Australian Engineered
Fasteners and Anchors Council

AEFAC STANDARD PART II

TESTING AND ASSESSMENT OF POST-INSTALLED AND CAST-IN FASTENERS TO CONCRETE

Public consultation draft
Public comment opens: 15th April, 2015
Public comment closes: 10th June, 2015

All feedback is to be included in the AEFAC Standard Public Comment Template available for download at www.aefac.org.au/resources.php.

Questions and feedback are to be submitted via email to David Heath, Chair of the AEFAC Standard Development Committee, djheath@swin.edu.au.
PREFACE

This Australian Engineered Fasteners and Anchors Council (AEFAC) Standard Part 2 was prepared by the AEFAC Standard Development Committee. This document was approved on XX/XX/2015.

This Standard was published on XX/XX/2015 and is available at www.aefac.org.au.

The following are represented on the AEFAC Standard Development Committee:

- Allthread Industries Pty Ltd
- Ancon Building Products
- Australian Building Codes Board
- Australian Engineered Fasteners and Anchors Council
- Australian Steel Institute
- Australian Window Association
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- Concrete Institute of Australia
- Edith Cowan University
- Engineers Australia
- Hilti (Aust.)
- Housing Industry Association Ltd
- Hobson Engineering Company Pty Ltd
- ITW Construction Systems
- National Precast Concrete Association Australia
- Simpson Strong-Tie
- Stanley Black & Decker Australia Pty Ltd (Powers)
- Swinburne University of Technology
- Würth Australia Pty Ltd
## CONTENTS

1. Scope and general
2. Test requirements
3. Assessment requirements
4. Manufacturing requirements
5. Alternate path to demonstrate product conformity
1 SCOPE AND GENERAL

1.1 SCOPE

This Standard sets the requirements for the testing and assessment of safety-critical post-installed and cast-in fasteners in order to establish the necessary design parameters for use with the AEFAC Standard Part 1 “Design of post-installed and cast-in fasteners in concrete”.

A product with a current European Technical Assessment/Approval (ETA) satisfies all the requirements of this Standard.

1.2 APPLICATION

This Standard applies to safety-critical post-installed and cast-in fasteners to concrete for use as required by AEFAC Standard Part 1.

1.3 NORMATIVE REFERENCES

The following documents are referred to in this Standard:

AEFAC Standard Part 1 “Design of post-installed and cast-in fasteners to concrete”

ETAG 001 “Guideline for European Technical Approval of Metal Anchors for Use in Concrete”

European Assessment Document “Anchor channels”

European Assessment Document “Headed fasteners”


1.4 DEFINITIONS

Assessment Body – The body that assesses the performance of the fastener on the basis of results from testing and is independent to the manufacturer/supplier of the fastener and independent to the Testing Body.

Cast-in fastener – A fastener that is installed into position prior to the casting of concrete

European Technical Assessment (ETA) (formerly European Technical Approval) – prequalification for a fastener that represents technical assessment of its fitness for an intended use.

Fastener - A type of fastener made from steel or malleable iron to be cast into or post-installed into hardened concrete. The function of the fastener is to transmit load from a fixture to the connected concrete member. A fastener may also be referred to as anchor.

Option – A term used in a European Technical Assessment/Approval that limits the specification of a fastener on the basis of various application parameters such as concrete strength and condition, edge/spacing criteria and loading direction.

Post-installed fastener – A fastener that is installed in concrete in the hardened state.
**Report of Assessment** – A report produced by the Assessment Body which provides the specifications and the design parameters as described in this Standard.

**Report of Testing** – A report produced by the Testing Body which provides the results of testing of the fastener as described in this Standard.

**Safety-critical fastener** – A fastener whose failure may result in collapse or partial collapse of the structure, endanger human life and/or cause considerable economic loss. The application may be structural or non-structural.

**Testing Body** – The testing laboratory or facility that is independent to the manufacturer/supplier of the fastener that undertakes testing of the fastener in accordance with a prescribed test procedure.

### 1.5 NOTATION

Unless otherwise noted, all parameters are in Standard International (SI) metric units.

A list of notation is provided in Appendix C including the design parameters established for the fastener.

## 2 TEST REQUIREMENTS

### 2.1 TESTING PROCEDURES

Testing of post-installed mechanical and chemical fasteners for suitability and admissible service conditions shall be performed in accordance with ETAG 001 Part 1 to Part 5, as relevant. The nature and extent of testing shall be defined by an Option number that is presented in ETAG 001 and reproduced in Table 1.

**TABLE 1: ASSESSMENT OPTIONS FOR POST-INSTALLED FASTENERS COVERED BY ETAG 001.**

<table>
<thead>
<tr>
<th>Option No.</th>
<th>Concrete condition</th>
<th>Concrete strength (MPa)</th>
<th>Characteristic resistance, $F_{ek}$</th>
<th>One value for all directions</th>
<th>Different value for different directions</th>
<th>$c_{cr}$</th>
<th>$s_{cr}$</th>
<th>$c_{min}$</th>
<th>$s_{min}$</th>
</tr>
</thead>
<tbody>
<tr>
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<td>10</td>
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<td>12</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Testing of cast-in headed fasteners shall be performed in accordance with the requirements of the European Assessment Document “Anchor channels”.

Testing of cast-in anchor channel shall be performed in accordance with the requirements of the European Assessment Document “Headed fasteners”.

2.2  SPECIFICATION OF TEST SAMPLES

Fasteners used for testing shall be randomly selected from a test sample provided by the supplier/manufacturer which is statistically representative of the production of the fastener.

In order for statistical sampling to be meaningful, the manufacturer or supplier needs to demonstrate how the above condition has been satisfied.

2.3  QUALIFICATION OF TESTING BODY

The Testing Body shall be independent to the product manufacturer and accredited by the International Laboratory Accreditation Cooperation (ILAC). The Testing Body shall provide a Report of Testing complying with the requirements of Appendix A.

3  ASSESSMENT REQUIREMENTS

The assessment of post-installed and cast-in fasteners shall be based on results listed in a Report of Testing. Assessment shall be undertaken by an Assessment Body that is independent to the manufacturer and Testing Body.

The design parameters to be published in the Report of Assessment are provided in Appendix C.

3.1  POST-INSTALLED FASTENERS

Assessment of post-installed fasteners for suitability and admissible service conditions shall be performed in accordance with ETAG 001 Part 1 to Part 5 as relevant.

The characteristic values to be determined on the basis of test results for applications involving static loading are listed in Table C2.

3.2  CAST-IN FASTENERS

Assessment of headed fasteners and anchor channel shall be performed in accordance with either the European Assessment Document “Cast-in channel” or the European Assessment Document “Headed fasteners”.

The characteristic values to be determined on the basis of test results for applications involving static loading are listed in Table C3.
4 MANUFACTURING REQUIREMENTS

The inherent assumptions in the fastener assessment and subsequent design procedures in relation to performance variability shall be satisfied if the manufacturer or supplier demonstrates that the fastener production is complying with the requirements of ISO/IEC Guide 67 level 5.

Irrespective of acceptable quality levels, the responsibility remains with the manufacturer or supplier to supply products that conform to the full requirements of the Standard.

5 ALTERNATE PATH TO DEMONSTRATE PRODUCT CONFORMITY

A fastener that has a current European Technical Approval/Assessment is deemed to have met all the requirements of this Standard.

Due to the origin of an ETA some notation requires adaptation to ensure compatibility with the AEFAC Standard. The required adaptations to notation are listed in Table C5.
APPENDIX A

REPORT OF TESTING

(NORMATIVE)

A.1 Qualifications on Report of Testing

A Report of Testing shall provide details in relation to the following:

(a) Tests as performed by the Testing Body.
(b) Details confirming the Testing Body is accredited by signatories to the International Laboratory Accreditation Corporation (ILAC) through their Mutual Recognition Agreement (MRA), in the field and class of testing.

NOTE: In Australia, ILAC (MRA) accredited bodies include National Association of Testing Authorities (NATA).

A.2 Minimum requirements for reports

In addition to Clause A.1, Report of Testing shall be provided in English and shall have the following:

(a) Manufacturer’s/supplier’s and Testing Body’s name
(b) Date
(c) Product, testing specification and grade
(d) Product type, strength grade, dimensions, size and ductility (where appropriate)
(e) Unique product identifiers for the tested units and other product that the report applies.
(f) Where relevant, mechanical testing or alternative information as noted in Section 2.
(g) The individual results from testing conducted in accordance with Section 2.
(h) Signatory from Testing Body.
B.1 Qualification and Report of Assessment

The body for assessment shall prepare a Report of Assessment that includes the following –

1. General conditions for the assessment
2. Definition of product and intended use
3. Characteristics of product including design parameters and methods of verification in the following format –
   a. Definition of product and intended use (range of sizes, details of concrete, installation requirements, protective coating or material type for durability design, etc.)
   b. Characteristics of the product and methods of verification (characteristic material values, dimensions and tolerances, testing and assessment procedures adopted for product approval, including Option number for post-installed fasteners)
   c. Reference to supplier’s manufacturing requirements
   d. Assumptions for the fitness of the product (Option number, any special provisions, requirements for installation)
   e. Recommendations concerning packaging, transport and storage (information required on fastener packaging and/or enclosed instruction sheet, special packing, transport and storage conditions)
   f. Appendices (illustration of product with labels and dimensions, list of material properties, tabulated installation parameters, installation instructions with illustrations, equipment required for installation with illustrations, summary of performance characteristics and design options, characteristic performance values for possible loading scenarios and environmental conditions, additional provisions for use)
4. Assumptions under which the fitness of the product for the intended use was favourably assessed (assumptions relate to manufacturing, design provisions, installation requirements, and labelling requirements on packaging or an enclosed instruction sheet).

The Report of Assessment shall remain valid for a period not exceeding five (5) years, provided that the supplier’s manufacturing requirements remain in place (refer to Section 4) and there is no modification to the product. Any modification to the manufacturing requirements or to the product shall make the Report of Assessment null and void.

Note: A request may be lodged to the assessment body for the Report of Assessment to be renewed for an additional five (5) years if a continuous system for manufacturing requirements has been implemented for the fastener and no modification has been made to the fastener.
APPENDIX C

DESIGN PARAMETERS FOR USE WITH AEFAC STANDARD

(NORMATIVE)

C.1 Notation

The following notation has been adopted in this Standard –

- \( A_h \) = area of the load-bearing head of a fastener
- \( A_s \) = stress cross-sectional area of the fastener
- \( b_{ch} \) = width of the anchor channel
- \( c_{cr} \) = edge distance of a single fastener required to ensure the characteristic strength of the fastener is achieved
- \( c_{cr,N} \) = edge distance of a single fastener required to ensure the characteristic strength of the fastener is achieved when loaded in tension
- \( c_{cr,sp} \) = characteristic edge distance in the case of splitting under load
- \( c_{min} \) = minimum edge distance to the fastener
- \( d \) = diameter of fastener bolt or thread diameter, or diameter of the stud or shank of a headed stud
- \( d_b \) = nominal diameter of a reinforcing bar
- \( d_h \) = diameter of the head of the fastener
- \( d_{nom} \) = outside diameter of the fastener
- \( F_{Rk} \) = characteristic strength of fastener
- \( f_{iy} \) = characteristic yield strength of reinforcement (referred to as \( R_e \) in AS/NZS 4671)
- \( f_{ys} \) = yield tensile strength of fastener
- \( f_{uf} \) = ultimate tensile strength of fastener
- \( f'c \) = characteristic compressive strength of concrete measured via cylinder tests at 28 days
- \( h_{ch} \) = height of anchor channel
- \( h_{ef} \) = effective embedment depth of a fastener
- \( h_{min} \) = minimum concrete member depth (published in the Report of Assessment)
- \( I_y \) = moment of inertia of channel relative to the y-axis of the channel
- \( k_{cr,N} \) = parameter relating to cracked concrete
- \( k_{cr,V} \) = parameter related to cracked concrete loaded in shear
- \( k_{u,c,N} \) = parameter relating to uncracked concrete
- \( k_{u,c,V} \) = parameter for uncracked concrete loaded in shear
- \( k \) = parameter
- \( l_f \) = parameter related to the length of the fastener
- \( M_{Rk,flex} \) = characteristic flexural strength of an anchor channel
- \( M_{Rk}^0 \) = reference characteristic flexural strength of a fastener
- \( N_{Rk,p} \) = characteristic tensile strength of a fastener to pull-out failure
- \( N_{Rk,s} \) = characteristic tensile strength of a fastener to steel failure
- \( N_{Rk,a} \) = characteristic tensile strength of a fastener in anchor channel against steel fracture
- \( N_{Rk,c} \) = characteristic tensile strength of a fastener in anchor channel against failure of the
connection between the anchor and channel

\[ N_{Rk,l} = \text{characteristic tensile strength of a fastener in anchor channel against local failure by flexure of the channel lips} \]

\[ N'_{Rk,sp} = \text{reference characteristic tensile strength of a fastener to splitting failure} \]

\[ S_{cr,N} = \text{spacing that is required for a fastener to develop its characteristic strength} \]

\[ S_{i} = \text{distance between fastener under consideration and neighbouring fastener} \]

\[ S_{min} = \text{minimum centre-to-centre spacing of fasteners} \]

\[ V_{Rk,s} = \text{characteristic shear strength of a fastener to steel failure} \]

\[ V_{Rk,a} = \text{characteristic shear strength of anchor against steel fracture} \]

\[ V_{Rk,a,l} = \text{characteristic shear strength of anchor channel to flexural failure of channel lip} \]

\[ V_{Rk,c} = \text{characteristic shear strength of anchor channel against failure of the connection between anchor and channel} \]

\[ \tau_{Rk,cr} = \text{characteristic bond strength for cracked concrete} \]

\[ \tau_{Rk,ucr} = \text{characteristic bond strength uncracked concrete} \]

\[ \alpha = \text{parameter} \]

\[ \phi_{c} = \text{capacity reduction factor for concrete} \]

\[ \phi_{\text{inst}} = \text{capacity reduction factor for installation} \]

\[ \phi_{Mp} = \text{capacity reduction factor for pull-out failure} \]

\[ \phi_{Ms,i} = \text{capacity reduction factor for steel failure mode} \]

\[ \phi_{Ms} = \text{capacity reduction factor for steel failure} \]

\[ \phi_{Ms,ca} = \text{capacity reduction factor for the connection between anchor and channel in tension and shear} \]

\[ \phi_{Ms,flex} = \text{capacity reduction factor for steel failure of anchor channel in flexure} \]

\[ \phi_{Ms,l} = \text{capacity reduction factor for local failure of anchor channel by bending of lips in tension and shear} \]

\[ \phi_{Ms,re} = \text{capacity reduction factor for tensile failure of supplementary reinforcement} \]

\[ \phi_{Ms,sp} = \text{capacity reduction factor for concrete splitting failure} \]

\[ \psi_{F,N} = \text{reduction factor applied to the tensile strength to account for the uneven distribution of the loads, provided in the Report of Assessment} \]

\[ \psi_{F,V} = \text{reduction factor applied to the shear strength to account for the uneven distribution of loads, provided in the Report of Assessment} \]

C.2 Design parameters to be determined

The design parameters to be established from testing and assessment for post-installed and cast-in fasteners are outlined in Table C2 to Table C4.
TABLE C2: PERFORMANCE CHARACTERISTICS OF MECHANICAL AND BONDED FASTENERS REQUIRED FOR DESIGN UNDER STATIC LOADING, AS NOTED IN THE REPORT OF ASSESSMENT.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mechanical</th>
<th>Post-installed</th>
<th>Bonded</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_{Rk,s}$, $V_{Rk,s}$</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>$M'_{Rk,s}$</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>$N_{Rk,p}$</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>$N'_{Rk,p}$</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>$\tau_{Rk,cr}$, $\tau_{Rk,ucr}$</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>$c_{cr,N}$</td>
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<td>•</td>
<td></td>
</tr>
<tr>
<td>$c_{cr,sp}$</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>$c_{min}$, $s_{min}$, $h_{min}$</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>$k_{cr,N}$, $k_{ucr,N}$</td>
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<td></td>
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<tr>
<td>$k_{3}$, $k_{7}$</td>
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</tr>
<tr>
<td>$k_{51}$</td>
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<td></td>
</tr>
<tr>
<td>$d_{nom}$, $h_{sp}$, $l_{p}$, $A_{s}$</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Fastener displacement under given tension and shear loads</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Limitations on concrete strength classes of base material</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>$\phi_{inst}$</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>$\phi_{c,a}$, $\phi_{Ms,i}$</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
</tbody>
</table>

*Recommended values included in the AEFAC Standard.
TABLE C3: PERFORMANCE CHARACTERISTICS OF HEADED FASTENERS AND ANCHOR CHANNEL REQUIRED FOR DESIGN UNDER STATIC LOADING, AS NOTED IN THE REPORT OF ASSESSMENT.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Headed fastener</th>
<th>Cast-in</th>
<th>Anchor channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_{Rk,s}$, $V_{Rk,s}$</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>$N_{Rk,s,a}$, $N_{Rk,s,c}$, $N_{Rk,s,l}$, $V_{Rk,s,a}$, $V_{Rk,s,c}$, $V_{Rk,s,l}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M_{Rk,fla}$</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>$N_{Rk,p}$</td>
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<td>$s_i$</td>
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<td>•</td>
</tr>
<tr>
<td>$k_{cr,V}, k_{acc,V}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$k_{2}, k_{3}, k_{7}$</td>
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<tr>
<td>$k_{5j}$</td>
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<td>•</td>
<td>•</td>
</tr>
<tr>
<td>$d_{nom}, h_{f0}, l_1, A_s$</td>
<td>•</td>
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<td>•</td>
</tr>
<tr>
<td>$d_{h}$</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>$A_{sh}, h_{sh}, d_{sh}, h_{sh}, A_{sh}, I_p$</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Fastener displacement under given tension and shear loads</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Limitations on concrete strength classes of base material</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>$\phi_c, \phi_{Ms,i}$</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
</tbody>
</table>

*Recommended values included in the AEFAC Standard.

TABLE C4: ADDITIONAL PERFORMANCE CHARACTERISTICS OF MECHANICAL FASTENERS, BONDED FASTENERS AND HEADED FASTENERS REQUIRED FOR DESIGN UNDER FATIGUE LOADING.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Post-installed</th>
<th>Cast-in</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi_{F,N}, \psi_{F,V}$</td>
<td>Mechanical</td>
<td>Bonded</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Maximum number of load cycles</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>$\Delta N_{Rk,s}, \Delta N_{Rk,p}, \Delta V_{Rk,s}$</td>
<td>•</td>
<td>•</td>
</tr>
</tbody>
</table>
TABLE C5: ADAPTATIONS REQUIRED FOR AN ETA TO BE COMPATIBLE WITH THIS STANDARD.

<table>
<thead>
<tr>
<th>Item</th>
<th>AEFAC Standard</th>
<th>Conversion from European notation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity reduction factors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel failure – fasteners:</td>
<td>$\phi_{M_t}$</td>
<td>$1/\gamma_{M_t}$</td>
</tr>
<tr>
<td>Steel failure – anchor channels:</td>
<td>$\phi_{M_r}$</td>
<td>$1/\gamma_{M_r}$</td>
</tr>
<tr>
<td>Connection between anchor and channel (tension and shear):</td>
<td>$\phi_{M_{ca}}$</td>
<td>$1/\gamma_{M_{ca}}$</td>
</tr>
<tr>
<td>Local failure of channel lips by bending under tension and shear:</td>
<td>$\phi_{M_{li}}$</td>
<td>$1/\gamma_{M_{li}}$</td>
</tr>
<tr>
<td>Flexural failure of anchor channel:</td>
<td>$\phi_{M_{flex}}$</td>
<td>$1/\gamma_{M_{flex}}$</td>
</tr>
<tr>
<td>Steel failure – supplementary reinforcement:</td>
<td>$\phi_{M_{re}}$</td>
<td>0.8</td>
</tr>
<tr>
<td>Supplementary reinforcement – tensile steel failure</td>
<td>$\phi_{M_{re}}$</td>
<td>$1/\gamma_{M_{re}}$</td>
</tr>
<tr>
<td>Concrete failure – tension:</td>
<td>$\phi_{c}$</td>
<td>$1/\gamma_{c}$</td>
</tr>
<tr>
<td>Installation safety – tension:</td>
<td>$\phi_{ins}$</td>
<td>$1/\gamma_{ins}$</td>
</tr>
<tr>
<td>Splitting failure:</td>
<td>$\phi_{M_p}$</td>
<td>$1/\gamma_{M_p}$</td>
</tr>
<tr>
<td>Pull-out failure &amp; combined pull-out and concrete cone failure:</td>
<td>$\phi_{M_p}$</td>
<td>$1/\gamma_{M_p}$</td>
</tr>
<tr>
<td>Characteristic compressive strength of concrete</td>
<td>$f'_c = 20 \text{ MPa}$</td>
<td>C20/25 (cylinder/cube)</td>
</tr>
<tr>
<td><strong>Fastener</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield strength in tension:</td>
<td>$f_{yt}$</td>
<td>$f_{yk}$</td>
</tr>
<tr>
<td>Ultimate strength in tension:</td>
<td>$f_{ut}$</td>
<td>$f_{uk}$</td>
</tr>
<tr>
<td><strong>Supplementary reinforcement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter of reinforcement bar:</td>
<td>$d_b$</td>
<td>$d_s$</td>
</tr>
<tr>
<td>Characteristic yield strength:</td>
<td>$f_{ys}$</td>
<td>$f_{ys,kr}$</td>
</tr>
</tbody>
</table>