BUREAU OF INDIAN STANDARDS

[ICS 91.100.30]

Draft Indian Standard

Glossary of Terms Relating to Post-Installed Anchoring Systems for Steel to Concrete Connections

Cement and Concrete Sectional Committee, CED 02

FOREWORD

(Formal clauses of the standard to be added later)

There has been considerable development in the field of anchors for use in concrete to transmit structural loads and related practices in last couple of decades in India resulting in usage of various associated terms related to anchors. Consequently, it became necessary to formulate a standard to standardize the terminology on a more exact basis so as to avoid ambiguity and confusion. It is hoped that the glossary of terms in this standard would help in fixing a more precise meaning of words which have acquired general usage. To facilitate ease of reference, the terms have been arranged alphabetically.

These definitions correspond to terms as applied to anchors in concrete only and do not necessarily correspond to the definitions of the same terms used in other fields.

Draft Indian Standard

Glossary of Terms Relating to
Post-Installed Anchoring Systems for Steel to Concrete Connections

[ICS 91.100.30]

1 SCOPE

The standard covers definition of commonly used terms relating to anchors in concrete.

2 TERMINOLOGY

2.1 Adhesive — A bonding material which is used in adhesive anchor systems. Such adhesives comprise of chemical components formulated from organic polymers (like, epoxies, polyurethanes, etc.) and/ or inorganic (cementitious) materials that cure when blended together.

2.2 Adhesive Anchor — A type of post-installed anchor. The adhesive anchors consist of threaded anchor rods or reinforcement bars, which are anchored in predrilled holes in hardened concrete by bonding the metal parts of the anchor/reinforcement to the sides of the drilled hole with an adhesive. Tensile loads are transmitted to the concrete through bonding between metal parts and adhesive, and between adhesive and concrete face of the drilled hole (*see* Fig. 1). Depending on adhesive dispensing technique, adhesive anchor systems are classified into bulk, cartridge, and capsule type adhesive anchoring systems.

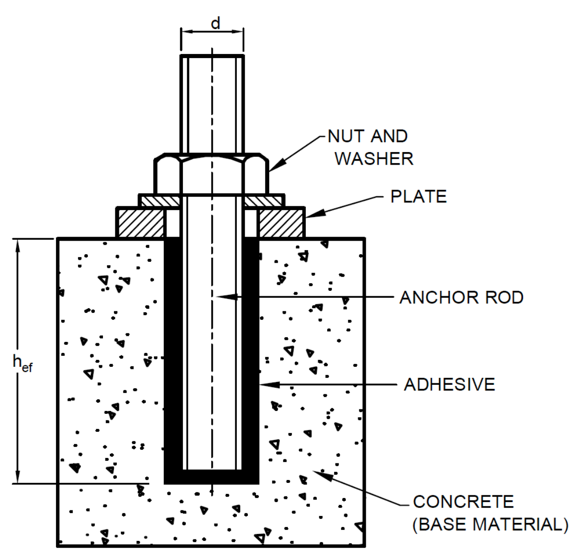


FIG. 1 ADHESIVE ANCHOR

2.3 Anchor – Steel element, either cast into concrete or post installed into hardened concrete, used to transmit the applied loads.

2.4 Anchorage or Anchoring System — An assembly of anchor or anchor group, fixture and base material (like concrete) surrounding each anchor in which it is installed.

2.5 Anchor Component Installation Temperature Range — The temperature range of the adhesive material and embedded part, immediately prior to installation.

2.6 Anchor displacement — Movement of the loaded end of the anchor relative to the concrete member into which it is installed, in the direction of the applied load. Displacement is measured parallel to the anchor axis in tension tests and perpendicular to the anchor axis in shear tests.

2.7 Anchor Group — A number of anchors with identical dimension and characteristics acting together to support a common attachment.

2.8 Anchor Installation — The process of installing anchor defined by the manufacturer for the subject anchor, unless otherwise specified.

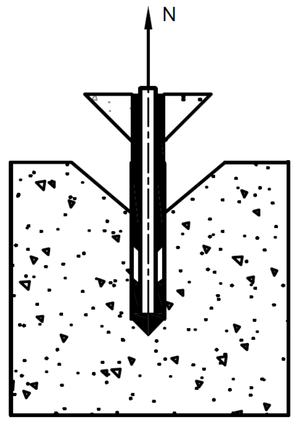
2.9 Annular gap – Gap between the fastening element and concrete when embedded.

2.10 Approval Body — An organization or group of experts that issue the Assessment Report (AR) for products, (in this case, the post-installed anchoring system) which may be qualified according to the Technical Assessment Document (TAD) for the designated use.

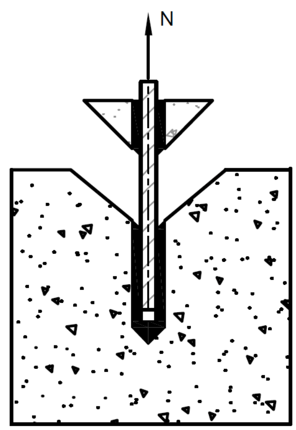
2.11 Assessment report (AR) – Assessment report of a product (in this case post installed anchor) is the summary of prequalification of the anchor based on TAD or a transparent and reproducible assessment that complies with the requirement relevant to the TAD.

2.12 Base Material — The material in which post-installed anchor is installed. It can be cured and hardened cast in-situ concrete or, precast concrete.

2.13 Bond Failure — A failure type observed for adhesive anchors in tension. This failure occurs either at the interface between the adhesive and the base material or between the adhesive and the embedded element (like threaded rod) of the adhesive anchor. This failure is typically accompanied with a shallow concrete cone at the loaded end of anchor. Bond failure is a sub type of pullout failure which is applicable only for adhesive anchors (*see* Fig. 2).



(2A) BOND FAILURE AT BASE MATERIAL AND ADHESIVE INTERFACE



(2B) BOND FAILURE AT ADHESIVE AND EMBEDDED ELEMENT INTERFACE

FIG. 2 BOND FAILURE

2.14 Bulk Adhesive Anchor System — One of the systems for large application for installing adhesive anchors.. This system comprises of two-component adhesive (resin and hardener) that are supplied either in barrels or cans. These incorporate bulk dispensing and mixing machine whereby preset quantities of the components are automatically controlled during dispensing (*see* Fig. 3).

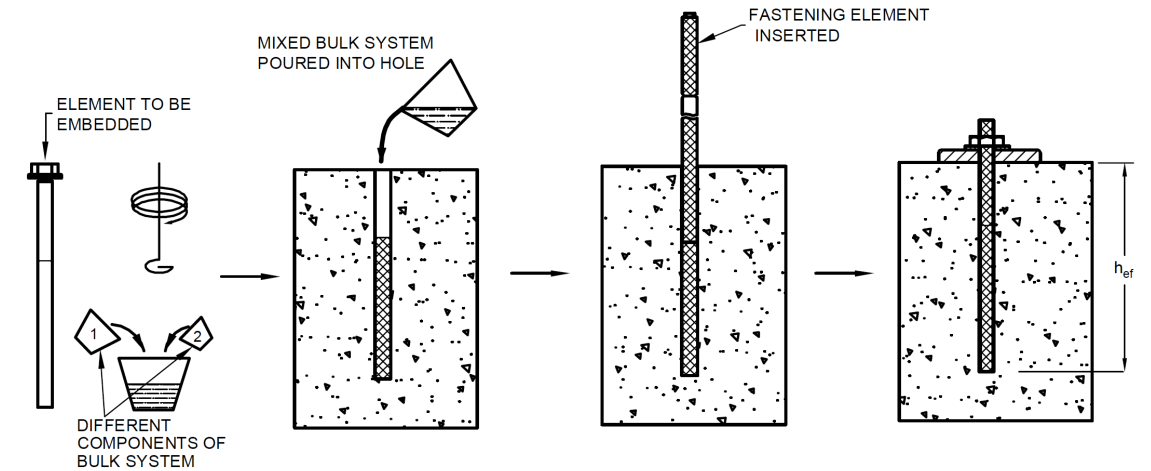


FIG. 3 TYPICAL BULK ADHESIVE SYSTEM

2.15 Capsule Adhesive Anchor System — One of the systems of installing adhesive anchors. In this system, the adhesive is packaged in glass or foil capsules. The diameter of capsule corresponds approximately to nominal anchor diameter. The quantity of resin and hardener in each capsule is such that it is suitable for single anchor application. Mixing of various components in each capsule is achieved during anchor installation process. The capsule gets fragmented, and it becomes part of the hardened resin matrix during anchor installation process (*see* Fig. 4).

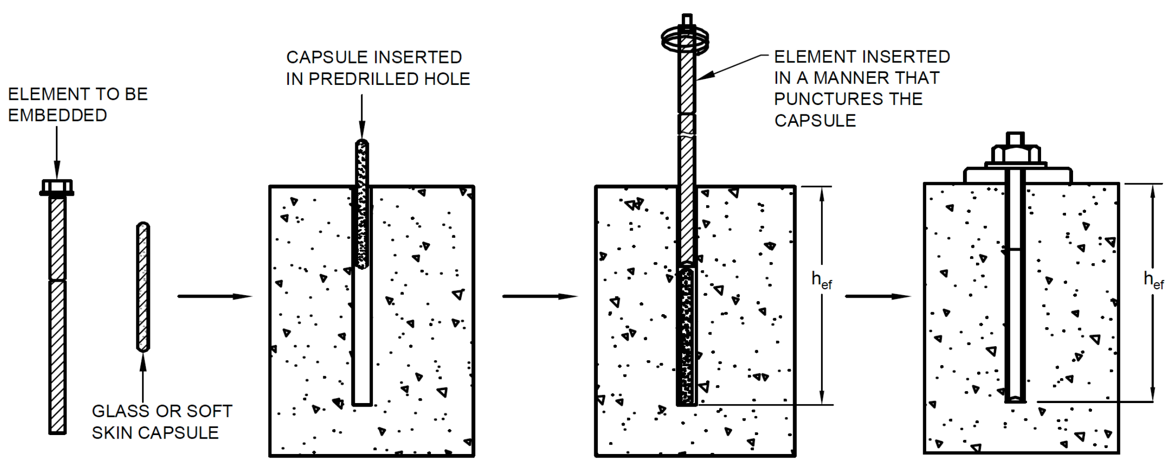


FIG. 4 TYPICAL CAPSULE ADHESIVE SYSTEM

2.16 Cartridge Adhesive Anchor System — This is one of the systems of installing adhesive anchors. In this system, two-component adhesives (resin and hardener) are packaged in cartridges for use with either manually- or power-driven dispensers. Metering and mixing of the components is automatically controlled as the adhesive is dispensed through a manifold and disposable mixing nozzle (*see* Fig. 5).

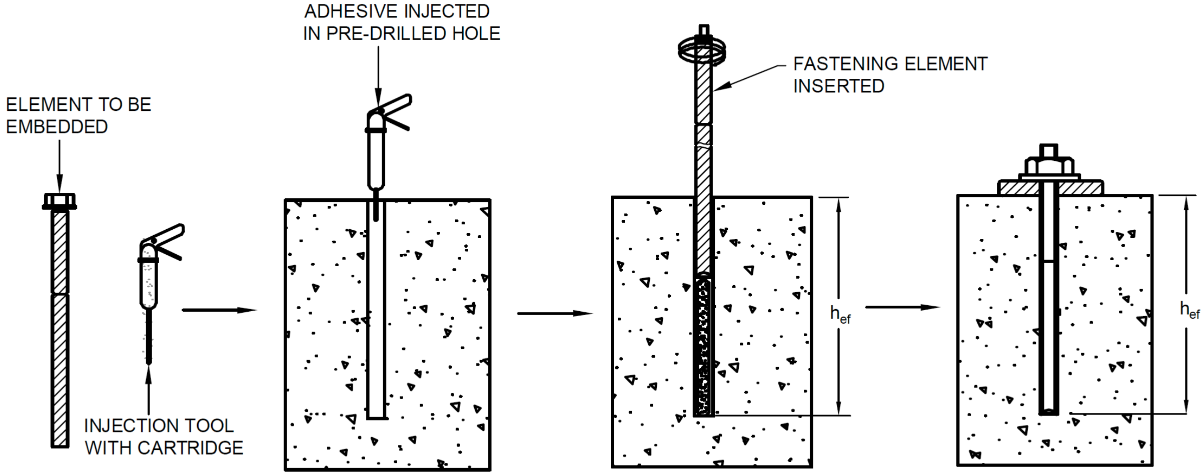


FIG. 5 TYPICAL CARTRIDGE ADHESIVE SYSTEM

2.17 Characteristic Value — The value below which not more than 5 percent of the test results are expected to fall (*see* Fig. 6).

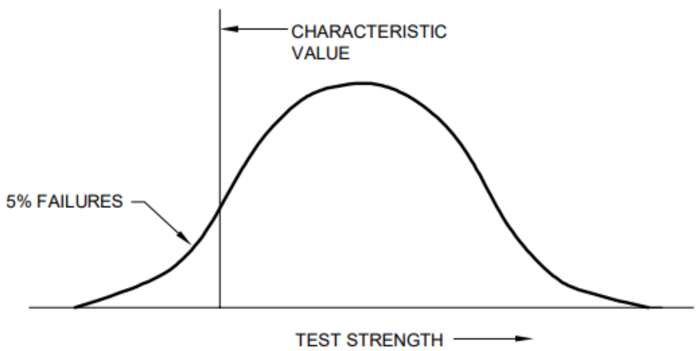


FIG. 6 TYPICAL CHARACTERISTIC VALUE

2.18 Concrete Cone Failure — This failure type is typically observed in both mechanical and adhesive anchors installed at shallow embedment depths under tension loading. This failure mechanism is characterized by the formation of a conical fracture surface originating at or near the embedded end of the anchor element and projecting to the surface of the concrete member. This failure mode is also observed in groups of mechanical and adhesive anchors installed at less than critical spacing. This type of failure can also occur when the anchor is located at a distance less than the critical edge distance (*see* Fig. 7).

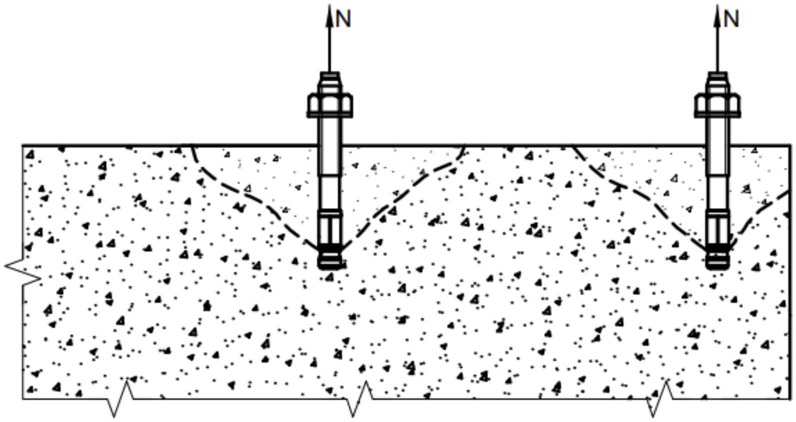


FIG. 7 TYPICAL CONCRETE CONE FAILURE

2.19 Concrete Edge Failure — This failure type is observed for both mechanical and adhesive anchors installed at less than critical edge distance under shear loading (with shear acting towards the free edge) (*see* Fig.8).

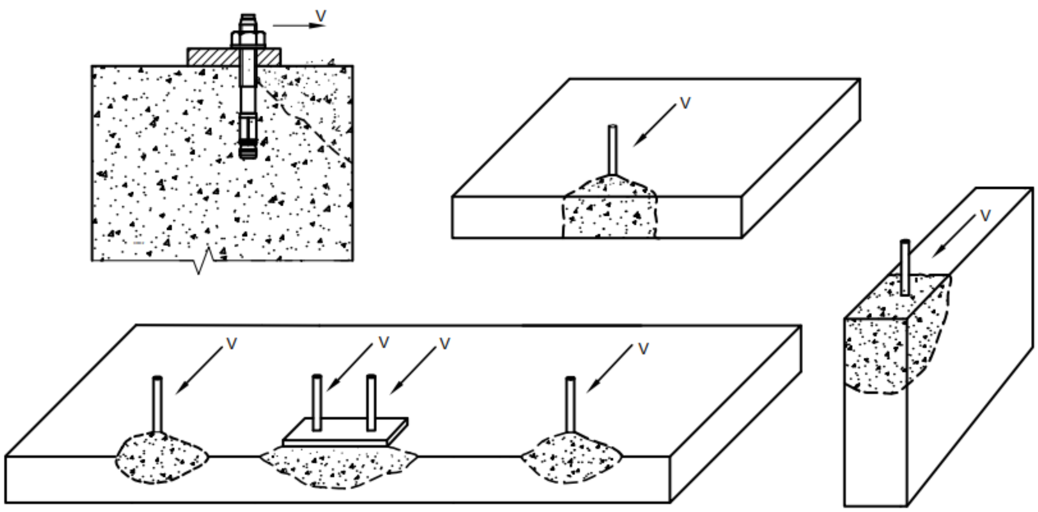


FIG. 8 TYPICAL CONCRETE EDGE FAILURE

2.20 Concrete Pry-out Failure — This failure type is observed for both mechanical and adhesive anchors installed at shallow embedment under shear loading (*see* Fig. 9). Concrete pry-out failure corresponds to the formation of a concrete spall opposite to the loading direction under shear loading.

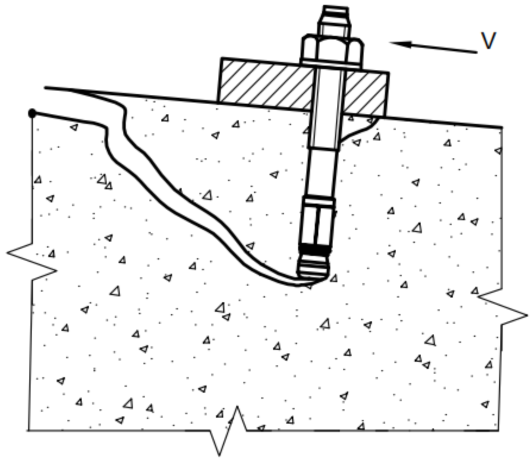


FIG. 9 TYPICAL CONCRETE PRY-OUT FAILURE

2.21 Concrete Screw — A type of post-installed anchor with threads that are screwed into a predrilled hole where threads create a mechanical interlock with the concrete (*see* Fig. 10).

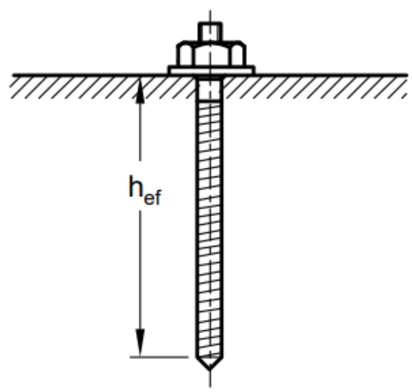


FIG. 10 TYPICAL CONCRETE SCREW

2.21 Cracked Concrete — Typically, concrete in tension may be assumed to be cracked. In addition, there is probability of formation of cracks after installation of anchor or significant expansion of existing cracks during the service life of the anchors. For test purposes, it is a test member with an approximately uniform crack width over the depth of the concrete test member.

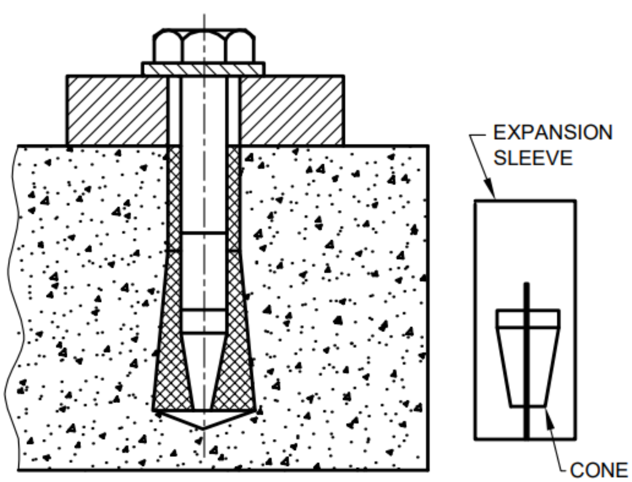
2.22 Critical Edge Distance — The minimum ~~edge~~ distance of an anchor from the face of concrete at which there is no influence of edge on its characteristic strength.

2.23 Critical Spacing — The minimum spacing ~~of~~ between anchors at which there is no influence of spacing on its characteristic strength.

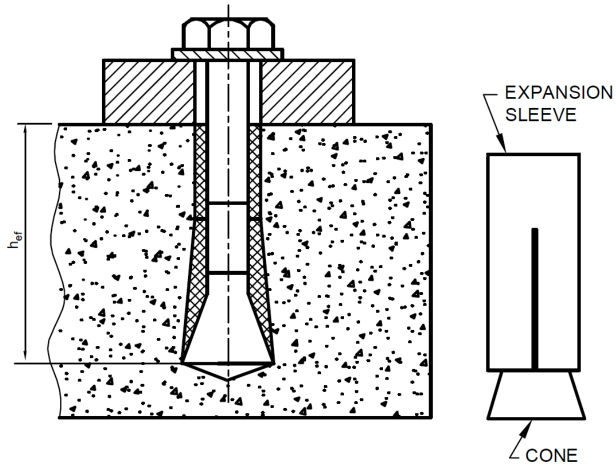
2.24 Curing Time — This term is applicable to adhesive anchors. It is the elapsed time from end of mixing of components of adhesive material in the drilled hole till it achieves required mechanical properties.

2.25 Durability (of products) — The ability of the product(s) to contribute during the service life of the structure under the corresponding service conditions at a performance level compatible with the essential functional requirements.

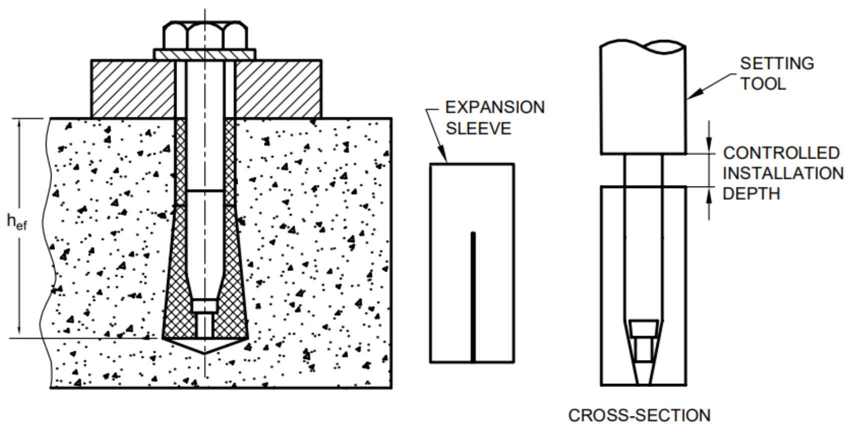
2.26 Displacement-controlled Expansion Anchor — A type of mechanical expansion anchor. It is set by expansion against the sides of the drilled hole through movement of an internal plug in the sleeve or through movement of the sleeve over an expansion element (like plug). This is achieved by driving through hammer blows or by percussion of a machine. Once set, no further expansion can occur. Displacement-controlled expansion anchors are installed by hammer blows or by percussion of a machine. In some types of displacement controlled expansion anchors, the sleeve is expanded by driving in a cone; the extent of expansion in this case is controlled by the length of travel of the cone (Fig. 11a). In other types, the sleeve is driven over an expansion element, wherein the extent of expansion is controlled by the travel of the sleeve over the expansion element (Fig. 11b). The expansion forces created during anchor installation along with tension forces are transferred into the concrete mainly by friction. Some of the common types of displacement-controlled expansion anchors are – Cone down type anchor like drop-in anchor (Fig. 11c), Sleeve-down type anchor (Fig. 11d) and Stud version of sleeve-down type anchor (Fig. 11e).



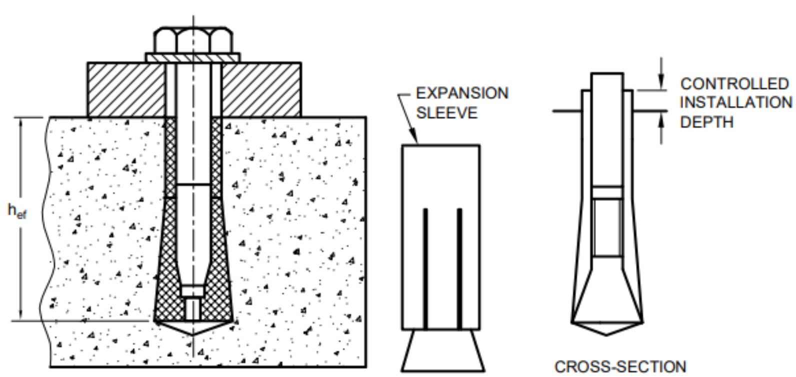
(11A) EXPANSION BEING CONTROLLED BY LENGTH OF TRAVEL OF THE CONE



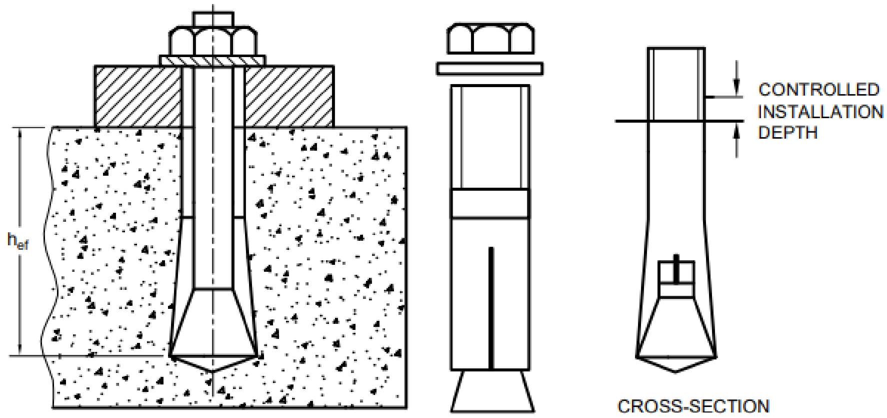
(11B) EXAMPLE OF DISPLACEMENT-CONTROLLED EXPANSION ANCHOR



(11C) CONE-DOWN TYPE ANCHOR



(11D) SLEEVE-DOWN TYPE ANCHOR DRILLING CONTROLLED BY STOP-DRILL BIT



(11E) STUD VERSION OF SLEEVE-DOWN TYPE ANCHOR

FIG.11 DISPLACEMENT-CONTROLLED EXPANSION ANCHORS

2.27 Edge distance - Distance perpendicular to the axis of the anchor from the center of anchor to the respective edge of the concrete member.

2.28 Effective embedment depth (h_{ef}) — The effective depth which actually transfers the forces in the anchor into the concrete.

2.29 Evaluation Agency — An independent body that evaluates the performance of a product (in this case, post installed anchors) based on test results carried out by a 3rd party testing laboratory, in accordance with the TAD This independent body should have proven experience of thorough testing and/ or evaluation of the product, compliant with the applicable TAD.

2.30 Expansion Anchors — Expansion anchors are a type of post-installed mechanical anchor. They are anchored in pre drilled holes in hardened concrete by forced expansion of sleeve. A tensile force applied to the anchor is transferred to the concrete by friction and some keying between an expanded sleeve and the concrete. Expansion anchors can be broadly classified into two types - Torque-controlled expansion anchor (*see* Fig. 18) and Displacement-controlled expansion anchor (*see* Fig. 11).

2.31 Fixture - Metal assembly that transmits loads to the anchor.

2.32 Hole clearance – Gap in the fixture between anchor and fixture.

2.33 Installation Expansion – The expansion achieved by applying a specified expansion energy which is reduced in relation to reference expansion. The installation expansion is used in the installation safety tests.

2.34 Installation Temperature Range — The environmental temperature range of the base material allowed by the manufacturer for installation.

2.35 Long Term Temperature — The temperature, within the service temperature range, which will be approximately constant over significant periods of time. Long term temperatures will include constant or near constant temperatures, such as those experienced in cold stores or next to heating installations.

2.36 Mechanical Anchor — A type of post-installed anchor i.e., anchor installed after casting and hardening of concrete. Mechanical anchors typically transfer load to concrete through friction, keying, mechanical interlocking, or combination of any of these three working principles. The post- installed mechanical anchoring systems are further subdivided into two categories - expansion anchors and undercut anchors, depending on their working principles.

2.37 Mechanical Interlock — A load transfer mechanism in which the load is transferred to a concrete member via interlocking surfaces.

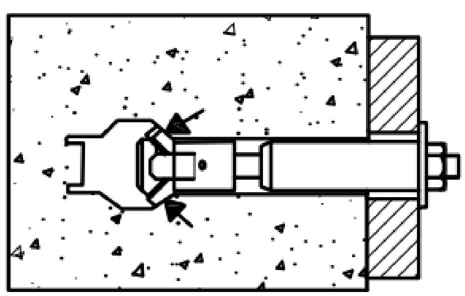
2.38 Minimum Edge Distance — The minimum edge distance at which the anchor can be installed without damaging the concrete member.

2.39 Minimum Spacing — The minimum spacing at which the anchor can be installed without damaging the base material.

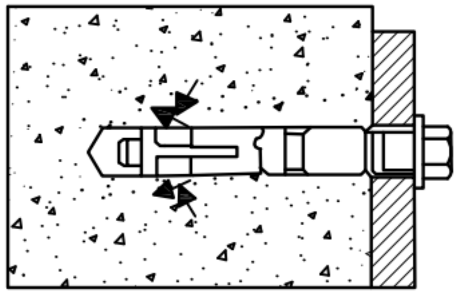
2.40 Nominal embedment — The depth at which the bottom of the anchor rests in the drilled hole.

2.41 Open time — This term is applicable to adhesive anchors. It is the time from the point of mixing or activating the adhesive and inserting the fastening element (like threaded rod). If the fastening element is moved after open time, it can hamper the performance and strength of the connection.

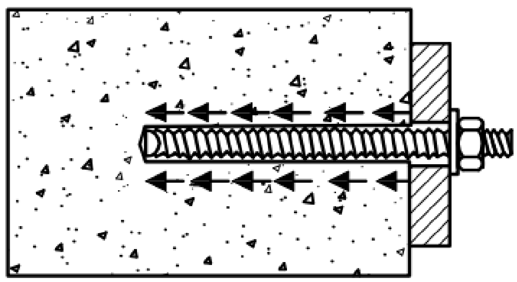
2.42 Post-installed Anchor — A type of anchor in which the anchor is installed into cured and hardened concrete. It can transfer applied loads through friction, keying, adhesion or a combination of these working principles (*see* Fig. 12). Post-installed anchors are broadly divided in two categories – Mechanical anchors and Adhesive anchors.



(12A) LOAD TRANSFER DUE TO FRICTION & KEYING BETWEEN METAL PARTS & CONCRETE



(12B) LOAD TRANSFER DUE TO MECHANICAL INETRLOCK (BEARING) BETWEEN METAL PART & CONCRETE



(12C) LOAD TRANSFER DUE TO BOND BETWEEN METAL PARTS & ADHESIVE AND BETWEEN CONCRETE & ADHESIVE

FIG.12 TYPICAL LOAD TRANSFER MECHANISM OF POST-INSTALLED ANCHORS

2.43 Pull-out Failure — This failure type is observed for mechanical anchors under tension loading. It is characterized by the withdrawal of the anchor element from the concrete without rupture of the embedded part. The formation of limited-depth conical breakout surfaces are also considered as pullout failures (*see* Fig. 13).

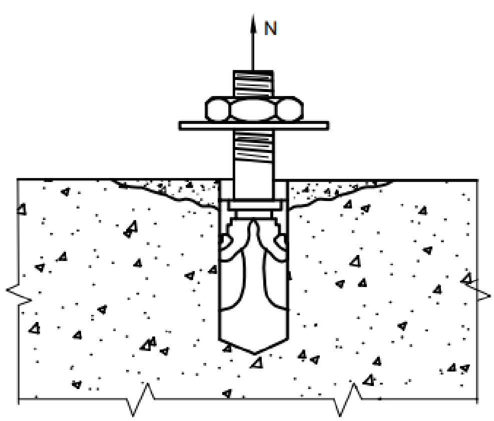


FIG. 13 TYPICAL PULL-OUT FAILURE

2.44 Pull-through Failure — This failure type is observed for mechanical anchors under tension loading in which the anchor body pulls through the expansion sleeve without development of the full steel or concrete capacity (*see* Fig. 14).

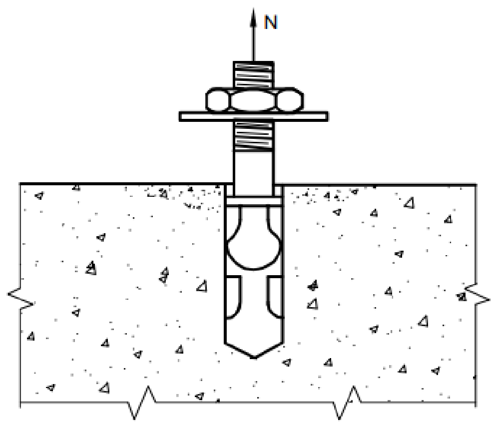


FIG. 14 TYPICAL PULL-THROUGH FAILURE

2.45 Reference Expansion — Expansion achieved by applying specified expansion energy. The reference expansion is used to evaluate the suitability tests.

2.46 Service Temperature Range — Range of ambient temperatures after installation and during the service lifetime of the anchorage.

2.47 Setting of an Anchor — The process of activating the load-transfer mechanism of an anchor in a drilled hole.

2.48 Spacing - Centre to centre distance between the anchors.

2.49 Short Term Temperature — Temperatures within the service temperature range which vary over short intervals, like, day/night cycles.

2.50 Splitting Failure — This failure type is observed for both mechanical and adhesive anchors installed in a 'thin' concrete member under tension loading. It is essentially a concrete failure mode in which the concrete fractures along a plane passing through the axis of the anchor or anchor group (see Fig. 15).

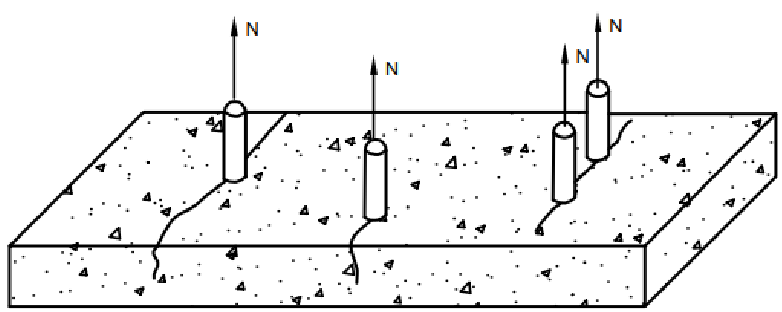
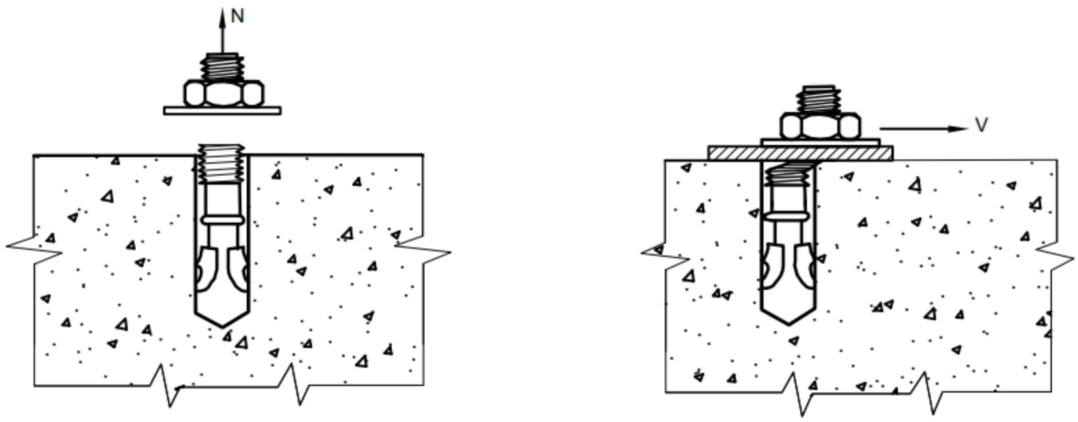


FIG. 15 TYPICAL SPLITTING FAILURE

2.51 Steel Failure — This failure mode is observed for both mechanical and adhesive anchors under tension or shear loading. In this failure type, the steel anchor parts are fractured (*see* Fig. 16).



(16A) STEEL FAILURE IN TENSION (16B) STEEL FAILURE IN SHEAR

FIG. 16 TYPICAL STEEL FAILURE

2.52 Stretch Length - Length of the anchor that extends beyond concrete surface in which it is anchored.

2.53 Technical Assessment Document (TAD) – A uniform technical specification developed by the approval body which lays down the procedure to qualify and assess a product for a specific application or use (and refers to a designated design method, if applicable).

2.54 Test Member — Concrete member in which the anchor is tested.

2.55 Test Series — It comprises of a group of identical anchors tested under identical conditions. Identical conditions include anchor diameter, length, embedment, spacing, edge distance, drill hole diameter and depth, concrete density/weight, test member thickness and concrete compressive strength.

2.56 Third Party Testing Laboratories (Accreditation and Calibration) — Testing laboratories shall be accredited by an accreditation body. All required testing shall be conducted by the independent accredited testing laboratory in their facility, however, up to 50 percent of the admissible service-condition tests required by this criteria are permitted to be witnessed by the accredited testing laboratory in the manufacturer's facility.

2.57 Torque-controlled Adhesive Anchor — A type of adhesive anchor designed such that its outward/ upward movement relative to the hardened adhesive compound results in a follow-up expansion of the adhesive. The working principle is triggered by application of torque (*see* Fig. 17).

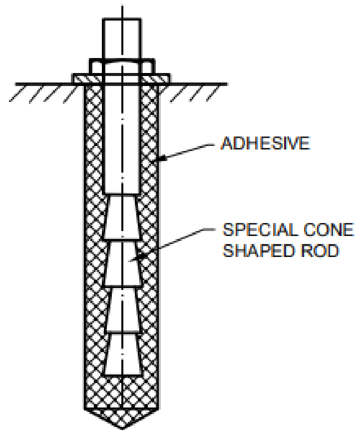
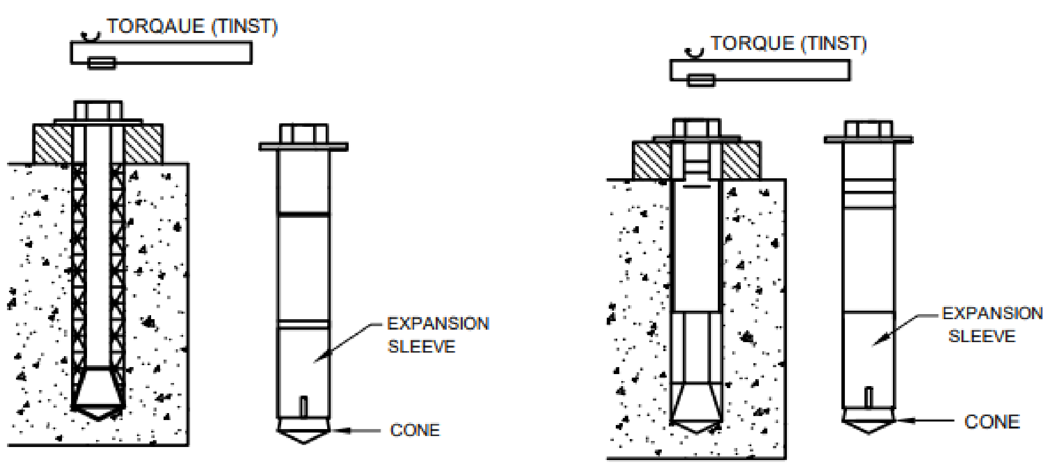


FIG. 17 TYPICAL TORQUE-CONTROLLED ADHESIVE ANCHOR

2.58 Torque-controlled Expansion Anchor — A type of mechanical expansion anchor. It is set by the expansion of one or more sleeves or other elements against the sides of the drilled hole through the application of torque, which pulls the cone(s) into the expansion sleeve(s). Tensile loading can cause additional expansion (follow-up expansion) after setting up of anchor. Some of the common types of torque-controlled expansion anchors are Sleeve type expansion anchors with one cone (Fig.18a) or more than one cone, Bolt type expansion anchors with one cone [Fig. 18b)] or more than one cone and combination of sleeve and bolt type.



(18A) SLEEVE TYPE

(18B) BOLT TYPE

FIG.18 TYPICAL TORQUE-CONTROLLED EXPANSION ANCHOR

2.59 Uncracked concrete — Concrete where there is no probability of the formation of cracks after installation, or the expansion of any existing crack (like shrinkage crack) is within the permissible limits during the service life of the anchors.

2.60 Undercut Adhesive Anchor — A type of adhesive anchor. It combines the undercut concept of mechanical anchor with bonding mechanism of adhesive anchor (*see* Fig. 19).

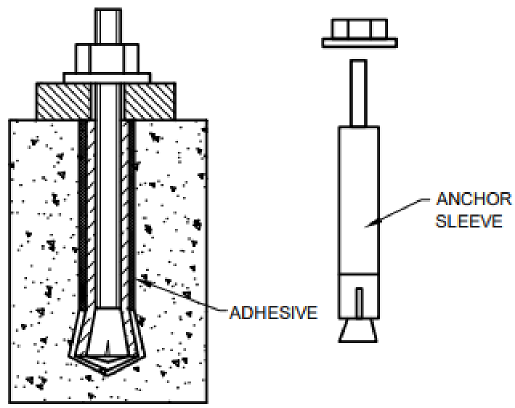
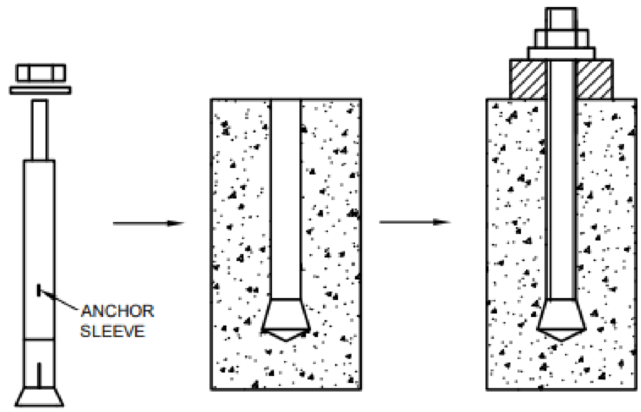


FIG. 19 TYPICAL UNDERCUT ADHESIVE ANCHOR

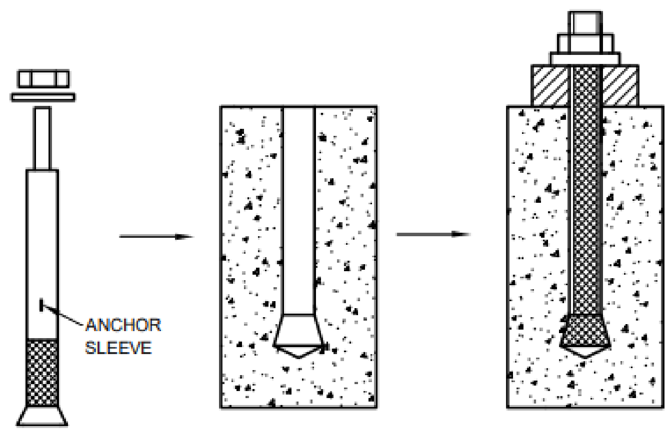
2.61 Undercut Anchor – A type of mechanical anchor. It is anchored by mechanical (bearing) interlock provided by an undercut in the concrete. It is a type of anchor which derives its strength from mechanical interlock provided by an undercut in the concrete at the embedded end of the fastener. The undercutting in undercut anchors may be achieved by:

- Hammering or turning (or both) the anchor sleeve into a drilled undercut hole.
- Hammering or turning (or both) the anchor sleeve on to the tapered bolt in a cylindrical hole. In this case, the concrete is mostly cut away rather than compressed.

Installation of undercut anchors can be sub-divided into displacement-controlled installations and torque-controlled installations. In case of displacement-controlled installations, the holes are drilled with a stop-drill to ensure correct installation depth for anchors. In case of torque-controlled installations, the expansion is controlled by defined torque moment (*see* Fig. 20).



(20A) UNDERCUT ANCHOR THAT REQUIRES UNDERCUT TO BE CREATED TO INSTALLATION



(20B) UNDERCUT ANCHOR THAT DOES NOT REQUIRE UNDERCUTTO BE CREATED PRIOR TO INSTALLATION

FIG. 20 TYPICAL UNDERCUT (MECHANICAL) ANCHOR

2.62 Unidirectional Crack — Crack running in one direction with an almost constant width over the member depth.

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