Designation: D5874 – 16

Standard Test Methods for
Determination of the Impact Value (IV) of a Soil[1]

This standard is issued under the fixed designation D5874; 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 determination of the Impact Value (IV) of a soil either in the field or a test mold, as follows:

1.1.1 *Field Procedure A*—Determination of IV alone, in the field.

1.1.2 *Field Procedure B*—Determination of IV and water content, in the field.

1.1.3 *Field Procedure C*—Determination of IV, water content, and dry density, in the field.

1.1.4 *Mold Procedure*—Determination of IV of soil compacted in a mold, in the lab.

1.2 The standard test method, using a 4.5 kg (10 lbm) hammer, is suitable for, but not limited to, evaluating the strength of an unsaturated compacted fill, in particular pavement materials, soils, and soil-aggregates having maximum particle sizes less than 37.5 mm (1.5 in.).

1.3 By using a lighter 0.5 kg (1.1 lbm) or 2.25 kg (5 lbm) hammer, this test method is applicable for evaluating lower strength soils such as fine grained cohesionless, highly organic, saturated, or highly plastic soils having a maximum particle size less than 9.5 mm (0.375 in.), or natural turfgrass.

1.4 By using a heavier 10 kg (22 lbm) or 20 kg (44 lbm) hammer, this test method is applicable for evaluating for harder materials at the top end the scales or beyond the ranges of the standard and lighter impact soil testers.

1.5 By performing laboratory test correlations for a particular soil using the 4.5 kg (10 lbm) hammer, IV may be correlated with an unsoaked California Bearing Ratio (CBR) or may be used to infer percentage compaction.

1.6 The values stated SI are to be regarded as the standard. The values stated in parentheses are given for information only.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.8 For purposes of comparing, a measured or calculated value(s) with specified limits, the measured or calculated value(s) shall be rounded to the nearest decimal or significant digits in the specified limits.

1.8.1 The procedures used to specify how data are collected/recorded or calculated, in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering design.

1.9 *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.*

NOTE 1—The equipment and procedures contained in this test method are similar to those developed by B. Clegg in the 1970s at the University of Western Australia, Nedlands, Australia. Impact Value is also commonly known as Clegg Impact Value (CIV).

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3))

D1556 Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))

D1883 Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

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*A Summary of Changes section appears at the end of this standard

D2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method

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

D4643 Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating

D4959 Test Method for Determination of Water (Moisture) Content of Soil By Direct Heating

D6026 Practice for Using Significant Digits in Geotechnical Data

D6938 Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

3. Terminology

3.1 *Definitions:*

3.1.1 Except as listed in 3.2, all definitions are in accordance with Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *as-compacted target IV, n*—the desired strength, in terms of IV, to be achieved in the field for a particular material and construction process, at the as-compacted moisture condition. This may also be referred to as the *as-compacted target strength.*

3.2.2 *dried-back target IV, n*—the desired strength, in terms of IV, to be achieved in the field for a particular material and construction process prior to continuing with a subsequent layer, or sealing, or opening to traffic, after moisture has left the system through evaporation and/or drainage. This may also be referred to as the dried-back target strength.

3.2.3 *heavy impact value (IV/H), n*—the IV derived from using a 20 kg (44 lbm) mass hammer 130 mm (5 in.) in diameter free falling 300 mm (12 in.).

3.2.4 *heavy medium heavy impact value (IV/HMH), n*—the IV derived from using a 10 kg (22 lbm) mass hammer 130 mm (5 in.) in diameter free falling 300 mm (12 in).

3.2.5 *impact soil tester, n*—testing apparatus used to obtain an IV of a soil.

3.2.6 *impact value (IV), n*—the value expressed in units of tens of gravities (*g*) and reported to the nearest whole number derived from the peak deceleration of a 4.5 kg (10 lbm) instrumented compaction hammer 50 mm (2.0 in.) in diameter free falling 450 mm (18 in.).

3.2.7 *in-service target IV, n*—the desired strength, in terms of IV, to be achieved in the field for a particular material and construction process once the road is opened to traffic and has reached equilibrium. This may also be referred to as the *in-service target strength.*

3.2.8 *light impact value (IV/L), n*—the IV derived from using a 0.5 kg (1.1 lbm) mass hammer 50 mm (2.0 in.) in diameter free falling 300 mm (12 in.).

3.2.9 *medium impact value (IV/M), n*—the IV derived from using a 2.25 kg (5 lbm) mass hammer 50 mm (2.0 in) in diameter free falling 450 mm (18 in.).

4. Summary of Test Method

4.1 The test apparatus is placed on the material to be tested either in a mold or on naturally occurring or compacted soil in the field. The hammer is raised to a set height and allowed to free fall. The instrumentation of the test apparatus displays a value in tens of gravities (*g*) of the peak deceleration of the hammer's impact as recorded by an accelerometer fitted to the top of the hammer body. A total of four blows of the hammer are applied on the same spot to determine the IV for each test performed.

4.2 A lighter hammer of 0.5 kg (1.1 lbm) or 2.25 kg (5 lbm) may be used for softer conditions or fragile materials instead of the 4.5 kg (10 lbm) standard hammer to determine the IV. When used the resulting value is termed the Light Impact Value (IV/L) for the 0.5 kg (1.1 lbm) hammer or Medium Impact Value (IV/M) for the 2.25 kg (5 lbm) hammer.

4.3 A larger, heavier hammer of 10 kg (22 lbm) or 20 kg (44 lbm) may be used instead of the 4.5 kg (10 lbm) standard hammer to determine the IV for harder conditions or to test through a larger zone both horizontally and vertically. When used, the resulting value is termed the Heavy Medium Heavy Impact Value (IV/HMH) for the 10 kg (22 lbm) hammer or Heavy Impact Value (IV/H) for the 20 kg (44 lbm) hammer.

5. Significance and Use

5.1 Impact Value, as determined using the standard 4.5 kg (10 lbm) hammer, has direct application to design and construction of pavements and a general application to earthworks compaction control and evaluation of strength characteristics of a wide range of materials, such as soils, soil aggregates, stabilized soil and recreational turf. Impact Value is one of the properties used to evaluate the strength of a layer of soil up to about 150 mm (6 in.) in thickness and by inference to indicate the compaction condition of this layer. Impact Value reflects and responds to changes in physical characteristics that influence strength. It is a dynamic force penetration property and may be used to set a strength parameter.

5.2 This test method provides immediate results in terms of IV and may be used for the process control of pavement or earthfill activities where the avoidance of delays is important and where there is a need to determine variability when statistically based quality assurance procedures are being used.

5.3 This test method does not provide results directly as a percentage of compaction but rather as a strength index value from which compaction may be inferred for the particular moisture conditions. From observations, strength either remains constant along the dry side of the compaction curve or else reaches a peak and declines rapidly with increase in water content slightly dry of optimum water content. This is generally between 95 and 98 % maximum dry density (see Fig. 1 and Fig. 2). An as-compacted target strength in terms of IV may be designated from laboratory testing or field trials as a strength to achieve in the field as the result of a compaction process for a
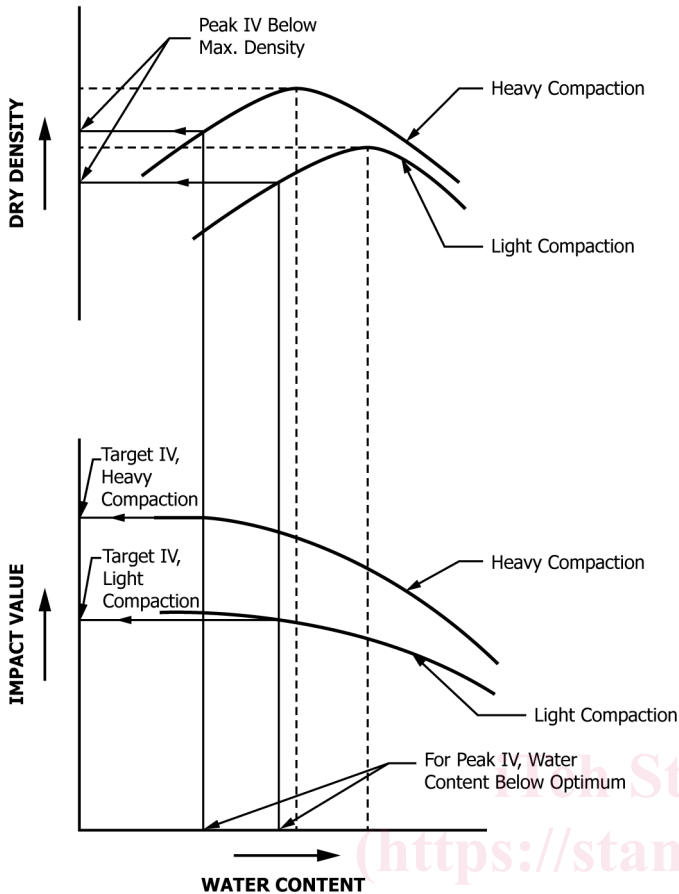
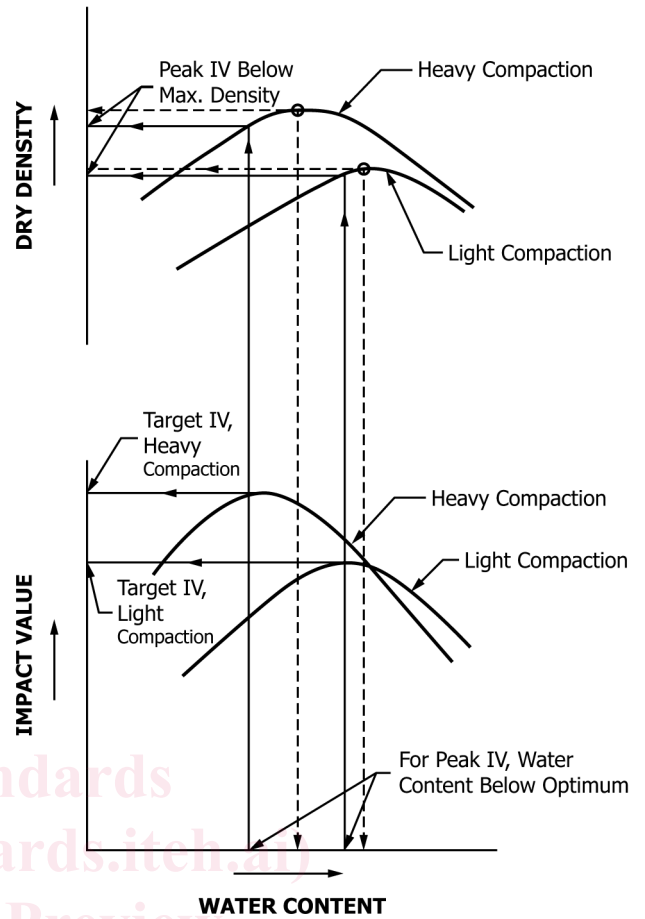FIG. 1 Illustration of Target IV for Material with No Peak

FIG. 2 Illustration of Target IV for Material with Pronounced Peak

desired density and water content. If testing is performed after compaction when conditions are such that the water content has changed from the critical value, determination of the actual water content by laboratory testing enables the field density to be inferred from regression equations using IV, density and water content.

NOTE 2—Impact Value may be used as a means to improve the compaction process by giving instant feedback on roller efficiency, uniformity, confirming the achievement of the target strength, and by inference the achieved density. When inferring density from IV, however, it should be considered as only indicative of density. Where strict acceptance on a density ratio basis is required, test methods that measure density directly shall be used.

5.4 This test method may be used to monitor strength changes during a compaction process or over time due to seasonal, environmental or traffic changes.

NOTE 3—For in-place soil strength evaluation where there may be a dry and hard surface layer (crust), testing both the crust and the underlying layer may be required.

5.5 The standard instrument is based on a 4.5 kg (10 lbm) compaction hammer using a 450 mm (18 in.) drop height. The hammer has been equipped with an accelerometer and instrumented using a peak hold electronic circuit to read the peak deceleration on impact. The circuitry is filtered electronically to remove unwanted frequencies and the peak deceleration is displayed in units of ten gravities (g) with the output below units of ten gravities truncated.

5.6 The peak deceleration on which IV is derived represents the area under the deceleration versus time curve which for most soils may be assumed as half a sinusoid. Applying double integration provides first the time velocity relationship and second, the time penetration relationship. As force is also directly related to deceleration, the IV therefore, represents both stress and penetration and may be taken as a direct measurement of stiffness or strength (see Fig. 3).

5.7 Impact Value may be correlated with an unsoaked CBR.

5.8 Impact Value may be expressed as a hammer modulus, analogous with elastic modulus or deformation modulus.

5.9 The light hammer uses the same accelerometer and instrumentation as the standard hammer. The smaller mass of 0.5 kg (1.1 lbm) results in more sensitivity for lower strength materials compared to the standard mass; that is, the zero to 100 IV scale is expanded with this lighter hammer mass and provides more definition on softer materials. To avoid confusion, the IV of the light hammer is notated as IV/L.

5.10 Light Impact Value has applications for recreation turf hardness evaluation, where the condition of the surface affects ball bounce characteristics, the performance or injury potential to participants, and where more sensitivity compared to the standard hammer is required or an imprint left by the 4.5 kg (10 lbm) hammer or other test methods is undesirable, such as on a golf putting green.

Assumed Sinusoidal Deceleration vs. Time Curve
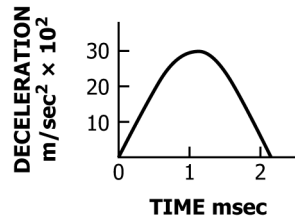
First Integration of Area under the Deceleration vs. Time Curve
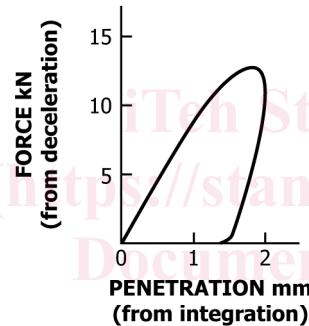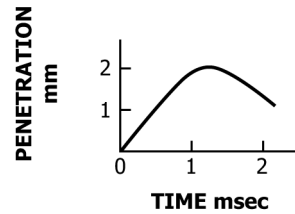
Second Integration

FIG. 3 Development of Force-Penetration from Deceleration Versus Time

larger zone both horizontally and vertically. The IV of the heavy hammer is notated as IV/H.

5.16 The Heavy Impact Value has application to testing the same materials as those tested by the standard, light, medium, and heavy medium heavy impact soil testers, but the greater mass of this impact soil tester provides less sensitivity of the output so is applicable for harder materials at the top end the scales or beyond the ranges of the lighter impact soil testers. The larger diameter mass of the heavy impact soil tester tests through a larger zone both horizontally and vertically than the smaller diameter impact soil testers.

NOTE 4—The quality of the results produced by this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D3740 does not in itself ensure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Impact Soil Tester*—A test apparatus consisting of a hammer, guide tube, and electronic instrumentation. Detailed information on the apparatus is contained in Annex A1. A typical configuration is shown in Fig. 4.

5.11 The medium hammer uses the same accelerometer and instrumentation as the standard hammer and provides a sensitivity between that of the standard hammer and light hammer. The IV of the medium hammer is notated as IV/M.

5.12 The Medium Impact Value has application to sand and earthworks, and natural turfgrass and artificial turf hardness evaluation, the last primarily in relation to performance or injury potential to the participants, and is preferable over the Light Impact Value in relation to thicker thatch and longer grass for such application.

5.13 The heavy medium heavy hammer uses the same accelerometer and instrumentation as the standard hammer, and tests through a larger zone both horizontally and vertically because of its larger diameter mass. The IV of the heavy medium hammer is notated as IV/HMH.

5.14 The Heavy Medium Heavy Impact Value has application to testing the same materials as those tested by the standard, light and medium impact soil testers, for evaluation of a layer of soil up to about 380 mm.

5.15 The heavy hammer uses the same accelerometer and instrumentation as the standard hammer, and tests through a
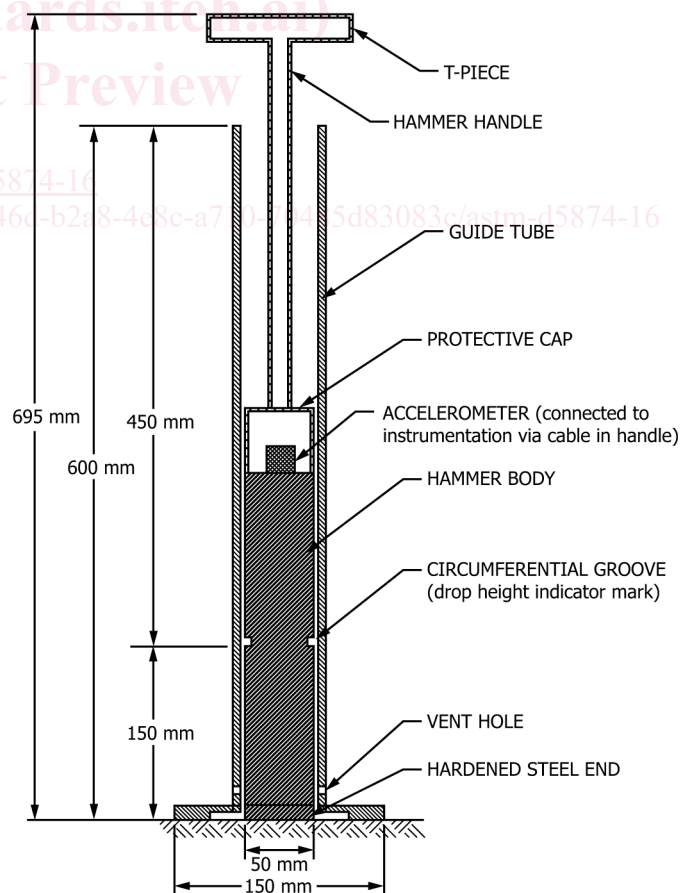

FIG. 4 Illustration (Cross Section) of the Standard 4.5 kg Impact Soil Tester with Hammer at Rest in the Guide Tube

6.2 *Mold*—A 152.4 ± 0.7 mm (6.000 ± 0.026 in.) diameter mold conforming to the requirements of Test Methods D698 Procedure C, D1557 Procedure C, or D1883 with a spacer disc.

6.2.1 Molds of other, typically larger, dimensions may be used but must be reported accordingly in the report.

NOTE 5—For a particular material, the smaller 101.6 mm (4 in.) mold may be used if it has been proven by a laboratory test comparison with the 152.4 mm (6 in.) mold that there is no significant difference in the IV results. Mold dimensions are to be consistent with Test Methods D698 and D1557.

7. Procedure

7.1 *Operational Verification Checks*—Perform operational verification checks at the commencement of any testing program, after repair, or when the instrument is suspect using the operational check ring as follows.

7.1.1 Place the ring on a dry, grease free smooth hard surface of a solid massive object, such as a concrete floor over ground. Place the guide tube centrally over the ring and drop the hammer five times from the set height mark as described in A2.1.3 for the standard 4.5 kg hammer or A2.1.4 for the light 0.5 kg hammer. Operate the instrumentation so as to obtain five separate readings. If this operational check procedure gives significantly different values than shown on the ring, examine the dryness, cleanliness, smoothness and firmness of the support for the ring and the ring itself and review the operational check procedure and rerun the check at the same or another location. If the ring value is not satisfactorily achievable, an electronic check may be carried out according to the manufacturer's calibration instruction for the accelerometer.

NOTE 6—To avoid the possibility of damage to the electronics or the hammer, the impact soil tester should not be used directly on hard surfaces such as concrete or otherwise in such a way on materials that it would give results of more than 100 IV (1000 *g*).
NOTE 7—The impact energy provided by the 4.5 kg hammer can cause undesired damage to surfaces and materials such as brick or concrete paving slabs or smoothly prepared turf surfaces.

7.2 Determine an IV as follows:

7.2.1 The peak deceleration that is the highest of the four successive blows is taken as the IV. The maximum of the first four blows has been found through experiment and practice to be the simplest means by which to obtain consistent results. Analysis of the blow count has shown that the first blow or two may be considered as seating procedure as they create a compacted wedge or hemisphere of soil that is subsequently forced into the body of the soil causing an increase in deceleration, that is, an increase in IV, as successive blows are applied. In general, deceleration remains practically unchanged after the third or fourth blow with additional blows continuing to produce a constant amount of penetration. If lower values occur with subsequent blows, this is due apparently to the hammer striking the sides of the indentation or by loose material falling onto the strike surface causing a bias in this direction.

7.2.2 Impact Values obtained from other blow counts, or an average thereof, shall be reported accordingly in the report.

7.3 *Field Procedure A*—If necessary, prepare the surface of the compacted or natural soil to be tested by lightly scuffing with the foot to remove loose surface material. Before beginning a test, ensure that the hammer strike face is clean of any soil build-up and that the guide tube is reasonably clean so as not to restrict a free fall. Place the impact soil tester in position with the guide tube base set on the ground. Steady the guide tube to hold vertical in place, activate the instrumentation, and apply four free falling blows in succession from the set height of drop. Take and record the highest value of the four blows as the IV.

NOTE 8—A method of securing the guide tube in a vertical position is for the operator to place a foot on the guide tube base and steady the guide tube with the lower leg or knee, or both. Raising of the hammer is done by the hand on the same side of the body as the foot securing the guide tube.
NOTE 9—For sloping sites, a level test surface may need to be prepared so that the guide tube base rests on the surface with the guide tube as near to vertical as possible.

7.4 *Field Procedure B*—Follow *Field Procedure A* but determine the water content of the material at a location 100 mm (4 in.) to 150 mm (6 in.) from the edge of the guide tube flange content. Determine the water content according to the applicable test methods listed in 2.1.

7.5 *Field Procedure C*—Follow *Field Procedure B* but determine also the density of the material at a location 100 mm (4 in.) to 150 mm (6 in.) from the edge of the guide tube flange. Determine the density according to the applicable test methods listed in 2.1.

7.6 *Mold Procedure*—Obtain a soil sample representative of that to be tested in the field and prepare a test specimen according to the requirements of either Test Method D698 or D1557. Prepare the test specimen at a water content and density at which it is desired to determine the IV. Compact the test specimen in a mold as given in 6.2. Perform the impact test on the compacted specimen in the mold with the base plate left attached to the mold. Before beginning a test, ensure that the hammer strike face is clean of any soil build-up and that the guide tube is reasonably clean so as not to restrict a free fall. To aid in centering and steadying the guide tube, replace the mold collar after trimming the surface of the compacted soil and brushing off loose material if necessary. Place the mold with the specimen on a firm, smooth base such that it cannot be rocked. Place the impact soil tester on the trimmed surface in a vertical position with the guide tube base set inside the mold collar or centered on the soil. Activate the instrumentation, and without moving the guide tube, apply four free falling blows in succession from the standard height of drop. Take and record the highest value of the four blows as the IV.

8. Correlation of IV with Other Soil Properties and Determination of an As-Compacted Target IV

8.1 *An As-Compacted Target Strength,* for a particular soil, may be chosen from the following IV correlations. All procedures given below for determination of an As-Compacted Target IV are performed with a compaction curve according to either Test Method D698 or D1557. Each of the following three procedures apply to density or CBR correlations. Where CBR correlations are requested, a duplicate specimen is required for each of the following procedures, that is, an IV test is

performed on one specimen and an unsoaked CBR test is carried out on the duplicate specimen.

8.1.1 *As-Compacted Target IV at Optimum Water Content Only*—After determining the optimum water content of the sample in accordance with either Test Method D698 or D1557, compact a specimen in a mold as described in 6.2 to the desired optimum water content and maximum dry unit weight or percent compaction using the specified compaction procedure from soil prepared to within ±0.5 % of optimum water content. Obtain the As-Compacted Target IV according to 7.6. If requested, obtain an unsoaked CBR according to Test Method D1883 on a duplicate specimen.

8.1.2 *As-Compacted Target IV from a Range of Water Contents*—Determine the optimum water content of the sample according to either Test Method D698 or D1557. Prepare four specimens using the mold size as described in 6.2 at a range of water contents such that they bracket the optimum water content. The water contents shall vary about 2 %. Compact each specimen using 100 % compactive effort according to the nominated compaction method. Obtain an IV according to 7.6 for each specimen molded to produce a curve of IV versus water content. Determine the As-Compacted Target IV from the correlation curve at the point at which an increase in water content results in a corresponding loss of strength. If requested, obtain corresponding unsoaked CBRs on duplicate specimens and plot the IV versus CBR relationship.

8.1.3 *As-Compacted Target IV from a Range of Densities at Optimum Water Content*—Determine the maximum dry density and optimum water content of the sample according to either Test Method D698 or D1557. Compact four specimens all at optimum water content ±0.5 % using the mold size as given in 6.2. Compact each specimen using a differing number of blows per layer for each specimen. Vary the number of blows per layer as necessary to prepare specimens having unit weights above and below the desired value, typically covering the range of 90 to 100 % percent compaction. Specimens compacted at 56, 30, 20, and 10 blows per layer is often satisfactory. Obtain an IV according to 7.6 for each specimen molded. Plot the IV versus the relative compaction at optimum water content. Determine the As-Compacted Target IV for the desired percent compaction from the correlation curve. If requested, obtain corresponding unsoaked CBRs on duplicate specimens and plot the IV versus CBR relationship.

9. Field Trial Procedure to Determine As-Compacted Target IV

9.1 This procedure determines an As-Compacted Target IV using a field trial to compact several test strips at differing water conditions using compaction procedures known to be capable of producing the required density level.

9.1.1 Uniformly mix the particular soil to be used in the field trial. Allow for field moisture curing before compacting if necessary according to standard water preparation practice for the particular soil. Prepare four test strips of uniform layer thickness at different water contents determined visually or predetermined by laboratory tests to bracket optimum water content. It is suggested that the test strips be not less than one roller width by five roller lengths (including the prime mover),

and that testing be confined to a central three roller length section of each test strip. The layer thickness may be varied to suit the material type and compaction equipment being used. In general, a loose placed nominal layer thickness of 230 mm (9 in.) gives a final compacted layer thickness of 150 mm (6 in.).

9.1.2 For each test strip, randomly perform at least five IV tests after the second, fourth, eighth, and sixteenth successive roller pass. Calculate and record the mean IV for each set of impact tests for each test strip at the completion of each of the above designated number of roller passes. It is important that there is no significant change in the water content of the test strips throughout the trial.

9.1.3 Determine the field water content of each test strip at the completion of the field trial in accordance with either Test Method D4643 or D4959. Plot a correlation curve for the mean IV at the sixteenth roller pass for each test strip versus the water content. Determine the As-Compacted Target IV from the correlation curve at the point at which an increase in water content results in a corresponding loss of strength. The roller efficiency may be evaluated by comparing the number of roller passes versus the mean IV for each test strip at each water content.

9.1.4 If requested, perform a density test on each test strip after the second, fourth, eighth, and sixteenth roller passes. Determine density in accordance with any of these Test Methods: D1556, D2167, or D2937.

9.1.5 If requested, determine and record the field water content of each test strip after the second roller pass according to the applicable test methods listed in 2.1.

NOTE 10—The completion of the field trial after sixteen roller passes is nominal only and this number may need to be varied depending on the roller and material used. Experience, however, has shown that sixteen passes for a heavy roller achieves 100 % modified compactive effort for finished layers up to 150 mm (6 in.) thickness.

10. Report: Test Data Sheet(s)/Form(s)

10.1 The methodology used to specify how data are recorded on the test data sheet(s) and form(s) as given below is covered in 1.7 and 1.8 and in Practice D6026.

10.2 Record, as a minimum, the following information:

10.2.1 Date of test and procedure used,

10.2.2 Operator's name,

10.2.3 Test location, elevation, thickness of layer tested or other pertinent data to locate or identify the test,

10.2.4 Description or type of soil and, for field procedures, whether compacted or natural,

10.2.5 For *Field Procedure A*, the IV, or variant as defined in 3.2, of the soil (in units of ten gravities to the nearest whole number),

10.2.6 For *Field Procedure B*, the IV, or variant as defined in 3.2, (in units of tens of gravities to the nearest whole number), water content, and density to the nearest 1 % or 0.1 % according to the procedure followed,

10.2.7 For *Field Procedure C*, the IV, or variant as defined in 3.2, (in units of tens of gravities to the nearest whole number), water content, and density to the nearest 1 % or 0.1 % according to the procedure followed,