Warehouse design
Module 2: Global design principles

October 2025

Introduction

This module focuses on the foundational principles that govern warehouse structural design across all regions and applications. While specific design requirements may vary by location, building codes, and operational needs, these global principles form the framework for conceiving and developing all warehouse structures. Understanding these universal concepts is crucial before delving into detailed requirements, specialised structural systems, or specific operational configurations.

The principles outlined here address fundamental aspects of structural stability, load management, system integration, and long-term durability - elements that remain constant regardless of the warehouse's location or intended use. By mastering these core concepts, designers and engineers can more effectively tailor their solutions to local conditions while maintaining structural integrity and operational efficiency.

Structural system behaviour

Ductility considerations

- **Where will plastic hinges form in your design?** Have you considered the implications if they form in locations other than intended?
- **How have you justified your chosen ductility level?** What analysis supports this decision?
- **When using SCNZ standard knee joints with less than 100% compatibility:**
  - Is your rafter designed to be the weakest element in the system?
  - Have you verified that columns and connections are stronger and stiffer than the rafter?
- **For structures with ductility greater than one:**
  - How have you addressed movement compatibility between different systems?
  - Have you considered how the portal frame movement affects cladding and other attached elements?

Structural configuration analysis

- Is your structure regular or irregular? What implications does this have for load distribution?
- For 3-sided box or other non-standard configurations:
  - Have you identified the centre of resistance and centre of pressure/gravity?
  - What is the resulting torsional moment and how is it distributed?
  - How do your diaphragm connections distribute these additional forces?
  - Can you trace clear load paths from all points to your lateral resisting elements?

System robustness evaluation

- How does your structure respond to unexpected loading events? Will it maintain life safety if design loads are exceeded?
- What happens if your structure is subjected to impact loads from vehicles or equipment?
- How have you enabled system-level performance? Consider:
  - Would fly braces improve your structure's resilience?
  - Have you minimised connection eccentricities?
  - Does your design allow for catenary action during extreme events?
  - How does the entire structure work as a system rather than as individual elements?

Loading considerations

Have you accounted for all relevant loads?

- Gravity loads: Are all dead and live loads clearly defined and calculated?
- Environmental loads:
  - How have you determined appropriate wind loads for your specific building geometry?
  - For snow-prone regions, have you considered drift effects on roof structure?
  - What seismic performance objectives have you established?
- Accidental loads:
  - What impact scenarios are relevant to your warehouse operations?
  - Has a risk assessment identified any need to consider explosion or other extreme events?

Application context

- How do these principles apply to your specific portal frame structure? Consider:
  - Are there special considerations for your building use (agricultural, industrial, commercial)?
  - How do span arrangements (single, multi-span) affect your design approach?
  - What unique challenges arise from your chosen structural form (gable, mono-slope, propped)?

Components of a warehouse

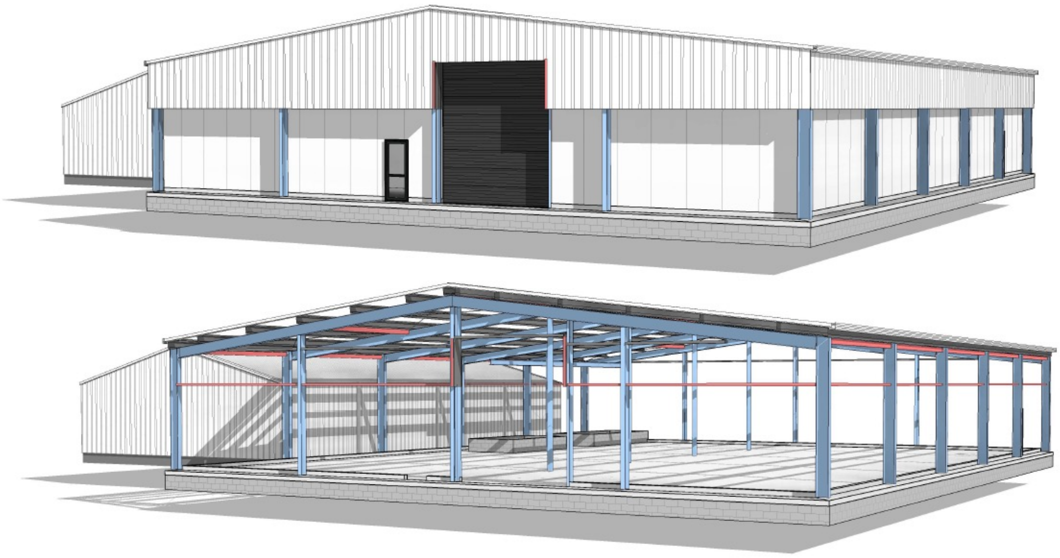

Figure 1: Typical warehouse

Using this drawing, label the following different components:

- purlins
- girts
- collectors
- portal knee, rafters and legs
- wind posts
- foundation.

Add bracing to the sketch.

Structural stability fundamentals

Load path continuity

- Ensure continuous and clearly defined load paths from all points of load application to the foundation
- Design structure as a complete system with effective force transfer between all structural elements
- Verify adequate connection design to maintain intended load paths
- Implement static and dynamic equilibrium principles

The following three sketches provide an example illustrating load paths and connections.

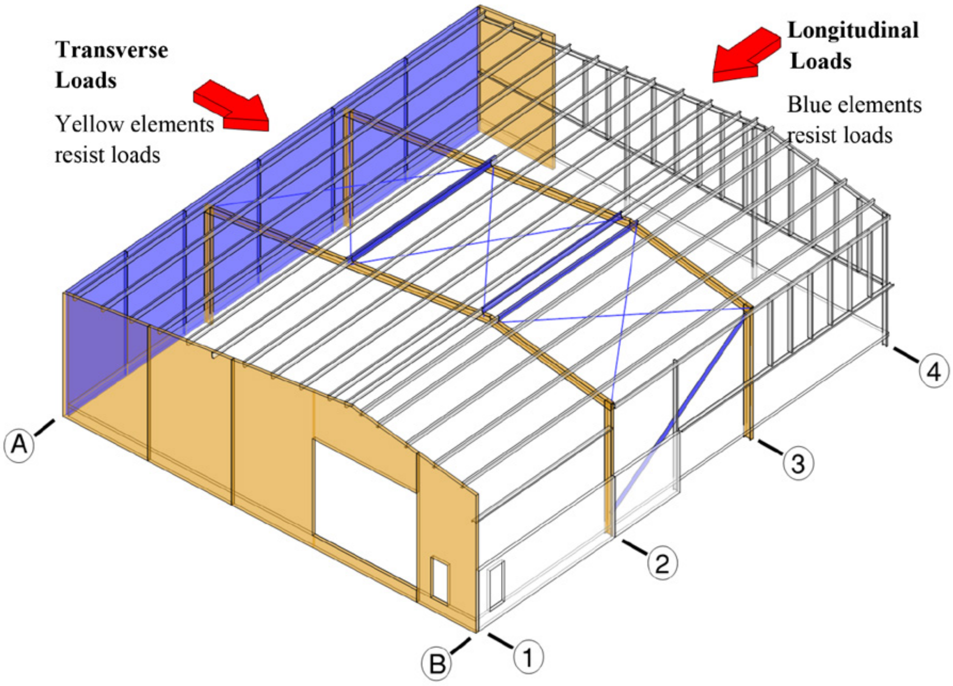

Figure 2: Global load resisting system. Adapted from Grant, M.L. (2021), *Seismic review of a typical low rise commercial building – a case study.*[1]

1 repo.nzsee.org.nz/bitstream/handle/nzsee/2388/O4A.6%20Grant.pdf?sequence=1

Critical connection points

You must ensure there is a robust, continuous load path to the ground.

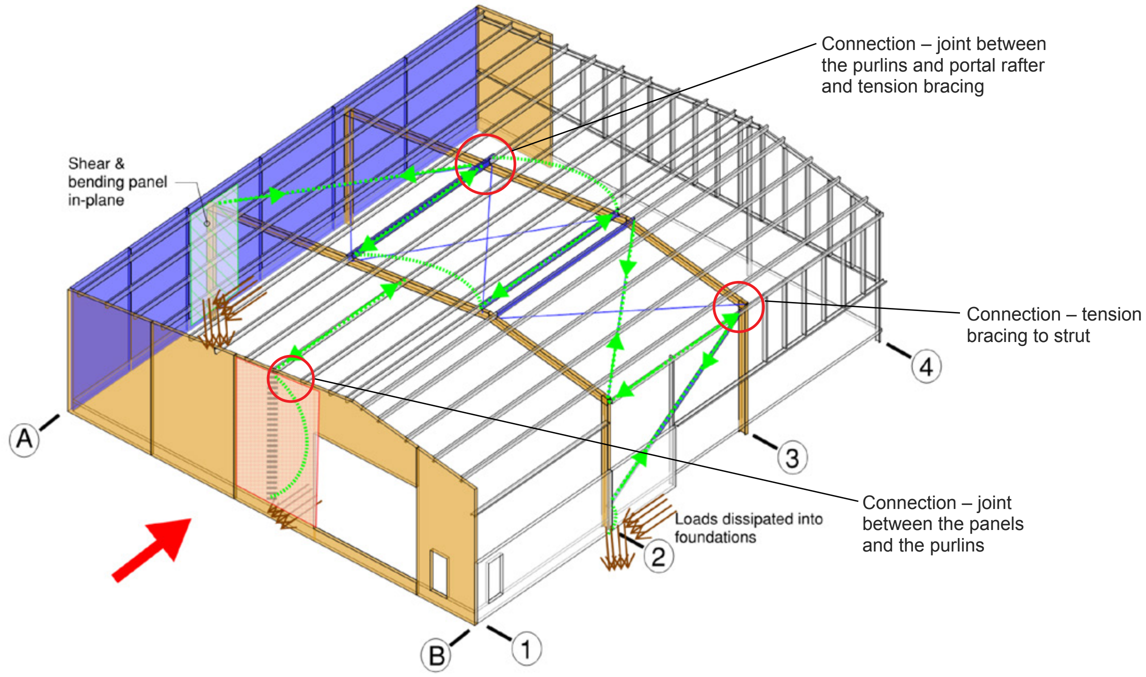

Figure 3: Longitudinal critical connections. Adapted from Grant, M.L.

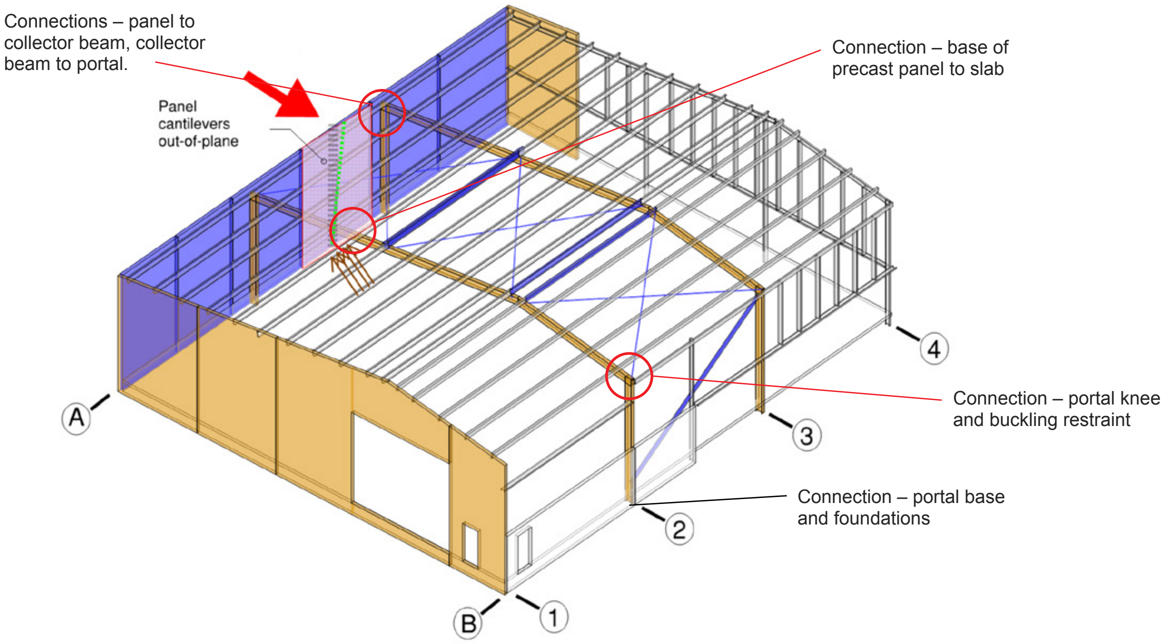

Figure 4: Transverse critical connections. Adapted from Grant, M.L.

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