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GUIDE TO SEGMENTAL RETAINING WALLS

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INTRODUCTION

Segmental retaining walls (SRWs) are gravity retaining walls that rely primarily on their mass (weight) for stability. The system consists of concrete masonry units which are placed without the use of mortar (dry stacked), and which rely on a combination of mechanical interlock, unit to unit interface friction or shear capacity and mass to prevent overturning and sliding. The units may also be used in combination with horizontal layers of soil reinforcement which extend into the backfill to increase the effective width and weight of the gravity mass.

Segmental retaining walls are considered flexible structures, so the footing does not need to be placed below the frost line provided there is sufficient foundation bearing capacity.

SRW units are manufactured in conformance with industry standards and specifications to assure that units delivered to a project are uniform in weight, dimensional tolerances, strength, and durability—features not necessarily provided in site cast materials.

SYSTEM ADVANTAGES

Segmental retaining walls afford many advantages; among which are design flexibility, aesthetics, economics, ease of installation, performance and durability.

Design flexibility: The SRW system is composed of units whose size and weight makes it possible to construct walls in the most difficult of locations. Curves and other unique layouts can be easily accommodated. Segmental retaining walls have the ability to function equally well in large-scale applications (highway walls, bridge abutments, erosion control, parking area supports, etc.) as well as smaller residential landscape projects.

Aesthetics: Since SRW units are available in a variety of sizes, shapes, textures and colors, segmental retaining walls provide designers and owners with both an attractive and a structurally sound wall system. Figure 1 illustrates some of the units available.

Economics: SRWs provide an attractive, cost effective alternative to conventional cast-in-place concrete retaining walls. Savings are gained because on-site soil can usually be used eliminating costs associated with importing fill and/or removing excavated materials, and because there is no need for extensive formwork or heavy construction equipment.

Ease of installation: Most SRW units can be placed by a single construction worker. The dry stack method of laying units without mortar allows erection of the wall to proceed rapidly.

Performance: Unlike rigid retaining wall structures, which may display cracks when subjected to movement, the flexible nature of segmental retaining walls allows the units to move and adjust relative to one another without visible signs of distress.

Durability: Segmental units are manufactured of high compressive strength, low absorption concrete which helps make them resistant to spalling, scour, abrasion, the effects of freeze-thaw cycles, rot, and insect damage.

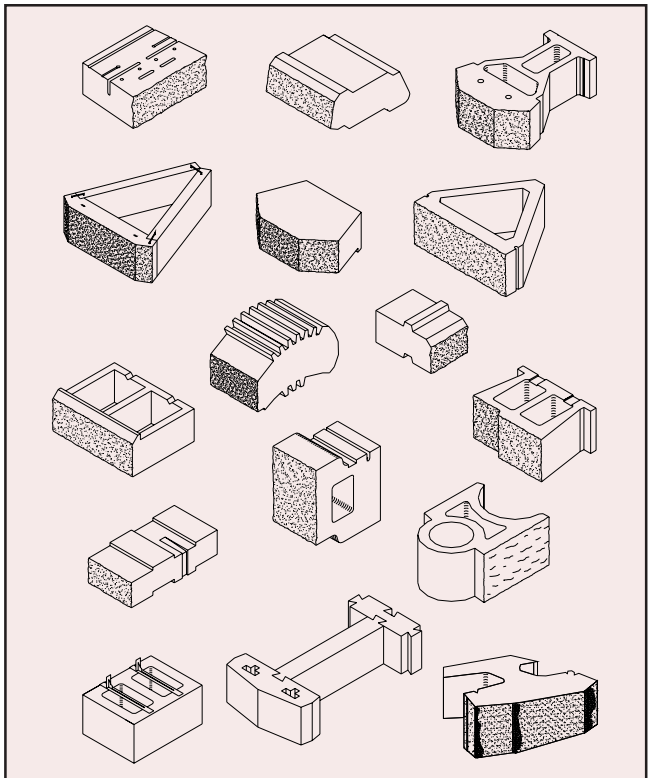

Figure 1—Examples of Segmental Retaining Wall Units

WALL TYPES

Segmental retaining walls can be designed as either conventional or as reinforced soil, as illustrated in Figure 2. The structural capacity of the SRW system will vary with the SRW unit size, shape, batter, etc. Manufacturers recommendations should be followed regarding the capacity of their particular system for the soil loads under consideration.

Conventional

Conventional SRWs are constructed with either single or multiple depths of units. For stability, the conventional SRW structure must have sufficient mass to prevent both sliding at the base and overturning about the toe of the structure. Since the system consists of individual units dry stacked one atop another, shear capacity is an important component to assure that the units act together as a coherent mass.

Shear capacity provides a means of transferring lateral forces from each course to the succeeding course. This is provided by the frictional resistance between SRW units; and in the form of "keys" or leading/trailing lips which are an integral part of the units; or by the use of clips, pins, or compacted columns of aggregate placed in the open cores (Figure 3).

Structural stability of the SRW can be increased by increasing the wall batter. Batter is achieved through the setback between SRW units from one course to the next. In most cases, the batter is controlled by the location of shear pins or leading/trailing lips (Figure 3), however, some systems allow some adjustment to the batter.

Taller walls can also be achieved by using multiple depths of units, shown in Figure 2a. The multiple depths of units increase the weight of the wall system and provide a more stable base and greater resistance to soil pressures.

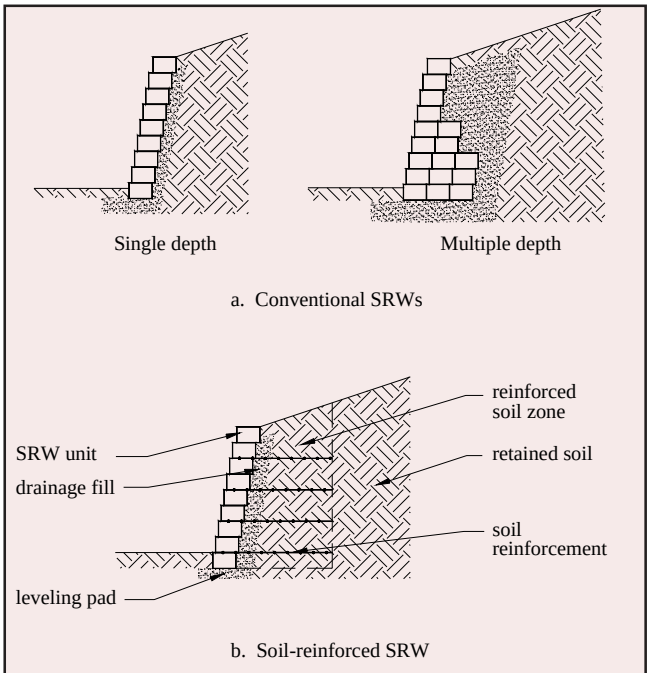

Figure 2—Segmental Retaining Wall Systems

Reinforced Soil

Reinforced soil walls should be specified when the maximum height for conventional gravity walls is exceeded or when lower structures are surcharged by sloping backfills, live loads, and/or have poor foundations. A reinforced soil SRW is designed and constructed with multiple layers of soil reinforcement placed between the SRW courses and extending back into the soil behind the wall at designated heights and lengths as shown in Figure 2b. The geosynthetic reinforcement and the soil in the reinforced zone acts as a composite material, effectively increasing the size and weight of the gravity wall system.

SYSTEM COMPONENTS

The basic elements of each segmental retaining wall system are the foundation soil, leveling pad, segmental retaining wall units, retained soil, drainage fill, and, for reinforced soil SRWs, the soil reinforcement.

Foundation soil: The foundation soil is the soil which supports the leveling pad and the reinforced soil zone of a soil-reinforced SRW system.

***Leveling pad*:** The leveling pad is a level surface, consisting of crushed stone or unreinforced concrete, which distributes the weight of the SRW units over a wider area and provides a working surface during construction. The leveling pad typically extends typically 6 in. (152 mm) from the toe and heel of the lowermost SRW unit and is at least 6 in. (152 mm) thick.

Segmental retaining wall units: Segmental retaining wall units are concrete masonry units that are used to create the mass necessary for structural stability, and to provide stability, durability, and visual enhancement at the face of the wall.

Retained soil: Retained soil is the undisturbed soil for cut walls or the common backfill soil compacted behind infill soils.

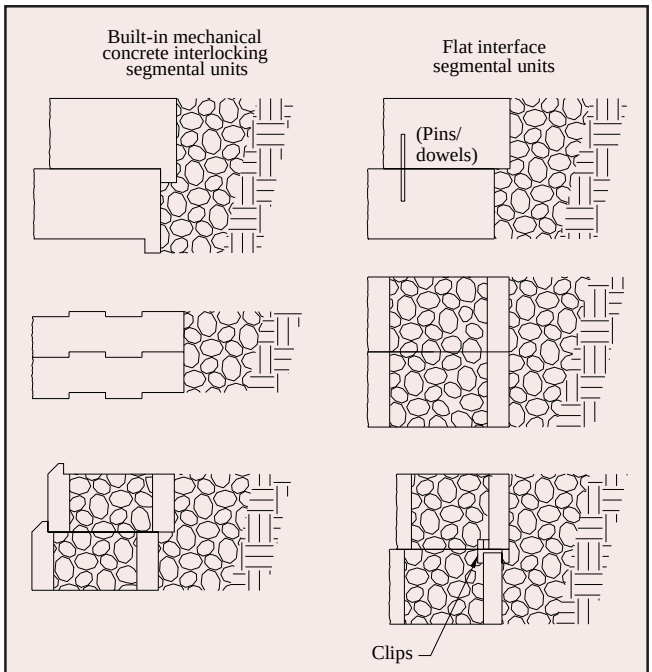

Figure 3—Shear Connectors for SRW Units

Drainage fill: Drainage fill is free-draining granular material placed behind the wall to facilitate the removal of groundwater and minimize buildup of hydrostatic pressure on the wall (ref. 4). It is sometimes also used to fill the cores of the units to increase the weight and shear capacity. The dry stacked method of construction used for segmental retaining walls permits water to drain through the face of the wall, aiding in the removal of groundwater. In some cases, a geotextile filter is installed between the drainage fill and the infill to protect the drainage fill from clogging.

Reinforced soil: Reinforced soil is compacted structural fill used behind soil-reinforced SRW units which contains horizontal soil reinforcement. A variety of geosynthetic soil reinforcement systems are available.

DESIGN CONSIDERATIONS

Typical designs and specifications for segmental retaining walls should be prepared by a designer who has technical knowledge of soil and structural mechanics. Each SRW unit manufacturer can provide design information tailored to that product, which will indicate the wall heights and design conditions when an SRW should be designed by a qualified engineer. In addition, SRW systems should be designed by a qualified engineer when:

- structures will be surcharged
- walls will be subjected to live loads
- walls will be founded on poor foundations
- the nature of the design conditions requires special consideration.

The following general site information should be provided:

- a wall profile, including the grade at the top and bottom of the wall, the physical elevation of the top and bottom of the structure to be retained, and the variation of the design section along the height of the wall,
- a description of the infill, foundation, and retained soils,
- a wall plan, which should include geometry for curved wall lengths and the proximity to any existing or proposed surcharges, structures, or utilities that may affect wall construction or performance. Ends of the wall should be designed with consideration of how surface water flow is directed around the wall ends to prevent erosion.

This data should be sufficiently accurate to develop an efficient, safe, and cost-effective structural design.

GUIDE SPECIFICATIONS

Guide specifications for segmental retaining walls are available in standard Construction Specifications Institute (CSI) format in the *Design Manual for Segmental Retaining Walls*, (ref. 1). Two guides are presented: a materials specification (product/method) and an end-result specification (design/build).

The traditional product/method specification, designating materials and installation requirements, stipulates that a site-specific design be performed by the engineer. Designs should be such that specified SRW and soil reinforcement properties can be met by a number of manufacturers, and should include properties of the on-site soil. SRW and soil reinforcement properties are then specified as the minimum properties that must be met.

The end-result specification can be used to solicit proposals from various segmental retaining wall suppliers. Each supplier is then required to furnish a project-specific engineering design for that supplier's particular system. This type of specification requires one source, experienced in the design and construction of SRWs, to be responsible for the wall and assures it will be built economically due to competition.

In addition, the specification for SRW units may be found in ASTM C 1372-04, *Standard Specification for Segmental Retaining Wall Units* (ref. 3).

CONSTRUCTION

The success of any segmental retaining wall installation depends on complete and accurate field information, careful planning and scheduling, the use of specified materials, proper construction procedures, and inspection.

It is good practice to have the retaining wall location verified by the owner's representative. Existing and proposed finish grades shown on the drawings should be verified to ensure the planned design heights are in agreement with the topographic information from the project grading plan.

The contractor should coordinate the delivery and storage of materials at the site to ensure unobstructed access to the work area and availability of materials. Materials delivered to the site should be accompanied by the manufacturer's certification that the materials meet or exceed the specified minimum requirements.

Construction occurs in the following sequence:

1. excavation and leveling pad construction
2. setting, leveling, and backfilling base course
3. placement and backfilling of units in succeeding courses
4. placement, tensioning, and backfilling of soil reinforcement (when required)
5. compaction of backfill to the specified density
6. capping and finish grading.

As with any structure used to retain soil, careful attention should be paid to the compaction equipment and procedures used during construction. When compacting soil within 3 ft (0.9 m) of the front face of a wall, compaction tools should be limited to hand operated equipment, preferably a vibrating plate compactor. Reinforced soil can be compacted with walk-behind or self-propelled riding compaction equipment.

REFERENCES

1. *Design Manual for Segmental Retaining Walls*, Second Edition. National Concrete Masonry Association, 1997.
2. Simac, M. R. and J. M. Simac, "Specifying Segmental Retaining Walls", *Landscape Architecture*, March 1994.
3. *Standard Specification for Segmental Retaining Wall Units*, ASTM C 1372-04. American Society for Testing and Materials, 2004.
4. *Segmental Retaining Wall Drainage Manual*. National Concrete Masonry Association, 2004.

GLOSSARY OF COMMONLY USED TERMS

Batter	The facing angle created by SRW unit setback, measured from a vertical line drawn from the toe of the wall. Typical batter angles are 3° to 15° from vertical, sloping toward the infill soil.
Drain rock	Drainage fill placed within and immediately behind the SRW units, and in other areas for drainage.
Drainage composite	A system, usually comprised of a dimpled plastic core with a geotextile fabric applied to prevent soil from clogging the drainage area. It is used to collect water usually behind the backfill, under the reinforced soil zone, or immediately under the SRW system.
Foundation soil	The soil which supports the leveling pad and the reinforced soil zone of a soil-reinforced SRW system.
Geogrid	A synthetic material formed into a grid-like structure for use in soil reinforcement. Usually comprised of polypropylene, polyester or polyethylene.
Geosynthetic	A generic term used to describe synthetic or plastic materials used in soil, such as fabrics, geogrids, drainage composites and erosion control mats.
Geotextile	A textile-like material used in soil drainage and reinforcement applications. Usually comprised of polypropylene or polyester, it can be woven or nonwoven.
Global stability	Resistance to overall mass movement of the SRW system in a circular mode. May be a problem of tiered walls, walls with weak foundation soils, and walls with a slope at the top or bottom.
HDPE	High density polyethylene. Usually refers to the material used to manufacture drain pipe or geogrid.
Infill	Soil located behind the SRW units and drainage fill. May be reinforced with soil reinforcement.
Leveling pad	The level surface, consisting of crushed stone or unreinforced concrete, which distributes the weight of the SRW units over a wider area and provides a working surface during construction.
Long term design strength	The allowable strength in the soil reinforcement at the end of the service life of the soil-reinforced SRW. It is the maximum load that the reinforcement can carry and is taken into account in the design process.
MSE	Mechanically stabilized earth. Soil-reinforced SRWs are considered MSE structures.
Overturning	An external stability failure mechanism of an SRW whereby lateral external forces cause the entire reinforced soil mass to rotate about the base.
Permeable	The ability of a material to pass water.
f Angle	Describes the internal friction angle or strength of a particular soil material. Usually expressed in degrees.
Proctor (density)	A method used to determine the compaction or density of soil materials.
PVC	Polyvinyl chloride. Usually refers to the material used to manufacture drain pipe.
Reinforced soil zone	The area of a soil-reinforced SRW which contains the soil reinforcement.
Retained soil	The undisturbed soil for cut walls or the common backfill soil compacted behind infill soils.
Sliding	An external stability failure mechanism of an SRW whereby lateral external forces cause the entire soil mass to slide forward along its base or internally along a particular layer of soil reinforcement.
Soil-reinforced	An SRW which uses soil reinforcement to increase the mass of the SRW, thereby increasing stability.
Surcharge	External load, usually applied at the top of an SRW. A roadway or building foundation can be a surcharge.
Swale	A small ditch or depression formed on top and behind the SRW system to collect water and carry it away.