

SECTION 680 - BONDED ANCHORS

##This section cross-references Sections 175 and 611.

If either of the above sections are relevant, they should be included in the specification.

If either of the above sections are not included in the specification, all references to those sections should be struck out, ensuring that the remaining text is still coherent:

680.01 GENERAL

This section specifies the requirements for supply of materials, installation, workmanship and testing of bonded anchors installed in concrete..

The design of bonded anchors shall comply with the VicRoads Bridge Technical Note BTN2012/002 Design Guidelines for Bonded Anchors.

Where bonded anchors are proposed, the Contractor shall demonstrate that the selected bonded anchor system satisfies the requirements of the design to the satisfaction of the Superintendent.

680.02 STANDARDS

Australian Standards are referenced in an abbreviated form (e.g. AS 2193).

(a) Australian Standards

AS 2193 Calibration and classification of force-measuring systems

AS 1391 Metallic materials - Tensile testing at ambient temperature

(b) Additional Test Methods

ASTM E 488 Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements

ASTM E 1512 Standard Test Methods for Testing Bond Performance of Adhesive-Bonded Anchors

(c) Additional Documents and Referenced Specifications

SA TS 101 Technical Specification – Design of post-installed and cast-in fastenings for use in concrete (published by Standards Australia)

ATIC-SPEC 38 – Metal anchors for use in concrete (published by the Australian Technical Infrastructure Committee (ATIC))

BTN2012/002 VicRoads Bridge Technical Note, Design Guidelines for Bonded Anchors

ETAG (European Technical Assessment Guideline) 001 Part 5

ICC-ES (USA) – International Code Council Approvals, Evaluation service for post installed anchors and other building products

Section 175 details the relevant references to these documents.

680.03 DEFINITIONS

Anchor: a steel stud, threaded rod, steel bolt or reinforcing steel drilled and secured into the existing hardened concrete.

Bonded anchor: a system comprising an anchor and a chemical adhesive that transmits loads from the embedded anchor into the hardened concrete.

Chemical adhesive: a material or bonding agent used to bond together steel and concrete components to hardened concrete and provide the pathway for the required load transfer of the bonded anchor system.

Discrete population: A population of bonded anchors that has bonded anchors of the same type (manufacturer and model), installed in the same substrate (e.g. same type and strength, same installation conditions such as wet or dry and temperature) and have all been installed by the same work crew.

Proof load test: A test performed on a bonded anchor whose installation is complete and is intended to validate correct installation, by allowing bond failure but precluding concrete failure via a confined test. The proof load shall not exceed the lesser of the yield strength of the anchor rod or the design bond strength of the chemical adhesive.

Ultimate load test: A test performed on a bonded anchor whose installation is complete and is intended to aid in establishing the suitability of the bonded anchor in a particular hardened concrete where all the properties required for design are not known, by allowing concrete failure and/or bond failure via an unconfined test.

680.04 DESIGN AND LIMITATIONS ON USE

The design and limitations on use of bonded anchors shall be in accordance with the requirements of BTN2012/002.

Where SA TS 101 is referenced in the design of bonded anchors, BTN2012/002 shall take precedence where they differ.

The design of the bonded anchor system shall make allowance for the following performance influencing factors:

- (a) the substrate conditions at the time of installation
- (b) the in-service substrate conditions (i.e. dry or wet, temperature, concrete strength, drilling method)
- (c) the geometry of the host concrete member (i.e. edge distance, spacing between bonded anchors, member thickness)
- (d) the nature of the applied loads (i.e. static, dynamic, cyclic, sustained)
- (e) the effect of the composition of the chemical adhesive on the load carrying capacity and performance.

The bonded anchor system design shall be certified by a Design Engineer who is a member of Engineers Australia and with a minimum of 5 years experience in the design and construction of bonded anchor systems of similar complexity. The bonded anchor system design shall be verified in accordance with the Contract to confirm that the design satisfies the performance requirements of the bonded anchors.

The bonded anchor system design shall be proof engineered by a Proof Engineer, who is independent of the design consultant's firm and is prequalified at Level PE under the VicRoads' prequalification scheme.

HP Subject to the requirements of BTN2012/002, if it is proposed to use bonded anchors in tension as described in Clause 3.5 of btn2012/002, the Contractor shall submit full details of the proposal, including a Proof Engineering Certificate of Compliance, for the approval of the Superintendent, not later than two weeks prior to the intended use.

Any amendment to the design after the issue of the Proof Engineering Certificate of Compliance shall be referred to the Proof Engineer for review and written confirmation that the Certificate of Compliance remains valid.

680.05 MATERIALS

(a) General

Bonded anchor systems shall be certified in accordance with a third party materials accreditation scheme or a technical approval scheme approved by the Superintendent. For this purpose, certification in accordance with one of the following is acceptable:

- (i) SA TS101 Appendix B
- (ii) ATIC SP 38
- (iii) ETAG (European Technical Approval) 001 Part 5
- (iv) ICC (USA).

Bonded anchor systems with current ETA (European Technical Assessment/Approval) automatically conform to the requirements of SA TS101 Appendix B.

Components from different types of bonded anchor or from different bonded anchor suppliers shall not be mixed, exchanged or substituted for the specified system. As a minimum the technical information to be specified on design drawings shall include the following:

- (i) bonded anchor: manufacturer's name, product name
- (ii) details of steel element: strength grade, depth of embedment
- (iii) drilled hole: diameter, depth, method of drilling
- (iv) sequence of installation, including cleaning steps
- (v) working time for the chemical adhesive
- (vi) curing time of the chemical adhesive to gain strength sufficient to allow the bonded anchor to be loaded
- (vii) tightening torque.

HP If the Contractor proposes to use an alternative to the specified bonded anchor system, including any deviation from the product, substrate or installation specified, the Contractor shall submit full details of the proposed alternative system and its design for approval by the Superintendent no later than two weeks prior to the proposed installation of the bonded anchors.

(b) Chemical Adhesives

In addition to satisfying all requirements stipulated by the bonded anchor supplier, the following restrictions apply:

- (i) chemical adhesives containing styrenes are not permitted
- (ii) polyester type chemical adhesives susceptible to alkaline hydrolysis shall not be used if the bonded anchor will be exposed to moisture during the life of the structure
- (iii) the chemical adhesive shall be used in holes which have been drilled using the technique (e.g. carbide-tipped rotary hammer or diamond-tipped core drill) prescribed by the manufacturer (refer to manufacturer's installation instructions)
- (iv) the selected chemical adhesive shall perform in accordance with the design for expected ranges of temperature and moisture content over the design life of the structure
- (iv) the Contractor shall comply with all requirements for the correct use of the chemical adhesive specified by the supplier in the manufacturer's installation instructions, including but not limited to, temperature range, curing time, shelf life, mixing requirements and moisture content
- (v) bonded anchors used under sustained tensile loading shall be prequalified for this loading type in accordance with Clause 680.05(a).

(c) Metallic Components and Coatings

Steel reinforcement shall comply with the requirements of Section 611 and shall be prequalified for use with the chemical adhesive in accordance with Clause 680.05(a).

Coatings for metal components shall have sufficient durability to achieve the required design life of the structure.

Galvanised steel components may only be used in permanently dry conditions where the design life is 25 years or less.

Stainless steel grades 1.4401, 1.4404, 1.4362 and 1.4571 (marking A4) may not be used in conditions where the component is either permanently inundated in seawater or in the splash zone. Stainless steel grades 1.4529 (marking C) may be used in conditions where the component is either permanently inundated in seawater or in the splash zone.

Proprietary threaded anchor rods and metallic bolts shall be subject to certification by the third party materials accreditation scheme or technical approval scheme As required in Clause 680.05(a).

680.06 COMPETENCY AND TRAINING OF PERSONNEL

The bonded anchor installer shall be certified by the Australian Engineered Fasteners and Anchors Council (AEFAC), or shall be able to provide evidence of competency acceptable to the Superintendent.

All personnel who are required to install bonded anchors shall be AEFAC certified installers or be trained by the supplier of the bonded anchor system in the specific installation requirements of the project before bonded anchor installation commences.

Individuals who have successfully completed training shall be issued with either a card, which includes their name and photograph, or a certificate of training. The Contractor shall hold evidence of this training on site and present it to the Superintendent on request.

The bonded anchor system installation supervisor shall be trained and qualified in all aspects of the applied techniques and shall be present at each stage of the bonded anchors installation works, including any trial installations and all testing.

680.07 EQUIPMENT

Bonded anchors shall be installed using the equipment specified or provided by the bonded anchor supplier in the manufacturer's installation instructions.

680.08 WORKMANSHIP AND INSTALLATION

(a) General

Bonded anchors shall be installed in the manner specified by the bonded anchor supplier by a competent person who has received appropriate training in accordance with Clause 680.06.

Holes for bonded anchors shall be drilled with carbide or diamond drill bits in accordance with the manufacturer's installation instructions and shall be of the length and diameter specified by the supplier for the selected bonded anchor and as required by the design.

Holes for bonded anchors must be positioned to avoid damage to reinforcement and pre-stressing tendons or to services. Prior to drilling of holes, reinforcing bars and pre-stressing cables that lie within the depth of the drill hole must be accurately located by reference to as-constructed drawings. The actual position of bars and tendons shall then be located by use of a recently calibrated concrete cover meter, operated by a competent person. If reinforcement is encountered during drilling, drilling shall cease immediately and the Contractor (following consultation with the design engineer) shall provide the Superintendent with an acceptable course of action consistent with the design requirements

Holes for bonded anchors shall be drilled and cleaned in accordance with the manufacturer's installation instructions. However, as a minimum, the procedure for drilling and cleaning of holes shall be as follows:

- (i) drill to required depth
- (ii) air flush twice
- (iii) brush clean twice
- (iv) air flush twice
- (v) fingertip test the hole surface for dust, and if dust is still present, brush clean and air-flush until all dust is removed including a potential dust plug at the end of the hole which reduces embedment depth. At the end of the cleaning process, the hole shall be clean and free of debris, dust particles, oil and other contaminants over its full depth.

If a mechanical compressor is used to provide the air flush, the compressed air shall be free of oil.

If the hole is not immediately filled with chemical adhesive and is allowed to stand open for any period of time, the cleaning process shall be repeated prior to installation of bonded anchors.

A discrete population of bonded anchors shall be installed by the same work crew

(b) Additional specific requirements

The following requirements shall also be met:

- (i) Immediately prior to installation of the bonded anchor system, holes for bonded anchors shall be completely free of water (dry) or be free of standing water (damp), in accordance with the manufacturer's installation instructions
- (ii) Bonded anchors shall not be used if the temperature of the concrete is less than -5°C , above 40°C , or outside the requirements specified in the manufacturer's installation instructions.
- (iii) Check temperature of hole prior to injecting chemical adhesive, note the working time which is the time allowed to place the anchor rod into the chemical adhesive and the curing time which is the time for the chemical to gain strength from the time of first mixing until

the time when the bonded anchor can be loaded.

- (iv) The procedure for placing chemical adhesives and anchors shall be in accordance with the manufacturer's installation requirements
- (v) Chemical adhesive shall not be injected into the drilled hole until it is thoroughly mixed using the proprietary equipment to a uniform consistency, colour and appearance in accordance with the manufacturer's installation requirements.
- (vi) The initial discharge of chemical adhesive from the mixing nozzle and for every new mixing nozzle used thereafter shall be discarded.
- (vii) Each hole shall be checked visually to ensure that the chemical adhesive is injected to the correct depth (typically 2/3 of the hole depth) prior to insertion of the metal anchor rod.
- (viii) Excessive chemical adhesive shall be removed from the concrete and anchor rod surfaces after inserting the anchor rod.
- (ix) The anchor rod shall not be disturbed or moved during curing.
- (x) If a popping or cracking sound is heard while inserting the anchor rod, air voids are present in the chemical adhesive. Remove the anchor rod, allow the chemical adhesive to fully harden, redrill the hole and repeat the entire installation process.
- (xi) Following mixing, the chemical adhesive shall be used within the time limit working time or gel time) stated in the manufacturer's installation requirements.
- (xii) Capsule chemical adhesives shall be installed in accordance with the manufacturer's installation instructions.

Chemical adhesives shall be allowed to gain strength for the minimum time specified by the manufacturer's installation instructions before torque is applied to bolts and load is applied to the bonded anchor system.

680.09 LOAD TESTING OF INSTALLED ANCHORS

I(a) General

The scope of the testing described in this clause is limited to demonstration of the suitability of the selected bonded anchor for use in a particular application and for validating the quality of installation. Certification and testing of the bonded anchor system and components required by Clause 680.05 shall be conducted in accordance with the nominated independent third-party materials testing body.

The requirements for site-testing of bonded anchors are limited to testing of tensile capacity.

Separate requirements are given below for suitability testing and for testing of working anchors.

Test bonded anchors shall be installed by suitably competent and experienced personnel, as described in Clause 680.06, in positions that are representative of the positions of the bonded anchors required by the design.

Testing shall be conducted by a competent person who has experience in testing of bonded anchors and test reporting.

Bonded anchors shall be tested using testing equipment that has been calibrated as a minimum, on an annual basis at the required intervals in accordance with AS 2193.

HP One week prior to testing the Contractor shall submit to the Superintendent calibration certificates conforming to the requirements of AS 2193 Grade B for the jack and pressure gauges or other force measuring devices to be used.

The measuring equipment shall allow the applied force to be determined to the accuracy $\pm 2\%$. If measurement of displacement is required, the measuring equipment shall comply with AS 1391 and shall allow elongation to be determined with an accuracy of ± 0.02 mm, with measurements made directly on the head of the anchor.

The test load shall be applied at pre-determined increments and loading rates.

HP Details of the test method including load increments and duration of sustained loading shall be submitted to the Superintendent for review not later than one week prior to the testing.

Test bonded anchors shall be identified with a unique reference number.

(b) Ultimate Load Testing for the suitability of bonded anchors

Unless approved otherwise by the Superintendent, where the proposed bonded anchor system or where the characteristics of the substrate and/or installation are outside the scope of the bonded anchor prequalification as specified in Clause 680.05(a), the Contractor shall carry out ultimate load tests to validate the suitability of the bonded anchor system design and to demonstrate that the bonded anchor components, chemical adhesives, the substrate preparation and the proposed procedure will achieve the specified bonded anchor durability and load capacity.

Ultimate load tests shall be conducted in advance of the installation of working bonded anchors after the manufacturer's curing time has elapsed.

Bonded anchors to be tested for ultimate load shall be installed in an identical manner and shall be situated in a substrate identical to that of the working anchors, and shall be positioned such that the installation and performance of the working bonded anchors is not compromised in any way. A sample consisting of at least five of the proposed total number of bonded anchors required by the design shall be subject to an ultimate load test. Ultimate load testing shall be conducted for each of the combinations of anchors and chemical adhesives in each type of concrete or other substrate material, in each orientation and in uncracked and, if present, cracked concrete.

The testing personnel shall ensure that the bonded anchors are installed in accordance with the specification and the manufacturer's installation instructions. Testing personnel shall be suitably competent and possess the relevant experience at conducting testing of bonded anchors on site and reporting the findings including the different possible modes of failure.

The mode of failure and corresponding ultimate load for each test shall be recorded in the test report. In the event that multiple failure modes are observed, testing shall continue until the required minimum number of dominant mode of failure results are achieved. The capacity of the bonded anchor shall be calculated from test results of the dominant mode of failure.

Bonded anchors shall be tested to the Ultimate load certified by the design engineer for the bonded anchor used, in accordance with the requirements of ASTM E 488 and ASTM E 1512 based on the unconfined test method.

(c) Proof Load Testing of working bonded anchors

All working bonded anchors that will be subject to tensile loads and whose failure could lead to failure or instability of a structure shall be subject to a proof-load test.

For all other bonded anchors, a sample consisting of a minimum of 5 or 2.5% whichever is the greater, of the total number of working bonded anchors shall be subject to a proof load test. For sampling and testing purposes each discrete population of bonded anchors shall be considered as a separate group and tested separately.

Proof load testing shall not occur prior to the completion of curing time stated in the manufacturer's installation instructions. The application of load shall occur smoothly with the proof load being achieved between one to three minutes from the commencement of loading. A bonded anchor shall be deemed to have failed a test if either visible displacement is detected at a load less than or equal to the test load, or if the anchor fails to achieve the required test load. If failure is encountered in any sample all anchors within the discrete area shall be proof load tested.

Working bonded anchors shall be proof load tested to 1.5 x the maximum design load certified by the design engineer for the bonded anchor used in accordance with the requirements of ASTM E 488 and ASTM E 1512 based on the confined test method. Working bonded anchors in cracked concrete shall be proof load tested to 2 x the maximum design load certified by the design engineer for the bonded anchor used in accordance with the requirements of ASTM E 488 and ASTM E 1512 based on the confined test method.

The proof load shall be maintained for a minimum period of 60 seconds.

(d) Actions if a bonded anchor test fails

HP In the event that a bonded anchor fails either the ultimate load testing for suitability or the working bonded anchor proof load test, the Contractor shall submit rectification proposals for review by the Superintendent prior to any further bonded anchor installation.

680.10 REPORTING

The Contractor shall provide a test report to the Superintendent for review. The test report shall identify the performance of each tested bonded anchor, including the following:

- (a) tester's name and employer
- (b) supplier and type of bonded anchor
- (c) date of installation of bonded anchor
- (d) date of testing
- (e) bonded anchor reference number
- (f) bonded anchor position
- (g) condition of bonded anchor
- (h) condition of concrete substrate – all defects such as cracks and delamination to be reported
- (i) strength of concrete substrate - including how this was determined
- (j) testing equipment
- (k) calibration certificate for testing equipment
- (l) test method including load increments and duration of sustained loading
- (m) test load and time of holding at the test load
- (n) failure load (if applicable)
- (o) mode of failure (if applicable)
- (p) amount of permanent displacement
- (q) any other relevant comments or observations.