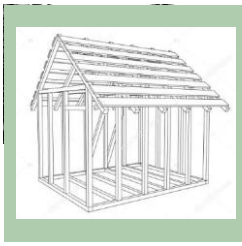
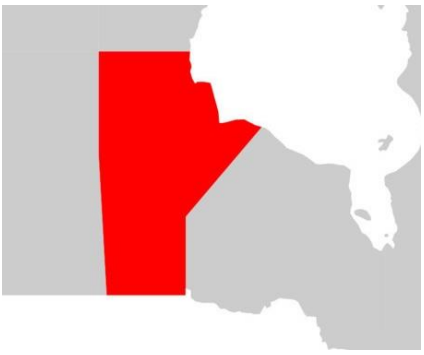


BOOKLET 9: STRUCTURE

TECHNICAL GUIDE FOR NORTHERN HOUSING



→ TAILORED FOR REMOTE NORTHERN MANITOBA COMMUNITIES

DISCLAIMER

The information in this publication is based on the most current research available to FNNBOA and has been reviewed by housing industry experts. Readers are advised to evaluate the information, materials and techniques carefully and to consult appropriate professional resources to determine courses of action suitable for their situations. The figures and text are intended as general practice guides only. Project and site-specific factors of climate, cost, geotechnical conditions and architecture must be taken into consideration. Any photographs in this book are for illustration purposes only and may not necessarily represent currently accepted standards. Electronic reproduction of content or this publication is made available for information only and is not an official version of the document. Individuals who download these documents do so at their own risk. FNNBOA will not be responsible for any damage to your computer or any of the information on it.

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1st Edition [June 2022]

Provided by FNNBOA under licence from the National Research Council of Canada

The story of house structures in the north

Historically, housing in northern Manitoba has been built based on Part 9 of *The National Building Code*, which prescribes specific requirements for wood framing. Certified carpenters know it well, and do not require any design input from an engineer.

However, the wood framing requirements in Part 9 of the building code are based on a stable and continuous foundation wall or concrete slab for the wood framing to be mounted on. In the north, raised foundations that are not continuous, but provide intermittent support points, are the norm. The most basic is the bottom floor of a house resting on wood cribbing, which rests on the ground surface.

However, this cribbing is prone to settling and heaving, due to underlying ground conditions. This has historically resulted in significant structural distortion and damage to the house (for example, broken windows, doors that don't close, roof leaks and air leaks through walls).

Lower-risk foundation approaches are recommended in Booklet #1, but foundation movement to some degree is still likely with screw-jack and space-frame foundation approaches. The wood structure needs to be able to withstand these foundation movements, which involves approaches to stiffening the structure not covered in Part 9 of the building code, which assumes continuous foundation support.

Fixed steel piles or piers on bedrock foundations are likely not to experience movement and are more appropriately matched with a built-up floor-beam structure, also outside the scope of Part 9 of the building code.

In addition, a roof structure consisting of engineered wood is recommended as more compatible with the shipping and erecting constraints that exist for many northern communities.

The Practice of Engineering

Structural approaches that fall outside the scope of Part 9 wood-framing practices of the building code are conceptually presented in this booklet. Some aspects of the structure, such as wall framing, generally remain as specified in Part 9.

Aspects of house design not covered under Part 9 of the building code must be designed by a professional engineer licensed in Manitoba.

Engineering practice includes any act of design that requires an engineer with knowledge of engineering principles, and legally licensed to practice, for the protection of the public.

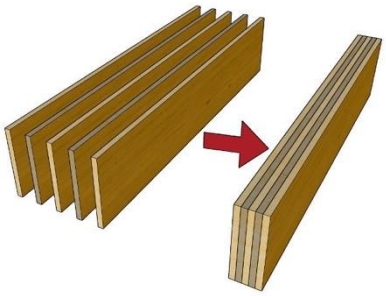
The content of this guide is not suitable to use directly for construction.

During construction, the contractor should refer to the design documents created by the engineer for that specific project, and/or follow the prescriptive framing requirements within Part 9 of the building code.

The approaches shown herein are for initial high-level decision-making, early-stage budget estimating and planning purposes.

This booklet can be used as a reference in determining the necessary "scope of work" for an engineer the community needs to hire for their new housing project.

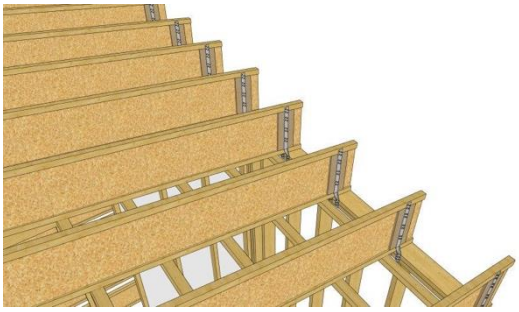
RECOMMENDED APPROACHES: The structural systems presented in this booklet



Floor Beams: Built-up LVL beams
(engineered wood)

Floor Framing: I-joists
(engineered wood)

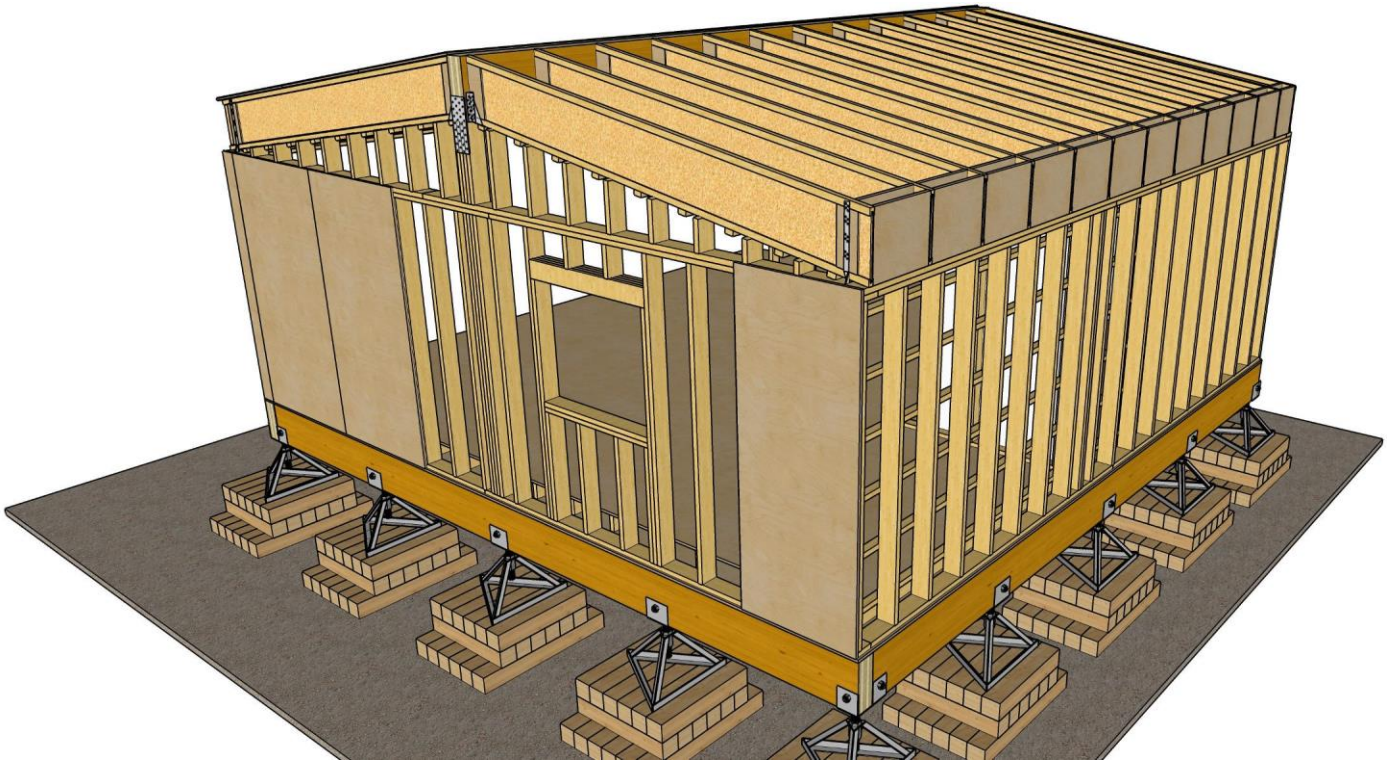
Wall Framing: Conventional framing
(as per Part 9)



Roof Framing: Built-up LVL ridge beam and I-joist rafters
(engineered wood)

READ THIS BOOKLET IF YOU NEED TO:

1. Determine what type of structural systems to use for a new *sturdy* house in a northern community.
2. Learn more about factors to consider when planning the construction of the structure of a new *sturdy* house in a northern community.



Sturdy—The goal of this guide is to improve the overall well-being and quality of life for community members, by advising on structural approaches well-suited to the foundations used in the north, and construction challenges/constraints, so that structural distortions and damage are avoided.

GENERAL CONSIDERATIONS

Several general recommendations should be considered throughout the design and construction of a wood-frame structure in northern Manitoba.

DIMENSIONS:
The overall structural layout should be based on *increments of four feet* wherever possible, to take advantage of the standard sizing of construction materials (e.g. plywood, framing members). Doing this will help reduce waste of materials, and minimize the amount of on-site cutting required, which will save on time, labour and budget.

PROTECTION:
Construction materials must be protected from the elements during transportation, while stored on site, and during installation. For all wood products, confirm that a moisture content of 19 per cent or lower is reached prior to installation, to avoid unwanted shrinkage.

STRUCTURAL ENGINEER:
This booklet widely recommends the use of engineered wood products, for reasons discussed in the corresponding sections. For these structures, a structural engineer will be needed to provide design documents for the structural member sizes/lengths and connections specific to the house being constructed.

GENERAL CONSIDERATIONS

If the structure is built on steel piles, a foundation option discussed in Booklet #1, the wall framing can be completed as per Part 9 of the building code, since it is expected that minimal movement will occur in this foundation system.

With foundation systems other than steel piles, the building will be required to accommodate more movement than is covered under Part 9.

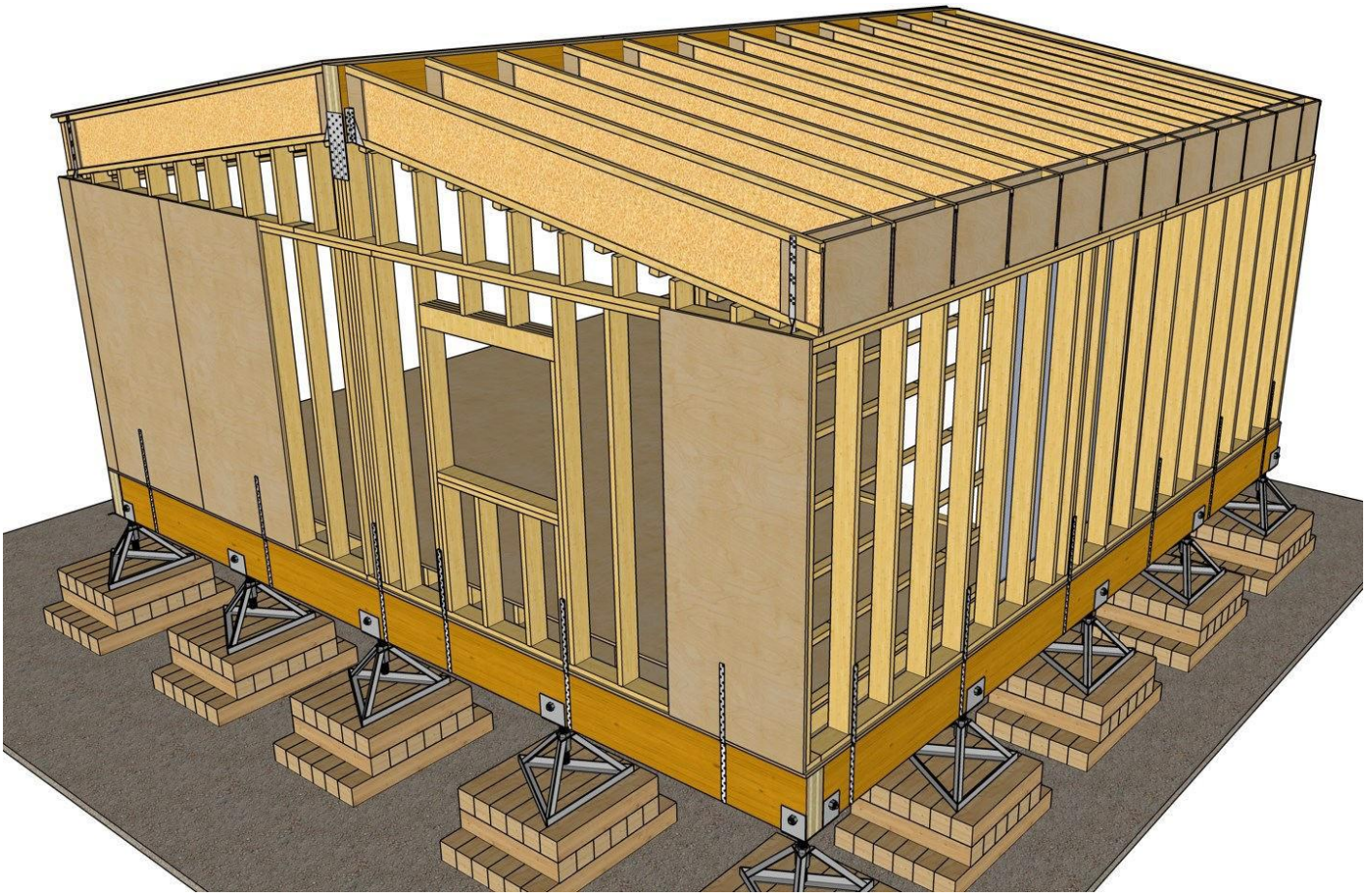
The more movement expected, the stronger and more rigid the overall structure needs to be to avoid structural distortions and damage to interior finishes, windows, etc. In this booklet, approaches for making the structure stronger and more rigid are discussed, such as tie-downs, thicker sheathing and strapping.

STRUCTURE COMPONENTS

This booklet outlines the recommended general structural approach for a wood-framed residential dwelling in northern Manitoba, with intermittent foundation support (pier-type) and all the challenges summarized in the Introduction booklet.

The structure of a residential building can be divided into four main sections:

- Floor beams
- Floor framing
- Wall framing
- Roof framing



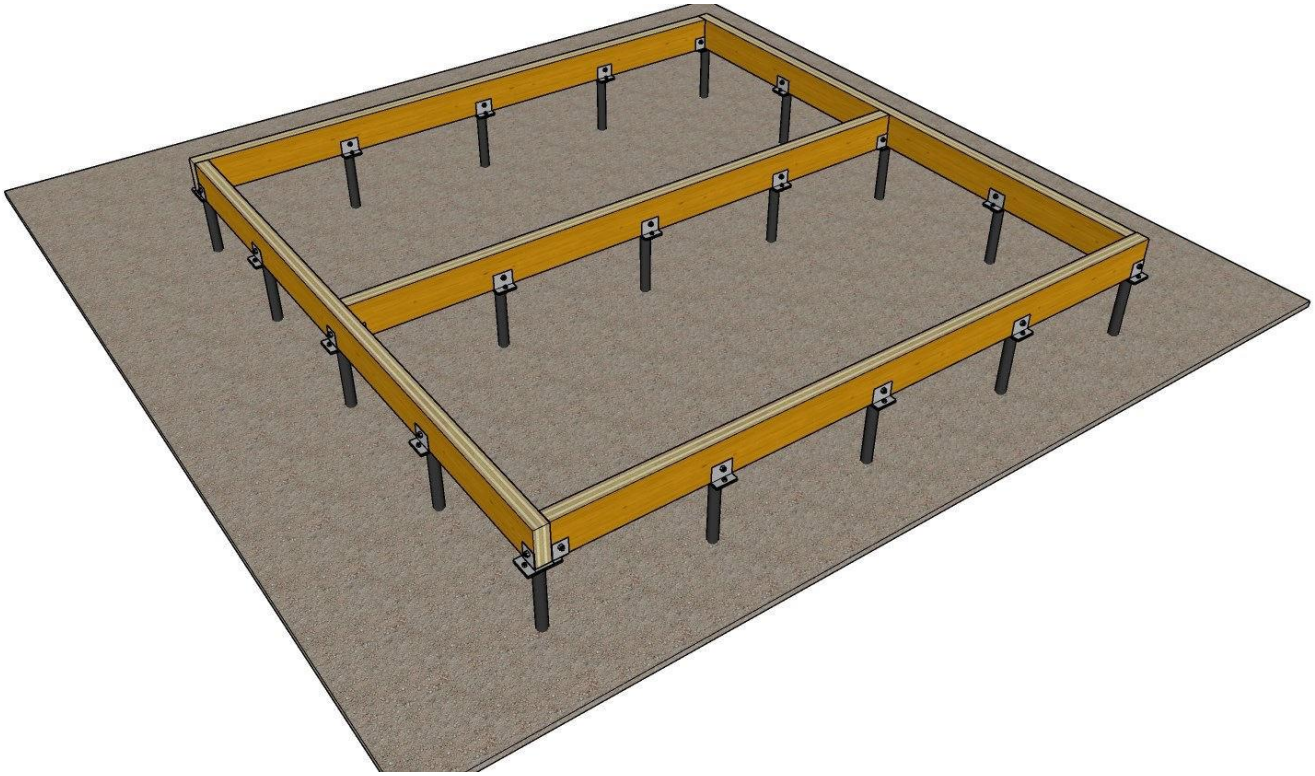
Floor Beams

Built-up LVL beams

Floor Beams

LVL beams

In the foundation systems discussed in Booklet #1, perimeter and spaced floor beams will be required to support the floor structure. Because point-load pier foundation styles are mostly used in the north, a structural engineer is required, as this configuration of framing is not covered in the prescriptive methods of Part 9 of the building code.

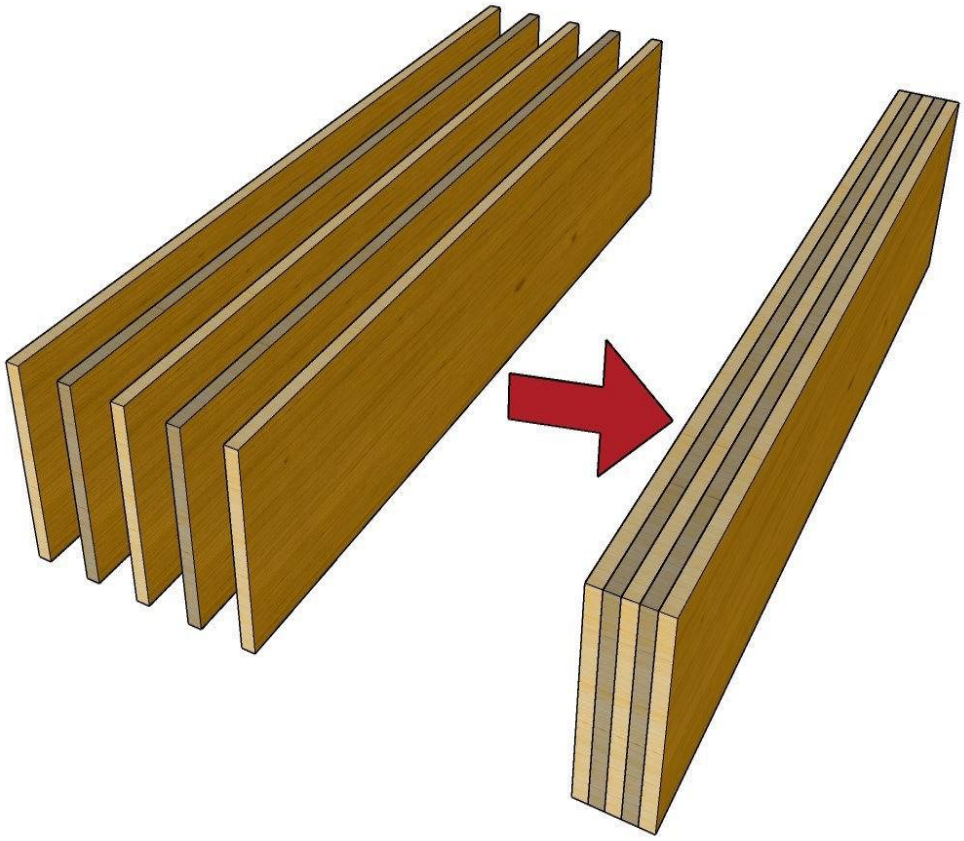


It is recommended that floor and perimeter beams be constructed of engineered, exterior-grade, laminated veneer lumber (LVL) beams. Multi-ply LVL beams provide a structure that is much stiffer and stronger than conventional Part 9 framing. LVL sizes are readily available in depths that match I-joists (deeper than conventional lumber joists) and can be built up in multiple layers on-site, to provide a “continuous” beam, which makes it very rigid. As the individual LVL layers can be moved separately and then nailed/screwed together, handling and construction by construction personnel are much more feasible than if a solid steel beam or large wood beam is used.

Floor Beams

Built-up LVL beams

An LVL member is an engineered-wood product comprised of multiple layers of thin wood veneer, like plywood. It can be built up with multiple plies of LVL fastened with adhesive and screws when site-assembled, to create a composite built-up product to be used as a long beam.



The various individual plies in a built-up LVL beam do not need to span the full length of the overall beam, as the individual members within the built-up beam can be staggered. This means the beam can be shipped in not only thinner, lighter segments, but also in shorter segments. LVL beams can be shipped in their separate layers (plies) and assembled on site with relative ease. Because the beam can be delivered to the site in shorter, thinner and lighter segments, costs are saved in shipping and site installation, since the beams can be moved around without the use of large equipment, which not all communities have access to.

An exterior-grade LVL beam is recommended to minimize the risk of degradation during construction.

Floor Framing

Wood I-joists

Floor Framing

Wood I-joists

In current conventional residential houses, floor joists are either dimensional lumber or engineered-wood I-joists. Either floor-joist system is acceptable for residential dwellings in northern Canada; however, it is recommended that where feasible, engineered-wood I-joists be used for floor framing.

Engineered-wood I-joists are lighter than conventional lumber, which results in lower shipping costs and easier installation on site. Wood I-joists also have greater span capabilities than dimensional lumber, which can result in fewer supports being required. They also come in deeper sections, which creates more room for insulation (refer to Booklet #7).

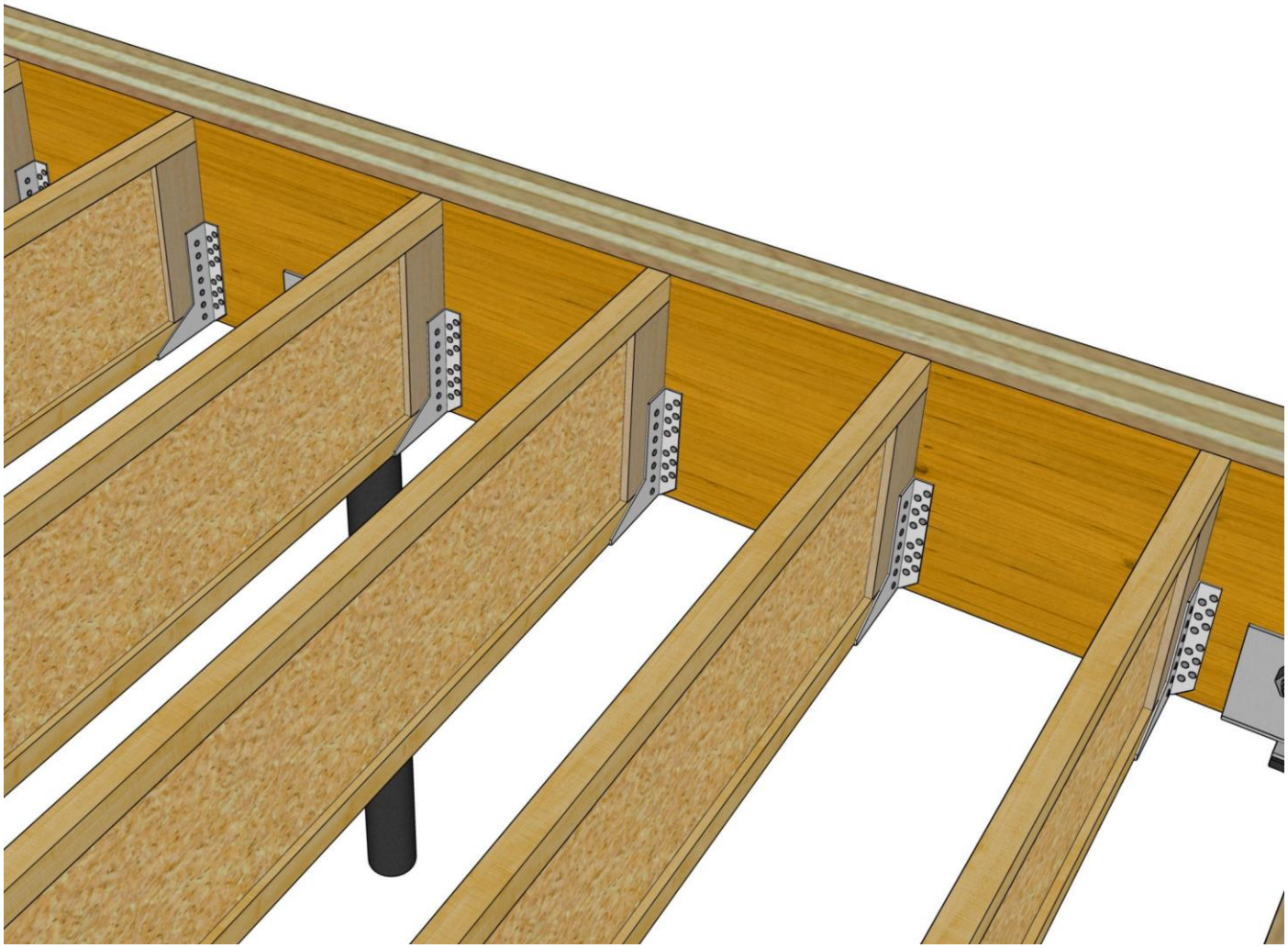
Whether conventional lumber or engineered-wood I-joists are used, methods of strengthening and stiffening the beam and floor system can be implemented. This will allow the floor system to better withstand foundation settlements without excessive deformation. One method of stiffening the floor system is to install blocking between the floor joists (see image below).

Floor Framing

Wood I-joists

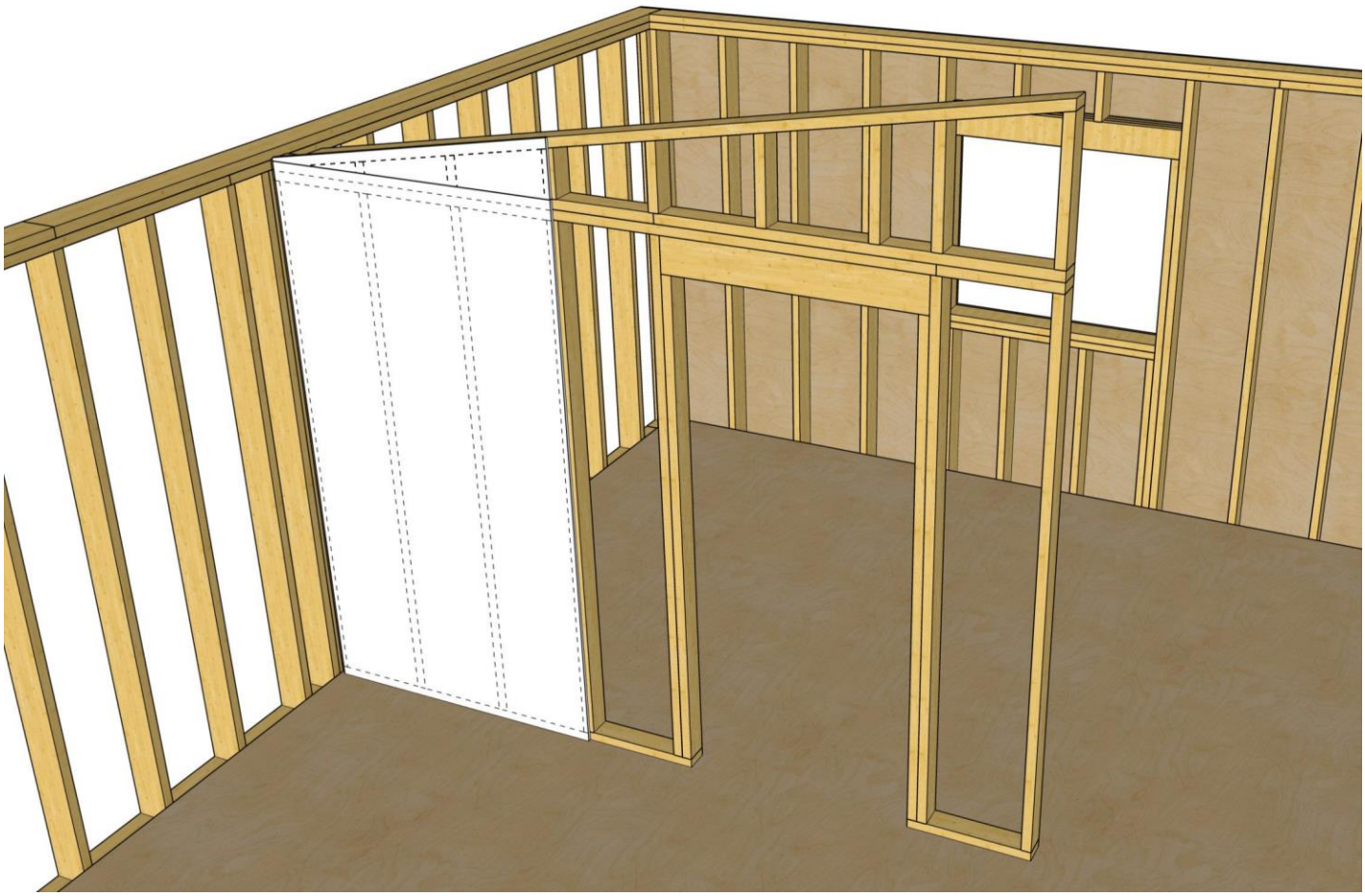
Regardless of whether engineered-wood I-joists or dimensional lumber is used, it is recommended that the floor joists be installed with joist hangers, as opposed to lumber joists being toe-nailed into their support. Joist hangers are sturdier than toe-nailed joists. Joist hangers are also able to better accommodate movement in the structure.

The subfloor ties everything together so the floor structure acts as a unit. It should be glued and screwed, and a minimum of 5/8" tongue-and-groove plywood panels used. Upgrading to a 3/4" plywood subfloor would be an improvement.



Wall Framing

Conventional wood studs

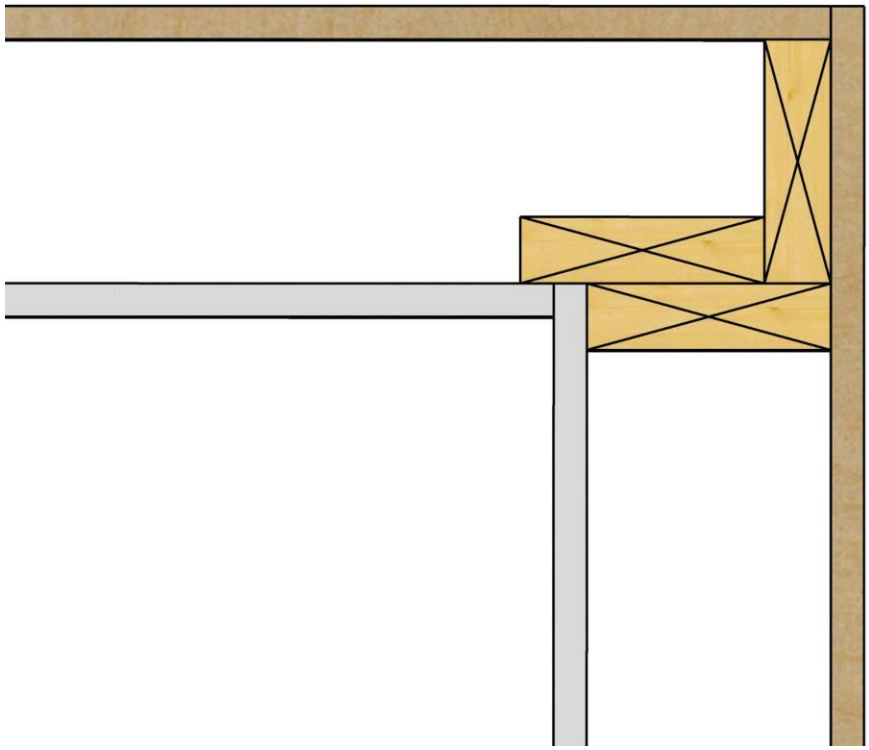


Wall Framing

Conventional wood studs

Walls can be framed per Part 9 of the building code; however, it is recommended that additional precautions be taken where some degree of foundation movement is anticipated, such as with a screw-jack foundation.

Backing support should be provided at the edges of all drywall and sheathing boards (especially in room corners) to help prevent cracks from forming—see the image below for a recommended corner-stud layout. Spacing the studs at an increment that evenly goes into four feet will reduce the amount of extra framing members required.



Wall Framing

Conventional wood studs

Although Section 9.23.16.2 of Part 9 of the building code requires a minimum thickness for plywood wall sheathing of six mm (1/4-inch), it is recommended that a minimum sheathing thickness of 12.7 mm (1/2-inch) be used. For structures with foundations that are susceptible to experiencing more movement (i.e. structures supported on a surface-mounted screw jack foundation), it is recommended that 19 mm (3/4-inch) wall sheathing be used. The required number of nails and the nailing pattern required for sheathing can be found in Part 9 of the building code.

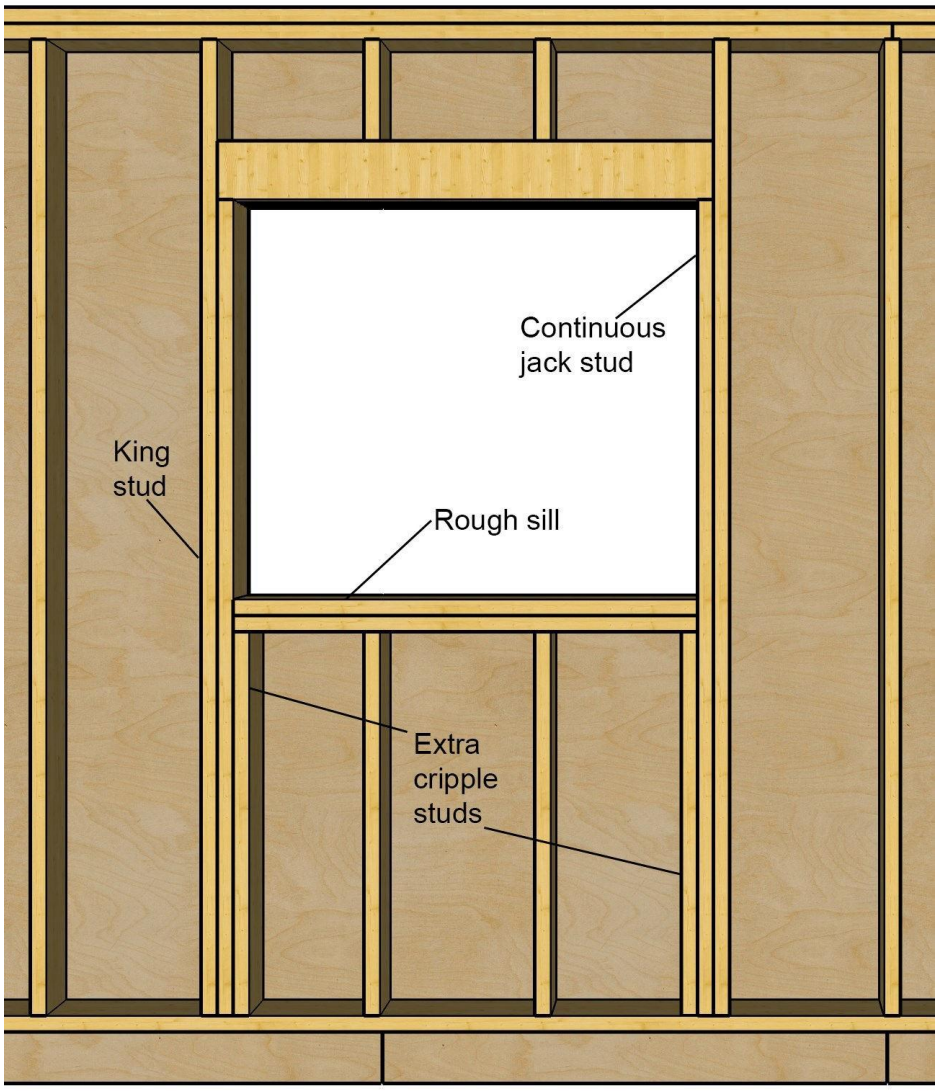
Ensure that all edges of wall sheathing and gypsum board are supported by a framing member. Blocking should be installed in the wall if the edges of the wall boards do not align with an existing framing member, such as when sheathing is installed horizontally or when the height of the wall is greater than the standard eight-foot length of sheathing installed vertically.

Blocking between studs in an exterior wall to support the horizontal joints in the plywood sheathing

Wall Framing

Conventional wood studs

All door and window openings can be framed as per Part 9 of the building code. The code allows for multiple ways of framing openings. For durability, the following details are recommended (see image below): continuous jack studs on the sides of the opening to support the opening header; a double rough sill; full-height king studs on either side of the opening; cripple studs above and below the opening at the same spacing as the studs in the wall; and extra cripple studs to support the ends of the rough sill.



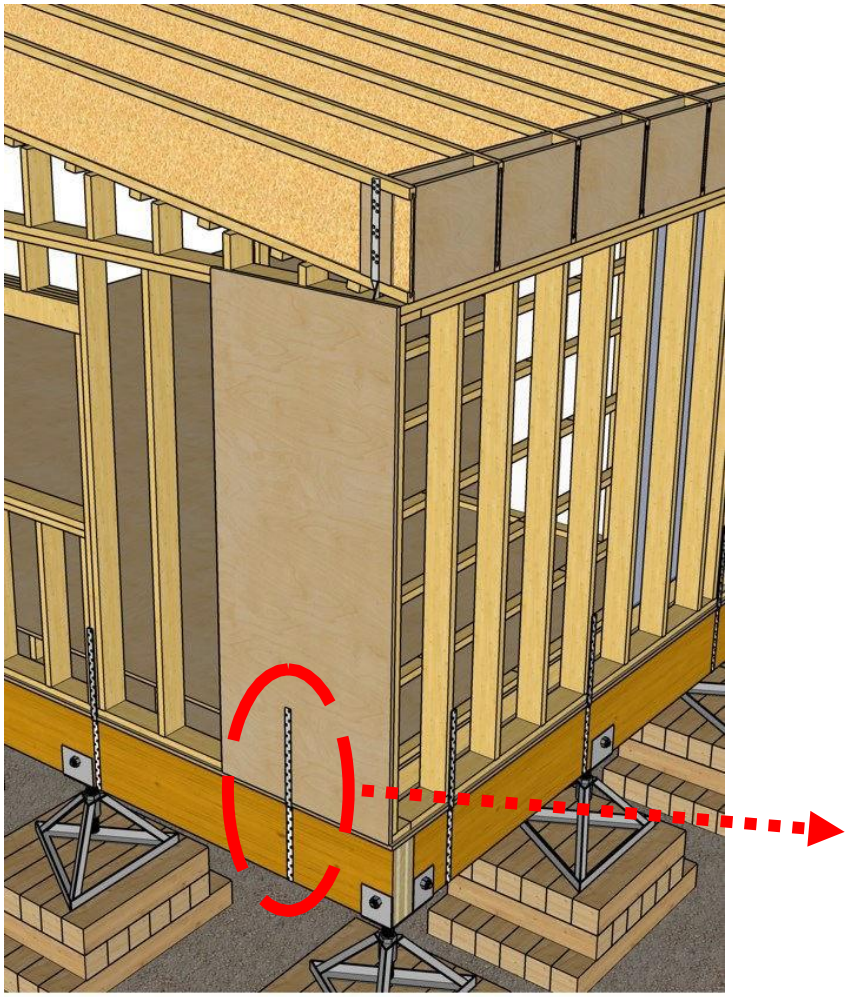
Wall Framing

Conventional wood studs

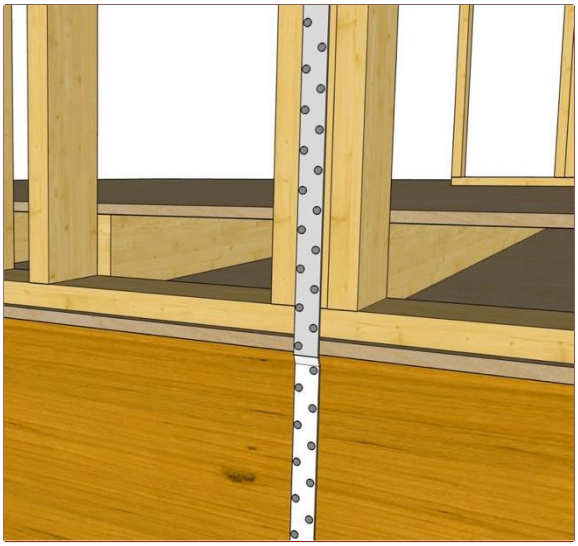
A single-ply sill (bottom) plate is recommended in the wall framing with a double-ply top plate.

It is generally recommended that the exterior walls be tied down to the perimeter beams that support the house. Steel-strap anchors can be used for this purpose and can easily be integrated into the house design at minimal cost. These structural tie-downs of the exterior wall to the beams add significant structural rigidity to beams and will reduce the number of deflections or deformations that may occur due to foundation settlement or heaving.

The size and spacing of the strap anchors should be determined by the structural engineer. The images below show the concept of an exterior wall tied down with strap anchors.



Steel-strap tie-down of the exterior wall to the perimeter support beams



Steel straps aligned with wood studs

Roof Framing

Built-up LVL ridge beam and I-joist rafters

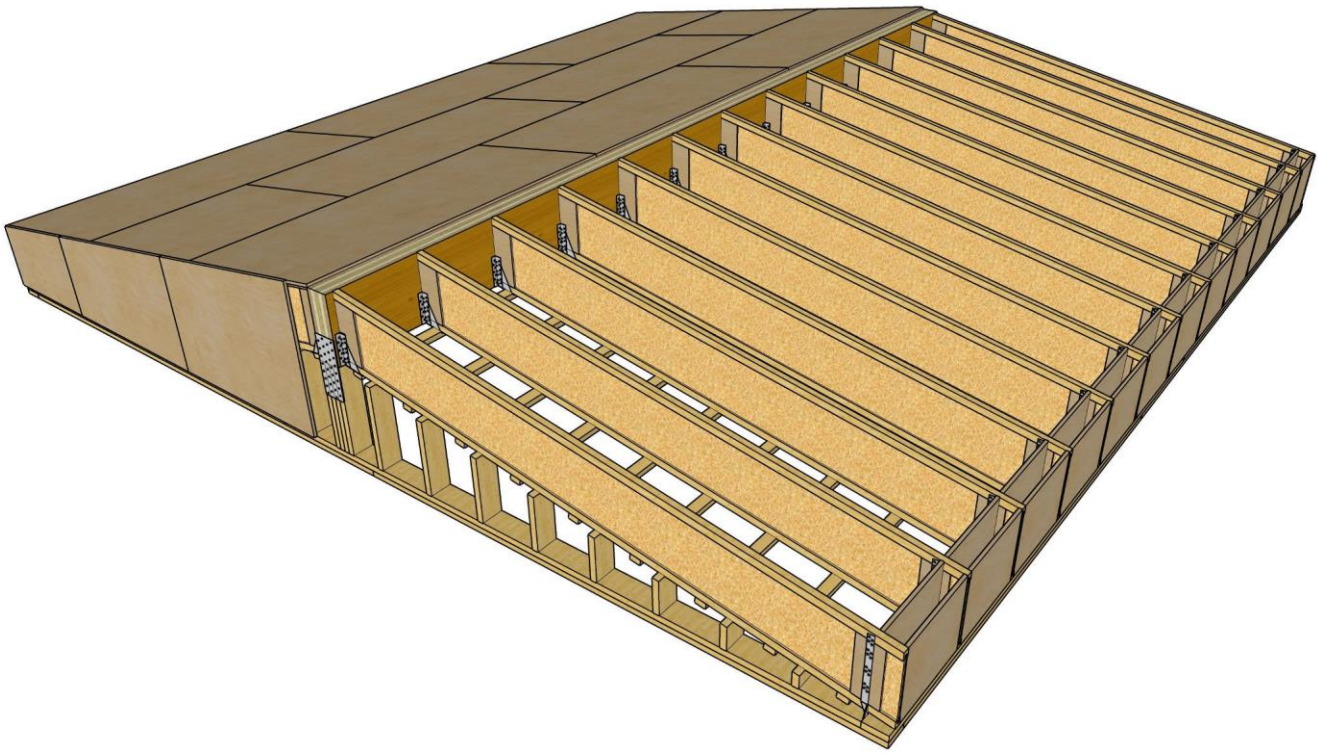
Roof Framing

Built-up LVL ridge beam and I-joist rafters

In urban parts of Canada, the two most common roof systems in a residential dwelling are wood-truss or wood-rafter (dimensional lumber or engineered-wood I-joist) systems. Due to their large size, for transportation and site maneuverability a wood-truss system is not recommended for the north.

For reasons discussed in the floor-framing section of this booklet, engineered-wood I-joists are recommended for the roof-rafter system, rather than dimensional lumber. A rafter system requires a ridge beam. It is recommended that an engineered LVL beam be used for the ridge beam, for the same reasons it is recommended for the floor. As discussed previously, a built-up LVL beam can be transported to the site in smaller components and assembled on site.

As with the wall sheathing, the rafters should be spaced to accommodate the standard sheathing size of four feet by eight feet, to minimize required cutting and waste of the roof sheathing.

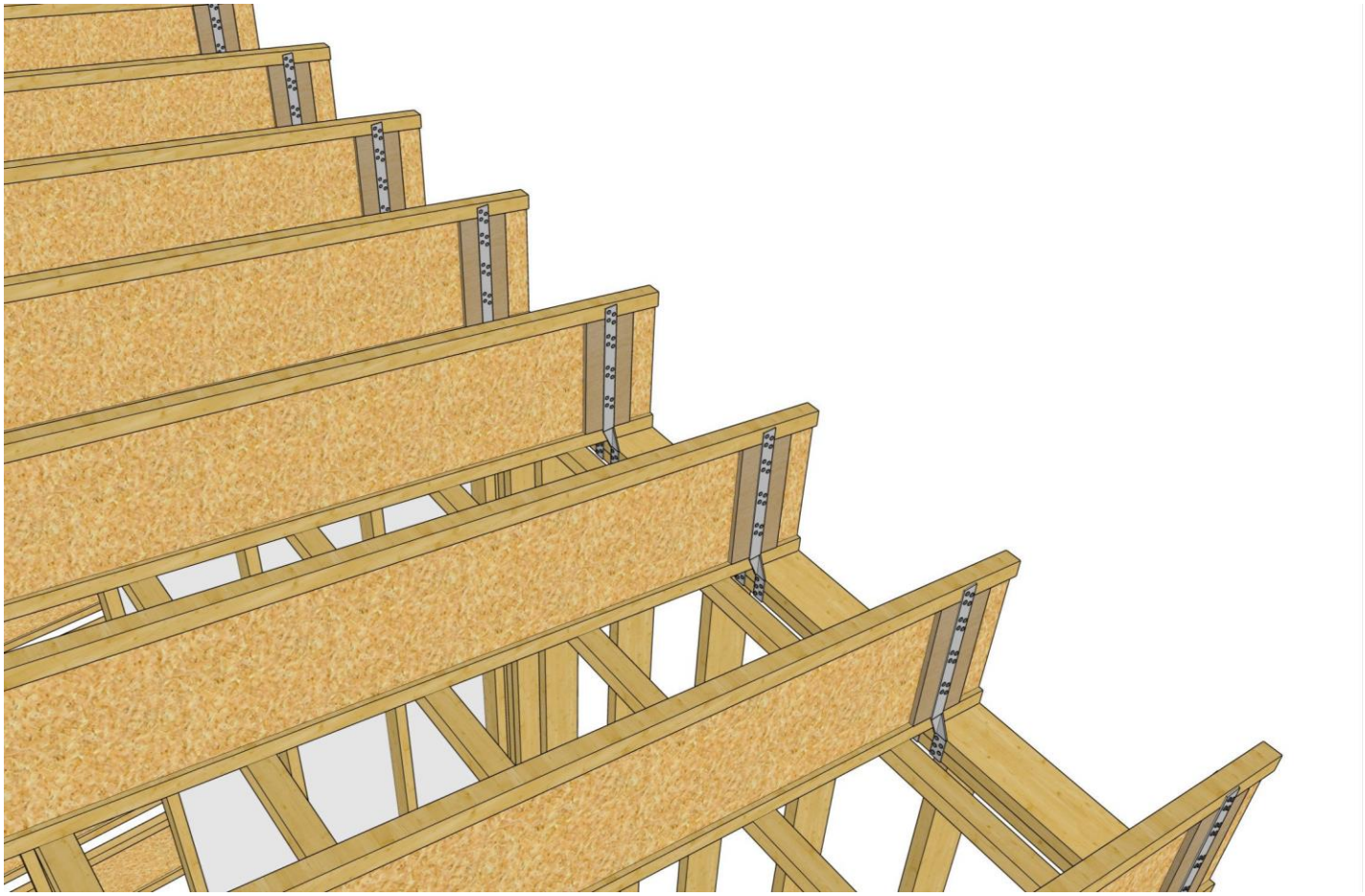


Roof Framing

Built-up LVL ridge beam and I-joist rafters

Whether I-joists or dimensional lumber are used for the roof rafters, attachment should be with hangers as opposed to toenailing to the ridge beam.

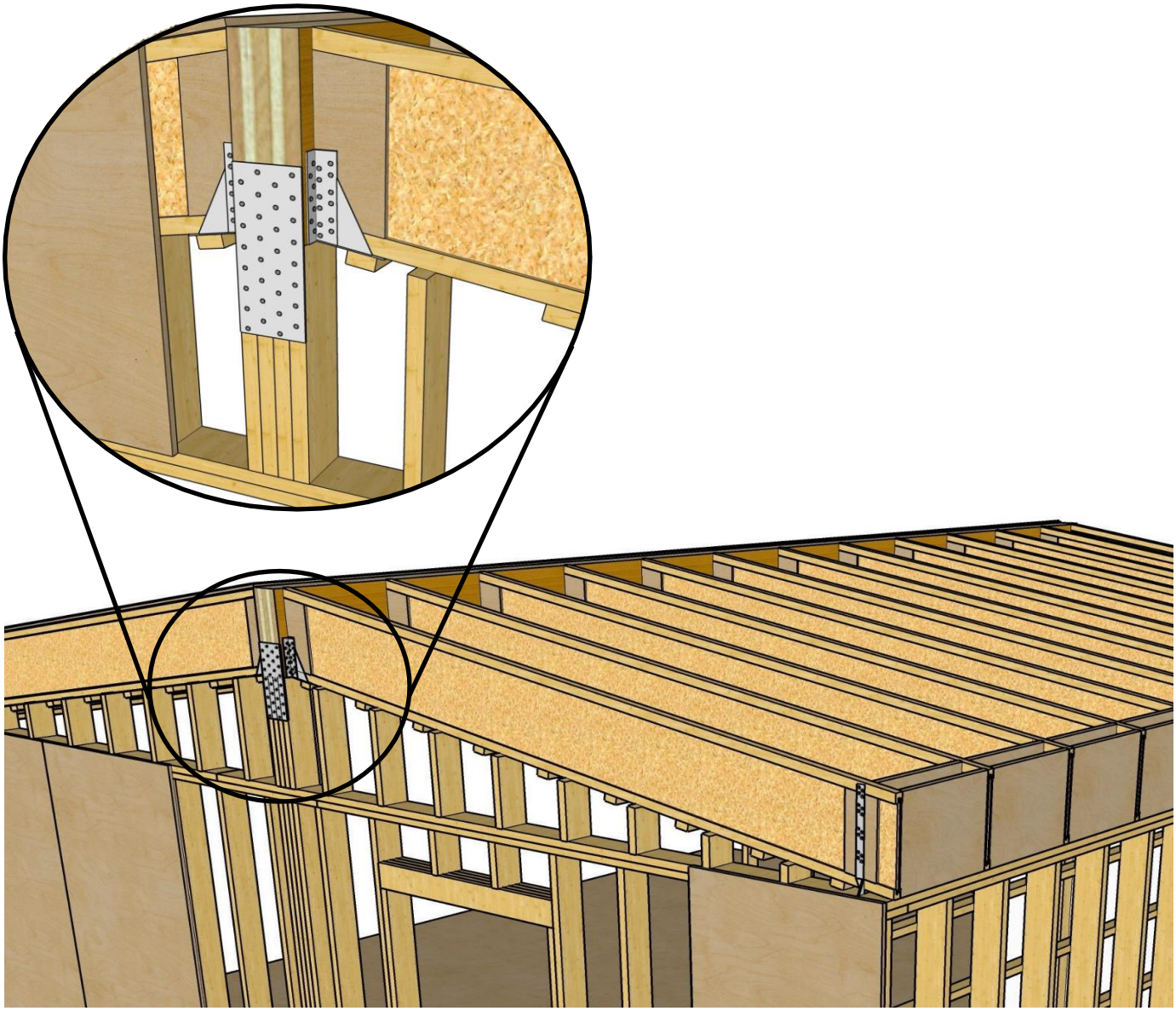
Tie-down brackets are recommended to fasten the roof rafters to the wall framing. These brackets help the roof structure resist the uplift loading caused by high winds. Because engineered-wood I-joists have a relatively narrow web (middle vertical component), in-fill blocking will need to be installed locally where hangers and tie-downs are fastened to the rafters.



Roof Framing

Built-up LVL ridge beam and I-joist rafters

The walls below the ends of the ridge beam require built-up stud “columns” to carry loads from the ridge beam to the perimeter beam. The ridge beam and built-up column system need to be designed by an engineer. It is recommended that a mending plate be installed at the end of the beam to secure it to the built-up stud post below and strengthen the connection.



ADDITIONAL RESOURCES

Handbooks and Design Manuals

- *Wood Design Manual,* Canadian Wood Council
- CSA O86-09, *Engineering Design in Wood*

Building Codes

- *National Building Code*
- *Manitoba Building Code*

This technical booklet was developed to help community decision-makers and building officers choose among different technical options in the delivery of residential housing for First Nations communities, in remote northern Manitoba.

IMPORTANT NOTE

This booklet addresses general structural approaches suitable for houses in northern communities. Detailed engineering is required in most cases, and should be performed by a professional engineer, licensed in the Province of Manitoba. Detailed engineering of engineered-wood connections is beyond the scope of this booklet; it involves a profession that requires years of university education and project-based internship.

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