SRW INSPECTION GUIDELINES

SRW HISTORY ARTICLE SERIES

This is the eighth article in a series of ten articles on the history of segmental retaining walls developed under a grant from the NCMA Education and Research Foundation.

INTRODUCTION

A previous article (*SRW Construction*, Ref. 3) discusses design, specifications, and construction and highlights the importance of inspection to ensure long-term wall performance. This article addresses inspection through the process of Quality Assurance (QA), that refers to the engineering activities implemented in a quality system so that requirements for a product or service will be fulfilled (ASQ Definition). It is the systematic measurement, comparison with a standard, monitoring of processes and an associated feedback loop that confers error prevention. The standards used for QA are the building codes, contract specifications, published literature (*NCMA TEK 15-5B*, Ref. 7 and *NCMA TEK 18-11B*, Ref. 8) and industry practices (*Segmental Retaining Wall Installation Guide*, Ref. 6).

Figure 1. Property Completed and Inspected Wall

The "inspector" referenced in this article could be from someone from the building department, a consultant for the owner, a quality assurance person from the contractor or the owner themselves. They are not the designers or engineers of record, but professionals "that confirm" the construction process is following the contract documents and applicable building codes. It is not their responsibility to accept or reject the construction process, but to document and report the process is following the published requirements. The acceptance or rejection would come from the owner or the building department if the code is not being followed properly. Figure 1 shows a wall inspected and completed properly.

This article will review contract documents, reinforcing key items that should be on an inspector's checklist during construction. The objective of inspection and QA is to get the product that was specified (i.e. paid for) and be sure the system is installed as designed. If the contract documents are followed, the owner should be comfortable that the right decision was made with the product and contractor selected.

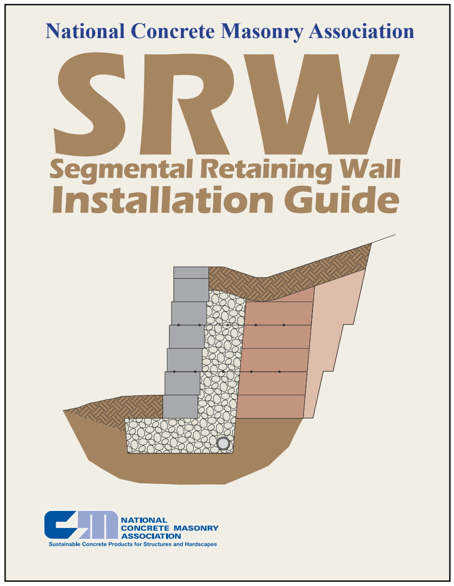
SPECIFICATIONS

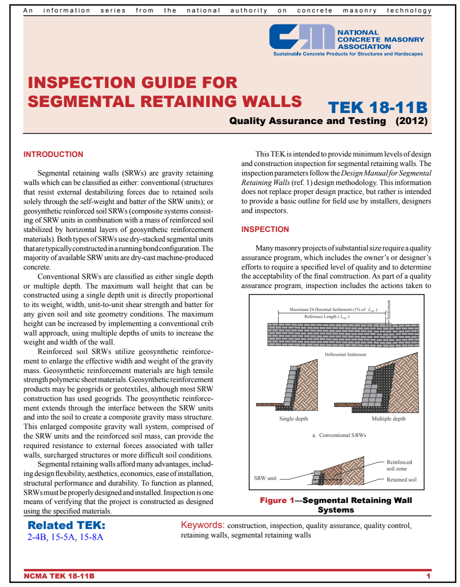
The contract documents and building codes are the basis for all inspection. An overview of the project is called out: 1.01 Description: "*Furnish all materials, labor equipment and supervision to install a segmental retaining wall (SRW) in accordance with these specifications…*" Construction drawings should be provided as an integral part of the contract documents.

The contract specifications give the inspector specific design information to confirm:

1. Approved Materials: Approved Segmental Retaining Wall Systems, acceptable gradations on the soil and gravel used to construct the SRW retaining wall - (gravel fill and reinforced fill), geotextile filter, and geogrid reinforcing.
2. Quality Assurance Documents: ASTM Referenced Test Methods, quality assurance requirements on the delivered product, quality assurance requirements on the delivered and geogrid reinforcement products.

3. References to other sections of the contract: References to other specifications or contracts associated with the project.





An information series from the national authority on concrete masonry technology

NATIONAL CONCRETE MASONRY ASSOCIATION
Sustainable Concrete Products for Structures and Hardscapes

INSPECTION GUIDE FOR SEGMENTAL RETAINING WALLS

TEK 18-11B

Quality Assurance and Testing (2012)

INTRODUCTION

Segmental retaining walls (SRWs) are gravity retaining walls which can be classified as either: conventional (structures that resist external destabilizing forces due to retained soils solely through the self-weight and batter of the SRW units); or geosynthetic reinforced soil SRWs (composite systems consisting of SRW units in combination with a mass of reinforced soil stabilized by horizontal layers of geosynthetic reinforcement materials). Both types of SRWs use dry-stacked segmental units that are typically constructed in a running bond configuration. The majority of available SRW units are dry-cast machine-produced concrete.

Conventional SRWs are classified as either single depth or multiple depth. The maximum wall height that can be constructed using a single depth unit is directly proportional to its weight, width, unit-to-unit shear strength and batter for any given soil and site geometry conditions. The maximum height can be increased by implementing a conventional crib wall approach, using multiple depths of units to increase the weight and width of the wall.

Reinforced soil SRWs utilize geosynthetic reinforcement to enlarge the effective width and weight of the gravity mass. Geosynthetic reinforcement materials are high tensile strength polymeric sheet materials. Geosynthetic reinforcement products may be geogrids or geotextiles, although most SRW construction has used geogrids. The geosynthetic reinforcement extends through the interface between the SRW units and into the soil to create a composite gravity mass structure. This enlarged composite gravity wall system, comprised of the SRW units and the reinforced soil mass, can provide the required resistance to external forces associated with taller walls, surcharged structures or more difficult soil conditions.

Segmental retaining walls afford many advantages, including design flexibility, aesthetics, economics, ease of installation, structural performance and durability. To function as planned, SRWs must be properly designed and installed. Inspection is one means of verifying that the project is constructed as designed using the specified materials.

This TEK is intended to provide minimum levels of design and construction inspection for segmental retaining walls. The inspection parameters follow the *Design Manual for Segmental Retaining Walls* (ref. 1) design methodology. This information does not replace proper design practice, but rather is intended to provide a basic outline for field use by installers, designers and inspectors.

INSPECTION

Many masonry projects of substantial size require a quality assurance program, which includes the owner's or designer's efforts to require a specified level of quality and to determine the acceptability of the final construction. As part of a quality assurance program, inspection includes the actions taken to

Maximum Differential Settlement (1% of L_{ref})
Reference Length (L_{ref})
Settlement
Differential Settlement
Single depth
Multiple depth
a. Conventional SRWs
SRW unit
Reinforced soil zone
Retained soil

Figure 1—Segmental Retaining Wall Systems

Related TEK: 2-4B, 15-5A, 15-8A

Keywords: construction, inspection, quality assurance, quality control, retaining walls, segmental retaining walls

NCMA TEK 18-11B 1

Figure 2: NCMA SRW Installation Guide (Ref. 6) and NCMA TEK 18-11B Inspection Guide for Segmental Retaining Walls (Ref. 8)

CONTACT DRAWINGS

Drawings are a key element to give the contractor planned grades for the top and bottom of the wall, start and stop points, and possible easement constraints. If soil reinforcement is used, then the lengths and elevations of the reinforcement should be shown. Bearing pressures are usually shown as well as minimum embedment below finished grade. A good plan set should include:

1. Plan layout
2. Assumed soil conditions used in the design
3. Possible obstruction/utility clearance views
4. Location of terraced walls
5. Design loads (live load or dead load surcharges)
6. Surface and subsurface groundwater conditions
7. Geometry or conditions that would require a global stability analysis
8. Seismic design requirements
9. Contract quantities (face area, reinforcement quantities)

When the project is completed, any notes from inspection or construction should be added to the plan set and archived with the completed project file.

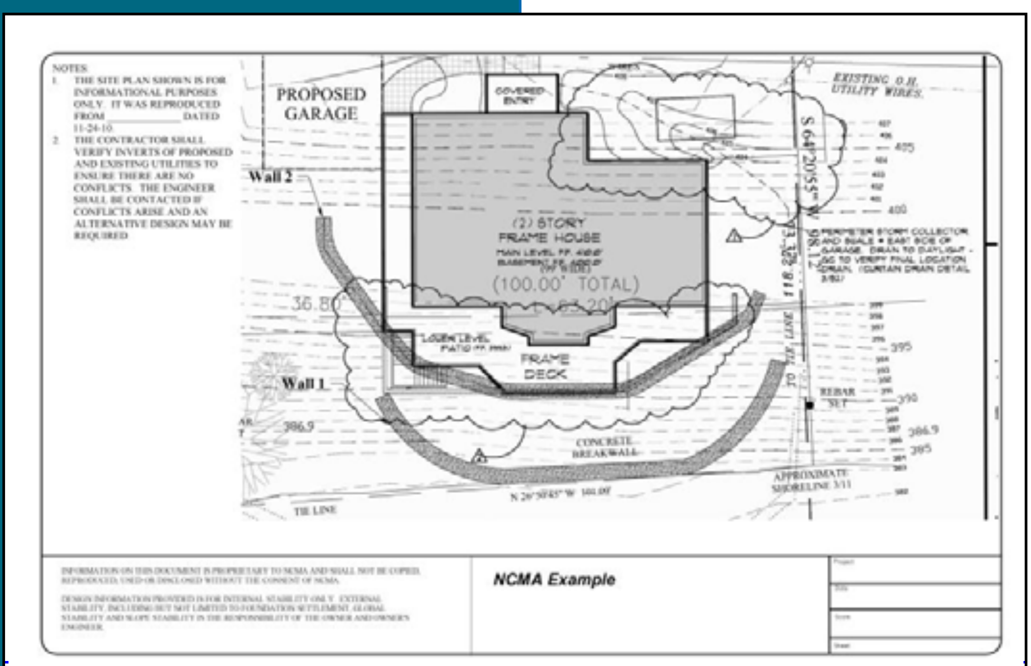


Figure 3a. Example Contract Drawing

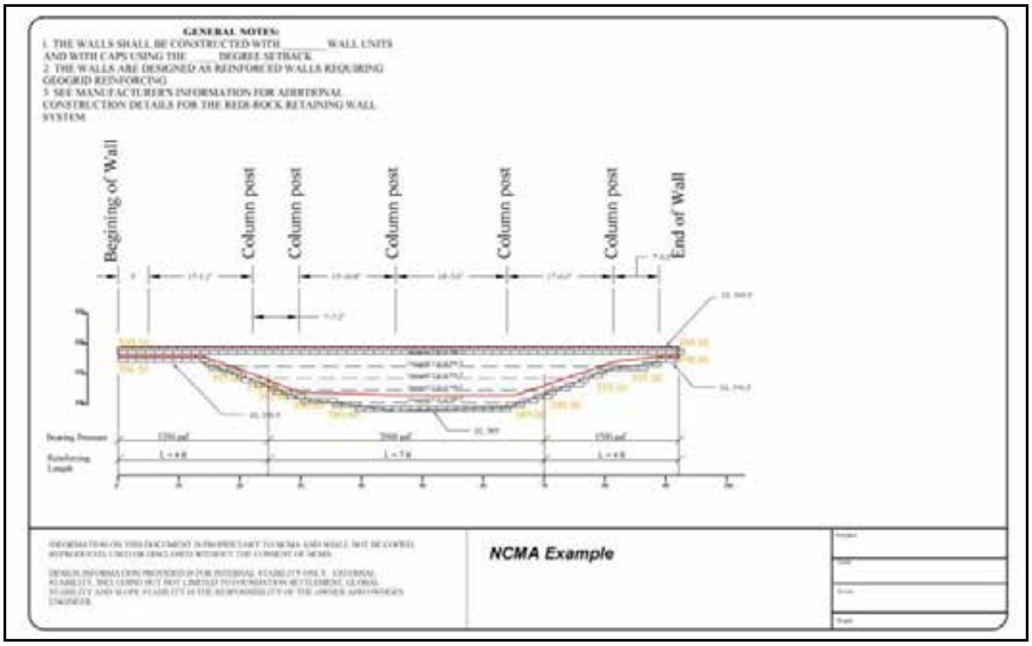


Figure 3b. Example Contract Drawing

CONFIRM SITE CONDITIONS

The most important item for the contractor and inspector is to confirm the design provided for the site is based on the site layout, conditions and materials found at the site. For instance, if the reinforcing is 10 ft (3 m) long and the wall is 5 ft (2.5 m) off the property line, the wall cannot be built and the inspector should note that on the plans. If the on-site material is specified as the backfill material and the design calls for a silty sand with a friction angle of 28°, then a clay soil (lower permeability, lower strength) on site would not meet the design requirements and should be noted. If the foundation bearing loads are 3,000 psf (140 kN/sm) but the foundation soils are soft, then the foundation conditions should be rejected and corrective measures taken. As a note to the inspector, it is a good practice to collect representative soil samples and have a geotechnical laboratory analyze the native soil to verify that the soil meets the design criteria.

The location of the wall should be confirmed/approved by the owner prior to construction (plan location, elevations). The location of the wall should also confirm location of utilities and other possible obstructions within the wall's footprint.

Groundwater and control of the sources for groundwater should also be investigated. In cut situations (a design where the wall is cut into an existing slope) there may be seams in the back-cut that could be flow channels for groundwater. If groundwater is noted, then this information should be passed on to the design engineer and the contractor.

Another item to be aware of is underground utilities and pipe trenches. Although the ground may appear to be firm, the backfill in utility trenches may not have been well compacted and the loading from the SRW retaining wall can cause settlement into the trench area. The settlement can be a dip in the wall or if the trench is parallel to the wall, the wall can settle into the trench. Again, a condition noted by the inspector that should be documented and relayed to the design engineer for consideration.

CONFIRM THE FOUNDATION AND LEVELING PAD

In typical contract documents the item [3.02 Foundation Preparation] calls for inspection of the foundation soils after the excavation for the leveling pad has been made. If the inspector or Owner's Engineer determine the soils are not capable of supporting the design load, corrective measures will be required. It is important the construction be started correctly on a firm foundation. Any corrective action required after construction begins requires the wall to be removed and to start again at the foundation level.

The leveling pad is either a crushed stone or unreinforced concrete. The purpose of the leveling pad is to provide a level surface to begin the wall construction, but it also

Figure 4. Leveling Pad and First Block Installation

serves as a structural element to distribute the bearing load of the SRW units to the foundation soils. If the leveling pad is not a sufficient depth or width, the concrete units may settle into the foundation soils and could cause the wall to lean forward. The requirement for and placement of the leveling pad is important for wall performance and should be noted in the inspection reports.

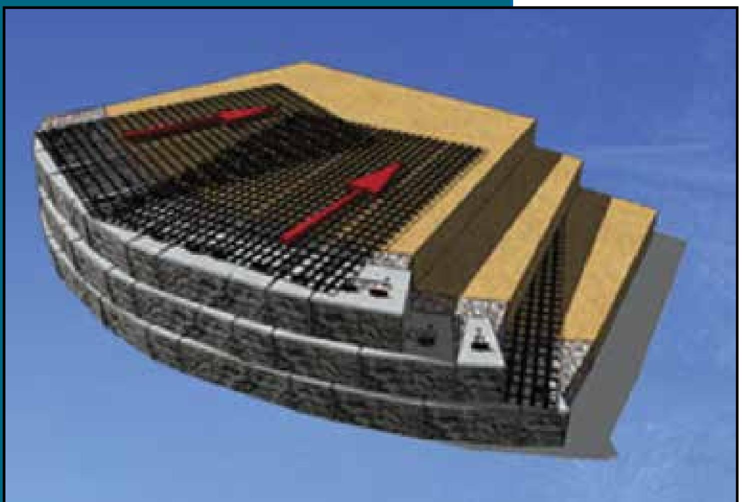


Figure 5. Example of Manufacturer Recommendations for Curves

SRW UNIT PLACEMENT

SRW unit placement is usually covered by the manufacturer's recommendations because there are many unit types. The recommendation will include:

1. Unit placement
2. Pins, clips, lugs, or lips for alignment
3. Wall batter is a function of pin/clip placement
4. Tips for aligning the units
5. Leveling the units front to back
6. Leveling the units side to side
7. Placement of geogrid (use of pins, clips, or connector pieces)
8. Placement of unit fill
9. Placement and attachment of the cap units (pinning, clipping, gluing)

Even SRW Units meeting the specifiction may have some height inconsistences that need to be corrected during construction. It is acceptable in those cases to shim or grind the SRW units. Asphalt shingles or geogrid pieces work well when shimming is necessary but they should be installed to appropriately distribute the load of the upper course. The maximum allowable shim thickness is $^1/_8$ in. (3 mm).

These recommendations should be included in the contract documents, but may only be referenced as "in accordance with manufacturer's recommendations." In either case, the manufacturer recommendations should be included with the contract documents and provided as a reference to the inspector during construction.

BACKFILL PLACEMENT AND COMPACTION

The contract documents are based on "best practices" for SRW construction, specifying construction items that have proven to work well in the past and provide a level of performance expected. The maximum lift thickness for fill soils is 8 in. (200 mm). Compaction should be accomplished in a predetermined number of passes of compaction equipment and should be verified by on-site compaction testing. Only hand-operated compaction equipment should be allowed within 3 ft (914 mm) of the back of wall face, preferably a vibrating plate compactor with a minimum weight of 250 lb (113 kg), if smaller equipment is used lift heights may need to be smaller to reach the specified densities. The specifications call for a density of 95% of the standard Proctor design at a moisture content of -1% to +3% of the optimum water content. Inspection should note the method of compaction and compaction equipment. Test reports should be kept to confirm the soils tested met the design requirements. If the method of compaction (lift thickness, soil type, number of passes, etc.) change, additional compacted tests should be taken to confirm the required densities are being "consistently" achieved. QA on backfill placement and compaction requires a consistent pattern of placement and a consistent method of compaction along with a known source of backfill material.

Figure 6. Compaction Process

As we noted in the Article 7 SRW Construction, compaction testing does not confirm all the soils are well compacted, it only confirms the top of the soil lift was compacted in the exact location where the test was taken. It should be the responsibility of the contractor, confirmed by the inspector, to make sure a consistent compaction method is used over the entire area and the random compaction tests confirm consistent results.

SOIL REINFORCEMENT PLACEMENT

Geogrid reinforcement is an important element in reinforced SRW design and construction as it provides the tensile elements in mechanically stabilized earth construction. Three elements are important in construction:

1. Design strength
2. Orientation and placement
3. Vertical spacing

Section 3.05, SRW and Geosynthetic Reinforcement Placement, of the NCMA example specification calls out that the reinforcement be placed horizontal at the proper elevations, the proper orientation, and in the manner recommended by the manufacturer. The reinforcing should be pulled taut to remove any looseness in the material and the backfill soils should be placed from the face toward the tail of reinforcement to tension the layer during compaction. Geogrid pieces should be placed side by side without overlapping at the facing and if they overlap in the back (curves and corners) 3 in. (8 mm) of soil should be included between layers (see Figure 7, which illustrates a poor installation). The principal direction of the geogrid (strength direction) should also be kept perpendicular to the facing blocks in all locations, including curves and corners following the manufacturer's recommended details.

Figure 7. Improperly Placed Geogrid (geogrid is being overlapped at the face and without soil between geogrid sheets)

The strength of the material may not be obvious from looking at the material, but as the material is delivered, the packaging should indicate the geogrid designation. This should be recorded and the labels kept as part of the construction record.

The strength direction of the geogrid material should be in the roll direction. Placement of the material should be from the wall face rolling the material out toward the depth of the cut (See Figure 8).

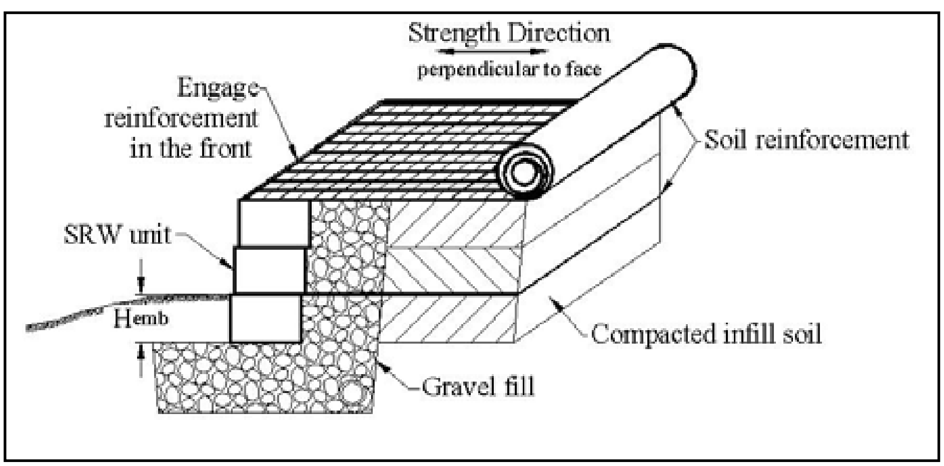


Figure 8. Geogrid Placement on the Strength Direction

CONSTRUCTION TOLERANCE

Construction tolerance may not be called out in the specifications, but it is an important part of the finished wall appearance. Figure 9 is an excerpt from NCMA TEK 18-11B. In tolerance specifications, the alignment from the vertical proposed batter line is important. Walls that have a negative batter are not pleasant to look at but may be structurally stable. It is important to note this during construction inspection and get it corrected when first noted. Horizontal alignment is also important and procedures should be put in place during construction to provide guidance to the construction crew and avoid discrepancies. The vertical and horizontal alignment can be adjusted as the wall is constructed so notification to the owner is important. Again, the wall may be structurally stable but have aesthetic problems that could have been solved during the construction process.

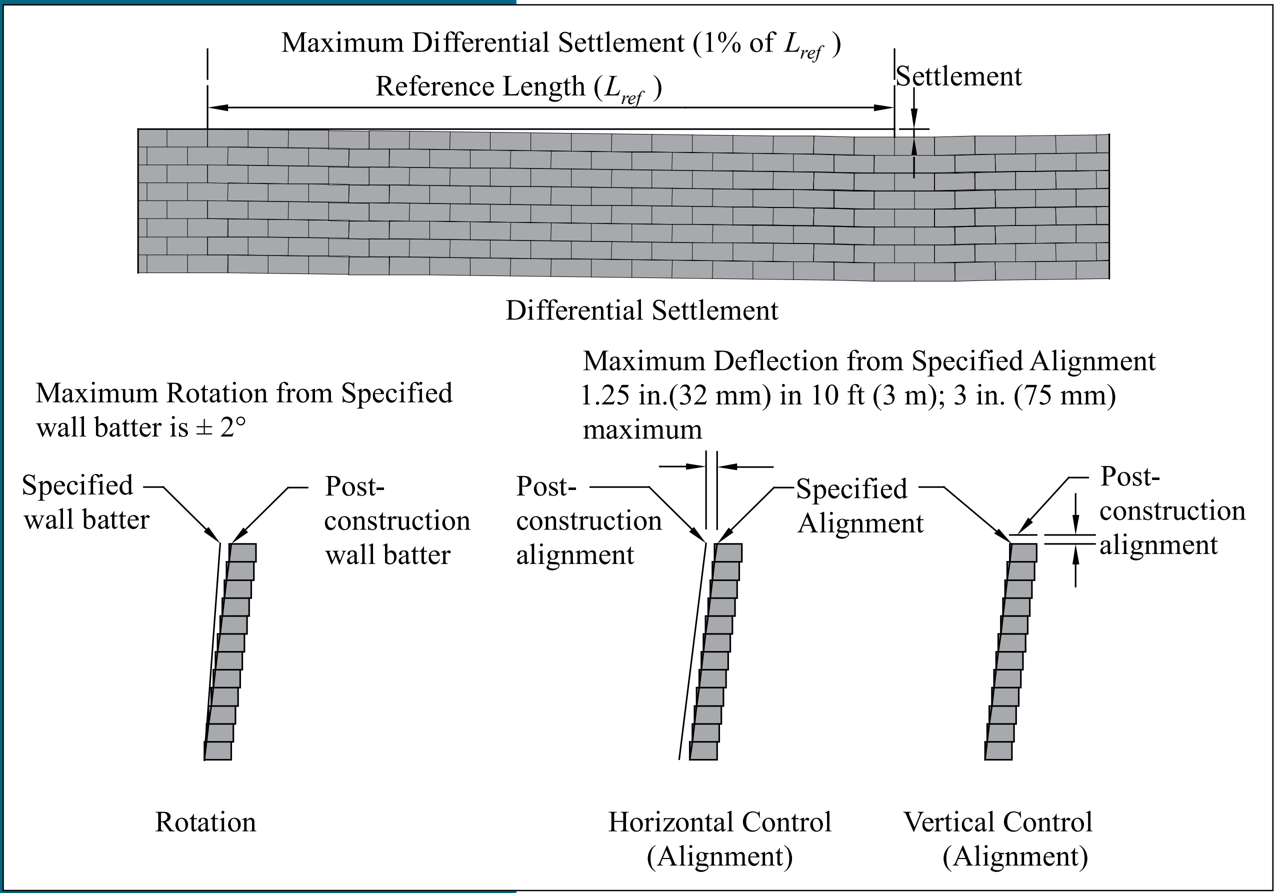


Figure 9. Construction Tolerances

SUMMARY

Inspection should be required on all wall construction, whether it is a residential wall or a commercial wall construction. The frequency of inspections may be dictated by special provisions of the building code, the contract documents or by the Owner depending on the needs of the project. With a good system of QC by the Contractor and good QA by the Owner or Owner's representatives, an aesthetically pleasing, structurally sound, and long-lasting SRW retaining wall can be attained as the final product (see the successful application on Figure 10).

Figure 10. Commercial SRW Application

REFERENCES

1. Design Manual for Segmental Retaining Walls, 3rd Ed., TR 127B, National Concrete Masonry Association, Herndon, VA. 2009.
2. Race, R, "Article 5: SRW Specifications," NCMA SRW Market History Series, NCMA, 2012.
3. Race, R., "Article 7: Construction," NCMA SRW Market History Series, NCMA 2015.
4. Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m-m^3)), ASTM D 698, ASTM International.
5. Standard Method for Particle Size Analysis of Soils, ASTM D 422, ASTM International, 2007.
6. Segmental Retaining Wall Installation Guide, TR-146, National Concrete Masonry Association, Herndon, VA 2010.
7. TEK 15-5B, Segmental Retaining Wall Design, National Concrete Masonry Association, Herndon, VA 2010.
8. TEK 18-11B, Inspection Guide For Segmental Retaining Walls, National Concrete Masonry Association, Herndon, VA 2012.