

INFORMATION SHEET

SEISMIC DESIGN

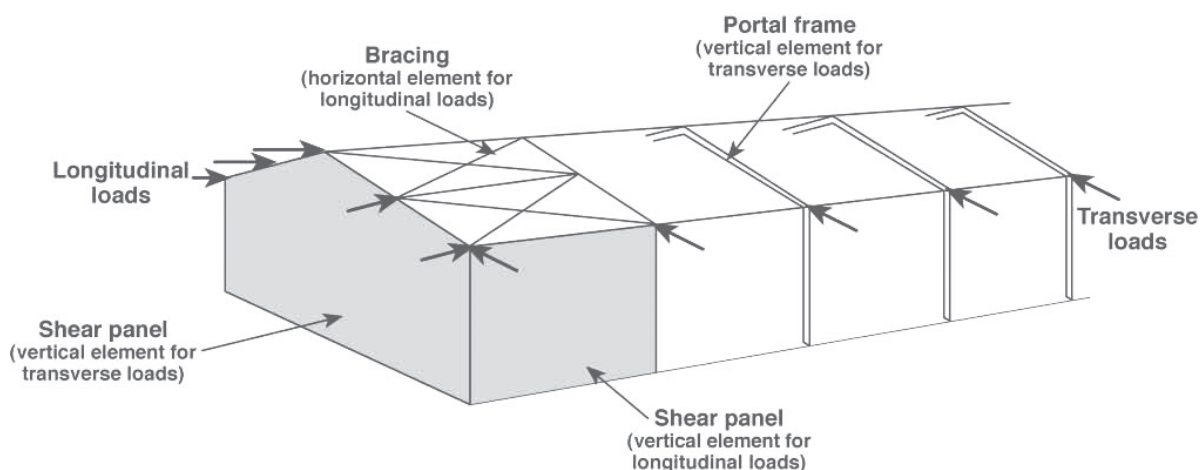
LATERAL FORCE RESISTING SYSTEMS

The information provided below has been taken from the New Zealand Timber Design Guide 2007, published by the Timber Industry Federation and edited by Professor A H Buchanan. To purchase a copy of the Timber Design Guide, visit www.nztif.co.nz

VERTICAL ELEMENTS

The vertical elements of a lateral force resisting system may consist of frames, cantilevers, diagonal bracing, or vertical shear panels. These elements are shown schematically in diagram 1.

Diagram 1: Typical industrial building using a combination of lateral force-resisting elements



MOMENT-RESISTING FRAMES

Moment-resisting frames must have a sufficient number of rigid connections to resist lateral forces. Frames are most often used in single storey industrial buildings where they resist vertical loads from the roof as well as lateral forces. Frames are suitable for large buildings with few internal walls, such as industrial buildings or multi-storey offices. Moment-resisting frames are more expensive than pinned frames because of the high cost of moment-resisting connections in timber structures. Frames tend to be much less stiff than shear wall systems which may be a problem for some types of buildings. Multi-storey office buildings with moment-resisting frames may need to have stiffer shear walls around the lift shafts or stairwells to control lateral deflections.

CANTILEVERS

A cantilever post fixed rigidly into the ground is the simplest system for resisting lateral forces. Timber poles are often used as cantilevers in single storey industrial or agricultural buildings, to support roof loads and to resist lateral forces. Tall cantilevered timber poles are rather flexible so other bracing may be required to limit lateral displacements, particularly where dynamic forces from cranes (in factories), or washing machines (in homes) are involved. Refer to the Pole building section.

DIAGONAL BRACING

Diagonal bracing is often the most economical vertical element for a lateral force resisting system. The bracing is located in the plane of a wall or a frame. The diagonal members may be designed to act in tension or compression or both, to form a vertical truss structure. Forces are hence transferred through a small number of members and their connections to the foundations. All parts of the vertical truss must be capable of carrying the imposed loads. In order to avoid a sloppy structural system in seismic loading, it is desirable to use members which can resist actions in tension and compression, although this is not always feasible.

VERTICAL SHEAR PANELS

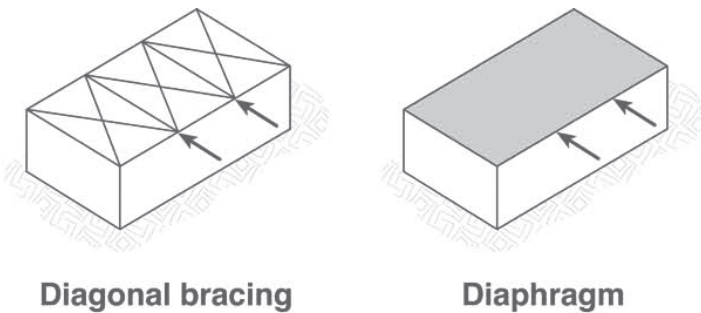
Vertical shear panels consist of walls which provide resistance to racking forces. If walls are required for other reasons, they are often also used for lateral force resistance. In timber wall systems, shear panels consist of flat sheets of panel product fixed to timber framing. Shear forces are transferred through a large number of connections (such as nails) at all the panel edges. Overturning moments are resisted by the studs at the ends of the walls. In buildings of composite materials, vertical shear panels may consist of concrete or masonry walls. The effects of window or door openings in the shear panels must always be considered.

The chords of vertical shear panels must be securely fixed to the foundations to prevent uplift or overturning.

HORIZONTAL ELEMENTS

The horizontal elements of a lateral force resisting system are either horizontal diaphragms or diagonal bracing, as shown in diagram 2. All buildings require some form of horizontal diaphragm at each floor level and at roof level. This section also applies to sloping roofs which may not be exactly horizontal.

Diagram 2: Horizontal elements of a lateral force-resisting system



HORIZONTAL DIAPHRAGMS

Horizontal diaphragms are flat horizontal elements such as the flooring. At the roof level, diaphragms may be formed from the ceiling material or from sarking under the roof cladding. Horizontal diaphragms act as horizontal beams, carrying lateral forces to adjacent vertical elements. In flooring, for example, the flooring sheeting carries the shear forces, while perimeter joists and plates carry the flexural actions. The thickness of sheeting and size of joists will often be governed by vertical rather than lateral forces. Floor diaphragms in timber buildings are nearly always particle board or plywood.

DIAGONAL BRACING

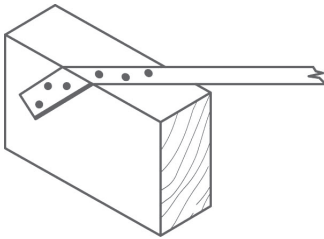
Diagonal bracing is usually used as the horizontal element at roof level, unless panel materials are required for other reasons. For buildings with sloping roofs, the bracing is often located in the plane of the roof, but may also be in the plane of a horizontal ceiling. Diagonal bracing acts as a horizontal truss, carrying forces to adjacent vertical elements. All components of the truss, including the connections, must be checked for their load carrying capacity.

CONNECTIONS

The strength of diagonal bracing elements will be governed by end connections. The connections are often the most awkward part of a bracing system to detail. Some guidance follows.

Connections must be custom-designed to ensure that the strength of the bracing can be developed. Many alternative systems are possible. The strength of most diagonal bracing systems depends on the number of nails or bolts at each end of each brace, with an upper limit fixed by the strength of the steel strap or timber member. For light steel straps, the number of nails can be increased by folding the end around the timber member as shown in diagram 3.

Diagram 3: Connection detail for steel strap



Some possible connection details for timber bracing elements are shown in diagram 4, and for structural steel bracing elements in diagram 5. Note that bolt strengths and bending stresses in steel plates must be checked. High strength bolts (eg grade 8.8) will be required in many situations.

Diagram 4: Alternative connection details for timber bracing

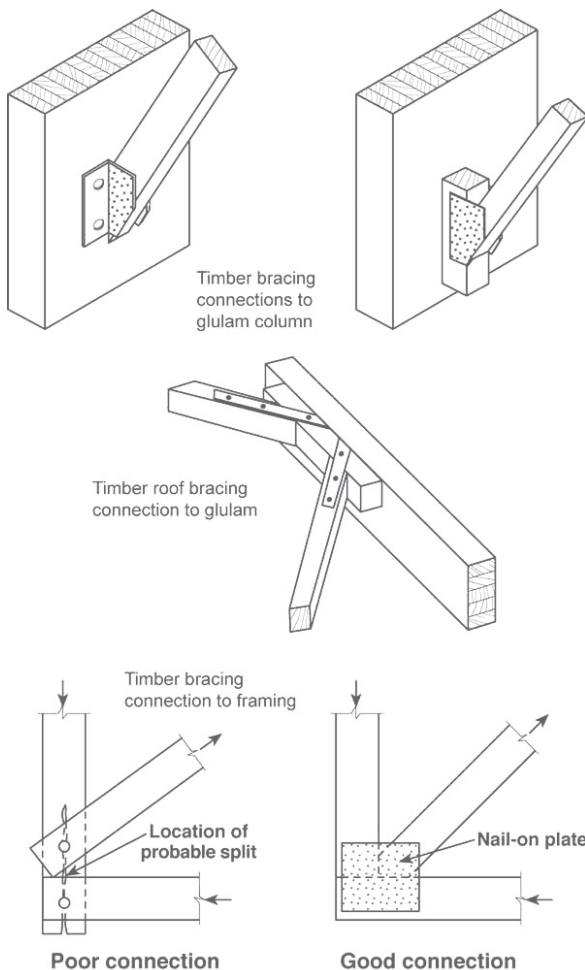


Diagram 5: Alternative connection details for steel bracing

