Holmes Solutions

Level 2, 254 Montreal Street
Christchurch Central 8013
PO Box 6718
Upper Riccarton, Christchurch 8442
holmessolutions.com

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ITW Construction Asia Pacific
25 Poland Road
Wairau Valley
Auckland
Attention: Emanuele Naccini
Subject: RE: Summary of RB32 ReidBrace testing

Dear Emanuele,

This letter summarizes the results of experimental testing undertaken at Holmes Solutions' test laboratory on Ramset Reid's new RB32 ReidBrace tension only bracing system. This summary includes suggested design parameters to be adopted in design. Stiffness formulas derived from the testing, including test results for 12mm – 25mm ReidBrace systems tested at the University of Auckland (UoA), (refer UoA letter dated December 2021, titled "*Summary of Revised Outcomes from ReidBrace Testing at the University of Auckland Structures Test Hall and Recommendation for Bearing Capacity of Ply Supporting the ReidBrace, plus the change from connector elements from bolts to pins*) are also proposed.

Scope of testing completed at Holmes Solutions:

- Monotonic tensile testing of 32mm ReidBar at both ambient and -10°C to determine performance of the bar used for subsequent testing
- Monotonic tensile testing at ambient temperatures of shorter specimens (~1.3m) to determine system stiffness and ultimate failure mode
- Impact tensile testing at ambient and -10°C temperatures. This was undertaken to determine the performance of the system under high strain rates and at different temperatures
- Cyclic testing of longer (~4.5m) specimens at increasing displacement targets, following the procedure outlined in ANSI AISC 341-22 chapter K3, to determine the performance of the ReidBrace system under reversing cyclic loading

For full test procedure and results, refer to Holmes Solutions' test report: "*Structural performance testing of RB32 ReidBrace system*".

1 SUMMARY OF TESTING

The following design parameters have been derived from the test results.

1.1 Design ductility factor (μ) for RB32 ReidBrace

Table 1 - Design Ductility factor, μ, for ReidBrace

Component[1]	Structure category 4 max μ_{des}	Structure category 3 max μ_{des}	Structure category 2 max μ_{des}	Structure category 1 max μ_{des}
ReidBrace 32	1	1.25	-	-

[1]Design ductility factor for 12mm to 25mm ReidBrace can be found in the University of Auckland letter "Summary of Revised Outcomes from ReidBrace Testing at the University of Auckland Structures Test Hall and Recommendation for Bearing Capacity of Ply Supporting the ReidBrace, plus the change from connector elements from bolts to pins" dated December 2021

1.2 Design strength

The tested capacity, derived from ultimate loads reached in testing, divided by a factor to account for the variability of structural units, as defined in AS/NZS1170.0 Appendix B, are reported in Table 2.

Table 2 - Tested capacity, derived from UTS and reduced by k_t value as per AS/NZS1170.0 Appendix B3

Component	ϕN_u(kN)
ReidBrace 32	479

As the yielding element in all tests was the grade 500E ReidBar, the design capacity of the ReidBrace system can be based on the yield strength of the ReidBar. Design capacities based on this approach are shown in Table 3, including nominal strengths used for overstrength determination. This approach is recommended, as ReidBar with a yield strength above the 50th percentile was used during the testing, to try induce failure in the ReidBrace components.

Table 3 - Design capacity based on NZS 3404 approach

Component	ϕN_t(kN)	N_{nom}(kN)
ReidBrace 32	362	402

1.3 Overstrength factors

Overstrength factors determined in accordance with NZS3404 and stated in the UoA letter for the RB25 system are also suitable for the RB32 ReidBrace system, as the yielding element is the ReidBar. Overstrength factors are repeated in Table 4 below. Overstrength factors for category 1 and 2 members are not provided due to the lack of test data at higher ReidBar stresses.

Table 4 - Overstrength factors for design

	M. Cat 4 max μ_{des}	M. Cat 3 max μ_{des}	M. Cat 2 max μ_{des}	M. Cat 1 max μ_{des}
Overstrength (ϕ_{oms})	1.0	1.25	-	-

1.4 System stiffness

The stiffness of the 32mm ReidBrace system has been characterised based on test results of the three series of assembly testing. Treating the ReidBrace system as a series of springs of different stiffnesses (one spring representing the ReidBar and one spring representing the brace hardware) allows for more accurate modelling of ReidBrace tension bracing within structures. Recommended design values determined through testing are shown in Table 5 below. The results of the University of Auckland testing have also been analysed and equations have also been given for these brace sizes based on the University of Auckland test results. Full derivation of the below formula can be found in the Holmes Solutions test report "*Structural performance testing of RB32 ReidBrace system*"

The E_{eq} values in Table 5 below should be used with the gross cross-sectional area of the ReidBar.

Table 5 - ReidBrace system stiffness calculated values

Component	L^{RB}_{st}	Average E^{st}_{rq} (MPa)	L^{RB}_{cyclic}	Average E^{RB}_{cyc}	Elastic modulus (MPa) equation (any length) (L_{total} in mm)	Elastic modulus (MPa) for braces > 4.0m suggested by Ramset Reid
ReidBrace 12[1]	1368	101,757	4230	151,438	$E_{eq} = \frac{(200,000 \times L_{total})}{(1340 + L_{total})}$	160,000
ReidBrace 16[1]	1368	76,094	4230	133,217	$E_{eq} = \frac{(200,000 \times L_{total})}{(2170 + L_{total})}$	145,000
ReidBrace 20[1]	1368	63,554	4230	125,337	$E_{eq} = \frac{(200,000 \times L_{total})}{(2715 + L_{total})}$	140,000
ReidBrace 25[1]	1368	61,931	4230	119,350	$E_{eq} = \frac{(200,000 \times L_{total})}{(2950 + L_{total})}$	135,000
ReidBrace 32	930	74,800	4500	135,700	$E_{eq} = \frac{(200,000 \times L_{total})}{(1875 + L_{total})}$	155,000

[1]Interpreted from University of Auckland test results

1.5 Impact testing of 32mm ReidBrace system at -10°C

No component failures were observed during any of the impact tests of the 32mm ReidBrace system at both ambient and -10°C temperatures tested at Holmes Solutions' laboratory. Reference should be made to the University of Auckland testing for performance of smaller ReidBrace sizes at lower temperatures.

1.6 Ply in bearing

The design of end clevis plates used in the Holmes Solutions testing followed the design equations stated in the UoA letter. 28mm thick, grade 450 plate was used. Minor pin deformation was observed in all tests taken to failure. Ramset Reid suggest the use of the design equations stated in the UoA letter. A summary of capacities for different plate sizes and grades based on these design equations is presented in Table 6 below.

Table 6 - Clevis plate bearing capacity

	ϕVb Ply in bearing (kN)		
Steel grade	Thickness of steel plate (mm)		
	28	30	32
G 250	556	596	636
G 300	649	695	741
G 350	708	758	809

N_{nom} = 402kN (member category 4)

$\phi_{oms}N_{nom}$ = 1.25*402kN = 503kN (member category 3)

All plate sizes and grades stated in Table 6 are suitable for category 3 & 4 structures (μ≤1.25).

2 RECOMMENDATIONS

The testing programme completed at Holmes Solutions test lab demonstrates that the RB32 ReidBrace system meets the performance requirements of the New Zealand Building Code clause B1 – Structure, including associated standards AS/NZS1170.0:2002 and NZS 3404:1997. Holmes Solutions recommends that the design of the RB32 ReidBrace system adopts the aforementioned standards and the design provisions presented in this letter.

Regards,

Hayden Wright P.Eng; CMEngNZ
STRUCTURAL ENGINEER