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All testing has been performed by independent testing laboratories and PEL. See below for details.

Reinforcement Technical Assessment

RTA-20/0008
of 02/06/2021

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

Trade name of the construction product	ReidBar™ Grout Sleeve System,
Product family to which the construction product belongs	ReidBar™ Reinforcement System used in concrete structures sizes RB12, RBA16, RB20, RB25, RB32
Manufacturer	ramsetreid 1 Ramset Drive Chirnside Park Victoria 3116 Australia
Manufacturing plant	ramsetreid
This Technical Assessment contains	13 pages & 9 Annexes which form an integral part of this assessment.
This Technical Assessment for NZS3101 is in accordance with the performance requirements stipulated in NZS 3101:2006 A3.	Tests performed by WSP Opus Research Reference reports: • WSP Opus ➔ 5-24E97.00 Tests performed by Melbourne Testing Services Reference reports: • MTS ➔ 20-0745 Tests performed by PEL (ITW QA Lab): Reference reports: • ITW QA Lab ➔ 15135,16298,16183,16238, 16463

1. Technical description of the product

ReidBar™ Grout Sleeve™ is used as part of the ReidBar Mechanical Anchorage and Mechanical Splicing System.

ReidBar Grout Sleeve is manufactured from Spheroidal Graphite Ductile Cast Iron (Grade 600/3) and the 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 A.

2. Specification of intended use

The performances given in Section 3 are only valid if the Reidbar Grout Sleeve System is used in compliance with the specifications and conditions given in Annex B.

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

3.1 Performance Requirement of Mechanical Connections

Criteria	Performance
Elongation at $0.7f_y$ NZS 3101:2006 A3: Cl 8.7.5.2 (b)	See Annex C1
Alternating Large Strains NZS 3101:2006 A3: Cl 8.9.1.3 (a)	See Annex C2
Ultimate Tensile Strength NZS 3101:2006 A3: Cl 8.6.11.1 & 8.6.11.2	See Annex C3
Mode of Failure NZS 3101:2006 A3: Cl 8.6.11.1, 8.6.11.2, 8.6.11.3	See Annex C4
Resistance to Brittle Fracture NZS 3101:2006 A3: Cl 8.6.11.4	See Annex C5

3.2 Testing Methodology of Mechanical Connections

3.2.1 Elongation at $0.7f_y$ – Cl 8.7.5.2 (b) NZS 3101:2006 A3

The bars and connectors were loaded into the test machine and loaded in tension up to 0.7 times the nominal yield load. Once at $0.7f_y$, the bars were held at $0.7f_y$, for 20 seconds before the loading was increased to perform the ISO 15835-2 Clause 5.6 testing. 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 average displacement over the final 5 seconds of the $0.7f_y$ loading was recorded.

The allowable displacement was calculated from tests done on two non-coupled ReidBars™ of each size. These bars were loaded to $0.7f_y$ and the strain recorded using a calibrated extensometer. The average strain was then converted into a displacement using the gauge length for each coupler option.

The allowable displacement criteria for each grout sleeve was determined using the following process:

• The strain (ε_{350}) in the un-spliced ReidBars was measured at $0.7f_y$ using an extensometer with nominal 150 mm gauge length.

• The strain is converted into a displacement over the length of the coupler ($\Delta_{c,bar}$) using the following equation: $\Delta_{c,bar} = \varepsilon * L_c$

• The allowable displacement is double the extension in an unspliced bar over the length of the coupler: $\Delta_{allowable,B} = 2 * \Delta_{c,bar}$

To convert the displacement measured over the gauge length (L_g) on the samples to the equivalent over the length of the coupler, for comparison against the allowable displacement ($\Delta_{allowable,B}$), the following procedure has been followed:

• The displacement of the sample over the gauge length (Δ_g) has been measured directly during the testing. This measured displacement is made up of two components, the displacement over the coupler length and the displacement in the ReidBar.

• For grout sleeves, the gauge length is made up from the coupler length and 8 times the nominal diameter in length of ReidBar: $L_g = L_c + 8*d$

• To find the measured displacement over the Grout Sleeve only (Δ_c), the displacement from the lengths of Reidbar within the gauge length needs to be removed. This has been done using the strain (ε_{350}) measured in the un-spliced lengths of ReidBar: $\Delta_c = \Delta_g - \varepsilon_{350} * 8 * d$

Finally, the measured displacement, converted to be over the coupler length (Δ_c) can be compared to the allowable displacement ($\Delta_{allowable,B}$).

3.2.2 Alternating tension and compression test of large strains – Cl 8.9.1.3 (a) NZS 3101:2006 A3

From the load of $0.7f_{y,}$ the bars began the low-cycle testing as defined in ISO 15835-2 Clause 5.6.2. From a load of $0.7f_y$ in tension, the bars were further loaded to twice the nominal yield strain with the load then reversed and the sample loaded to half the nominal yield load in compression. The cycle was completed by loading in tension back up to twice the nominal yield strain. This cycle was repeated four times. Subsequently the bar was loaded in tension to five times the nominal yield strain and another four cycles performed between five times the nominal yield strain and half the nominal yield load in compression.

The residual elongations, u_4 and u_8, as detailed in ISO 15835, are measured from plots of the force against displacement over the gauge length on the last cycle at two and five times the nominal yield strain.

From the end of the final loop, at five times the nominal yield strain, the displacement gauges were removed, and the samples were loaded through to failure in tension with the Ultimate Tensile Strength (UTS) and MOF recorded.

3.2.3 Ultimate Tensile Strength – Cl 8.6.11.1 & 8.6.11.2 NZS 3101:2006 A3

NZS 3101 A3, at Clause 8.6.11.2, defines the Upper Bound Breaking Strength of the reinforcing bar as 1.25 times the Upper Characteristic Yield Strength of the bar. For ReidBar, being 500E grade, this corresponds to 750MPa. Mechanical anchorages, at Clause 8.6.11.1, and mechanical couplers, at clause 8.7.5.2 (a), are required to be capable of developing the Upper Bound Breaking Strength.

Specifically heat treated ReidBars are connected to the Grout Sleeve threaded end to be tested against this requirement. The thermal treatment allows the bar to develop a tensile strength above the minimum 750MPa required for the test.

The assembly is then loaded to failure, and UTS is recorded. The mode of failure is also recorded. However, this is just for the record, because, as long as failure occurs beyond the UBBS threshold, the outcome of the test is considered successful, regardless of what the failure mode was.

3.2.4 Mode of Failure – Cl 8.6.11.1 & 8.6.11.3 NZS 3101:2006 A3

This particular test is often paired with other tests, like the 0.7fy or the ISO 15835 for large strains, to become the conclusive part of those tests. Once the main test is finished, the test sample is pulled to failure and the Mode of Failure is recorded.

3.2.5 Resistance to Brittle Fracture – Cl 8.6.11.4 NZS 3101:2006 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, particularly considering that ReidBar Grout Sleeve is made of Spheroidal Graphite Iron.

In 2018 another ReidBar product, ReidBrace™, was the subject of an extensive testing program at the University of Auckland. The constituent material of ReidBrace, SG Iron Grade 600/3, is exactly the same of the ReidBar Grout Sleeve. One of the key steps of the test program was to determine the behavior of the components at temperatures below 0°C. This was accomplished by freezing the components at different temperatures between 0°C and -10°C and applying a load with an actuator at a rate of 10mm/s until failure, to simulate rapid tensile loading during earthquake.

3.3 Performance Requirements of High Strength Non-Shrink Grout

In order to comply with the ReidBar Grout Sleeve System Installation Guide, Ramset PoziFlo Grout HS mixed to flowable consistency is required for the sleeve grouting.

According to the PoziFlo Grout HS Technical Datasheet, for a 20kg bag to be mixed to flowable consistency, 3.2l to 3.5l of water are required.

The expected compressive strength at 28 days, when tested in accordance with ASTM C 109M-08, is 83MPa.

3.3.1 Compressive strength of the grout at 28 days - ASTM C 109M-08

The grout, Ramset PoziFlo™ Grout HS, is mixed to flowable consistency according to Ramset PoziFlo Grout HS TDS.

The 50mm cube samples are prepared using steel molds and stored for curing as per ASTM C 109M-08.

In preparation for testing, the mass and critical dimensions of the cube samples are recorded.

Each sample is centrally installed between the platens of a calibrated compression testing frame; the upper platen is spherically seated to permit articulation.

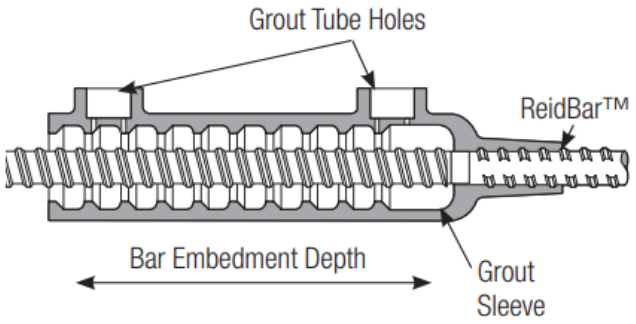
The load is applied at a rate of 1.5kN/s until a reduction in peak load is evident.

4 Material Safety Data Sheet

Refer to the following ChemAlert documents for Safety Data Sheet according to New Zealand HSNO requirements:

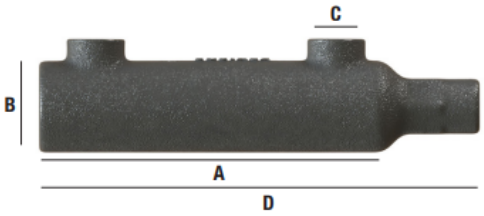
- 10 Apr 2018 Version No:1 (EPCON C8)
- 15 Jan 2019 Version No:1 (Remset PoziFlo Grout HS)

ReidBar™ Grout Sleeve™
RB12GS, RBA16GS, RB20GS, RB25GS, RB32GS



ReidBar™ Grout Sleeves

ReidBar Grout Sleeves offer a precast panel on panel splicing solution which meets the performance requirements of NZS3101:2006 Amendment 2. Whilst made of Cast SG Iron, ReidBar Grout Sleeves also had been tested to the performance requirements of NZS3101:2006 Amendment 3. Refer to the documents section for more information.



Part No.	Suits ReidBar	(A) Max Internal Embedment Depth (mm)	(B) Body ID (mm)	(C) Internal Grout Hole Diam (mm)	(D) Tube Length (mm)
RB12GS	RB12	150	28-40	21	200
RBA16GS	RB16	190	32	21	240
RB20GS	RB20	224	40	21	290
RB25GS	RB25	274	48	21	360
RB32GS	RB32	320	55	26	445

Refer to the Reid Precast Solutions Product Guide for related products. Available from www.reids.co.nz

ReidBar™ Grout Sleeve™	**Annex A 1**
Product description Mechanical couplers and 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

Specifications of intended use

Technical Assessment and Literature:

This document is complimentary to the following Independent Technical Assessment and Certification:

- Branz Appraisal No. 1084 (2019): ReidBar™ Grout Sleeve System
- Branz CodeMark No. BRANZ-CM-1024: ReidBar™ Grout Sleeve System

This document is to be read in conjunction with the following technical literature:

- ReidBar™ Grout Sleeve System – Installation Guide – November 2020
- Ramset™ PoziFlo™ Grout HS – Technical Data Sheet – August 2013
- Ramset Epcon™ C8 Xtrem™ - Technical Data Sheet – March 2015

Connections subject to:

- Seismic, Static and quasi-static load.
- Not tested for high cycle fatigue load conditions.
- Not suitable for in-service temperature below -5˚C.

Base materials

- Reinforced normal weight concrete for use in construction in accordance with NZS 3101:2006 A3.
- Non-cracked and cracked concrete
- Reinforcement is 500E Grade ReidBar in accordance with AS/NZS 4671:2019 in bar sizes RB12, RBA16, RB20, RB25, RB32

Design:

- Mechanical Spliced Connections are designed in accordance with the Standards New Zealand NZS 3101:2006 A3 – “Concrete Structures Standard” under the responsibility of an engineer experienced in structural design and concrete work.

Installation:

- Installation of ReidBar Grout Sleeve System is carried out by Precast Concrete manufacturers or building contractors under the guidance of a Chartered Professional Engineer, in accordance with the Technical Literature and instructions published by ramsetreid.

ReidBar™ Components	**Annex B 1**
Intended use Specifications	

Table C1: Elongation at 0.7fy: Cl 8.7.5.2 (b) NZS 3101:2006 A3

Sample	Part No.	Lg Gauge length [mm]	Lc Coupler length [mm]	No. (of Sampl. Tested)	ε_{350} Non-spliced ReidBar strain at $0.7f_y$	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 Grout Sleeve									
12mm Grout Sleeve	RB12GS	296	200	3	2.12	39.55	0.19	0.85	WSP-Opus 5-24E97.00
20mm Grout Sleeve	RB20GS	450	290	3	1.86	109.9	0.31	1.08	WSP-Opus 5-24E97.00
32mm Grout Sleeve	RB32GS	701	445	3	2.04	281.4	0.41	1.81	WSP-Opus 5-24E97.00

Table C2: Large Strains: Cl 8.9.1.3 (a) - NZS 3101:2006 A3

Sample	Part No.	No. (of Samples Tested)	Criteria assessed						Test report reference(s)
			ISO $u_4 \leq 0.3$mm [mm]		ISO $u_8 \leq 0.6$mm [mm]		UTS ≥575MPa referred to the nominal area of the bar [MPa]		
			$u_{4(min)}$	$u_{4(max)}$	$u_{8(min)}$	$u_{8(max)}$	$UTS_{(min)}$	$UTS_{(max)}$	
ReidBar Grout Sleeve									
12mm Grout Sleeve	RB12GS	3	-0.11	-0.06	-0.03	0.04	638.9	640.8	WSP-Opus 5-24E97.00
20mm Grout Sleeve	RB20GS	3	-0.14	-0.04	0.00	0.11	654.5	654.8	WSP-Opus 5-24E97.00
32mm Grout Sleeve	RB32GS	3	-0.13	-0.07	0.02	0.08	657.6	678.6	WSP-Opus 5-24E97.00

Table C3: Ultimate Tensile Strength – Cl 8.6.11.1 & 8.6.11.2 NZS 3101:2006 A3

Sample	Part No.	No. (of Samples Tested)	Criteria assessed		Mode of Failure	Test report reference(s)
			UTS ≥750MPa referred to the nominal area of the bar [MPa]			
			$UTS_{(min)}$	$UTS_{(max)}$		
ReidBar Grout Sleeve						
12mm Grout Sleeve	RB12GS	4	973.4	1008.8	4 hardened ReidBar break	ITW QA Lab Rep. N. 15135
16mm Grout Sleeve	RBA16GS	4	793.5	865.7	4 hardened ReidBar pull out of thread	ITW QA Lab Rep. N. 16298
20mm Grout Sleeve	RB20GS	3	907.6	955.4	No failure, tests interrupted after reaching a load well beyond requirements	ITW QA Lab Rep. N. 16183
25mm Grout Sleeve	RB25GS	3	935.0	971.7	2 hardened ReidBar break 1 hardened ReidBar pull out of thread	ITW QA Lab Rep. N. 16238
32mm Grout Sleeve	RB32GS	2	769.7	789.6	2 Grout Sleeve neck failure	ITW QA Lab Rep. N. 16463

Table C4: Mode of Failure – Cl 8.6.11.1, 8.6.11.2, 8.6.11.3 NZS 3101:2006 A3

Sample	Part No.	No. (of Samples Tested)	Criteria assessed			Test report reference(s)
			UTS referred to the nominal area of the bar [MPa]		Mode of Failure	
			$UTS_{(min)}$	$UTS_{(max)}$		
ReidBar Grout Sleeve						
12mm Grout Sleeve	RB12GS	3	638.9	640.8	3 ReidBar ductile failure clear of coupler	WSP-Opus 5-24E97.00
20mm Grout Sleeve	RB20GS	3	654.5	654.8	3 ReidBar ductile failure clear of coupler	WSP-Opus 5-24E97.00
32mm Grout Sleeve	RB32GS	3	675	692	3 ReidBar ductile failure clear of coupler	MTS 20-0745

Table C5: Resistance to brittle fracture – Cl 8.6.11.4 NZS 3101:2006 A3

Samples	Material	Temperat. (of Tested Samples)	Criteria assessed		Test report reference(s)
			Minimum Service Temp.	Abstract from "Summary of Outcomes from Reidbrace Testing at the University of Auckland"	
		[°C]	[°C]		
ReidBrace* Components 12mm, 16mm, 20mm, 25mm Total N. of Test Samples: 28	Spheroidal Graphite Iron Grade 600/3	0°≤T≤-10°	-5	"Component failures occasionally occurred when they were tested under impact tensile loading at -10°C, however improvement in performance was noted when tested at -5°C. It was therefore theorised that the ductile to brittle transition temperature of the product lies between -5°C and -10°C, and that the service temperature for the design of the ReidBrace System shall be limited to -5°C."	Static and Dynamic Testing of ReidBrace™ System [25/05/18 - The University of Auckland] & Summary of Outcomes from ReidBrace Testing at the University of Auckland [30/08/18 - The University of Auckland]

* All tested components are part of the ReidBrace system, which utilizes the same reinforcing bars (ReidBar, grade 500E reinforcement) and the fittings are made of the same material.

Table C6: Compressive strength of the grout

Part No.	No. of samples	Cast date	Test date	Criteria assessed							Test report reference(s)
				Dimensions [mm]			Cube density [kg/m^3]		Compressive strength [MPa]		
				L	W	H	$\rho_{(min)}$	$\rho_{(max)}$	$f'c_{(min)}$	$f'c_{(max)}$	
Ramset PoziFlo Grout HS											
RPGHS	3	25/06/20	27/07/20*	50	50	50	2220	2280	94.0	98.8	MTS 20-0745

*From the Ramset PoziFlo TDS, the expected compressive strength at 7 days is 75MPa and at 28 days is 83MPa.
The extrapolated expected strength at 32 days is 84MPa.