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SAMPLING AND TESTING SEGMENTAL RETAINING WALL UNITS

TEK 18-10
Quality Assurance and Testing (2005)

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INTRODUCTION

Segmental retaining wall (SRW) units are subject to the minimum requirements of *Standard Specification for Dry-Cast Segmental Retaining Wall Units*, ASTM C 1372 (ref. 1). This standard includes criteria for minimum compressive strength, maximum water absorption, maximum permissible variations in dimensions, and when required freeze-thaw durability. Test methods used to demonstrate compliance with these requirements are outlined herein.

SAMPLING SEGMENTAL RETAINING WALL UNITS

Segmental retaining wall units are sampled using the same procedures as for other concrete masonry units. The purpose of selecting multiple test specimens for unit testing is to ensure that the range of results is representative of the entire lot of units from which the specimens were taken. Selecting units from only one portion of a pallet, or choosing only the most or least desirable units may misrepresent the properties of the lot.

Selected specimens should be randomly chosen from each lot, and should all have similar unit configurations and dimensions. A minimum of six units is required for compression, absorption and dimensional evaluation in accordance with ASTM C 140 (ref. 2). If freeze-thaw durability testing is also required, an additional five units should be selected for this testing method. Each test specimen is marked with a unique identification, which makes the test specimen immediately identifiable at any point during the testing. Immediately after marking, each unit is weighed to determine the received weight. Note that any loose material should be removed prior to weighing.

The selected test specimens are divided into groups as necessary to conduct the specified tests. The six units sampled for one complete C 140 test are often separated initially into three groups of two: one for the two heaviest units, the second for the two lightest units, and the third for the remaining two units. One unit from each of these three groups is set aside for compression testing, and the other three for absorption. This procedure is based on the general rule of thumb that, within a given lot, units with higher received weights may have been better compacted during manufacture and may therefore tend to have higher compressive strengths, higher densities and lower absorptions. Distributing units by this method is not required by the ASTM standards, but is considered good practice, as the average results are more likely to be representative of the entire lot.

MEASUREMENT OF DIMENSIONS

Unit dimensions are used to verify that the overall length, width and height are within the allowable $\pm$ $^1/_8$ in. (3.2 mm) tolerances permitted by ASTM C 1372. This tolerance does not apply to architectural surfaces, such as split faces.

For each unit, the overall width is measured at the mid-length of the unit across the top and bottom bearing surfaces of the unit using a steel scale marked with $^1/_{10}$-in. (2.5-mm) divisions (or smaller). Similarly, the overall height is measured at the mid-length of the front and back face and the overall length is measured at the mid-height of the front and back face. The reported overall dimensions are determined as the average of each respective measurement for width, height and length.

Additional dimensional and testing information can be found in *Segmental Retaining Wall Units*, TEK 2-4B (ref. 5).

ABSORPTION TESTING

Absorption describes the amount of water a unit can hold when saturated. Absorption can be an indicator of the level of compaction of the concrete mix, the aggregate gradation or simply the volume of voids within a unit. Data collected during absorption testing is used to calculate absorption and density. During absorption testing, the weight of each specimen is

determined in the following order and condition: received weight; immersed weight; saturated weight; and oven-dry weight. The saturated and immersed weights should always be determined following 24 hours of immersion and prior to oven drying the specimens.

ASTM C 140 allows for absorption testing of either full units or coupons. Because of the size and weight of SRW units, coupon specimens are typically tested in lieu of full size units. Sampling location typically has little effect on tested results.

The absorption specimens are immersed in water with a temperature between 60 and 80°F (15.6 to 26.7°C) for 24 hours, and each specimen is weighed while suspended by a metal wire and completely submerged in water to determine immersed weight. After 24 hours, the units are removed from the tank and allowed to drain for one minute by placing them on a $^3/_8$-in. (9.5-mm) or coarser wire mesh. A damp cloth is used to remove surface water, since a dry cloth may absorb water from the masonry unit. Each unit is weighed again to determine the saturated weight.

Testing larger specimens for absorption requires particular attention to drying times, because it takes a greater length of time to remove all of the moisture from larger masses. To reach an oven-dry condition, the units must be dried for at least 24 hours in a ventilated oven at a temperature of 212 to 239°F (100 to 115°C). For most laboratories, this means a drying time of more than 24 hours, since several hours are typically required to raise the oven temperature to the specified range after the room-temperature SRW units are inserted.

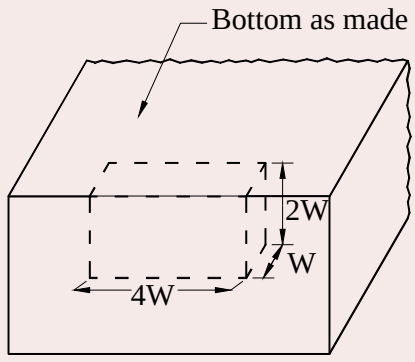
After at least 24 hours, unit weights are recorded in two-hour intervals to ensure the units are no longer losing weight due to moisture loss. The unit is considered oven dry when two successive weighings differ by 0.2% or less. Note that when weighing the units using an electronic scale, insulating materials for the scale may be necessary, because heat radiating from a unit just removed from the oven may cause the scale to return inaccurate results.

ASTM C 1372 (ref. 1) includes the maximum water absorption requirements shown in Table 1.

Table 1—Maximum Water Absorption for SRW Units (ref. 1)

Unit weight classification[a]:	Lightweight < 105 pcf (< 1,682 kg/m³)	Medium weight 105 to < 125 pcf (1,682 to < 2,002 kg/m³)	Normal weight ≥ 125 pcf (≥ 2,002 kg/m³)
Max. absorption, in lb/ft³ (kg/m³):	18 (288)	15 (240)	13 (208)

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



Note: the preferred coupon size is 2 x 4 x 8 in. (51 x 102 x 203 mm)

Figure 1—SRW Coupon for Compressive Strength Testing

COMPRESSIVE STRENGTH TESTING

Compressive strength tests are used to ensure that the SRW units meet the minimum strength requirements of ASTM C 1372: minimum net average compressive strength of 3,000 psi (20.7 MPa) for an average of three units with no individual unit less than 2,500 psi (17.2 MPa).

Some critical areas of compression testing that are necessary to insure accurate testing include:

- appropriate capping stations with stiff, planar plates with smooth surfaces,
- compression machines with spherically seated heads and bearing plates meeting the requirements of ASTM C 140 (ref. 2), and
- proper specimen alignment within the testing machine (specimen's center of mass aligned with machine's center of thrust).

The ASTM C 140 (ref. 2) testing procedures for compressive strength of SRW units are the same as those for conventional concrete masonry units (see TEK 18-7, ref. 4), with the exception that coupons are tested in lieu of full-size units (see ASTM C 140 section 6.2.6).

The tested compressive strength can be influenced by the size and shape of the specimen tested and the location of the cut of the coupon. For these reasons, it is important that all retaining wall units be tested using a similar size and shape. In addition, the SRW unit supplier should be contacted for the recommended coupon sample location. 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 have a diameter large enough to make each required cut in a single pass.

Coupons are required by ASTM C 140 (ref. 2) to have a height to thickness ratio of 2:1 before capping and a length to thickness ratio of 4:1 (see Figure 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). Coupon dimensions must be within $^1/_8$ in. (3 mm) of the targeted dimension. The coupon height is taken 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.

FREEZE-THAW DURABILITY

In areas where the segmental retaining wall is likely to be exposed to repeated freezing and thawing under saturated conditions, ASTM C 1372 requires that freeze-thaw durability be demonstrated in one of the following ways:

1. proven field performance,
2. each of five specimens shall have less than 1% weight loss after 100 cycles, or
3. four of five specimens shall each have less than 1.5% weight loss after 150 cycles.

When required, testing is in accordance with ASTM C 1262, *Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units* (ref. 3), an accelerated laboratory test that provides an indication of relative performance when the units are placed in service. Testing in accordance with ASTM C 1262 can be conducted using water or saline (3% sodium chloride by weight) as the media. ASTM C 1372, however, does not require freeze-thaw evaluation in saline, recognizing that for most applications, tests in water are considered sufficient. If the units are to be exposed to deicing salts on a regular basis, local project specifications should be consulted to determine if testing in saline is required.

Freeze-thaw durability test methods are prescribed because freeze-thaw durability cannot be reliably predicted based on factors such as compressive strength, absorption or concrete density. A unit's freeze-thaw durability can be influenced by manufacturing variables such as:

- aggregate type,
- production methods,
- cement content and
- presence of admixtures;

as well as field variables, including:

- exposure to moisture (source, volume, frequency)
- environment (drainage, exposure to shade or sunlight, exposure to salt and chemicals) and
- temperatures (rate of change, peak values, number of cycles, cycle lengths).

C 1262 testing is carried out on five specimens representative of the entire lot. These units should be marked for identification, as for C 140 testing. Specimens used for C 140 absorption testing should not subsequently be used for freeze-thaw testing.

One coupon is saw-cut from each SRW unit. The side of the coupon has a surface area 25 to 35 in.^{2} (161 to 225 cm^2) and a thickness of $1^1/_4$ in. $\pm$ $^1/_{16}$ in. (32 $\pm$ 2 mm) (see Figure 2). The coupon should be cut from the exposed face of the unit (as it will be placed in service), unless that face is split, fluted, ribbed or otherwise nonplanar. In these cases, the coupon should be cut from another flat molded surface. Saw-cut coupons are then rinsed in water (not submerged), brushed with a soft bristle brush to remove residue and any loose particles then allowed to air dry on edge for at least 48 hours.

Each specimen is placed in a container, as shown in Figure 3, with the appropriate liquid media. After one hour, more liquid is added as necessary to maintain the prescribed level. After 24 hours in the container, the specimen is removed and allowed to drain for one minute on a $^3/_8$-in. (9.5-mm) or coarser wire mesh, removing surface water with a damp cloth. The specimen is immediately weighed to determine the reference weight W_p, after which the specimen is returned to the container and additional water or saline is added if necessary prior to the cyclic freeze-thaw testing.

Specimens are then subjected to freezing and thawing cycles, as follows (see Figure 4):

Freeze cycle: 4 to 5 hr, or longer to ensure that all water is

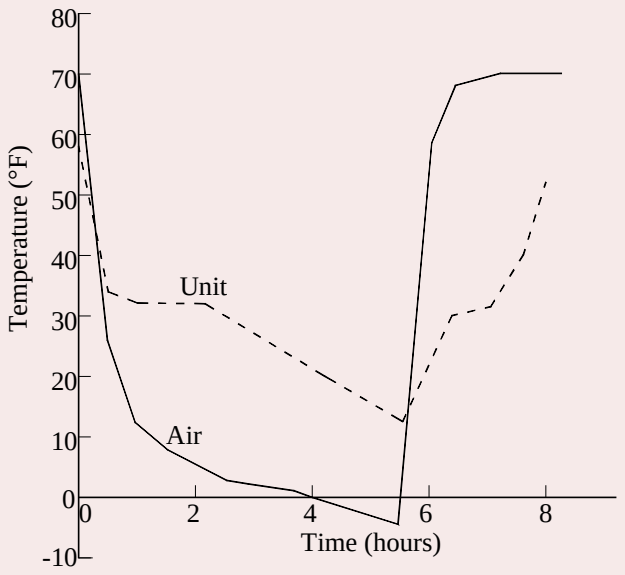


Figure 4—Freeze-Thaw Cycle Requirements

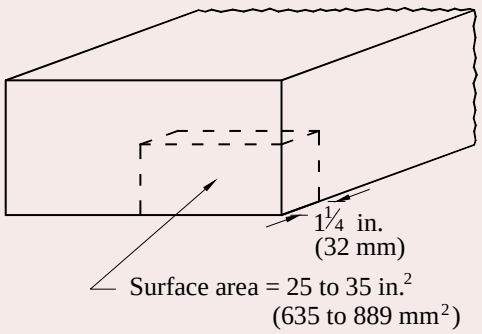


Figure 2—Coupon for Freeze-Thaw Durability Testing

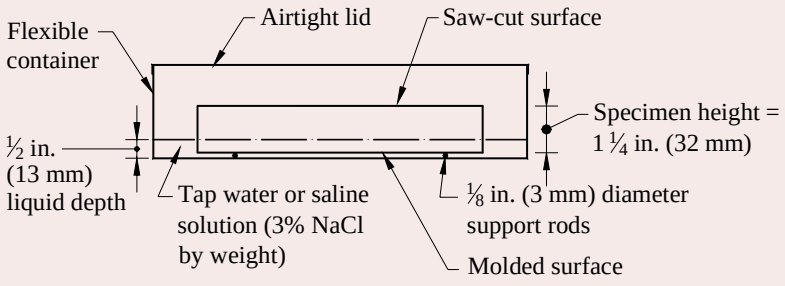


Figure 3—Freeze-Thaw Immersion

frozen, at 0 ± 10°F (-17 to -5°C) air temperature
Thaw cycle: 2.5 to 96 hr, to ensure that all ice has thawed, at 75 ± 10°F (24 ± 5°C) air temperature.

After the specified number of cycles is complete, any residue is collected, dried and weighed to determine the percentage weight loss, as follows:

- determine weight of residue from each evaluation period, W_r, from (weight of the dried residue and filter paper) - (initial weight of the filter paper)
- add W_r from each evaluation period to determine total accumulated residue weight, $W_{residue}$
- after the freeze-thaw testing is complete, dry each specimen and weigh to determine W_{final}
- calculate the initial weight of the specimen from: $W_{initial} = W_{final} + W_{residue}$
- determine the cumulative weight loss of each residue collection interval both in grams and as a percentage of $W_{initial}$ as shown in Table 2.

REFERENCES

1. *Standard Specification for Dry-Cast Segmental Retaining Wall Units*, C 1372-04e1. ASTM International, 2004.
2. *Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units*, ASTM C 140-03. ASTM International, 2003.
3. *Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units*, ASTM C1262-98e1. ASTM International, 1998.
4. *Compressive Strength Testing Variables for Concrete Masonry Units*, TEK 18-7. National Concrete Masonry Association, 2004.
5. *Segmental Retaining Wall Units*, TEK 2-4B. National Concrete Masonry Association, 2005.

Table 2—Procedure for Calculating Weight Loss Due to Freeze-Thaw Testing (ref. 3)

interval number:	residue weight, g:	cumulative residue weight, g:	cumulative weight loss, g:	cumulative weight loss, %:
1	W_{r1}	W_{r1}	$W_{initial} - W_{r1}$	$(W_{initial} - W_{r1})/W_{initial}$
2	W_{r2}	$W_{r1} + W_{r2}$	$W_{initial} - (W_{r1} + W_{r2})$	$[W_{initial} - (W_{r1} + W_{r2})]/W_{initial}$
:	:	:	:	:
n	W_{rn}	$W_{r1} + W_{r2} + ...W_{rn}$	$W_{initial} - (W_{r1} + W_{r2} + ...W_{rn})$	$[W_{initial} - (W_{r1} + W_{r2} + ...W_{rn})]/W_{initial}$