

# Bonded anchors

**BTN 006**

Version 1.2 February 2021

## 1. Scope and application

BTN006 Bonded Anchors states Department of Transport's (DoT) requirements for the design of post-installed bonded anchors used to make structural connections to reinforced concrete members of bridges and tunnels, structural roadway components and other related structural applications. It focusses primarily on the design of the chemical 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, Standard Specification Section 680 and other relevant DoT 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 shall be conducted by an engineering consultancy that is, as a minimum, prequalified in accordance with DoT's Prequalification Scheme at the Structures Simple level.

Any design of bonded anchors shall also be proof engineered by an engineering consultancy that is, as a minimum, prequalified in accordance with DoT's Prequalification Scheme at the Structures Simple level.

Bonded anchors shall 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 anchor and adhesive system.
- a threaded bar and adhesive.
- a reinforcing bar and adhesive.

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

Designers shall position bonded anchors to avoid intersection with embedded reinforcement and pre-

stressing tendons which can result in damage to reinforcement and pre-stressing tendons. In this context, positional dimensions for bonded anchors shall allow for the overall depth and diameter of the required hole.

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

Standard Specification Section 680 - Bonded Anchors states requirements for the following:

- use of chemical adhesive in holes cut with a diamond-tipped core drill or carbide-tipped rotary hammer.
- use of chemical adhesives appropriate to the nature of the loading, the geometry of the structure and the condition of the existing concrete substrate.
- design life of 50 years and 100 years as required in the specified in-service exposure conditions and any other specific use.

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

The final arrangement of anchors shall comply with the requirements for spacing of anchors and minimum edge-distance required by the design method and the manufacturer's recommendation.

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

### 2.2. Design life

Subject to the restrictions stated in this document, bonded anchors may be used for applications in existing or new structures that are required to have a maximum design life of 50 years and 100 years as required in the specified in-service exposure conditions.

For applications in existing structures, 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.

The design life of bonded anchors shall be demonstrated by testing in accordance with the relevant European Assessment Documents (EADs) published by the European Organisation for Technical Assessment (EOTA) as it relates to the application to which the bonded anchor is to be used for.

Grade 316 stainless steel anchors may be used for permanent applications in bridges, tunnels and road-related structures provided they have been formally tested and meet all the specified requirements.

## 2.3. Restrictions on use

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

- in new structures
- in existing structures where a positive connection can be adopted <sup>(Note 1)</sup>
- 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 - refer Clause- 2.6 - Bonded anchors in tension
- as holding-down bolts or connections for use of structures and light poles
- 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.
- in applications where the chemical adhesive bonded anchor will be subjected to fatigue loadings i.e. stresses that vary with time.
- Galvanised steel components shall not be used as bonded anchors when used with a chemical adhesive. <sup>(Note 2)</sup>

Note 1 - Positive connections are defined as structural connections that are achieved by cast-in fitments 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.

Note 2 – DoT is unaware of any testing of bonded anchors certified to a current European Technical Assessment (ETA) which is based on EOTA European Assessment Document (EAD) that have utilised galvanised steel components. DoT has the following concerns:

- DoT (VicRoads) practice has been to limit the use of galvanised components to permanently dry conditions only, where design life is 25 years or less which is less than the 50 and 100 year design life nominated.
- There is typically a high degree of variability in the zinc coating and a potential exists for initiation of galvanic corrosion in the non-passive environment which will affect the durability of the bonded anchor.

- The coating thickness may affect the shape of the bar which reduces the 'mechanical' grip within the bonded anchor.
- DoT has observed instances where galvanised components are installed in locations of black steel reinforcement without appropriate wrapping/isolation to minimise any effects of galvanic corrosion contrary to specified requirements.
- Design departures shall be raised with DoT where galvanised steel components are considered for use in bonded anchors and both designers and proof engineers have considered and mitigated these nominated issues for the required design life.

## 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. i.e. the lower connector bars which would be in compression if impacted.
- to attach small items such as small pipes (<150mm diameter), conduits and cables to a structure.

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 shall be verified.

## 2.5. Design of the Bonded Anchor

The type of anchor and chemical 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 shall 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 shall 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 (refer Clause-. 2.1 - Design general):

- proprietary fasteners - a Concrete Capacity (CC) method as described in AS 5216, 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 (Concrete).

Design loads and load factors shall be determined in accordance with AS5100.2 - Bridge Design (Design Loads).

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

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

where for the load effect being considered:

$\Phi$  = 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 following conditions:

- use is subject to compliance with Standard Specification Section 680 - Bonded Anchors
- use is subject to the written approval of the Superintendent – refer to Standard Specification 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 chemical adhesive shall 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 shall not affect the serviceability and durability of the structure – for example if it results in excessive crack-width
- bonded anchors in tensile connections shall be tested in accordance with Standard Specification Section 680 - Bonded Anchors
- the required number and size of anchors shall be determined in accordance with one of the methods

listed in Clause 2.5 subject to the application of an additional capacity reduction factor  $\Phi_{BAT}$  to the design of the adhesive anchor components such that:

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

for the load effect being considered:

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

$\Phi$  = 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 Clause 2.3.

## 3. Training, equipment, workmanship, installation, testing

Training, equipment, workmanship, installation and testing shall comply with Standard Specification Section 680 - Bonded Anchors.

## Contact Details

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