# *BIS-PE GEN3* NEW Next Generation Epoxy Injection System for Post-Installed Rebar Connections

(Design in accordance with AEFAC TN08 and AS 3600)

ICCONS® Serious Connections®

# Contents



DONE AND DUSTLESS

COMPLIES WITH AS 5216 FOR POST-INSTALLED FASTENINGS


## Epoxy Injection Adhesive Post Installed Rebar Connections ETA Assessment (ETA-21/0959)

### Features

- For extreme loads
- Slow curing for more flexibility
- Fire Rated
- Seismic assessed
- Styrene free
- Low VOC A+ rating
- Potable Water approved

### Use Conditions

- Installation in reinforced and un-reinforced concrete C16/20 to C50/60
- For post-installed rebar N10 to N32
- Hammer/compressed air drilled holes
- Diamond cored holes
- Hollow drill bits
- Dry or wet concrete (must not be installed in flooded holes)
- Overhead installation allowed
- 50 and 100 Year Design Life

### Approvals & Test Reports

ETA - 21/0959

ETA - 19/0850

100+ YEAR DESIGN LIFE

SEISMIC

ÉMISSIONS DANS L'AIR INTÉRIEUR A+

LEED

NCC TM NATIONAL CODE COMPLIANT


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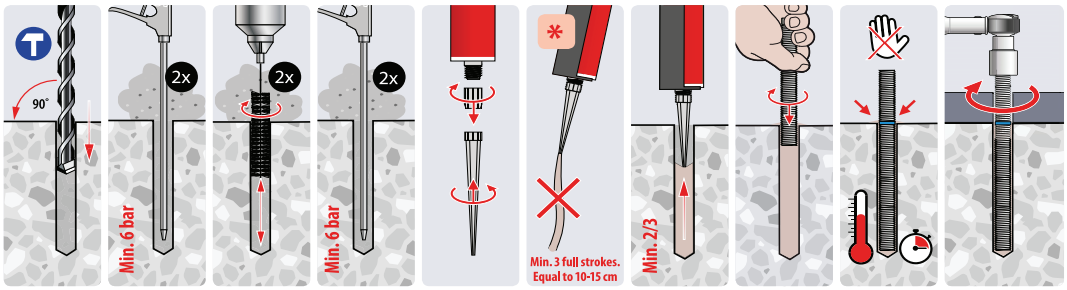
## Temperature Range

- B+BTec BIS-PE GEN3 injection mortar may be applied in the temperature ranges given below.
- An elevated base material temperature leads to a reduction of the bond resistance.
- **Max. long term base material temperature:** Long term elevated base material temperatures are roughly constant over significant periods of time.
- **Max. short term base material temperature:** Short term elevated base material temperatures are those that occur over brief intervals, e.g. as a result of diurnal cycling.

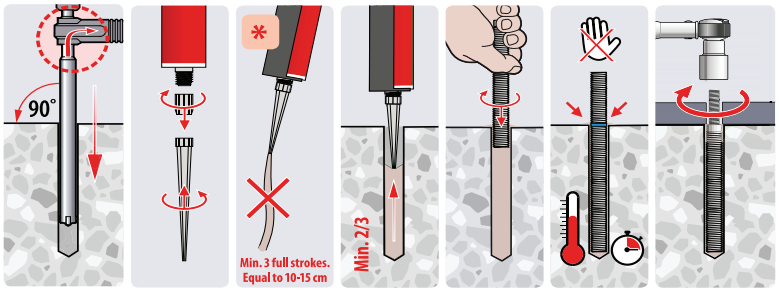
| Temperature Range | Temperature Base Material | Max. Long Term Base Material Temperature | Max. Short Term Base Material Temperature |
|---|---|---|---|
| Temp. Range | -40°C to +80°C | + 50°C | +80°C |

## Installation Procedures (Hammer Drilling)

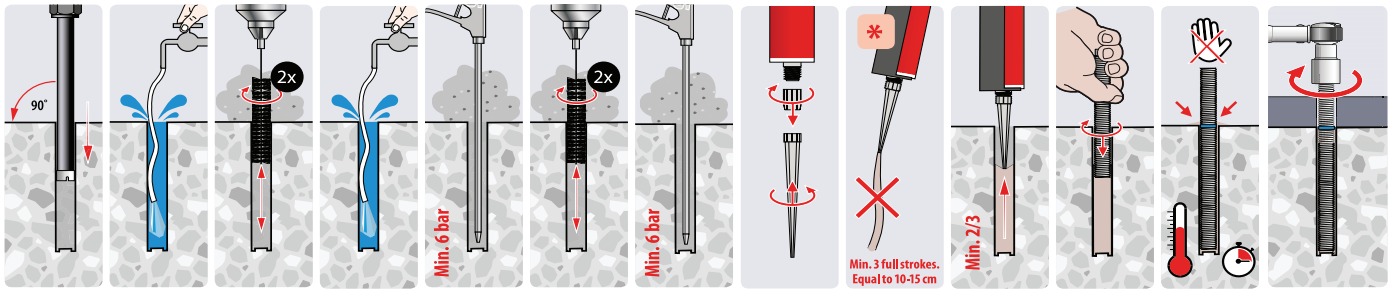
* Sqeeze out seperately a minimum of 3 full strokes (Equal to 10-15 cm ) until the mortar shows a consistent colour.




## Installation Procedures (Hollow Drilling)




## Installation Procedures (Diamond Drilling) -




## Curing Times[1)]

| Temperature[2)] °C | +5 to +9 | +10 to + 14 | +15 to +19 | +20 to +24 | +25 to +34 | +35 to +39 | +40 |
|---|---|---|---|---|---|---|---|
| Processing/Working Time | 80 min | 60 min | 40 min | 30 min | 12 min | 8 min | 8 min |
| Curing Time Dry Holes | 48 h | 28 h | 18 h | 12 h | 9 h | 6 h | 4 h |
| Curing Time Wet Holes | 96 h | 56 h | 36 h | 24 h | 18 h | 12 h | 8 h |

[1)] Cartridge Temperature must be between +5°C and +40°C. [2)] Concrete Temperature



## Material Properties

B+BTec, BIS-PE GEN3 injection mortar may be applied in cracked and non-cracked concrete, lightweight-concrete, aerated-concrete and natural stone (Attention! natural stone can discolour, this shall be checked in advance.). In the table below the physical properties of the B+BTec BIS-PE GEN3 are listed.

| Properties | Test Method | Result |
|---|---|---|
| Compressive strength | EN 196-1 | 122 N/mm² |
| Flexural strength | EN 196-1 | 66,0 N/mm² |
| Axial tensile strength | DIN EN | 44,2 N/mm² |
| E modulus | DIN EN | 6.300 N/mm² |
| Elongation at fracture | DIN EN | 1 % |
| Degree of shrinkage | DIN 52450 | ≤ 1,4 ‰ |
| Hardness Shore A | DIN EN | 99,4 |
| Hardness Shore D | DIN EN | 86,1 |
| Density | | ≤ 1,5 kg/dm³ |
| Thermal conductivity | DIN EN 993-15 | 0.50 W/mK |
| Heat capacity | DIN EN 993-15 | 1.350 J/kgK |
| Electrical resistance | DIN IEC 93 | $8{,}0 \cdot 10^{12}$ Ω |

## Chemical Resistance

The resistance of the B+BTec, BIS-PE GEN3 injection mortar to chemical substances is given in the table below. The data in this table are applicable to brief periods of chemical contact with full cured adhesive (e.g. temporary contact with adhesive during a spill).

| Chemical Agent | Concentration | Resistant | Not Resistant |
|---|---|---|---|
| Acetic acid | 40 | | ● |
| Acetone 10 | 10 | | ● |
| Ammonia, aqueous solution | 5 | ● | |
| Aniline 100 | | ● | |
| Beer 100 | | ● | |
| Benzine (kp 100-140°F) | 100 | ● | |
| Benzene | 100 | | ● |
| Boric Acid, aqueous solution | | ● | |
| Calcium carbonate, suspended in water | All | ● | |
| Calcium chloride, suspended in water | | ● | |
| Calcium hydroxide, suspended in water | | ● | |
| Carbon tetrachloride | 100 | ● | |
| Caustic soda (Sodium hydroxide) | 40 | ● | |
| Citric acid | All | ● | |
| Chlorine | All | ● | |
| Diesel oil | 100 | ● | |
| Ethyl alcohol, aqueous solution | 50 | | ● |
| Formaldehyde, aqueous solution | 30 | ● | |
| Formic acid (Methanoic acid) | 100 | | ● |

## Chemical Resistance

The resistance of the B+BTec, BIS-PE GEN3 injection mortar to chemical substances is given in the table below. The data in this table are applicable to brief periods of chemical contact with full cured adhesive (e.g. temporary contact with adhesive during a spill).

| Chemical Agent | Concentration | Resistant | Not Resistant |
|---|---|---|---|
| Formic acid (Methanoic acid) | 10 | ● | |
| Freon | | ● | |
| Fuel Oil | | ● | |
| Gasoline (premium grade) | 100 | ● | |
| Glycol (Ethylene glycol) | | ● | |
| Hydrogen peroxide | 30 | | ● |
| Hydrochloric acid (Muriatic Acid) Conc. | | | ● |
| Isopropyl alcohol | 100 | | ● |
| Lactic acid | All | | ● |
| Laitance | | ● | |
| Linseed oil | 100 | ● | |
| Lubricating oil | 100 | ● | |
| Magnesium chloride, aqueous solution | All | ● | |
| Methanol | 100 | | ● |
| Motor oil (SAE 20 W-50) | 100 | ● | |
| Nitric acid | 10 | | ● |
| Oleic acid | 100 | ● | |
| Perchloroethylene | 100 | ● | |
| Petroleum | 100 | ● | |
| Phenol, aqueous solution (Carbonic acid) | 8 | | ● |
| Phosphoric acid | 85 | ● | |
| Phosphoric acid | 10 | ● | |
| Potash lye (potassium hydroxide, 10% and 40% solutions) | | ● | |
| Potassium carbonate, aqueous solution | All | ● | |
| Potassium chlorite, aqueous solution | All | ● | |
| Potassium nitrate, aqueous solution | All | ● | |
| Sodium carbonate, aqueous solution | All | ● | |
| Sodium chloride, aqueous solution | All | ● | |
| Sodium phosphate, aqueous solution | All | ● | |
| Sodium silicate | All | ● | |
| Sulfuric acid | 30 | | ● |
| Tartaric acid | All | ● | |
| Tetrachloroethylene | 100 | ● | |
| Toluene | | | ● |
| Turpentine | 100 | ● | |
| Trichloroethylene | 100 | | ● |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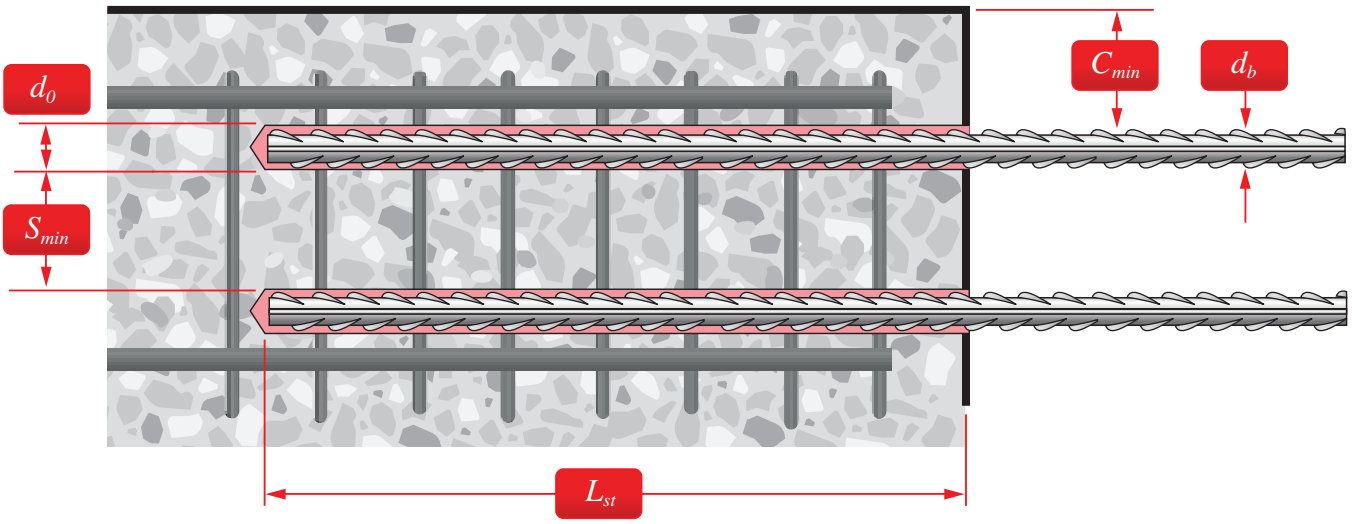
# Design of post-installed rebar connections

ETA - 21/0959




## Design Guidelines for Post-Installed Rebar Connections.

This document provides the design provisions and load tables for Post-installed Rebar Connections designed in accordance with AS3600 Section 13.1.2 and AEFAC technical note – TN08 Post Installed Rebar Connections Version 1.1, August 2019. To ensure post installed rebar performance is similar to that of cast-in rebar as outlined in AS3600 only adhesive systems that are prequalified according to EAD 330087 shall be used. The embedment length of post-installed rebars should not be less than the development length obtained from equation (A) as highlighted below and in AS 3600 13.1.2.2.

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

**EQUATION (A)**

$$L_{sy.t} = \frac{(0.5 k_1 k_3 f_{sy} d_b)}{k_2 \sqrt{f_c'}} \geq 0.058\ f_{sy}\ k_1\ d_b$$

Where,

$k_1$ = 1.3 for rebar with more than 300mm of concrete cover

= 1.0 otherwise

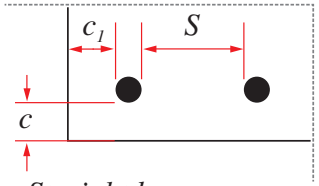
$k_2$ = $(132 - d_b) / 100$

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

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

$c_d$ = Minimum of clear cover on each side and half of clear spacing between rebars

$f_c'$ ≤ 65MPa




*Straight bars*

$c_d$ = min $(S/2, c_1, c)$

Note: Equation A is valid for cracked and uncracked concrete if no additional requirement is provided in product ETA.

## Development Length to Develop less than Yield strength $(L_{st})$

Where it may be necessary to achieve a development length that develops a tensile stress $(\sigma_{st})$ less than yield due to design parameters or base material restrictions, the Development Length $(L_{st})$ for post-installed rebar shall be designed according to equation (B) below.

**EQUATION (B)**

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

The development length $(L_{st})$ calculated from equation (B) should be greater than $12d_b$ or other provisions as specified in AS 3600.
The reduced nominal capacity of the post-installed rebar $(N_{st})$ can be calculated from equation (C) or (D) below.

**EQUATION (C)**

$$N_{st} = A_s\,\sigma_{st}$$

**EQUATION (D)**

$$N_{st} = A_s f_{sy}\frac{L_{st}}{L_{sy.t}}$$

Where,

$$A_s = \frac{\pi d_b^{\,2}}{4}$$

## Concrete Cover & Spacing of Rebar

Provisions for adequate concrete cover (Cmin) are highlighted in EAD 330087 and in table A below. Where a drilling guide is used factors are reduced accordingly.

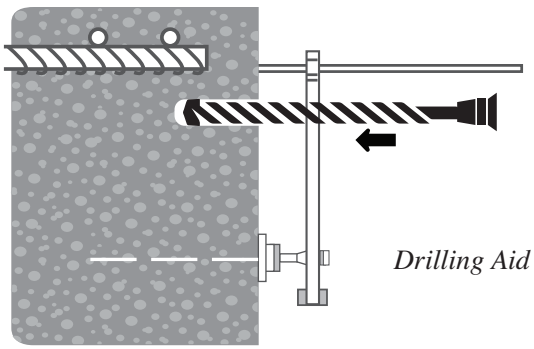
## Minimum Concrete Cover $(C_{min})$

**TABLE A**

| Drilling Method | Rebar ø [mm] | Without Drilling Aid | With Drilling Aid |
|---|---|---|---|
| Hammer Drilling (HD), | <25 | 30mm + 0.06· $l_v \geq 2$ ø | 30mm + 0.02 · $l_v \geq 2$ ø |
| Hammer Drilling with hollow drill (HDB) | ≥25 | 40mm + 0.06· $l_v \geq 2$ ø | 40mm + 0.02 · $l_v \geq 2$ ø |
| Diamond Drilling (DD) | <25 | Drilling rig used as aid | 30mm + 0.02 · $l_v \geq 2$ ø |
| | ≥25 | Drilling rig used as aid | 40mm + 0.02 · $l_v \geq 2$ ø |
| Compressed Air Drilling (CD) | <25 | 50mm + 0.08· $l_v$ | 50mm + 0.02 · $l_v$ |
| | ≥25 | 60mm + 0.08· $l_v \geq 2$ ø | 60mm + 0.02 · $l_v \geq 2$ ø |

## Minimum (clear) spacing between post-installed rebars $(S_{min})$ is;

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





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## Design Values of Ultimate Bond Resistance[2] $f_{bd}$ in $N/mm^2$

| Rebar | Concrete Class | | | | | | |
|---|---|---|---|---|---|---|---|
| | C20 | C25 | C32 | C35 | C40 | C45 | C50 |
| Ø10 - 32 mm | 2.3 | 2.7 | 3.2 | 3.4 | 3.7 | 4.0 | 4.3 |

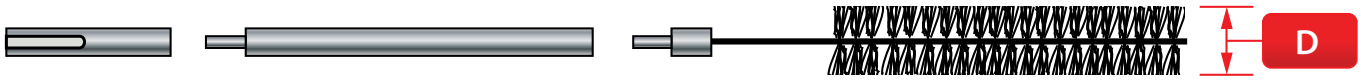
**Important:** Information contained in this documents shall be read in conjunction with the provisions and guidelines set out in;-

- AS 3600 (Concrete Structures)
- AEFAC Technical Note (Post Installed Rebar Connections) Version 1.1 August 2019 – TN08
- EAD 330087 (Systems for Post-Installed rebar connections with mortar)
- Product ETA in accordance with EAD 330087

For splicing of reinforcement please follow guidelines highlighted in AS3600 section 13.2.

## Installation Dimensions

| Rebar Size | $d_b$ | | Ø10 | Ø12 | Ø16 | Ø20 | Ø24 | Ø28 | Ø32 |
|---|---|---|---|---|---|---|---|---|---|
| Hole Diameter | $d_o$ | [mm] | 14 | 16 | 20 | 25 | 32 | 35 | 40 |
| Min. Anchoring Length | $12d_b$ | [mm] | 120 | 144 | 192 | 240 | 288 | 336 | 384 |
| Max. Embedment Depth | $L_{max}$ | [mm] | 1000 | 1200 | 1600 | 2000 | 2000 | 2000 | 2000 |
| Min. (clear) Spacing | $S_{min}$ | [mm] | 40 | 48 | 64 | 80 | 96 | 112 | 128 |
| Required Volume per cm Embedment Depth | $V_s$ | [ml/cm] | 0.90 | 1.06 | 1.36 | 2.12 | 3.76 | 4.16 | 5.43 |




## Steel Brush & Piston Plug Dimensions

| Rebar Size | $d_b$ | | Ø10 | Ø12 | Ø16 | Ø20 | Ø24 | Ø28 | Ø32 |
|---|---|---|---|---|---|---|---|---|---|
| Brush Diameter | D | [mm] | 16 | 18 | 22 | 27 | 34 | 37 | 41,5 |
| Min. Brush Diameter | $D_{min}$ | [mm] | 14.5 | 16.5 | 20.5 | 25.5 | 32.5 | 35.5 | 40.5 |
| Piston Plug | # | - | 14 | 16 | 20 | 25 | 32 | 35 | 40 |

## Stress Development in Reinforcement

Development length for post-installed reinforcement in tension in accordance with AS3600 (clause 13.1.2)

| Rebar designation | | | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
|---|---|---|---|---|---|---|---|---|---|
| Diameter of rebar | $d_b$ | (mm) | 10 | 12 | 16 | 20 | 24 | 28 | 32 |
| Drill hole size | $d_0$ | (mm) | 14 | 16 | 20 | 25 | 32 | 35 | 37 |
| Cross Sectional Area of Rebar | $A_s$ | ($mm^2$) | 79 | 113 | 201 | 314 | 452 | 616 | 804 |
| Yield Strength of Rebar (D500N) | | (kN) | 39.5 | 56.5 | 100.5 | 157 | 226 | 308 | 402 |
| 12 x $d_b$ (min.) | | (mm) | 120 | 144 | 192 | 240 | 288 | 336 | 384 |
| $0.058\ f_{sy}\ k_1\ d_b$ | | (mm) | 290 | 348 | 464 | 580 | 696 | 812 | 928 |
| $\frac{(0.5k_1\ k_3\ f_{sy}\ d_b)}{k_2\ \sqrt{f_c'}}$ | $f'_c$ =20<br>$f'_c$ =32 | (mm)<br>(mm) | 389<br>308 | 475<br>376 | 655<br>518 | 849<br>671 | 1056<br>835 | 1279<br>1011 | 1521<br>1202 |
| Assumptions in accordance with AS3600 Section 13.1.2 | | | | | | | | | |
| $k_1$ | | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| $k_2$ | | | 1.22 | 1.20 | 1.16 | 1.12 | 1.08 | 1.04 | 1.00 |
| $k_3$ | | | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| c (Clear cover to concrete edge)* | | (mm) | 20 | 24 | 32 | 40 | 48 | 56 | 64 |
| s (Clear spacing b/w bars) | | (mm) | 40 | 48 | 64 | 80 | 96 | 112 | 128 |
| s min. | | | 40 | 48 | 64 | 80 | 96 | 112 | 128 |

* c clear cover shall be the greater of the c value above and the value highlighted in table A (page 5) which is based on drilling process.

## $L_{st}$ Development Length less than yield -AS3600 (for $C_d$=2 x $d_b$) $k_3$=0.85, 20MPa

| | Reinforcing Bar Capacity (kN) | | | | | | |
|---|---|---|---|---|---|---|---|
| $L_{st}$ (mm) | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
| 120 | 12.2 | | | | | | |
| 145 | 14.7 | 17.3 | | | | | |
| 200 | 20.3 | 23.8 | 30.7 | | | | |
| 240 | 24.3 | 28.6 | 36.8 | 44.4 | | | |
| 300 | 30.4 | 35.7 | 46.0 | 55.5 | 64.3 | | |
| 340 | 34.5 | 40.5 | 52.2 | 63.0 | 72.8 | 81.8 | |
| **389** | **39.5** | 46.3 | 59.7 | 72.0 | 83.3 | 93.6 | 102.9 |
| 440 | | 52.4 | 67.5 | 81.5 | 94.3 | 105.9 | 116.4 |
| **475** | | **56.5** | 72.9 | 87.9 | 101.8 | 114.3 | 125.6 |
| 540 | | | 82.8 | 100.0 | 115.7 | 130.0 | 142.8 |
| 620 | | | 95.1 | 114.8 | 132.8 | 149.2 | 164.0 |
| **655** | | | **100.5** | 121.3 | 140.3 | 157.7 | 173.2 |
| 700 | | | | 129.6 | 150.0 | 168.5 | 185.1 |
| 740 | | | | 137.0 | 158.5 | 178.1 | 195.7 |
| 800 | | | | 148.1 | 171.4 | 192.6 | 211.6 |
| **849** | | | | **157.0** | 181.9 | 204.3 | 224.6 |
| 990 | | | | | 212.1 | 238.3 | 261.9 |
| **1056** | | | | | **226.0** | 254.2 | 279.3 |
| 1100 | | | | | | 264.8 | 290.9 |
| **1279** | | | | | | **308.0** | 338.3 |
| 1400 | | | | | | | 370.3 |
| **1521** | | | | | | | **402.0** |
| Length to develop yield $L_{sy,t}$ (mm) | **389** | **475** | **655** | **849** | **1056** | **1279** | **1521** |

## $L_{st}$ Development Length less than yield -AS3600 (for $C_d$=2 x $d_b$) $k_3$=0.85, 32MPa

| | Reinforcing Bar Capacity (kN) | | | | | | |
|---|---|---|---|---|---|---|---|
| $L_{st}$ (mm) | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
| 120 | 15.4 | | | | | | |
| 145 | 18.6 | 21.8 | | | | | |
| 200 | 25.7 | 30.1 | 38.8 | | | | |
| 240 | 30.8 | 36.1 | 46.6 | 56.2 | | | |
| **308** | **39.5** | 46.4 | 59.8 | 72.1 | 83.5 | | |
| 340 | | 51.2 | 66.0 | 79.6 | 92.1 | 103.5 | |
| **376** | | **56.5** | 73.0 | 88.1 | 101.9 | 114.5 | |
| 440 | | | 85.4 | 103.0 | 119.2 | 134.0 | 147.2 |
| 475 | | | 92.2 | 111.2 | 128.7 | 144.6 | 158.9 |
| **518** | | | **100.5** | 121.3 | 140.4 | 157.7 | 173.3 |
| 620 | | | | 145.2 | 168.0 | 188.8 | 207.4 |
| **671** | | | | **157.0** | 181.8 | 204.3 | 224.5 |
| 700 | | | | | 189.7 | 213.1 | 234.2 |
| 740 | | | | | 200.5 | 225.3 | 247.6 |
| 800 | | | | | 216.8 | 243.6 | 267.7 |
| **835** | | | | | **226.0** | 254.2 | 279.4 |
| 990 | | | | | | 301.4 | 331.2 |
| **1011** | | | | | | **308.0** | 338.2 |
| 1100 | | | | | | | 368.0 |
| 1150 | | | | | | | 384.8 |
| **1202** | | | | | | | **402.0** |
| Length to develop yield $L_{sy,t}$ (mm) | **308** | **376** | **518** | **671** | **835** | **1011** | **1202** |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## Stress Development in Reinforcement

Development length for post-installed reinforcement in tension in accordance with AS3600 (clause 13.1.2)

| Rebar designation | | | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
|---|---|---|---|---|---|---|---|---|---|
| Diameter of rebar | $d_b$ | (mm) | 10 | 12 | 16 | 20 | 24 | 28 | 32 |
| Drill hole size | $d_0$ | (mm) | 14 | 16 | 20 | 25 | 32 | 35 | 37 |
| Cross Sectional Area of Rebar | $A_S$ | ($mm^2$) | 79 | 113 | 201 | 314 | 452 | 616 | 804 |
| Yield Strength of Rebar (D500N) | | (kN) | 39.5 | 56.5 | 100.5 | 157 | 226 | 308 | 402 |
| 12 x $d_b$ (min.) | | (mm) | 120 | 144 | 192 | 240 | 288 | 336 | 384 |
| $0.058\ f_{sy}\ k_1\ d_b$ | | (mm) | 290 | 348 | 464 | 580 | 696 | 812 | 928 |
| $\frac{(0.5k_1\ k_3\ f_{sy}\ d_b)}{k_2\ \sqrt{f_c'}}$ | $f'_c$ =40<br>$f'_c$ =50 | (mm)<br>(mm) | 275<br>246 | 336<br>301 | 463<br>415 | 600<br>537 | 747<br>668 | 905<br>809 | 1075<br>962 |
| Assumptions in accordance with AS3600 Section 13.1.2 | | | | | | | | | |
| $k_1$ | | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| $k_2$ | | | 1.22 | 1.20 | 1.16 | 1.12 | 1.08 | 1.04 | 1.00 |
| $k_3$ | | | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| c(Clear cover to concrete edge)* | | (mm) | 20 | 24 | 32 | 40 | 48 | 56 | 64 |
| s (Clear spacing b/w bars) | | (mm) | 40 | 48 | 64 | 80 | 96 | 112 | 128 |
| s min. | | | 40 | 48 | 64 | 80 | 96 | 112 | 128 |

* c clear cover shall be the greater of the c value above and the value highlighted in table A (page 5) which is based on drilling process.

## $L_{st}$ Development Length less than yield -AS3600 (for $C_d$=2 x $d_b$) $k_3$=0.85, 40MPa

| | Reinforcing Bar Capacity (kN) | | | | | | |
|---|---|---|---|---|---|---|---|
| $L_{st}$ (mm) | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
| 120 | 16.3 | | | | | | |
| 145 | 19.8 | 23.6 | | | | | |
| 200 | 27.2 | 32.5 | 43.3 | | | | |
| 240 | 32.7 | 39.0 | 52.0 | 62.8 | | | |
| **290** | **39.5** | 47.1 | 62.8 | 75.9 | 87.9 | | |
| **348** | | **56.5** | 75.4 | 91.1 | 105.4 | 118.5 | |
| 390 | | | 84.5 | 102.1 | 118.2 | 132.8 | 145.9 |
| 440 | | | 95.3 | 115.2 | 133.3 | 149.8 | 164.6 |
| **464** | | | **100.5** | 121.5 | 140.6 | 157.9 | 173.6 |
| 520 | | | | 136.2 | 157.6 | 177.0 | 194.5 |
| **600** | | | | **157.0** | 181.8 | 204.2 | 224.4 |
| 650 | | | | | 196.9 | 221.3 | 243.1 |
| 700 | | | | | 212.1 | 238.3 | 261.8 |
| **747** | | | | | **226.0** | 254.3 | 279.4 |
| 800 | | | | | | 272.3 | 299.2 |
| 850 | | | | | | 289.3 | 317.9 |
| **905** | | | | | | **308.0** | 338.5 |
| 950 | | | | | | | 355.4 |
| **1075** | | | | | | | **402.0** |
| **Length to develop yield $L_{sy,t}$ (mm)** | **290** | **348** | **464** | **600** | **747** | **905** | **1075** |

## $L_{st}$ Development Length less than yield - AS3600 (for $C_d$=2 x $d_b$) $k_3$=0.85, 50MPa

| | Reinforcing Bar Capacity (kN) | | | | | | |
|---|---|---|---|---|---|---|---|
| $L_{st}$ (mm) | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
| 120 | 16.3 | | | | | | |
| 145 | 19.8 | 23.6 | | | | | |
| 200 | 27.2 | 32.5 | 43.3 | | | | |
| 240 | 32.7 | 39.0 | 52.0 | 65.0 | | | |
| **290** | **39.5** | 47.1 | 62.8 | 78.6 | 94.3 | | |
| **348** | | **56.5** | 75.4 | 94.3 | 113.1 | 132.0 | |
| 390 | | | 84.5 | 105.6 | 126.8 | 147.9 | 163.1 |
| 440 | | | 95.3 | 119.2 | 143.0 | 166.9 | 184.0 |
| **464** | | | **100.5** | 125.7 | 150.8 | 176.0 | 194.0 |
| 520 | | | | 140.8 | 169.0 | 197.2 | 217.5 |
| **580** | | | | **157.0** | 188.5 | 219.9 | 242.6 |
| 650 | | | | | 211.3 | 246.5 | 271.8 |
| **696** | | | | | **226.0** | 263.9 | 291.1 |
| 747 | | | | | | 283.3 | 312.4 |
| **812** | | | | | | **308.0** | 339.6 |
| 850 | | | | | | | 355.5 |
| 905 | | | | | | | 378.5 |
| **962** | | | | | | | **402.0** |
| **Length to develop yield $L_{sy,t}$ (mm)** | **290** | **348** | **464** | **580** | **696** | **812** | **962** |

## Stress Development in Reinforcement

Development length for post-installed reinforcement in tension in accordance with AS3600 (clause 13.1.2)

| Rebar designation | | | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
|---|---|---|---|---|---|---|---|---|---|
| Diameter of rebar | $d_b$ | (mm) | 10 | 12 | 16 | 20 | 24 | 28 | 32 |
| Drill hole size | $d_0$ | (mm) | 14 | 16 | 20 | 25 | 32 | 35 | 37 |
| Cross Sectional Area of Rebar | $A_S$ | ($mm^2$) | 79 | 113 | 201 | 314 | 452 | 616 | 804 |
| Yield Strength of Rebar (D500N) | | (kN) | 39.5 | 56.5 | 100.5 | 157 | 226 | 308 | 402 |
| 12 x $d_b$ (min.) | | (mm) | 120 | 144 | 192 | 240 | 288 | 336 | 384 |
| $0.058\ f_{sy}\ k_1\ d_b$ | | (mm) | 290 | 348 | 464 | 580 | 696 | 812 | 928 |
| $\frac{(0.5k_1\ k_3\ f_{sy}\ d_b)}{k_2\ \sqrt{f_c'}}$ | $f'_c$ =20<br>$f'_c$ =32 | (mm)<br>(mm) | 321<br>254 | 391<br>309 | 540<br>427 | 699<br>552 | 870<br>687 | 1054<br>833 | 1252<br>990 |
| Assumptions in accordance with AS3600 Section 13.1.2 | | | | | | | | | |
| $k_1$ | | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| $k_2$ | | | 1.22 | 1.20 | 1.16 | 1.12 | 1.08 | 1.04 | 1.00 |
| $k_3$ | | | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| c(Clear cover to concrete edge)* | | (mm) | 30 | 36 | 48 | 60 | 72 | 84 | 96 |
| s (Clear spacing b/w bars) | | (mm) | 60 | 72 | 96 | 120 | 144 | 168 | 192 |
| s min. | | | 40 | 48 | 64 | 80 | 96 | 112 | 128 |

* c clear cover shall be the greater of the c value above and the value highlighted in table A (page 5) which is based on drilling process.

## $L_{st}$ Development Length less than yield - AS3600 (for $C_d \geq 3 \times d_b$) $k_3$=0.7, 20MPa

| | Reinforcing Bar Capacity (kN) | | | | | | |
|---|---|---|---|---|---|---|---|
| $L_{st}$ (mm) | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
| 120 | 14.7 | | | | | | |
| 145 | 17.8 | 21.0 | | | | | |
| 200 | 24.5 | 28.9 | 37.3 | | | | |
| 240 | 29.4 | 34.7 | 44.7 | 54.0 | | | |
| **321** | **39.5** | 46.4 | 59.8 | 72.2 | 83.5 | | |
| 340 | | 49.1 | 63.3 | 76.4 | 88.5 | 99.4 | |
| **391** | | **56.5** | 72.8 | 87.9 | 101.7 | 114.3 | 125.6 |
| 440 | | | 82.0 | 98.9 | 114.5 | 128.6 | 141.3 |
| 500 | | | 93.1 | 112.4 | 130.1 | 146.1 | 160.6 |
| **540** | | | **100.5** | 121.3 | 140.4 | 157.7 | 173.3 |
| 620 | | | | 139.4 | 161.3 | 181.2 | 199.1 |
| 680 | | | | 152.9 | 176.9 | 198.7 | 218.4 |
| **699** | | | | **157.0** | 181.7 | 204.2 | 224.3 |
| 740 | | | | | 192.5 | 216.3 | 237.7 |
| 800 | | | | | 208.1 | 233.8 | 256.9 |
| **870** | | | | | **226.0** | 253.9 | 279.0 |
| 990 | | | | | | 289.3 | 318.0 |
| **1054** | | | | | | **308.0** | 338.4 |
| 1100 | | | | | | | 353.3 |
| 1150 | | | | | | | 369.4 |
| **1252** | | | | | | | **402.0** |
| Length to develop yield $L_{sy,t}$ (mm) | **321** | **391** | **540** | **699** | **870** | **1054** | **1252** |

## $L_{st}$ Development Length less than yield - AS3600 (for $C_d \geq 3 \times d_b$) $k_3$=0.7, 32MPa

| | Reinforcing Bar Capacity (kN) | | | | | | |
|---|---|---|---|---|---|---|---|
| $L_{st}$ (mm) | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
| 120 | 16.3 | | | | | | |
| 150 | 20.3 | 24.4 | | | | | |
| 200 | 27.1 | 32.5 | 43.3 | | | | |
| **290** | **39.5** | 47.1 | 62.8 | 78.6 | | | |
| 300 | | 48.8 | 65.0 | 81.3 | 97.5 | | |
| 320 | | 52.0 | 69.3 | 86.7 | 104.0 | | |
| **348** | | **56.5** | 75.4 | 94.3 | 113.1 | 128.7 | |
| 400 | | | 86.7 | 108.3 | 130.0 | 147.9 | 162.5 |
| **464** | | | **100.5** | 125.7 | 150.8 | 171.5 | 188.5 |
| 500 | | | | 135.4 | 162.5 | 184.8 | 203.1 |
| 540 | | | | 146.3 | 175.5 | 199.6 | 219.4 |
| **580** | | | | **157.0** | 188.5 | 214.4 | 235.6 |
| 620 | | | | | 201.5 | 229.2 | 251.9 |
| **696** | | | | | **226.0** | 257.3 | 282.8 |
| 700 | | | | | | 258.8 | 284.4 |
| 740 | | | | | | 273.6 | 300.6 |
| 800 | | | | | | 295.8 | 325.0 |
| **833** | | | | | | **308.0** | 338.4 |
| **990** | | | | | | | **402.0** |
| Length to develop yield $L_{sy,t}$ (mm) | **290** | **348** | **464** | **580** | **696** | **833** | **990** |


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## Stress Development in Reinforcement

Development length for post-installed reinforcement in tension in accordance with AS3600 (clause 13.1.2)

| Rebar designation | | | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
|---|---|---|---|---|---|---|---|---|---|
| Diameter of rebar | $d_b$ | (mm) | 10 | 12 | 16 | 20 | 24 | 28 | 32 |
| Drill hole size | $d_0$ | (mm) | 14 | 16 | 20 | 25 | 32 | 35 | 37 |
| Cross Sectional Area of Rebar | $A_s$ | ($mm^2$) | 79 | 113 | 201 | 314 | 452 | 616 | 804 |
| Yield Strength of Rebar (D500N) | | (kN) | 39.5 | 56.5 | 100.5 | 157 | 226 | 308 | 402 |
| 12 x $d_b$ (min.) | | (mm) | 120 | 144 | 192 | 240 | 288 | 336 | 384 |
| $0.058\ f_{sy}\ k_1\ d_b$ | | (mm) | 290 | 348 | 464 | 580 | 696 | 812 | 928 |
| $\frac{(0.5k_1\ k_3\ f_{sy}\ d_b)}{k_2\ \sqrt{f_c'}}$ | $f'_c$ =40<br>$f'_c$ =50 | (mm)<br>(mm) | 227<br>203 | 277<br>247 | 382<br>341 | 494<br>442 | 615<br>550 | 745<br>666 | 885<br>792 |
| Assumptions in accordance with AS3600 Section 13.1.2 | | | | | | | | | |
| $k_1$ | | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| $k_2$ | | | 1.22 | 1.20 | 1.16 | 1.12 | 1.08 | 1.04 | 1.00 |
| $k_3$ | | | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| c(Clear cover to concrete edge)* | | (mm) | 30 | 36 | 48 | 60 | 72 | 84 | 96 |
| s (Clear spacing b/w bars) | | (mm) | 60 | 72 | 96 | 120 | 144 | 168 | 192 |
| s min. | | | 40 | 48 | 64 | 80 | 96 | 112 | 128 |

* c clear cover shall be the greater of the c value above and the value highlighted in table A (page 5) which is based on drilling process.

## $L_{st}$ Development Length less than yield - AS3600 (for $C_d \geq 3 \times d_b$) $k_3$=0.7, 40MPa

| | Reinforcing Bar Capacity (kN) | | | | | | |
|---|---|---|---|---|---|---|---|
| $L_{st}$ (mm) | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
| 120 | 16.3 | | | | | | |
| 150 | 20.3 | 24.4 | | | | | |
| 200 | 27.1 | 32.5 | 43.3 | | | | |
| **290** | **39.5** | 47.1 | 62.8 | 78.6 | | | |
| 300 | | 48.8 | 65.0 | 81.3 | 97.5 | 113.8 | |
| 320 | | 52.0 | 69.3 | 86.7 | 104.0 | 121.3 | 138.7 |
| **348** | | **56.5** | 75.4 | 94.3 | 113.1 | 132.0 | 150.8 |
| 400 | | | 86.7 | 108.3 | 130.0 | 151.7 | 173.4 |
| **464** | | | **100.5** | 125.7 | 150.8 | 176.0 | 201.1 |
| 500 | | | | 135.4 | 162.5 | 189.6 | 216.7 |
| 540 | | | | 146.3 | 175.5 | 204.8 | 234.0 |
| **580** | | | | **157.0** | 188.5 | 219.9 | 251.4 |
| 620 | | | | | 201.5 | 235.1 | 268.7 |
| **696** | | | | | **226.0** | 263.9 | 301.6 |
| 700 | | | | | | 265.4 | 303.4 |
| 740 | | | | | | 280.6 | 320.7 |
| **812** | | | | | | **308.0** | 351.9 |
| 833 | | | | | | | 361.0 |
| **928** | | | | | | | **402.0** |
| Length to develop yield $L_{sy,t}$ (mm) | **290** | **348** | **464** | **580** | **696** | **812** | **928** |

## $L_{st}$ Development Length less than yield - AS3600 (for $C_d \geq 3 \times d_b$) $k_3$=0.7, 50MPa

| | Reinforcing Bar Capacity (kN) | | | | | | |
|---|---|---|---|---|---|---|---|
| $L_{st}$ (mm) | N10 | N12 | N16 | N20 | N24 | N28 | N32 |
| 120 | 16.3 | | | | | | |
| 150 | 20.3 | 24.4 | | | | | |
| 200 | 27.1 | 32.5 | 43.3 | | | | |
| **290** | **39.5** | 47.1 | 62.8 | 78.6 | | | |
| 300 | | 48.8 | 65.0 | 81.3 | 97.5 | 113.8 | |
| 320 | | 52.0 | 69.3 | 86.7 | 104.0 | 121.3 | 138.7 |
| **348** | | **56.5** | 75.4 | 94.3 | 113.1 | 132.0 | 150.8 |
| 400 | | | 86.7 | 108.3 | 130.0 | 151.7 | 173.4 |
| **464** | | | **100.5** | 125.7 | 150.8 | 176.0 | 201.1 |
| 500 | | | | 135.4 | 162.5 | 189.6 | 216.7 |
| 540 | | | | 146.3 | 175.5 | 204.8 | 234.0 |
| **580** | | | | **157.0** | 188.5 | 219.9 | 251.4 |
| 620 | | | | | 201.5 | 235.1 | 268.7 |
| **696** | | | | | **226.0** | 263.9 | 301.6 |
| 700 | | | | | | 265.4 | 303.4 |
| 740 | | | | | | 280.6 | 320.7 |
| **812** | | | | | | **308.0** | 351.9 |
| 833 | | | | | | | 361.0 |
| **928** | | | | | | | **402.0** |
| Length to develop yield $L_{sy,t}$ (mm) | **290** | **348** | **464** | **580** | **696** | **812** | **928** |

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