

Code of Practice

Bonded anchors

1. Scope and application

BTN006 Bonded Anchors states VicRoads' requirements for the design of post-installed bonded anchors used to make structural connections to reinforced concrete substrates. It focusses primarily on the design of the adhesive at the anchor/concrete interface.

Bridge Technical Notes are a Code of Practice. Compliance with Bridge Technical Notes is mandatory.

Other than as stated in this document and relevant VicRoads standard specifications, the provisions of AS5100:2017 shall apply. Where this document differs from AS5100:2017, its requirements override those of AS5100:2017.

The requirements in this document are intended to reduce the risk of failure of connections made with bonded anchors.

The design, selection and specification of bonded anchors must be conducted by an engineering consultancy that is, as a minimum, prequalified in accordance with VicRoads' Prequalification Scheme at the Structures Simple level.

Anchors must have the load-carrying capacity required by the design and sufficient durability to achieve the required design life of the structure.

2. Design

2.1. Design general

Bonded anchors may be one of the following types:

- a proprietary fastener and adhesive system
- a threaded bar and adhesive
- a reinforcing and adhesive.

The following provisions focus primarily on the design of the anchor/adhesive/substrate interface.

Designers must position bonded anchors to avoid intersection with embedded reinforcement and pre-stressing tendons which can result in damage to reinforcement, pre-stressing tendons. In this context, positional dimensions for bonded anchors must allow for the overall depth and diameter of the required hole.

Designers shall select anchor components and adhesives to meet the requirements of the design, the service conditions and the construction methodology.

Standard Specification 680 Bonded anchors states requirements for the following:

- use of epoxy adhesive in holes cut with a diamond-tipped core drill
- use of adhesives appropriate to the nature of the loading, the geometry of the structure and the condition of the existing concrete substrate.

The performance of bonded anchors in cracked concrete varies with the type of anchorage system.

The final arrangement of anchors must comply with the requirements for spacing of anchors and minimum edge-distance required by the design method.

The design of bonded anchors shall be in accordance with the following clauses.

2.2. Design life

Bonded anchors are unsuitable for use in new structures which are required to have a design-life of 100 years.

Subject to the restrictions stated in this document, bonded anchors may be used in structures that are required to have a maximum design life of 50 years.

Bonded anchors shall have a design life equal to or greater than the remaining design life of the existing structure in which the components are being connected but not more than 50 years in any case.

2.3. Restrictions on use

Bonded anchors **must not** be used in the following circumstances:

- in new structures
- in existing structures if the connection can be achieved with the use of positive connections*
- if the required design life or the residual design life of the structural components being connected exceeds 50 years
- as tensile continuity connections between beams in adjacent spans and other elements in a bridge superstructure – for example to connect superstructure and substructure components in an integral bridge

- to support tensile loads in any orientation, if failure of an anchor or anchors could result in collapse, instability or failure of a structure or a component - see Cl. 2.6 Bonded anchors in tension**
- as holding-down bolts or connections for use with cantilever or portal sign structures and high mast light structures
- as holding-down bolts or connections for steel and concrete bridge barriers and bridge barrier posts
- if the thickness of the concrete substrate into which the anchor is being placed is less than 1.25 x required length of the anchor
- if the concrete substrate into which the anchor is being placed is friable, shows signs of de-lamination or any other defect
- in concrete with characteristic strength less than 20 MPa or greater than 50 MPa.

*Positive connections are defined as structural connections that are achieved by cast-in fittings such as rag-bolt assemblies, threaded ferrules or by clamping either through or around the full depth of the elements being connected. For example, a threaded rod (or bolt) in a full-depth hole together with a backing plate.

2.4. Permitted uses

Subject to appropriate design considerations, selection of adhesive and the restrictions on use stated in this document, bonded anchors are suitable for use in applications where they are subjected primarily to axial compressive forces and shear forces transverse to the anchor – for example:

- as longitudinal shear connectors in bridge-deck overlays
- in side-mounted bridge barriers provided that the tensile force arising from impact is resisted by a cast-in bar embedded in the overlay.

Bonded anchors may be used in concrete that is subject to formation of flexural cracks provided that the adhesive is pre-qualified for use in cracked concrete and this is supported by manufacturer's test data. However, the capacity of the anchor may be substantially reduced in this case and must be verified.

2.5. Design of the anchor

The type of anchor and adhesive shall be appropriate to the serviceability and ultimate limit state requirements of the design.

Consideration shall be given to the probable failure mechanism of the bonded anchor and the effect of such a failure on the stability and durability of the structure.

Designers must consider the risk of progressive failure and ensure that in the event of failure of an anchor, this does not lead to progressive failure of the remaining anchors.

Designers must consider the effects of erection methodology which may result in variations in the load applied to bonded anchors which function as a group.

Design of bonded anchors shall be in accordance with one of the following depending on the anchor type (see Cl. 2.1 above):

- proprietary fasteners - a Concrete Capacity (CC) method as described in SA TS101, ETAG Annex C, TR 029 or ACI 318:2014
- reinforcing or threaded bars - reinforcement theory, which shall comply with the requirements of AS5100.5 Bridge design.

Design loads and load factors shall be determined in accordance with AS5100.2 Bridge design.

The required number and size of anchors must be determined in accordance with one of the methods listed in Cl. 2.5 such that:

$$S^* \leq \Phi R_u$$

where for the load effect being considered:

Φ = capacity reduction factor required by the design method

R_u = nominal ultimate strength of the connection

S^* = design action effect

If the strength of an adhesive material in a bonded anchor is known to diminish over time, the reduced strength at the end of the design life of the adhesive material shall be used for the purposes of design.

2.6. Bonded anchors in tension

** If it is not possible to use a cast-in anchorage or to achieve a positive connection, bonded anchors may be used in tension subject to the maximum design life of 50 years and the following conditions:

- use is subject to compliance with Standard Section 680 Bonded anchors
- use is subject to the written approval of the Superintendent – refer to Standard Section 680 Bonded anchors for further detailed requirements
- use is subject to compliance with all other parts of this Bridge Technical Note
- if a bonded anchor is required to support a sustained tensile load, the adhesive must be one that has been subjected to testing for long-term displacement, the results of which enables the long-term displacement and strength properties of the anchor to be quantified
- the predicted creep must not affect the serviceability and durability of the structure – for example if it results in excessive crack-width
- bonded anchors in tensile connections must be tested in accordance with Standard Section 680 Bonded anchors

- the required number and size of anchors must be determined in accordance with one of the methods listed in Cl. 2.5 **subject to the application of an additional capacity reduction factor Φ_{BAT}** to the design of the adhesive anchor components such that:

$$S^* \leq \Phi_{\text{BAT}} \Phi R_u$$

where for the load effect being considered:

Φ_{BAT} = additional capacity reduction factor for bonded anchors in tension which has a value of 0.5

Φ = capacity reduction factor required by the design method

R_u = nominal ultimate strength of the connection

S^* = design action effect

- increase in embedment length may also be considered subject to the maximum depth of concrete substrate described in Cl. 2.3.

3. Training, equipment, workmanship, installation, testing

Training, equipment, workmanship, installation and testing must comply with Standard Specification Section 680 Bonded anchors.

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Bridge Technical Notes are subject to periodic review and may be superseded.