GIB®

Bracing Supplement Document

Issue Date December 2016

GIB® Bracing design notes

SUPPLEMENT	ISSUE DATE
GIB Ezybrace® Systems 2016 BU/m Ratings	Sept-16
Designing and Building with GS2-NOM	Sept-16
Multi Layer Bracing Systems	Aug-16
GIB® News article: Wings, Blocks & Diaphragms	Apr-13
GIB® News article: Low Damage Solutions for Non- Structural Elements	Jul-12
GIB® News article: Canterbury Earthquake Online Guides	Mar-12
Bracing Light Timber Frame Buildings Using Sheet Materials	Nov-11
Distribution of Wall Bracing Elements	Nov-11
Designing Bracing Upgrades	Jun-11

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GIB Ezybrace® Systems 2016 BU/m Ratings

Issue Date September 2016

The BU/m ratings for GIB EzyBrace® Systems shown below are responsibly conservative and are provided to allow manual calculation, and for use in alternative proprietary software.

The GIB EzyBrace® 2016 software delivers more accurate demand calculations based on specific building parameters entered, and bracing resistance (BU/m) is often higher than the values presented below. Do not use this table to assess bracing substitutions.

Table 1: GIB® Standard Bracing Unit Ratings

Type	Minimum Length (m)	Lining	Other Requirements	BU/m	
				W	EQ
GS1-N	0.4	GIB® Standard plasterboard one side	N/A	50	55
	1.2			70	60
GS2-N	0.4	GIB® Standard plasterboard both sides	N/A	70	65
	1.2			95	85
GS2-NOM	0.4	GIB® Standard plasterboard both sides (standard GIB® site guide fastener pattern)	N/A	50	50
GSP-H	0.4	GIB® Standard plasterboard one side, structural plywood the other	Panel hold-down fixings	100	115
	1.2			150*	150*

Table 2: GIB Braceline® Bracing Unit Ratings

Type	Minimum Length (m)	Lining	Other Requirements	BU/m	
				W	EQ
BL1-H	0.4	GIB Braceline® one side	Panel hold-down fixings	90	100
	1.2			125*	105
BLG-H	0.4	GIB Braceline® one side, GIB® Standard plasterboard the other	Panel hold-down fixings	110	115
	1.2			150*	145*
BLP-H	0.4	GIB Braceline® one side, structural plywood the other	Panel hold-down fixings	120*	135*
	1.2			150*	150*

** Timber Floors – A limit of 120 BU/m for NZS 3604:2011 timber floors applies unless specific engineering ensures that uplift forces generated by elements rated higher than 120 BU/m can be resisted by floor framing.*

Wall Heights other than 2.4m

The published Bracing Unit ratings are based on a 2.4 metre height. For greater heights, the ratings must be multiplied by a factor f = 2.4 divided by the actual wall height. The Bracing Unit ratings for walls higher than 2.4 metres will reduce.

For example:

The Bracing Unit rating of a 2.7 metre high wall is obtained by multiplying the values in Tables 1 and 2 by f = 2.4/2.7 = 0.89

The Bracing Unit rating of a 3.6 metre high wall is obtained by multiplying the values in Tables 1 and 2 by f = 2.4/3.6 = 0.67

The height of walls with a sloping top plate can be taken as the average height.

Walls lower than 2.4 metres shall be rated as if they were 2.4 metres high.

For more information visit gib.co.nz/ezybrace or call the GIB® Helpline on 0800 100 442.

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Designing and Building with GS2-NOM

Issue Date September 2016

GIB EzyBrace® Systems 2016 literature and software includes the option of allowing nominally fixed internal walls lined on both sides with GIB® plasterboard to contribute to the building's bracing resistance. The fixing pattern as illustrated below represents the standard fixing pattern as published on page 38-39 of the GIB® Site Guide (December 2014).

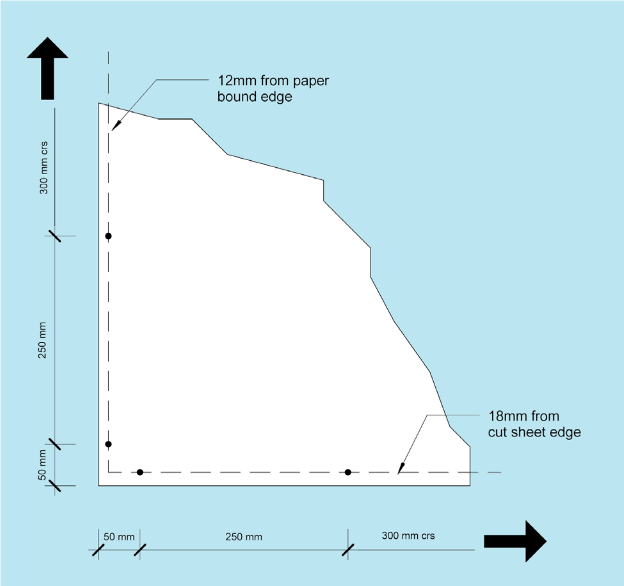
Building investigations following the Canterbury earthquakes have confirmed that not only designated bracing elements (such as GS1-N & GS2-N) resist lateral forces. Nominally fastened internal walls also contribute (often substantially) to the building's total resistance. An earthquake does not distinguish between designated GIB® plasterboard bracing elements and nominally fastened GIB® plasterboard linings. All the walls contribute to providing resistance against wind and earthquake forces.

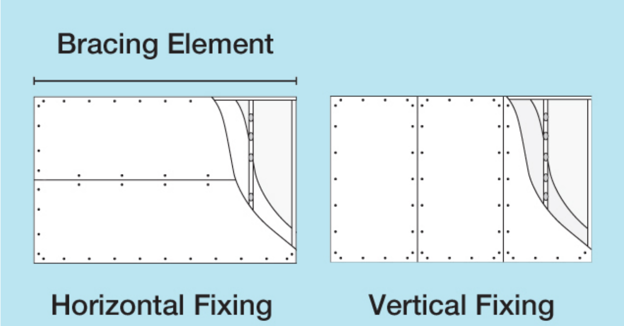
Permitting nominally fixed internal GIB® plasterboard linings to contribute to bracing resistance means that the total number of nails or screws can be reduced significantly. This results in a simpler and more uniform fastener pattern and a reduction in the risks of fastener 'popping' as a result of timber movement. This improves the chance of achieving a high quality of finish.

When compared with GS1-N and GS2-N, the same Bracing Unit (BU) rating can be achieved with GS2-NOM using 30% to 40% fewer screws.

The design examples on the following pages illustrate how fastener numbers can be reduced.

FIGURE 1: GS2-NOM SCREW FIXING PATTERN





GS2-NOM - DESIGN APPROACH 1

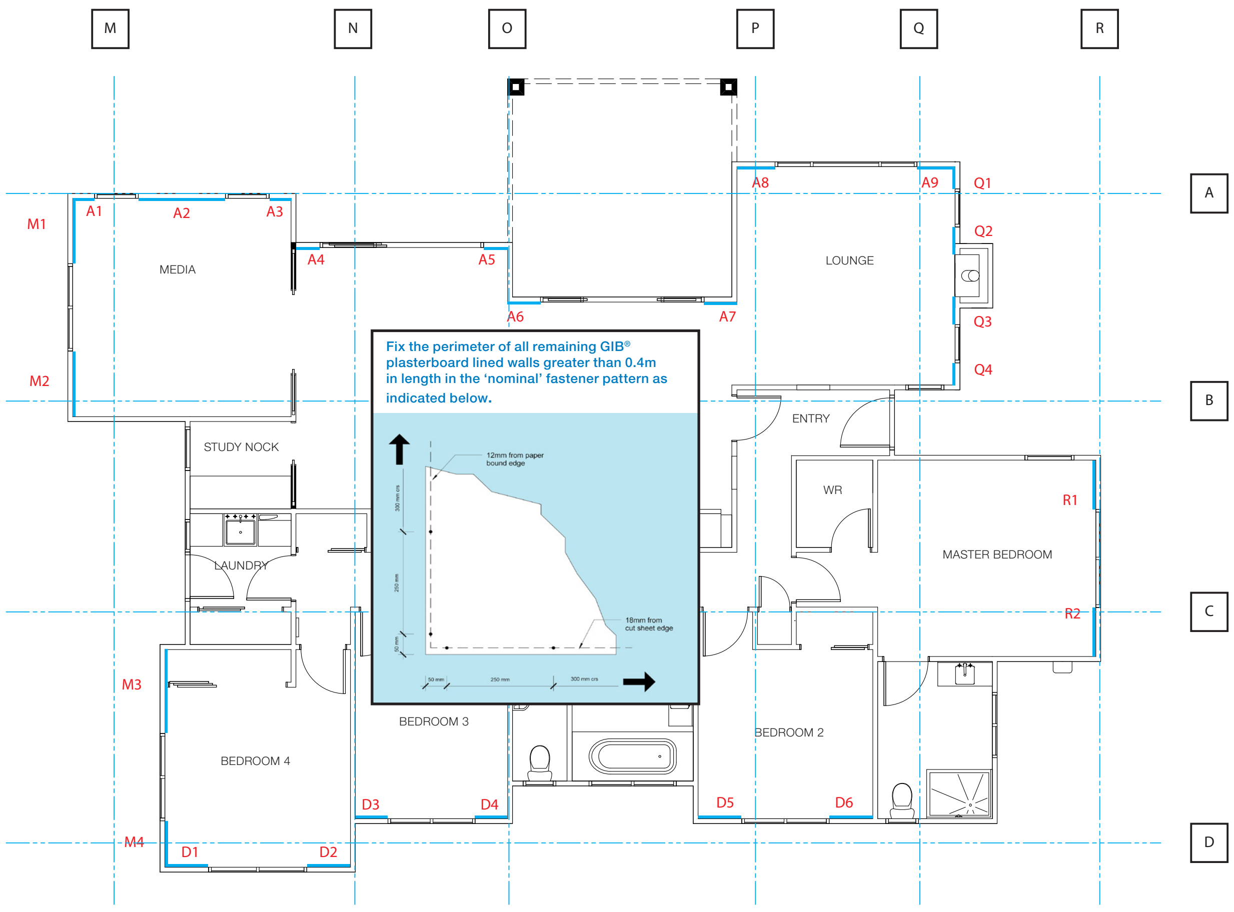
The design example in Figure 2 below shows designated bracing elements GS1-N and BL1-H used around the perimeter of the house. A note is added that all remaining GIB® plasterboard linings are fixed at the nominal GIB® Site Guide pattern.

In this particular case the design calculations in Figure 3 show that bracing resistance exceeds demand by 60% when accounting for nominally fixed GS2-NOM throughout. Had GS1-N or GS2-N designated internal bracing elements been used, in addition to nominally fixed (not counted) remaining walls, the fastener count could have increased by more than 500 screws.

The calculations also show how lengths of GS2-NOM can be accumulated on a bracing line. Lengths of internal wall equal or greater than 0.4 m can be added, provided walls are lined both sides with a minimum of 10 mm GIB® Standard plasterboard fixed in the nominal GIB® Site Guide pattern. The accumulated length is then entered in the bracing resistance calculations. Bathroom walls and walls with significant openings are not added to the accumulated length.

In this case the Building Official should be able to take the design redundancy into account, ensure internal walls lined both sides are generally fixed in accordance with the standard GIB® Site Guide GS2-NOM pattern, and focus more specifically on critical elements around the building perimeter.

FIGURE 2: DESIGN APPROACH 1– BRACING LAYOUT PLAN



This design considers the inherent bracing provided by the structure and tops up with designated bracing elements where required. To avoid any potential for miscommunication and delays onsite during construction and inspection, designers should clearly note the intent to use standard GIB® Site Guide GS2-NOM fixing on bracing plans.

FIGURE 3: DESIGN APPROACH 1 - BRACING RESISTANCE CALCULATIONS INCLUDING GS2-NOM

Single Level Along Resistance Sheet

Job Name:

Wind	EQ
Demand	
624	712
Achieved	
992	976
159%	137%

Line	Element	Length (m)	Angle (degrees)	Stud Ht. (m)	Type	Supplier	Wind (BUs)	EQ (BUs)	Wind	EQ
A	1	0.40		2.4	GS1-N	GIB®	21	23		
	2	1.60		2.4	GS1-N	GIB®	110	96		
	3	0.40		2.4	GS1-N	GIB®	21	23		
	4	0.50		2.4	GS1-N	GIB®	28	29		
	5	0.50		2.4	GS1-N	GIB®	28	29		
	6	0.70		2.4	GS1-N	GIB®	41	41		
	7	0.70		2.4	GS1-N	GIB®	41	41		
	8	0.80		2.4	GS1-N	GIB®	49	47		
	9	0.80		2.4	GS1-N	GIB®	49	47		
	External Length = 15								388 OK	377 OK
B	1	1.60		2.4	GS2-NOM	GIB®	80	80		
	2	1.60		2.4	GS2-NOM	GIB®	80	80		
									160 OK	160 OK
C	1	1.80		2.4	GS2-NOM	GIB®	90	90		
	2	1.80		2.4	GS2-NOM	GIB®	90	90		
									180 OK	180 OK
D	1	0.80		2.4	GS1-N	GIB®	49	47		
	2	0.80		2.4	GS1-N	GIB®	49	47		
	3	0.60		2.4	GS1-N	GIB®	34	35		
	4	0.60		2.4	GS1-N	GIB®	34	35		
	5	0.80		2.4	GS1-N	GIB®	49	47		
	6	0.80		2.4	GS1-N	GIB®	49	47		
	External Length = 15								264 OK	259 OK

Single Level Across Resistance Sheet

Job Name:

Wind	EQ
Demand	
785	712
Achieved	
1155	1103
147%	155%

Line	Element	Length (m)	Angle (degrees)	Stud Ht. (m)	Type	Supplier	Wind (BUs)	EQ (BUs)	Wind	EQ
M	1	1.30		2.4	GS1-N	GIB®	90	78		
	2	1.30		2.4	GS1-N	GIB®	90	78		
	3	1.60		2.4	GS1-N	GIB®	110	96		
	4	0.90		2.4	GS1-N	GIB®	57	53		
	External Length = 12								347 OK	305 OK
N	1	3.20		2.4	GS2-NOM	GIB®	160	160		
									160 OK	160 OK
O	1	3.20		2.4	GS2-NOM	GIB®	160	160		
									160 OK	160 OK
P	1	2.00		2.4	GS2-NOM	GIB®	100	100		
									100 OK	100 OK
Q	1	0.40		2.4	GS1-N	GIB®	21	23		
	2	0.40		2.4	GS1-N	GIB®	21	23		
	3	0.40		2.4	GS1-N	GIB®	21	23		
	4	0.40		2.4	GS1-N	GIB®	21	23		
	5	2.00		2.4	GS2-NOM	GIB®	100	100		
									185 OK	193 OK
R	1	0.90		2.4	BL1-H	GIB®	102	92		
	2	0.90		2.4	BL1-H	GIB®	102	92		
	External Length = 12								204 OK	185 OK

GS2-NOM - DESIGN APPROACH 2

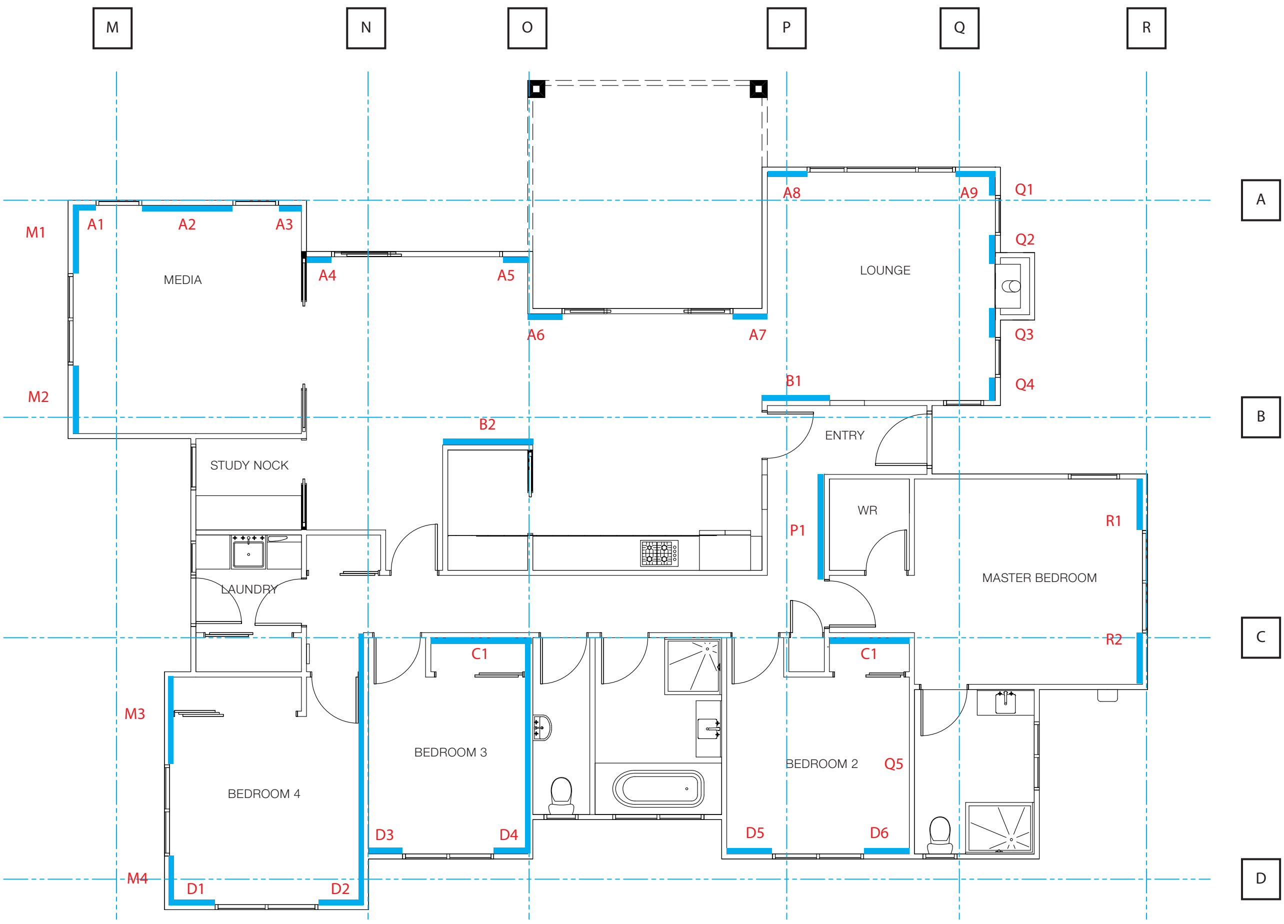
The design approach in Figure 4 below shows designated bracing elements GS1-N and BL1-H used around the perimeter of the house. Standard GIB® Site Guide fixing is used on internal walls lined both sides. Specific sections of these internal walls are nominated as GS2-NOM bracing elements, sufficient to meet or exceed the minimum bracing demand on the particular bracing grid line.

In this case GS2-NOM is used as a conventional bracing element. This method might be preferred by some designers, builders and building officials as it represents a more traditional approach to bracing resistance calculations and construction and permits focus on designated elements.

The outcome in terms of number of fastener is the same as that achieved with DESIGN APPROACH 1 where the fastener count could have increased by 500 screws if GS1-N or GS2-N designated internal bracing elements had been used in place of GS2-NOM.

In this case the calculations show how GS2-NOM is used as an orthodox bracing element and the building consent and inspection processes are also conventional. Given the many internal walls not counted in this case, it is still suggested that inspection focus should be more specifically on critical elements around the building perimeter.

FIGURE 4: DESIGN APPROACH 2 – BRACING LAYOUT PLAN



This design uses GS2-NOM as a conventional bracing element and designers should clearly identify designated elements on the bracing plan. Not counted internal walls fastened in the standard GIB® Site Guide pattern add further redundancy.

FIGURE 4: DESIGN APPROACH 2 – BRACING LAYOUT PLAN

Single Level Along Resistance Sheet

Job Name:

	Wind	EQ
Demand	624	712
Achieved	1152	1136
	185%	160%

Line	Element	Length (m)	Angle (degrees)	Stud Ht. (m)	Type	Supplier	Wind (BUs)	EQ (BUs)	Wind	EQ
A	1	0.40		2.4	GS1-N	GIB®	21	23		
	2	1.60		2.4	GS1-N	GIB®	110	96		
	3	0.40		2.4	GS1-N	GIB®	21	23		
	4	0.50		2.4	GS1-N	GIB®	28	29		
	5	0.50		2.4	GS1-N	GIB®	28	29		
	6	0.70		2.4	GS1-N	GIB®	41	41		
	7	0.70		2.4	GS1-N	GIB®	41	41		
	8	0.80		2.4	GS1-N	GIB®	49	47		
	9	0.80		2.4	GS1-N	GIB®	49	47		
					External Length =	15			388 OK	377 OK
B	1	5.00		2.4	GS2-NOM	GIB®	250	250		
									250 OK	250 OK
C	1	5.00		2.4	GS2-NOM	GIB®	250	250		
									250 OK	250 OK
D	1	0.80		2.4	GS1-N	GIB®	49	47		
	2	0.80		2.4	GS1-N	GIB®	49	47		
	3	0.60		2.4	GS1-N	GIB®	34	35		
	4	0.60		2.4	GS1-N	GIB®	34	35		
	5	0.80		2.4	GS1-N	GIB®	49	47		
	6	0.80		2.4	GS1-N	GIB®	49	47		
					External Length =	15			264 OK	259 OK

Single Level Across Resistance Sheet

Job Name:

	Wind	EQ
Demand	785	712
Achieved	1645	1593
	210%	224%

Line	Element	Length (m)	Angle (degrees)	Stud Ht. (m)	Type	Supplier	Wind (BUs)	EQ (BUs)	Wind	EQ
M	1	1.30		2.4	GS1-N	GIB®	90	78		
	2	1.30		2.4	GS1-N	GIB®	90	78		
	3	1.60		2.4	GS1-N	GIB®	110	96		
	4	0.90		2.4	GS1-N	GIB®	57	53		
					External Length =	12			347 OK	305 OK
N	1	5.00		2.4	GS2-NOM	GIB®	250	250		
									250 OK	250 OK
O	1	5.00		2.4	GS2-NOM	GIB®	250	250		
									250 OK	250 OK
P	1	5.00		2.4	GS2-NOM	GIB®	250	250		
									250 OK	250 OK
Q	1	0.40		2.4	GS1-N	GIB®	21	23		
	2	0.40		2.4	GS1-N	GIB®	21	23		
	3	0.40		2.4	GS1-N	GIB®	21	23		
	4	0.40		2.4	GS1-N	GIB®	21	23		
	5	5.20		2.4	GS2-NOM	GIB®	260	260		
									345 OK	353 OK
R	1	0.90		2.4	BL1-H	GIB®	102	92		
	2	0.90		2.4	BL1-H	GIB®	102	92		
					External Length =	12			204 OK	185 OK

GS2-NOM ADHESIVE FIXING OPTION AT REBATED JAMBS

When rebated jambs are used, GS2-NOM fastener numbers can be further reduced by using a continuous bead of GIBFix® All-Bond solvent-based adhesive on studs adjacent to the opening, as illustrated below. This method only applies to GS2-NOM fixing and not to other designated bracing elements.

If the adhesive fixing method is preferred, it is strongly recommended that it is discussed with the site building official at an early stage, prior to starting lining installation, so that an inspection and sign-off process can be agreed.

There should be ample opportunity to do this given that lining installation commences at an advanced stage of the project.

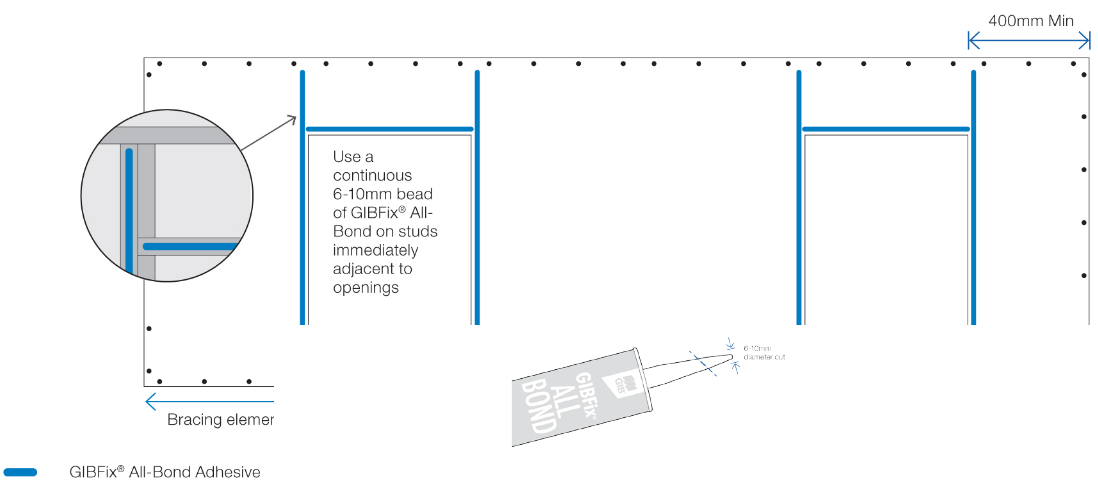
CLEAR COMMUNICATION BETWEEN THE DESIGNER, BUILDER AND BUILDING CONSENT AUTHORITY IS KEY!

A poor outcome would be when the designer and builder have elected to use the adhesive fixing method but have failed to advise the site building official prior to lining. If the building official has reservations about the application of adhesive, one of the following processes can be agreed;

A number of random core holes can be requested. They can be drilled with a small hole-saw in locations above openings as agreed between the building official and installer. If presence of GIB® All-Bond adhesive is evident it is at the building official's discretion to accept the installation 'on reasonable grounds'.

If the decision is made to reject the adhesive fixing method post-lining, screws can be installed in accordance with the Figure 1 GS2-NOM fixing pattern. If GIBFix® All-Bond adhesive has been used it is prudent to wait 7 days for the adhesive to fully cure before applying screws.

FIGURE 6: GS2-NOM SCREW AND GIBFIX® ALL-BOND FIXING FOR REBATED JAMBS



SUMMARY GS2-NOM DESIGN, INSTALLATION AND INSPECTION

GS2-NOM

- GS2-NOM permits internal walls lined in accordance with standard GIB® Site Guide fixing to contribute to bracing resistance
- Using GS2-NOM can result in a significant reduction of screw fixings which in turn aids quality of finish
- Using GS2-NOM can result in a more uniform fastener pattern
- The decision to use GS2-NOM requires agreement between the various parties involved in the design and construction process
- Using GS2-NOM in calculations often results in designs with bracing resistance well exceeding bracing demand because most internal walls can be counted. In addition, conservative Bracing Unit ratings have been assigned to GS2-NOM in the GIB EzyBrace® Systems 2016 software.
- When inspecting GS2-NOM installations, the design margin should be taken into account
- When design margins are tight, focus should first be on bracing distribution and the design and construction of critical bracing elements, e.g. narrow panels adjacent to significant openings such as large windows, ranch sliders or garage doors.
- GS2-NOM specifies 300 mm maximum perimeter screw centres. Closer fixing is permitted.

GS2-NOM ADHESIVE FIXING OPTION

- If the GS2-NOM adhesive fixing method is preferred, prior communication between the contractor, installer, and building official is required. Installation of adhesive fixed GS2-NOM without prior consultation with the site building official is discouraged.
- The lining installer may wish to take a photographic record of the installation. However, acceptance depends on the practices adopted by the particular Building Control Authority and prior communication is once again recommended.
- If adhesive fixed GS2-NOM has been installed without prior consultation with the site building official, random core holes can be drilled to determine the presence of adhesive and establish'reasonable grounds' for sign off. If required, installation of additional screws can be requested.

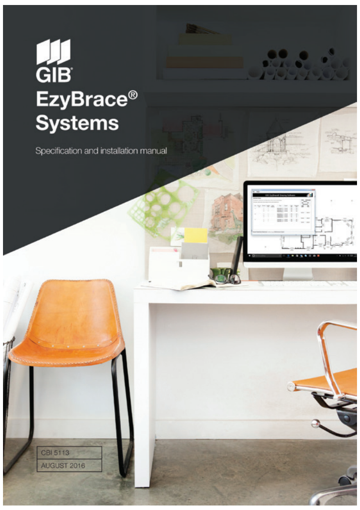
COMMUNICATION IS KEY WHEN DESIGNING AND INSPECTING BRACING, INCLUDING GS2-NOM FIXING.

PRODUCT SUBSTITUTION

- In order for GIB® systems to perform as tested, all components must be installed exactly as prescribed. Substituting components producesan entirely different system and may compromise performance. Follow system specifications.

TECHNICIAL MATERIAL & ASSISTANCE

Technical specification materials are available from www.gib.co.nz/ezybrace. Or call the GIB® Helpline 0800 100 442 for more information.



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Multi Layer Bracing Systems

Issue Date August 2016

In a two layer wall system such as GIB® Fire or Noise control systems, the plasterboard bracing element sheets can be either:

Applied directly to the framing, with fasteners set out as per the bracing instructions and a fastener length as per the system being installed. The inner layer can be left unstopped. Or,

Applied to the outer sheets with the outer layer fasteners being installed as per the bracing instructions and fastener length as per the system being installed.

The outer layer is to be tapped and stopped as per GIB® Site Guide.

When a GIB® Bracing element has been designated for a section of wall, BU ratings can not be increased by incorporating additional proprietary bracing elements within that same section of wall.

GIB®

Wings, Blocks and Diaphragms

Issue Date April 2013

We are often asked if separate bracing calculation is required for 'wings' or 'blocks'.

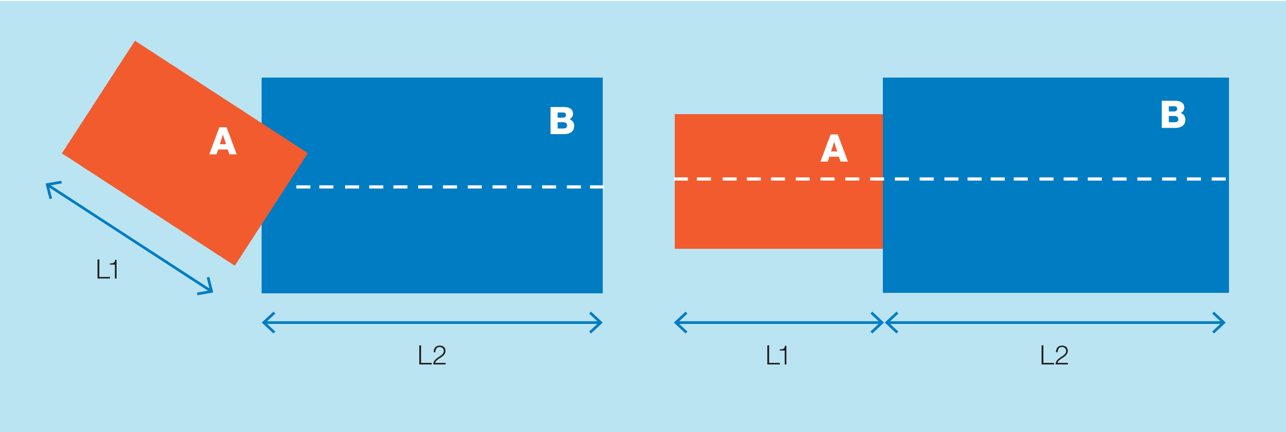
NZS 3604:2011 paragraph 5.1.5 requires wings or blocks to 'provide sufficient bracing individually' if they extend more than 6 metres from main building. Note that this requirement refers to the provision of bracing, and that separate calculation is not mentioned as a requirement.

The intent of the clause is that provision of bracing is relative to floor area. In other words, if a wing represents 20% of the total building floor area, then at least 20% of the bracing demand must be provided in that wing. This can be achieved by separate calculation, but is often more readily achieved by treating the building as a single unit and simply ensuring bracing distribution is balanced and proportional to floor area.

Even when wings or blocks are at an angle to the main building, a single calculation can be carried out. NZS3604:2011 paragraph 5.4.4 gives guidance for walls at angles to the bracing grid and is intended for single or few individual walls. Wings or blocks at an angle are better treated separately or by 'stretching' the building along the ridge line for calculation purposes and treating it as a single rectangular structure. The angle to bracing line function in the GIB EzyBrace® calculation sheet does not need to be applied in this situation.

Using a 'stretched' rectangular design will deliver the same outcome as doing two separate calculations. Again the important issue is to ensure that bracing provision and distribution is proportional to floor area.

Calculating A and B separately give the same bracing demand as treating them as a single 'stretched' building. Ensure that bracing provision is proportional to floor area.



The other frequently encountered bracing question relates to ceiling diaphragms and when they are required.

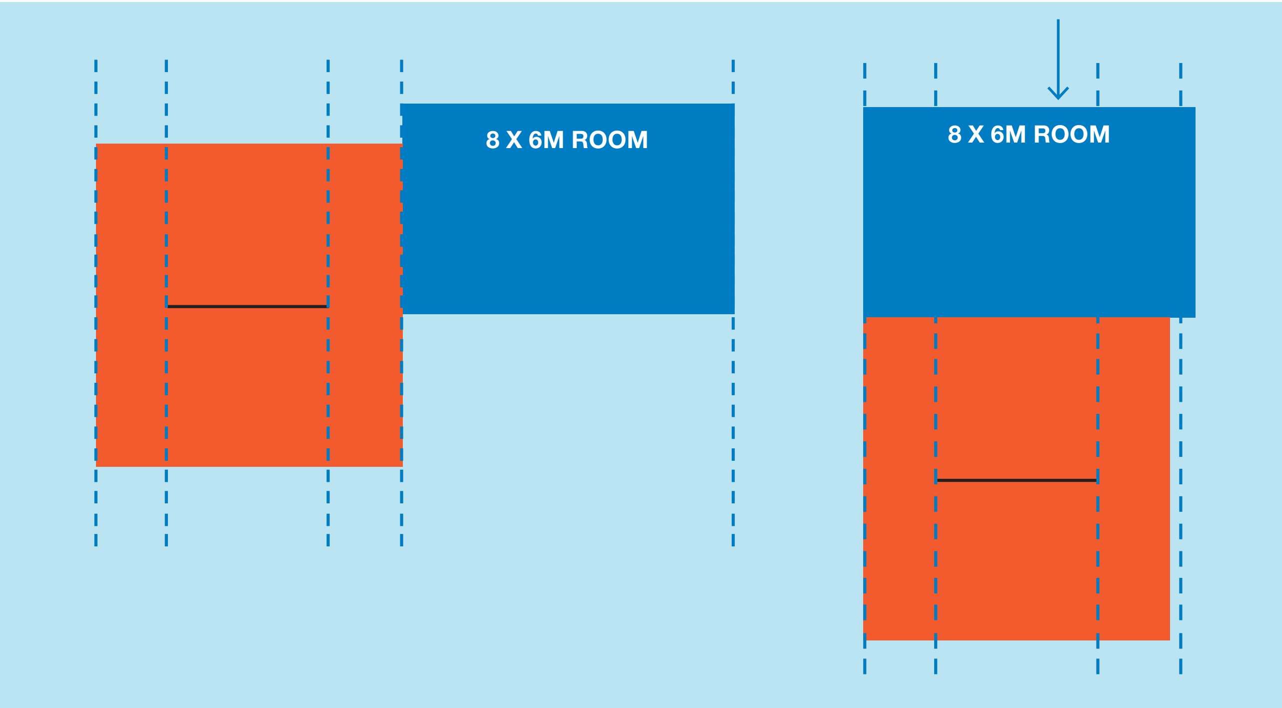
We often see diaphragms specified where they are not needed.

NZS3604:2011 paragraph 5.4.6 states that bracing lines 'shall not be at more than 6 m centres provided that there need be no bracing lines within the area covered by a diaphragm …' . The need for a diaphragm is thus determined by the spacing of bracing lines and not by the dimensions of a particular room.

The illustration below shows two designs incorporating a 8 x 6 m room. In one case NZS3604:2011 requires a ceiling diaphragm and in the other case it does not because bracing lines dissecting the room are spaced at less than 6 m.

A point to note is that the underlying NZS3604 assumption is that structural framing, such as trusses, rafters and their connections, provide support to the external wall (indicated by an arrow) back to the bracing grid. Use a ceiling diaphragm if there is any doubt whether such structural connections exist.

The 8 x 6m room on the left requires a ceiling diaphragm whilst the same size room on the right does not because bracing lines at less than 6m dissect the space.



GIB®

Low damage solutions for non-structural elements

Issue Date July 2012

Over the past 12 months Winstone Wallboards has been working closely with the engineering faculty at the University of Canterbury to develop improved systems for interior linings within commercial buildings.

Following the Canterbury earthquakes, many commercial buildings have suffered significant damage. As widely reported most high rise buildings in the Christchurch CBD have been, or are being, deconstructed. The many low-to-medium rise buildings that survived have often suffered significant damage to non-structural elements such as internal partitions and ceilings. Damage to these elements has generally been more costly than damage to the structure itself. Damage to non-structural elements also causes significant business disruption, either directly or during the repair process.

Non-structural ceilings and partitions are commonly lined with gypsum plasterboard and the owner's preference, often guided by the specifier, is more often than not for a flush monolithic finish. Expansive wall and ceiling areas are flush-finished and corners at wall and wall-to-ceiling intersections are typically square stopped. Non-structural elements tend to be tightly fitted into the main structure. Once taped and stopped, gypsum plasterboard lined walls and ceilings are very stiff. When locked into the main structure these elements do not have the ability to follow expected structural movement and 'inter-storey drifts' that occur during serviceability and design level earthquakes.

As a result non-structural elements can suffer significant damage. This has been evident in Christchurch and even after re-fixing, plasterstopping and painting, damage has repeated following further aftershocks.

Testing at Canterbury University has shown that 'low damage' solutions can be achieved by simply incorporating regular control joints. Negative details at wall junctions and intersections with the main structure, and breaking up expansive areas with regular control joints, will provide freedom for the non-structural elements to accommodate movements of the main structure.

Testing rig at University of Canterbury

Comments from the researchers include;

“The details work astonishingly well. Partitions stay flawless till 2.0% drift”

“Even at triple the current serviceability requirements, damage was minimal or in serviceable condition”

“Gaps can be arranged by simple calculation with a very high precision”

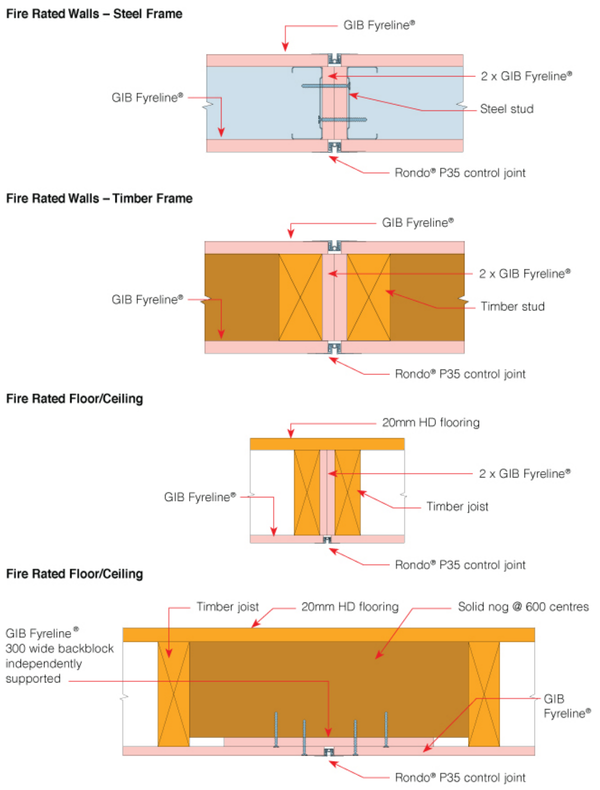
“Gaps can easily be made aesthetically pleasing or hidden with trim finishes”

“This cannot be achieved with existing monolithic finish practices”

Recommended details are as simple as they are effective, but a shift in owner and architectural expectation is required to make them work. The challenge to the architectural profession is to incorporate and ‘celebrate’ these expressed details if we are to have ‘low’ or ‘no damage’ solutions for non-structural elements in seismic zones.

For further information contact the GIB® Technical Helpline 0800 100 442. A detailed information bulletin is being prepared and will be available shortly.

Control joint illustrations from GIB® Fire Rated Systems 2006



Canterbury Earthquake Online Guidelines

Issue Date March 2012

A series of possible details to provide freedom of movement & reduce earthquake damage to non-structural linings.

New updated Technical Bulletins can now be viewed at www.gib.co.nz/canterburyearthquake. These include guidelines for the damage assessment and repair of plasterboard linings in earthquake damaged properties. Guidance is also available for the repair of lath and plaster linings, and for the design of supplementary bracing using other sheet materials.

We must remember that the Canterbury earthquakes are structural events that test a building's bracing system in real life. Before committing to repairs it is essential to assess and reinstate where necessary, the structure's resistance to possible future events. Failure to do so can result in repeated damage and the need for ongoing repairs. Keep an eye out for updates on our website. Within the near future we will be launching a simple 'bracing assessment' tool aimed at assisting assessors, designers, and builders with evaluating structural adequacy of houses.

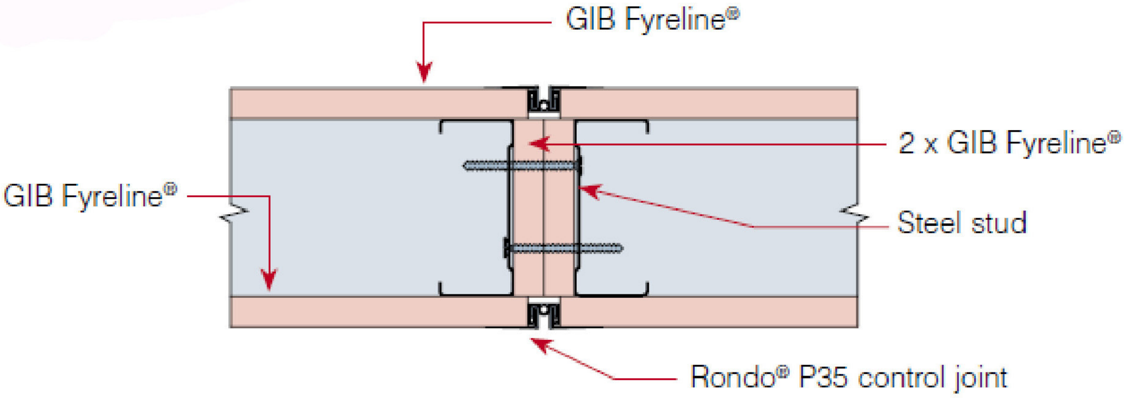
We have also posted a paper by our engineers Hans Gerlich and Richard Hunt summarising their observations relating to the performance of houses in and around Christchurch. In low-rise timber or steel framed buildings plasterboard linings will attract earthquake forces first and must be designed to resist them.

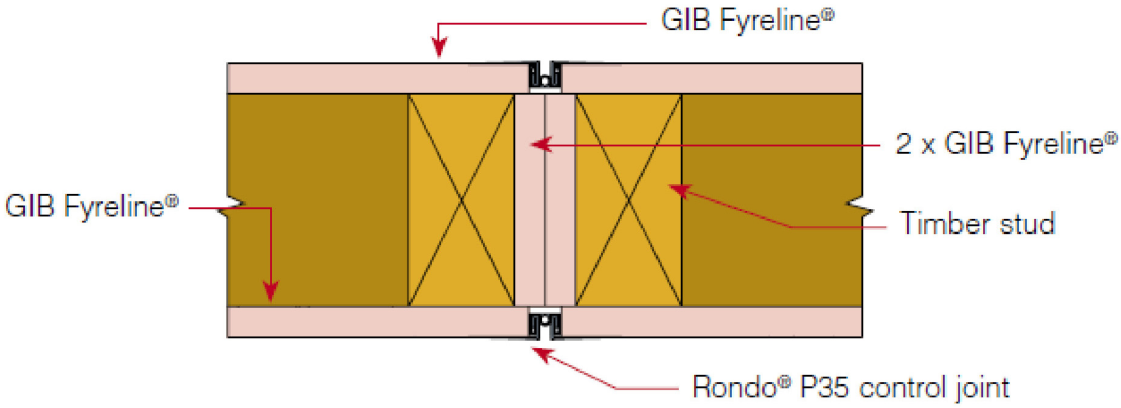
In commercial buildings, gypsum plasterboard linings obviously cannot be designed to resist forces resulting from imposed lateral movements of the main structure during a design level earthquake (see below).

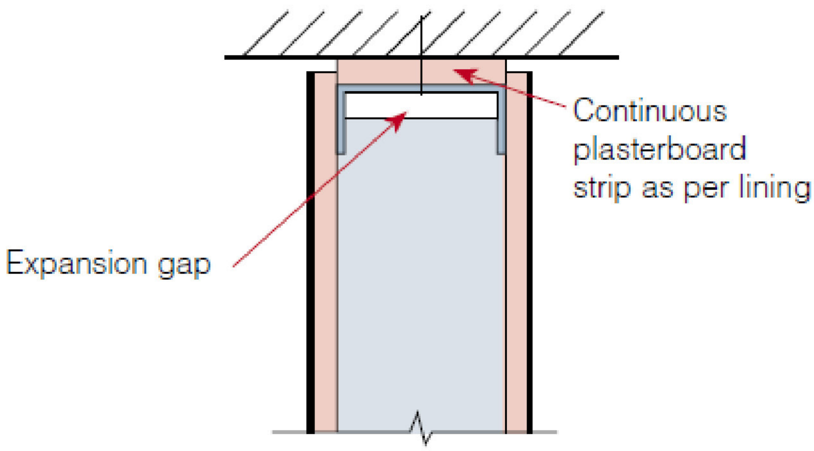
Gypsum plasterboard linings in a commercial building being severely damaged and forced off the wall framing by structural movement

Where gypsum plasterboard cannot be expected to resist such forces, a degree of freedom must be provided. The illustrations below show the principles of control and movements joints which can be easily incorporated in partition designs (whilst maintaining other performance attributes such as fire resistance or noise control).

Unfortunately architectural trends and owner requirements often dictate that walls are finished flush with a minimum of visual interruptions. A change in aesthetic design and acceptability of such details is required if we are to minimise post-earthquake damage in commercial structures.


GIB Fyreline®
2 x GIB Fyreline®
GIB Fyreline®
Steel stud
Rondo® P35 control joint


GIB Fyreline®
2 x GIB Fyreline®
GIB Fyreline®
Timber stud
Rondo® P35 control joint


Continuous plasterboard strip as per lining
Expansion gap

Bracing light timber framed buildings using sheet materials

Issue Date November 2011

BRACING UNITS

Bracing Units (BUs) were introduced for use with NZS3604 in the late 1970s in recognition of the contribution sheet linings and claddings make to the bracing resistance of light timber framed structures. A 2.4 m high by 2.4 m long wall, with a cut-in metal angle brace and gypsum plasterboard on one face, was tested and achieved a bracing resistance of 5 kN (approximately 500 kg). This was defined as 100 BUs (or 42 BU/m).

Since then the bracing rating (BU/m) for many proprietary systems have been established using the BRANZ P21 Wall Bracing Test and Evaluation Procedure.

The approach adopted by NZS3604 aims to achieve bracing resistance by evenly distributing moderately rated bracing elements throughout the structure. The sum total of these BUs must exceed the design wind and earthquake forces (the demand).

DISTRIBUTION

The NZS3604 rules regarding bracing distribution have been tightened in 2011, but they are still minimum guidelines. It is the responsibility of the building designer to ensure even distribution of bracing and to seek professional engineering input in case of any doubt.

"Lop-sided" distribution can result in irregular response to wind and earthquake forces causing unpredictable damage.

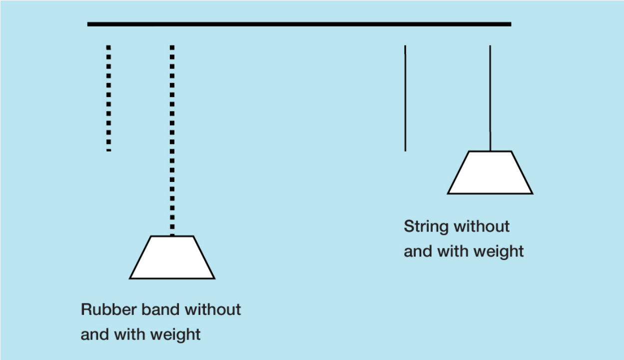
COMBINING DIFFERENT SHEET MATERIALS

Different sheet materials bring different attributes. The internal gypsum plasterboard lining system is inevitably very stiff once sheets are interconnected, taped and stopped. However, gypsum plasterboard bracing is less ductile than structural plywood sheet bracing.

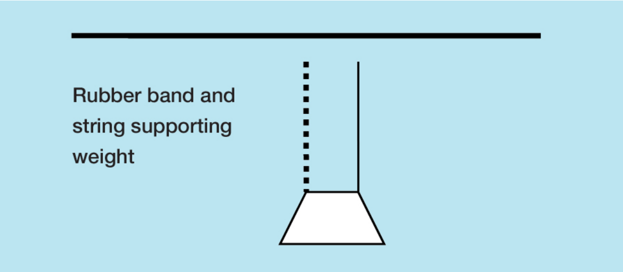
Structural plywood sheet bracing, installed on the outside of external framing, provides excellent ductility but offers less stiffness than plasterboard.

Whether we like it or not, the internal plasterboard linings will attract wind and earthquake forces first before they can be transmitted to other more flexible bracing systems. If we do not design plasterboard linings to accept these forces, then we can expect more damage than might otherwise be the case. The Canterbury earthquakes have shown plasterboard failures to be far more extensive when internal linings were poorly or not designed and installed to withstand earthquake forces.

To help illustrate this principle imagine a length of rubber band (ductile plywood bracing) and a similar length of string (stiff gypsum plasterboard bracing) both capable of supporting a certain weight (the bracing demand). The rubber band stretches considerably when the weight is applied. However, there is minimal stretch when the same weight is supported by the string.



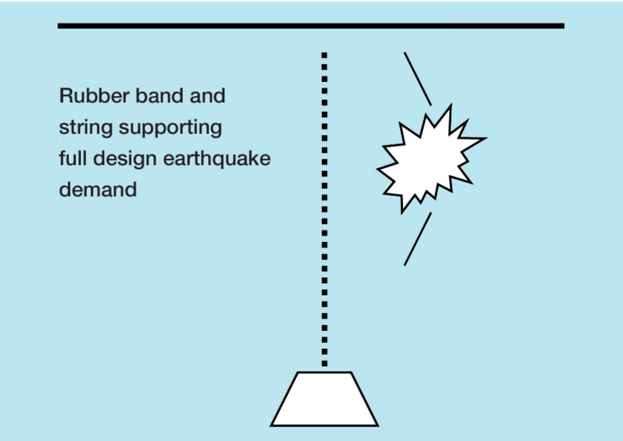
If we use the rubber band and string together to support the weight then the string does most of the work and needs to break before weight is transferred to the rubber band as illustrated below.



Now what happens when we apply these principles to buildings and do not design the stiffer element (gypsum plasterboard) to resist the full design wind and earthquake forces? In other words, what if the rubber band (plywood) has been designed to accept the bracing demand but the string (gypsum plasterboard) has only nominal fixings?

At frequent "serviceability" winds and small earthquake forces the string will perform as illustrated above.

However when forces approach "ultimate" design demand, the string will suffer damage or break before forces are transferred to the rubber band. So, although the plywood is likely to offer structural stability and protection from catastrophic failure well past design loads, the gypsum plasterboard lining system will suffer significant damage.



CONCLUSIONS

Sheet materials provide the most effective means of achieving bracing resistance in light timber framed structures such as houses.

The internal gypsum plasterboard lining system is the stiffest structural element in light timber framed structures and will attract design wind and earthquake forces first. Gypsum plasterboard linings must be designed and fixed to resist these forces regardless of whether supplementary bracing, such as structural plywood, is installed.

Discretionary use of high performance sheet materials such as structural plywood provides added ductility to enhance protection of structures against catastrophic failure.

The combination of gypsum plasterboard and structural plywood provides early strength and stiffness at design level events and added ductility when structures are subjected to even greater wind or earthquake actions.

Using a more flexible bracing system alone, based on multiple individual sheets or discrete length panels, and not fixing internal gypsum plasterboard linings to withstand wind and earthquake forces, is likely to result in significantly greater internal lining damage during a design and even more frequent serviceability events.

The best bracing system relies on a combination of internal gypsum plasterboard linings and plywood sheet bracing.Plasterboard provides strength and stiffness and plywood adds strength and ductility. To minimise damage during serviceability and ultimate design events, design plasterboard bracing to accept the full design demand and supplement with structural plywood for added strength and ductility as desired. Winstone Wallboards and Carter Holt Harvey publish combined GIB® / Ecoply® bracing systems where both the gypsum plasterboard and structural plywood are installed as a bracing element.

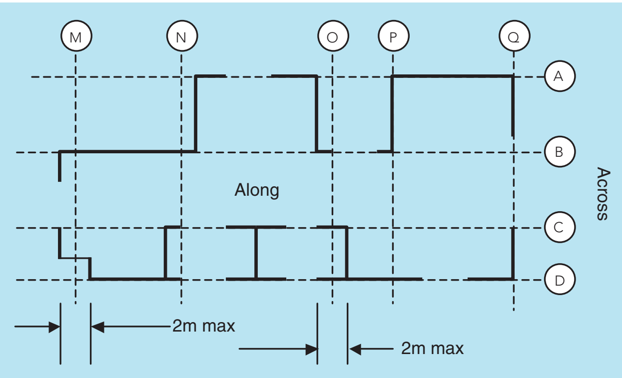
GIB®

Distribution of Wall Bracing Elements

Issue Date November 2011

Distribute bracing by drawing a grid pattern of bracing lines along and across the building. Bracing lines must coincide as much as possible with wall bracing elements.

Pairs of bracing elements may be counted on a single line provided they are no more than 2m apart as illustrated below. Locate wall bracing elements evenly throughout the building and as close as practical to corners of external walls.



Bracing lines must be spaced no more than;

— 6m for standard construction with any GIB® plasterboard ceiling, or

— 7.5m where dragon ties in accordance with NZS 3604:2011 have been installed to provide lateral strength to walls, or

— 12m with a GIB® plasterboard ceiling diaphragm, constructed in accordance with this publication. (Refer to the GIB® Ceiling Diaphragms technical note).

No bracing line shall have a capacity less than the greater of 100 bracing units or 50% of the total bracing demand

(D) divided by the number of bracing lines (n) in the direction being considered (0.5 x D/n).

For this purpose bracing lines less than 1m apart shall be considered one line.

For example, if the bracing demand for the building shown in the diagram above is 2,500 BUs (Wind) and 2,000 BUs

(Earthquake) in the across direction (M, N, O, P, Q) each line must each have at least the maximum of 0.5 x 2,500 /5 = 250 BUs (Wind) and 0.5 x 2,000 /5 = 200 BUs (Earthquake).

In addition external walls shall have a bracing capacity no less than 15 bracing units per metre of external wall length.

Wall bracing elements on timber floors shall not be rated higher than 120 BU/m.

Wall bracing elements on concrete floors shall not be rated higher than 150 BU/m.

GIB®

Designing Bracing Upgrades

Issue Date June 2011

Following the earthquake events in Christchurch homeowners may be looking for additional bracing performance.

As the New Zealand Building Code is based on a minimum requirement, customers may decide to specify above this level. This bulletin has been created to assist designers with upgrading bracing resistance using GIB EzyBrace® , for buildings that fall within the design scope of NZS 3604:2011.

PROBABILITY OF EXCEEDANCE AND BRACING RESISTANCE

The New Zealand Building Code requirements for Earthquake Bracing design are based on the probability that a certain design event is exceeded, as illustrated below.

Annual Probability of Exceedance	Return Period Factor for Specific Design[1]
Once in 500 years or 1/500	1.0
Once in 1000 years or 1/1000	1.3
Once in 2500 years or 1/2500	1.8

[1] *Equivalent Static Method of NZS1170.5:2004 compared with the GIB EzyBrace® software*

An earthquake with a probability of being exceeded once in 2500 years is much more severe than one with a 1/500 year probability of exceedance. Most residential buildings, such as those constructed in accordance with NZS 3604:2011, are required to meet a minimum 1/500 annual probability of exceedance, assuming a 50 year life expectancy. When a residential home is designed for a 100 year life expectancy, the required earthquake design period is 1/1000.

Multi-tenanted and public buildings such as hotels, apartments, offices, schools, medical centres, etc. can often be built to NZS 3604:2011 but commonly need to be designed for a different annual probability of exceedance ranging from 1/500 to 1/2500, depending on importance level and design working life.

To place some perspective, analysis of the information from the 22nd February Christchurch earthquake indicates that this event was close to the 1/2500 annual probability of exceedance.

UPGRADING BRACING RESISTANCE USING GIB EZYBRACE®

GIB EzyBrace® systems have been tested and appraised to meet the requirements of the New Zealand Building Code using New Zealand Standard NZS 3604:2011 and the default setting for earthquake design is an annual probability of exceedance of 1/500.

The GIB EzyBrace® software now incorporates an easy way to design for increased bracing resistance by selecting an increased annual probability of exceedance level.

Simply select the annual probability of exceedance using the drop down box in the demand sheet. For a 1/1000 probability, the bracing requirement (demand) increases by 30% and for a 1/2500 probability, bracing demand increases by 80% when compared with the default 1/500 minimum annual probability of exceedance.

Wind Zone	**High**	**Earthquake Zone**	**Soil Type**
Select by Building Consent Authority Map		3 ▼	D&E (deep to very soft) ▼
or Preference	High ▼	Annual exceedance probability	
Wind region	Preference selected ▼	1/1000 (NZS3604:2011 x 1.3) ▼ *	
Lee Zone	Preference selected ▼	This design has been upgraded to resist	
Ground Roughness	Preference selected ▼	an annual earthquake exceedance	
Site Exposure	Preference selected ▼	probability of 1/1000	
Topographic Class	Preference selected ▼	** Options include the default setting of 1/500, or increased annual probabilities of exceedance of 1/1000 or 1/2500*	

When designing for increased bracing resistance a statement, similar to that below, should be highlighted on all bracing plans and associated information;

"The bracing design of this building has been upgraded at the clients request to exceed the requirements of a 1/[select] annual probability. This design must not be modified or substituted as this will affect the specified bracing performance of this building"

DESIGN ACROSS THE WHOLE BUILDING

As a general rule of thumb it is recommended to exceed the minimum bracing requirements by 10 to 20%. This means a target bracing resistance value of between 110 and 120%.

As is reflected in NZS 3604:2011 bracing should ideally be distributed evenly across the whole building and not just isolated to the external walls or building ends.

External walls generally only account for around 1/3 of the total bracing performance of a house. Therefore if bracing on the external walls is increased by say 30%, the actual improvement over the whole building is likely to be only 10% or less.

Also modifying plasterboard linings alone will often deliver limited improvement. To achieve a higher overall building performance, full bracing system specifications must be installed which often includes additional hardware such as panel hold-downs.