ISSUES WITH RESIDENTIAL HOLD DOWN SYSTEMS

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Bracing systems in New Zealand commonly use hold-down bolts like the MiTek screw bolt/GIB HandiBrac system. Recent conversations with engineers and designers have raised potential issues to be aware of when using them on internal bracing lines with concrete slabs and detailing for timber floors.

While this article uses MiTek as an example, we primarily illustrate the need to follow a reliable load path and consider the requirements of the system specified, regardless of the manufacturer.

INTRODUCTION

The GIB EzyBrace software provides calculators for plasterboard type bracing elements on residential projects. Engineers, architects and architectural designers use the system extensively.

When specifying BLG-H or BL1-H, hold-downs are required to resist a 15kN characteristic uplift loading on a concrete slab or 12kN for timber floors. MiTek and GIB recommend using those braces on external lines with foundation beams in slabs or double joists for timber floors.

However, designers (including engineers) frequently use the braces internally, without considering a reliable load path or whether the slab thickness is sufficient for the screw length.

Engineers, architects, architectural designers and builders must ensure floor structures can provide adequate resistance and durability to the applied uplift forces.

CONCRETE FLOORS

In July 2021, an engineer raised problems with builders using GIB HandiBracs on internal bracing walls. She said builders had mentioned they had punched through the slab when drilling. When discussing the issue, another engineer pointed out durability requirements may also be compromised, particularly if the damp proof membrane is compromised.

The depth of a slab to NZS3604:2011 is 100mm, and the minimum hole depth required from the MiTek supplier statement is 96mm. However, a waffle type slab is typically only 85mm thick. That means without a thickening under the bracing wall, the screw will punch through the slab and not achieve minimum embedment for the rated capacity of the screw.

A Taupō engineer stated that he had discussed the issue with multiple architects and architectural designers, who hadn't been aware of the problem. Several of them rejected the idea of having a thickening under the slab as they felt it wasn't required.

Designers of all persuasions should know that MiTek's PS1 specifies a minimum embedment depth into concrete. A slab thickening would be required to ensure a robust connection. It may be that MiTek's PS1 isn't valid if the designer does not meet those requirements.

TIMBER FLOORS

Since the initial conversation regarding connecting to slabs, concerns have surfaced regarding using 12kN hold-down connections on timber framing. Many engineers and designers are not checking the load path through the foundations, considering the potential splitting of timber due to limited edge distance or checking whether joists can resist the applied uplift forces.

David Auer (Wellington Chair of Architectural Designers New Zealand) had been unaware of the issue. However, he believes that designers need to change practice to ensure the hold-down systems function as intended and according to all the manufacturers' requirements for the system.

NZS3604 primarily provides guidance on bottom plate fixings without bracing elements. Still, clause 7.5.12 mentions a minimum requirement "Anchors providing end fixings of bracing elements shall comply with all the requirements of 7.5.12 as well as their function of resisting bracing element uplift".

Joist spacing and sizes

The MiTek screw bolt for a timber floor requires 66mm embedment near the centreline of a 140x45 joist (on edge).

Specifications on the timber floor structure are vague, as it specifies a minimum joist size of 140x45 with no mention of spans or centres. 140x45 joists can span up to 2.7m using NZS3604 table 7.1a, but can they support a characteristic uplift load of 12kN?

Calculated to NZS3603, the capacity of a 140x45 joist is 1.65kNm under brief loading. If we use PL/6 to account for multiple spans, the demand on a 2.7m span is 5.4kNm. Even if we double up the joists, there is theoretically a maximum span of 1.9m.

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[2] Also refer P.20 for other contributors

A 1.9m maximum span is unlikely to be the case, as we cannot accurately model the system. However, doubling the joists and nail laminating them across a reduced span would seem justified.

Detailing blocking

It is also possible the bracing element will run perpendicular to the joists, so the uplift load will require blocking, as in Figure 1.

If you consider the uplift on the blocking, it is unlikely that a couple of nails into the end grain will suffice.

If you position the bracket centrally in the blocking, there will potentially be a 6kN uplift force on each end, indicating that a 6kN connection is potentially required.

Frequently this is missed from drawings, and the contractor adds blocking at the last minute on-site to pick up the HandiBrac detail.

External walls

Bracing elements on external walls can also produce issues with detailing. The detail recommended by GIB in Figure 2 sits over a single joist on the boundary, and the bracket should sit directly over the external joist centrally. However, there is often a double joist. If relying on the double joist for strength, they must be nail laminated (or similar) together.

Contractors often make mistakes on-site where they place the HandiBrac centrally on the double member, with the blue screw splitting the members and reducing any capacity.

How will you ensure these mistakes don't occur with your jobs? Better detailing, construction monitoring, educating contractors, or a mix of the three?

NZS3604 also specifies cantilevered floor joists, but are they designed to resist a potential 12kN force at the end? We know the capacity of a 140x45 joist is 1.65kNm, but having a hold-down bracket at the end of a 1m cantilever requires a 12kNm capacity. How can you be sure the joists can carry the load? If you don't seek a specific engineering design, could you re-arrange the bracing system to avoid the problem?

Handrails

Building Consent Authorities around New Zealand have varying requirements around handrail compliance under B1. Some councils allow architectural designers to sign-off handrail connections, while others insist on engineering input. Designers and engineers extensively use the HandiBrac and blue screw combination in other situations such as handrail base connections.

Like the external boundary joist situation mentioned above, designers often detail the blue screw splitting the double joist right down the middle.

This detailing, and misunderstandings around the sub-floor requirements for the HandiBrac, have the potential to be a more significant problem since horizontal handrail loadings may be more likely to impact the structure during its lifetime than ultimate wind or earthquake loads.

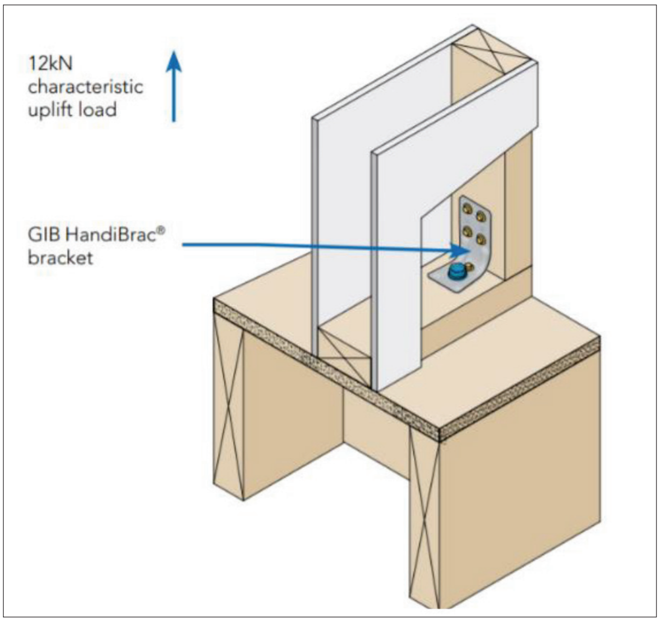

Figure 1: HandiBrac on blocking

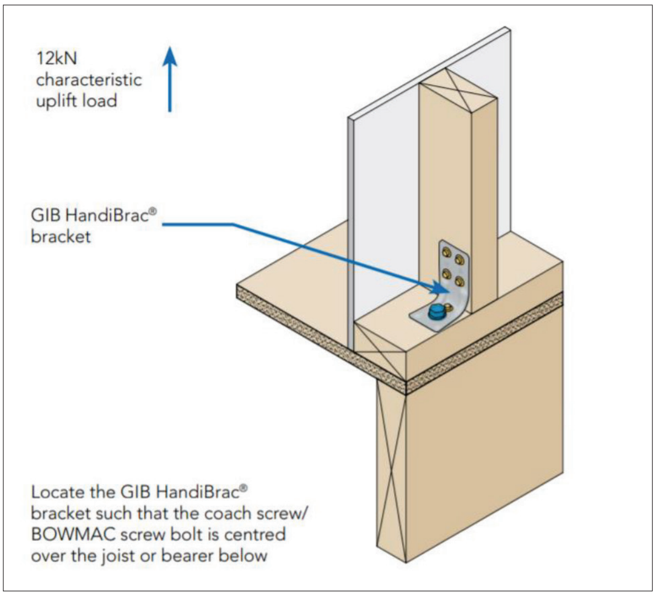

Figure 2: HandiBrac on external joist

POINTS TO CONSIDER

Concrete foundations

There are problems with hold-downs punching through slabs. When you're detailing hold-downs into a slab, how can you be sure the screw won't punch through?

As the designers of the bracing systems, it is our responsibility to ensure that our designs are robust and have a reliable load path. As such, it is worth considering (as a minimum):

- When installing a bracing line on external foundation beams, how are you ensuring the bracket has sufficient edge distance? Ideally, the screw will be sitting inside the longitudinal steel.

- What if there's a masonry header block? You likely cannot count the shell towards the edge distance. Is 140mm framing being used?
- If there's a 100mm NZS3604 slab, how can you ensure the contractor won't punch through the slab? Will you specify a pad or thickening?
- If you specify a waffle slab system, the embedment required is greater than the slab thickness. Positioning the wall over a 100mm wide rib won't suffice. You need a 59mm edge distance. How will you stay within the manufacturer's specifications?

Timber floors

When detailing the bracing, consider the load path and detail for it. Keep in mind the following points:

- Consider how the load is moving through the foundations. How are the loads getting into the joists? From the joist to the bearers? What about from the bearers to the piles? Do you need additional hold-downs or piles?
- Do you have a good detail for blocking available? Where will the bracing line end? What if it doesn't sit on top of a joist?
- Think about the span of the joists. Do you need to reduce the span and specify nail laminated double joists where hold-downs are close to mid-span?
- How will you ensure the contractor locates the screw centrally in the joist?
- How will you ensure the contractor nail laminates the joists where required?
- Do you have bracing lines ending on cantilevers? Have you calculated the load on the joist?

CONCLUSION

There are undoubtedly more issues than have been raised in this article. However, as a designer, whether working in the engineering or architecture space, it is your responsibility to follow the load path, think of any potential problems and make sure the system you specify will work as intended.

Concrete slabs are likely to require a thickening underneath them if specifying hold-downs on internal walls.

You should design subfloor systems to take the loads (positive and negative) that may be imposed upon them.

It's a good idea to ensure the contractor has details that work, and check the contractor has built it properly when undertaking construction monitoring.

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The Institution of Structural Engineers Structural Awards 2021

Holmes Consulting win Supreme award for Structural Engineering Excellence and Structural Heritage at the IstructE awards for the Christchurch Town Hall project.

On the 5th of November the Institution of Structural Engineers (IStructE) announced the winners of their annual structural engineering awards in London.

Now in its 54th year, the IstructE Structural Awards is a celebration of some of the best engineering projects the world has to offer. The criteria the judges considered in choosing the winners included: sustainability, creativity and innovation, elegance and good detailing, value and ease of constructability.

New Zealand structural engineering was represented by Holmes Consulting for their work on the restoration of the Christchurch Town Hall. Holmes took out the ‘Structural Heritage’ award as well as being a joint winner of the overall ‘Supreme’ award – a fantastic result for both Holmes and the New Zealand structural engineering industry.

The judges noted that the Christchurch Town Hall project “demanded a full spectrum of technically complex structural and geotechnical solutions. Solving ground stabilisation issues and predicting the future performance of the structure and foundations were achieved through detailed analysis and intensive co-ordination between the geotechnical and structural engineers.”

The judges considered the project “an excellent example of what structural engineers can bring to a devastated existing building. By understanding its behaviour and failure, the team was able to repair and preserve this important structure.”

Congratulations to Holmes and all involved in this landmark project and exciting win!

We know the high standard of structural engineering excellence in New Zealand and that many of you are providing great solutions for clients while solving complex challenges. Next year’s IstructE award applications open in January 2022. Keep an eye on the IstructE website to apply and potentially get your project onto an international stage.

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