Redco NZ Ltd
Redco House
470 Otumoetai Road
TAURANGA 3110
Telephone: 07 571 7070
Facsimile: 07 571 7080
Email: red@redco.co.nz
www.redco.co.nz

Ref: 20295 / Metalcraft Thin Panel Bracing Assessment (v3) (2023.05.05).docx

5 May 2023

Metalcraft Insulated Panels Ltd
139 Roscommon Road
Manakau
AUCKLAND

For the attention of: Peter Zeeman

Dear Peter

Re: Metalcraft 50mm & 75mm Thick Panel Bracing Capacities

Metalcraft had their 100mm thick ThermoPanel EPS and MetecnoPanel PIR insulated panels tested by Scion in accordance with the BRANZ P21 test method and engaged Airey Consultants Ltd to prepare a report on those tests. That report (ACL Ref. 12191-01 and appended) includes the bracing capacity and fixing requirements of the panels but the scope and limitations of that report (Section 1.3, page 2), neither confirms nor precludes the applicability of the report to other panel thicknesses.

The AspirePanel™ PIR has been added to the range of products available and has been independently certified under pass™ certificate number 19049, attached, as being comparable to ThermoPanel EPS with respect to compliance with Clause B1.

You have engaged Redco to consider whether the bracing values provided within the Airey report are applicable to the thinner 50mm and 75mm thick panels, and to the AspirePanel™ PIR.

Redco's opinion has been based upon our previous experience in designing and using metal insulated panels over more than 20 years, our internal assessment of their structural behaviour, our assessment and interpretation of the Airey report, and supported by the independent certification noted above.

In summary, as noted on page 5 of the Airey report, the bracing capacity of the panels is governed by their fixings and no failures were observed in the core material, the skins buckling or the lamination between these elements.

Accordingly, it is Redco's opinion that the bracing capacity of the panels is not governed by the thickness of the panels under review, and that the bracing values provided within the report may be applied to ThermoPanel EPS, MetecnoPanel PIR and AspirePanel PIR panels 50mm thick and above. All other aspects of the construction, including but not limited to the flashings, fixings, and hold-down requirements, must be installed as specified within the Airey report.

It is the designer's responsibility to assess the panel's suitability to accommodate all loads and combinations of loads likely to be applied to the panel during its design life.

Note, the report is not considered to be applicable to profiled panels such as the ThermoSpan, MetecnoSpan, and AspireSpan range of products, which will be subject to specific engineering design.

Yours sincerely
Redco NZ Ltd

David Barnard
BEng (Hons), MIStructE, CEng (UK), CMEngNZ

CONSULTING CIVIL &
STRUCTURAL ENGINEERS
8th Floor
BDO Tower
19-21 Como Street
P.O. Box 33103 Takapuna
North Shore 0740
Telephone: +64 9 486 4542
Facsimile: +64 9 489 5455
Email: takapuna@aireys.co.nz
www.aireys.co.nz

Members of ACENZ

AIREY CONSULTANTS LTD.

02 December 2016

ACL Ref. 12191-01

The Manager,

Metalcraft Panel Systems,

PO Box 43-154,

Mangere Central,

Auckland

Attention: Mr Peter Zeeman

Dear Peter

Re: Metacraft wall panel structural performance:

1.0 Introduction:

We are writing to report on our review and calculations relating to the performance of the Metalcraft wall panels information as it relates to the following NZ Building Code Clauses:

B1.3.1, B1.3.2, taking into account the following physical conditions **B1.3.3 (a), b), (c), (e), (f), (i), (j), (l), (m) & (q)** and having made due allowance in terms of B1.3.4(a, b, c, d, e)

This work relates to **Metalcraft ThermoPanel EPS** and **MetecnoPanel PIR** which are structurally insulated panels (SIP) with a 100mm nominal width. (see Section 1.1 below for a description)

Do you want to say anything about the applicability of your conclusions in respect of other panels?

All other building code clauses fall outside the scope of our engagement and therefore this report.

This review is based on current building legislation ie: at the date of this report, which may change with time. Care should therefore be taken to ensure that the use of this information is applicable to the legislation applicable at the time of use.

1.1 Metalcraft SIP Building Method - Description

As noted above this review is limited to the performance of **Metalcraft MetecnoPanel (PIR)** and **ThermoPanel EPS**, in terms of their structural integrity and their contribution to the structural performance of the *building*. The Metalcraft SIP Building Method is described as follows.

Both panel types are structurally insulated panels (SIP) comprising a 100mm nominal width with a bonded CP Grade pre-painted galvanised steel facing each side. The Metecno (PIR) panels have a PIR, polyisocyanurate core. The ThermoPanel EPS have an EPS Class S standard expanded polystyrene core. Refer to the applicable Metalcraft data sheets included in **Appendix A** of this report).

For additional information on the building method refer to the Metalcraft Design and Installation Manual (April 2015/Version 1) for more information on these systems.

1.2 Use

The intended use of the Metalcraft wall panels is for both non-loadbearing and loadbearing structural walls in buildings complying with the NZ Building Code in internal and external applications as external wall panels, partitions and/or wall bracing elements.

Metalcraft panels can be used to provide bracing in buildings designed and constructed within the scope of New Zealand non-specific design standards and for buildings that have been designed using Specific Engineering Design (**SED**) by a Chartered Professional Engineer (CPEng(NZ)) in accordance with NZ/AS 1170 (See further comment regarding SED in Section 5.5 below)

1.3 Scope and limitations

This review is limited to the use of **Metalcraft MetecnoPanel (PIR)** and **ThermoPanel EPS**, within the following scope:

- **Importance Level 2** Building as defined in Clause A3 of the NZ Building Code
- Designed in accordance with AS/NZS1170 Parts 1, 2, 3 and 5.
- Founded on ***good ground*** (as defined in NZS3604 (Ref. 1))
- Building height of **10m** (as defined in clause A2 of the NZBC.
- Floor loads not to exceed a 3.0kPa UDL nor a 2.7kN concentrated load.
- Snow loads up to 1.0kPa.
- Wind zone up to ***Extra High*** (as defined in NZS3604 (Ref. 1))
- Unlimited floor area.
- Constructed on reinforced concrete floors or timber floors complying with the NZBC

In order that the tabulated bracing capacities are achieved, no departure from the tested construction details should be made unless otherwise allowed in this report. (Refer to **Appendix A** for standard Metalcraft bracing panel details).

2.0 Document review:

Our review of the available documentation regarding the use of Metalcraft panels for structural bracing indicated shortcomings in that information and a lack of technical guidance as to the derivation of the bracing ratings and the capacity of the connections.

Consequently our advice was that testing and evaluation of Metalcraft wall panel systems intended to be used for bracing should be carried out using the **BRANZ P21 test method** (Ref. 1).

3.0 Test programme:

3.1 Basis for using P21 test methodology

Scion were engaged to test a range of **Metalcraft ThermoPanel EPS** and **MetecnoPanel (PIR)** SIP wall panels by **Scion** (A division of the New Zealand Forest Research Institute Ltd.) to determine their bracing capacity with respect to the requirements of NZS3604: 2011 (Ref. 2).

The full Scion test results and a summary table are included in **Appendix B** of this report.

The Scion test reports all note that **"The procedure is not intended to be used for evaluating the performance of concrete or masonry walls, steel-framed walls, post and beam, plank construction or panelised construction, unless the critical components of the wall are laterally loaded steel fasteners installed in timber"**

It is important to note that the P21 test relates specifically to Light Timber Framed (**LTF**) assemblies lined with either plasterboard sheet products or timber sheet products fixed with steel fasteners ie: nails or screws (but not glued). Ductility and hence seismic energy absorption is derived from the deformation of the fixings within the framing and sheet linings.

Whilst the Metalcraft panels tested do not meet the above criteria, the test methodology is essentially generic and considered appropriate. The evaluation of the results and determination of bracing capacity using the P21 methodology has some limitations. This report discusses the method of test assessment and strength evaluation with respect to meeting the wind and seismic bracing demand requirements or NZ Building Code.

3.2 BRANZ P21 (2010) Section 14.2:

Section 14.2 relates to the use of the test methodology in situations other than timber framed, lined walls and states that:

*This procedure produces bracing ratings for stick-framed timber walls with sheet lining, as stated in Section 1. Testing agencies wishing to use it for other bracing systems should be aware that the **K4** factors and the definition used to measure specimen ductility were derived for these types of systems only. Other bracing systems (for example, masonry, steel-framed walls etc.) will have different hysteretic behaviour, thus invalidating the basis of the **K4** factors. **Use of the test method in these circumstances will require a statement in the test report giving derivation or justification for the K4 factors (or equivalent) used for the analysis.***

The following sections of this report provide the derivation/justification for the K4 factor used to verify the bracing capacity of the tested Metalcraft wall panel systems.

It is noted that the Scion tests have, in all cases, determined the ductility, μ to be greater than 4 and hence determined that K4 = 1.00 based on the P21 test evaluation methods however, as noted above, the final K4 design value requires validation.

3.3 Test observations and results:

The Scion test reports give general comments on the Metalcraft test panel construction details and observed failure mechanisms. We provide additional comment as follows:

4.0 Failure mechanism observations:

a) 1.2m test walls:

Typical failure mechanisms observed were: do you want to comment on the difficulty to arrive at the failure point?

- Uplift of the ends due to bending of the bottom aluminium angles
- Splitting of the aluminium base angles in the end regions

Image 1: End region uplift and yielding of bottom aluminium angle:

b) 2.4m test wall:

A single 2.4m long wall assembly was tested. This comprised 2x1.2m standard panels joined top and bottom by continuous 40x40x1.6mm Aluminium trimming angles on each side of the wall. (See typical details in Appendix A) There were no connections between the vertical panel joints on either side of the panels. In normal practice this joint is sealed using a silicon sealant that has been shown to possess relatively high bond strength.

Prior to the tests being carried out, an analysis of the 2.4m long wall by way of structural calculations predicted a hierarchy of 'failure' mechanisms and the likely lateral load that these failures would occur.

This included, in order of predicted failure sequence:

- Elongation of the riveted holes in the steel face sheets
- Failure of the rivets at the end regions and central joint region
- Bending failure/yielding of the aluminium base angles
- Significant racking differential displacements between the two panels

Generally all the predicted failures were observed in the order they were expected.

A notable difference was that the end region rivets did not fail, but the mid region rivets progressively failed ('unzipped')

The aluminium angles in the middle vertical joint region were also observed to buckle. This was due to the racking induced, high local curvatures and compression in the vertical leg of the angles, unrestrained laterally once the rivets had failed in this region.

There were no obvious signs of face steel sheets buckling or failure of the EPS core material or any lamination failure between these elements.

It is noted that installation of multiple vertically joined panels would normally have silicon sealant applied at the vertical panel joint interfaces. However, given the normal cure times involved, this was not applied to the test panel joints. Consequently, the observed failure mechanisms may not have been apparent had the joint sealant been applied and allowed to cure.

As a result of the observed failure mechanisms, it was decided to add additional rivets at the central joint region, and top and bottom angles on both sides of the wall. The purpose of adding these rivets was to preclude the observed, significant differential racking displacement, rivet failure and buckling of the angles.

An additional 6 rivets were added at close centres in these regions and the tested panel assembly was retested. The relatively simple and inexpensive repair resulted in significantly improved performance with the panel assembly essentially acting as a single 2.4m long unit. The capacity was improved to the extent that the test rig could not fail the test wall assembly, even after the damage caused by the initial test. A displacement of 50mm was achieved at the limit of the test rig.

Image 2 below shows the reinforced joint region of the 2.4m long Metalcraft test panel ie: using the additional rivets. A similar strengthening was used at the top of the joint, on both sides of the panel.

Buckling damage of the angles at this location is also evident (although hammered back for the repair) and also either side of the joint, failed riveted connections are evident.

Image 2: Strengthening of joint region of 2.4m long Metalcraft test panel.

Deformation of the modified panel was then observed to be in the end regions with distortion of the base angle, similar to that observed with the subsequent 1.2m long wall panel tests.

4.1 Displacement observations:

In the case of the Metalcraft SIPs, the measured lateral displacement at the top of the wall is made up from 3 primary components:

- shear displacement
- flexural displacement (cantilever action)
- rigid body rotation due to rocking ie: uplift at the hold-down connection locations.

Simple calculations based on first principles can be used to estimate the first two components. These calculations and test observations indicate that **the major component of the lateral displacement is due to the rocking mode** ie: effective rigid body rotation of the wall about the down side bottom corner. This was evident by the uplift of the near side (load side) corner of the wall panels and consequent deformation of the bottom angles at the location of the hold down bolts (See **Image 1** above). Per the attached calculations, **Appendix C**, the shear and flexural displacement components of the panels are minor.

The above observations indicate that, the Metalcraft panel ductility was derived from the deformation/yielding of the bottom aluminium trimming angles, the screw connection of these to the bottom plate and the end anchors and mild steel plate washers. This contrasts with typical sheathed light timber frame (LTF) braced wall systems, where the ductility is primarily derived from the yielding of the multiple sheet connections, BRANZ SR220 (EM3-V3) (Ref. 6) Section 9.2 indicates that using the height ratio "is justifiable only if the panel strength is **governed by rocking**". The strength of the Metalcraft panels are, as noted above, governed by rocking and this method is therefore justifiable.

5.0 Bracing demand and capacity calculations:

Bracing demand for buildings can be determined either by Specific Engineering Design (**SED**) using AS/NZS1170 or by using non-specific design standards such as **NZS3604:2011 Timber Framed Buildings** (Ref. 2)

More specifically, with respect to lateral loads, AS/NZS1170.2 (Ref. 8) covers wind loads and NZS1170.5 (Ref. 4) covers seismic loads.

5.1 Wind bracing rating

The P21 method for calculating the wind rating is covered in Section 12.2 of that document. The calculated rating is the lesser of:

- **W = P_y**
- **W = (P8 x K1) x K2/0.71**

Where **K2 = 1.2** when the building meets the general bracing distribution requirements of NZS 3604 as noted in Section 6.5 of this report (below), otherwise this factor should be taken as K2 = 1.0.

An explanation of the derivation of the 0.71 factor is given in Section 12.2 of P21. It is also noted that this factor is the ratio of SLS *resistance* / ULS *demand.*

The calculated wind bracing capacities are given in Table 4 below.

5.2 Earthquake bracing demand

Seismic bracing demand for buildings can be derived by SED using NZS1170.5 (Ref. 4) or using the non-specific design standard NZS3604 2011 (Ref. 2).

Section 3.2 of "The Engineering Basis of NZS3604" (BRANZ, Ref. 3) covers the derivation of earthquake bracing demands (per clause 5.3 of NZS3604). This section lists the parameters used in deriving the seismic demand for LTF buildings. Specifically, these are:

- Building Importance Level, **IL2** (As defined in Clause A3 of the NZ Building Code)
- Structural performance factor, **S_p = 0.70** (for $\mu \geq 2$)
- Return period factor (ULS), **R = 1.0**
- Near fault factor, **N(T,D) = 1.0**
- Site hazard factor, **Z** = zone dependent and independently accounted for in tables.
- Structure elastic period, **T ≤ 0.4 second.**
- Displacement ductility, **μ = 3.5** (per Ref. (2) and NZS 4203 committee 1999 and Shelton, 2007)
- **k_μ** calculated in accordance with NZS1170.5

- The system elastic damping, ζ_{el} is generally taken as 5% of critical damping per NZS1170.5.
- *Site subsoil class* per NZS1170.5.

The formulae used to calculate demand are as follows:

Seismic demand = base shear, $\mathbf{V = C(T_1)\ (S_p/k_\mu)\ W_t}$

Where: $\mathbf{C(T_1) = C_h(T)\ Z\ R\ N(T,D)}$

And: $\mathbf{W_t}$ = the effective seismic mass of the building

Where any of the above parameters differ, the demand must be modified accordingly.

Bracing design in accordance with NZS3604: 2011 uses the concept of matching the calculated bracing demand of the building with the capacity provided by the chosen bracing elements, as determined by test.

The term 'Bracing Unit' (or **BU**) was introduced in 1978 to provide a convenient way of measuring both demand and capacity. **20 Bracing Units (BU)** is equal to **1kN** (kiloNewton).

The P21 method determines the seismic bracing capacity of a test wall using the smaller of the values derived from the following equations, per Section 12.1:

- **EQ = K4 x R_y**
- **EQ = (P8 x K1) x K2/0.55**

An explanation of the derivation of the 0.55 factor is given in Section 12.1 of P2. The P21 uses μ = **3.5** to determine this factor ie: not μ = **4.0**. The reason for this difference is not given but the ratio of SLS *resistance* / ULS *demand* is 3.5..

For definition of these parameters refer to the P21 method.

5.3 The K Factors

The modification factors K1, K2 and K4 warrant further discussion with respect to the Metalcraft panel test results and determination of bracing capacity.

5.3.1 The K1 factor

K1 factor has been determined in accordance with the P21 method and no modification is considered necessary with respect to the Metalcraft panels as the factor C used to determine K1 for LTF walls is also applicable to Metalcraft panel bracing.

5.3.2 The K2 Factor

The P21 method includes a ***system factor*** **K2**, to account for redundancies associated with typical LTF building that results in a higher bracing capacity for the building as a whole when compared with the sum of the individual braced element capacities. The K2 factor is applied to the serviceability load P8 as noted above. EM3-V3 calls this the F2 factor (Section 3.3) suggesting that the value for F2 should be conservatively taken as 1.2. This is the value used in the P21 method.

Where Metalcraft bracing panels are used in buildings generally falling within the scope of NZS3604 ie: with respect to distribution of bracing, minimum bracing requirements etc. (See Section 6.5 of this report below), then using **K2 = 1.2** is considered appropriate.

Care needs to be taken in the use of the K2 factor, particularly with modern buildings which often don't possess the same level of redundancy as typical LTF buildings. It is therefore recommended that the K2 factor be taken as 1.0 for buildings braced with Metalcraft panel systems with a distribution that doesn't meet the general bracing distribution requirements of NZS3604 unless more detailed testing of larger full scale assemblies determine that a larger value can be used.

5.3.3 The ductility modification factor, K4 Factor

The P21 method, Section 12.1 uses a **K4** capacity reduction factor (the ductility modification factor) related to the ductility determined through testing. Where the calculated ductility, **μ**, is less than **4** a reduction factor must be applied to the test resistance, **R_Y**,

The ULS based earthquake rating is calculated as follows: **EQ = K4 x R_Y**

Table 2: K4 factor per P21

μ	1.00	2.00	2.50	2.75	3.00	3.50	4.00
K4	0.35	0.60	0.67	**0.71**	0.74	0.87	**1.00**

With respect to the Metalcraft panel test results, the K4 factor is the most important of the three factors as noted above in relation to Section 14.2 of the P21 method. Hence, the determination of the appropriate K4 factor forms the main basis of this report.

The method for the derivation of K4 is described in TR10 (Ref. 5) which indicates that this has been determined in accordance with the draft NZ standard, DZ 4203: 1991.

ie: **$K4 = C_b(0.4,4)/C_b(0.4,\mu)$**

Section 14.2 of the P21 method indicates that, because other types of bracing systems will have different hysteretic behaviour. This will invalidate the use of P21 based K4 factors. It goes on to say that use of the test in other than the intended circumstances will require a statement giving derivation or justification for the K4 factor that is adopted.

The following discussion provides the required derivation/justification for the **K4 factor** applied to the Metalcraft wall panel test results. More specifically, the determination of the system ductility, μ (**u** in the P21 capacity evaluation procedure) upon which the K4 factor is based.

6.0 Ductility, μ and the K4 factor determination:

6.1 Term definitions

Ductility is defined as the ability for a structure or structural element to deform inelastically without significant loss of strength. Ductility allows seismic and other vibratory energy to dissipate. For assessment purposes, ductility is defined as the ratio of ultimate displacement δ_u to yield displacement, δ_y. That is (displacement) ductility, $\mu = \delta_u/\delta_y$.

However, determining the yield point and hence the yield displacement is difficult.

In the P21 method, the ultimate displacement, δ_u is taken as the displacement at peak load (value **d**), that is the point at which the 3rd cycle resistance starts to decrease.

However, technically, the ultimate displacement is the displacement at which the element fails. Consequently, we consider it more appropriate to name δ_μ, as the displacement capacity ie: the displacement limit from which the available ductility, μ can be determined.

Hysteresis is the force/displacement path traced out by a yielding (ductile) system undergoing reversed cyclic loading (per the Scion test plots). Generally the larger the enclosing area of the hysteretic loop, the more ductility and therefore greater damping and energy dissipation a system will have. This is discussed further in the following sections.

6.2 Calculation of displacement ductility

There have been a significant number of reports and papers on the determination of ductility from test results.

BRANZ Study Report SR220 (2010) Evaluation Method EM3 – V3 (Ref. 6) reviews the P21 test and comments on pitfalls of the P21 procedures especially with respect to the determination of available ductility.

The P21 test procedure refers to a BRANZ Technical report TR10 (1991) "Supplement to P21: An evaluation method of P21 test results for use with NZS3604: 1990" (Ref. 5)

This report considers the issue of the difficulty in defining the yield displacement, δ_y (value **y** in the P21 method) and hence how to calculate the available ductility of the test specimen(s). The defining equation, ductility, $\mu = \delta_\mu/\delta_y$ (or **u = d/y** in the P21 method), noting that P21 unjustifiably defines the yield displacement, **y** as the displacement at P/2).

We have therefore not relied upon the P21 method to determine the ductility as generally it will give ductilities well in excess of 4 and no less than 2 even where an elastic response. This is not sense since the ductility for an elastic response should be $\mu = 1.00$.

Section 5.1 of TR10 refers to a method by Park (1989) with accompanying diagrams but then does not use any of these methods to derive the ductility as they *"have proved difficult to translate to degrading timber systems"*. Instead, TR10 adopts the simplified approach noted above ie: (incorrectly) defining the yield displacement, **y** as the displacement at P/2.

According to SR220 (Ref. 6), the P21 test assumes a full Elasto-Plastic hysteretic loop in determining the system ductility. Consequently the damping, ζ and the available ductility, μ, and the bracing capacity of the tested system are all over estimated. To counter this, SR220 proposes a modification factor, **F4** . F4 is a response adjustment factor ie: lower ductility results in higher response and therefore greater demand. In the context of NZS3604, it is easier to adjust ie: reduce the tested capacity rather than adjust the demand.

It is noted that SR220: EM3-V3 (Ref. 6) is not referenced by NZS3604 and hence the methods proposed are not technically valid until such time as either the P21 procedure is revised to incorporate these recommendations or SR220 is specifically referenced in NZS 3604. Partly for this reason, we have chosen not to use this methodology.

6.3 Equivalent static method

The *Equivalent Static* method of NZS1170.5 uses an elastic seismic design spectra modified for the level of ductility achieved ie: the response and therefore the demand is reduced to account for the ductility achieved.

In terms of the Metalcraft panel systems, all parameters with the exception of ductility and the ductility factor, $\mathbf{k_\mu}$ remain the same. $\mathbf{S_p}$ is dependent on ductility, but this is constant for ductilities of 2 or more ie: $\mathbf{S_p = 0.70}$

When using ductility μ, as the response reduction parameter, the **response reduction factor,** $\mathbf{k_d}$ = $\mathbf{S_p/k_\mu}$ That is, it is applied to the elastic response spectra. Larger reduction factors are more conservative as the demand is therefore greater.

A significant problem with the use of ductility to determine response ie: $\mu = \delta_u/\delta_y$ is that this takes no account of the shape of the hysteretic loop. For instance, all the hysteresis diagrams shown in **Appendix C** have the same ductility as calculated by this equation but different damping energy dissipation, as related to the areas of the hysteretic loops. This is apparent by comparing the spectral reduction factors for each case ie: they vary from **0.394** for Full Elasto-Plastic case to **0.746** for the Flag Shape case ie: 190% greater demand for the Flag shape case.

Also evident from the various hysteresis shapes is that, using the P21 method, the ductility would be 7.0/1.0 = 7 for the two Elasto-plastic cases and 7.0/(4/3) = 5.25 for the Bi-Linear and Flag shape cases, limited in both cases to μ = 4.0 per the P21 method but still greater than the actual ductility of 3.5.

Some of these issues have been raised in SR220 (Ref. 6) and a new modification factor, F1, the Hysteresis factor is proposed in Section 6 of this report to account for the difference in the assumed

Hysteresis loop shape and the effect on seismic demand. Various formulae are proposed to determine the F1 factor for different types of systems and for different soil classes.

The F1 factors are summarised in Table 7 of SR220: EM3-V3 (Ref. 6) for Plasterboard lined, nailed LTF walls and "other" types of lined, nailed LTF walls (eg: plywood sheathed) for a range of wall deflections, and it is noted in SR220 that NZS3604 is based on NZS4203 and if NZS3604 adopts NZS1170 then the F1 factors will need modification.

6.4 Approach used for Metalcraft SIP

The method used in this report to determine the system ductility is, to some extent, based on the methods proposed by Park. By inspection of the hysteretic loops produced from the Scion tests, an approximate elastic stiffness is determined ie: for μ = 1.0 in order to derive a 'best fit' bi-linear elasto-plastic design hysteresis curve. Typically this is based on the force at a displacement of 8mm This is the SLS (elastic) displacement limit adopted in the P21 test method, based on a 2400mm high bracing panel and an acceptable SLS displacement limit of height/300. The yield displacement is then calculated by assuming a bi-linear force/displacement diagram of the same effective area as the actual 'parent' curve from the test hysteresis diagram (essentially equal areas = equal energy). See Figure 1 below as an example for the 1200mm long Metalcraft panel test.

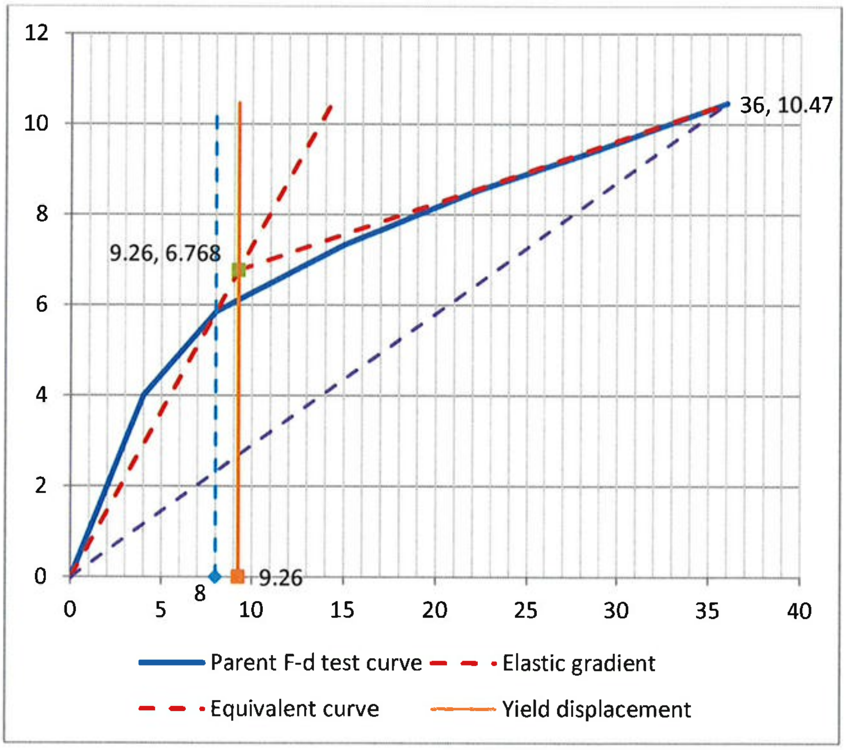


Figure 1: Equivalent Bi-linear elasto-plastic curve, 1200mm long Metalcraft test panel

Once the yield displacement, δ_y has been determined, the displacement ductility, μ can be determined ie: $\mu = \delta_u/\delta_y$ and from this, the response reduction factor, $k_d = S_p/k_\mu$ per NZS1170.5.

The results of the assessment based on this methodology are included in **Appendix C**

6.5 Recommended K4 factors

On the basis of the above discussions, the K4 factor derived from the P21 tests as used in the Scion test reports (all taken as K4 = 1.00) should be revised down per **Table 3** below appropriate to the ductility achieved in the tests. (Refer to calculations included in **Appendix C**)

Table 3: Recommended K4 factors:

μ	1.00	2.00	2.50	2.75	3.00	3.50	4.00
K4	0.30	0.69	0.80	**0.85**	0.90	**1.00**	1.10

7.0 Bracing Ratings:

7.1 Summary

Based on the testing and analysis the following is a summary of the bracing capacity

Brace Type	Panel Type	Core type	Minimum. Length (mm)	Wind BU/m*	EQ BU/m*
MC-T12	ThermoPanel	EPS	1200	161	175
MC-M11	MetecnoPanel	PIR	1120	148	158
MC-T6	ThermoPanel	EPS	610	105	116
MC-M6	MetecnoPanel	PIR	610	98	109

Notes:

(1) Based on a tested wall height of **2.4m**. See 5.1 below for capacity adjustment for walls of other heights.

(2) *Maximum BU/m = **120 for timber floors**

(3) *Maximum BU/m = **150 for concrete floors**

(4) 100BU's = 5kN ie: 1kN = 20 BU's

(5) Higher values indicated may be used with SED subject to a CPEng(NZ) engineer verifying the capacity of the hold-down connections. (See further comments below).

(6) Panels with large openings are not considered suitable as bracing panels ie: only panels with small penetrations such as power outlets and light switches may be used for bracing.

7.2 Discussion

Bracing capacities have been calculated generally in accordance with the P21 method using the formulae and parameters indicated below Table 4.

Values are given in kN and have then been multiplied by 20 to give BU/m (Bracing Units per metre length of wall).

Table 4: Summary bracing ratings:

Test #	Length (mm)	$R_{y(av.)}$ (kN)	P_8 (kN)	$P_{y(av.)}$ (kN)	δ'_y (mm)	ductility μ_{eff} (2)	K4 (3)	Wind BU/m	EQ BU/m
1 (1)	2400	25.00	12.90						
2	1200	10.01	5.85	11.13	9.26	3.89	1.047	161	175
3	1120	8.75	4.90	9.47	9.66	3.73	1.010	148	158
4	610	3.74	1.90	3.94	10.47	3.44	0.945	105	116
5	610	3.80	1.77	4.07	11.50	3.13	0.876	98	109

(1) Test wall 1 capacity could not be determined as capacity of test rig was exceeded

(2) Effective ductility for equivalent Bi-Linear elasto-plastic curve

(3) Based on demand ductility μ = **3.5** per NZS 3604:2011

- **K1** = per Scion test results; **K2** = **1.20** Per P21 method
- Earthquake bracing capacity the lesser of: **EQ** = **(k_ζ/S_p) . R_y** or **EQ** = **(P8.K1) . K2/0.55**
- Wind bracing capacity the lesser of: **W** = **P_y** or **W** = **(P8 . K1) . K2/0.71**

8.0 Recommendations:

8.1 Capacity adjustment for different wall lengths:

The P21 method (Section 14.5) allows the bracing capacity in BU's/m determined from tests to be applied to walls **up to twice the tested wall length** eg: for a tested wall length of 1.2m, the bracing capacity may be applied to walls up to 2.4m in length.

It is interesting to note that NZS3604 Section 8.3.1.3 does not place the same limit on walls longer than those tested. There is no guidance in Ref. 3 as to why this limit is ignored in NZS3604:2011. **It is therefore recommended that the Metalcraft bracing panel lengths are limited to no more than twice the tested length.**

8.2 Capacity adjustment for different wall heights:

The bracing capacity has been derived from tests of 2.4m high panels. NZS3604 Section 8.3.1.4 applies a pro rata factor to the capacity of walls of heights greater than 2.4m but no adjustment is permitted for wall less than 2.4m high ie: the rating must be the same as if the wall was 2.4m high.

BRANZ SR220 (EM3-V3) (Ref. 6) Section 9.2 indicates that using the height ratio "is justifiable only if the panel strength is governed by rocking". The strength of the Metalcraft panels are, as noted in Section 2.2 above, governed by rocking and this method is therefore justifiable for Metalcraft panel systems.

From a SED point of view, this is also justifiable where the strength of the panel is governed by the capacity of the end hold-down connections, as is the case with the Metalcraft panel bracing systems. Calculations indicate that slightly larger capacities can be achieved by longer panels but this generally exceeds the upper limits (See Section 8.3 below) of 120BU/m for timber floors and 150BU/m for concrete floors ie: there is no benefit in using these higher values unless full SED is carried out.

8.3 Maximum bracing values:

The use of **120BU/m for Metalcraft panels** with **timber** floors and **150BU/m** with **concrete** floors is considered acceptable based on the Scion test results.

Higher values indicated in table 4 may be used with SED subject to a CPEng(NZ) engineer verifying the capacity of the hold-down connections.

8.4 General bracing provisions of NZS3604:

Given that the Metalcraft wall test results typically indicate hysteresis loops similar or better (ie: 'fatter') than sheet lined LTF walls, it is considered reasonable that all the general provisions of NZS3604: 2011, Section 5 with respect to bracing distribution, minimum bracing units, diaphragm requirements etc. can also be applied to buildings braced with Metalcraft wall panel systems where they fall within the general scope noted in Section 1.0 above.

8.5 Specifically designed bracing systems used in conjunction with Metalcraft wall bracing systems:

The use of BU's is intended for use with NZS3604 LTF types of construction and the BU rating assumes inherent redundancies associated with LTF buildings. BU capacities are not based on *characteristic* values but on *mean ultimate* values. Design engineers should be aware of these crucial differences and make appropriate allowance for the resistance of critical structural elements. Consequently, where specifically designed bracing systems eg: steel portal frames or similar are used in conjunction with Metalcraft wall panel bracings systems, the use of strength reduction factors may be appropriate.

It is noted that, in the design of SED bracing elements such as steel portal frames, the SLS limit for the steel portal frame usually determines the frame size, so the above factors are not likely to influence the design of SED bracing systems if an appropriate rational **displacement based design** methodology is used.

REPORT PREPARED BY:

R J TWINAME
CPENG(NZ)
INTPE(NZ)
BE, MIPENZ (CIVIL, STRUCTURAL)

References:

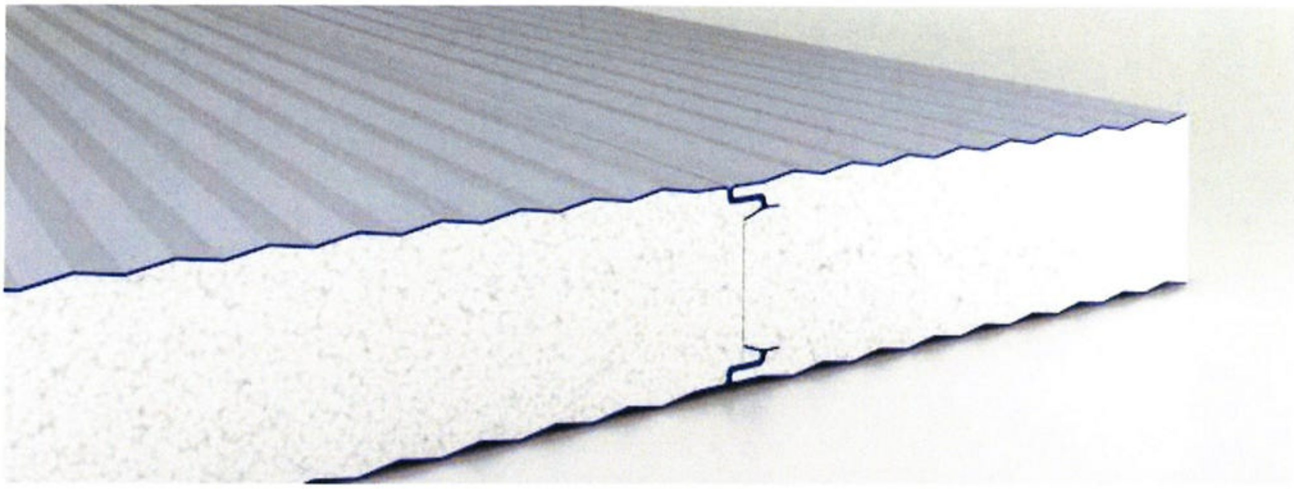
1. BRANZ Technical Paper P21(2010) "A wall bracing test and evaluation procedure", Roger Shelton
2. NZS 3604: 2011: Timber-framed buildings
3. BRANZ "Engineering Basis of NZS3604", April 2013.
4. NZS1170.5: 2004: Earthquake actions – New Zealand
5. Technical Recommendation No:10, December 1991(TR10), A B King and K Y S Lim
6. BRANZ SR220(2010): EM3-V3, S. J. Thurston
7. AS/NZS1170.0: 2002: General Principles
8. AS/NZS1170.2: 2011: Wind Actions

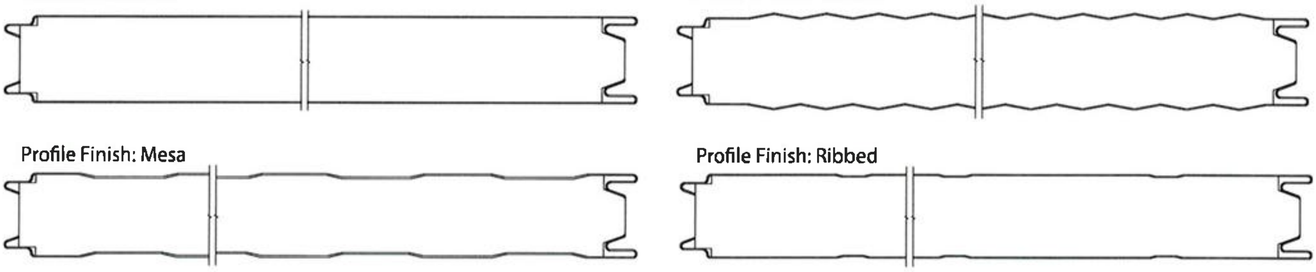
Appendix A: Product data sheets and bracing panel details:

ThermoPanel EPS

Metalcraft
Insulated Panel Systems
Ph: (09) 2620267
Fax: (09) 2620268
Issue Date June 2009

ThermoPanel EPS is a stressed skin sandwich panel, comprised of pre-painted steel skins continuously laminated over a fire retardant Polystyrene (EPS) core. The EPS core is fire retardant. ThermoPanel EPS is available is a range of colours with a variety of profile finishes, providing greater strength in walls and a clean, smooth aesthetic look.





Product Properties

Width:	1200mm
Panel External Facing:	0.59mm CP Grade Prepainted Galvanised Steel. Titania colour standard.
Panel Internal Facing:	0.59mm CP Grade Prepainted Galvanised Steel. Titania colour standard.
Panel Core:	Class S Standard
Fire Rated:	No
Fire Resistant:	No
FM Approved:	No

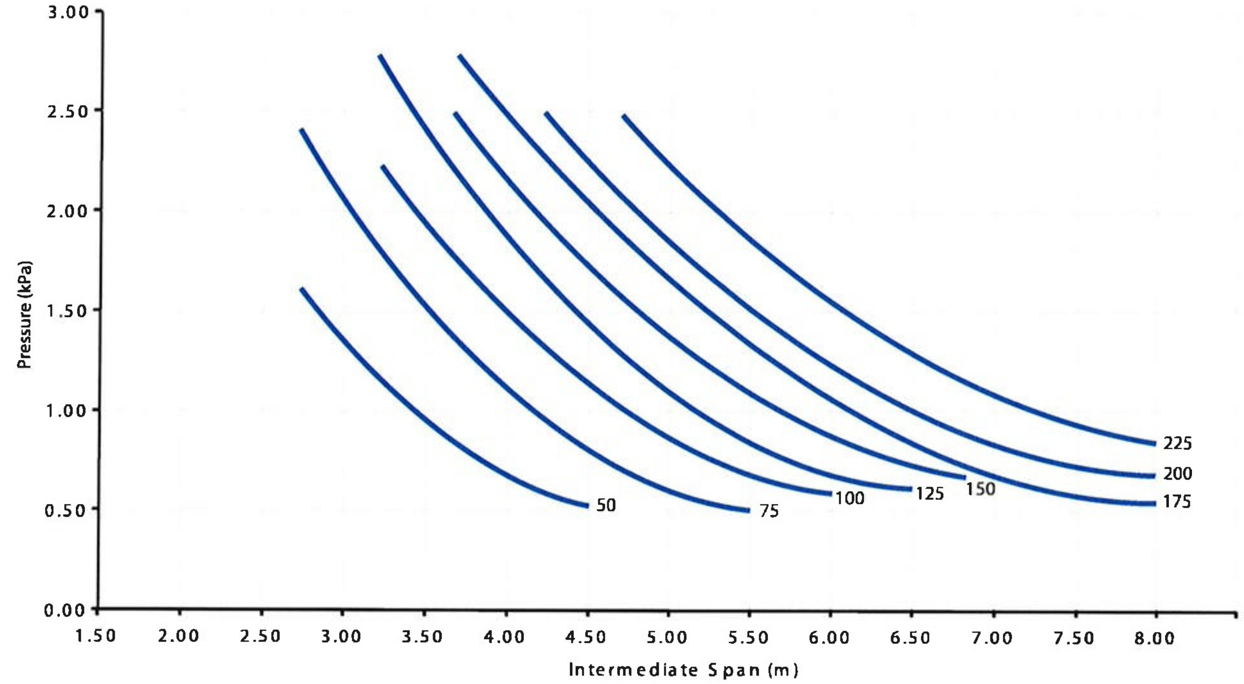
Thickness(mm)	50	75	100	125	150	200	250
Mass (Kg/m ^{2})	11.30	11.60	12.00	12.30	12.70	13.30	14.00
U Value (W/m ^{2}K)	0.76	0.51	0.38	0.30	0.25	0.19	0.15
R Value (m ^{2}K/W)	1.32	1.97	2.63	3.29	3.95	5.26	6.58

ThermoPanel EPS

Metalcraft
Insulated Panel Systems

Ph: (09) 2620267
Fax: (09) 2620268
Issue Date June 2009

ThermoPanel EPS UDL Graph



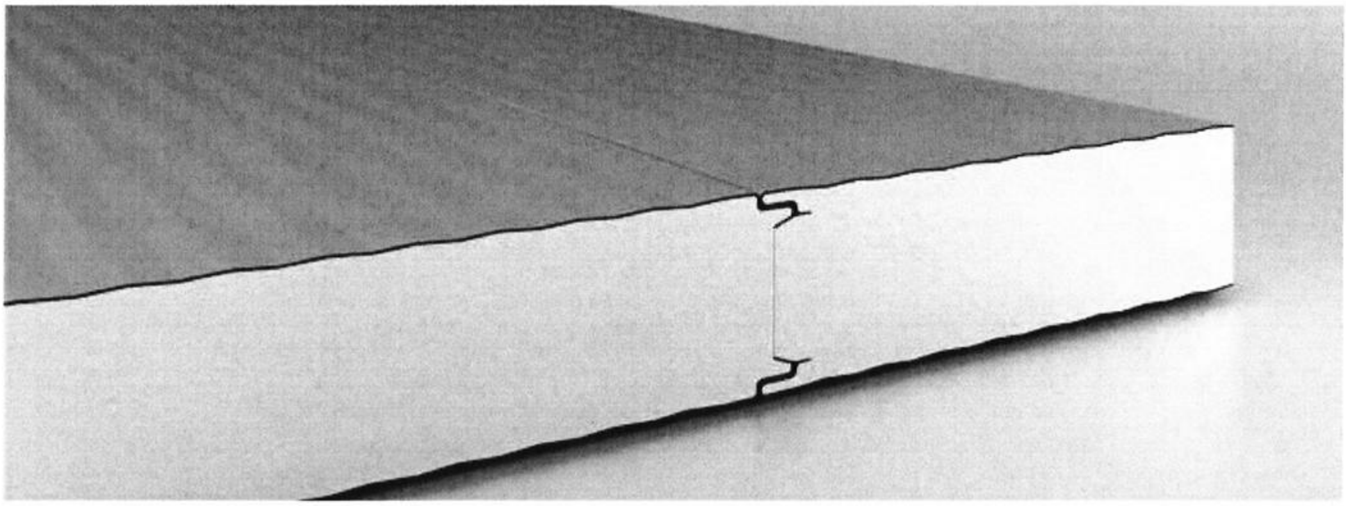
1. Allowable wind pressure is in accordance with AS1170.2 for permissible stress analysis.
2. Factor of Safety = 1.80 on Ultimate

MetecnoPanel

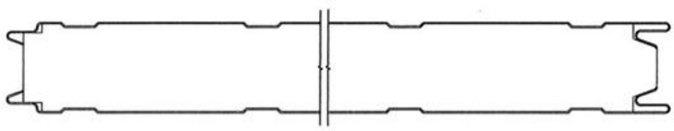
Metalcraft
Insulated Panel Systems

Ph: (09) 2620267
Fax: (09) 2620268
Issue Date June 2009

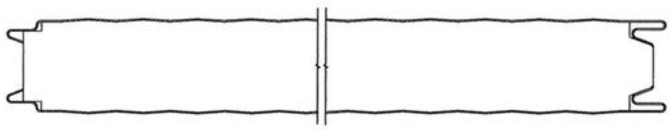
MetecnoPanel is a lightweight sandwich panel with a built in PIR fire resistant core. MetecnoPanel is available in a variety of thicknesses and three different finishes. Durable and aesthetically attractive, MetecnoPanel wall and ceiling panels provide high thermal resistance, mechanical resistance and dimensional stability.



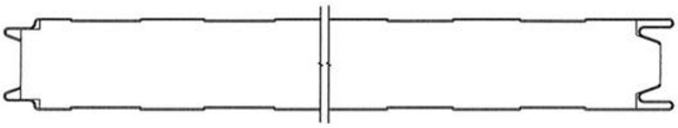
Profile Finish: Standard Rib



Profile Finish: Satinline



Profile Finish: Fineline



Product Properties

Width:	1100mm
Panel External Facing:	0.60mm CP Grade Prepainted Galvanised Steel. Titania colour standard.
Panel Internal Facing:	0.60mm CP Grade Prepainted Galvanised Steel. Titania colour standard.
Panel Core:	PIR, Polyisocyanurate
Fire Rated:	No
Fire Resistant:	Yes
FM Approved:	Yes

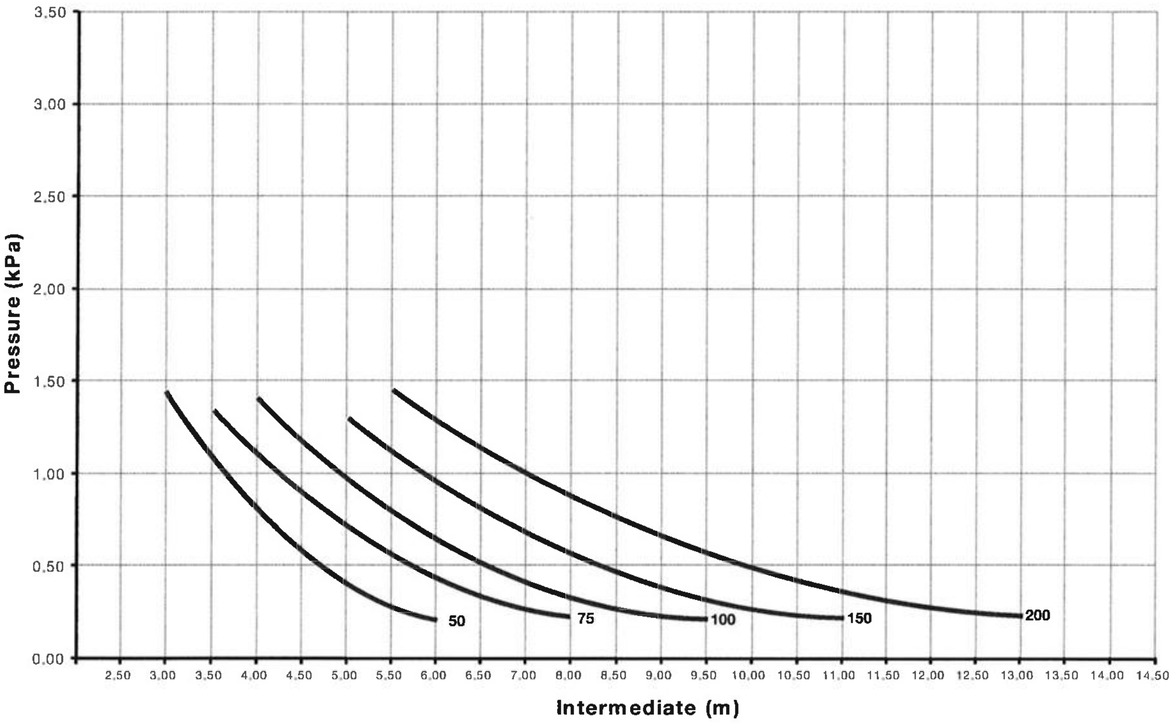
Thickness(mm)	50	75	100	150	200
Mass (Kg/m²)	12.03	13.00	13.99	15.49	17.39
U Value (W/m²K)	0.41	0.28	0.21	0.14	0.11
R Value 8°C (m²K/W)	2.40	3.60	4.80	7.10	9.10

MetecnoPanel

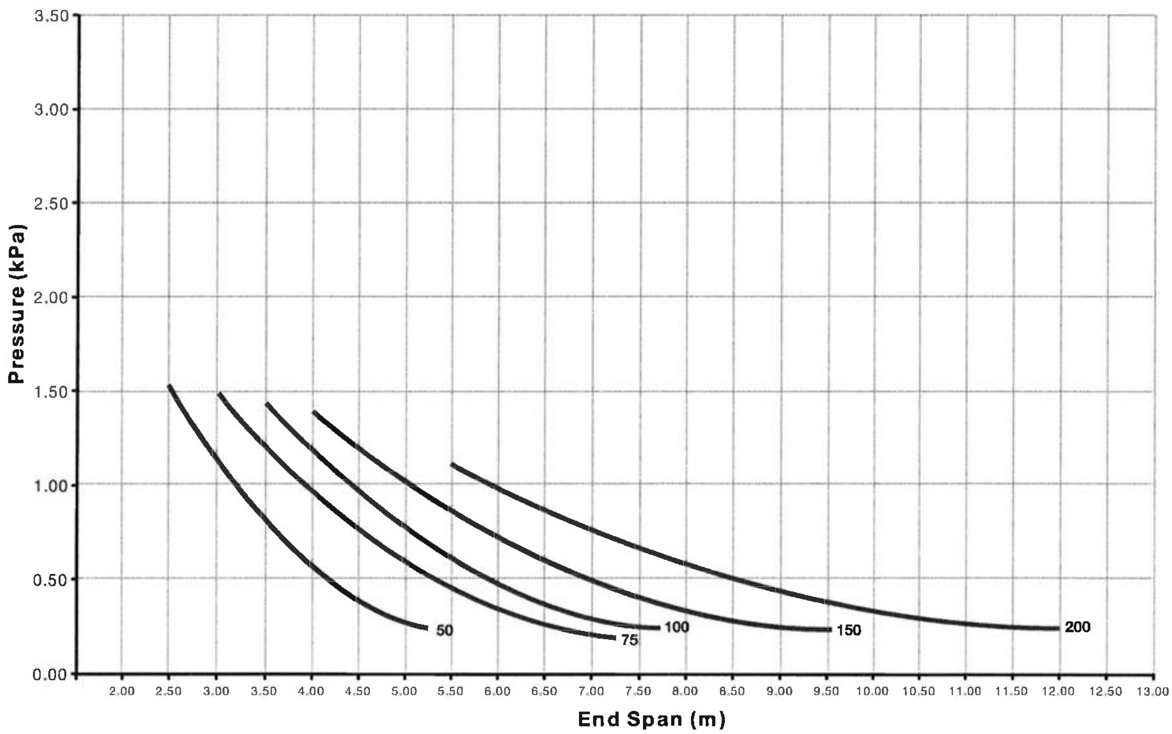
Metalcraft
Insulated Panel Systems

Ph: (09) 2620267
Fax: (09) 2620268
Issue Date June 2009

MetecnoPanel UDL Graph Multiple Span Case



MetecnoPanel UDL Graph Single Span Case



1. MetecnoPanel has 0.60mm base steel skins with a Polyisocyanurate core.
2. Tabulated values apply for uniform live loads only. No dead loads.
3. Permissible spans are based on a deflection limit of span/200 and a minimum safety coefficient of 3 on ultimate strength.

Technical Specification Sheet

Metalcraft Insulated Panel Systems

TABLE 1: FIRE PERFORMANCE

	POLYPHEN	PIR	EPS
Insurer approved	Yes FM 4880 Class 1	Yes FM 4880 Class 1	Refer to Insurer
AS 1530.4 Fire rating of elements **Structural element requires specific engineering**	100mm -/45/45 125mm -/60/60 200mm -/120/120	200mm -/30/30	-/10/-
Flame barrier NZBC C/AS1 part 6	Yes	Yes	Yes
ISO 9705 BCA Classification	Group 1-S	Group 1-S	Group 1-S & 2
SMOGRA Smoke Growth Rate	2.2	1.0	3.0
Toxicity	Very Low	Low	Low

***Specific construction system required.**

TABLE 2: ENGINEERING DETAILS

	POLYPHEN	PIR	EPS
Water absorption W/ V%	Very low	Very low	Very low
Crushing/compressive strength to 10% deformation	126kPa	>100kPa – average 130	85kPa
Cross breaking strength	248kPa	240kPa	186kPa
Thermal Control.	Good	Best	Good
Recyclable	Yes	Yes	Yes
Workability	Excellent. No requirement for protection.	Dust masks recommended.	Excellent. No requirement for protection.
Span capabilities of panel.	Good	Good	Better

TABLE 3: NOMINAL WEIGHTS (kg/m²)

	POLYPHEN	PIR	EPS
50mm	12.7	12.0	11.6
75mm	14.0	13.0	12.0
100mm	15.2	14.0	12.3
150mm	17.6	15.5	13.1
200mm	19.2	N/A	13.9
250mm	20.8	N/A	14.7

TABLE 4: THERMAL RESISTANCE (R Value at 15oc)

	POLYPHEN	PIR	EPS
50mm	1.50	2.4	1.31
75mm	2.27	3.6	1.96
100mm	3.00	4.8	2.62
150mm	4.45	7.1	3.92
200mm	6.04	N/A	5.23
250mm	7.64	N/A	6.54

TABLE 5: THICKNESS FOR CHILLERS AND FREEZERS

OPERATING TEMPERATURES (°C)	POLYPHEN	PIR	EPS
7.0 down to -3.0	75mm	50mm	75mm
3.0 down to -3.0	100mm	75mm	100mm
-3.0 down to -18.0	125mm	100mm	150mm
-18.0 down to -23.0	150mm	150mm	175mm
-23.0 down to -30.0	175mm	150mm	200mm

*Allow an additional 50mm thickness for walls and roofs exposed to direct sunlight.
*Consideration should be given to insulating floor detail.
*Values are guides only and are given for cool rooms operating under average ambient conditions.

TABLE 6: SPAN DATA

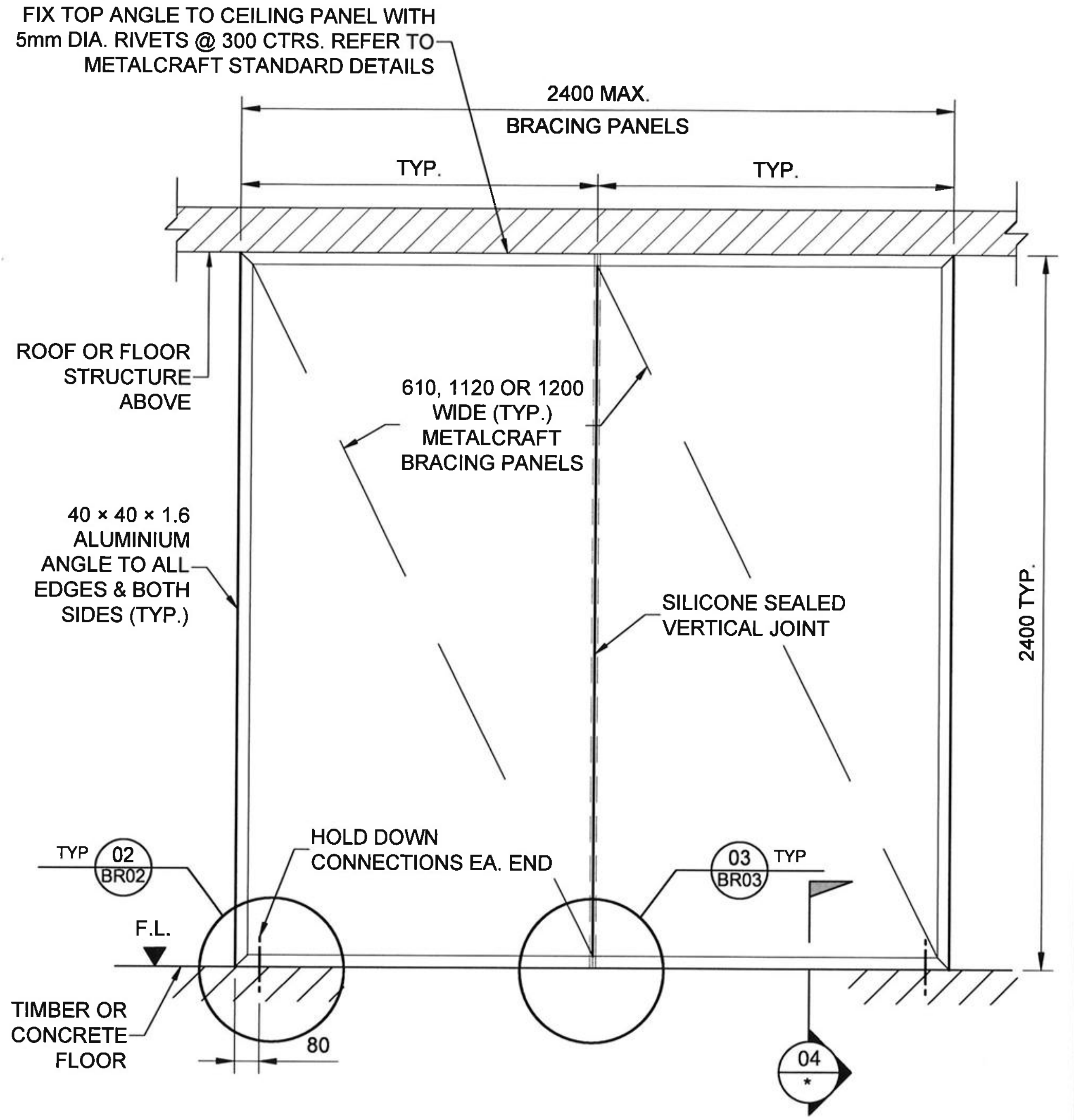
	POLYPHEN			PIR			EPS		
	Internal Wall & Ceiling 0.50kPa*	External 0.75kPa	External 1.0kPa	Internal Wall & Ceiling 0.50kPa*	External 0.75kPa	External 1.0kPa	Internal Wall & Ceiling 0.50kPa*	External 0.75kPa	External 1.0kPa
50mm	6.0	4.6	4.0	4.9	3.9	3.5	5.0	4.0	3.5
75mm	7.3	5.7	4.9	5.8	4.8	4.1	5.9	4.9	4.4
100mm	8.4	6.6	5.7	6.7	5.4	4.9	6.9	5.6	5.0
150mm	9.1	8.1	7.0	8.2	6.7	6.0	8.5	7.0	6.1
200mm	11.5	9.4	8.1	9.2	7.7	6.8	9.6	8.0	7.0
250mm	12.8	10.5	9.1	10.0	8.4	7.7	10.5	8.8	7.8

*Spans are indicative only and apply to wall and roof profiles using 0.6 BMT steel, specific site conditions and fire rated structures need to be calculated by a certified engineer.
*For canopies and snow load use AS1170.3.
*For wind speed direction refer to code AS1170.2 regions A6 and A7 and W, by default use 1.00Kpa, note wind pressure depends on life of building.
*0.50kPa loading takes account of fire load.

TABLE 7: DIMENSIONS AND TOLERANCES

BUILDING COMPONENT	PROFILE	EFFECTIVE COVER ±1mm	MIN. LENGTH ±5mm	MIN. ROOF PITCH
Wall & Ceilings – Thermopanel	Flat, Ribbed, Satin Line	1200mm	500mm	N/A
Roofing – Thermospan	Flat, Ribbed, Satin Line	1000mm	500mm	3°
Roofing – Thermopanel	Flat, Ribbed, Satin Line	1200mm	500mm	3°

* Roof pitches will vary depending on site conditions, loads, purpose, configuration, snow loading and span requirements.
* Buildings designed with widely spaced purlins and portal frames may require a frame pitch increase of 1.5%.
* Under the building code, insulated panel used as a cladding is an Alternative Solution. In a roofing application, Metalcraft New Zealand panel satisfies the requirements of the NZBC External Moisture – Clause E2, when correctly specified and installed with flashings, which direct the flow of water away from the building envelope.



01 - TYPICAL BRACING PANEL LAYOUT

* REFER TO RELEVANT BR4 DETAILS:

- BR4-ET : EXTERNAL, TIMBER FLOOR
- BR4-EC : EXTERNAL, CONCRETE FLOOR
- BR4-IT : INTERNAL, TIMBER FLOOR
- BR4-IC : INTERNAL, CONCRETE FLOOR

Checked By: RT

Scale: 1:20 Date: 09/2016

AIREY CONSULTANTS LTD.
CONSULTING CIVIL & STRUCTURAL ENGINEERS
Takapuna, Pukekohe, Howick, Queenstown

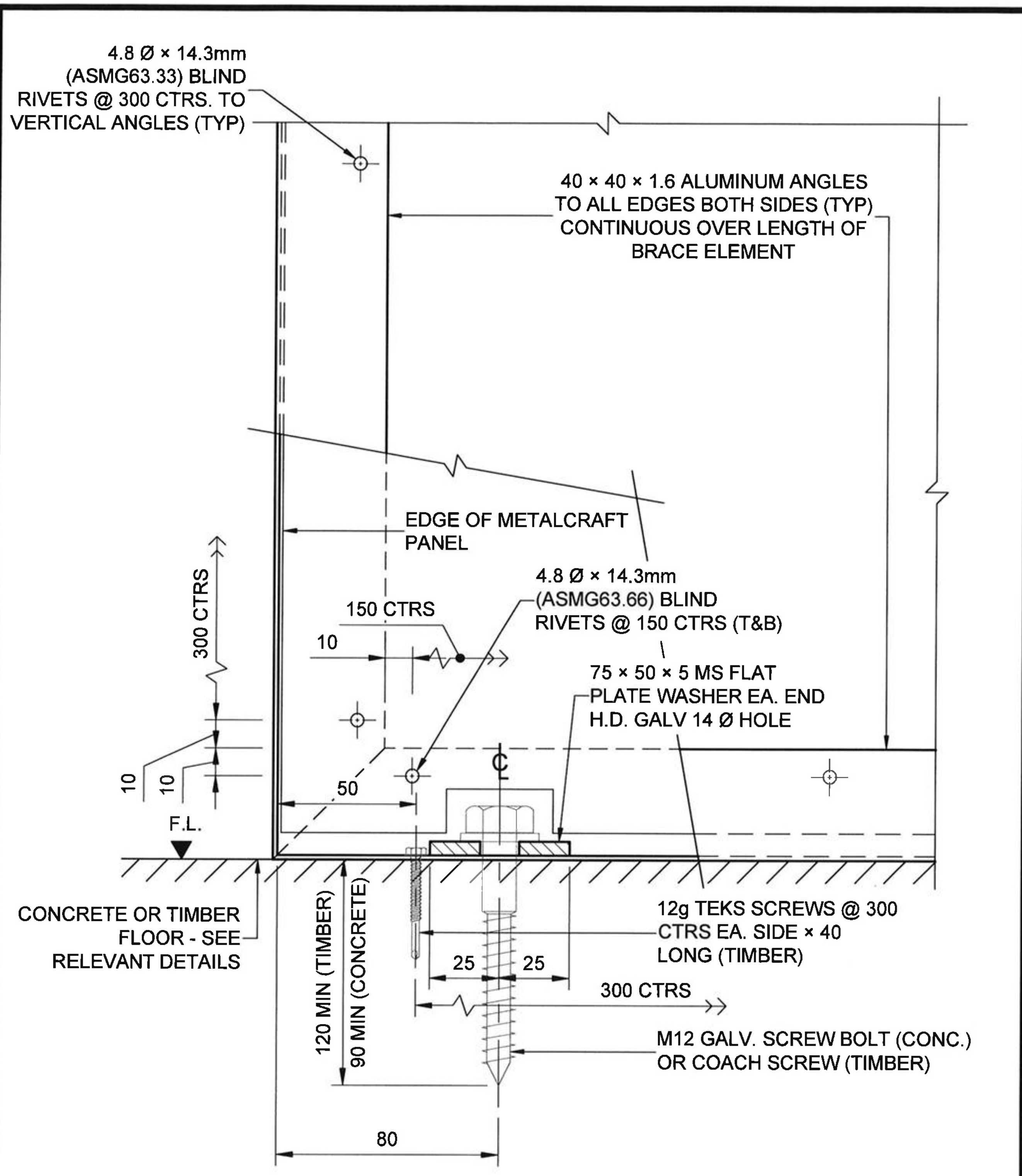
METALCRAFT BRACING SYSTEMS

TYPICAL BRACING PANEL LAYOUT - ELEVATION

File No. 12191-01

Sht. No. BR01

CAD Filename: 12191-01-002-B01-B04.dwg



02 / BR01 TYPICAL HOLD DOWN DETAILS

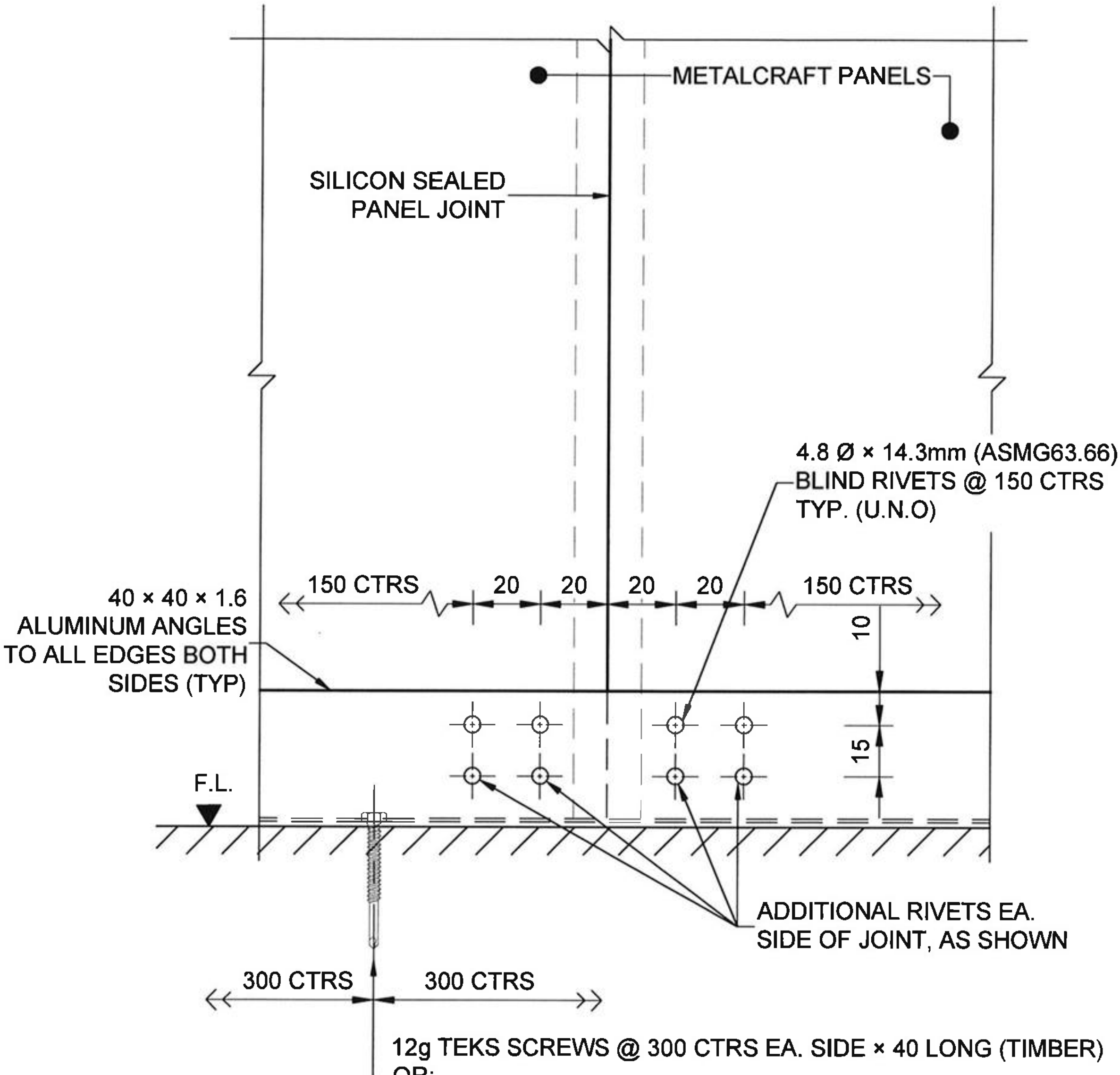
Checked By: RT

Scale: 1:2

Date: 09/2016

AIREY CONSULTANTS LTD. CONSULTING CIVIL & STRUCTURAL ENGINEERS Takapuna, Pukekohe, Howick, Queenstown	METALCRAFT BRACING SYSTEMS	TYPICAL HOLD DOWN DETAILS	
		File No. 12191-01	Sht. No. BR02

CAD Filename: 12191-01-002-B01-B04.dwg



03 / BR01

TYPICAL PANEL JOINT DETAIL

NOTE:

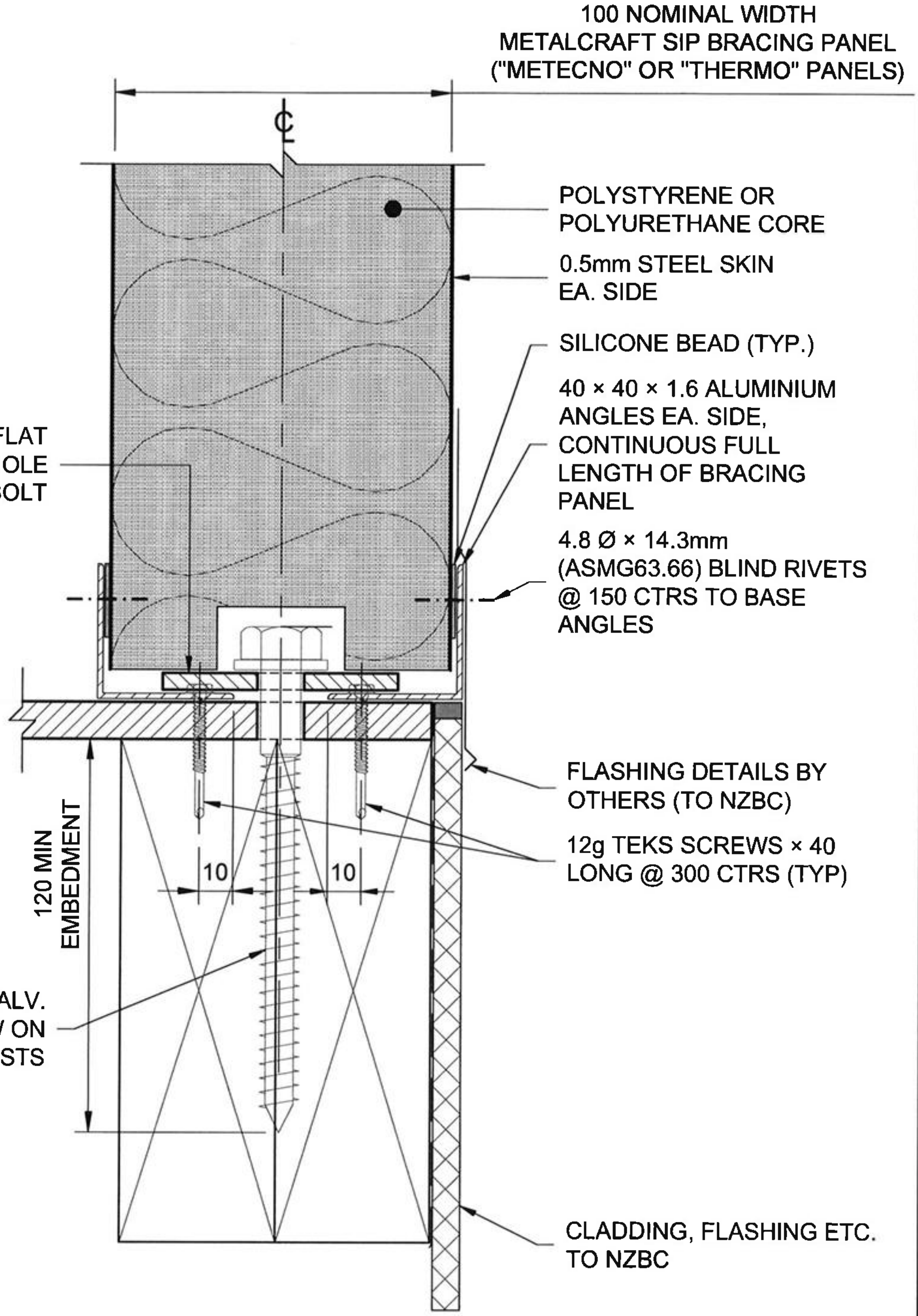
- DETAILS SIMILAR AT TOP & BOTTOM OF ALL BRACING PANELS, BOTH SIDES

Checked By: RT

Scale: 1:2 Date: 09/2016

AIREY CONSULTANTS LTD. CONSULTING CIVIL & STRUCTURAL ENGINEERS Takapuna, Pukekohe, Howick, Queenstown	METALCRAFT BRACING SYSTEMS	TYPICAL PANEL JOINT DETAIL
		File No. 12191-01 / Sht. No. BR03

CAD Filename: 12191-01-002-B01-B04.dwg



04 / BR01

TYPICAL BRACING PANEL DETAILS
EXTERNAL TIMBER

NOTE:

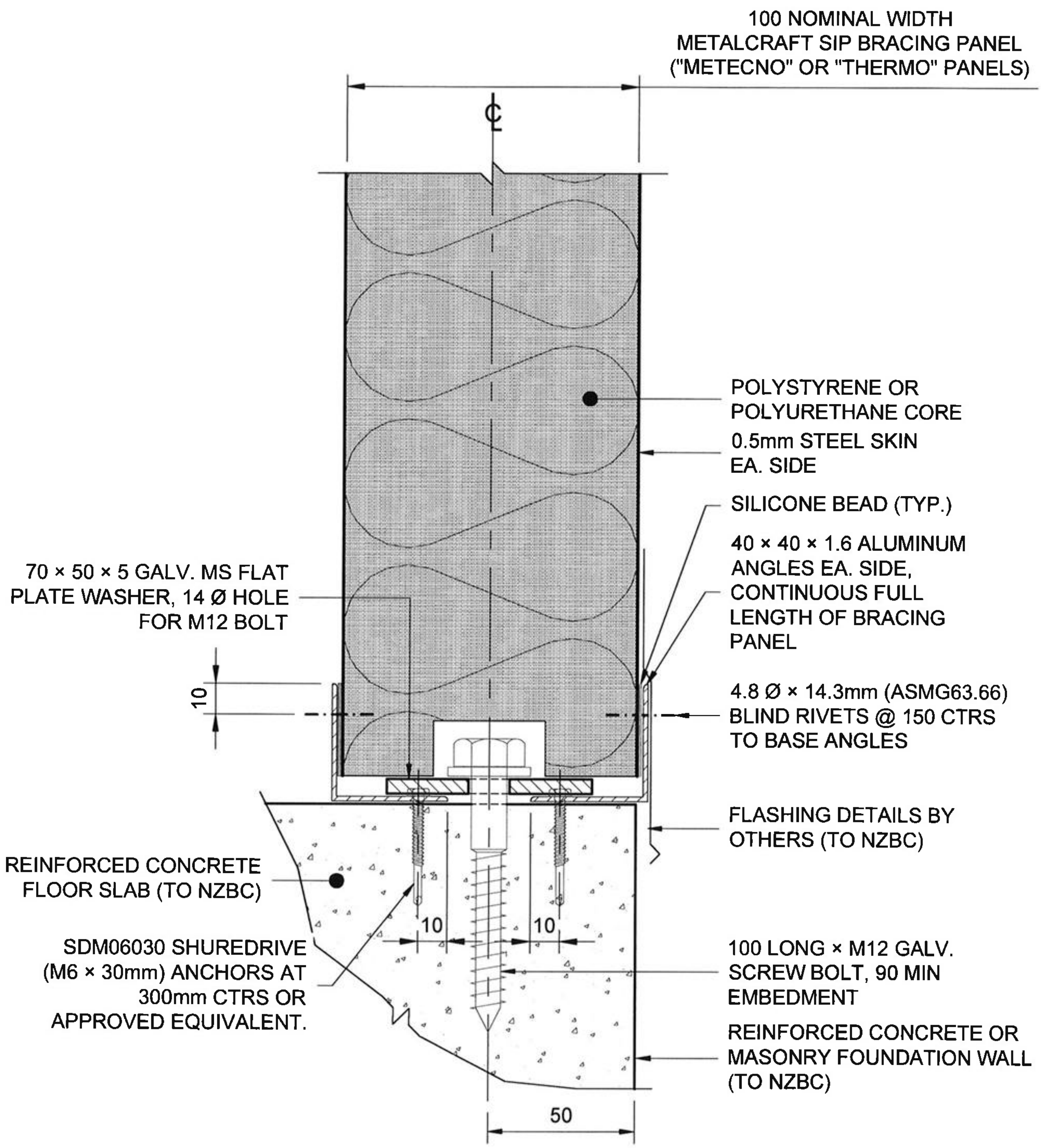
- ALL TIMBER FLOOR DETAILS TO E2/AS1 & NZBC.

Checked By: RT

Scale: 1:2 | Date: 09/2016

AIREY CONSULTANTS LTD. CONSULTING CIVIL & STRUCTURAL ENGINEERS Takapuna, Pukekohe, Howick, Queenstown	METALCRAFT BRACING SYSTEMS	TYPICAL BRACING PANEL DETAILS- EXTERNAL TIMBER	
		File No. 12191-01	Sht. No. BR4-ET

CAD Filename: 12191-01-002-B01-B04.dwg



04 / BR01 TYPICAL BRACING PANEL DETAILS
EXTERNAL CONCRETE FLOOR

Checked By: RT

Scale: 1:2

Date: 09/2016

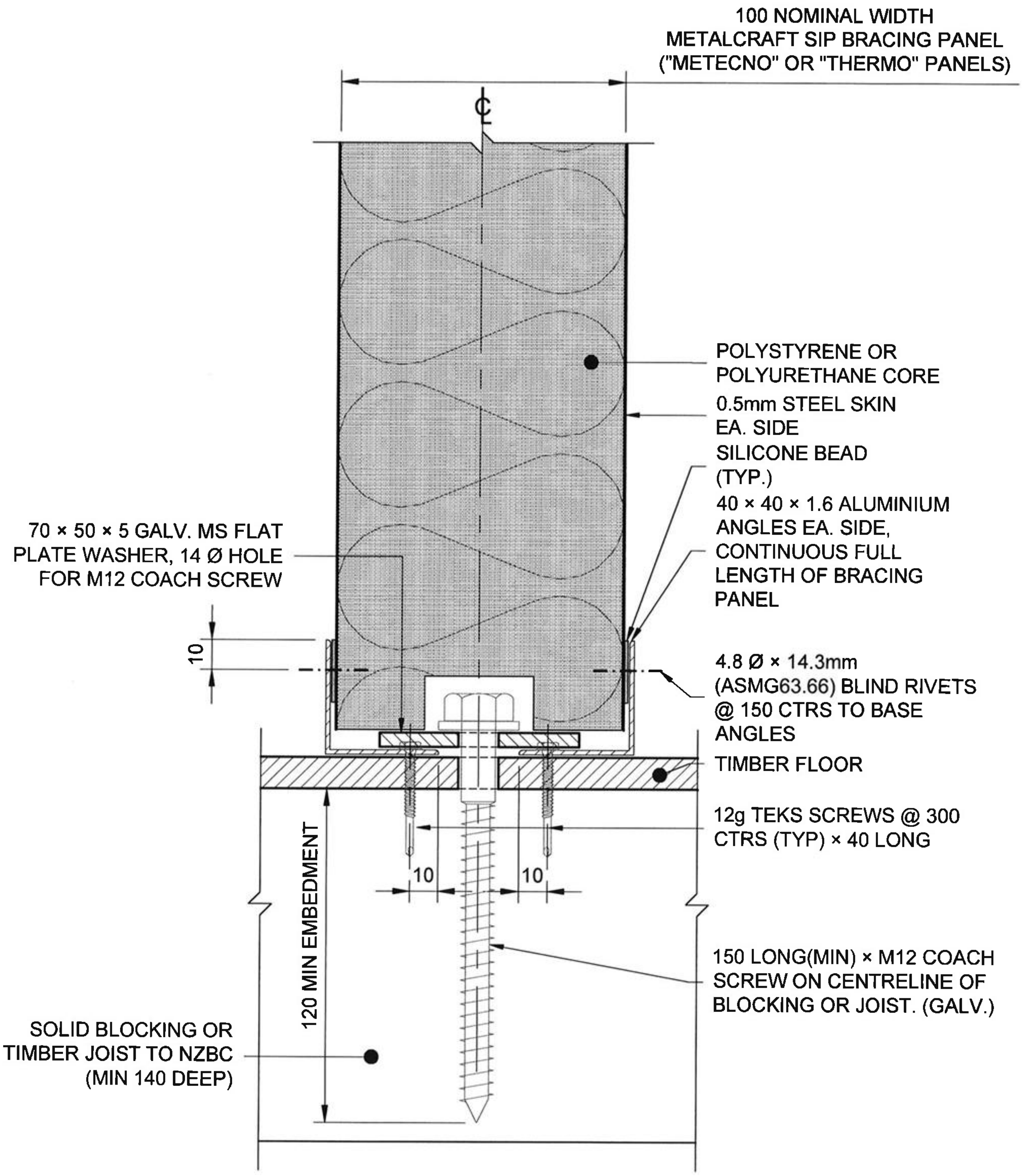
AIREY CONSULTANTS LTD.
CONSULTING CIVIL & STRUCTURAL ENGINEERS
Takapuna, Pukekohe, Howick, Queenstown

METALCRAFT BRACING SYSTEMS

TYPICAL BRACING PANEL DETAILS - EXTERNAL CONC.

File No.	Sht. No.
12191-01	BR4-EC

CAD Filename: 12191-01-002-B01-B04.dwg



04
BR01

TYPICAL BRACING PANEL DETAILS
INTERNAL TIMBER FLOOR

Checked By: RT

Scale: 1:2

Date: 09/2016

AIREY CONSULTANTS LTD.
CONSULTING CIVIL & STRUCTURAL ENGINEERS
Takapuna, Pukekohe, Howick, Queenstown

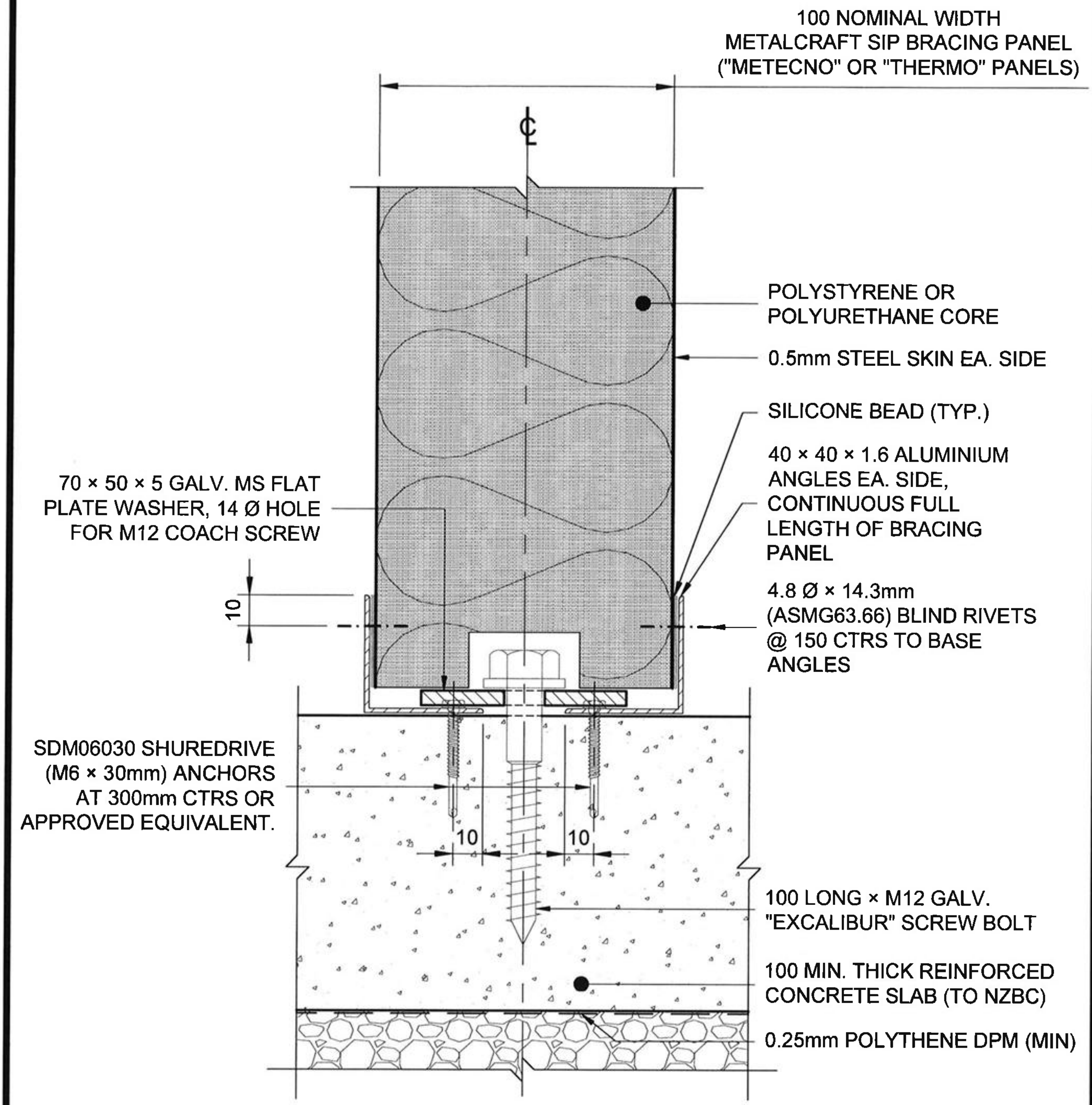
METALCRAFT BRACING SYSTEMS

TYPICAL BRACING PANEL DETAILS - INTERNAL TIMBER

File No.
12191-01

Sht. No.
BR4-IT

CAD Filename: 12191-01-002-B01-B04.dwg



04 / BR01 TYPICAL BRACING PANEL DETAILS

INTERNAL CONCRETE FLOOR (NON-LOAD BEARING)

NOTE:

- LOAD BEARING WALL DETAILS SIMILAR BUT WITH SLAB THICKENING TO NZS 3604.

Checked By: RT

Scale: 1:2 Date: 09/2016

AIREY CONSULTANTS LTD. CONSULTING CIVIL & STRUCTURAL ENGINEERS Takapuna, Pukekohe, Howick, Queenstown	METALCRAFT BRACING SYSTEMS	TYPICAL BRACING PANEL DETAILS - INTERNAL CONC.	
		File No. 12191-01	Sht. No. BR4-IC

CAD Filename: 12191-01-002-B01-B04.dwg

Appendix B: Scion test results:

The full Scion test results are included in the following pages.

A Summary table follows:

Test #	Lab #	Length (mm)	P (kN)	$R_{y(av.)}$ (kN)	ductility μ (2)	CoV (R_y) (%)	Wind BU/m	EQ BU/m
1 (1)	275434-5 (n = 2)	**2400**	25.00	25.00	**2.00**	-	**>100**	**>100**
2	275436-8 (n = 3)	**1200**	11.13	10.01	**4.50**	6.45	**163**	**167**
3	275439-41 (n = 3)	**1120**	9.47	8.75	**4.72**	8.5	**144**	**156**
4	275442-4 (n = 3)	**610**	3.94	3.74	**4.72**	5.07	**108**	**122**
5	275445 (n = 1)	**610**	4.07	3.80	**4.44**	2.24	**109**	**124**

(1) Test wall 1 capacity could not be determined as capacity of test rig was exceeded
(2) Upper limit of ductility, μ permitted by P21 test = 4.0
(3) Wall height = 2400mm for all tests
(4) Values of P, R_y and μ are as defined in the P21 method
(5) CoV is the *coefficient of variation*, per the P21 method and as determined by the Scion testing.

49 Sala Street
Private Bag 3020
Rotorua
New Zealand
Telephone: +64 7 343 5899
DDI: +64 7 343 5763
Facsimile: +64 7 348 0952
Email: douglas.gaunt@scionresearch.com

Results

To:	Peter Zeeman	**From:**	Doug Gaunt
Organisation:	Metalcraft	**Subject:**	P21:2010 – 2400mm Polystyrene SIP
Location:	Auckland	**Date:**	23 June 2016
Fax No.:	09 2778842	**No. of Pages:**	3
Tel No.:	027 2764354		

Please call +64 7 343 5763 if transmission incomplete

Peter

Please find below the results of your single P21:2010 2400mm polystyrene structural insulated panel (SIP) wall bracing test.

1. BU wind = 412 (172 BU/m) as limited by the serviceability load capacity.
2. BU Earthquake = # (# BU/m) as limited by the ultimate load capacity.
   # could not be determined as maximum load of capacity of test rig exceeded.

Please note the P21:2010 test requires three replicates to determine bracing ratings so the results of this single test can only be seen as indicative.

Figure 1 shows the load deflection plot for the first test wall 275434, Figure 2 shows the load deflection plot for the second test wall 275435.

Wall Construction

- 100mm thick Polystyrene core, 0.59mm steel lined SIP
- 40x40x1.6mm aluminium angle each side each face with 4.8x14.3mm (ASMG63.66) blind aluminium rivets at 300mm centres
- 40x40x1.6mm aluminium angle each end each face with 4.8x14.3mm blind aluminium rivets at 300mm (first test) 150mm (second test) centres, held down to bottom plate with 40mm timber Tek screws at 300mm centres.
- 90x45 H1.2 SG8 top, bottom plates and end studs, with two 100mm Tek screws from studs into end of bottom and top plates
- 12mm Hold downs with 70x50x5mm flat steel washers over aluminium angle and 90x45 bottom plate, one each end of wall.

Please note that P21:2010 states that

> "The procedure is not intended to be used for evaluating the performance of concrete or masonry walls, steel-framed walls, post and beam, plank construction or panellised construction, unless the critical components of the wall are laterally loaded steel fasteners installed in timber."

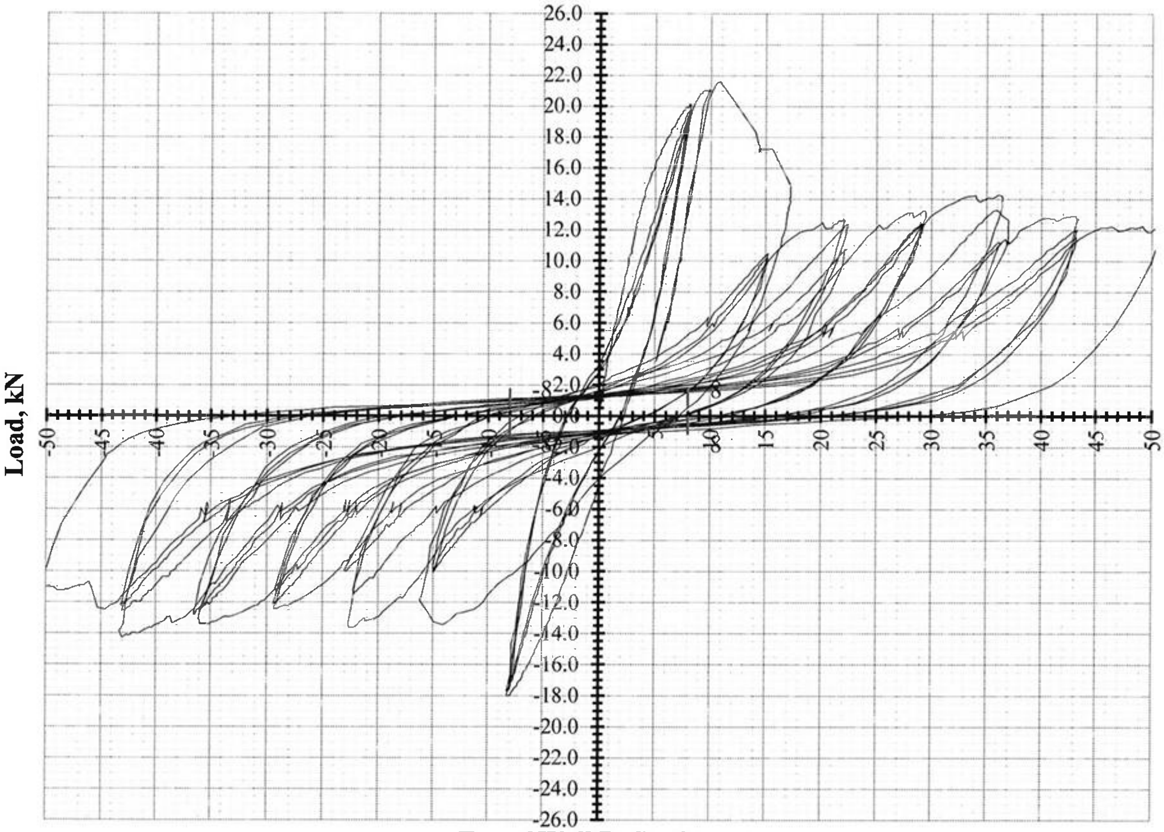


Figure 1: *Wall 275434 (first test)*

<u>Wall test observations</u>

- 70x70x5mm hold down washers bending,
- Buckling of aluminium angles at bottom plate,
- 100mm Tek screws at bottom plate to stud connection bending as studs lift up
- Rivet failure along bottom plate, Note rivets at 300mm centres.

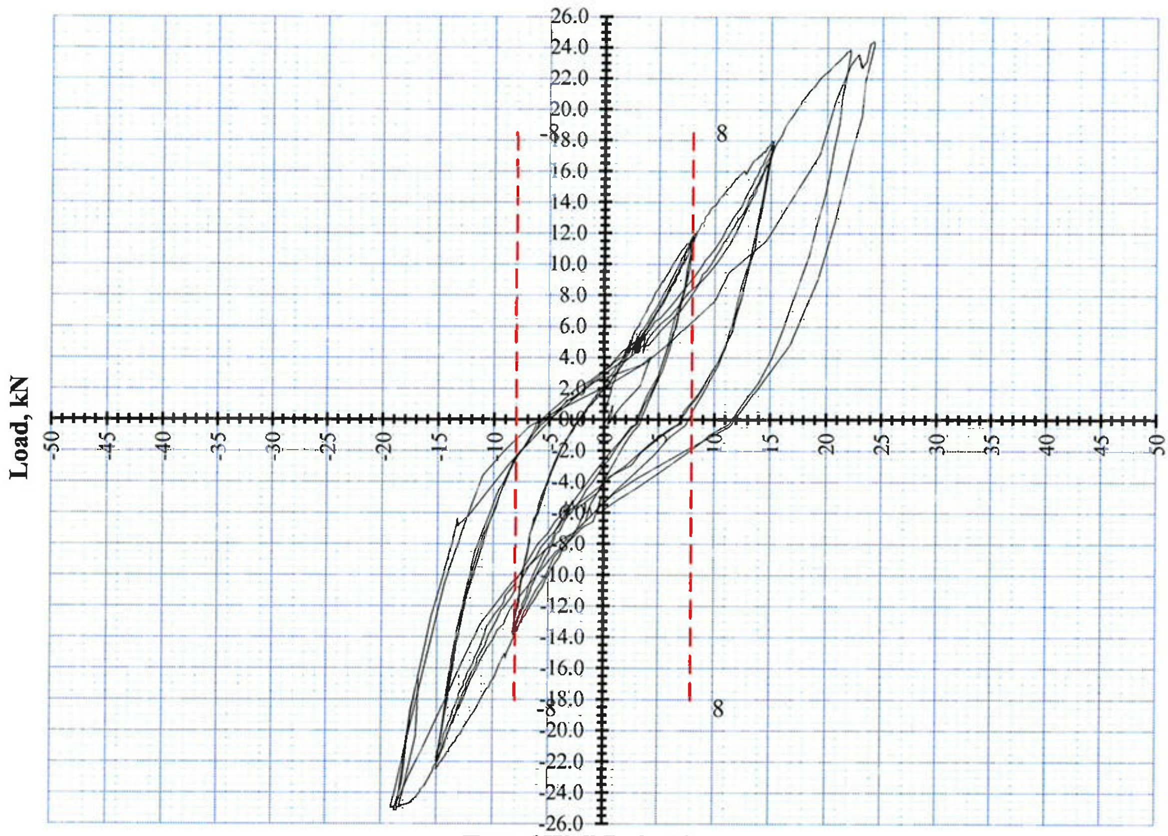


Figure 2: *Wall 275435 (second test)*
Reuse of wall 275434

<u>Wall test observations</u>

- Wall test stopped as maximum load (25kN) of test rig achieved.
- 70x70x5mm hold down washers starting to bend,
- Buckling starting of aluminium angles at bottom plate,
- 100mm Tek screws at bottom plate to stud connection bending as studs lift up
- No Rivet failure along bottom plate, Note rivets at 150mm centres.

Please feel free to contact me to discuss this information.

Doug Gaunt

SCION forests · products · innovation

49 Sala Street
Private Bag 3020
Rotorua
New Zealand
Telephone: +64 7 343 5899
DDI: +64 7 343 5763
Facsimile: +64 7 348 0952
Email: douglas.gaunt@scionresearch.com

Results

To:	Peter Zeeman	**From:**	Doug Gaunt
Organisation:	Metalcraft	**Subject:**	P21:2010 – 1200mm Polystyrene SIP
Location:	Auckland	**Date:**	22 June 2016
Fax No.:	09 2778842	**No. of Pages:**	5
Tel No.:	027 2764354		

Please call +64 7 343 5763 if transmission incomplete

Peter

Please find below the results of your three P21:2010 1200mm polystyrene structural insulated panel (SIP) wall bracing tests.

1. BU wind = 196 (163 BU/m) as limited by the serviceability load capacity.
2. BU Earthquake = 200 (167 BU/m) as limited by the ultimate load capacity.

Figures 1, 2 & 3 show the load deflection plots, Figure 4 shows the P21:2010 calculations.

Wall Construction

- 100mm thick Polystyrene core, 0.59mm steel lined SIP
- 40x40x1.6mm aluminium angle each side each face with 4.8x14.3mm (ASMG63.66) blind aluminium rivets at 300mm centres
- 40x40x1.6mm aluminium angle each end each face with 4.8x14.3mm blind aluminium rivets at 150mm centres, held down to bottom plate with 40mm timber Tek screws at 300mm centres.
- 90x45 H1.2 SG8 top, bottom plates and end studs, with two 100mm Tek screws from studs into end of bottom and top plates
- 12mm Hold downs with 70x50x5mm flat steel washers over aluminium angle and 90x45 bottom plate, one each end of wall.

Please note that P21:2010 states that

> "The procedure is not intended to be used for evaluating the performance of concrete or masonry walls, steel-framed walls, post and beam, plank construction or panellised construction, unless the critical components of the wall are laterally loaded steel fasteners installed in timber."

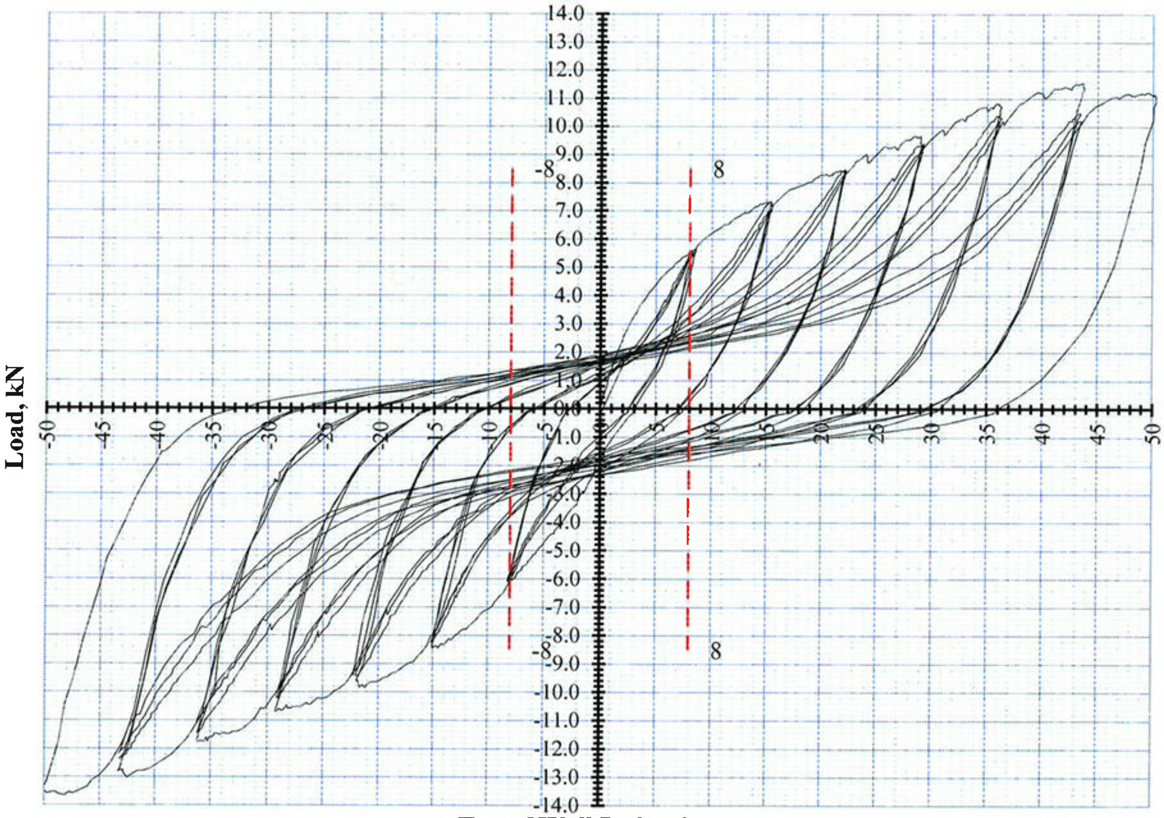


Figure 1: *Wall 275436*

<u>Wall test observations</u>

- 70x70x5mm hold down washers bending,
- Buckling of aluminium angles at bottom plate,
- 100mm Tek screws at bottom plate to stud connection bending as studs lift up
- No rivet failure.

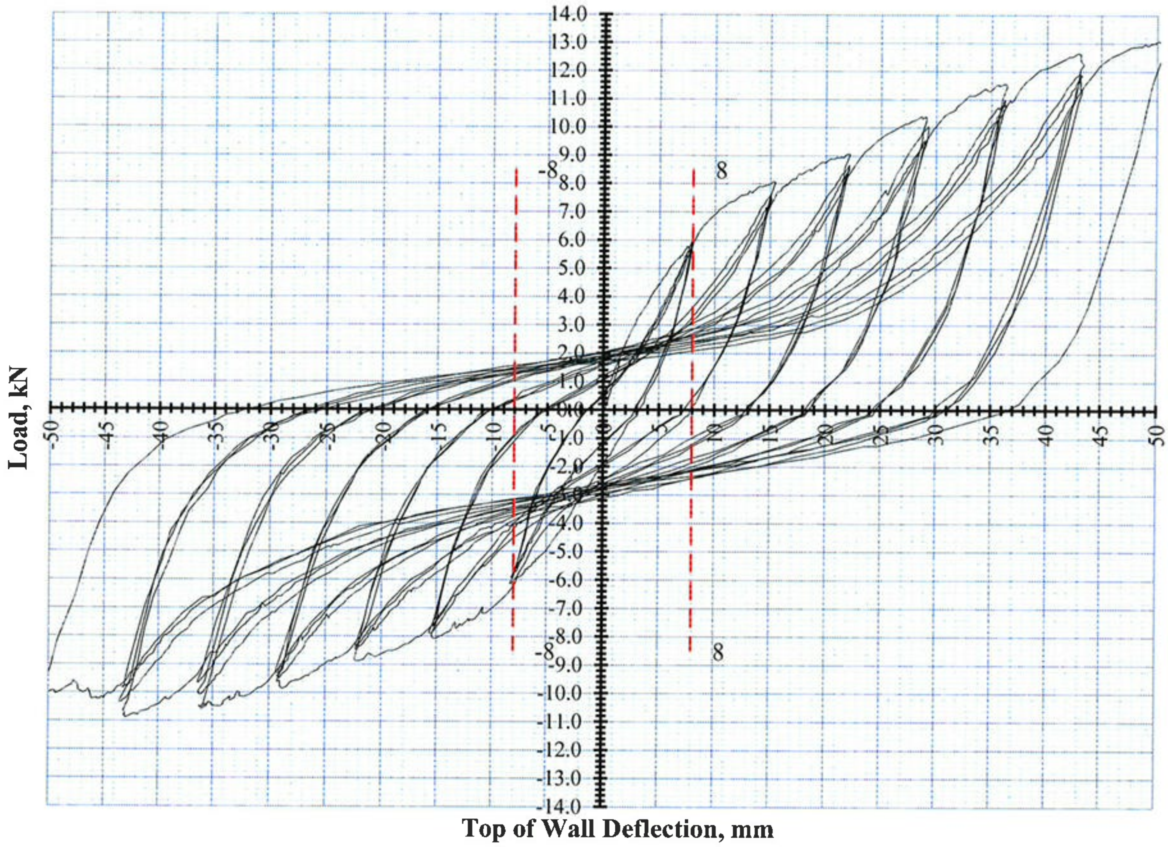


Figure 2: *Wall 275437*

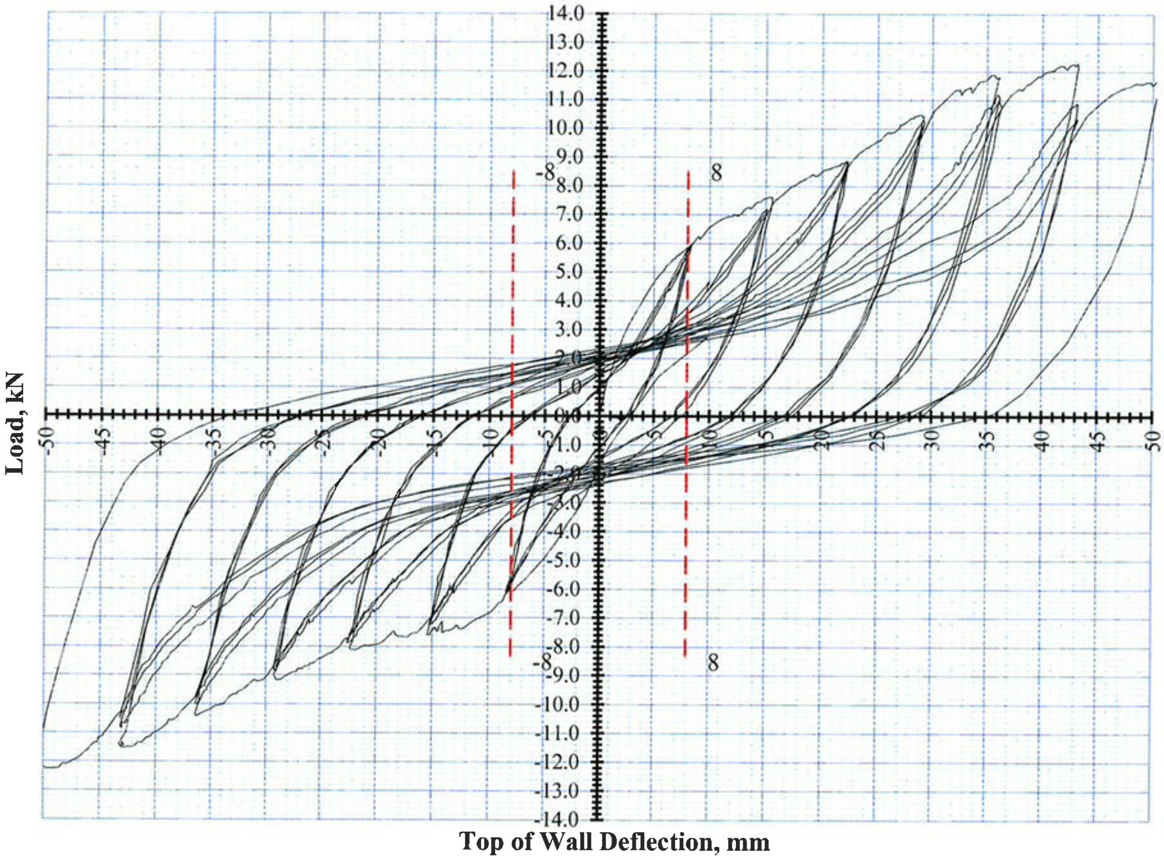


Figure 3: *Wall 275438*

P21:2010 BRACING RACKING TEST RESULT EVALUATION

Wall Construction *Scion, Private Bag 3020 Rotorua. Timber Engineering Lab*

1200mm, 100mm thick Polystyrene core, 0.59mm steel lined SIP, 40x40x1.6mm aluminium angle each side, each end, each face with 4.8x14.3mm blind aluminium rivets at 300mm c/c's (sides) 150mm c/c's (ends), held down to bottom plate with 40mm Tek screws at 300mm centres. 90x45 H1.2 SG8 plates and end studs, with two 100mm Tek screws from studs to plates. 12mm Hold downs with 70x50x5mm flat steel washers over aluminium angle and 90x45 bottom plate, one each end of wall

Summary		
Earthquake	167 (U)	BU/m
Wind	163 (S)	BU/m

Date of test:-	20-Jun-16	Ship No.	2897	Tested by	Bruce Davy
Date of calc's:-	21-Jun-16	Job No.	TE15-070	Analysed by	Doug Gaunt

Calculated to BRANZ P21:2010, AS/NZS1170.2&5, NZS3604:2010

Lab Number	Direction	Serviceability Cycles: Cycle to H/300 or DLQ or DLW 8.0 Loads (P_8) kN	Serviceability Cycles: X mm Residual Defln, C mm	Ultimate Cycles: Cycle to Displacement y=(mm) Maximum Load P(kN)	Ultimate Cycles: def @ P y (mm)	P/2 (kN)	Wall dimensions L(mm) 1200, H(mm) 2400: d at P/2 d mm	4th,R kN
275436	+	5.60	3.80	10.80	36.0	5.40	8.1	9.90
	-	6.10	3.80	11.78	36.0			10.70
275437	+	5.90	3.00	11.50	36.0	5.75	7.9	10.60
	-	6.05	1.50	10.55	36.0			9.05
275438	+	5.85	2.90	11.80	36.0	5.90	8.0	10.50
	-	6.08	2.70	10.37	36.0			9.30

	(P_8)	(C)	(P)	(y)	P/2 (kN)	(d)	(Ry)
Averages	5.93	2.95	11.13	36.00	5.68	8.00	10.01
Coefficient of Variation %	2.94	26.31	5.23	0.00	3.69	1.02	6.45

y = average failure deflection or peak deflection of the three tests.
d= average first cycle displacement at half peak, (the very first cycle wall reaches the load)
R = Residual load, P = Peak Load, S = Serviceability load
Displacement Recovery Factor (K1), (0.8 <= K1 <= 1.0) Systems factor K2 = 1.2
Average Structural Displacement Ductility factor u = y/d 4.50
Ductility Modification factor K4 = 1.00
DLW = Selected deflection limit for wind forces | DLQ = Selected deflection limit for earthquake forces

P21:2010 BR Calc's		K1	EQ ultimate	EQ service	Wind Ultimate	Wind Service
Lab Number		(= 1.4 - C/X)	BU's	BU's	BU's	BU's
275436	(BU)	0.93	206.0	236.1	225.8	182.9
	(BU/m)		172	197	188	152
275437	(BU)	1.00	196.5	260.7	220.5	202.0
	(BU/m)		164	217	184	168
275438	(BU)	1.00	198.0	260.3	221.7	201.6
	(BU/m)		165	217	185	168

<20% Result Check				
275436	*4% Ok result*	*-10% Ok result*	*2% Ok result*	*-10% Ok result*
275437	*-3% Ok result*	*5% Ok result*	*-1% Ok result*	*5% Ok result*
275438	*-2% Ok result*	*5% Ok result*	*-1% Ok result*	*5% Ok result*

Note: Where the value of BR Wind or BR EQ for any specimen is more than 20% greater than either of the other two specimens, assign it a value of 1.2 times the lower value before averaging.

Average Earthquake BR — **Ultimate**: EQ (BU's) 20 x K4 x Ry = **200**, **167 BU/m** — **Serviceability**: (P8 x K1) x (K2/0.55) = **252** — Limited by **Ultimate limit state**

Average Wind BR — **Ultimate**: Wind (BU's) 20 * P = **223**, **163 BU/m** — **Serviceability**: (P8 x K1) x (K2/0.71) = **196** — Limited by **Serviceability limit state**

Figure 4: *P21:2010 calculations for the 1200mm Polystyrene SIP*

Please feel free to contact me to discuss this information.

Doug Gaunt

49 Sala Street
Private Bag 3020
Rotorua
New Zealand
Telephone: +64 7 343 5899
DDI: +64 7 343 5763
Facsimile: +64 7 348 0952
Email: douglas.gaunt@scionresearch.com

Results

To:	Peter Zeeman	**From:**	Doug Gaunt
Organisation:	Metalcraft	**Subject:**	P21:2010 – 1120mm Polyurethane SIP
Location:	Auckland	**Date:**	22 June 2016
Fax No.:	09 2778842	**No. of Pages:**	5
Tel No.:	027 2764354		

Please call +64 7 343 5763 if transmission incomplete

Peter

Please find below the results of your three P21:2010 1120mm polyurethane structural insulated panel (SIP) wall bracing tests.

1. BU wind = 162 (144 BU/m) as limited by the serviceability load capacity.
2. BU Earthquake = 175 (156 BU/m) as limited by the ultimate load capacity.

Figures 1, 2 & 3 show the load deflection plots, Figure 4 shows the P21:2010 calculations.

Wall Construction

- 100mm thick Polyurethane core, 0.50mm steel lined SIP
- 40x40x1.6mm aluminium angle each side each face with 4.8x14.3mm (ASMG63.66) blind aluminium rivets at 300mm centres
- 40x40x1.6mm aluminium angle each end each face with 4.8x14.3mm blind aluminium rivets at 150mm centres, held down to bottom plate with 40mm timber Tek screws at 300mm centres.
- 90x45 H1.2 SG8 top, bottom plates and end studs, with two 100mm Tek screws from studs into end of bottom and top plates
- 12mm Hold downs with 70x50x5mm flat steel washers over aluminium angle and 90x45 bottom plate, one each end of wall.

Please note that P21:2010 states that

> "The procedure is not intended to be used for evaluating the performance of concrete or masonry walls, steel-framed walls, post and beam, plank construction or panellised construction, unless the critical components of the wall are laterally loaded steel fasteners installed in timber."

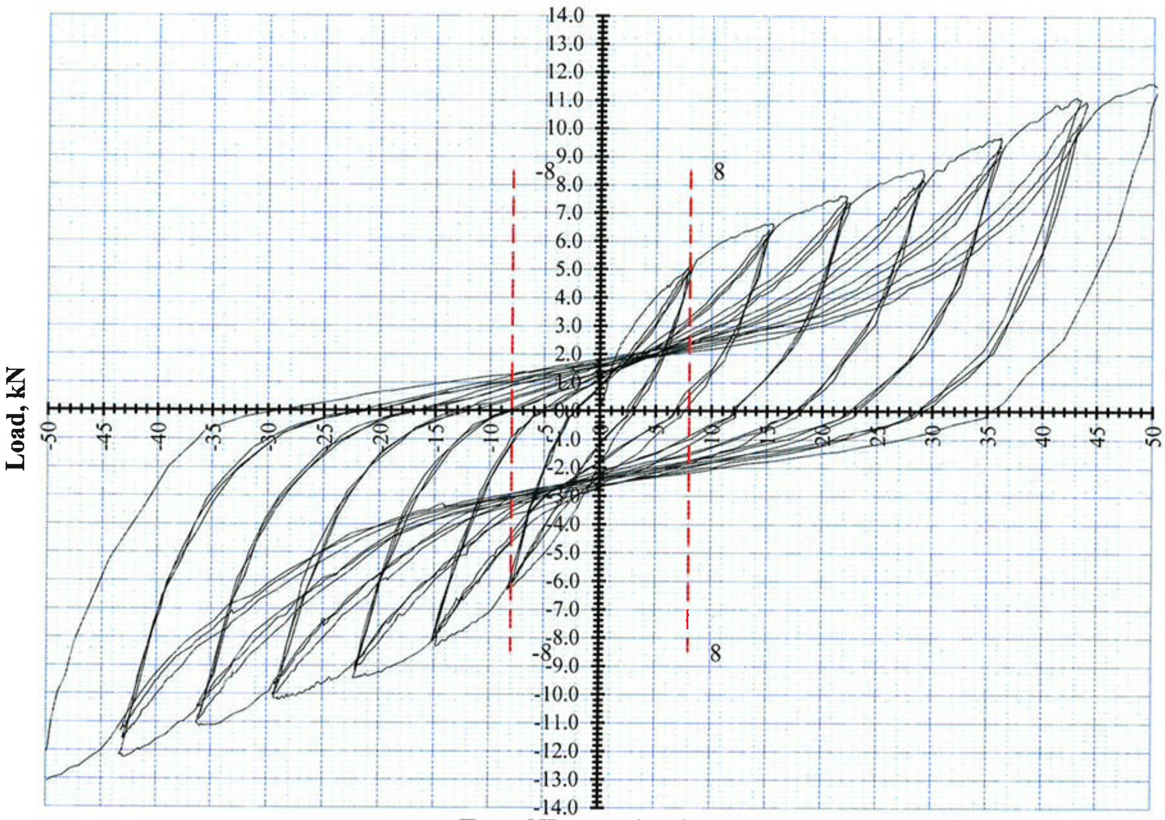


Figure 1: *Wall 275439*

Wall test observations

- 70x70x5mm hold down washers bending,
- Buckling of aluminium angles at bottom plate,
- 100mm Tek screws at bottom plate to stud connection bending as studs lift up
- No rivet failure.

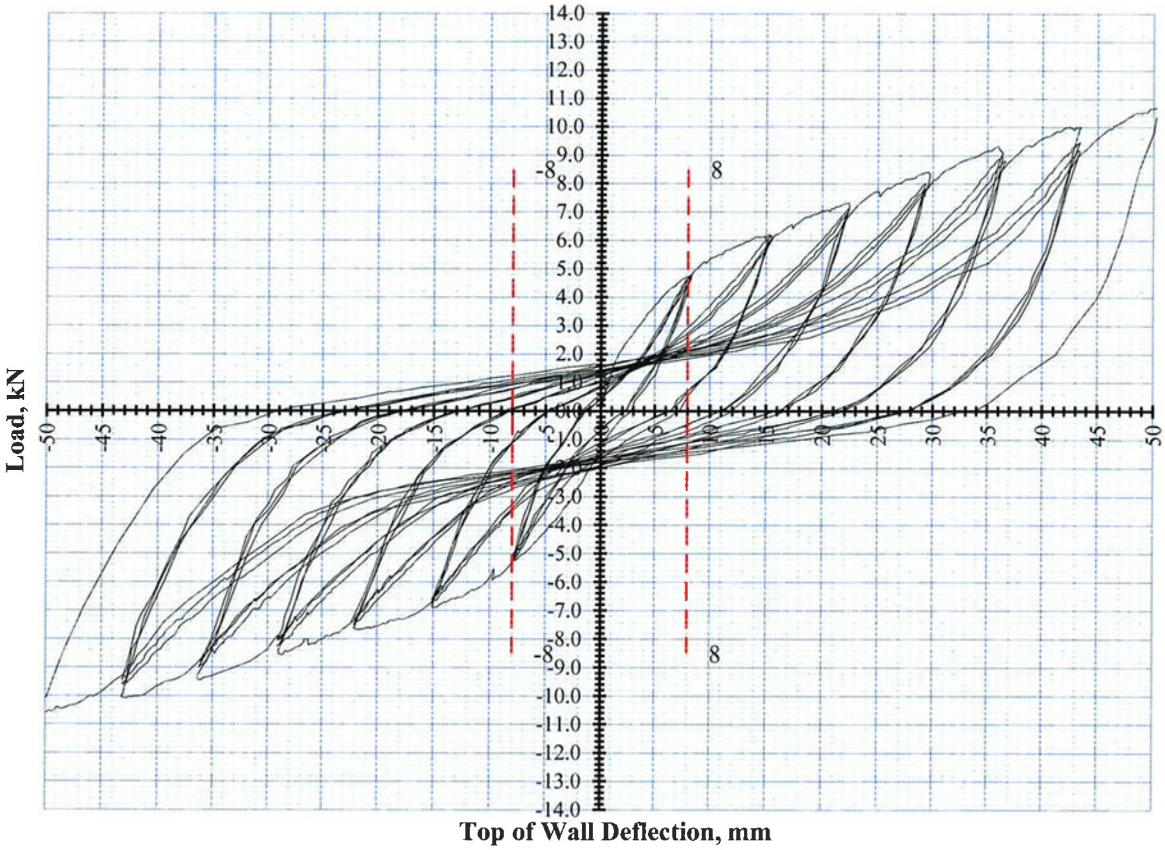


Figure 2: Wall 275440

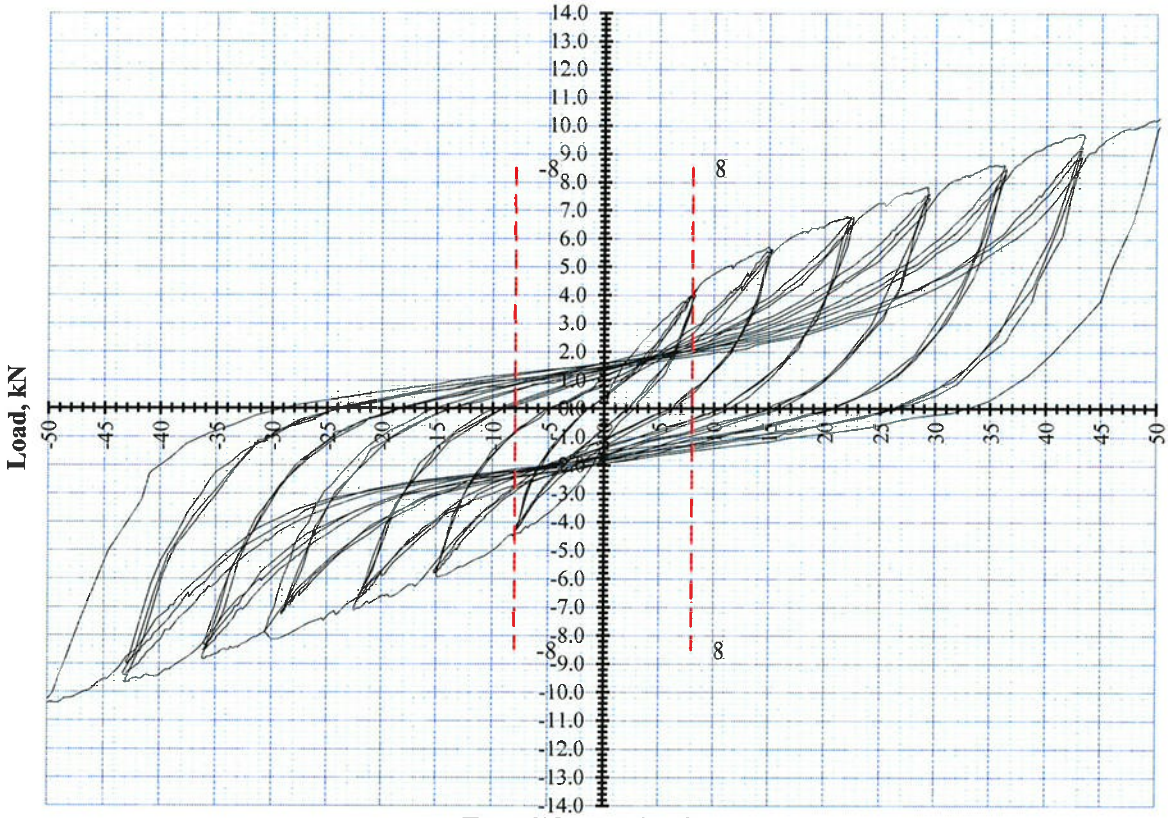


Figure 3: *Wall 2275441*

P21:2010 BRACING RACKING TEST RESULT EVALUATION

Wall Construction *Scion, Private Bag 3020 Rotorua. Timber Engineering Lab*

1120mm, 100mm thick Polyurethane core, 0.50mm steel lined SIP, 40x40x1.6mm aluminium angle each side, each end, each face with 4.8x14.3mm blind aluminium rivets at 300mm c/c's (sides) 150mm c/c's (ends), held down to bottom plate with 40mm Tek screws at 300mm centres. 90x45 H1.2 SG8 plates and end studs, with two 100mm Tek screws from studs to plates. 12mm Hold downs with 70x50x5mm flat steel washer over aluminium angle and 90x45 bottom plate, one each end of wall

Summary		
Earthquake	156 (U)	BU/m
Wind	144 (S)	BU/m

Date of test:-	20-Jun-16	Ship No.	2897	Tested by	Bruce Davy
Date of calc's:-	21-Jun-16	Job No.	TE15-070	Analysed by	Doug Gaunt

Calculated to BRANZ P21:2010, AS/NZS1170.2&5, NZS3604:2010

Lab Number	Direction	Serviceability Cycles: Cycle to H/300 or DLQ or DLW 8.0 Loads (P_8) kN	Serviceability Cycles: X mm Residual Defln, C mm	Ultimate Cycles: Cycle to Displacement y=(mm) Maximum Load P(kN)	def @ P y (mm)	P/2 (kN)	Wall dimensions L(mm) 1120: d at P/2 d mm	H(mm) 2400: 4th,R kN
275439	+	5.10	2.80	9.60	36.0	4.80	6.8	9.10
	-	6.20	2.20	11.10	36.0			10.20
275440	+	4.70	2.80	9.30	36.0	4.65	7.8	8.38
	-	5.25	1.80	9.40	36.0			8.65
275441	+	4.07	2.50	8.60	36.0	4.30	8.3	7.95
	-	4.45	1.60	8.82	36.0			8.20
		(P_8)	(C)	(P)	(y)	P/2 (kN)	(d)	(Ry)
Averages		4.96	2.28	9.47	36.00	4.58	7.63	8.75
Coefficient of Variation %		13.67	20.29	8.50	0.00	4.57	8.17	8.50

y = average failure deflection or peak deflection of the three tests.
d= average first cycle displacement at half peak, (the very first cycle wall reaches the load)
R = Residual load, P = Peak Load, S = Serviceability load
Displacement Recovery Factor (K1), (0.8 <= K1 <= 1.0) Systems factor K2 = 1.2
Average Structural Displacement Ductility factor u = y/d 4.72
Ductility Modification factor K4 = 1.00
DLW = Selected deflection limit for wind forces | DLQ = Selected deflection limit for earthquake forces

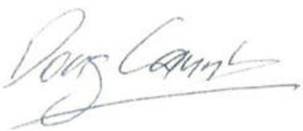
P21:2010 BR Calc's		**K1**	**EQ ultimate**	**EQ service**	**Wind Ultimate**	**Wind Service**
Lab Number		**(= 1.4 - C/X)**	**BU's**	**BU's**	**BU's**	**BU's**
275439	(BU)	1.00	193.0	246.5	207.0	191.0
	(BU/m)		172	220	185	171
275440	(BU)	1.00	170.3	217.1	187.0	168.2
	(BU/m)		152	194	167	150
275441	(BU)	1.00	161.5	185.9	174.2	144.0
	(BU/m)		144	166	156	129
		275439	*14% Ok result*	*223.1*	*13% Ok result*	*172.8*
<20% Result Check		*275440*	*-4% Ok result*	*0% Ok result*	*-2% Ok result*	*0% Ok result*
		275441	*-12% Ok result*	*-25% Ok result*	*-13% Ok result*	*-25% Ok result*

Note: Where the value of BR Wind or BR EQ for any specimen is more than 20% greater than either of the other two specimens, assign it a value of 1.2 times the lower value before averaging.

Average Earthquake BR		**Ultimate**		**Serviceability**
EQ (BU's)	20 x K4 x Ry =	**175**	(P8 x K1) x (K2/0.55) =	**209**
		156 BU/m	**Limited by**	**Ultimate limit state**
Average Wind BR		**Ultimate**		**Serviceability**
Wind (BU's)	20 * P =	**189**	(P8 x K1) x (K2/0.71) =	**162**
		144 BU/m	**Limited by**	**Serviceability limit state**

Figure 4: *P21:2010 calculations for the 1200mm Polyurethane SIP*

Please feel free to contact me to discuss this information.

Doug Gaunt 

49 Sala Street
Private Bag 3020
Rotorua
New Zealand
Telephone: +64 7 343 5899
DDI: +64 7 343 5763
Facsimile: +64 7 348 0952
Email: douglas.gaunt@scionresearch.com

scion forests · products · innovation

Results

To:	Peter Zeeman	**From:**	Doug Gaunt
Organisation:	Metalcraft	**Subject:**	P21:2010 – 610mm Polystyrene SIP
Location:	Auckland	**Date:**	23 June 2016
Fax No.:	09 2778842	**No. of Pages:**	5
Tel No.:	027 2764354		

Please call +64 7 343 5763 if transmission incomplete

Peter

Please find below the results of your three P21:2010 610mm polystyrene structural insulated panel (SIP) wall bracing tests.

1. BU wind = 66 (108 BU/m) as limited by the serviceability load capacity.
2. BU Earthquake = 75 (122 BU/m) as limited by the ultimate load capacity.

Figures 1, 2 & 3 show the load deflection plots, Figure 4 shows the P21:2010 calculations.

Wall Construction

- 100mm thick Polystyrene core, 0.59mm steel lined SIP
- 40x40x1.6mm aluminium angle each side each face with 4.8x14.3mm (ASMG63.66) blind aluminium rivets at 300mm centres
- 40x40x1.6mm aluminium angle each end each face with 4.8x14.3mm blind aluminium rivets at 150mm centres, held down to bottom plate with 40mm timber Tek screws at 300mm centres.
- 90x45 H1.2 SG8 top, bottom plates and end studs, with two 100mm Tek screws from studs into end of bottom and top plates
- 12mm Hold downs with 70x50x5mm flat steel washers over aluminium angle and 90x45 bottom plate, one each end of wall.

Please note that P21:2010 states that

> "The procedure is not intended to be used for evaluating the performance of concrete or masonry walls, steel-framed walls, post and beam, plank construction or panellised construction, unless the critical components of the wall are laterally loaded steel fasteners installed in timber."

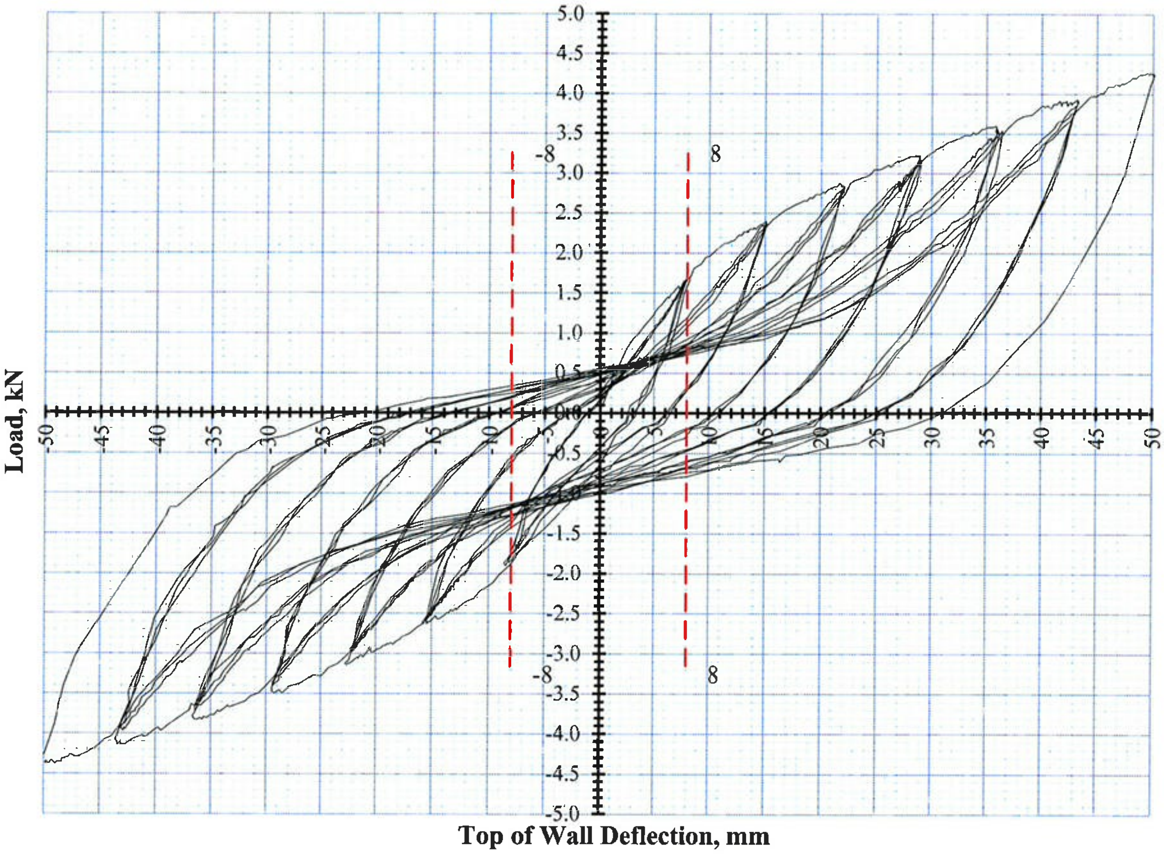


Figure 1: *Wall 275442*

<u>Wall test observations</u>

- Minimal bending of the 70x70x5mm hold down washers,
- Minimal buckling of aluminium angles at bottom plate,
- No rivet failure.

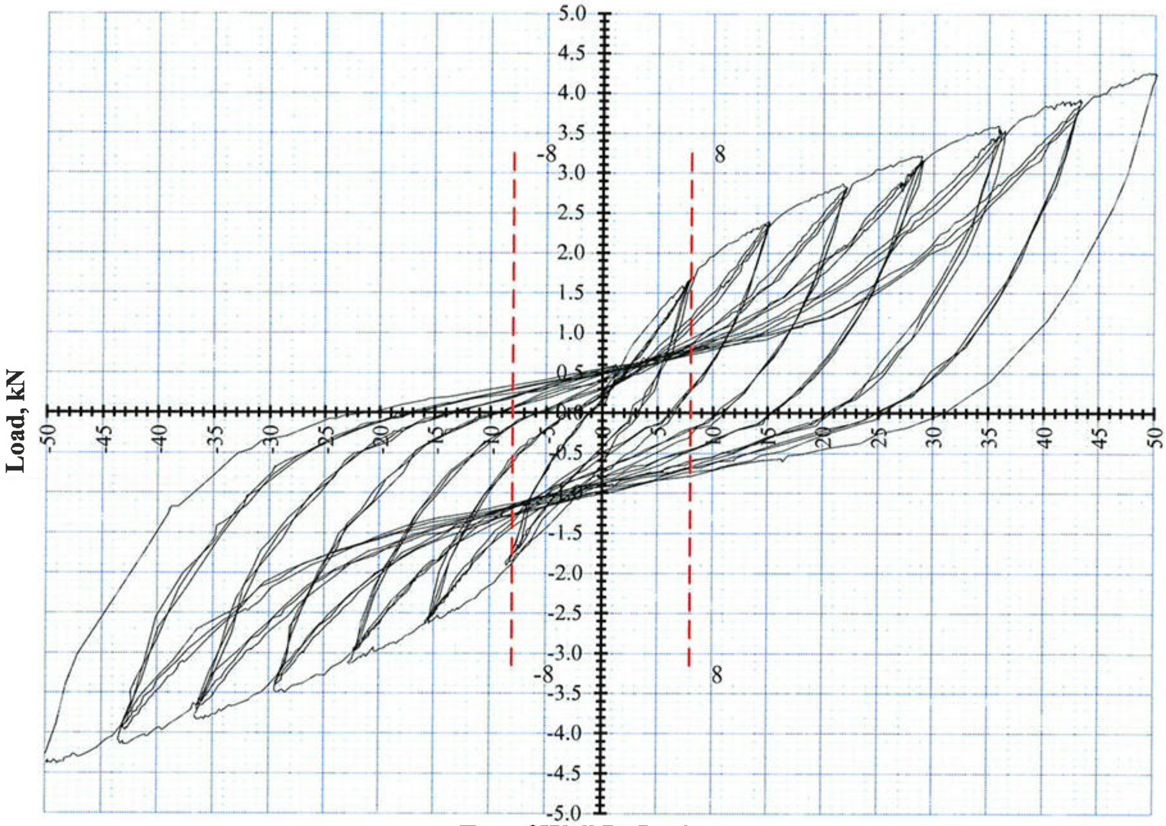


Figure 2: Wall 275443

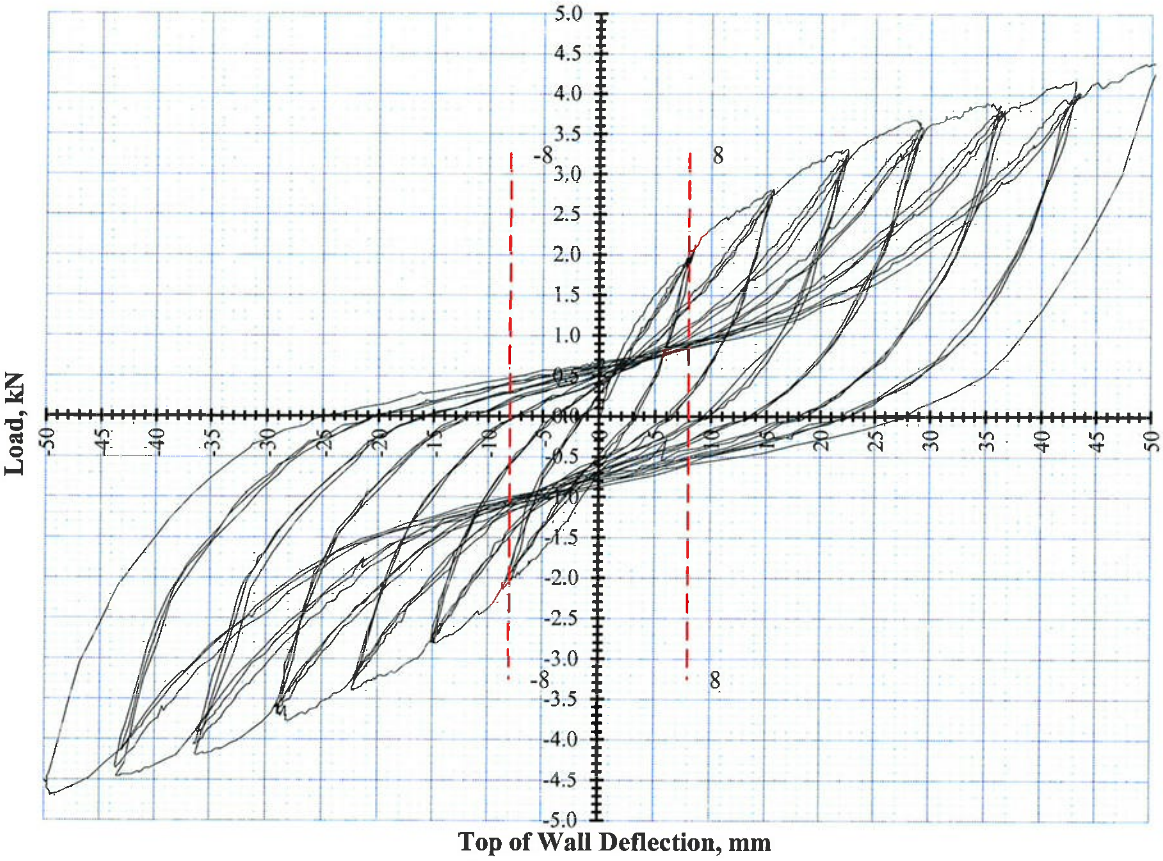


Figure 3: *Wall 275444*

P21:2010 BRACING RACKING TEST RESULT EVALUATION

Wall Construction *Scion, Private Bag 3020 Rotorua. Timber Engineering Lab*

610mm, 100mm thick Polystyrene core, 0.59mm steel lined SIP, 40x40x1.6mm aluminium angle each side, each end, each face with 4.8x14.3mm blind aluminium rivets at 300mm c/c's (sides) 150mm c/c's (ends), held down to bottom plate with 40mm Tek screws at 300mm centres. 90x45 H1.2 SG8 plates and end studs, with two 100mm Tek screws from studs to plates. 12mm Hold downs with 70x50x5mm flat steel washer over aluminium angle and 90x45 bottom plate, one each end of wall

Summary		
Earthquake	122 (U)	BU/m
Wind	108 (S)	BU/m

Date of test:-	21-Jun-16	Ship No.	2897	Tested by	Bruce Davy
Date of calc's:-	22-Jun-16	Job No.	TE15-070	Analysed by	Doug Gaunt

Calculated to BRANZ P21:2010, AS/NZS1170.2&5, NZS3604:2010

Lab Number	Direction	Serviceability Cycles: Cycle to H/300 or DLQ or DLW 8.0 Loads (P_8) kN	X mm Residual Defln, C mm	Ultimate Cycles: Cycle to Displacement y=(mm) Maximum Load P(kN)	def @ P y (mm)	P/2 (kN)	Wall dimensions L(mm) 610 — d at P/2 d mm	H(mm) 2400 — 4th,R kN
275442	+	1.69	3.00	3.58	36.0	1.79	8.4	3.40
	-	1.83	1.20	3.83	36.0			3.60
275443	+	2.00	2.60	4.12	36.0	2.06	8.4	3.98
	-	2.16	2.50	4.10	36.0			3.84
275444	+	2.02	3.20	3.82	36.0	1.91	7.8	3.74
	-	2.04	1.50	4.19	36.0			3.85
		(P_8)	(C)	(P)	(y)	P/2 (kN)	(d)	(Ry)
Averages		1.96	2.33	3.94	36.00	1.92	8.20	3.74
Coefficient of Variation %		7.84	31.66	5.45	0.00	5.75	3.45	5.07

y = average failure deflection or peak deflection of the three tests.
d= average first cycle displacement at half peak, (the very first cycle wall reaches the load)
R = Residual load, P = Peak Load, S = Serviceability load
Displacement Recovery Factor (K1), (0.8 <= K1 <= 1.0) Systems factor K2 = 1.2
Average Structural Displacement Ductility factor u = y/d 4.39
Ductility Modification factor K4 = 1.00
DLW = Selected deflection limit for wind forces | DLQ = Selected deflection limit for earthquake forces

P21:2010 BR Calc's Lab Number		K1 (= 1.4 - C/X)	EQ ultimate BU's	EQ service BU's	Wind Ultimate BU's	Wind Service BU's
275442	(BU)	1.00	70.0	76.8	74.1	59.5
	(BU/m)		115	126	121	98
275443	(BU)	1.00	78.2	90.8	82.2	70.3
	(BU/m)		128	149	135	115
275444	(BU)	1.00	75.9	88.6	80.1	68.6
	(BU/m)		124	145	131	112

<20% Result Check					
	275442	*-10% Ok result*	*-17% Ok result*	*-10% Ok result*	*-17% Ok result*
	275443	*7% Ok result*	*9% Ok result*	*6% Ok result*	*9% Ok result*
	275444	*2% Ok result*	*5% Ok result*	*2% Ok result*	*5% Ok result*

Note: Where the value of BR Wind or BR EQ for any specimen is more than 20% greater than either of the other two specimens, assign it a value of 1.2 times the lower value before averaging.

Average Earthquake BR **Ultimate** **Serviceability**
EQ (BU's) 20 x K4 x Ry = **75** (P8 x K1) x (K2/0.55) = **85**
122 BU/m **Limited by Ultimate limit state**

Average Wind BR **Ultimate** **Serviceability**
Wind (BU's) 20 * P = **79** (P8 x K1) x (K2/0.71) = **66**
108 BU/m **Limited by Serviceability limit state**

Figure 4: *P21:2010 calculations for the 610mm Polystyrene SIP*

Please feel free to contact me to discuss this information.

Doug Gaunt

forests · products · innovation

49 Sala Street
Private Bag 3020
Rotorua
New Zealand
Telephone: +64 7 343 5899
DDI: +64 7 343 5763
Facsimile: +64 7 348 0952
Email: douglas.gaunt@scionresearch.com

Results

To:	Peter Zeeman	**From:**	Doug Gaunt
Organisation:	Metalcraft	**Subject:**	P21:2010 – 610mm Polyurethane SIP
Location:	Auckland	**Date:**	23 June 2016
Fax No.:	09 2778842	**No. of Pages:**	3
Tel No.:	027 2764354		

Please call +64 7 343 5763 if transmission incomplete

Peter

Please find below the indicative results of your single P21:2010 610mm polyurethane structural insulated panel (SIP) wall bracing test.

1. BU wind = 66 (109 BU/m) as limited by the serviceability load capacity.
2. BU Earthquake = 76 (124 BU/m) as limited by the ultimate load capacity.

Please note the P21:2010 test requires three replicates to determine bracing ratings so the results of this single test can only be seen as indicative.

Figure 1 shows the load deflection plot, Figure 2 shows the P21:2010 calculations.

Wall Construction

- 100mm thick Polyurethane core, 0.50mm steel lined SIP
- 40x40x1.6mm aluminium angle each side each face with 4.8x14.3mm (ASMG63.66) blind aluminium rivets at 300mm centres
- 40x40x1.6mm aluminium angle each end each face with 4.8x14.3mm blind aluminium rivets at 150mm centres, held down to bottom plate with 40mm timber Tek screws at 300mm centres.
- 90x45 H1.2 SG8 top, bottom plates and end studs, with two 100mm Tek screws from studs into end of bottom and top plates
- 12mm Hold downs with 70x50x5mm flat steel washers over aluminium angle and 90x45 bottom plate, one each end of wall.

Please note that P21:2010 states that

> "The procedure is not intended to be used for evaluating the performance of concrete or masonry walls, steel-framed walls, post and beam, plank construction or panellised construction, unless the critical components of the wall are laterally loaded steel fasteners installed in timber."

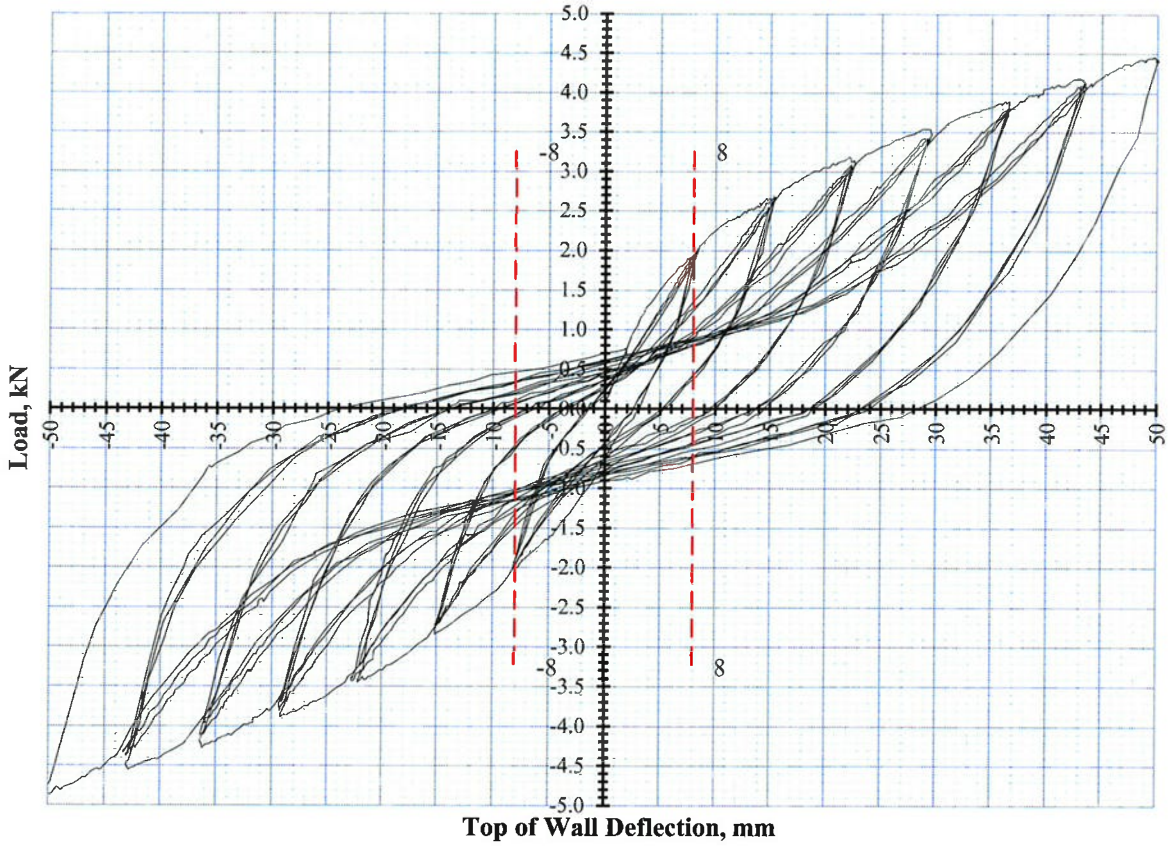


Figure 1: *Wall 275445*

Wall test observations

- Minimal bending of the 70x70x5mm hold down washers,
- Minimal buckling of aluminium angles at bottom plate,
- No rivet failure.

P21:2010 BRACING RACKING TEST RESULT EVALUATION

Wall Construction *Scion, Private Bag 3020 Rotorua. Timber Engineering Lab*

610mm, 100mm thick Polyurethane core, 0.50mm steel lined SIP, 40x40x1.6mm aluminium angle each side, each end, each face with 4.8x14.3mm blind aluminium rivets at 300mm c/c's (sides) 150mm c/c's (ends), held down to bottom plate with 40mm Tek screws at 300mm centres. 90x45 H1.2 SG8 plates and end studs, with two 100mm Tek screws from studs to plates. 12mm Hold downs with 70x50x5mm flat steel washer over aluminium angle and 90x45 bottom plate, one each end of wall

Summary		
Earthquake	#DIV/0!	BU/m
Wind	#DIV/0!	BU/m

Date of test:-	22-Jun-16	Ship No.	2897	Tested by	Bruce Davy
Date of calc's:-	22-Jun-16	Job No.	TE15-070	Analysed by	Doug Gaunt

Calculated to BRANZ P21:2010, AS/NZS1170.2&5, NZS3604:2010

Lab Number	Direction	Serviceability Cycles: Cycle to H/300 or DLQ or DLW 8.0 Loads (P_8) kN	X mm Residual Defln, C mm	Ultimate Cycles: Cycle to Displacement y=(mm) Maximum Load P(kN)	def @ P y (mm)	P/2 (kN)	Wall dimensions L(mm) 610: d at P/2 d mm	H(mm) 2400: 4th,R kN
275445	+	1.92	2.80	3.88	36.0	1.94	8.1	3.71
	-	2.00	1.60	4.25	36.0			3.88
	+				36.0	0.00		
	-				36.0			
	+				36.0	0.00		
	-				36.0			
		(P_8)	(C)	(P)	(y)	P/2 (kN)	(d)	(Ry)
Averages		1.96	2.20	4.07	36.00	0.65	8.10	3.80
Coefficient of Variation %		2.04	27.27	4.55	0.00	141.42	0.00	2.24

y = average failure deflection or peak deflection of the three tests.
d= average first cycle displacement at half peak, (the very first cycle wall reaches the load)
R = Residual load, P = Peak Load, S = Serviceability load
Displacement Recovery Factor (K1), (0.8 <= K1 <= 1.0) Systems factor K2 = 1.2
Average Structural Displacement Ductility factor u = y/d 4.44
Ductility Modification factor K4 = 1.00
DLW = Selected deflection limit for wind forces | DLQ = Selected deflection limit for earthquake forces

P21:2010 BR Calc's		**K1** (= 1.4 - C/X)	**EQ ultimate BU's**	**EQ service BU's**	**Wind Ultimate BU's**	**Wind Service BU's**
Lab Number						
275445	(BU)	1.00	75.9	85.5	81.3	66.3
	(BU/m)		124	140	133	109
0	(BU)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
	(BU/m)		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0	(BU)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
	(BU/m)		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
		275445	*#DIV/0!*	*#DIV/0!*	*#DIV/0!*	*#DIV/0!*
<20% Result Check		*0*	*#DIV/0!*	*#DIV/0!*	*#DIV/0!*	*#DIV/0!*
		0	*#DIV/0!*	*#DIV/0!*	*#DIV/0!*	*#DIV/0!*

Note: Where the value of BR Wind or BR EQ for any specimen is more than 20% greater than either of the other two specimens, assign it a value of 1.2 times the lower value before averaging.

Average Earthquake BR — **Ultimate**: EQ (BU's) 20 x K4 x Ry = **#DIV/0!**; **#DIV/0!** **BU/m** — **Serviceability**: (P8 x K1) x (K2/0.55) = **#DIV/0!**; **Limited by** **#DIV/0!**

Average Wind BR — **Ultimate**: Wind (BU's) 20 * P = **#DIV/0!**; **#DIV/0!** **BU/m** — **Serviceability**: (P8 x K1) x (K2/0.71) = **#DIV/0!**; **Limited by** **#DIV/0!**

Figure 2: *P21:2010 calculations for the 610mm Polyurethane SIP*

Please feel free to contact me to discuss this information.

Doug Gaunt

Appendix C: Assessment calculations:

Table 1: Hysteretic data:

Test #	Length (mm)	F_4 (kN)	F_8 (kN)	F_{15} (kN)	F_{22} (kN)	F_{29} (kN)	F_{36} (kN)	δ_0 (mm)
1	2400	4.20	12.90	19.90	24.00	0.00	0.00	12.50
	Areas							
2	1200	4.00	5.85	7.33	8.50	9.45	10.47	25.83
	Areas	8.00	19.70	46.14	55.42	62.83	69.71	53.21
3	1120	3.50	4.90	6.35	7.27	8.00	8.87	24.33
	Areas	7.00	16.80	39.38	47.66	53.43	59.03	51.72
4	610	1.25	1.90	2.65	3.15	3.55	3.90	21.50
	Areas	2.50	6.30	15.93	20.30	23.45	26.08	28.28
5	610	1.35	1.77	2.53	2.98	3.33	3.58	22.17
	Areas	2.70	6.23	15.05	19.31	22.11	24.21	24.78

Table 2: Ductility and design K4 factors:

Test #	Length (mm)	K_{el}	ΣA	A'	δ'_y (mm)	μ	k_μ	K4	K1
1	2400	1.613							
2	1200	0.731	261.79	115.0	9.26	3.89	0.264	1.047	0.977
3	1120	0.613	223.30	95.9	9.66	3.73	0.274	1.010	1.000
4	610	0.238	94.55	45.9	10.47	3.44	0.293	0.945	1.000
5	610	0.221	89.61	39.4	11.50	3.13	0.316	0.876	1.000

(effective)

Table 3: K4 factors

μ	1.00	2.00	2.50	2.75	3.00	3.50	4.00
K4	0.28	0.67	0.77	0.83	0.89	1.00	1.12
S_p/k_μ	1.00	0.42	0.36	0.33	0.31	0.28	0.25

Table 4: Summary bracing ratings:

Test #	Length (mm)	$R_{y(av.)}$ (kN)	P_8 (kN)	$P_{y(av.)}$ (kN)	δ'_y (mm)	ductility μ_{eff} (2)	K4(3)	Wind BU/m	EQ BU/m
1(1)	2400	25.00	12.90						
2	1200	10.01	5.85	11.13	9.26	3.89	1.047	161	175
3	1120	8.75	4.90	9.47	9.66	3.73	1.010	148	158
4	610	3.74	1.90	3.94	10.47	3.44	0.945	105	116
5	610	3.80	1.77	4.07	11.50	3.13	0.876	98	109

(1) Test wall 1 capacity could not be determined as capacity of test rig was exceeded

(2) Effective ductility for equivalent Bi-linear elasto-plastic curve

(3) Based on demand ductility μ = **3.5** per NZS 3604: 2011

System factor, **K2** = **1.20**

Full Elasto - Plastic:

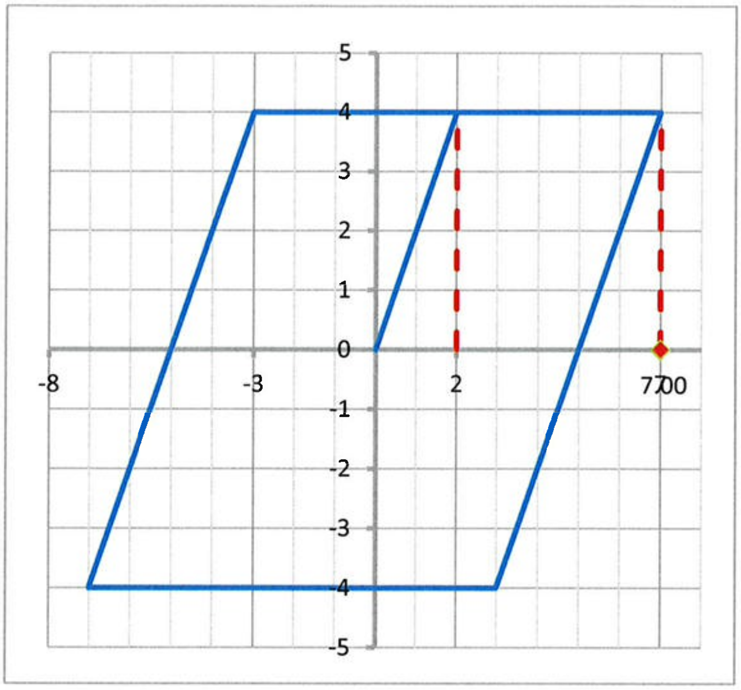
$\mu =$ **3.50**

$$\xi_{hyst} = \frac{2(\mu - 1)}{\mu \pi}$$

= 0.455

= **45.5%**

$\Rightarrow R_\zeta =$ **0.365**



Half Elasto - Plastic:

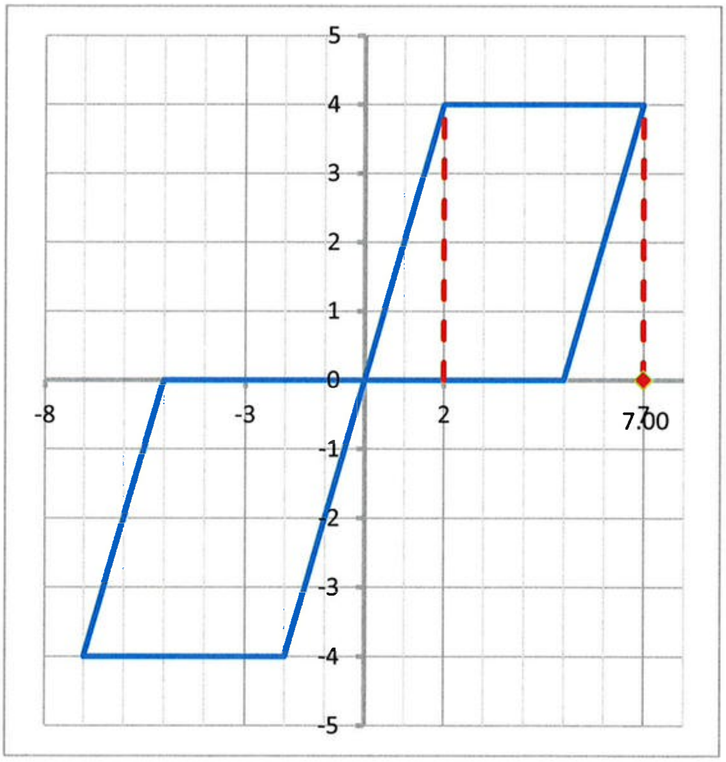
$\mu =$ **3.50**

$$\xi_{hyst} = \frac{(\mu - 1)}{\mu \pi}$$

= 0.227

= **22.7%**

$\Rightarrow R_\zeta =$ **0.485**



Bi - Linear:

μ = **3.50**

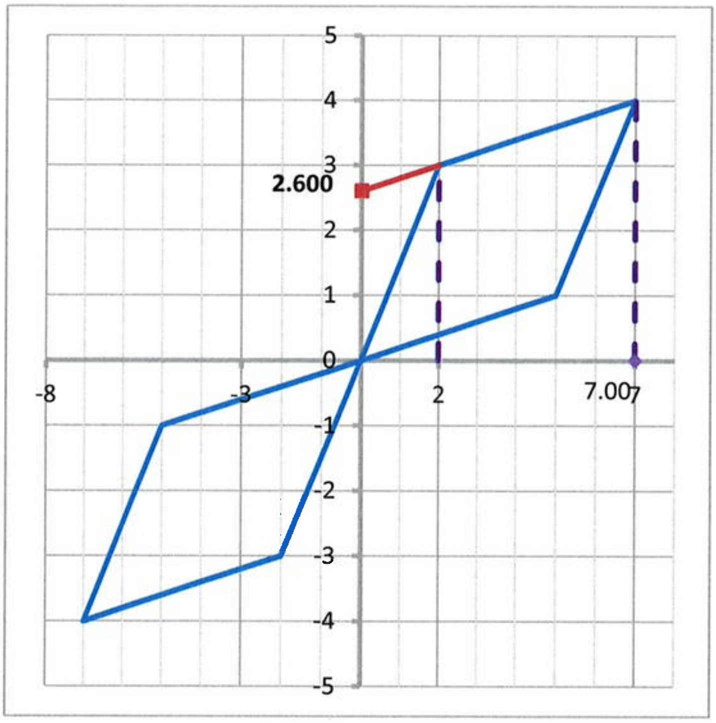
$$\xi_{hyst} = \frac{Q(\mu - 1)}{F_u \mu \pi}$$

= 0.148

= **14.8%**

⇒ R_ζ = **0.567**

Q = 2.600



Flag Shape:

μ = **3.50**

$$\xi_{hyst} = \frac{Q(\mu - 1) \cdot \beta}{F_u \mu \pi}$$

= 0.074

= **7.4%**

β = **0.50**

⇒ R_ζ = **0.697**

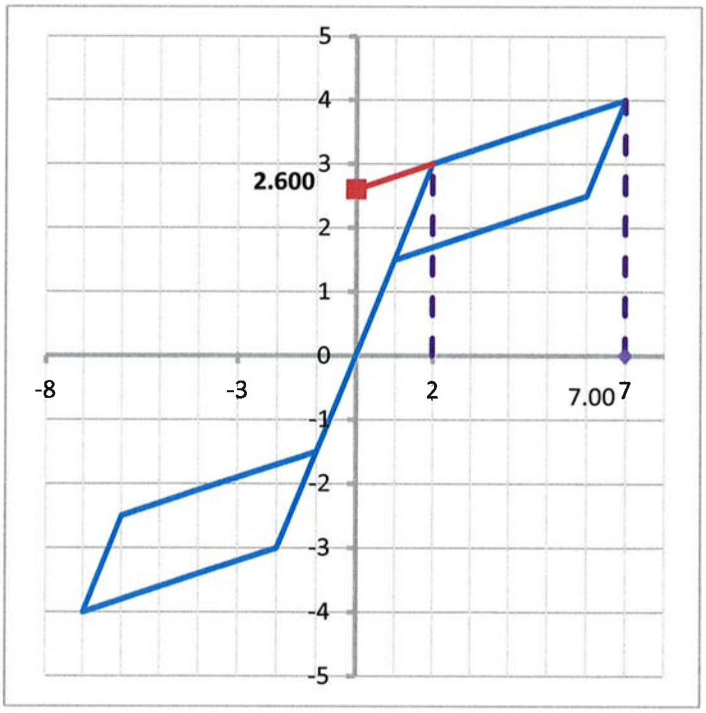


Table 5: Stiffness calculations:

Wall #	L_i (m)	I_i ($\times 10^6 mm^4$)	k_v	k_{ev}	$k_{v,rel}$	M_y (kNm)	M_y /(EI) (rads/mm)	P_y (kN)
w_1	0.6	21.24	0.957	882.2	0.14	21.2	5.00E-06	8.85
w_2	**1.2**	169.92	0.847	6,250.0	**1.00**	**85.0**	2.50E-06	35.4
w_3	1.8	573.48	0.712	17,715.7	2.83	191.2	1.67E-06	79.65
w_4	2.4	1,359.36	0.581	34,302.3	5.49	339.8	1.25E-06	141.6
w_5	3.0	2,655.00	0.471	54,227.9	8.68	531.0	1.00E-06	221.25
w_6	3.6	4,587.84	0.382	76,001.9	12.16	764.6	8.33E-07	318.6

face sheet thickness, **t** = 0.59 mm

No. of layers, **n** = 2

wall height, **H** = 2.40 m

$k_v = 1/(1 + 0.72 (L_i / h_w)^2)$

shear adjusted stiffness, $k_v = (3EI / H^3)\, k_v$

E = 2.00E+05 MPa

Yield stress, F_y = 300.0 MPa

Table 6: Deflections:

Wall #	L_i (m)	$\delta_{y,flex}$ (mm)	δ_v (mm)	$\delta_{y,tot}$ (mm)
w_1	0.6	9.60	0.43	10.03
w_2	**1.2**	4.80	0.86	5.66
w_3	1.8	3.20	1.30	4.50
w_4	2.4	2.40	1.73	4.13
w_5	3.0	1.92	2.16	4.08
w_6	3.6	1.60	2.59	4.19

Rocking stiffness:

Horizontal displacement at top, $\delta_h = \delta_{up}$. **(H/L$_e$)**

Vertical displacement at top, δ_h = **(P_{up} / k_{HD})** (at hold down)

Hold down reaction force, **R_{up}** = **P_h . (H/L_e)**

⇒ Horizontal displacement at top, δ_h = **(P_h / k_{HD}).(H/L_e)^2**

or hold down stiffness, **k_{HD}** = **(P_h / δ_{rock}).(H/L_e)^2**

From test results:

Wall height, **H_w** =	**2.40**	m
Test wall length, **L_w** =	**1.20**	m
eccentricity of hold down from end, **e_{HD}** =	**100**	mm
Effective wall length, **L_e** =	1.10	m
Horizontal displacement, **δ_h** =	**36.0**	mm
Applied load, **P_h** =	**10.01**	kN
BU rating =	**167**	BU/m
shear displacement, δ_v =	0.244	mm
flexural displacement, δ_{flex} =	1.357	mm
net horizontal deflection, δ_{rock} =	**34.4**	mm
⇒ hold down stiffness, **k_{HD}** =	**1,385**	N/mm

Hold down reaction force, **R_{up}** = **P_h . (H/L_e)**

= 21.84 kN

⇒ Rocking uplift displacement, δ_{up} = **R_{up} / k_{HD}**

= **15.8** mm

For wall length, L_w = **2.40** m

eccentricity of hold down from end, e_{HD} = **100** mm

Effective wall length, L_e = 2.30 m

⇒ maximum P_h = $R_{up} L_e / H$

= **20.93** kN

⇒ shear displacement, δ_v = 0.255 mm

flexural displacement, δ_{flex} = 0.355 mm

horizontal deflection, δ_{rock} = $(P_h / k_{HD}).(H/L_e)^2$

= 16.45 mm

⇒ Total horizontal displacement at top, δ_h = **17.1** mm

BU rating = **174** BU/m

For wall length, L_w = **3.60** m

eccentricity of hold down from end, e_{HD} = **100** mm

Effective wall length, L_e = 3.50 m

⇒ maximum P_h = $R_{up} L_e / H$

= **31.85** kN

⇒ shear displacement, δ_v = 0.259 mm

flexural displacement, δ_{flex} = 0.160 mm

horizontal deflection, δ_{rock} = $(P_h / k_{HD}).(H/L_e)^2$

= 10.81 mm

⇒ Total horizontal displacement at top, δ_h = **11.2** mm

BU rating = **177** BU/m

pass™ PRODUCT ASSURANCE SUPPLIER STATEMENT

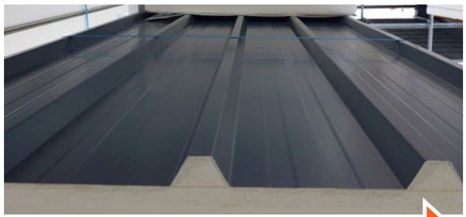
pass™ no: 19049 | Expires: 12/2023

Metalcraft Insulated Panels Limited

METALCRAFT INSULATED PANELS ASPIREPANEL

ASPIREPANEL™

MADE IN NZ FOR LONGER LENGTHS AND QUICKER SUPPLY



PURPOSE

Metalcraft Insulated Panels Limited supply Aspirepanel for use as insulated, fire-resistant, fully finished wall and roof panel.

EXPLANATION

Aspirepanels are lightweight, thermally efficient wall and roof panels manufactured in New Zealand. The panels have a polyisocyanurate (PIR) core sandwiched between 0.59 mm layers of galvanised steel and with a factory applied Colorsteel® finish. The Colorsteel® finish will depend on the specific exposure zone and use.

The panels are 1000 m in width, custom lengths and in the following thicknesses (mm): 50, 75, 100, 125, 150, 200, 250, 300. The thickness depends on the thickness of PIR core. The thickness determines thermal performance and span capability.

The panels are supplied with a tongue and groove joint and a lapped corrugation on both edges. The facings are available in the following profiles:

- Flat smooth profile
- Silkline
- Mesa
- Ribbed indented.

For further assistance please contact:

WE COMPLY s14G BUILDING ACT 2004

+64 9 277 8844

sales@metpanels.co.nz

www.metalcraftpanels.co.nz

SCOPE AND LIMITATIONS OF USE

Scope	Limitations
Location	
In all wind zones up to and including extra high wind zone as defined in NZS 3604:2011 or a calculated wind design pressure (ULS) of 2.5 kPa.	› In accordance with Aspirepanel load span tables.
With a snow loading of up to 1 kPa.	
In all exposure zones as defined in NZS 3604:2011.	› Where the system is to be used in a microclimate (as defined in clause 4.2.2, NZS 3604:2011), Metalcraft Insulated Panels is to be consulted. › In exposure zone D, Colorsteel® Maxx® must be specified. › In exposure zone C, Colorsteel® Maxx® or Endura® may be specified. › In exposure zone B, any Colorsteel® product may be specified.
Any proximity to a relevant boundary.	
Building	
In new buildings where the relevant part of the building complies with the NZ Building Code or in existing buildings where the designer and installer have assured themselves that the relevant part of the building is adequate for the intended building work.	› In accordance with Aspirepanel load span tables. › Fixings must be appropriate for loads as given by AS/NZS 1170 Set.
In all building uses.	› Where compliance with G3.3.2 (a, b) is required, Colorsteel® CP-Antibacterial must be specified for the internal facing of the panel.
As a wall panel.	› Where the panels are to be load-bearing, they must be installed in conjunction with steel or timber structural framing and on a concrete slab or subfloor structure. › With joinery that complies with NZS 4211:2008. › Where fire-resistance rating (FRR) for passive fire protection is required, the passive fire protection systems must be specifically designed. › For buildings less than 10 m in building height.
As a roof panel.	› With a minimum roof pitch of 3º.

CONDITIONS

The specification and installation of Aspirepanel are to be in accordance with the ThermoPanel EPS specification and installation. This documentation is available from https://www.metalcraftgroup.co.nz/products/metal-insulated-panels/products/thermopanel-eps/.

USEFUL INFORMATION

For information on the design, installation and maintenance of Aspirepanel, and for our warranty, refer to **www.metalcraftpanels.co.nz**.

OTHER CERTIFICATIONS AND APPROVALS HELD BY NZ STEEL ASSURANCE:

As the manufacturer of the steel that is used in the manufacture of Aspirepanel, New Zealand Steel Ltd. provides assurance that the steel:

- has been manufactured in accordance with AS 1397-2001
- is coated in accordance with AS/NZS 2728:2013 or galvanized in accordance with AS/NZS 2312.2:2014.

New Zealand Steel Ltd. has established an Environmental Management System certified to ISO 14001.

For more information on the specific exposure zones and environmental impacts of the product, refer to **www.colorsteel.co.nz**.

VERSION: 2.1

PERFORMANCE CLAIMS

If designed, installed and maintained in accordance with all Metalcraft Insulation Panels requirements, Aspirepanel will comply with or contribute to compliance with the following performance claims:

NZ Building Code clauses	Compliance statement	BASIS OF COMPLIANCE Demonstrated by
B1 Structure B1.3.1, B1.3.2, B1.3.3 (a, b, e, f, h, j), B1.3.4 (b, c, d e)	ALTERNATIVE SOLUTION	❯ Product is comparable to ThermoPanel EPS with respect to compliance with Clause B1. Compliance of ThermoPanel based on GlobalMark CodeMark certification evaluation (GlobalMark, 28/06/2017). ❯ Span in accordance with Aspirepanel load span tables.
B2 Durability B2.3.1(a)	ALTERNATIVE SOLUTION	❯ Product is comparable to ThermoPanel EPS with respect to compliance with Clause B2. Compliance of ThermoPanel based on GlobalMark CodeMark certification evaluation (GlobalMark, 28/06/2017).
C3 Fire affecting areas beyond the fire source C3.4 (a) C3.5 C3.7 (b, c)	ACCEPTABLE SOLUTION C/AS2 1st Edition June 2019	❯ Steel melts at temperatures >750 °C (refer to para. C7.1.5, C/AS2). ❯ Material group 1S when tested to ISO 9705:1993 [BRANZ FI11055-001, 17/04/2019]. ❯ Metalcraft Insulated Panel Systems confirmed the PIR core in Aspirepanel is the same as that tested in BRANZ Type Test FI11055-001.
E2 External moisture E2.3.1, E2.3.2, E2.3.3, E2.3.7 (b, c)	ALTERNATIVE SOLUTION	❯ Product is comparable to ThermoPanel EPS with respect to compliance with Clause E2. Compliance of ThermoPanel based on GlobalMark CodeMark certification evaluation (GlobalMark, 28/06/2017).
E3 Internal moisture E3.3.1, E3.3.4, E3.3.5, E3.3.6	ALTERNATIVE SOLUTION	❯ Product is comparable to ThermoPanel EPS with respect to compliance with Clause E3. Compliance of ThermoPanel based on GlobalMark CodeMark certification evaluation (GlobalMark, 28/06/2017).
F2 Hazardous building materials F2.3.1	ALTERNATIVE SOLUTION	❯ Product is comparable to ThermoPanel EPS with respect to compliance with Clause F2. Compliance of ThermoPanel based on GlobalMark CodeMark certification evaluation (GlobalMark, 28/06/2017).
G3 Food preparation and prevention of contamination G3.3.2 (a, b)	ALTERNATIVE SOLUTION	❯ Product is comparable to ThermoPanel EPS with respect to compliance with Clause G3. Compliance of ThermoPanel based on GlobalMark CodeMark certification evaluation (GlobalMark, 28/06/2017).
H1 Energy Efficiency H1.3.1 (a, b), H1.3.2E	ALTERNATIVE SOLUTION	❯ Determination of R-values and energy performance of PIR [DASCO, 30/08/2019].

Other performance statement	Performance statement	BASIS OF STATEMENT Demonstrated by
Aspirepanel will not contaminate potable water.	AS/NZS 4020:2005.	❯ Claimed by New Zealand Steel Ltd. [New Zealand Steel Ltd. 2018]. ❯ BRANZ statement that metal roof is suitable [BRANZ, 2018].

SOURCES OF INFORMATION

- BRANZ. [17 April 2019] *BRANZ TYPE TEST AS ISO 9705 & ISO 9705 FIRE TEST OF THERMOPANEL PIR*. Report No. FI11055-001.
- BRANZ. *Water. Harvesting rainwater.* Retrieved from http://www.level.org.nz/water/water-supply/mains-or-rainwater/harvesting-rainwater/. [Accessed on 25/06/2020].
- DASCO. [30/08/2019*] Product Test Report. R-Value (m2.K/W). Test method: KS M 3809.* Report No. DA-190830-22-01.
- Global-Mark. [28 June 2017] *Metalcraft Insulated Panel System CodeMark Certificate of Conformity*. Certificate No. GM-CM30078-RevC. Retrieved from https://www.building.govt.nz/assets/Uploads/building-code-compliance/certifications-programmes/product-certification-scheme/product-certificate-register/metalcraft-insulated-panel-system.pdf. [Accessed on 18/06/2020].
- red co Consulting Professional Engineers. [n.d.] *Metalcraft suPIRspan – Load-span Curves.*
- New Zealand Steel Ltd. [October 2018] *Product technical statement v2018.1* Retrieved from https://tinyurl.com/y7hldxx6. [Accessed on 18/06/2020].
- New Zealand Steel Ltd. [October 2018] *Environmental Categories, Warranty & Product Maintenance Recommendations.* Retrieved from https://tinyurl.com/y9paxqag. [Accessed on 18/06/2020].
- New Zealand Steel Ltd. [October 2018] *Incompatible Materials.* Retrieved from https://tinyurl.com/ybspk5y6. [Accessed on 18/06/2020].

1. Where a standard is referenced it is to be read as amended by the acceptable solution or verification method as applicable.
2. Sources of information also include the Building Act 2004 and its regulations, including the Building Code (Schedule 1 of the Building Regulations 1992), Acceptable Solutions and Verification Methods, and relevant cited standards.
3. The quality and assurance that the supplied products meet the performance claims stated in this pass™ are the responsibility of the company that is the holder of this pass™.

Scan or click this QR code for a full download of Compliance Documentation for this pass™.
www.metalcraftgroup.co.nz

Metalcraft Insulated Panels confirms that if Aspirepanel is used in accordance with the requirements of this pass™ the product will comply with the Building Code and other performance claims set out in this pass™ and the company has met all of its obligations under s14 G of the Building Act.

Date of first issue:	4/4/2021
Date of current issue:	19/12/2022
NZBN:	9429036310852

Kevin Brunton

Kevin Brunton, Technical Director, TBB confirms that this pass has been prepared on behalf of Metalcraft Insulated Panels and in accordance with MBIE PTS guidelines and in accordance with the TBB pass™ process which is within the scope of TBB's ISO 9001 certification.

9606D66ADE51EA6CCC25850D00239F99

139 Roscommon Road, Wiri, Auckland ❯ sales@metpanels.co.nz ❯ 64 9 277 8844 ❯ www.metalcraftpanels.co.nz

VERSION: 2.1