Standard Test Methods for Apparent Density of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes[1]

This standard is issued under the fixed designation C 905; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods cover the procedures for determining the uncured (wet) and conditioned (dry) densities of resin, silicate, silica, and sulfur-based chemical-resistant mortars, grouts, monolithic surfacings, and polymer concretes.

1.2 *Density Method I: Apparent Uncured Density of Resin, Silica, and Silicate Materials*—This test method is not applicable to sulfur materials.

1.3 *Density Method II: Apparent Conditioned Density of Resin and Sulfur-based Materials*—This test method may be applicable to silica or silicate materials if they are not water-sensitive.

1.4 *Density Method III: Apparent Conditioned Density of Silica and Silicate Materials that are Water Sensitive.*

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 470 Specification for Molds for Forming Concrete Test Cylinders Vertically[2]

C 904 Terminology Relating to Chemical-Resistant Nonmetallic Materials[2]

C 1312 Practice for Making and Conditioning Chemical-Resistant Sulfur Polymer Cement Concrete Test Specimens in the Laboratory[2]

3. Terminology

3.1 *Definitions*—For definitions of terms used in these test methods, see Terminology C 904.

4. Significance and Use

4.1 The results obtained by these test methods may be used for estimating purposes, as a means of checking on uniformity of a product, or even to help identify a specific product. Differences between uncured and conditioned densities may also be a measure of the loss or absorption of solvents, salts, plasticizers, etc.

5. Apparatus

5.1 *Balance for Determining Density,* capable of weighing to four significant numbers. The balance should be equipped with either a below-balance weighing hook or a "pan straddle" or similar support plus wire assembly basket or loop to allow for density determinations.

5.2 *Equipment for Mixing Resin, Silica, and Silicate Materials*—Use a flat-bottom container of suitable size, preferably made of corrosion-resistant metal or porcelain, and a trowel having a 4 to 5 in. (100 to 125 mm) blade.

5.2.1 *Equipment for Mixing Sulfur Materials*—Use a stainless steel or cast iron pot for melting the material along with a power-driven revolving paddle mixer.

5.3 *Specimen Molds:*

5.3.1 *Mold Method A*—These molds shall be right cylinders 1 ± 1/16 in. (25 ± 1.6 mm) in diameter by 1 ± 1/16 in. high. The molds may be constructed in any manner that will allow formation of a test specimen of the desired size. Typical molds consist of a 1-in. (25-mm) thick, flat plastic sheet in which 1 in. diameter, smooth-sided holes have been cut, and to the bottom of which a 1/4 in. (6 mm) thick, flat plastic sheet (without matching holes) is attached by means of screws or bolts. Alternately, the molds may consist of sections of round plastic tubing or pipe, 1 in. inside diameter and 1 in. long, having sufficient wall thickness to be rigid and retain dimensional stability during the molding operation, and a 1/4 in. thick, flat plastic sheet on which one open end of each section can be rested. With the latter style of mold, the tubing segment may be sealed with a material, such as caulking compound or stopcock grease. For most types of specimens it is satisfactory to simply seal one end of the tubing segment with masking tape.

NOTE 1—For use with sulfur mortars, an additional piece of flat plastic sheet at least 1/8 in. (3 mm) thick, containing a 1/4 in. (6 mm) hole and a section of plastic tubing or pipe 1 in. (25 mm) in diameter by 1 in. high are required. They are used to form a pouring gate and reservoir in the preparation of sulfur mortar specimens.

5.3.2 *Mold Method B*—Molds for the 2 in. (50 mm) cube specimens shall be tight fitting and leakproof. The molds shall have not more than three cube compartments and shall be separable into not more than three parts. The parts of the molds, when assembled, shall be positively held together. The molds shall be made of metal not attacked by the material. The sides of the molds shall be sufficiently rigid to prevent spreading or warping. The interior faces of the molds shall be manufactured to ensure plane surfaces with a

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[1] These test methods are under the jurisdiction of ASTM Committee C-3 on Chemical-Resistant Nonmetallic Materials and are the direct responsibility of Subcommittee C03.01 on Test Methods.

Current edition approved Sept. 10, 1996. Published November 1996. Originally published as C 905 – 79. Last previous edition C 905 – 85(1990).

[2] *Annual Book of ASTM Standards*, Vol 04.05.

permissible variation of 0.002 in. (0.05 mm). The distances between opposite faces shall be 2 ± 1/16 in. (50 ± 1.6 mm). The height of the molds, measured separately for each cube compartment, shall be 2 ± 1/16 in. The angle between adjacent interior faces and between interior faces and top and bottom planes of the mold shall be 90 ± 0.5° measured at points slightly removed from the intersection of the faces.

5.3.3 *Mold Method C*—Molds shall be right cylinders made of heavy gage metal or other rigid nonabsorbent material. The cylinder diameter shall be at least four times the nominal maximum aggregate size in the mix. The minimum cylinder diameter shall be 2 in. (50 mm). The cylinder height shall be two times the diameter. The plane of the rim of the mold shall be at right angles to the axis within 0.5°. The mold shall be at right angles to the axis within 0.5°. The mold shall not vary from the prescribed diameter by more than 1/16 in. (1.6 mm) nor from the prescribed height by more than 1/8 in. (3 mm). Molds shall be provided with a flat base plate with a means for securing it to the mold at a right angle to the axis of the cylinder in the instance of reusable metal molds. For molds other than metal, a mechanically attached smooth flat metal or integrally molded flat bottom of the same material as the sides shall be used. Single use molds shall conform to Specification C 470.

NOTE 2—The material from which the mold is constructed must be chemically inert and have anti-stick properties. Polyethylene, polypropylene, polytetrafluoroethylene, and metal forms having either a sintered coating of tetrafluoroethylene or a suitable release agent compatible with the material being tested are satisfactory. Because of their superior heat resistance, only trifluorochloroethylene and tetrafluoroethylene mold release agents should be used with sulfur materials.

5.4 *Weighing Equipment for Mixing Materials*, shall be capable of weighing to ±0.3 % accuracy.

6. Calibration of Molds

6.1 All molds used shall be calibrated for volume, prior to use in accordance with the following procedure:

6.1.1 Weigh each mold to the nearest 0.01 g and then fill the mold carefully, until it is even with the face of the mold, with distilled water at 73 ± 1°F (23 ± 0.5°C) and reweigh. Calculate the volume of each mold to the nearest 0.01 cm³ as follows:

$$V = \frac{W_b - W_a}{0.9975}$$

where:
V = volume of mold, cm³,
W_a = weight of unfilled mold, g,
W_b = weight of mold filled with water, g, and
0.9975 = density of water at 23°C, g/cm³.

7. Test Specimens

7.1 *Number of Specimens*—Four specimens shall be prepared from the same mix.

7.2 *Resin, Silica, and Silicate Materials*—Mix a sufficient amount of the components in the proportions and in the manner specified by the manufacturer of the materials. All materials should be at 73 ± 4°F. Fill the molds one-half full. Remove any entrapped air by using a cutting and stabbing motion with a spatula or rounded-end rod. Fill the remainder of the mold, working down into the previously placed portion. Upon completion of the filling operation, the tops of the specimens should extend slightly above the tops of the molds. When the molds have been filled, strike off the excess material even with the top of the mold. Permit the material to remain in the mold until it has set sufficiently to allow removal without danger of deformation or breakage.

7.3 *Sulfur Materials:*

7.3.1 *Sulfur Mortars*—Slowly melt a minimum of 2 lb (900 g) of material in a suitable container at a temperature of 265 to 290°F (130 to 145°C) with constant agitation. Stir to lift and blend the aggregate without beating air into the melt. Place the piece of plastic sheet containing the 1/4 in. (6 mm) round hole over the open face of the mold with the hole centered on the face. On top of the piece of plastic sheet and surrounding the hole, place a section of plastic tubing or pipe 1 in. (25 mm) in diameter by 1 in. high. Pour the melted material through the hole into the mold and continue to pour until the section of tubing or pipe is completely filled. The excess material contained in the hole in the plastic sheet acts as a reservoir to compensate for the shrinkage of the material during cooling. Allow the specimen to remain in the mold until it has completely solidified.

7.3.2 *Sulfur Concrete*—Prepare samples in accordance with Practice C 1312.

8. Conditioning

8.1 For determination of the uncured density of any material, no conditioning is necessary.

8.2 *For Determination of Conditioned Density:*

8.2.1 *Resin and Silica Materials*—In accordance with the manufacturer's specifications, the test specimen shall not be demolded until it has set sufficiently to allow removal without danger of deformation or breakage. Age the test specimens at 73 ± 4°F (23 ± 2°C) for a period of at least 7 days, including the cure time in the molds, before testing.

8.2.2 *Silicate Materials*—Follow 8.2.1, except the relative humidity of the surrounding air shall be kept below 80 %. Some silicates may require covering during the curing period. After removal from the molds, acid-treat the specimens if required in accordance with the recommendations given by the manufacturer. No other treatment shall be permitted. Record the method of treatment in the Report section under Conditioning and Treatment.

8.2.3 *Sulfur Materials*—After filling the molds, allow the specimens to remain in the molds until they are completely solidified. Upon removal from the molds, file, grind, or sand the surface of the specimens to remove the excess material remaining at the pouring gate. Age the specimens for at least 24 h, including the time in the mold.

9. Procedure

9.1 *Density Method I*—Immediately after filling as described in Section 7, weigh the mold, and then calculate the uncured density of the test material as follows:

$$D_u = \frac{W_m - W_a}{V}$$

where:
D_u = apparent uncured density, g/cm³,
W_m = weight of mold plus material, g,
W_a = weight of unfilled mold, g, and
V = volume of mold, cm³.

9.2 *Density Method II:*

9.2.1 *Determination of Conditioned Weight*—Weigh the conditioned specimens to four significant places.

9.2.2 *Determination of Suspended Weight*—Attach the wire assembly to the below-balance or pan-support hook so that the basket or loop which will hold the specimen is completely immersed in water (Note 3) to the same depth as is used when the specimens are in place. Tare the balance and place the specimen in the basket or loop. Remove adhering air bubbles from the specimen with a fine wire and weigh to four significant places (Note 4). Calculate the conditioned density of the test specimen as follows:

$$D_c = \frac{0.9975\ S}{S - I}$$

where:

D_c = apparent conditioned density, g/cm^3,
S = weight of specimen in air, g, and
I = weight of specimen immersed in water, g.

NOTE 3—Use distilled water at 73 ± 1°F (23 ± 0.5°C).

NOTE 4—If the suspended weight cannot be obtained due to a porous specimen absorbing liquid rapidly, the density should be obtained by measuring the dimensions of the specimen to obtain volume.

9.3 *Density Method III:*

9.3.1 *Determination of Conditioned Weight*—Weigh the conditioned specimens to four significant places.

9.3.2 *Determination of Suspended Weight*—Attach the wire assembly to the below-balance or pan-support hook so that the basket or loop that will hold the specimen is completely immersed in xylene (Note 5) to the same depth as is used when the specimens are in place. Tare the balance and place the specimen in the basket or loop. Remove adhering air bubbles from the specimen with a fine wire and weigh to four significant places (Note 4). Calculate the conditioned density of the test specimen as follows:

$$D_c = \frac{d_s\ S}{S - I_s}$$

where:

D_c = apparent conditioned density, g/cm^3,
S = weight of specimen, g,
I_s = weight of specimen in xylene (or of solvent used if other than xylene), g, and
d_s = density of xylene (or of solvent used if other than xylene), g/cm^3.

NOTE 5—The density of commercial xylene is approximately 0.870 g/cm^3. Any suitable solvent that does not affect the integrity of the specimen may be used in place of xylene. When making the density calculations, be sure to use the density for the actual solvent used in the procedure.

10. Report

10.1 Report the following information:

10.1.1 Complete material identification,

10.1.2 Mixing ratio,

10.1.3 Type and method of vibrating if used,

10.1.4 Conditioning and treatment,

10.1.5 Density Method(s) I, II, or III,

10.1.6 Mold Method(s) A, B, or C,

10.1.7 Specimen Dimensions for Method C, and

10.1.8 Individual and averaged density results in lbs/cf (g/cm^3).

11. Precision and Bias

11.1 Test specimens that are manifestly faulty or that give density values differing by more than 2 % from the average value of all specimens made from the same sample material and tested in the same series shall not be considered in determining the average density. If after discarding outlying values, there are less than three density values remaining for the determination of the average density, the entire test shall be repeated.

12. Keywords

12.1 apparent density; brick mortars; chemical-resistant; density; machinery grouts; monolithic surfacings; polymer concrete; resin materials; silicate materials; sulfur materials; tile grouts

Standard Specification for Precast Concrete Water and Wastewater Structures[1]

This standard is issued under the fixed designation C 913; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers the recommended design requirements and manufacturing practices for monolithic or sectional precast concrete water and wastewater structures with the exception of concrete pipe, box culverts, utility structures, septic tanks, and items included under the scope of Specification C 478.

NOTE 1—Water and wastewater structures are defined as solar heating reservoirs, cisterns, holding tanks, leaching tanks, extended aeration tanks, wet wells, pumping stations, grease traps, distribution boxes, oil-water separators, treatment plants, manure pits, catch basins, drop inlets, and similar structures.

NOTE 2—Insulation and sealant requirements should receive special consideration due to special features of the application.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

A 82 Specification for Steel Wire, Plain, for Concrete Reinforcement[2]

A 184/A 184M Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement[2]

A 185 Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement[2]

A 416/A 416M Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete[2]

A 421 Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete[2]

A 496 Specification for Steel Wire, Deformed, for Concrete Reinforcement[2]

A 497 Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement[2]

A 615/A 615M Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement[2]

A 616/A 616M Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement[2]

A 617/A 617M Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement[2]

C 33 Specification for Concrete Aggregates[3]

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens[4]

C 94 Specification for Ready-Mixed Concrete[3]

C 150 Specification for Portland Cement[5]

C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[3]

C 260 Specification for Air-Entraining Admixtures for Concrete[3]

C 330 Specification for Lightweight Aggregates for Structural Concrete[3]

C 478 Specification for Precast Reinforced Concrete Manhole Sections[6]

C 494 Specification for Chemical Admixtures for Concrete[3]

C 595 Specification for Blended Hydraulic Cements[5]

C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete[3]

C 685 Specification for Concrete Made by Volumetric Batching and Continuous Mixing[3]

C 890 Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures[6]

2.2 *American Concrete Institute Standard:*

ACI318 Building Code Requirements for Reinforced Concrete[7]

2.3 *Federal Specification*:

SS-S-210A Sealing Compound, Preformed Plastic, for Expansion Joints and Pipe Joints[8]

3. Ordering Information

3.1 Unless otherwise designated by the purchaser before placing an order, a structure designed in accordance with Section 5 of this specification and found to satisfactorily meet

[1] This specification is under the jurisdiction of ASTM Committee C-27 on Precast Concrete Products and is the direct responsibility of Subcommittee C27.30 on Water and Wastewater Containers.

Current edition approved Dec. 10, 1998. Published February 1999. Originally published as C 913 – 79. Last previous edition C 913 – 96.

[2] *Annual Book of ASTM Standards*, Vol 01.04.

[3] *Annual Book of ASTM Standards*, Vol 04.02.

[4] *Annual Book of ASTM Standards*, Vol 04.07.

[5] *Annual Book of ASTM Standards*, Vol 04.01.

[6] *Annual Book of ASTM Standards*, Vol 04.05.

[7] Available from American Concrete Institute, P.O. Box 19150, Detroit, MI 48219.

[8] Available from Standardization Documents, Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094. Attn: NPODS.

the requirements imposed when tested and inspected as described herein shall be acceptable. The test of materials as required shall be done in accordance with applicable ASTM standards. Inspection, when required, shall include checks on fabrication and placing of reinforcement and concrete in accordance with approved design drawings.

4. Materials

4.1 *Cement*—Portland cement shall conform to the requirements of Specification C 150 or shall be portland blast-furnace slag cement or portland-pozzolan cement conforming to the requirements of Specification C 595.

4.2 *Aggregates*—Aggregates shall conform to Specification C 33 and lightweight aggregates shall conform to Specification C 330, except that the requirements for grading shall not apply.

4.3 *Water*—Water used in mixing concrete shall be clean and free of injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances incompatible with concrete or steel.

4.4 *Admixtures*—Admixtures shall conform to Specification C 494 or C 618 and shall not be injurious to other products used in the concrete.

4.4.1 *Air-Entraining Admixtures*—Air-entraining admixtures conforming to Specification C 260 shall be used when there is a risk that the concrete may be exposed to freeze-thaw cycles. The concrete mixture shall contain 5.5 ± 1.5 % air by volume as determined by Test Method C 231.

4.5 *Steel Reinforcement*—Steel reinforcement shall conform to Specification A 82 or A 496 for wire; Specification A 185 or A 497 for wire fabric; Specifications A 416/A 416M and A 421 for prestressed wire and strand; or Specification A 184/A 184M, A 615/A 615M, A 616/A 616M or A 617/A 617M for bars.

5. Design Requirements

5.1 *Design Method*—The method of structural design of reinforced concrete as outlined in the ACI—318 Building Code shall be used to design the concrete sections, including the reinforcement required, when the structure is subjected to the loading conditions covered in Practice C 890. Design requirements in excess of these specifications shall be identified by the purchaser.

5.1.1 *Alternative Method to Design*—The alternative method to the design of a structure may be by making such performance tests on the complete structure as required to conform to the adequacy of the structure.

5.2 *Access Openings*—The structural design shall take into consideration the number, placement, and size of access openings.

5.3 *Floors*—The minimum floor thickness resulting from slope shall be considered as nominal floor thickness in the structure.

5.4 *Knockouts and Sumps*—Knockouts and sumps shall be designed to carry the loads imposed upon them. The basic structure shall be designed to carry all imposed loads with knockouts removed.

5.5 *Placement of Reinforcement*—The minimum concrete cover for reinforcing bars, mats, or fabric shall not be less than 1 in. (25 mm) for water retaining structures and ¾ in. (19 mm) for other structures subject to the provisions of Section 7.

5.6 *Concrete Strength*—The minimum compressive strength (f'_c) for design shall be 4000 psi (28 MPa) at 28 days of age.

5.7 *Joints*—Where required, sealed joints in sectional precast concrete structures shall be of such a design to prevent unacceptable leakage when used with a sealant (Note 3) approved by the user and acceptable to the supplier. The criteria for unacceptable leakage will be determined by user's specifications. Where potable water is involved, caution advises selecting a sealant that will not contaminate the water for its intended purposes.

NOTE 3—Refer to Federal Specification SS-S-Z10A for guidance.

5.8 *Lifting Devices*—Design of embedded lifting devices shall conform to requirements as specified in 8.4 under Special Loading Considerations of Practice C 890.

6. Manufacture

6.1 *Mixture*—The aggregates, cement, and water shall be proportioned and mixed to produce a homogeneous concrete meeting the requirements of this specification, and in accordance with Specification C 94 or C 685.

6.2 *Forms*—The forms used in manufacture shall be sufficiently rigid and accurate to maintain the dimensions of the structure within the tolerances given in Section 7. All casting surfaces shall be of smooth nonporous material. Form releasing agents used shall not be injurious to the concrete.

6.3 *Reinforcement*—Reinforcement must be securely tied or welded (as allowed by the design) in place to maintain position during concrete placing operations. Where specified all chairs, bolsters, braces, and spacers in contact with forms shall have a corrosion-resistant surface.

6.4 *Concrete Placement*—Concrete shall be placed in the forms at a rate such that the concrete is plastic at all times and consolidates in all parts of the form and around all reinforcement steel and embedded fixtures without segregation of materials.

6.5 *Curing*—The precast concrete sections may be cured by any method or combination of methods that will develop the specified compressive strength at 28 days or less.

6.6 *Concrete Quality*—The quality of the concrete shall be in accordance with the chapter on concrete quality of ACI 318, current edition, except for frequency of tests, which shall be specified by the purchaser. Concrete tests shall be conducted in accordance with Test Method C 39.

7. Tolerances

7.1 *Dimensional Tolerances*—The length, width, height, or diameter measurements of the structure when measured on the inside surface shall not deviate from the design dimensions more than the following:

Dimension	Tolerance
0 to 5 ft (0 to 1.5 m)	± ¼ in. (± 6 mm)
5 to 10 ft (1.5 to 3.0 m)	± ⅜ in. (± 10 mm)
10 to 20 ft (3.0 to 6.1 m)	± ½ in. (± 13 mm)
20 ft (6.1 m) and over	as agreed upon between manufacturer and purchaser

7.2 *Squareness Tolerance*—The inside of the rectangular precast concrete component shall be square as determined by diagonal measurements. The difference between such measurements shall not exceed:

Measured Length	Allowable Difference
0 to 10 ft (0 to 3.0 m)	½ in. (13 mm)
10 to 20 ft (3.0 to 6.1 m)	¾ in. (19 mm)
20 ft (6.1 m) and over	as agreed upon between manufacturer and purchaser

7.3 *Joint Surfaces*—The following joint tolerances for water retaining structures shall apply:

7.3.1 *Flexible Joint*—The inside joint seam gap between two sections placed together before a joint sealant is applied shall not exceed ⅜in. (10 mm).

7.3.2 *Grout Joint*—The opening to be grouted in a group joint shall not exceed 1 in. (25 mm).

7.4 *Reinforcement Location*—With reference to thickness of wall or slab, reinforcement shall be within ± ¼ in. (6 mm) of the design location, but in no case shall the cover be less than 1 in. (25 mm) for water-retaining structures and ¾ in. (19 mm) for nonwater-retaining structures. The varations in reinforcement spacing shall not be more than one tenth of the designed bar spacing nor exceed 1½ in. (38 mm). The total number of bars shall not be less than that computed using the design spacing.

7.5 *Slab and Wall Thickness*—The slab and wall thickness shall be uniform and shall not be less than that shown in the design by more than 5 % or ⅜ in. (10 mm), whichever is greater. A thickness greater than that required in the design shall not be a cause for rejection.

8. Repairs

8.1 Repairs shall be performed by the manufacturer in a manner to ensure that the repaired structure will conform to the requirements of this specification.

9. Rejection

9.1 Precast concrete structures or sections of structures shall be subject to rejection because of failure to conform to any of the requirements contained herein.

10. Marking

10.1 The following information shall be clearly marked on each structure or section of structure, by indentation, waterproof paint, or other approved means:

10.1.1 Date of manufacture,

10.1.2 Name or trademark of the manufacturer, and

10.1.3 Initials or symbols to indicate the intended use of the structure.

11. Keywords

11.1 concrete; precast; structures; wastewater; water

APPENDIXES

(Nonmandatory Information)

X1. DESIGNS FOR RECTANGULAR BOXES

X1.1 Description of Designs

X1.1.1 The designs in Table X1.1 are provided as a convenience for specifying, purchasing, and manufacturing. Riser and base sections are shown in Fig. X1.1.

X1.1.2 The successful performance of the product depends upon the proper selection (based on field conditions), good manufacturing practices, and proper installation.

X1.1.3 Refer to Appendix X2 for instructions on the use of the designs.

X1.2 Structural Analysis

X1.2.1 The analysis is based on the slope-deflection solution of a frame with nonprismatic members.

X1.2.2 Loads are based on Practice C 890.

X1.3 Design Calculations

X1.3.1 The concrete shall be designed to be proportioned for f_c' = 4000 psi (28 MPa).

X1.3.2 Reinforcing steel shall be Grade 60 (minimum yield strength of 60 000 psi) (3.84 MPa).

X1.3.3 The strength design method described in ACI-318 is used with U.L.F. = 1.7.

X1.3.4 Minimum reinforcement is 0.002 times the gross concrete area of the cross section.

X1.3.5 Calculations for units with integral slab (top or

TABLE X1.1 Designs for Rectangular Boxes[A]

Size L by W	t (in)	d (in)	Class w (psf)			Reinforcing A_{sh} (in.^{2}/ft)	Reinforcing A_{sv} (in.^{2}/ft)
2 ft by 2 ft	6	3	300	500	700	0.14	0.14
2 ft 6 in. by 2 ft	6	3	300	500	700	0.14	0.14
2 ft 6 in. by 2 ft 6 in.	6	3	300	500	700	0.14	0.14
3 ft by 2 ft	6	3	300	500	700	0.14	0.14
3 ft by 2 ft 6 in.	6	3	300	500	700	0.14	0.14
3 ft by 3 ft	6	3	300	500	700	0.14	0.14
3 ft 6 in. by 2 ft	6	3	300	500	700	0.14	0.14
3 ft 6 in. by 2 ft 6 in.	6	3	300	500	700	0.14	0.14
3 ft 6 in. by 3 ft	6	3	300	500	700	0.14	0.14
3 ft 6 in. by 3 ft 6 in.	6	3	300	500	700	0.14	0.14
4 ft by 2 ft	6	3	300	500	700	0.14	0.14
4 ft by 2 ft 6 in.	6	3	300	500	700	0.14	0.14
4 ft by 3 ft	6	3	300	500	700	0.14	0.14
4 ft by 3 ft 6 in.	6	3	300	500	700	0.14	0.14
4 ft by 4 ft	6	3	300	500	700	0.14	0.14
4 ft 6 in. by 2 ft 6 in.	6	3	300	500	700	0.14	0.14
4 ft 6 in. by 3 ft	6	3	300	500	700	0.14	0.14
4 ft 6 in. by 3 ft 6 in.	6	3	300	500	700	0.14	0.14
4 ft 6 in. by 4 ft	6	3	300	500	700	0.14	0.14
4 ft 6 in. by 4 ft 6 in.	6	3	300	500	700	0.14	0.14
6 ft by 5 ft 6 in.	6	3	300			0.14	0.14
6 ft by 5 ft 6 in.	6	3		500		0.17	0.14
6 ft by 5 ft 6 in.	6	3			700	0.24	0.14
6 ft by 6 ft	6	3	300			0.14	0.14
6 ft by 6 ft	6	3		500		0.18	0.14
6 ft by 6 ft	6	3			700	0.27	0.14

[A] One in. = 25.0 mm.

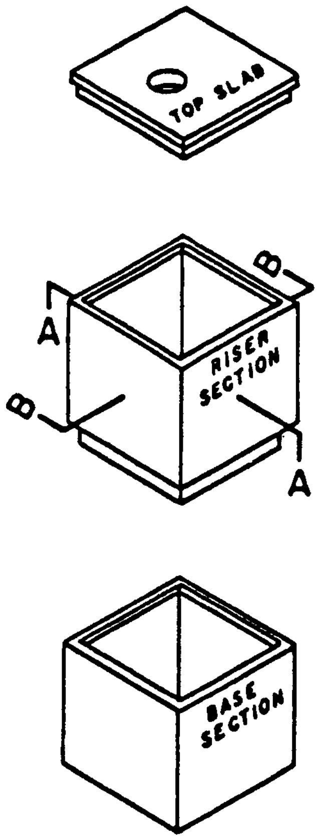

FIG. X1.1 Typical Assembly

bottom) do not take into consideration rigidity or support from slab.

X1.4 Definitions

X1.4.1 *t*—Total thickness of wall (Fig. X1.2).

X1.4.2 *d*—Distance from centerline of horizontal steel to inside face of wall (Fig. X1.2).

X1.4.3 A_{sh}—Area of horizontal steel per vertical foot (Fig. X1.2).

X1.4.4 A_{sv}—Area of vertical steel per horizontal foot (Fig. X1.3).

X1.4.5 *Class*—a term that can be used to describe the product, for example, 300, 500, 700. The number also refers to the capacity of the unit in terms of lb/ft^2 (Pa).

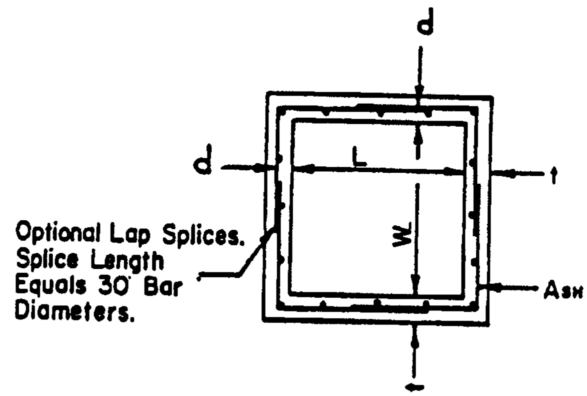

FIG. X1.2 Section AA

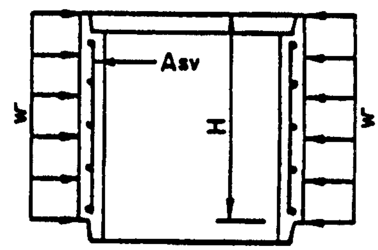

FIG. X1.3 Section BB

X2. INSTRUCTIONS FOR USE OF DESIGNS IN TABLE X1.1

X2.1 Each section can be designed individually but in an effort to save time select the section that carries the heaviest loads and use it for the whole box.

X2.1.1 Assume the height of each section based upon the size and location of pipes entering or leaving the box. The designs in the tables assume continuity of steel around the box. If a hole is made in a section, there should be concrete above and below and sufficient additional reinforcing to transfer forces across the opening.

X2.1.2 Determine depth of section to be designed (h_1 and h_{11} in Fig. X2.1).

X2.1.3 Determine depth of water table (*d* in Fig. X2.1).

X2.1.4 Assume a lateral soil pressure of 40 psf/ft of height and water weighing 62.4 lb/ft^3.

X2.1.5 From Fig. X2.1:

$$P(1) = 40\,h_1 + 62.4\,h_2 \qquad \text{(X2.1)}$$

$$P(2) = 40\,h_{11} + 62.4\,h_{22}$$

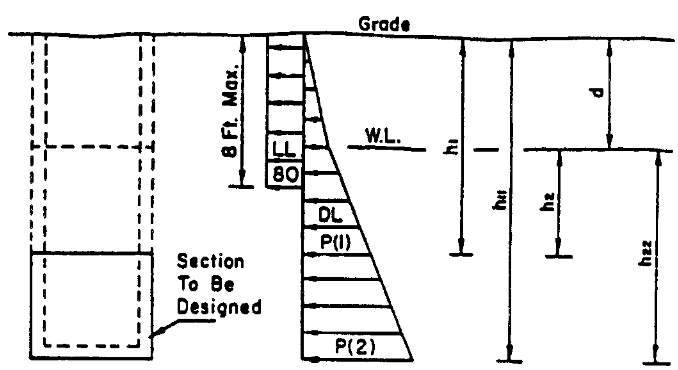

FIG. X2.1 Depth of Section

$$P = \frac{P(1) + P(2)}{2}$$

X2.1.6 Choose a Class (300, 500, 700) with capacity greater than *P*. Enter the table with desired size to obtain wall thickness, amount of reinforcing steel, and location of steel in the wall.

X2.2 Example Problem

X2.2.1 Select a Class for a concrete rectangular box to be used as a catch basin when the invert of the base is 11 ft (3.4 m) below grade and water level is 5 ft (1.5 m) below grade. Catch basin is in a highway.

X2.2.2 Since the catch basin is in a highway, a live load (*LL*) from truck traffic must be considered. Refer to Fig. X2.2 for load diagram.

X2.2.3 From Fig. X2.2:

$$h_1 = 8 \text{ ft } (2.4 \text{ m}) \tag{X2.2}$$

$$h_{11} = 11 \text{ ft } (3.4 \text{ m})$$

$$h_2 = 3 \text{ ft } (0.91 \text{ m})$$

$$h_{22} = 6 \text{ ft } (1.8 \text{ mm})$$

$$P\,(1) = 40 \times 8 + 62.4 \times 3 = 507 \text{ lbf/ft}^2 (24.3 \text{ kPa})$$

$$P\,(2) = 40 \times 11 + 62.4 \times 6 = 814 \text{ lbf/ft}^2 \ (38.9 \text{ kPa})$$

$$P = \frac{507 + 814}{2} = 660 \text{ lbf/ft}^2 (31.6 \text{ kPa})$$

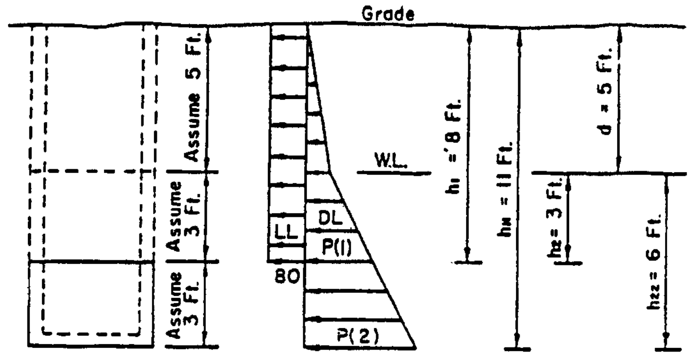

FIG. X2.2 Load Diagram

X2.2.4 Choose Class 700 since 700 is greater than 660. Go to the tables with desired size to obtain information necessary to produce the box.

X2.2.5 If P is greater than 700, the tables do not apply. An engineer should be engaged to provide design.