize settlement where essential to the application.
- e) A detailed review and implementation of a water management plan is essential. This should include a detailed drawing for water collection and water flow diagrams for both above and below grade drainage. Below grade utilities and above grade structures should be included in the overall site design to ensure that site details such as storm drains and curb and gutters do not influence the overall wall envelope or effect performance. Unless designed to accommodate hydrostatic loading, it is essential that the reinforced soil mass not be exposed to outside water sources that would rise above the level of incidental water.
- f) As walls get taller the internal stresses increase and depending on the soils used, can cause lateral loads pushing on the back of the facing. To minimize internal lateral loads on the Allan Block facing, it is recommended to utilize the described soils above and to expand the depth of the wall rock column behind the facing, See Section 8.2.b for more information. Expanding the wall rock zone behind the wall also reduces down drag forces on the geogrid caused by localized settlement and allows for easier compaction directly behind the block.
- g) In addition to the compaction and wall rock parameters, tall walls require the design engineer to evaluate the overall stability of the soil structure and the subsoils beneath the wall. The reinforced soil structure should be evaluated for internal settlement which may require additional select fill to mitigate. The subsoils cannot be ignored due to similar reasons. The overburden of the tall wall can cause unwanted settlements in the foundation material. Removal of the subsoils and replacement with quality select fill may be required to mitigate these possible settlements.

- 8.4) As walls increase in height the active earth forces also increase in the lower portion of the wall. Therefore it is not uncommon in taller walls to increase the strength of the lower geogrid layers or decrease the grid spacing to accommodate the higher design forces.
- 8.5) The overall global stability of tall walls must be considered separately from the standard wall design to ensure the stability of the entire project site. For more information on global stability see Chapter 9.0 Global Stability - General and Chapter 10.0 Global Stability – Terraced Walls.
- 8.6) Internal Compound Stability (ICS) calculations provide insight into potential global or overall stability issues. When more than 50% of the slip arcs originate at the back of the design envelope, as defined in Chapter 1, Section 1.7 b, a full global/overall stability analysis should be recommended to the owner by the owner's geotechnical engineer.
- 8.7) Minimum Wall Facing Depth.
 - a) The recommendations contained within this guide, including those for geogrid spacing and length as discussed in Sections 2.9 – 2.11, are based on the use of a facing unit that has an average (front to back) depth of at least 10 in. (25 cm). The 10 in. (25 cm) minimum depth of facing unit is recommended because SRW units of this depth or greater have a proven performance record while in service over many decades. This recommendation also recognizes that as the unit depth decreases, so does the stability of the facing, particularly overturning resistance during construction or while in service.

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9.0 Global Stability – General

9.1) Wall embedment depth should be determined by the wall design engineer based on typical industry standard and specific site requirements.

a) Walls with slopes below must have additional buried course for stability. For walls with slopes below, local ordinances commonly reference to bury enough blocks to have a 5 - 7 ft (1.5 - 2.1 m) level bench in front of the wall, and then the 1 in (2.5 cm) of depth per 1.0 ft (30 cm) of wall height rule is used beyond that point, Figure 9-1. After the wall is complete, the level area can be backfilled to continue the appearance of a continuous slope.

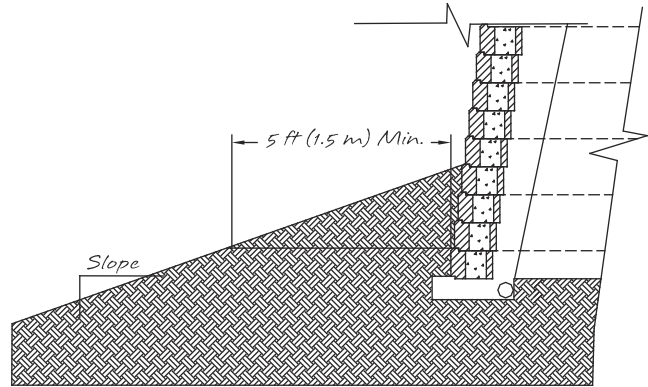


Figure 9-1: Toe Slope Embedment

b) In general when a slope below the wall is present, there is need for a global stability analysis to confirm the overall stability of the site.

9.2) If a global stability analysis is not included in the wall designer's scope of work, establish that when a global stability analysis is required by the wall designer, using their best engineering judgment, then the owner will contract with a geotechnical engineer for overall site stability. Global stability analysis should be run for a variety of conditions including:

a) For those walls with slopes below or above.

b) Walls built in sites with clays, silts, poorly graded sands, expansive clays and/or soils with a PI greater than 20 and or a LL greater than 40.

i) The infill soil used must meet or exceed the designed friction angle and description noted on the design cross sections, and must be free of debris and consist of one of the following inorganic USCS soil types: GP, GW, SW, SP, GP-GM or SP-SM meeting the following gradation as determined in accordance with ASTM D422.

c) For walls where more than 50% of the Internal Compound Stability (ICS) slip arcs fall at the back of the wall design envelope when ICS is run in AB Walls. We have identified a Design Envelope for the wall designer that defines the extents of an ICS evaluation within that envelope. An ICS analysis does not take into account a slope below the wall, as the bottom slip arc is located at the base of the bottom block. Therefore it will not provide guidance for what happens below the wall. One easy to identify guide for additional global evaluation may be found by reviewing where the ICS slip arcs with the minimum factors of safety originate. When a concentration of ICS slip arcs originate at the back of the Design Envelope, a complete global stability analysis should be conducted, See Figure 9-2.

Sieve Size	% Passing
1 in (24 mm)	100 - 75
No. 4 (4.75 mm)	100 - 20
No. 40 (0.425 mm)	0 - 60
No. 200 (0.075 mm)	0 - 35

9.3) For walls with global stability concerns, it is common to increase the stability by:

a) Increasing the length of the geogrid layers to force the minimum slip arcs deeper into the hillside.

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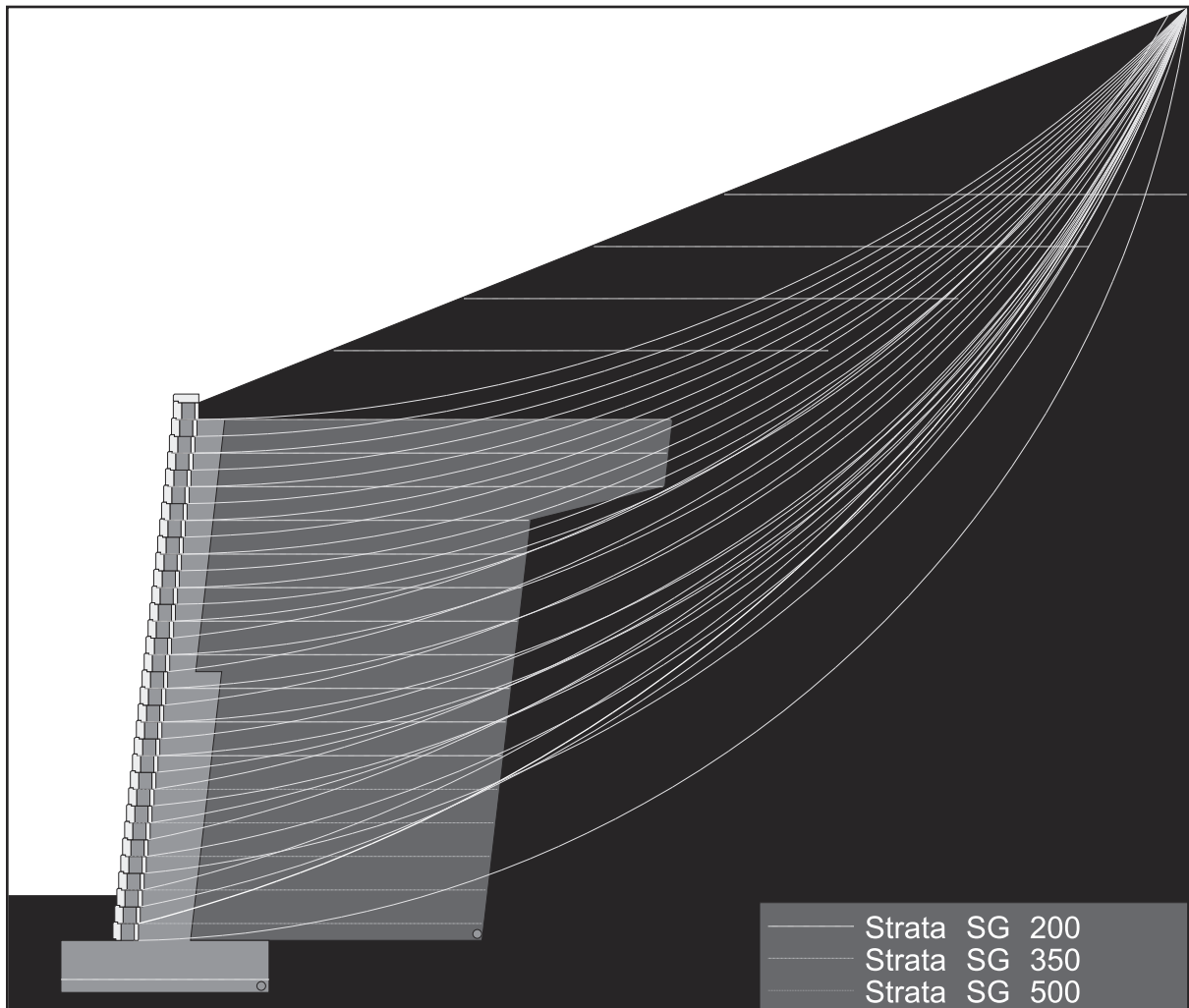


Figure 9-2: Design Envelope ICS

- b) Increasing the depth of buried block to force the minimum slip arcs deeper into the hillside.
- c) Increasing the strength of the geosynthetic reinforcement layers to force the minimum slip arcs deeper into the hillside.
- d) Increasing the friction angle of the infill soil will increase the soil's shear resistance which will increase stability.
- e) If the cause for the global stability problems is weak foundations soils, it may be necessary for the geotechnical engineer on the project to do foundation improvements before the retaining walls are built.

9.4) Whenever the groundwater is within $0.66H$ of the bottom of the wall, the global stability of the SRW system should be analyzed to assure that the adequate factor of safety exists for deep failures that pass behind the geosynthetic reinforcement and for compound failures that pass partially through the reinforced soil mass and partially behind the reinforced soil mass.

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10.0 Global Stability – Terraced Walls

- 10.1) Whenever walls are constructed in a terraced arrangement, or any of the other conditions listed, the designer must consider the overall global stability of the structure.
- It is common to have the design grid lengths for the bottom terrace equal to at least 60% of the total terraced structure height.
 - Subsequent terraces above would use similar rationale to determine their minimum grid lengths.
 - When determining the surcharge applied from the upper wall onto the lower wall, it is common to consider the walls as independent if they are spaced apart a minimum of twice the height of the lower wall. If they are spaced closer, the lower wall must be designed to carry the surcharge of the upper wall(s), Figure 10-1.

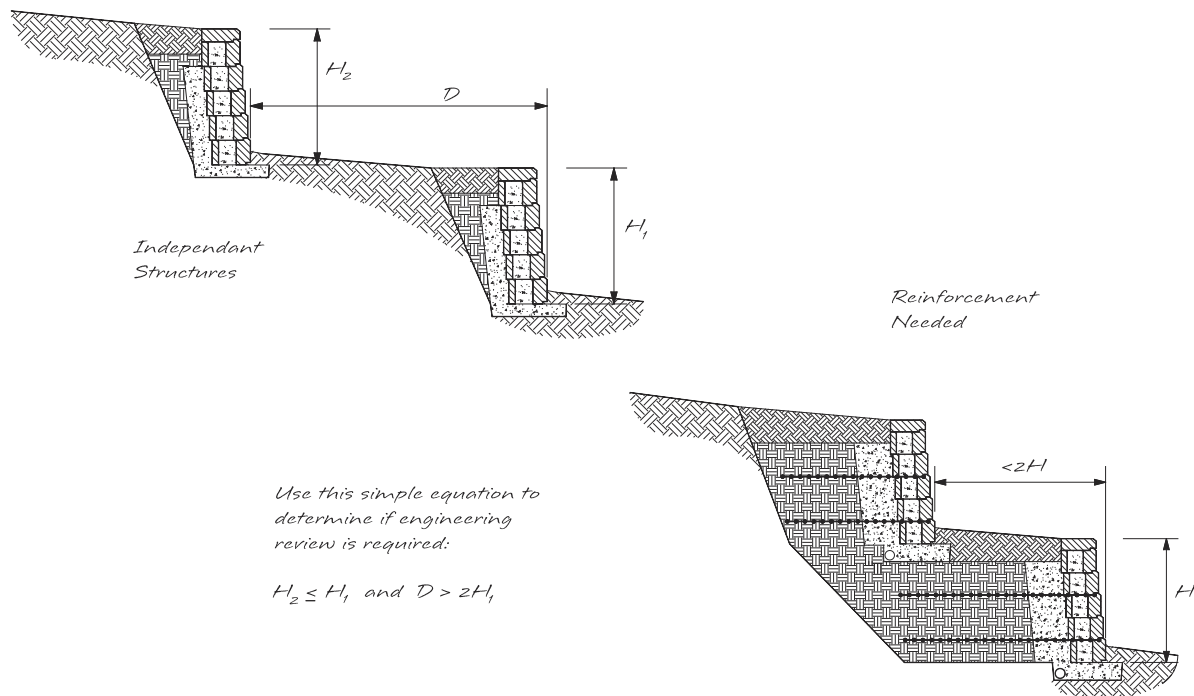


Figure 10-1: Terraced Wall Applications

- These recommendations do not eliminate the need to consider a global stability analysis.
- Greater attention to compaction should be placed on the foundation soils below the upper terraces and in transition areas where the wall splits from one wall into two.
 - If the soils are not properly compacted in these areas, settlement can occur over time that could cause aesthetic concerns.

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11.0 Seismic Considerations

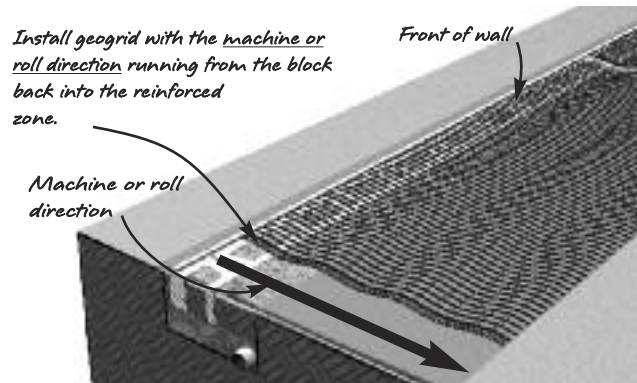
- 11.1) For walls with dynamic loading:
- a) Designer must understand the local seismic code requirements before starting design.
 - b) Closer spacing of geogrid is recommended, maximum 16 in (40 cm).
 - c) Extension of the top layers of geogrid. Typically the top layers will be extended to roughly 90% or more of the wall height to satisfy design requirements.
 - d) Using select/structural backfill will reduce the effects of the dynamic loading.
 - e) For more information on seismic design and the effects on segmental retaining walls, see the Allan Block Executive Summary of the independent full-scale seismic testing conducted by Columbia University and the National Research Institute of Japan.
- 11.2) When dealing with a slope above a wall with seismic loading applied to the wall, the same acceleration coefficient applied to the wall must also be applied to the stability calculations of the slope.
- 11.3) The Mononobe-Okabe (M-O) seismic methodology places limits on the steepness of any slope above the wall. If during the design phase it is determined that the desired slope is not allowed, the site grading should be altered or the wall height should be increased to reduce the steepness of the slope above. See section 12.4 for description of slope steepness.
- 11.4) While the M-O method is the standard used in the seismic design of segmental retaining wall, a trial wedge method may be utilized to investigate walls when the M-O method becomes limited due to slopes above. Using methods similar to a global stability model the trial wedge method determines the weight of the soil wedge above the failure plan and determines the active earth pressure of the soil wedge acting at the back of the soil mass. Using the trial wedge method is not without limitations as well. The solution it provides is purely mathematical and understanding soil mechanics and the slope steepness limits is also important. The limitation to the steepness of a slope discussed in section 12.4 still apply, and if the designer chooses to utilize the trial wedge method for walls with slopes above that exceed the soil mechanic limits, they must review the slope stability in a global stability program and possibly reinforce the slope above the wall. For a greater discussion on the Trial wedge method see Chapter Five, Seismic Design, in the Allan Block Engineering Manual.

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12.0 Above Wall Considerations

12.1) Minimum grid lengths.

- a) Top layers of grid should be lengthened to 90% of wall height or an additional 3 ft (0.9 m), whichever is greater, in seismically active areas or with any type of loading above the wall including slopes and surcharges. In the event that an interference may exist with the top layer based on other structures in the reinforced zone it is acceptable to move this extended layer to a lower grid elevation at the top of the structure.
- b) The portion of wall above the top layer of geogrid should be reviewed as a gravity wall taking into account all soils and surcharge parameters.



12.2) Details for fencing and other potential lateral loads from objects located above or within the reinforced soil mass.

- a) Impact structures or fence posts should be positioned a minimum of 3 ft (0.9 m) from the back of top course to allow a properly designed load for local overturning.
- b) If fence posts must be placed within 3 ft (0.9 m) of the back of the wall facing, the designer must consider the localized top of wall overturning force into their design.
- c) Common lateral loads from railings are 50 lb/lf (0.74 kN/m) along the top of the railing or 200 lb (2.92 kN/m) point load at the top of the post or both depending on the local requirements.
- d) Common post footings are formed by using construction tubes placed at desired on-center locations during construction. If posts are placed after construction is complete, holes must be hand dug as using a power auger will cause severe damage to the geogrid layers.
- e) If the post design calls for an engineered product to solve localized overturning forces, a product such as the Sleeve-IT® System can be specified. Sleeve-IT® is a Stratagrid product designed for use in segmental retaining walls to resist top of wall overturning forces from fences and railing. For more information on design capacities and installation, contact Stratagrid at www.geogrid.com.

12.3) Details for placement and compaction of a slope above the wall structure.

- a) Proper lift and compaction recommendation should be followed from the geotechnical recommendations. See Chapter 6.0 Soils and Compaction.

12.4) Stability of slopes above the wall.

- a) There are limits to the steepness of a slope above a wall that must be considered when designing any soil structure.
 - i) In static designs, the maximum unreinforced slope angle above any wall cannot exceed the friction angle of the soil used to reconstruct the slope.
 - ii) In seismic designs, the maximum unreinforced slope angle above any wall cannot exceed the friction

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angle of the soil used to reconstruct the slope minus the seismic inertial angle. The seismic inertial angle is based on the horizontal and vertical seismic coefficients (k_h and k_v) determined by the soils engineer for that specific project site.

If the desired slope above exceeds either of the two limits above, the designer must analyze the slope above in a global stability program and provide slope reinforcement as required.

- 12.5) Slopes above the wall must be compacted following the proper lift and compaction recommendation from the geotechnical recommendations. See chapter 6.0, Soils and Compaction.
- 12.6) Reinforcing the slope above the wall may be necessary to provide adequate stability to the wall system. Geogrid lengths typically matching the standard grid lengths in the wall along with their spacing are commonly used in walls with steep slopes above, greater than 3:1, and/or any slopes with poor soils or walls with seismic requirements.
- 12.7) Details for plantings located above the wall structure.
 - a) In general, plantings in the reinforced zone are acceptable and may in fact enhance the reinforced soil mass provided:
 - i) Engineer should review with the owner the planting plans from the landscape architect to verify size of root balls and if any geogrid layers will be disrupted.
 - ii) Language can be placed in the project specifications.
 - iii) Augers should never be used within the reinforced grid zone.
 - iv) Consider the effect of excess irrigation. See Water Management, Chapter 3.0.

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