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SEGMENTAL RETAINING WALL UNITS

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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 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 weigh approximately 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

Shoreline erosion control

Terracing

Figure 1—Examples of Segmental Retaining Wall Installations

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) and *Segmental Retaining Wall Drainage Manual* (ref. 2).

Segmental retaining wall units are factory manufactured to quality standards in accordance with ASTM C 1372, *Standard Specification for Segmental Retaining Wall Units* (ref. 3). 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 C 1372 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 C 1372 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 C 1372 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 C 90, *Standard Specification for Loadbearing Concrete Masonry Units* (ref. 4).

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 determine 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 C 140, *Standard Method of Sampling and Testing Concrete Masonry Units* (ref. 5) requires that specimens cut from full-size units for compression testing shall 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 measured in the same direction as the unit height dimension. If these procedures are followed, the compressive strength of the coupon is considered to be 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.

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

Table 1—Strength and Absorption Requirements (ref. 3)

Minimum required net area compressive strength psi (MPa)		Maximum water absorption requirements lb/ft³ (kg/m³) Weight classification—oven dry density of concrete lb/ft³ (kg/m³)		
Average of three units	Individual unit	Lightweight less than 105 (1680)	Medium weight 105 (1680) to less than 125 (2000)	Normal weight 125 (2000) or more
3,000 (20.68)	2,500 (17.24)	18 (288)	15 (240)	13 (208)

on a masonry table saw are recommended. The blade should have a diameter sufficient enough to make all cuts in a single 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 C 140 permits the testing of segments saw-cut from full-size units to determine absorption and density. Sampling location typically has little effect on tested results.

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. As previously discussed, this relationship is opposite of the absorption characteristics of the material.

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 C 140 requires that specimens be dried for a period of not less than 24 hours at a temperature of at least 212 °F (100 °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 C 140 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 dried adequately, 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 not more than $\pm 1/8$ 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 can not be held to a specific tolerance.

Finish and Appearance

Finish and appearance requirements are virtually the same as those in ASTM C 90 for loadbearing concrete masonry units. 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 not larger than 1 in. (25.4 mm) in any dimension, or cracks not wider than 0.02 inches (0.5 mm) and not longer than 25% of the nominal height of the unit.

Freeze-Thaw Durability

Segmental retaining wall units may be used in aggressive freezing and thawing environments. However, 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.

ASTM C 1372 includes three different methods of satisfying freeze-thaw durability requirements:

1. proven field performance,
2. five specimens shall each have less than 1% weight loss after 100 cycles in water using ASTM C 1262 (ref. 6), or
3. four of five specimens shall have less than 1.5% weight loss after 150 cycles in water using ASTM C 1262.

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 can be conducted in accordance with ASTM C 1262 using water or saline as the media. For most applications, tests in water are considered sufficient.

If the units are to 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

Guidance regarding compliance is also provided in ASTM C 1372. If a sample fails, the manufacturer can then 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 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 payment of 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 TEK 18-10 *Sampling and Testing Segmental Retaining Wall Units* (ref. 7) for more detailed information on SRW unit sampling, testing, and acceptance.

REFERENCES

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