Construction Systems

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Product Engineering Laboratory

Reid™ Product Engineering Laboratory
All testing has been performed by independent IANZ accredited testing laboratories. See below for details.

Reinforcement Technical Assessment RTA-22/0013 of 13/05/2022

This Technical Assessment meets the testing requirements stipulated in clauses 8.7.5.2 (b), 8.9.1.3 (a), (b), 8.6.11.1,2,3 & 4 of NZS 3101:2006 A3

Trade name of the construction product	ReidBar™ Steel Components: Flange Nuts & iPort Flange Anchors
Product family to which the construction product belongs	ReidBar™ Reinforcement System used in concrete structures sizes RB12, RBA16, RB20, RB25 & RB32
Manufacturer	Reid Construction Systems 1 Ramset Drive Chirnside Park Victoria 3116 Australia
Manufacturing plant	Reid Construction Systems
This Technical Assessment contains:	19 pages & 14 Annexes which form an integral part of this assessment.
This Technical Assessment is in accordance with the requirements stipulated in NZS 3101:2006 A3 & NZTA Bridge Manual 3rd Edition A3	Tests performed by Holmes Solutions Reference reports: - 139628.00 RP 022 Tests performed by WSP Opus Research Reference reports: - 5-24E97.00/A2-02 - 5-24E97.00/C1-01 - 5-24E97.00 Phase E - 15-524D57.00 Tests performed by X-Ray Laboratories Ltd Reference reports: - 9606B1

1. Technical description of the product

ReidBar™ Steel Flange Nuts and ReidBar™ Steel iPort Flange Anchors are part of the ReidBar™ System and are used as Mechanical Anchorage.

ReidBar™ reinforcing steel is Grade 500E (Seismic) produced in accordance with AS/NZS 4671:2019.

The illustration and the description of the product are given in Annex A1 and A2.

2. Specification of intended use

The performances given in Section 3 are only valid if the anchor Reinforcement System is used in compliance with the specifications and conditions given in Annex B1. Furthermore, installation guidelines are provided in Annex B2, B3 and B4.

3. Performance of the product and references to the methods used for its assessment

3.1 Performance Requirement of Mechanical Anchors

Criteria	**Performance**
Elongation at $0.7f_y$ NZS 3101:2006 A3: Cl 8.7.5.2 (b) NZTA Bridge Manual 3rd ed. A3: Cl 4.2.1 (f) (i)	See Annex C1
High Cycle fatigue NZS 3101:2006 A3: Cl 8.7.5.2 (c), 8.9.1.3 (b)	See Annex C2
High Cycle fatigue NZTA Bridge Manual 3rd ed. A3: Cl 4.2.1 (f) (i)	See Annex C3
Alternating Large Strains NZS 3101:2006 A3: Cl 8.9.1.3 (a) &	See Annex C4
Alternating Large Strains NZTA Bridge Manual 3rd ed. A3: Cl 4.2.1 (f) (i)	See Annex C5
Ultimate Tensile Strength NZS 3101:2006 A3: Cl 8.6.11.1 & 8.6.11.2 NZTA Bridge Manual 3rd ed. A3: Cl 4.2.1 (f) (i)	See Annex C6
Mode of Failure NZS 3101:2006 A3: Cl 8.6.11.1, 8.6.11.2, 8.6.11.3 NZTA Bridge Manual 3rd ed. A3: Cl 4.2.1 (f) (i)	See Annex C7
Resistance to Brittle Fracture NZS 3101:2006 A3: Cl 8.6.11.4 NZTA Bridge Manual 3rd ed. A3: Cl 4.2.1 (f) (iii)	See Annex C8

3.2 Testing Methodology of Mechanical Anchors

The purpose of the test programme developed with Holmes Solutions was twofold:

1. To validate the use of the new Steel iPort Flange Anchor design, which includes an injection port for epoxy application.

2. To demonstrate that both the current ReidBar Steel Flange Nuts and the new version with the injection port (nominated ReidBar Steel iPort Flange

Anchor), can meet the performance requirements for mechanical anchors, as defined by various clauses of the New Zealand Standard 3101:2006 – Concrete Structures (Amendment 3) and the NZTA Bridge Manual SP/M/022 3rd Edition (Amendment 3).

3.2.1 Elongation at $0.7f_y$ - Cl 8.7.5.2 (b) NZS 3101:2006 A3 & Cl 4.2.1 (f) (i) NZTA BM 3rd Edition A3 [WSP-Opus]

The bars and connectors were loaded into the test machine and loaded in tension up to 0.7 times the nominal yield load at a rate of 300 kN/min. Once at $0.7f_y$, the bars were held at $0.7f_y$, for 20 seconds before being returned to zero load. The displacement was measured using dual gauges over a fixed gauge length throughout the test with the displacement and load recorded at a rate of approximately 100 Hz.

The gauge length of the steel couplers is defined by ISO 15835-2:2009 *Steels for the reinforcement of concrete – Test methods*. Unlike couplers, anchors like the Steel Flange Nuts are joined to only one bar. Therefore, it has been considered the gauge length (L_g) for the Steel Flange Nuts should be equal to the length of the fitting plus four times the bar diameter.

In order to determine the maximum elongation allowable, as per clause 8.7.5.2 (b) of NZS 3101, two samples of non-spliced ReidBar of the same size and from the same batches have been tested for reference. A tensile load, corresponding to a stress level of 350MPa ($0.7f_y$), has been applied on the reference bars and the corresponding strain measured. The average value (ε_{350}), between the two measurements, times two and times the length of the coupler, is used to determine the maximum allowable elongation over the coupler length.

ε_{350} is also used to determine the elongation over the coupler length, from the measured elongation over the gauge length, by discounting the elastic elongation of the bars outside the coupler.

3.2.2 Elongation at $0.7f_y$ - Cl 8.7.5.2 (b) NZS 3101:2006 A3 & Cl 4.2.1 (f) (i) NZTA BM 3rd Edition A3 [Holmes Solutions]

The test apparatus employed was HTM1. This multipurpose test machine has an axial static force capacity in excess of 1 MN in both compression and tension directions, and is equipped with hydraulic wedge locking jaws for mounting test specimens or fixtures

Applied force was measured using a single load cell located at the tail-stock of HTM1, specifically a PT Ltd LPCH-100 load cell with a measurement capacity of ± 1.5 MN.

The HTM1 is calibrated annually in strict accordance with the requirements of our ISO 17025 accreditation, and is deemed to be a Class-1 calibrated test machine capable of applying a given load with an accuracy of ± 1 %

A video non-contact extensometer (VNCX), an optical based strain measurement system, was used for measuring the elongation of test specimens in HTM1 without the need of physical connection to the specimen. The VNCX system uses one or more cameras to track painted markers on the test specimen, and after internal data processing it provides elongation and strain measurements as outputted values.

The VNCX system is calibrated to the required field of view prior to each testing programme in accordance with the requirements of our ISO 17025:2017 accreditation, with routine assessments completed on the calibration accuracy in accordance with our quality procedures. The camera system is deemed to be capable to provide an accuracy of ±1 % of the reading, which is equivalent with a Class 1 accuracy in accordance with the requirements outlined in ISO 9513:2013.

Motion control and data acquisition of HTM1 was achieved using a Delta Computer Systems RMC150E motion controller and associated signal input and conditioning hardware. Data was sampled at a rate of 50 Hz.

Uniaxial tensile load was applied to the specimen with a pseudo static displacement loading rate of 3 mm/min up to $0.7f_y$, where f_y is the lower characteristic yield strength in accordance with NZS 3101:1-2006 clause 8.1. f_y is equivalent to 500 MPa for Grade 500E reinforcing steel in accordance with AS/NZS4671:2019.

To calculate the maximum allowable elongation, for the coupler length L_c, the cumulative length of the structural component (ReidBar iPort Flange Anchor or Flange Nut) and of the locking nut (ReidBar Half Nut) is multiplied times 2 the theoretical elastic strain at 350MPa.

The elongation over L_c is determined from the elongation measured over the gauge length L_g, by discounting the elastic elongation of the bar outside L_c.

3.2.3 High Cycle fatigue – Cl 8.9.1.3 (b) NZS 3101:2006 A3 [WSP-Opus]

ISO 15835-2:2009 §5.5 requires the test piece be subjected to an axial tensile force, which varies cyclically according to a sinusoidal wave-form of constant frequency in the elastic range.

Test and performance requirements:
• The mechanical splices shall sustain a fatigue loading of at least 2 megacycles.
• The frequency shall be between 1Hz and 200Hz.
• The stress range shall be 60MPa.
• The upper stress shall be 0.6 of the specified characteristic (or nominal) yield strength value of the reinforcing bar, $R_{eH,spec}$.

The test pieces shall comply with the performance requirements of ISO 15835-1 §5.4 without any failure.

The test was carried out under force control and the frequency of the load cycles was set at 20 Hz for all the samples.

3.2.4 High Cycle fatigue – Cl 4.2.1 (f) (i) NZTA BM 3rd Edition A3 [Holmes Solutions]

Mechanical anchors are required by NZS 3101 Cl. 8.9.1.3(b) to satisfy the requirements of Cl 5.4 of ISO 15835-1:2009. Testing must comply with Cl 5.5 of ISO 15835-2:2009.

Cl 5.4 of ISO 15835-1:2009 requires that mechanical splices shall sustain a fatigue loading of at least 2 megacycles with a stress range, $2\sigma_a$, of 60MPa without failure. The upper stress, σ_{max}, in the test shall be $0.6R_{eH, spec}$.

The test procedure is as per Cl 5.8 of ISO 15698.2:2012 with the required stress range referenced from ISO 15835.1:2009 for Category F.

The test method specified in ISO 15835.2:2009 Cl. 5.5 requires that the frequency of load cycles shall be between 1Hz and 200Hz.

A Shimadzu RH-50 servo-hydraulic controlled universal test machine (UTM2) was used to perform high-cycle fatigue testing. The UTM2 has a load capacity of 500kN, a maximum stroke of circa 300mm, and a peak table velocity of 1000mm/min. Machine control and data acquisition is handled using an incorporated Delta Computer Systems RMC motion controller and a proportional control valve.

The UTM2 is calibrated annually in strict accordance with the requirements of our ISO 17025 accreditation, and is deemed to be a Class-1 calibrated test machine capable of applying a given load with an accuracy of ±1 %.

3.2.5 Alternating tension and compression test of large strains – Cl 8.9.1.3 (a) NZS 3101:2006 A3 [WSP-Opus]

For testing the performance of mechanical splices, ISO 15835-2:2009 §5.6.2 specifies the following loading programme:

• From zero strain up to twice the yield strain (strain at nominal yield strength) in tension followed by downloading to a strain corresponding to half of the stress of the nominal yield strength value of the reinforcing bar ($0.5R_{eH,spec}$) in compression, alternating four times.

• Thereafter, from zero strain up to five times the yield strain in tension, followed by downloading to a strain corresponding to the stress $0.5R_{eH,spec}$ in compression, alternating four times, followed by tensioning the test piece to failure.

Performance requirements are:

• Tensile strength: at least $R_{m,spec}$, or $R_{eH,spec}$ x $(R_m/R_{eH})_{spec}$

• Residual elongation: u4 ≤ 0.3 mm, u8 ≤ 0.6 mm

Where $R_{m,spec}$ is the nominal tensile strength value of the reinforcing bar, $R_{eH,spec}$ is the nominal yield strength value of the reinforcing bar, and $(R_m/R_{eH})_{spec}$ is the specified tensile/yield strength ratio of the reinforcing bar.

The strain/stress rates were set according to ISO 6892-1:2009 Metallic materials – Tensile testing – Part1: Method of test at ambient temperature.

For couplers, in accordance with ISO 15835-2:2009, the gauge length (L_c) should be equal to the coupler length plus eight times the diameter.

ISO 15835-2:2009 describes test methods applicable to couplers for mechanical splices of two steel reinforcing bars. The Flange Nuts are joined to only one bar. Therefore, we have considered the gauge length (L_c) should be equal to the Flange Nut length plus four times the diameter.

3.2.6 *Alternating tension and compression test of large strains – Cl 4.2.1 (f) (i) - NZTA Bridge Manual 3rd Edition A3 [Holmes Solutions]*

The performance evaluation of anchorage capacity under low-cycle elastic-plastic loading in accordance with ISO 15698:2012 is specified in NZTA SP/M/022 V3.0 A3 cl. 4.2.1(f)(i). The test method specifies subjecting cast-in concrete specimens to the loading programme below:

- Stage 1: Twenty load cycles between 0.05 $R_{eH,spec}$ and 0.95 $R_{eH,spec}$
- Stage 2: Four load cycles between 0.05 $R_{eH,spec}$ and $2\varepsilon_{y,act}$
- Stage 3: Four load cycles between 0.05 $R_{eH,spec}$ and $5_{\varepsilon y,act}$
- Stage 4: Loading to failure.

where, for stages 2 and 3:

$R_{eH,spec}$ = specified characteristic yield strength.

$\varepsilon_{y,act}$ = actual yield strain of the reinforcing bar from control samples.

Control bars from each batch of ReidBar™ were tested in accordance with ISO 15630-1:2010. The yield strain was used to calculate the loading target for the Category S testing in stages 2 and 3.

The following requirements apply under Category S testing:

- The specimen must sustain the loading protocol from stage 1 to stage 3 without failure.
- Significant loss of stiffness, such as in concrete crushing, is deemed as failure.

A digital linear transducer was attached onto the head of the bar end, and a mechanical extensometer was attached to the protruding length of bar at a distance of at least 100 mm from where the bar exits the concrete prism. The following data channels were sampled, and logged continuously, using the Delta Computer Systems RMC150E motion controller at a rate 50 Hz:

▪ Applied force.

▪ Strain in the reinforcing bar.

▪ Displacement of the bar head relative to the free end of the concrete prism.

The loading sequence was controlled as described below:

▪ Stage 1: A tensile load was applied under force control at a rate of 20 MPa/s for cyclic loading between 0.05 $R_{eH,spec}$ and 0.95 $R_{eH,spec}$ for a total of 20 cycles.

▪ Stage 2: The specimen was loaded under strain control to twice the target yield strain at a maximum rate of 0.055 s^{-1} (this value is based on an equivalent stress rate of 20 MPa/s with an elastic modulus, E of 200 GPa), followed by loading under force control down to 0.05 $R_{eH,spec}$. The cyclic loading was repeated four times.

▪ Stage 3: The specimen was loaded up to five times of the average yield strain under strain control with maximum speed of 0.055 s^{-1}, followed by loading under force control down to 0.05 $R_{eH,spec}$. The cyclic loading was repeated four times.

▪ Stage 4: The specimen was loaded to failure under displacement control at a rate of 20 mm/s, at which point the mode of failure was observed.

3.2.7 Ultimate Tensile Strength – Cl 8.6.11.1 & 8.6.11.2 NZS 3101:2006 A3 [Holmes Solutions]

Mechanical anchors are required by NZS 3101 cl. 8.6.11.1 to be capable of developing the upper bound breaking strength of the reinforcing bar without damage to the concrete or overall deformation of the anchorage. No test method is specified in this clause.

The test method specified in ISO 15698.2:2012 Cl. 5.7 has been adopted which specifies monotonic loading at a rate of 10MPa/s. Specimens may be pre-loaded up to $0{,}9 \cdot R_{eH,spec}$ and released a number of times, in order to stabilize the head-to-concrete interaction before the specimen is exposed to static loading and head displacement is determined.

A digital linear transducer was attached onto the head of the bar end, and a mechanical extensometer was attached to the protruding length of bar at a distance of at least 100 mm from where the bar exits the concrete prism. The following data channels were sampled, and logged continuously, using the Delta Computer Systems RMC150E motion controller at a rate 50 Hz:

▪ Applied force

▪ Strain in the reinforcing bar

▪ Displacement of the bar head relative to the free end of the concrete prism

The loading sequence was controlled as described below:

▪ Stage 1: A tensile load was applied under force control at a rate of 20MPa/s for cyclic loading between 0.05 $R_{eH,spec}$ and 0.9 $R_{eH,spec}$ for a total of 10 cycles.

▪ Stage 2: The specimen was loaded under strain control to failure a maximum rate of 0.055 s^{-1} (this value is based on an equivalent stress rate of 20MPa/s with an elastic modulus, E of 200 GPa).

3.2.8 Mode of Failure – Cl 8.6.11.1 & 8.6.11.3 NZS 3101:2006 A3 [Holmes Solutions]

For mechanical anchors, NZS 3101 requires that the mode of failure for anchored bars is ductile yielding of the bar developing its ultimate tensile strength away from the mechanical anchorage and without thread stripping or significant distortion.

The wedge tensile testing, required by NZS 15698 to validate the robustness of the head-to-bar connection, serves this purpose very well, with a healthy degree of conservativism.

The specimens were tested against the requirements for Category B3 headed bars given in ISO 15698-1:2012 clauses 7.3.2 and ISO 15698-2:2012 clauses 6.2.

Specifically, the head shall be capable of anchoring the actual tensile strength of the reinforcing material that is being tested, by fulfilling at least one of the following.

▪ The failure occurs outside of the affected zone.

▪ The minimum specified elongation required for the bar is achieved.

▪ At least 0.95 $R_{m,act}$ is achieved by comparison with the actual tensile strength of non-headed specimens from the same batch.

Further, for threaded heads of Category B3, according to clause 7.2.3 the wedge tensile test is required to be executed on reinforcing bars with yield strength within both the upper and lower yield strength range for which the heads are intended. The wedge tensile test was performed at a wedge angle of 4°. A tensile load was applied monotonically at a loading rate of 20 mm/min until tensile failure of the bar occurred, at which point the mode of failure was observed.

3.2.9 Resistance to Brittle Fracture – Cl 8.6.11.4 NZS 3101:2006 A3 & Cl 4.2.1 (f) (iii) NZTA Bridge Manual 3rd Edition A3

As per Clause 8.6.11.4 of NZS 3101 A3, mechanical couplers and anchorages shall be proven, by an appropriate test method, to possess resistance to brittle fracture at the service temperatures at which they are intended for use. However, there is no indication on what an appropriate test method would be.

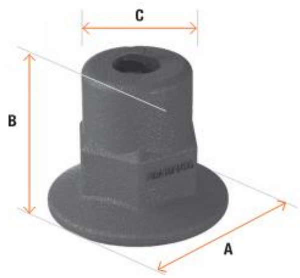
The NZTA Bridge Manual, at Clause 4.2.1 (f) (iii), provides more guidance on how to demonstrate resistance to brittle fracture through testing.

In accordance with AS 1544.2, a Charpy V-notched impact resistance equal to or greater than 27 Jules shall be achieved when standard 10mmx10mm test pieces are tested at 0°C.

4 Material Safety Data Sheet

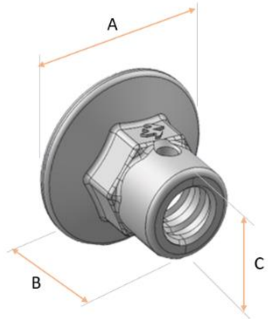
Refer to SDS ChemAlert SDS Date: 10 Apr 2018 Version No:1 (EPCON C8) for Safety Data Sheet according to New Zealand HSNO requirements.

ReidBar™ Steel Flange Nuts
RB12FNS, RBA16FNS, RB20FNS, RB25FNS, RB32FNS



Part No.	Description	Foot diameter (A) (mm)	Length (B) (mm)	Body Diameter (C) (mm)
RB12FNS	12mm ReidBar Steel Flange Nut	39	50	22
RBA16FNS	16mm ReidBar Steel Flange Nut	58	50	35
RB20FNS	20mm ReidBar Steel Flange Nut	67	50	35
RB25FNS	25mm ReidBar Steel Flange Nut	83	80	42
RB32FNS	32mm ReidBar Steel Flange Nut	92	95	55

NOTE: Hot dip galvanised finish also applicable



ReidBar™ Steel iPort Flange Anchor
RB12FAIPS, RBA16FAIPS, RB20FAIPS, RB25FAIPS, RB32FAIPS

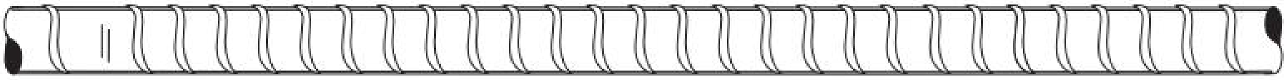
Part No.	Description.	Foot Diameter (A) (mm)	Length (B) (mm)	Body Diameter (C) (mm)
RB12FAIPS	REIDBAR 12MM FLANGE ANCHOR IPORT STEEL	39	50	22
RBA16FAIPS	REIDBAR 16MM FLANGE ANCHOR IPORT STEEL	58	50	35
RB20FAIPS	REIDBAR 20MM FLANGE ANCHOR IPORT STEEL	67	50	35
RB25FAIPS	REIDBAR 25MM FLANGE ANCHOR IPORT STEEL	83	80	42
RB32FAIPS	REIDBAR 32MM FLANGE ANCHOR IPORT STEEL	92	95	55

NOTE: Hot dip galvanised finish also applicable

ReidBar™ Steel Flange Nuts & iPort Flange Anchors	**Annex A1**
Product description Mechanical anchorages	

ReidBar™ Reinforcing bar RB12, RBA16, RB20, RB25, RB32

Seismic® 500E Micro Alloyed Reidbar™



Commercial reinforcing (E Class - Seismic) bar to AS/NZS 4671:2019

Product Characteristics	Value
Lower Characteristic yield strength $R_{ek.L}$ (MPa)	≥ 500
Upper Characteristic yield strength $R_{ek.U}$ (MPa)	≤ 600
Characteristic Minimum Ultimate to Yield ratio – R_m/R_e	≥ 1.15
Characteristic Maximum Ultimate to Yield ratio - R_m/R_e	≤ 1.40

ReidBar™ Reinforcing Steel

Product description
Reinforcing Bars

Annex A2

Specifications of intended use

Anchorages subject to:

- Seismic, Static and quasi-static load.

Base materials

- Non-cracked and cracked concrete for reinforcing bars RB12 to RB32.
- Reinforced or unreinforced normal weight concrete for use in construction in accordance with NZS 3101:2006 A3 and NZTA Bridge Manual 3rd Edition A3.

Design:

- The Mechanical anchorages are designed in accordance with the Standards New Zealand NZS 3101:2006 A3 – Concrete Structures Standard" and the NZTA Bridge Manual 3rd Edition A3 under the responsibility of an engineer experienced in structural design and concrete work.
- Verifiable calculation notes and drawings are prepared taking into account the loads to be anchored. The position of the anchor is indicated on the design drawings.

Installation:

- Reinforcement installation carried out in accordance with ReidBar connection installation procedures (including the application of EPCON C8 thread filler in the ReidBar fitment) by appropriately qualified personnel and under the supervision of the person responsible for technical matters of the site.

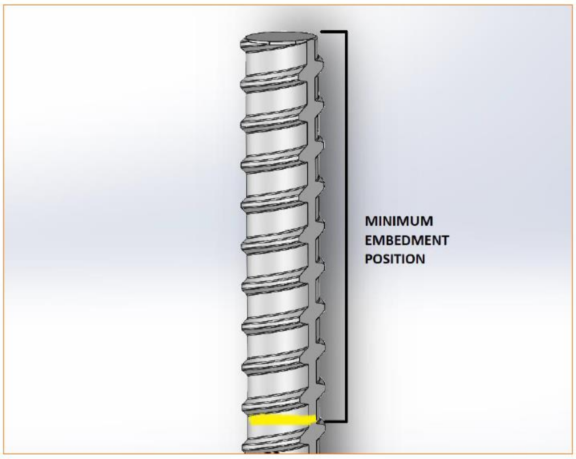
ReidBar™ Components	**Annex B1**
Intended use Specifications	

ReidBar Steel iPort Flange Anchor Installation Guidelines

Step 1

Follow product dimensions Column B (Length) and mark the **minimum** screwing position on the ReidBar. This ensures that there is full embedment in the Flange Nut when installed.

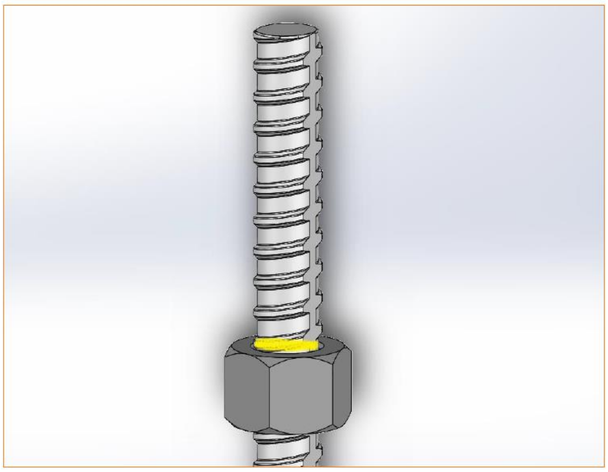
Foot diameter (A) (mm)	Length (B) (mm)	Body Diameter (C) (mm)
39	50	22
58	50	35
67	50	35
83	80	42
92	95	55
58	50	35
67	50	35
83	80	42
92	95	55



Step 2

Screw the ReidBar Half Nut onto the bar and pass the marking.

For Step 3 it is critical that the Half Nut remains beyond the marking.



ReidBar™ Steel iPort Flange Anchor	Annex B2
Intended use Installation procedure	

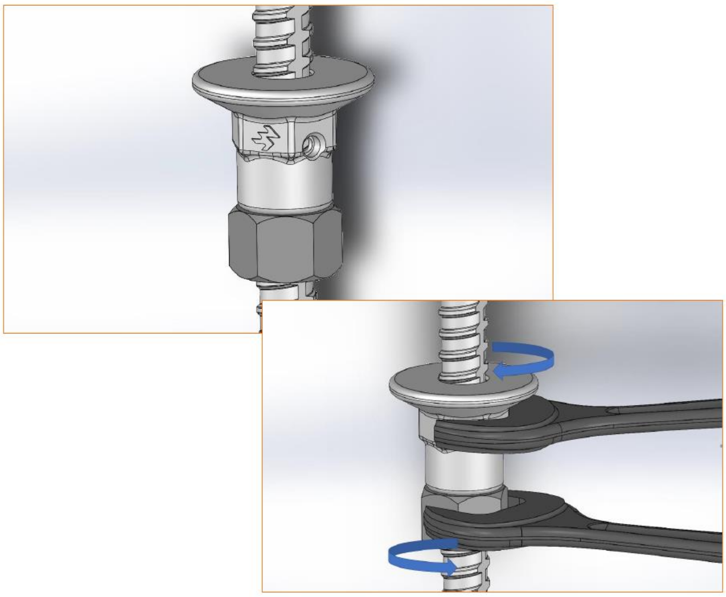
Installation instructions (cont'd)

Step 3

Screw the ReidBar Steel Flange Nut onto the bar and ensure that the Injection Port is oriented towards an accessible position for the injection nozzle of Ramset Epcon C8.

It is acceptable for the Flange Nut to be screwed beyond the marking, further down on the bar.

Use spanners to lock the two components snug tight and in position.



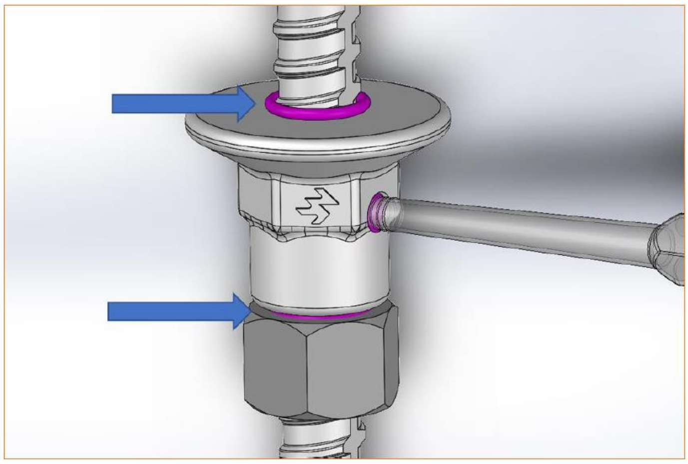
Step 4

For Ramset Epcon C8:

- Ensure the appropriate PPE is worn when working with Ramset Epcon C8 XTREM.
- Check use by Date on the cartridge
- Unscrew the cartridge cap and screw on the ISNE Mixing Nozzle
- Install into E108 Dispensing Tool
- Run out a bead of C8 onto a scrap board/card until the color is uniformly grey

Insert the nozzle into the Injection port (snug fit) and pump Epcon C8 until it comes out from both ends (top & bottom) of the Flange nut. Epcon C8 shown in pink in following image.

Allow for curing time, as per Ramset Epcon C8 instructions.



ReidBar™ Steel iPort Flange Anchor	**Annex B3**
Intended use Installation procedure	

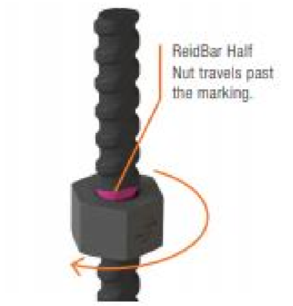
Steps

ReidBar Steel Flange Nut Installation Guidelines

1

Mark the location on the bar where the Flange Nut needs to stop.

2



Screw on ReidBar Half Nut. Note that this is a sacrificial component to assist with the filler delivery, to ensure consistent and thorough void-filling.

3

Inject the recommended number of pumps of Epcon C8 into the Flange Nut. Direct the nozzle of the filler towards the threads inside the fitting, and draw the nozzle out from the component in a rotating motion as the filler is being injected.

4

5

6

Screw the Flange Nut onto the ReidBar. Once the Flange Nut reaches the Half Nut, use spanner to tighten the two components together.

Wipe excess filler with cloth/fabric/carton.

Ensure the appropriate PPE is worn when working with Ramset Epcon C8 XTREM.
Refer to www.ramset.co.nz for Epcon C8 XTREM MSDS Sheet.

ReidBar™ Steel Flange Nut	**Annex B4**
Intended use Installation procedure	

Table C1: Elongation at 0.7fy: Cl 8.7.5.2 (b) NZS 3101:2006 A3
Cl 4.2.1 (f) (i) - NZTA Bridge Manual 3rd Edition A3

Sample	Part No.	Lg Gauge length [mm]	Lc* Coupler length [mm]	No. (of Sampl. Tested)	ε_{350} Non-spliced ReidBar strain at $0.7f_y$ (measure from reference bar test)	$0.7\ f_y$	Criteria assessed over Lc (coupler length)		Test report reference(s)
							Aver. displ. (over coupl. Length)	Allw. max. displ. (over coupl. length)	
					[mm/m]	[kN]	[mm]	[mm]	
ReidBar Steel Flange Nuts									
12mm Steel Flange Nuts	RB12FNS	98	50	5	2.12	39.55	0.08	0.21	WSP-Opus 5-24E97.00/C1-01
16mm Steel Flange Nuts	RBA16FNSG	115.5	51.5	5	2.07	70.35	0.16	0.21	WSP-Opus 5-24E97.00/A2-02
20mm Steel Flange Nuts	RB20FNSG	131.5	52	5	1.72	109.9	0.11	0.18	WSP 5-24E97.00PhaseE
25mm Steel Flange Nuts	RB25FNSG	181	81	5	1.77	171.85	0.21	0.29	WSP-Opus 5-24E97.00/A2-02
32mm Steel Flange Nuts	RB32FNSG	225	97	5	2.04	281.4	0.30	0.40	WSP-Opus 5-24E97.00/A2-02

* Lc = length of Flange Nut (samples held by the flange)

Sample	Part No.	Lc* Coupler length [mm]	No. (of Sampl. Tested)	ε_{350} non-spliced ReidBar strain at $0.7f_y$ (theoret.)	$0.7\ f_y$	Criteria assessed over Lc (coupler length)			Test report reference(s)
						Min Msrd displ.	Max Msrd displ.	Allw. max. displ.	
				[mm/m]	[kN]	[mm]	[mm]	[mm]	
ReidBar Steel iPort Flange Anchors									
12mm Steel iPort Flange Anchor	RB12FAIPS	67	3	1.75	39.55	0.07	0.09	0.23	Holmes Solutions 139628.00 RP 022
16mm Steel iPort Flange Anchor	RBA16FAIPSG	69	3	1.75	70.35	0.01	0.07	0.24	Holmes Solutions 139628.00 RP 022
20mm Steel iPort Flange Anchor	RB20FAIPSG	72	3	1.75	109.9	0.05	0.11	0.25	Holmes Solutions 139628.00 RP 022
25mm Steel iPort Flange Anchor	RB25FAIPSG	80	3	1.75	171.85	0.06	0.11	0.39	Holmes Solutions 139628.00 RP 022
32mm Steel iPort Flange Anchor	RB32FAIPSG	133	3	1.75	281.4	0.16	0.26	0.47	Holmes Solutions 139628.00 RP 022

* Lc = length of Flange Anchor + length of Half Nut (samples held by the Half Nut)

Table C2: High Cycle Fatigue: Cl 8.7.5.2 (c) & 8.9.1.3 (b) - NZS 3101:2006 A3

Sample	Part No.	No. (of Samples Tested)	In accordance with ISO 15835-1 & ISO 15835-2						Test report reference(s)
			Freq.	No. of cycles	Nomin. Yield Str. f_y	Cycle upper stress	Cycle lower stress	Result	
			[Hz]	`	[kN]	[kN]	[kN]		
ReidBar Steel Flange Nuts									
16mm Steel Flange Nut	RBA16FNSG	3	20	2,000,000	100.5	60.3	48.3	Pass	WSP-Opus 15-524D57.00
25mm Steel Flange Nut	RB25FNSG	3	20	2,000,000	245.4	147.3	117.8	Pass	WSP-Opus 15-524D57.00
32mm Steel Flange Nut	RB32FNSG	3	20	2,000,000	402.1	241.3	193.0	Pass	WSP-Opus 15-524D57.00

Table C3: High Cycle Fatigue: Cl 4.2.1 (f) (i) - NZTA Bridge Manual 3rd Edition A3 (mechanical anchors)

Sample	Par t No.	No. (of Samples Tested)	In accordance with ISO 15698-1 (Category F2) & ISO 15835-1 (Category F load cycles & stress range)						Test report reference(s)
			Freq.	No. of cycles	Nomin. Yield Str. f_y	Cycle upper stress	Cycle lower stress	Result	
			[Hz]	`	[kN]	[kN]	[kN]		
ReidBar Steel iPort Flange Anchors									
12mm Steel iPort Flange Anchor	RB12FAIPS	3	13	2,000,000	56.5	33.9	27.1	Pass	Holmes Solutions 139628.00 RP 022
20mm Steel iPort Flange Anchor	RB20FAIPSG	3	12	2,000,000	157.1	94.2	75.4	Pass	Holmes Solutions 139628.00 RP 022
25mm Steel iPort Flange Anchor	RB25FAIPSG	3	12	2,000,000	245.4	147.3	117.8	Pass	Holmes Solutions 139628.00 RP 022
32mm Steel iPort Flange Anchor	RB32FAIPSG	3	12	2,000,000	402.1	241.3	193.0	Pass	Holmes Solutions 139628.00 RP 022
ReidBar Steel Flange Nuts									
20mm Steel Flange Nut	RB20FNSG	3	12	2,000,000	157.1	33.9	75.4	Pass	Holmes Solutions 139628.00 RP 022

Note: In accordance with ISO 15698 Cl 5.5 Table 2, the samples tested cover the geometry in the entire ReidBar range RB12 to RB32.

Table C4: Large Strains: Cl 8.9.1.3 (a) - NZS 3101:2006 A3

Sample	Part No.	No. (of Samples Tested)	Criteria assessed: ISO $u_4 \leq 0.3mm$ [mm]		ISO $u_8 \leq 0.6mm$ [mm]		UTS ≥575MPa [MPa]		Test report reference(s)
			$u_{4(min)}$	$u_{4(max)}$	$u_{8(min)}$	$u_{8(max)}$	$UTS_{(min)}$	$UTS_{(max)}$	
ReidBar Steel Flange Nuts									
12mm Steel Flange Nuts	RB12FNS	3	0.03	0.07	0.06	0.08	622.3	624.2	WSP-Opus 5-24E97.00/C1-01
16mm Steel Flange Nuts	RBA16FNSG	3	0.04	0.14	0.07	0.18	654	680	WSP-Opus 15-524D57.00
20mm Steel Flange Nuts	RB20FNSG	3	0.05	0.11	0.16	0.17	661.7	662.7	WSP 5-24E97.00 Phase E
25mm Steel Flange Nuts	RB25FNSG	3	0.13	0.30	0.18	0.37	675	677	WSP-Opus 15-524D57.00
32mm Steel Flange Nuts	RB32FNSG	3	0.16	0.25	0.24	0.36	681.1	682.5	WSP 5-24E97.00 Phase E

Table C5: Large Strains: Cl 4.2.1 (f) (i) - NZTA Bridge Manual 3rd Edition A3 (mechanical anchors)

Sample	Part No.	No. (of Samples Tested)	$\varepsilon_{y,act}$ [mm/m]	In accordance with ISO 15698.1:2012 cl.7.2.4 (Category S): 20x load cycles between $0.05R_{eH,spec}$ & $0.95R_{eH,spec}$	4x load cycles between $0.05R_{eH,spec}$ & $2\varepsilon_{y,act}$	4x load cycles between $0.05R_{eH,spec}$ & $5\varepsilon_{y,act}$	Failure mode	Test report referenc e(s)
ReidBar Steel iPort Flange Anchors								
12mm Steel iPort Flange Anchor	RB12FAIPS	3	2.4	Pass	Pass	Pass	Ductile failure outside affected zone	Holmes Solutions 139628.00 RP 022
20mm Steel iPort Flange Anchor	RB20FAIPSG	3	3.2	Pass	Pass	Pass	Ductile failure outside affected zone	Holmes Solutions 139628.00 RP 022
25mm Steel iPort Flange Anchor	RB25FAIPSG	3	3.1	Pass	Pass	Pass	Ductile failure outside affected zone	Holmes Solutions 139628.00 RP 022
32mm Steel iPort Flange Anchor	RB32FAIPSG	3	2.1	Pass	Pass	Pass	Ductile failure outside affected zone	Holmes Solutions 139628.00 RP 022
ReidBar Steel Flange Nuts								
20mm Steel Flange Nuts	RB20FNSG	3	3.2	Pass	Pass	Pass	Ductile failure outside affected zone	Holmes Solutions 139628.00 RP 022

Note: In accordance with ISO 15698 Cl 5.5 Table 2, the samples tested cover the geometry in the entire ReidBar range RB12 to RB32.

Table C6: Ultimate Tensile Strength – Cl 8.6.11.1 & 8.6.11.2 NZS 3101:2006 A3
Cl 4.2.1 (f) (i) - NZTA Bridge Manual 3rd Edition A3

Sample	Part No.	No. (of Samples Tested)	Criteria assessed			Test report reference(s)
			UTS ≥750MPa [MPa]		Mode of Failure	
			$UTS_{(min)}$	$UTS_{(max)}$		
ReidBar Steel iPort Flange Anchors						
12mm Steel iPort Flange Anchor	RB12FAIPS	3	737*	873	3 heat-treated ReidBar break without incipient crushing of the concrete as defined in ISO 15698.1:2012 For one sample, the heat-treated bar failed 1.7% shy of the target load	Holmes Solutions 139628.00 RP 022
20mm Steel iPort Flange Anchor	RB20FAIPSG	3	1053	1195	3 heat-treated ReidBar break without incipient crushing of the concrete as defined in ISO 15698.1:2012	Holmes Solutions 139628.00 RP 022
25mm Steel iPort Flange Anchor	RB25FAIPSG	3	926	931	3 heat-treated ReidBar break without incipient crushing of the concrete as defined in ISO 15698.1:2012	Holmes Solutions 139628.00 RP 022
32mm Steel iPort Flange Anchor	RB32FAIPSG	3	792	873	3 heat-treated ReidBar break without incipient crushing of the concrete as defined in ISO 15698.1:2012	Holmes Solutions 139628.00 RP 022
ReidBar Steel Flange Nuts						
20mm Steel Flange Nuts	RB20FNSG	3	798	1061	3 heat-treated ReidBar break without incipient crushing of the concrete as defined in ISO 15698.1:2012	Holmes Solutions 139628.00 RP 022

* The specimen that achieved 737MPa failed in a section of the bar away from the affected zone, in a ductile manner, and is thought to have achieved less than 750MPa due to the intrinsic variation in the heat-treatment process.

Note 1: The above Ultimate Tensile test was conducted in accordance with ISO 15698.2:2012.

Note 2: In accordance with ISO 15698.1 Cl 5.5 Table 2, the samples tested cover the geometry in the entire ReidBar range RB12 to RB32.

Table C7: Mode of Failure – Cl 8.6.11.1, 8.6.11.2, 8.6.11.3 NZS 3101:2006 A3
Cl 4.2.1 (f) (i) NZTA Bridge Manual 3rd Edition A3

Sample	Part No.	No. (of Samples Tested)	In accordance with ISO 15698-1:2012 cl. 7.3.2 (Category B3) & ISO 15698-2:2012 cl. 6.2				Test report reference(s)
			UTS [MPa]		Bar type used -&- 0.95 $R_{M,act}$	Mode of Failure	
			$UTS_{(min)}$	$UTS_{(max)}$			
ReidBar Steel iPort Flange Anchors							
12mm St. iPort Fl. Anchor	RB12FAIPS	3	646.6	651.0	Upper 50%-ile -&- 640MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022
12mm St. iPort Fl. Anchor	RB12FAIPS	3	655.0	661.0	Lower 50%-ile -&- 630MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022
16mm St. iPort Fl. Anchor	RBA16FAIPS	3	685.8	689.0	Upper 50%-ile -&- 648MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022
16mm St. iPort Fl. Anchor	RBA16FAIPS	3	650.2	661.2	Lower 50%-ile -&- 622MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022
20mm St. iPort Fl. Anchor	RB20FAIPS	3	1052.7	1209.4	Heat treated -&- 1046MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022
20mm St. iPort Fl. Anchor	RB20FAIPS	3	657.5	660.7	Lower 50%-ile -&- 629MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022
25mm St. iPort Fl. Anchor	RB25FAIPS	3	667.8	678.5	Upper 50%-ile -&- 645MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022
25mm St. iPort Fl. Anchor	RB25FAIPS	3	662.1	668.9	Lower 50%-ile -&- 631MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022
32mm St. iPort Fl. Anchor	RB32FAIPS	3	662.3	668.1	Upper 50%-ile -&- 640MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022
32mm St. iPort Fl. Anchor	RB32FAIPS	3	660.4	669.9	Lower 50%-ile -&- 632MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022
ReidBar Steel Flange Nuts							
20mm St. Flange Nuts	RB20FNSG	3	1184.8	1273.8	Heat treated -&- 1046MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022
20mm St. Flange Nuts	RB20FNSG	3	658.6	661.1	Lower 50%-ile -&- 629MPa	3 ReidBar ductile failure away from affected zone	Holmes Solutions 139628.00 RP 022

Table C8: Resistance to brittle fracture – Cl 8.6.11.4 NZS 3101:2006 A3
Cl 4.2.1 (f) (iii) NZTA Bridge Manual 3rd Edition A3

Sample	Part No.	No. (of Samples Tested)	Criteria assessed: Energy Absorbed at 0°C (Average) [J]	Criteria assessed: Comments	Test report reference(s)
ReidBar Steel Flange Nuts					
32mm Steel Flange Nuts	RB32FNSG	3	65	10x10 samples	X-Ray Lab 9606B1

ReidBar Reinforcing Bar System

Performances: Resistance to Brittle Fracture
According to NZS3101:2006 A3 & AS/NZS 4671
NZTA Bridge Manual 3rd Edition A3

Annex C8