SEGMENTAL RETAINING WALL UNITS

INTRODUCTION

Mortarless segmental retaining walls are a natural enhancement to a variety of landscape projects. Applications range from 8 in. (204 mm) high terraces for erosion control to retaining walls 20 ft (6.1 m) or more in height. The individual concrete units can be installed to virtually any straight or curved plan imaginable.

Segmental retaining walls are used to stabilize cuts and fills adjacent to highways, driveways, buildings, patios and parking lots, and numerous other applications. Segmental retaining walls replace treated wood, cast-in-place concrete, steel, and other retaining wall systems because they are durable, easier and quicker to install, and blend naturally with the surrounding environment. Concrete units resist deterioration when exposed to the elements without the addition of toxic additives which can threaten the environment.

A variety of surface textures and features are available, including split faced, stone faced, and molded face units, any one of which may be scored, ribbed, or colored to fit any project application. Construction of segmental retaining walls does not require heavy equipment access, nor does the system require special construction skills to erect. Manufactured concrete retaining wall units generally weigh 30 to 100 lb (14 to 45 kg) each and are placed by hand on a level or sloped gravel bed.

Successive courses are stacked dry on the course below in the architectural pattern desired. Mechanical interlocking and/or frictional shear strength between courses resists lateral soil pressure. In low-height walls, overturning forces due to soil pressure are resisted by the weight of the units, sometimes aided by an incline toward the retained soil. Higher walls resist lateral soil pressures by inclining the wall toward the retained earth, or by other methods such as anchoring to geosynthetic reinforcement embedded in the soil. Further information on the design of segmental retaining walls can be found in *Design Manual for Segmental Retaining Walls* (ref. 1).

Tall walls used to create additional buildable space

Residential landscaping incorporating SRW retaining walls, seat walls, and fireplace

Figure 1—Examples of Segmental Retaining Wall Installations

Segmental retaining wall units are factory-manufactured to quality standards in accordance with ASTM C1372, *Standard Specification for Segmental Retaining Wall Units* (ref. 2). These requirements are intended to assure lasting performance, little or no maintenance, structural integrity, and continued aesthetic value.

Segmental retaining wall units complying with the requirements of ASTM C1372 have been successfully used and have demonstrated good field performance. Segmental retaining wall units currently being supplied to the market should be produced in accordance with this standard so that both the purchaser and the supplier have the assurance and understanding of the expected level of performance of the product.

ASTM C1372 covers both solid and hollow units which are to be installed without mortar (dry-stacked). Units are designed to interlock between courses or to use mechanical devices to resist sliding due to lateral soil pressure. If particular features are desired, such as a specific weight classification, higher compressive strength, surface texture, finish, color, or other special features, they should be specified separately by the purchaser. However, local suppliers should be consulted as to the availability of units with such features before specifying them.

Materials

ASTM C1372 includes requirements that define acceptable cementitious materials, aggregates, and other constituents used in the manufacture of concrete segmental retaining wall units. These requirements are similar to those included in ASTM C90, *Standard Specification for Loadbearing Concrete Masonry Units* (ref. 3).

Compressive Strength

Minimum compressive strength requirements for segmental retaining wall units are included in Table 1. Units meeting or exceeding these strengths have demonstrated the integrity needed to resist the structural demands placed on them in normal usage. These demands include impact and vibration during transportation, the weight of the units above them in the wall, nonuniform distribution of loads between units, and the tensile stresses imposed as a result of typical wall settlement.

Segmental retaining wall units will not fail in service due to compressive forces since axial loads are only a result of self-weight. Due to the direct relationship between compressive strength and tensile strength, this minimum requirement is used to ensure overall performance.

Compressive strength testing of full size units is impractical due to the large size and/or unusual shape of some segmental retaining wall units. Therefore, compressive strength of these units is determined from testing coupons cut from the units. The results of tests on these smaller coupons will typically yield lower strengths than if the larger, full-size specimen were tested. The reason for the difference is size and aspect ratio. However, it is important to keep in mind that the compression test is not intended to determine the load-carrying capacity of the unit, since segmental retaining walls are not designed to carry vertical structural loads. Compressive strength is used solely to assess the quality of the concrete.

Because tested strengths are affected by size and shape of the specimen tested, it is important that all retaining wall units be tested using a similar size and shape. ASTM C140/C140M, *Standard Method for Sampling and Testing Concrete Masonry Units and Related Units* (ref. 4) requires that specimens cut from full-size units for compression testing must be a coupon with a height to thickness ratio of 2 to 1 before capping and a length to thickness ratio of 4 to 1. The coupon width is to be as close to 2 in. (51 mm) as possible based on the configuration of the unit and the capacity of the testing machine, but not less than 1.5 in. (38 mm). The preferred size is 2 x 4 x 8 in. (51 x 102 x 203 mm) (width x height x length). The coupon height is to be in the same direction as the unit height dimension. If these procedures are followed, the compressive strength of the coupon is considered the strength of the whole unit.

Alignment of the specimen in the compression machine is critical. Care should be taken in capping the test specimen to assure that capping surfaces are perpendicular to the vertical axis of the specimen. Capping needs to be performed in accordance with ASTM C1552, *Standard Practice for Capping Concrete Masonry Units, Related Units and Masonry Prisms for Compression Testing* (ref. 5).

Saw-cutting is the required method of extracting a test specimen from a full-size unit. Proper equipment and procedures are essential to prevent damaging the test specimen as a result of saw-cutting. Water-cooled, diamond-tipped blades on a masonry table saw are recommended. The blade should ideally have a diameter sufficient enough to make all cuts in a single

Table 1—Strength and Absorption Requirements (ref. 2)

Minimum required net average compressive strength psi (MPa)		Maximum water absorption requirements lb/ft³ (kg/m³) for weight classifications[a] of:		
Average of 3 units	Individual unit	Lightweight < 105 pcf (< 1,682 kg/m³)	Medium weight 105 to < 125 (1,682 to < 2,002 kg/m³)	Normal weight ≥ 125 pcf (≥ 2,002 kg/m³)
3,000 (20.68)	2,500 (17.24)	18 (288)	15 (240)	13 (208)

[a] Based on oven-dry density of concrete.

pass. Manufacturers of the unit (or licensors of proprietary shapes) should be consulted about recommended locations for obtaining the compression specimen.

Weight Classification

Weight classifications for segmental retaining wall units are defined in Table 1. The three classifications, lightweight, medium weight, and normal weight, are a function of the oven dry density of the concrete. Most segmental retaining wall units fall into the normal weight category.

Absorption

Absorption requirements are also included in Table 1. This value is used to represent the volume of voids in a concrete masonry unit, including voids inside the aggregate itself. The void space is measured by determining the volume of water that can be forced into the unit under the nominal head pressure that results from immersion in a tank of water.

Lightweight aggregates used in the production of lightweight and medium weight units contain voids within the aggregate itself that also fill with water during the immersion test. While reduced voids indicate a desired tightly compacted unit, tightly compacted lightweight and medium weight units will still have higher absorption due to the voids in the aggregates. For this reason the maximum allowable absorption requirements vary according to weight classification.

Similar to compression testing, it generally is not practical to test full-size retaining wall units in absorption tests due to their size and weight. Therefore, ASTM C140/C140M permits the testing of segments saw-cut from full-size units to determine absorption and density. When reduced-size units are used for absorption testing, the reduced-size specimen must have an initial weight of at least 20% of the full-size unit weight. This is intended to ensure that a sufficiently sized specimen is tested in order for the results to be representative of the entire unit.

Absorption limits are typically expressed as mass (weight) of water absorbed per concrete unit volume. This is preferred to expressing by percentage which permits a denser unit to absorb more water than a lighter weight unit.

Testing larger specimens requires particular attention to drying times, because it takes a greater length of time to remove all moisture from larger masses. ASTM C140/C140M requires that specimens be dried for a period of not less than 24 hours at a temperature of at least 221°F (105°C). The 24-hour time period does not start until the oven reaches the specified temperature. When placing larger specimens in an oven, it may take several hours for the oven to reach the prescribed temperature. ASTM C140/C140M then requires that specimen weights be determined every two hours to make sure that the unit is not still losing water weight (maximum weight loss in two hours must be less than 0.2% of the previous specimen weight). This will require 48 hours or more for some specimens. If not adequately dried, reported absorptions will be lower than the actual value.

Permissible Variations in Dimensions

Mortarless systems require consistent unit heights to maintain vertical alignment and level of the wall. For this reason, permissible variation in dimensions is limited to $\pm 1/8$ in. (3.2 mm) from the specified standard dimensions. Regarding dimensions, “width” refers to the horizontal dimension of the unit measured perpendicular to the face of the wall. “Height” refers to the vertical dimension of the unit as placed in the wall. “Length” refers to the horizontal dimension of the unit measured parallel to the running length of the wall.

Dimensional tolerance requirements for width are waived for split faced and other architectural surfaces. The surface is intended to be rough to satisfy the architectural features desired and cannot be held to a specific tolerance.

Finish and Appearance

Minor cracks incidental to the usual method of manufacture or minor chipping resulting from customary methods of handling in shipment and delivery are not grounds for rejection. Units used in exposed wall construction are not to show chips or cracks or other imperfections in the exposed face when viewed from a distance of not less that 20 ft (6.1 m) under diffused lighting. In addition, up to five percent of a shipment are permitted to: contain chips on the finished face not larger than 1 in. (25.4 mm) in any dimension; contain cracks on the finished face wider than 0.02 in. (0.5 mm) and longer than 25% of the nominal height of the unit; have dimensions outside the permissible dimensional variations; or be broken.

Freeze-Thaw Durability

Segmental retaining wall units may be used in aggressive freezing and thawing environments. Freeze-thaw damage can occur when units are saturated with water and then undergo temperature cycles that range from above to below the freezing point of water. Freezing and thawing cycles and a constant source of moisture must both be present for potential damage to occur.

Many variations can exist in exposure conditions, any of which may affect the freeze-thaw durability performance of the units. Such variations include: maximum and minimum temperatures, rate of temperature change, duration of temperatures, sunlight exposure, directional facing, source and amount of moisture, chemical exposure, deicing material exposure, and others.

When units are used in applications where freezing and thawing under saturated conditions can occur, ASTM C1372 includes three different methods of satisfying freeze-thaw durability requirements:

1. Proven field performance,
2. Five specimens shall have less than 1% weight loss after 100 cycles in water using ASTM C1262 (ref. 6), or
3. Four of five specimens shall have less than 1.5% weight loss after 150 cycles in water using ASTM C1262.

Segmental retaining wall units in many areas of the country are not exposed to severe exposures. Therefore, the requirements above apply only to “areas where repeated freezing and thawing under saturated conditions occur.”

Freeze-thaw durability tests are conducted in accordance

with ASTM C1262, *Standard Test Method for Evaluating the Freeze-Thaw Durability of Dry-Cast Segmental Retaining Wall Units and Related Concrete Units*, (ref. 6) using water or saline as the test solution. For most applications, tests in water are considered sufficient. If the units will be exposed to deicing salts on a regular basis, consideration should be given to performing the tests in saline. However, no pass/fail criteria has been adopted by ASTM for saline testing.

Compliance

ASTM C1372 also provides guidance regarding compliance. If a sample fails, the manufacturer can remove or cull units from the shipment. Then a new sample is selected by the purchaser from the remaining units of the shipment and tested, which is typically paid for by the manufacturer. If the second sample passes, then the remaining units of the lot being sampled are accepted for use in the project. If the second sample fails; however, the entire lot represented by the sample is rejected.

The specification also provides guidance on responsibility for paying for the tests. Unless otherwise provided for in the contract, the purchaser typically pays for the testing if the units pass the test. However, if the units fail the test, the seller bears the cost of the testing. See SRW-TEC-007-15, *Sampling and Testing Segmental Retaining Wall Units* (ref. 7) for more detailed information on SRW unit sampling, testing, and acceptance.

REFERENCES

1. *Design Manual for Segmental Retaining Walls*, 3rd edition, SRW-MAN-001-10, Concrete Masonry & Hardscapes Association, 2010.
2. *Standard Specification for Dry Cast Segmental Retaining Wall Units*, ASTM C1372. ASTM International, 2014.
3. *Standard Specification for Loadbearing Concrete Masonry Units*, ASTM C90. ASTM International, 2014.
4. *Standard Methods for Sampling and Testing Concrete Masonry Units and Related Units*, ASTM C140/C140M. ASTM International, 2023a.
5. *Standard Practice for Capping Concrete Masonry Units, Related Units and Masonry Prisms for Compression Testing,* ASTM C1552-14. ASTM International, 2014.
6. *Standard Test Method for Evaluating the Freeze-Thaw Durability of Dry-Cast Segmental Retaining Wall Units and Related Concrete Units*, ASTM C1262-10. ASTM International, 2010.
7. *Sampling and Testing Segmental Retaining Wall Units*, SRW-TEC-007-15, Concrete Masonry & Hardscapes Association, 2015.

ABOUT CMHA

The Concrete Masonry & Hardscapes Association (CMHA) represents a unification of the Interlocking Concrete Pavement Institute (ICPI) and National Concrete Masonry Association (NCMA). CMHA is a trade association representing US and Canadian producers and suppliers in the concrete masonry and hardscape industry, as well as contractors of interlocking concrete pavement and segmental retaining walls. CMHA is the authority for segmental concrete products and systems, which are the best value and preferred choice for resilient pavement, structures, and living spaces. CMHA is dedicated to the advancement of these building systems through research, promotion, education, and the development of manufacturing guides, design codes and resources, testing standards, and construction practices.