Overview of Residential Single and Double Storey Timber Framing Design

Prepared by:

Louis Tantri

Residential Manager

Intrax is one of the major service suppliers to the Australian volume housing industry, providing surveying, geotechnical, and structural engineering services for thousands of homes across the country every month. In this article, Residential (Structural) Manager Louis Tantri discusses the design process undertaken for timber framing in residential designs and when it's appropriate to use some of the simplified but more efficient methods available.

Introduction

Whilst the relevant Australian codes provide a good framework for design, it is important for an engineer to bring sound judgement and an ability to work from first principles to ensure builders receive framing designs that are safe, cost effective and practical on site.

Most single and double storey timber framing can be designed by Australian Codes AS 1684.1-1999 (Residential Timber-Framed Construction) & AS 1684.2-2010 (Residential Timber-Framed Construction - Non-Cyclonic Areas), these are simplified versions of AS 1170 that allow engineers to design in a more efficient manner.

Nevertheless, an engineer's judgement needs to apply when using the codes as they do not cover all cases. Whilst this article discusses the use of AS 1684 to improve efficiency in single and double storey timber framing designs, there are some common limitations of AS 1684 that must be considered before employing it:

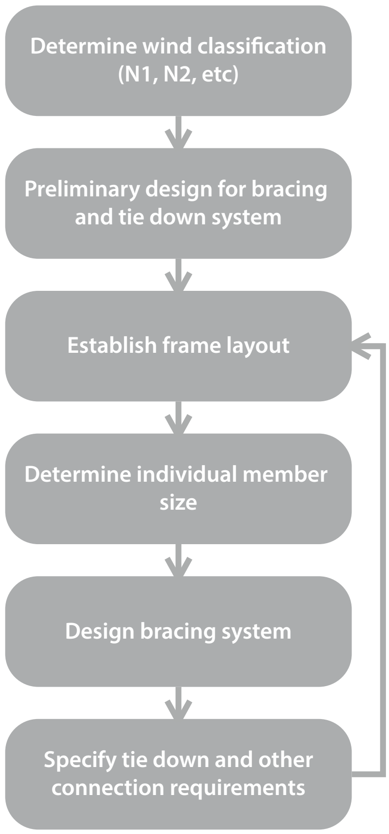
1) AS1684 is principally derived from the Australian codes in the AS 1170 series, and AS 1720.1. Hence, designers still need to refer to these two codes when they are not sure if AS 1684 can apply to their engineering jobs.

2) Geometric limitations (Shape of the house)

a. Overall width of house section, excluding eaves and lean-to verandahs but including verandahs under the main roof, does not exceed 16.0m;

b. The roof pitch does not exceed 35 degrees;

c. Roof shapes may be skillion, Gable, hip, gable ended, or any combination of these;



Framing Design Process

d. The number of trafficable floors supported by timber framing does not exceed two;

e. Wall height, measured from floor to ceiling, does not exceed 3.0m;

f. Bracing spacing limitation which is stipulated in AS1684.2-2010 clause 8.3.5.9.

Design Process

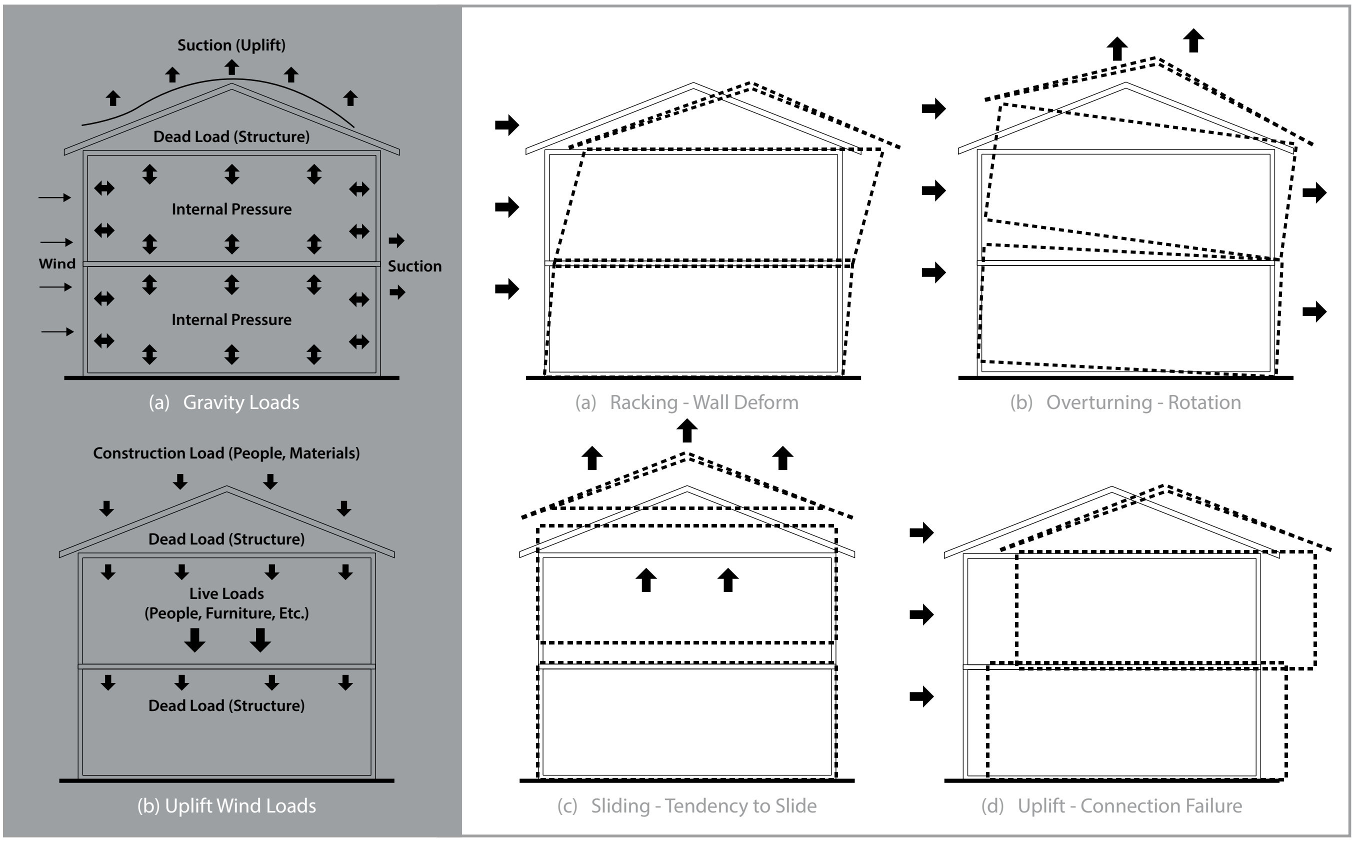
Determine Wind Classification

The reason wind classification is determined as the first input is that the majority of timber framing failures do not lie in inadequate vertical loading support but in **racking (wind) force resistance**. This is an even more critical input when designing houses subject to cyclones

method as it is a more efficient and conservative process that can save time whilst producing a cost effective design. Most builders using our engineering and site classification services choose to have Intrax provide a wind classification with the soil report, saving time for the structural engineer whilst ensuring any related queries can be quickly handled internally.

Preliminary Design for Bracing and Tie Down System

At this step, engineers can visualise their structural bracing & tie-down and show it on plan. One of the best ways to visualise this is to imagine the effect that forces may have on the building. Some common examples are illustrated below. In certain areas, designers must also take earthquake and snow load into consideration as well.



Typical Racking Forces to Consider

The wind classification can be determined using the following two methods for guidance:

1) Designing from first principles whilst referring to AS 1170.2;

2) Using a simplified method referring to AS 4055 – Whilst this is limited to N1 to N4 classes only with a total building height of 8.5m and width of 16m, this accounts for a majority of sites classified.

Due to the quick turnaround times required for residential designs, engineers can employ the second

Establish Frame Layout

Engineers show where they want the structural elements located on plan. This includes lintels over openings, floor and roof beams or supporting columns. This process involves considering the load path of the structure, as well as what sort of loading needs to be taken into consideration. Engineers can easily obtain this information in AS 1684.1-1999 Clause 1.4.9 or with less explicit direction from AS 1170.1.

In establishing the framing layout the engineer must consider common design loads and forces that will impact upon the structure. These include:

1) Dead Loads

- The mass of the roof, wall and floor constructions.
- Other permanent loads incurred due to services or plant

2) Live Loads

- An evenly distributed permanent 'live' load for the floor.
- Additional loading for balconies or decks 1m or more above the ground
- Occasional loading on roof and ceiling members during construction and maintenance

Once completed, the engineer must test all the loadings for the 'serviceability' and 'ultimate' loading states. These are effectively the expected and worst case loading scenarios that must be taken into account to ensure a safe and effective design.

Determine Individual Member (Beam/Lintel) Sizes

When designing beam/lintel strength capacity engineers need to refer to standards to check for what specific load impacts have on factors in the design. These factors may have a great impact on design choices such as material type and sizes of the beams/lintels. Intelligent consideration of all the factors is important for an engineer to produce a cost effective design over a conservative one.

When determining deflection (displacement under load), engineers can refer to either AS1684.1 or AS1172.0 for guidance. However, what they may find is that there are contradictory suggestions given by both standards in terms of absolute and span to ratio deflections. As a result, there are circumstances where the engineer must apply their own judgement from first principles. As there are multiple ways to achieve a workable design, client consultation and an understanding of preferences is essential to ensure the solution provided is both workable and suitable for the needs of the builder.

> *"It is important to ensure all structural elements specified are practical on site"*

Although all lintels/beams, studs, etc. are designed according to the standards, it is important to ensure all structural elements specified are practical on site. This prevents issues such as whether a lintel can fit between the top plate and the top of the window, or whether the number of studs specified can fit into a given length of wall. This process reduces site issues, amendments, and delays.

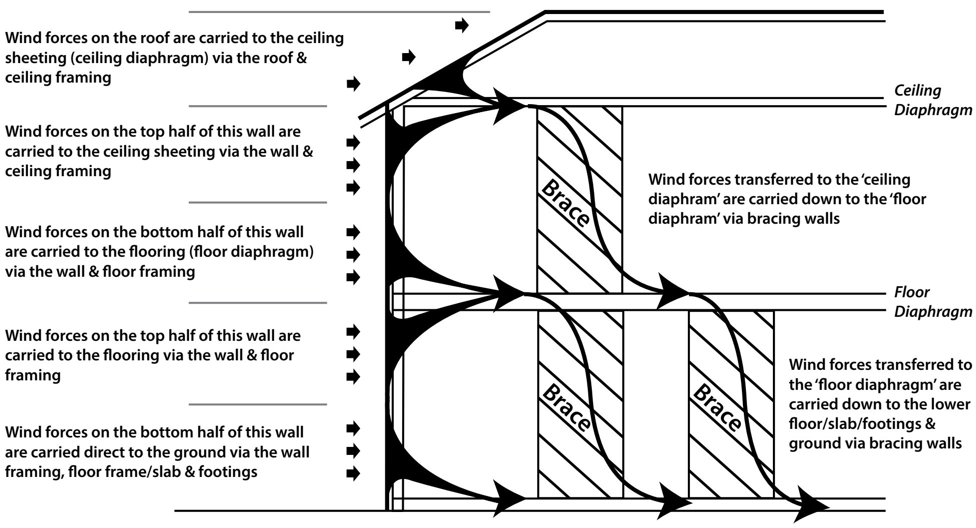
Design Bracing System

AS 1684 Section 8 requires permanent bracing to be provided to enable the roof, wall and floor framework to resist horizontal racking forces applied to the building. Appropriate connection must also be provided to transfer these forces through the framework and sub floor structure to the building's foundations.

Where required, bracing within the building will normally occur in vertical planes and be incorporated in walls or sub-floor supports and be distributed evenly throughout.

Where buildings are more than one storey in height, wall bracing is required to be designed for each storey. The below diagram demonstrates how typical racking forces transfer to the house & where the engineer should brace the wall.

Achieving stability against racking forces for



Bracing shall be initially placed in external walls and, where possible, at the corners of the building

Typical Racking (Wind) Forces Acting Upon a Home residential homes generally relies on the ability to brace load bearing external walls and internal walls against in-plane deformation. Generally this is achieved by attaching diagonal steel strap bracing or plywood sheeting to the surface area of the walls. However, modern house design are concentrated on open plan living and as such the amount of internal separation walls are reduced, limiting the surface area available to brace the building against external racking forces. This can pose a challenge for both builders and engineers to come up with economical solutions and makes the wind rating highly important for the design.

> *"Modern open-plan living house designs can pose a challenge for both builders and engineers to come up with economical solutions"*

When bracing capacities are not enough to resist the racking forces, an engineer may have to design from first principles and provide solutions to compensate for the remaining racking forces. The typical escalation process sees an engineer move from hardboard bracing, to a proprietary product such as Power Truss, through to designing portal frames. The ultimate solution will depend on the racking forces that need to be accounted for, as well as the client's preference.

Specify Tie Down and Other Connection Requirements

Based on the given criteria/scenario, the engineer can refer to table 9.2 of AS 1684.2 for a guide on the specific and nominal fixings required for elements in the house framing.

For specific tie down details, to determine uplift forces designers may refer to clause 9.6. From there designers can refer to Tables 9.27 to 9.30 for predetermined uplift capacities.

Conclusion

Overall, engineers can, within limitations, make full use of the timber framing codes for most single and double storey framing designs. However, designers need to have the capability to make sound judgement as to when to employ AS 1684, as well as the ability to guide builders through options in non-standard scenarios.

At Intrax, we design timber house framing on daily basis, giving us a thorough understanding of the limitations of the codes. In addition, regular contact and collaboration with major timber fabricators and truss manufacturers provides deep insight into timber framing solutions as well as the ability to directly troubleshoot problems, reducing back and forth communication, and improving outcomes for our clients.

Louis Tantri

Residential Engineering Manager

Intrax Consulting Engineers Pty Ltd
Victoria | Queensland | South Australia | New South Wales

Intrax
Engineering Confidence

ABN: 31 106 481 252
Head Office – 35 Bank Street, South Melbourne, VIC 3205
P: 03 8371 0100 F: 03 8371 0199
E: info@intrax.com.au
W: www.intrax.com.au

Publish Date: 22nd September 2014
Revision 1.0