

# TECHNICAL NOTE

**AEFAC**  
Australian Engineered  
Fasteners and Anchors Council



## POST-INSTALLED REBAR CONNECTIONS

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# AEFAC Technical Note

## on

# Post-Installed Rebar Connections

### 1. Scope

This Technical Note provides recommendations on design of post-installed rebar using adhesives in drilled holes in concrete for tensile load. This Technical Note covers the design for development length to achieve the characteristic yield strength of rebar. It also covers the determination of tensile capacity of post installed rebars to develop a stress less than the characteristic yield strength of rebar.

The basis of this Technical Note are EAD [1], ETAG 001 [2], EOTA TR 023 [3] and AS 3600 [4]. EAD, ETAG 001 and TR 023 are used for the prequalification of post-installed rebar system and AS 3600 is used for the design for development length and tensile capacity.

The provisions of AS 3600 are for cast-in rebar and do not address the behavior of post-installed rebar. The purpose of this Technical Note is to ensure that post-installed rebar performs in a similar manner to cast-in rebar (in terms of load transfer and load-displacement behaviour). Since a layer of adhesive is present between the rebar and the substrate in the post-installed rebar application, the overall behavior of the system is also dependent on the properties of the adhesive. Thus, in order to use this Technical Note, the post-installed rebar adhesive system must be **prequalified according to EOTA TR 023** to ensure its suitability for this application. The ETA (European Technical Assessment) based on TR 023 is referred to herein as **ETA-TR 023**. This is to distinguish the additional prequalification for the ETA which is issued based on EAD / ETAG 001 and referred to herein as just ETA which is used for designs according to SA TS 101:2015[5].

The product ETA-TR 023 for post-installed rebar system based on TR 023 is different from the product ETA for adhesive anchors issued based on EAD/ETAG 001 testing and evaluation method. The ETA-TR 023 specifically provides the design ultimate

bond strength (also called bond resistance) values ( $f_{bd}$ ) which are different from design bond strength values derived from the characteristic bond strength values ( $\tau_{Rk}$ ) in the ETA for adhesive anchors. For post-installed rebar connections, the design ultimate bond strength ( $f_{bd}$ ) as given in ETA-TR 023 are used.

In general, the design ultimate bond strength value in the ETA-TR 023 is lower than the bond strength in the ETA (based on EAD/ETAG 001). The lower value of bond strength must be considered to scale the development length obtained from equation (1) in Section 5 of this Technical Note. Please refer to Example 1 for  $f_{bd}$  of 2.5MPa.

The Technical Note covers straight deformed reinforcing bars with diameter greater than or equal to 10mm and concrete with minimum compressive strength of 20MPa with upper limits for concrete strength and rebar as defined by the relevant ETA-TR 023.

This Technical Note covers static loading and does not cover seismic, fatigue and fire actions. It covers post-installed rebars installed in dry and wet concrete (not in flooded holes).

The recommendations provided in this Technical Note are of general nature. For product specific detailed information, advice from the supplier/manufacturer should be sought.

For post-installed rebar connections, the required hole depth may be large and hence the installation quality is extremely important. The installation must be carried out in accordance with the manufacturer's installation instructions (MII). The installation should only be performed by **competent personnel**, either certified by AEFAC [6] or trained by anchor supplier for this specific application.

## 2. Terminology

The following terminologies and definitions are used in this Technical Note. Please refer to AEFAC Anchor Dictionary [7] for additional terminologies and definitions.

*Anchor:* a type of device that is post-installed into matured concrete or cast into concrete.

*Competent person:* A person who has acquired thorough training, qualification or experience, or a combination of these, the knowledge and skills to enable that person

to perform the required task.

*Cover:* Distance between the outside of rebar and the nearest surface of the substrate excluding any applied surface finish.

*Post-installed rebar:* Reinforcement that is anchored into matured concrete using adhesives in drilled hole.

## 3. Notation

$A_s$	=	Cross-sectional area of rebar
$c_d$	=	Distance between rebar and edge (clear cover)
$c_{min}$	=	Minimum clear cover
$d_b$	=	Diameter of rebar
$f_{bd}$	=	Ultimate bond strength (also called bond resistance) of post-installed rebar (given in ETA-TR 023)
$f'_c$	=	Characteristic compressive (cylinder) strength of concrete
$f_{sy}$	=	Characteristic yield strength of rebar
$k$	=	Factor or coefficient (with numerical subscripts) to determine development length of rebars according to AS 3600
$L_{st}$	=	Reduced development length to develop a stress $\sigma_{st}$ of deformed rebar in tension in accordance with AS3600
$L_{sy,t}$	=	Development length to develop a stress $f_{sy}$ of deformed rebar in tension in accordance with AS3600
$N_{st}$	=	Nominal tensile capacity of post-installed rebar with embedment depth $L_{st}$
$s_{min}$	=	Minimum clear spacing between two post-installed rebars
$\sigma_{st}$	=	Tensile stress in the rebar, less than the yield strength ( $f_{sy}$ )

## 4. General

Design of post-installed rebars is not covered in AS 3600. However, if the post-installed rebar system is prequalified according to TR 023 and installed based on the

instructions reported in the product ETA-TR 023, the provisions given in AS 3600 can be used for post-installed rebar design within the scope describe in Section 1 of this Technical Note and the ETA-TR 023.

TR 023 is used in Europe for the prequalification and design of post-installed rebars and it refers to the concrete design code Eurocode 2 [8]. In this Technical Note, the design provisions of AS 3600 are adopted rather than Eurocode 2 to be used with ETA-TR 023.

The qualification process for post-installed rebar is included in TR 023 which also includes the intended application range of post installed rebar as reported in Figure 1.1 to 1.5 of TR 023 and also reproduced in the product ETA-TR 023.

## 5. Design of Post-installed Rebar Connection

Unlike Eurocode 2, AS 3600 does not explicitly use bond strength ( $f_{bd}$ ) in the formula to obtain the development length. If the design ultimate bond strength ( $f_{bd}$ ) in the relevant product ETA-TR 023 is less than the values stated in TR 023 and shown in Table 1, then the calculated development length from equation (1) needs to be increased in proportion to the ratio of the value given in TR 023 and the value from the ETA-TR 023 for the given strength of concrete (see Example 1).

Table 1: Design bond strength according to TR 023 without limitation.

S.N.	Compressive strength of concrete (MPa)	Design ultimate bond strength $f_{bd}$ (MPa)
1	20	2.3
2	25	2.7
3	32	3.2
4	40	3.7
5	45	4.0
6	50	4.3

**Note:**  
*Design ultimate bond strength ( $f_{bd}$ ) provided in this table are for rebar with diameter less than or equal to 32mm.*

## 5.1. Determination of Development Length

The embedment length of post-installed rebars to develop characteristic yield strength of a rebar should not be less than the development length obtained from equation (1) which is in AS 3600.

The development length ( $L_{sy,t}$ ) to develop the characteristic yield strength of a rebar ( $f_{sy}$ ) in tension is given by equation (1).

$$L_{sy,t} = \frac{(0.5k_1 k_3 f_{sy} d_b)}{k_2 \sqrt{f'_c}} \geq 29k_1 d_b \quad \text{Eq (1)}$$

Where,

$$k_1 = \begin{aligned} &= 1.3 \text{ for a rebar with more than 300mm of concrete cover} \\ &= 1.0 \text{ otherwise} \end{aligned}$$

$$k_2 = (132 - d_b) / 100$$

$$k_3 = 1 - \frac{0.15(c_d - d_b)}{d_b}$$

(within the limits  $0.7 \leq k_3 \leq 1.0$ )

$$c_d = \text{Minimum of clear cover on each side and half of clear spacing between rebars}$$

$$f'_c \leq 65\text{MPa}$$

Equation (1) is valid for cracked and un-cracked concrete if no additional requirement is provided for cracked concrete in product ETA-TR 023.

### Notes:

- 1. The minimum limit of  $29k_1 d_b$  in equation (1) is intended for cast-in rebar applications. This requirement may lead to a conservative estimate (especially for higher strength concrete) for post-installed rebar connections.*
- 2.  $k_1$  can be assumed to be 1 for post installed rebars in fully cured concrete.*
- 3. For the product specific applications, relevant product ETA-TR 023 should be referred for concrete type and strength limit.*

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## Example 1:

Characteristic compressive strength of concrete,  $f'_c = 25\text{MPa}$

Diameter of rebar,  $d_b = 12\text{mm}$

Characteristic yield strength of rebar,  $f_{sy} = 500\text{MPa}$

$$\frac{(0.5k_1 k_3 f_{sy} d_b)}{k_2 \sqrt{f'_c}} = 350\text{mm}$$

And

$$29k_1 d_b = 348\text{mm} < 350\text{mm}$$

- a) If the design bond strength,  $f_{bd}$  is 2.7MPa in the product ETA-TR 023 (which is same as the value given in Table 1), the development length to yield the rebar is,

$$L_{sy,t} = 350\text{mm}.$$

- b) If the design bond strength,  $f_{bd}$  is 2.5MPa in the product ETA-TR 023 (which is less than the value given in Table 1), the development length to yield the rebar should be,

$$L_{sy,t} = 350 \times 2.7 / 2.5 = 378\text{mm}.$$

## Notes:

1. In this example the value of  $k_1$  and  $k_3$  are assumed as 1.0 and 0.7 respectively. According to Section 5.3, minimum cover for hammer drilled holes,  $c_{min}$  would be 51mm which is more than  $3d_b$ , resulting the value of  $k_3$  to be 0.7, provided that the clear spacing,  $s_{min}$  is greater than or equal to  $6d_b$ .
2. Design ultimate bond strength for the same parameters and installation methods (e.g., drill type, drilling method and hole and concrete condition) as for the intended application should be taken from the product ETA-TR 023. Advice from supplier/manufacturer should be taken if any of the parameters are outside the scope of product ETA-TR 023.

3. The development length to yield the rebar was governed by  $\frac{(0.5k_1 k_3 f_{sy} d_b)}{k_2 \sqrt{f'_c}}$

## 5.2 Determination of post-installed rebar capacity for $L_{st} < L_{sy,t}$

In some cases, it might not be possible or required to achieve the full development length of the rebar specified in Section 5.1 due to the structural dimensions or some other reasons.

The development length ( $L_{st}$ ) for a post-installed rebar to develop a tensile stress ( $\sigma_{st}$ ), which is less than the characteristic rebar yield strength is given in AS 3600 as -

$$L_{st} = L_{sy,t} \frac{\sigma_{st}}{f_{sy}} \quad \text{Eq (2)}$$

The development length ( $L_{st}$ ) calculated from equation (2) should not be less than  $12d_b$  or any other provisions specified in AS 3600.

Accordingly, the reduced nominal capacity of the post-installed rebar ( $N_{st}$ ) can be calculated from equation (3) or (4). (See Example 2).

$$N_{st} = A_s \sigma_{st} \quad \text{Eq (3)}$$

$$N_{st} = A_s f_{sy} \frac{L_{st}}{L_{sy,t}} \quad \text{Eq (4)}$$

Where,

$$A_s = \frac{\pi d_a^2}{4} \quad \text{Eq (5)}$$

### Note:

1. Alternative methods (e.g., SA TS 101:2015) can be used to determine the capacity of post-installed rebar if the product has ETA based on ETAG 001. The design approach, scope and applicable factors as given in SA TS 101:2015 should be followed.



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## Example 2:

Characteristic compressive strength of concrete,  $f'_c = 32\text{MPa}$

Diameter of rebar,  $d_b = 12\text{mm}$

Characteristic yield strength of rebar,  $f_{sy} = 500\text{MPa}$

$$\frac{(0.5k_1 k_3 f_{sy} d_b)}{k_2 \sqrt{f'_c}} = 310\text{mm}$$

And

$$29k_1 d_b = 348\text{mm} > 310\text{mm}$$

- a) If the design bond strength,  $f_{bd}$  is 3.2MPa in the product ETA-TR 023 (which is same as the value given in Table 1), the development length to yield the rebar is,

The development length ( $L_{sy,t}$ ) to develop the characteristic yield strength of a rebar ( $f_{sy} = 348\text{mm}$ )

The development length ( $L_{st}$ ) for a post-installed rebar to develop a tensile stress ( $\sigma_{st} = 300\text{MPa}$ ),

$$L_{st} = L_{sy,t} \frac{\sigma_{st}}{f_{sy}}$$

$$= 348 \times 300 / 500$$

$$= 209\text{mm}$$

The nominal capacity of the post-installed rebar ( $N_{st}$ ) installed for a depth of 209mm,

$$N_{st} = A_s \sigma_{st} = 113.1 \times 300 = 34000\text{N} = 34\text{kN} \quad \text{OR}$$

$$N_{st} = A_s f_{sy} \frac{L_{st}}{L_{sy,t}} = 113.1 \times 500 \times 209 / 348 = 34000\text{N} = 34\text{kN}$$

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b) If the design bond strength,  $f_{bd}$  is 3.0MPa in the product ETA-TR 023 (which is less than the value given in Table 1), the development length to yield the rebar should be,

$$L_{sy,t} = 348 \times 3.2 / 3.0 = 372 \text{mm.}$$

The development length ( $L_{st}$ ) for a post-installed rebar to develop a tensile stress ( $\sigma_{st} = 300 \text{MPa}$ ),

$$L_{st} = L_{sy,t} \frac{\sigma_{st}}{f_{sy}}$$

$$= 372 \times 300 / 500$$

$$= 224 \text{mm}$$

The nominal capacity of the post-installed rebar ( $N_{st}$ ), installed for a depth of 224mm,

$$N_{st} = A_s \sigma_{st} = 113.1 \times 300 = 34000 \text{N} = 34 \text{kN} \quad \text{OR}$$

$$N_{st} = A_s f_{sy} \frac{L_{st}}{L_{sy,t}} = 113.1 \times 500 \times 224 / 372 = 34000 \text{N} = 34 \text{kN}$$

## **Notes:**

1. Value of  $k_3$  is assumed to be 0.7 in this example.
2. The development length to yield the rebar was governed by  $29k_1 d_b$

## **5.3 Additional Design Provisions**

Adequate concrete cover should be provided to prevent damage to the concrete during installation.

TR 023 provides minimum concrete cover ( $c_{min}$ ) as -

$$c_{min} = 30 + 0.06L_{st} \geq 2d_b \text{ for hammer drilled holes}$$

$$c_{min} = 50 + 0.08L_{st} \geq 2d_b \text{ for compressed air drilled holes}$$

Where,  $L_{st}$  is the actual embedment depth of the post-installed rebar.

If drilling aid is used, the factors 0.06 and 0.08 could be reduced. Relevant product ETA-TR 023 should be followed for the actual requirements for the clear cover and spacing.

The minimum spacing between post-installed rebars ( $s_{min}$ ) should be -

$$s_{min} = 40\text{mm} \geq 4 d_b$$

## 6. References

- [1] EAD 330232-00-0601 "Mechanical Fasteners for Use in Concrete", European Organisation for Technical Assessment, October 2016.
- [2] EOTA, "ETAG 001: Metal Anchors for Use in Concrete," European Organization for Technical Approvals, 2013.
- [3] EOTA, "TR 023: Assessment of post-installed rebar connections," European Organization for Technical Approvals, 2006.
- [4] Standards Australia, "AS 3600: Concrete structures," Standards Australia, 2009.
- [5] Standards Australia, "SA TS 101: Design of post-installed and cast-in fastenings for use in concrete," Standards Australia, Australia, 2015.
- [6] AEFAC, "AEFAC Anchor Installer Certification Program," Australian Engineered Fasteners and Anchors Council. [www.aefac.org.au](http://www.aefac.org.au).
- [7] AEFAC, Technical Note, "AEFAC Anchor Dictionary," Australian Engineered Fasteners and Anchors Council. [www.aefac.org.au](http://www.aefac.org.au).
- [8] CEN, "BS EN 1992-1 : Design of concrete structures," 2004.



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