Bracing light timber framed buildings using sheet materials

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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

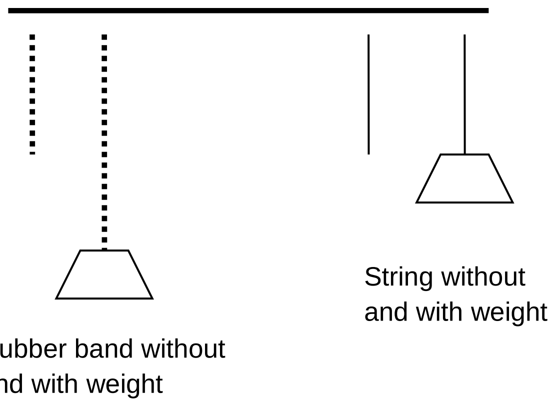
Different sheet materials bring different attributes.

The internal gypsum plasterboard lining system is inevitably very stiff once sheets are inter-connected, taped and stopped. However, gypsum plasterboard bracing is less ductile than structural plywood sheet bracing.

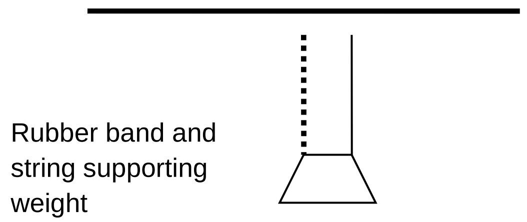
Structural plywood sheet bracing, installed on the outside of external framing, provides excellent ductility but offers less stiffness than plasterboard.

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.

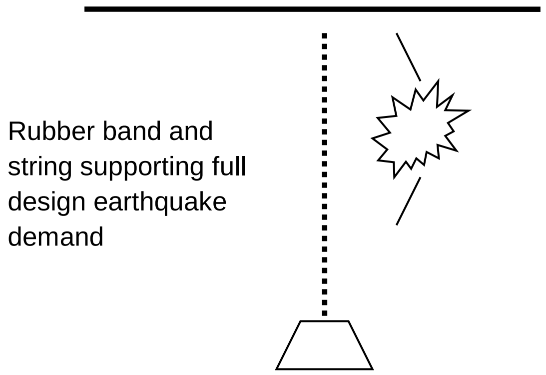


If we use the rubber band and string together to support the weight then the string does most of the work and needs to break before weight is transferred to the rubber band as illustrated below.



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.