Designation: C900 – 19

Standard Test Method for Pullout Strength of Hardened Concrete[1]

This standard is issued under the fixed designation C900; 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 determination of the pullout strength of hardened concrete by measuring the force required to pull an embedded metal insert and the attached concrete fragment from a concrete test specimen or structure. The insert is either cast into fresh concrete or installed in hardened concrete. This test method does not provide statistical procedures to estimate other strength properties.

1.2 The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this test method.

1.3 The text of this test method refers to notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this test method.

1.4 *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.* (**Warning—**Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2])

1.5 *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]

C125 Terminology Relating to Concrete and Concrete Aggregates

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

E4 Practices for Force Verification of Testing Machines

E74 Practices for Calibration and Verification for Force-Measuring Instruments

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this method, refer to Terminology C125.

4. Summary of Test Method

4.1 A metal insert is either cast into fresh concrete or installed into hardened concrete. When a measure of the in-place pullout strength is desired, the insert is pulled by means of a jack reacting against a bearing ring. The pullout strength is determined by measuring the maximum force required to pull the insert from the concrete mass. Alternatively, the insert is loaded to a specified load to verify whether a minimum level of in-place pullout strength has been attained.

5. Significance and Use

5.1 For a given concrete and a given test apparatus, pullout strengths can be related to compressive strength test results. Such strength relationships are affected by the configuration of the embedded insert, bearing ring dimensions, depth of embedment, and the type of aggregate (lightweight or normal weight). Before use, the relationships must be established for each test system and each new concrete mixture. Such relationships are more reliable if both pullout test specimens and compressive strength test specimens are of similar size, consolidated to similar density, and cured under similar conditions.

NOTE 1—Published reports (**1-17**)[4] by different researchers present their experiences in the use of pullout test equipment. Refer to ACI 228.1R (**14**) for guidance on establishing a strength relationship and interpreting test results. The Appendix provides a means for comparing pullout strengths obtained using different configurations.

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.64 on Nondestructive and In-Place Testing.

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[2] Section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol 04.02.

[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 boldface numbers refer to the list of references at the end of this test method.

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

5.2 If a strength relationship has been established experimentally and accepted by the specifier of tests, pullout tests are used to estimate the in-place strength of concrete to establish whether it has reached a specified level so that, for example:

(1) post-tensioning may proceed;

(2) forms and shores may be removed;

(3) structure may be placed into service; or

(4) winter protection and curing may be terminated.

In addition, post-installed pullout tests may be used to estimate the strength of concrete in existing construction.

5.3 When planning pullout tests and analyzing test results, consideration should be given to the normally expected decrease of concrete strength with increasing height within a given concrete placement in a structural element.

5.4 The measured pullout strength is indicative of the strength of concrete within the region represented by the conic frustum defined by the insert head and bearing ring. For typical surface installations, pullout strengths are indicative of the quality of the outer zone of concrete members and can be of benefit in evaluating the cover zone of reinforced concrete members.

5.5 Cast-in-place inserts require that their locations in the structure be planned in advance of concrete placement. Post-installed inserts can be placed at any desired location in the structure provided the requirements of 7.1 are satisfied.

5.6 This test method is not applicable to other types of post-installed tests that, if tested to failure, do not involve the same failure mechanism and do not produce the same conic frustum as for the cast-in-place test described in this test method (**16**).

6. Apparatus

6.1 The apparatus requires three basic sub-systems: a pull-out insert, a loading system, and a load-measuring system (Note 2). For post-installed inserts, additional equipment includes a core drill, a planing tool to prepare a flat bearing surface, a grinding tool to undercut a groove to engage the insert, and an expansion tool to expand the insert into the groove.

NOTE 2—A center-pull hydraulic jack with a pressure gauge that has been standardized according to Annex A1 and that reacts against a bearing ring has been used satisfactorily.

6.1.1 Cast-in-place inserts shall be made of metal that does not react with the constituents of the concrete. The insert shall consist of a cylindrical head and a shaft to fix embedment depth. The shaft shall be attached firmly to the center of the head (see Fig. 1). The insert shaft shall be threaded to the insert head so that it can be removed and replaced by a stronger shaft to pullout the insert, or it shall be an integral part of the insert and also function as the pullout shaft. Metal components of cast-in-place inserts and attachment hardware shall be of similar material to prevent galvanic corrosion. Post-installed inserts shall be designed so that they will fit into the drilled holes, and can be expanded subsequently to fit into the grooves that are undercut at a predetermined depth (see Fig. 2).

NOTE 3—A successful post-installed system uses a split ring that is coiled to fit into the core hole and then expanded into the groove.

6.1.2 The loading system shall consist of a bearing ring to be placed against the hardened concrete surface (see Figs. 1 and 2) and a tensile loading apparatus, with a load-measuring device that can be attached to the pullout shaft.

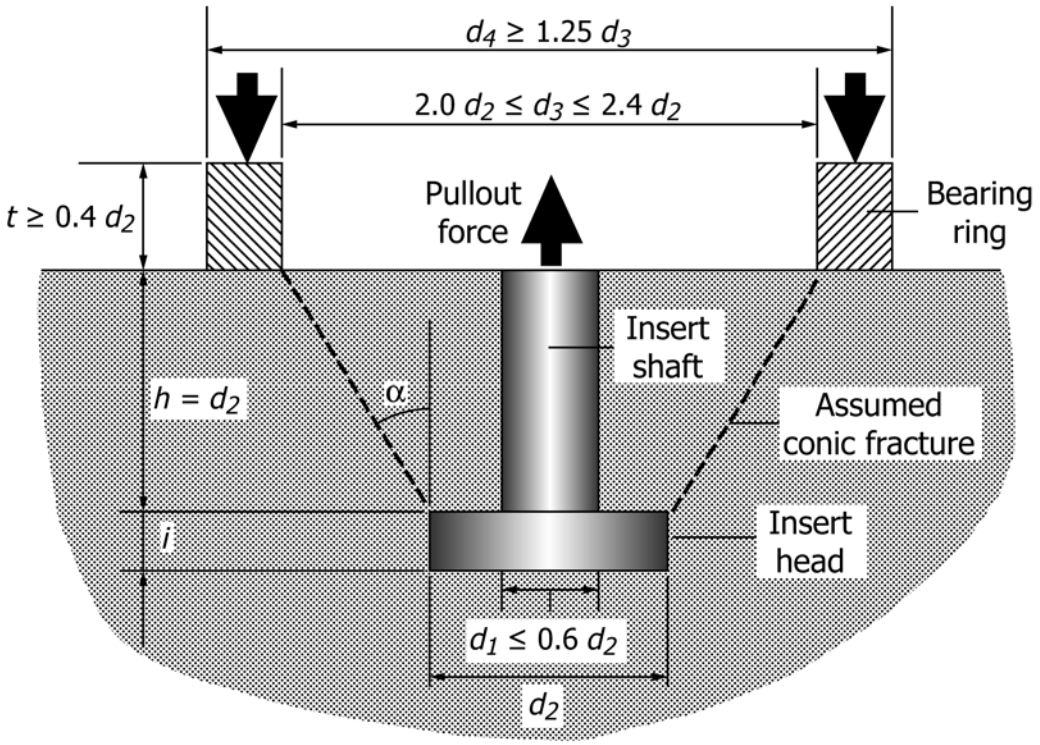

FIG. 1 Schematic Cross Section of Cast-in-Place Pullout Test

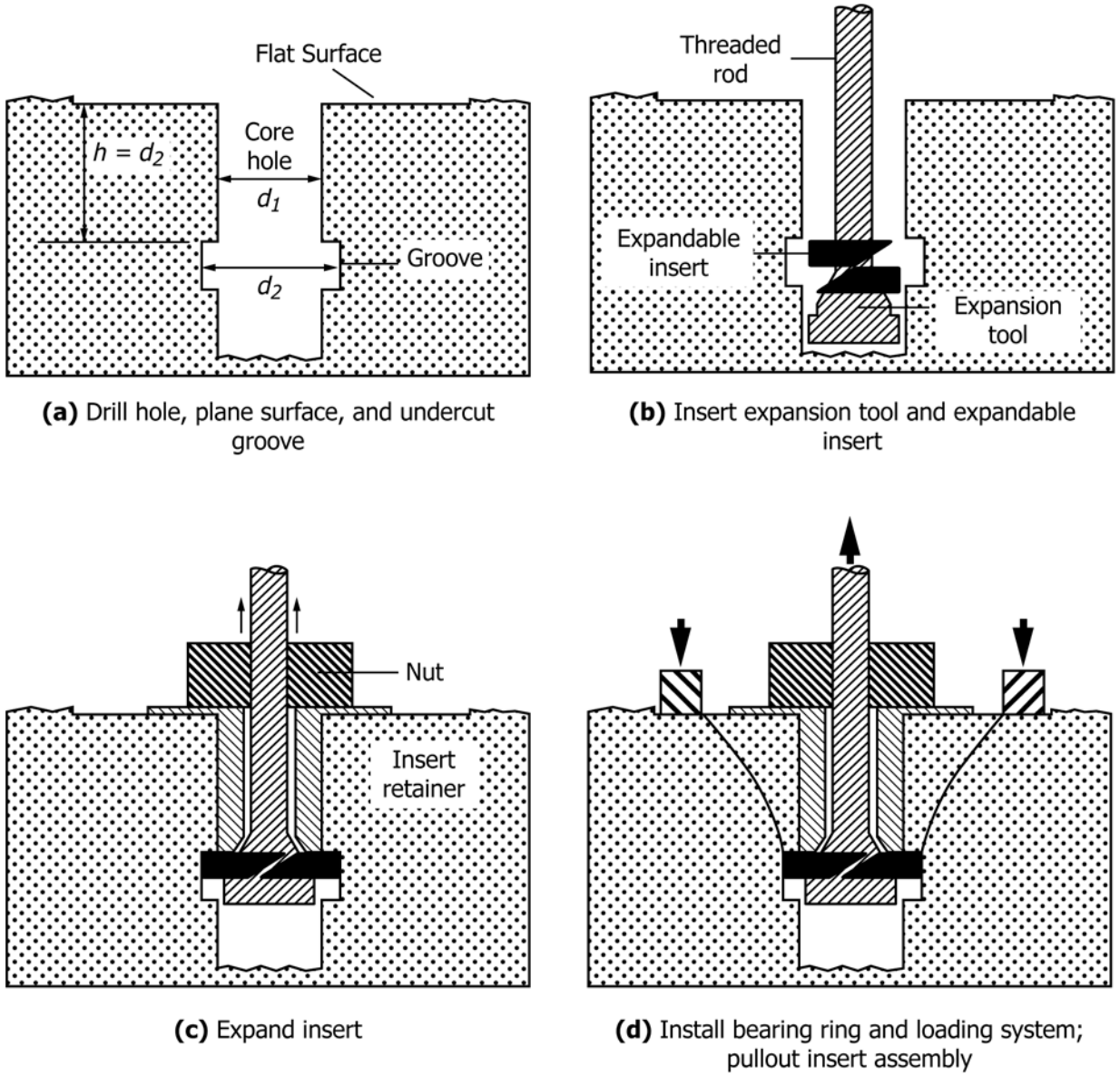

FIG. 2 Schematic of Procedure for Post-Installed Pullout Test

6.1.3 The test apparatus shall include centering features to ensure that the bearing ring is concentric with the insert, and that the applied load is axial to the pullout shaft, perpendicular to the bearing ring, and uniform on the bearing ring.

6.2 Equipment dimensions shall be determined as follows (see Fig. 1):

6.2.1 The diameter of the insert head (d_2) is the basis for defining the test geometry. The thickness of the insert head and the yield strength of the metal shall be sufficient to prevent yielding of the insert during test. The sides of the insert head shall be smooth (see Note 5). The insert head diameter shall be at least ⅔ of the nominal maximum size of aggregate.

NOTE 4—Typical insert diameters are 25 and 30 mm, but larger diameters have been used (**1**, **3**). Tests (**15**) have shown that nominal maximum aggregate sizes up to 1.5 times the head diameter do not have significant effects on the strength relationships. Larger aggregate sizes may result in increased scatter of the test results because the large particles can interfere with normal pullout of the conic frustum.

NOTE 5—Cast-in–place inserts may be coated with a release agent to minimize bonding with the concrete, and they may be tapered to minimize side friction during testing. The insert head should be provided with the means, such as a notch, to prevent rotation in the concrete if the insert shaft has to be removed prior to performing the test. As a further precaution against rotation of the insert head, all threaded hardware should be checked prior to installation to ensure that it is free-turning and can be easily removed. A thread-lock compound is recommended to prevent loosening of the insert head from the shaft during installation and during vibration of the surrounding concrete.

6.2.2 For cast-in–place inserts, the distance from the insert head to the concrete surface (h) shall equal the diameter of the insert head (d_2). The diameter of the insert shaft at the head (d_1) shall not exceed 0.60 d_2.

6.2.3 For post-installed inserts, the groove to accept the expandable insert shall be cut so that the distance between the bearing surface of the groove and concrete surface equals the