

# Envelope Integrity for Factory Built Houses

*By Ken Rauch*

## Introduction

It's a grey, cold, windy day in March. The rain is icy--and you're shingling. You hum to yourself as you stand up on the dry plywood deck to stretch your back for a bit. Around you framers, electricians, plumbers and drywallers are hard at work—no landscapers though. You must be in heaven! Angels hover over head—well, maybe those are ceiling fans. It's another workday in a housing factory.

## Advantages of Building in a Factory

The advantages of building construction in a climate-controlled facility are many. Comfort, safety, dry and clean work areas and materials, good lighting, ease of access--no slipping off wet or icy roofs or boots lost in the mud. No rain-soaked and edge-swollen subfloor to drive flooring installers nuts.

As well, construction can be sequenced for maximum efficiency and components and materials can be positioned for easy access. Permanent jigs, fixtures and even saws and nailers make short work of layout and assembly for floor, wall and roof systems. The power is always on. And the coffee machine and washroom are a short walk away.

Building construction in a factory differs from on-site construction in that all the trades are present most of the time. This permits tremendous opportunity for efficiencies not available to site builders. Typically, interior partitions with finish on one side are erected before the exterior walls are built—no need to close in before weather threatens. Plumbing fixtures and cabinets can be installed at this point with almost unimpeded access.

Exterior walls are constructed in jigs, complete with insulation, vapour barrier, and interior and exterior finish before being lifted into place onto the floor system. Talk about continuity!

Even the roof system is built at ground (or should I say floor) level, and lifted into place with interior finish, vapour barrier, insulation and even roofing installed.

The electrical panel and a whole-house wiring harness can be made up at the workbench and installed so as to minimize penetrations of the building envelope.

## There are Disadvantages Too

The disadvantages are few but significant—finished buildings usually have many kilometres to go before reaching their intended site, down highways and secondary roads with lots of low overpasses and overhead wires. Large buildings must be constructed in modules that fit into the work areas of the factory, and that can be transported on public roads. On site, connections between modules must be made secure structurally, and the integrity of envelope components must be maintained at these interfaces.

Of course, building and maintaining a factory introduces considerable overhead, which, depending on whether it's the kind that keeps the rain out or the one that drains the bank account, can be considered an advantage or a disadvantage.

## National Building Code of Canada Provisions

The NBC does not differentiate between site-built and factory-built buildings. Environmental separation requirements (or “acceptable solutions” as they are now called) revolve around control of condensation and transfer of heat, air, moisture and sound in, on and through building materials, components and assemblies and at interfaces between them—the usual.



## CSA Standards

The Canadian Standards Association has published National Standards of Canada for factory-built houses including mobile homes and modular housing units. The list includes standards for certification of the manufacturing facilities, the construction of the buildings themselves and setup on site including installation on pile or pier foundations, anchorage to the ground and joining of multiple-section units.

It is in the CSA setup standard (“Site Preparation, Foundation, and Anchorage of Manufactured Homes”) that we find requirements and example illustrations for maintaining environmental separation integrity.

In summary, requirements are:

- Multiple-section manufactured homes must be joined so that thermally insulated floor and roof systems and walls present a continuous barrier to the leakage of air from the interior of the unit into wall spaces, floor spaces, or roof spaces.
- For modular homes, the standard calls up another standard, CSA Z240.2.1, or the applicable provincial, territorial or municipal building codes for general air and vapour barrier requirements.
- Roofing and flashing at junctions of multiple-section manufactured homes must be installed so that water is prevented from entering roofs.
- Joints in sheathing membranes on exterior walls at the junctions of multiple-section manufactured homes must be lapped at least 100 mm, and, if applied horizontally, upper sheets must overlap lower sheets.
- End joints in horizontal siding at the junctions of multiple-section manufactured homes must be staggered in accordance with the siding manufacturers’ instructions.

Not much new there, except that the last point pretty-well dictates that the end-wall siding be installed on site.

## Achieving Envelope Integrity for Multiple-section Buildings

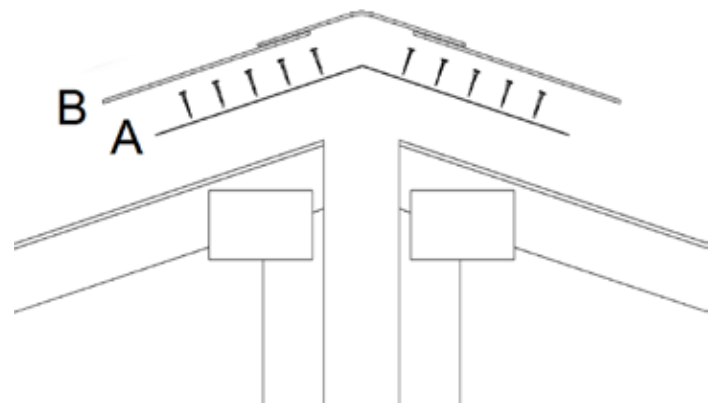
For modular housing and mobile homes, the most commonly encountered configuration is two single-storey modules joined on-site along their long sides. This very long junction is vulnerable to:

- water leakage along the roof ridge
- air leakage at the ceiling line where, typically, two mono-pitch trusses meet,
- air leakage at the floor line,
- water and air leakage at the end walls and
- damage due to structural movement along the join, which can lead to compromised envelope performance.

These challenges can met in various ways, and the following are but some techniques in current use.

### Roof Ridge

Along the length of the ridge is laid a continuous galvanized steel sheet, fastened to each truss, and providing a structural and watertight connection for the two roof sections (see A). The shingle ridge cap (see B) is installed over the sheet metal, resulting in a watertight, structurally-sound connection.

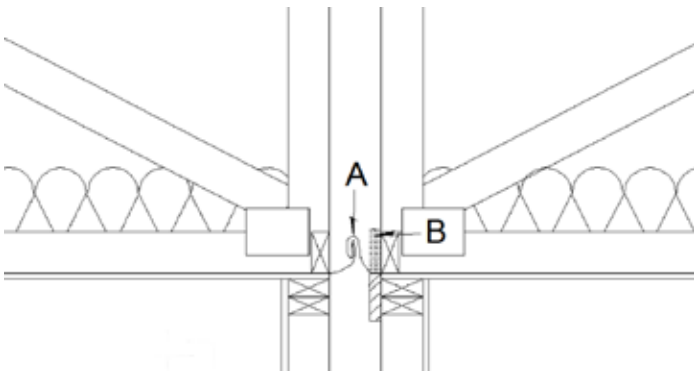


*Detail at Ridge*



## Ceiling

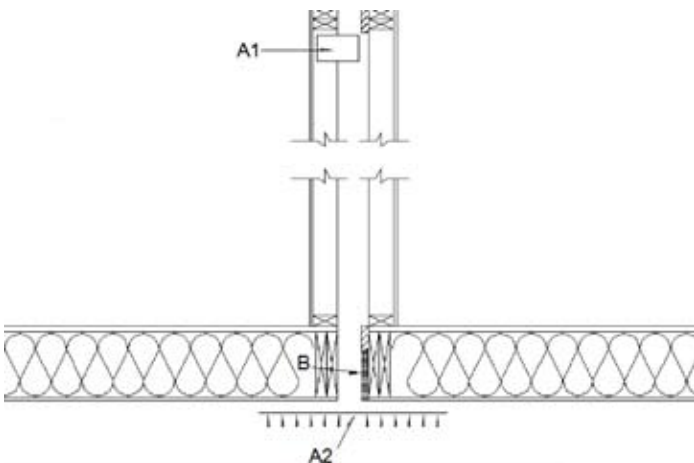
Polyethylene sheet and interior finish are installed to cover the entire ceiling of each module in the factory—before the roof module is lifted onto the wall system. At the mating walls of each module, an additional flap of the ceiling polyethylene is left (see A). These flaps are lapped to provide continuity of vapour barrier across modules. After the mating walls are brought into proximity (about 1 inch apart) foamed insulation is injected into the gap (see B) to seal the plane of the ceiling against air leakage.



*Detail at Ceiling*

## Floor

Steel ties (see A1 and A2) reinforce the connection between modules, and foamed insulation, similar to that installed at the ceiling line (see B) is installed between the two halves of a split longitudinal floor beam.



*Detail at Floor*

## End Walls

Once the units have been mated, sheathing membrane is installed on the end walls, or if pre-installed in the plant, overhanging flaps of sheathing membrane are overlapped and taped. Exterior finish and trim is installed over the entire end walls.

## Compliance Verification

The flexible procedures used in factories can present a challenge for compliance inspections where multiple inspection visits are not practicable. And closing in construction before inspection makes building officials cranky.

A practical answer is CSA certification whereby a factory first demonstrates it has the capability and quality-control procedures to routinely turn out a conforming product. Then periodic, unannounced inspections confirm that a representative sample of units meets requirements. At any inspection visit, the inspector is able to see pretty-well the complete construction process, albeit not necessarily on the same unit. Upon demonstrating ongoing compliance, the manufacturer is authorized to attach CSA certification labels to units leaving the factory. The responsibility for compliance remains with the manufacturer.

The fact that manufacturers usually build a standard range of models permits inspectors to infer that even work that has been closed in prior to an inspection can be accepted. One-of-a-kind designs and new design details might require additional inspections. Installation of buildings on their foundations including joining of modules and any site-built structures are subject to inspection by local building officials.



## Acknowledgement

*Many thanks to Peter Aitcheson of Triple M Homes in Lethbridge, Alberta, who reviewed text and illustrations for me. Peter, besides being a big wheel at Triple M, is chairman of the CSA technical committee responsible for factory-built houses and a member of the Standing Committee on Housing and Small Buildings of the National Building Code of Canada. So, if there are any mistakes or outright lies here, call him—just kidding.*

## Relevant Links

The Canadian Codes Centre:

[http://irc.nrc-cnrc.gc.ca/codes/home\\_E.shtml](http://irc.nrc-cnrc.gc.ca/codes/home_E.shtml)

The Canadian Standards Association:

<http://www.csa.ca/Default.asp?language=english>

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