INTERNATIONAL

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Standard Test Method for Measurement of Hydraulic Conductivity of Materials Derived from Scrap Tires Using a Rigid Wall Permeameter[1]

This standard is issued under the fixed designation D7760; 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 This test method covers laboratory measurement of the hydraulic conductivity (also referred to as *coefficient of permeability*) of water-saturated samples obtained from materials derived from scrap tires using a rigid-wall permeameter. The scrap tire materials covered in this method include tire chips, tire shreds, and tire derived aggregate (TDA) as described in Practice D6270 with particle sizes ranging from approximately 12 to 305 mm. Whole scrap tires are not included in this standard. A clear trend between hydraulic conductivity and shred size has not been established at a given vertical pressure for shreds ≥50 mm (**1**).[2]

1.2 A single- or dual-ring permeameter may be used in the tests. A dual-ring permeameter may be preferred over a single-ring permeameter to take into account and prevent short-circuiting of permeant along the sidewalls of the permeameter. The effects of sidewall flow is more significant at high stresses and when the cell diameter is less than 6 times the particle size (**1**).

1.3 The test method is used under constant head conditions.

1.4 Water is used as the permeant with the test method.

1.5 Test Method D2434 also can be used for determination of hydraulic conductivity of materials derived from scrap tires with sizes smaller than 19 mm under constant head conditions in a rigid-wall permeameter. Method D2434 includes the use of a permeameter with a single ring.

1.6 The values stated in SI units are to be regarded as the standard. Hydraulic conductivity has traditionally been expressed in cm/s in the US, even though the official SI unit for hydraulic conductivity is m/s.

1.7 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D2434 Test Method for Permeability of Granular Soils (Constant Head) (Withdrawn 2015)[4]

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

D6026 Practice for Using Significant Digits in Geotechnical Data

D6270 Practice for Use of Scrap Tires in Civil Engineering Applications

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms in this standard, refer to Terminology D653.

3.1.2 For definitions of terms related to scrap tires, refer to Practice D6270.

3.1.3 *hydraulic conductivity, k*—(also referred to as *coefficient of permeability* or *permeability*) the rate of discharge of

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[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.14 on Geotechnics of Sustainable Construction.

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[2] The boldface numbers in parentheses refer to a list of references at the end of this standard.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] The last approved version of this historical standard is referenced on www.astm.org.

water under laminar flow conditions through a unit cross-sectional area of porous medium under a unit hydraulic gradient and standard temperature conditions (20 °C).

3.1.4 *hydraulic gradient, i*—the change in total head (head loss, Δh) per unit distance (L) in the direction of fluid flow, in which $i = \Delta h/L$.

3.1.5 *permeameter*—the apparatus (cell) containing the test specimen in a hydraulic conductivity test.

4. Significance and Use

4.1 This test method is used to measure one-dimensional vertical flow of water through initially saturated samples of materials derived from scrap tires under an applied hydraulic gradient. Hydraulic conductivity is required in various civil engineering applications of scrap tires.

4.2 Samples are to be tested at a unit weight and under an overburden pressure representative of field conditions. Data from the literature indicate a reduction in hydraulic conductivity with increasing vertical pressure (**1**).

4.3 Use of a dual-ring permeameter is included in this test method in addition to a single-ring permeameter. The dual-ring permeameter allows for minimizing potential adverse effects of sidewall leakage on measured hydraulic conductivity of the test specimens. The use of a bottom plate with an inner ring with a diameter smaller than the diameter of the permeameter and two outflow ports (one from the inner ring, one from the annular space between the inner ring and the permeameter) allows for separating the flow from the central part of the test specimen from the flow near the sidewall of the permeameter.

4.4 Darcy's law is assumed to be valid, flow is assumed to be laminar (Reynolds number less than approximately 2000–3000), and the hydraulic conductivity is assumed to be essentially independent of hydraulic gradient. The validity of Darcy's law may be evaluated by measuring the hydraulic conductivity of a specimen at three hydraulic gradients. The discharge velocity ($v = k \times i$) is plotted against the applied hydraulic gradient. If the resulting relationship is linear and the measured hydraulic conductivity values are similar (i.e., within 25 %), then Darcy's law may be taken as valid.

NOTE 1—The quality of the result produced by this standard is dependent of the competence of the personnel using this standard and the suitability of the equipment and facilities. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of these factors.

5. Apparatus

5.1 Schematics of the various components of two setups used to determine hydraulic conductivity of samples of materials derived from scrap tires using rigid-wall permeameters under constant head conditions are provided for single-ring and dual-ring devices in Fig. 1(a) and (b), respectively.

5.2 *Constant-Head Hydraulic System*—The hydraulic system is used to apply, maintain, and measure heads and resulting hydraulic gradients in a test. The hydraulic system mainly consists of reservoirs that hold water and associated piping, tubing, valves, and connections. Pressure application setups may also be used to pressurize influent and effluent liquids, in particular to apply high hydraulic gradients. The system shall allow for maintaining constant hydraulic head to within ±5 % or better accuracy during a test. The system shall allow for measurement of the constant head to within ±5 % or better accuracy during a test. The head shall be measured with a graduated pipette, engineer's scale, pressure gauge, electronic pressure transducer, or any other device that has the resolution required for the determination of head to the accuracy provided above.

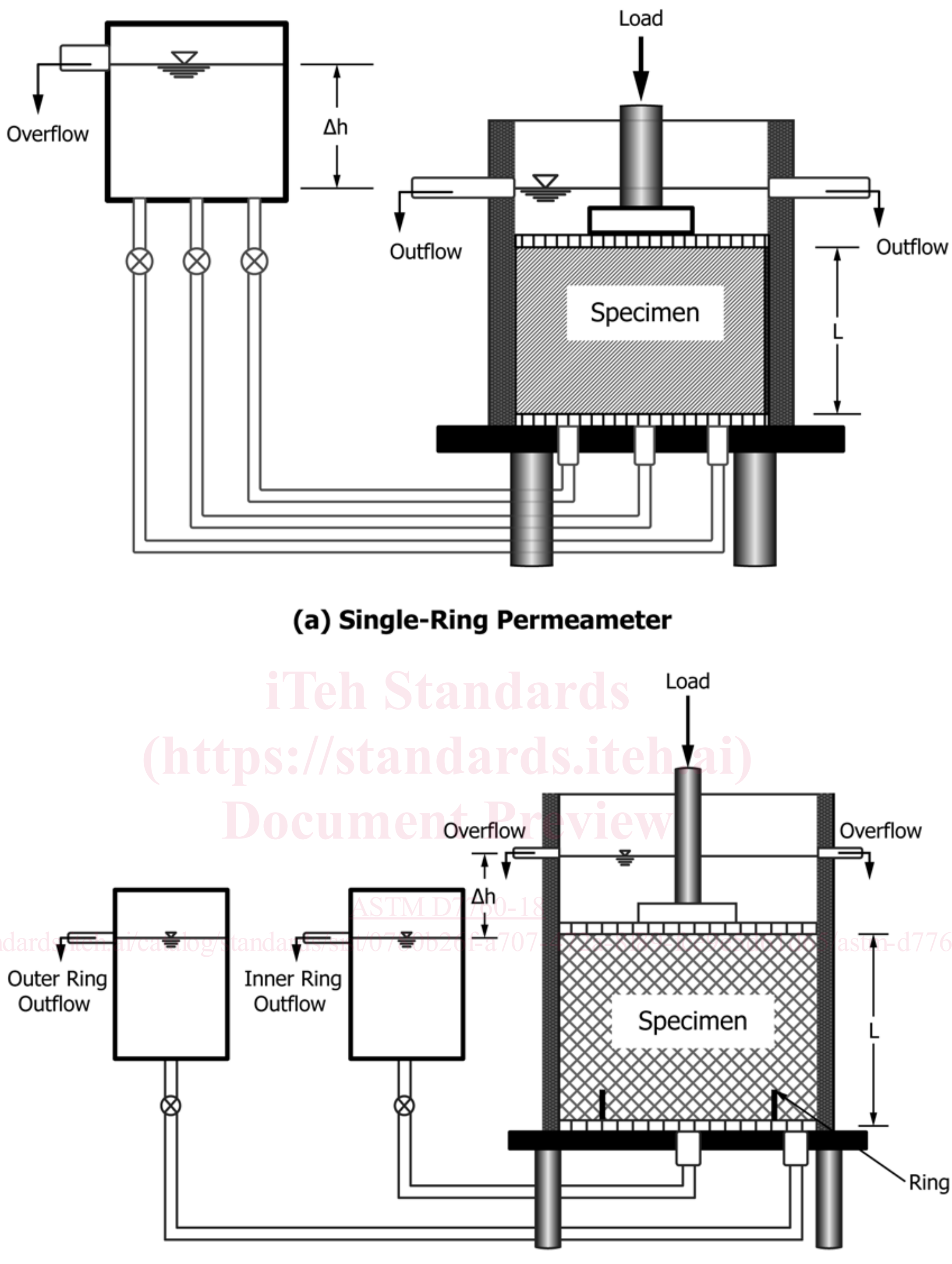
5.2.1 *System De-airing*—The hydraulic system shall be designed to facilitate rapid and complete removal of free air bubbles from flow lines. This can be accomplished for example by using properly sized tubing and ball valves, and fittings without pipe threads. Properly sized components are small enough to prevent entrapment of air bubbles, but are large enough not to cause head losses as described in 6.1.

5.3 *Flow-Measurement System*—Flow-measurement system is used to determine the amount of inflow and outflow from a specimen during a test. The measurement device shall allow for the measurement of the quantity of flow (both inflow and outflow) over an interval of time to within ±5 % or better accuracy. Flow-measurement system may consist of a graduated accumulator, Mariotte bottle, vertical standpipe in conjunction with an electronic pressure transducer, electromagnetic flow meter, or other volume-measuring device that has the resolution required to determine flow to the accuracy provided above. In most cases, these devices are common to the hydraulic system.

5.3.1 *De-airing and Dimensional Stability of the System*—The flow-measurement system shall contain a minimum of dead space and shall be equipped to allow for complete and rapid de-airing. Dimensional stability of the system with respect to changes in pressure shall be ensured by using a stiff flow-measurement system that includes glass pipe or rigid metallic or thermoplastic tubing.

5.4 *Vertical Pressure Application System*—The system for applying vertical pressure on the test specimen in the permeameter (if used) shall allow for applying and controlling the pressure to within ±5 % or better accuracy. The vertical pressure application system may include a dead-weight load application setup; a hydraulic load application system; or any other system that allows for application of the desired level of pressure to a specimen via the top of the specimen.

5.5 *Permeameter*—The permeameter shall consist of a permeameter cell and attached equipment that allow for connecting the permeameter to the hydraulic system, the flow-measurement system, and the pressure application system, as well as provisions to support a specimen and to permeate the specimen. The permeameter cell shall consist of a rigid mold, cover plate, base plate, and attachments to hold the components together without leakage during a test. The diameter of the permeameter shall be determined based on the nominal size (defined as the average particle size that comprises more than 50 % of a sample per Practice D6270) of the scrap tire derived material to be tested. A permeameter diameter at least 6 times



(a) Single-Ring Permeameter

(b) Dual-Ring Permeameter

FIG. 1 Example Test Setups

the nominal particle size has been shown to be adequate (**1**). A permeameter with a diameter of 0.30 m and a height of 0.12 m was demonstrated to be effective for testing tire chips with dimensions of 38 × 76 mm (**2**).

5.5.1 *Rigid Permeameter Mold*—The permeameter cell shall consist of a rigid-wall mold into which the tire specimen to be tested is placed and in which the test specimen is permeated. The mold shall be constructed of a rigid material such as steel, aluminum, brass, or plastic that will not be damaged during placement/compression of the specimen in the mold. The mold shall be cylindrical in shape. The cross-sectional area along the direction of flow shall not vary by more than ±2 % and the height shall not vary by more than ±1 %. The permeameter shall be designed and operated such