**Luncheon**
January 5, 2022

# ***Roofing Technical Update***

presented by

**Mark S. Graham**
Vice President, Technical Services
National Roofing Contractors Association (NRCA)

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## Topics

- Wood roof deck concerns
- Minnesota state codes:
  - Roofing related changes in the 2021 I-codes
- Construction-generated moisture
- Material substitutions
- Questions… and other topics

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RESEARCH+TECH

Know your steep-slope roof decks

Following plywood and OSB installation guidelines can help ensure a successful roof system performance

by Mark S. Graham

Plywood or oriented strand board structural panel sheathing are integral components of many steep-slope roof assemblies, and proper use of these products can help ensure successfully performing assemblies. If you use or encounter plywood and/or OSB structural panel sheathing roof decks, it is important to be knowledgeable of the applicable code requirements and APA—The Engineered Wood Association and NRCA guidelines applicable to them.

IRC 2018

The International Residential Code® provides specific requirements applicable to plywood and OSB structural panel sheathing used as roof decks for one- and two-family dwellings. In IRC's 2018 edition, specific requirements are provided in Section R803-Roof Sheathing.

IRC 2018 requires wood structural panels conform to the Department of Commerce's PS 1, "Structural Plywood," or PS 2, "Performance Standard for Wood-based Structural-Use Panels," or CSA Group™'s O325, "Construction Sheathing," or O437, "Standards on OSB and Waferboard." PS 1 and O325 generally are recognized to apply to plywood, and PS 2 and O437 apply to OSB.

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## Standards for wood structural panels

*International Residential Code, 2018 Edition*

**Plywood:**

- U.S. Department of Commerce PS-1, "Structural Plywood"
- CSA Group O325, "Construction Sheathing"

**Oriented-strand board (OSB):**

- U.S. Department of Commerce PS-2, "Performance Standard for Wood-based Structural-use Panels"
- CSA Group O437, "Standards for OSB and Waferboard"

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## Common, but not referenced in the Code

**Plywood and OSB:**

- APA-The Engineered Wood Association Standard PRP-108, “Performance Standards and Policies for Structural-Use Panels”

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## Roof sheathing attachment

**IRC 2018 Table 602.3(1), Rows 30-32 (minimum attachment):**

- Panel edges:
  - 2½-inch-long 8d common nails at 6 inches o.c. at supported panel edges
- Intermediate supports:
  - 2½-inch-long 8d common nails at 12 inches o.c. at intermediate supports

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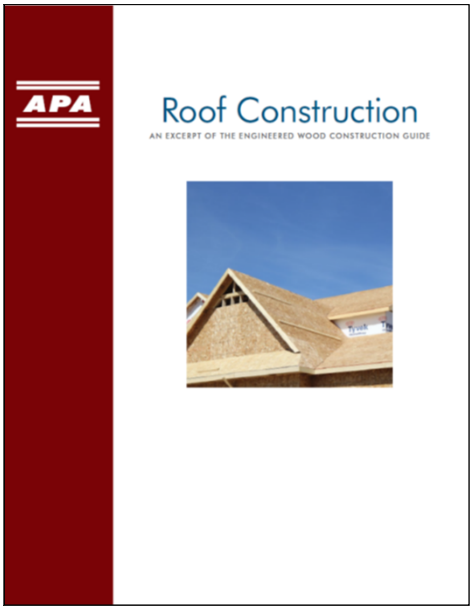


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**APA Form E30, "Roof Construction"**

--Roofing-specific excerpts from APA's *Engineered Wood Construction Guide* (102 pages)

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## Recommendations

Roof sheathing attachment

- **New construction:**
  - Be careful with deck "acceptance".
  - Deck acceptance should be limited to the visual surface and no visual presence of moisture on the surface
- **Reroofing:**
  - Since deck condition and attachment typically cannot be determined until roof covering tear-off, consider unit price or T & M pricing for deck replacement and/or deck re-fastening

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# Minnesota state codes

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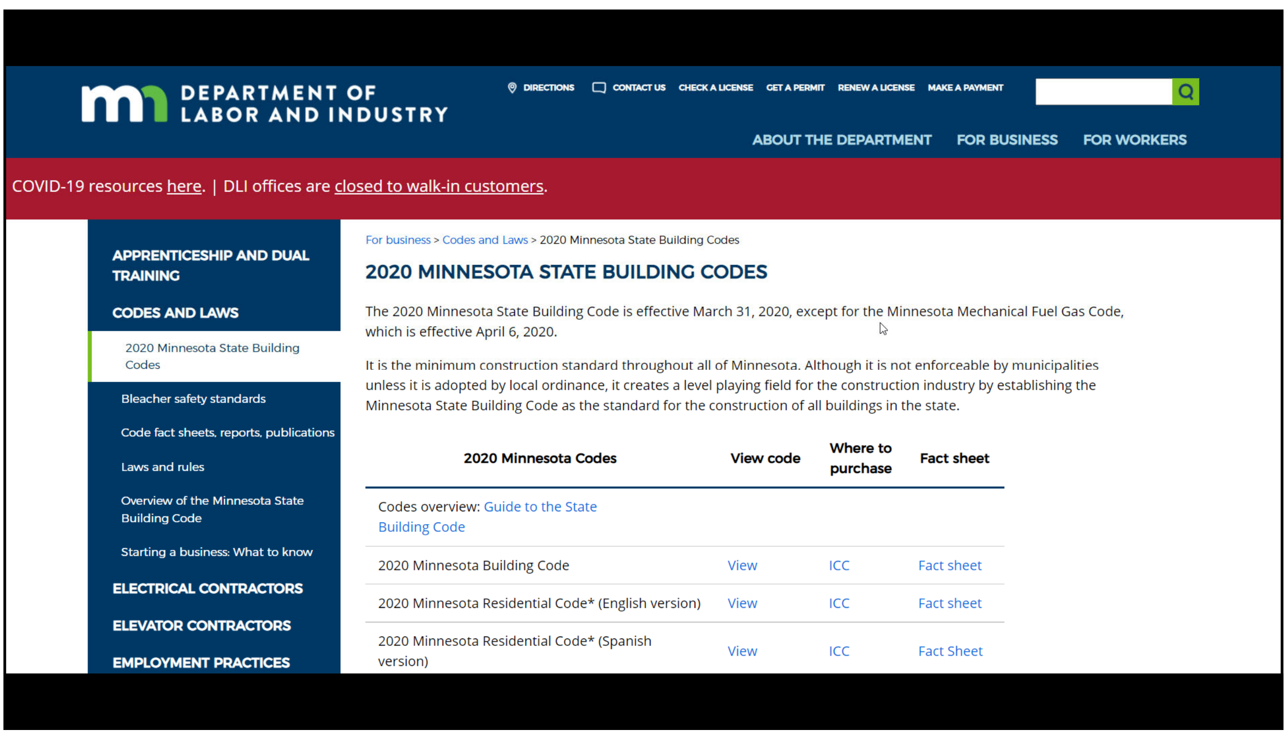

DEPARTMENT OF LABOR AND INDUSTRY

DIRECTIONS | CONTACT US | CHECK A LICENSE | GET A PERMIT | RENEW A LICENSE | MAKE A PAYMENT

ABOUT THE DEPARTMENT | FOR BUSINESS | FOR WORKERS

COVID-19 resources here. | DLI offices are closed to walk-in customers.

APPRENTICESHIP AND DUAL TRAINING

CODES AND LAWS

- 2020 Minnesota State Building Codes
- Bleacher safety standards
- Code fact sheets, reports, publications
- Laws and rules
- Overview of the Minnesota State Building Code
- Starting a business: What to know

ELECTRICAL CONTRACTORS

ELEVATOR CONTRACTORS

EMPLOYMENT PRACTICES

For business > Codes and Laws > 2020 Minnesota State Building Codes

## 2020 MINNESOTA STATE BUILDING CODES

The 2020 Minnesota State Building Code is effective March 31, 2020, except for the Minnesota Mechanical Fuel Gas Code, which is effective April 6, 2020.

It is the minimum construction standard throughout all of Minnesota. Although it is not enforceable by municipalities unless it is adopted by local ordinance, it creates a level playing field for the construction industry by establishing the Minnesota State Building Code as the standard for the construction of all buildings in the state.

| 2020 Minnesota Codes | View code | Where to purchase | Fact sheet |
|---|---|---|---|
| Codes overview: Guide to the State Building Code | | | |
| 2020 Minnesota Building Code | View | ICC | Fact sheet |
| 2020 Minnesota Residential Code* (English version) | View | ICC | Fact sheet |
| 2020 Minnesota Residential Code* (Spanish version) | View | ICC | Fact Sheet |

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CODE BOOK FACT SHEET

## 2020 MINNESOTA BUILDING CODE

Minnesota Department of Labor and Industry

### 2020 MINNESOTA BUILDING CODE

- Regulates the design, construction, addition, alteration, repair, use and location of all buildings and structures other than those regulated by the 2020 Minnesota Residential Code.
- Contains detailed provisions governing building construction. These include requirements for structural, means of egress, sanitation, life-safety, fire-safety, and moisture protection.
- Located in Minnesota Rules Chapter 1305. This rule chapter adopts by reference Chapters 2 through 33 and 35 of the 2018 International Building Code (IBC) and includes amendments to the IBC.

### EFFECTIVE DATE

- Minnesota Building Code is effective March 31, 2020.

### CODE BOOK

The 2020 Minnesota Building Code is a custom code book published for Minnesota by the International Code Council (ICC). It includes Minnesota's amendments into the body of changed sections and reads as a unified code book. It also includes Minnesota chapters about administration, radon and elevators. There is no longer a need to separately purchase the ICC model code and Minnesota amendments and refer to them both. Now they are contained in a single reformatted Minnesota-specific code book.

Code books are available for purchase and free, online viewing is available.


### TO VIEW CODES ONLINE FREE

- Visit www.dli.mn.gov/business/codes-and-laws to view the code.

### TO PURCHASE CODE BOOKS

- International Code Council
  https://shop.iccsafe.org/state-and-local-codes/minnesota.html
  701-931-4533

DEPARTMENT OF LABOR AND INDUSTRY CONSTRUCTION CODES AND LICENSING

Construction Codes and Licensing Division
Web: www.dli.mn.gov Phone: 651-284-5012

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CODE BOOK FACT SHEET

## 2020 MINNESOTA ENERGY CODE

Minnesota Department of Labor and Industry

### 2020 MINNESOTA ENERGY CODE

- Provides energy-conserving standards for the design, construction, alteration, renovation and repair of residential and commercial buildings.
- Contains design and construction standards regarding heat-loss control, illumination and climate control.
- Located in Minnesota Rules Chapters 1322 and 1323. This rule chapter adopts by reference Chapters 2(RE) through 5(RE) of the 2012 International Energy Conservation Code (IECC) for residential, 2(CE) through 4(CE) and 6(CE) of the 2018 IECC for commercial, and optional AHSRAE Standard 90.1-2016, the 2012 IECC and Minnesota amendments to the IECC. The IECC includes requirements for both residential and commercial buildings.

### EFFECTIVE DATE

- Commercial Energy Code with ANSI/ASHRAE/IES Standard 90.1-2016 is effective March 31, 2020.
- Residential Energy Code is effective Feb. 14, 2015.

### CODE BOOK

The 2020 Minnesota Energy Code is a custom code published for Minnesota by the International Code Council (ICC). It includes Minnesota's amendments into the body of changed sections and reads as a unified code book. It also includes a Minnesota chapter on Administration. There is no longer a need to separately purchase the ICC model code and Minnesota amendments and refer to them both. Now they are contained in a single reformatted Minnesota-specific code book.

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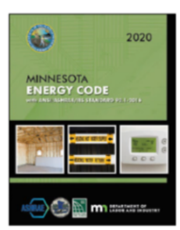


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## 2021 IBC


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## Edge metal testing

Changes in IBC 2021, Section 1504-Performance Requirements

**1504.6 Edge systems for low-slope roofs.** Metal edge systems, except gutters and counterflashing, installed on built-up, modified bitumen and single-ply roof systems having a slope less than 2 units vertical in 12 units horizontal (2:12) shall be designed and installed for wind *loads* in accordance with Chapter 16 and tested for resistance in accordance with Test Methods RE-1, RE-2 and RE-3 of ANSI/SPRI ES-1, except basic design *wind speed*, V, shall be determined from Figures 1609.3(1) through 1609.3(12) as applicable.

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## Gutter testing

Changes in IBC 2021, Section 1504-Performance Requirements

**1504.6 Edge systems for low-slope roofs.** Metal edge systems, except gutters and counterflashing, installed on built-up, modified bitumen and single-ply roof systems having a slope less than 2 units vertical in 12 units horizontal (2:12) shall be designed and installed for wind *loads* in accordance with Chapter 16 and tested for resistance in accordance with Test Methods RE-1, RE-2 and RE-3 of ANSI/SPRI ES-1, except basic design *wind speed*, V, shall be determined from Figures 1609.3(1) through 1609.3(12) as applicable.

**1504.6.1 Gutter securement for low-slope roofs.** Gutters that are used to secure the perimeter edge of the roof membrane on low-slope (less than 2:12 slope) built-up, modified bitumen, and single-ply roofs, shall be designed, constructed and installed to resist wind loads in accordance with Section 1609 and shall be tested in accordance with Test Methods G-1 and G-2 of SPRI GT-1.

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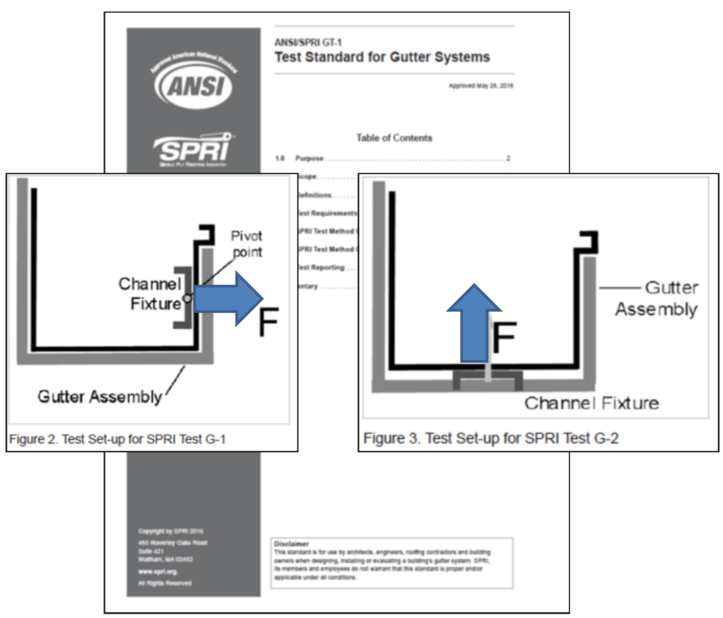
## ANSI/SPRI GT-1

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## Aggregate surfacing

Changes in IBC 2021, Section 1504-Performance Requirements

**1504.9 Wind resistance of aggregate-surfaced roofs.** Parapets shall be provided for aggregate surfaced roofs and shall comply with Table 1504.9.

**TABLE 1504.9**
**MINIMUM REQUIRED PARAPET HEIGHT (INCHES) FOR AGGREGATE SURFACED ROOFS[a, b, c]**

| AGGREGATE SIZE | MEAN ROOF HEIGHT (ft) | WIND EXPOSURE AND BASIC DESIGN WIND SPEED (MPH) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Exposure B | | | | | | | | | Exposure C[d] | | | | | | | | |
| | | ≤ 95 | 100 | 105 | 110 | 115 | 120 | 130 | 140 | 150 | ≤ 95 | 100 | 105 | 110 | 115 | 120 | 130 | 140 | 150 |
| ASTM D1863 (No. 7 or No. 67) | 15 | 2 | 2 | 2 | 2 | 12 | 12 | 16 | 20 | 24 | 2 | 13 | 15 | 18 | 20 | 23 | 27 | 32 | 37 |
| | 20 | 2 | 2 | 2 | 2 | 12 | 14 | 18 | 22 | 26 | 12 | 15 | 17 | 19 | 22 | 24 | 29 | 34 | 39 |
| | 30 | 2 | 2 | 2 | 13 | 15 | 17 | 21 | 25 | 30 | 14 | 17 | 19 | 22 | 24 | 27 | 32 | 37 | 42 |
| | 50 | 12 | 12 | 14 | 16 | 18 | 21 | 25 | 30 | 35 | 17 | 19 | 22 | 25 | 28 | 30 | 36 | 41 | 47 |
| | 100 | 14 | 16 | 19 | 21 | 24 | 27 | 32 | 37 | 42 | 21 | 24 | 26 | 29 | 32 | 35 | 41 | 47 | 53 |
| | 150 | 17 | 19 | 22 | 25 | 27 | 30 | 36 | 41 | 46 | 23 | 26 | 29 | 32 | 35 | 38 | 44 | 50 | 56 |
| ASTM D1863 (No. 6) | 15 | 2 | 2 | 2 | 2 | 12 | 12 | 12 | 15 | 18 | 2 | 2 | 2 | 13 | 15 | 17 | 22 | 26 | 30 |
| | 20 | 2 | 2 | 2 | 2 | 12 | 12 | 13 | 17 | 21 | 2 | 2 | 12 | 15 | 17 | 19 | 23 | 28 | 32 |
| | 30 | 2 | 2 | 2 | 2 | 12 | 12 | 16 | 20 | 24 | 2 | 12 | 14 | 17 | 19 | 21 | 26 | 31 | 35 |
| | 50 | 12 | 12 | 12 | 12 | 14 | 16 | 20 | 24 | 28 | 12 | 15 | 17 | 19 | 22 | 24 | 29 | 34 | 39 |
| | 100 | 12 | 12 | 14 | 16 | 19 | 21 | 26 | 30 | 35 | 16 | 18 | 21 | 24 | 26 | 29 | 34 | 39 | 45 |
| | 150 | 12 | 14 | 17 | 19 | 22 | 24 | 29 | 34 | 39 | 18 | 21 | 23 | 26 | 29 | 32 | 37 | 43 | 48 |

For SI: 1 inch = 25.4 mm; 1 foot = 304.8 mm; 1 mile per hour = 0.447 m/s.
a. Interpolation shall be permitted for mean roof height and parapet height.
b. Basic design wind speed, *V*, and wind exposure shall be determined in accordance with Section 1609.
c. Where the minimum required parapet height is indicated to be 2 inches (51 mm), a gravel stop shall be permitted and shall extend not less than 2 inches (51 mm) from the roof surface and not less than the height of the aggregate.
d. For Exposure D, add 8 inches (203 mm) to the parapet height required for Exposure C and the parapet height shall not be less than 12 inches (305 mm).

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## Roof coatings

Changes in IBC 2021, Section 1509-Roof Coatings (new)

### SECTION 1509
### ROOF COATINGS

**1509.1 General.** The installation of a *roof coating* on a *roof covering* shall comply with the requirements of Section 1505 and this section.

**1509.2 Material standards.** Roof coating materials shall comply with the standards in Table 1509.2.

**TABLE 1509.2**
**ROOF COATING MATERIAL STANDARDS**

| MATERIAL | STANDARD |
|---|---|
| Acrylic coating | ASTM D6083 |
| Asphaltic emulsion coating | ASTM D1227 |
| Asphalt coating | ASTM D2823 |
| Asphalt roof coating | ASTM D4479 |
| Aluminum-pigmented asphalt coating | ASTM D2824 |
| Silicone coating | ASTM D6694 |
| Moisture-cured polyurethane coating | ASTM D6947 |

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## Liquid-applied membrane roof systems

Changes in IBC 2021, Section 1507.14-Liquid-applied Roofing

**1507.14 Liquid-applied roofing.** The installation of liquid-applied roofing shall comply with the provisions of this section.

**1507.14.1 Slope.** Liquid-applied roofing shall have a design slope of not less than $^1/_4$ unit vertical in 12 units horizontal (2-percent slope).

**1507.14.2 Material standards.** Liquid-applied roofing shall comply with ASTM C836, ASTM C957 or ASTM D3468.

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## Roof zones

Changes in IBC 2021, Section 1603-Construction Documents

CHAPTER 16
STRUCTURAL DESIGN

**1603.1.4 Wind design data.** The following information related to wind *loads* shall be shown, regardless of whether wind *loads* govern the design of the lateral force-resisting system of the structure:

1. Basic design *wind speed*, *V*, miles per hour and *allowable stress design wind speed*, $V_{asd}$, as determined in accordance with Section 1609.3.1.
2. *Risk category*.
3. Wind exposure. Applicable wind direction if more than one wind exposure is utilized.
4. Applicable internal pressure coefficient.
5. Design wind pressures and their applicable zones with dimensions to be used for exterior component and cladding materials not specifically designed by the *registered design professional* responsible for the design of the structure, pounds per square foot (kN/m²).

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## Attic ventilation

Changes in IBC 2021, Section 1203-Unvented Attics and Unvented Enclosed Rafter Spaces

5.2.7. The roof slope shall be greater than or equal to 3 units vertical in 12 units horizontal (3:12).

5.2.8. Where only air-permeable insulation is used, it shall be installed directly below the structural roof sheathing, on top the attic floor, or on top of the ceiling.

5.2.9. Where only air-permeable insulation is used and is installed directly below the structural roof sheathing, air shall be supplied at a flow rate greater than or equal to 50 cubic feet per minute (23.6 L/s) per 1,000 square feet (93 $m^2$) of ceiling.

5.3. The air shall be supplied from ductwork providing supply air to the occupiable space when the conditioning system is operating. Alternatively, the air shall be supplied by a supply fan when the conditioning system is operating. Where preformed insulation board is used as the air-impermeable insulation layer, it shall be sealed at the perimeter of each individual sheet interior surface to form a continuous layer.

**Exceptions:**

1. Section 1202.3 does not apply to special use structures or enclosures such as swimming pool enclosures, data processing centers, hospitals or art galleries.
2. Section 1202.3 does not apply to enclosures in Climate Zones 5 through 8 that are humidified beyond 35 percent during the three coldest months.

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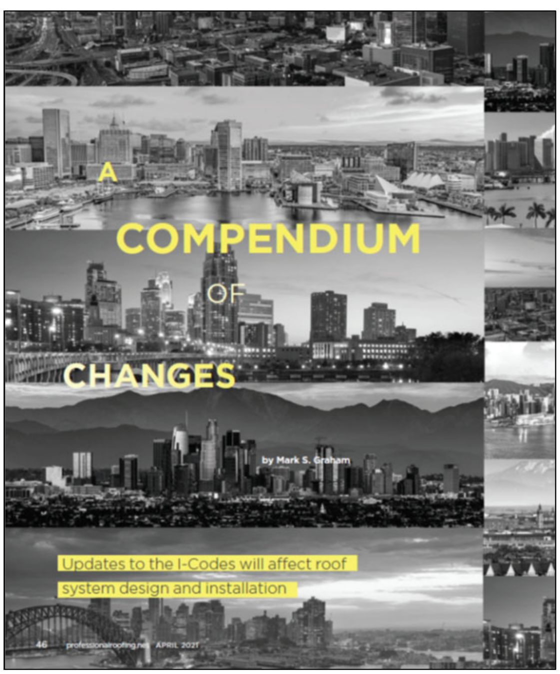


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April 2021

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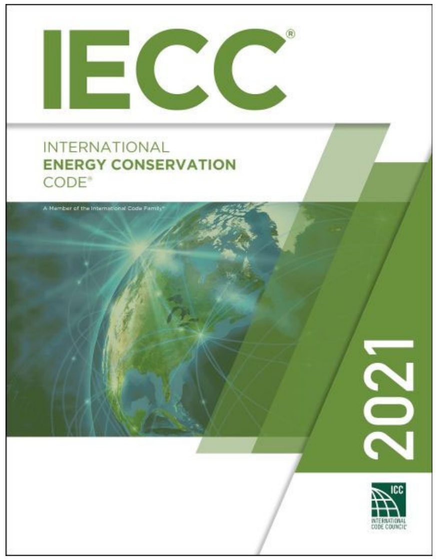
## 2021 IECC

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## 2021 IECC Commercial – Tapered insulation

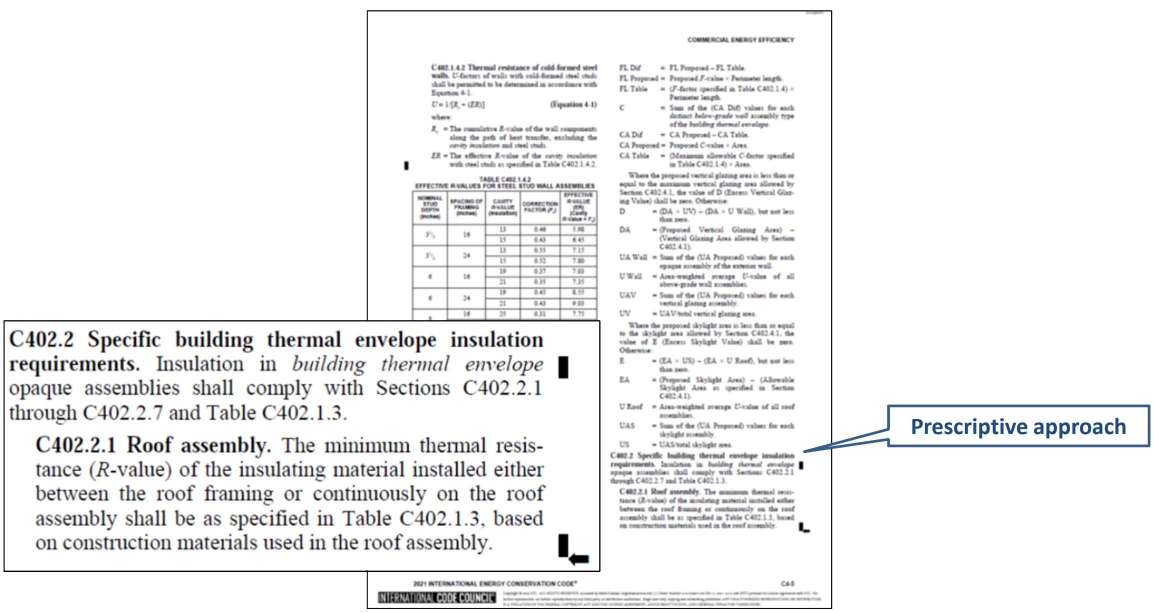


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**TABLE C402.1.3**
**OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, *R*-VALUE METHOD[a]**

| CLIMATE ZONE | 0 AND 1 | | 2 | | 3 | | 4 EXCEPT MARINE | | 5 AND MARINE 4 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R |
| **Roofs** | | | | | | | | | | | | | | | | |
| Insulation entirely above roof deck | R-20ci | R-25ci | R-25ci | R-25ci | R-25ci | R-25ci | R-30ci | R-30ci | R-30ci | R-30ci | R-30ci | R-30ci | R-35ci | R-35ci | R-35ci | R-35ci |
| Metal buildings[b] | R-19 + R-11 LS | R-19 + R-11 LS | R-19 + R11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-25 + R-11 LS | R-30 + R-11 LS | R-30 + R-11 LS | R-30 + R-11 LS | R-25 + R-11 + R-11 LS | R-25 + R-11 + R-11 LS |
| Attic and other | R-38 | R-38 | R-38 | R-38 | R-38 | R-38 | R-49 | R-49 | R-49 | R-49 | R-49 | R-49 | R-60 | R-60 | R-60 | R-60 |
| Metal framed | R-13 + R-5ci | R-13 + R-5ci | R-13 + R-5ci | R-13 + R-7.5ci | R-13 + R-7.5ci | R-13 + R-7.5ci | R-13 + R-7.5ci | R-13 + R-7.5ci | R-13 + R-10ci | R-13 + R-10ci | R-13 + R-12.5ci | R-13 + R-12.5ci | R-13 + R-12.5ci | R-13 + R-15.6ci | R-13 + R-18.8ci | R-13 + R-18.8ci |
| Wood framed and other | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 | R-13 + R-3.8ci or R-20 | R-13 + R-7.5ci or R20 + R3.8ci | R-13 + R-7.5ci or R-20 + R-3.8ci | R-13 + R-7.5ci or R-20 + R-3.8ci | R-13 + R-7.5ci or R-20 + R-3.8ci | R-13 + R-7.5ci or R-20 + R-3.8ci | R-13 + R-7.5ci or R-20 + R-3.8ci | R-13 + R-18.8ci | R-13 + R-18.8ci |
| **Walls, below grade** | | | | | | | | | | | | | | | | |
| Below-grade wall[c] | NR | NR | NR | NR | NR | NR | R-7.5ci | R-10ci | R-7.5ci | R-10ci | R-10ci | R-15ci | R-15ci | R-15ci | R-15ci | R-15ci |
| **Floors** | | | | | | | | | | | | | | | | |
| Mass[e] | NR | NR | R-6.3ci | R-8.3ci | R-10ci | R-10ci | R-14.6ci | R-16.7ci | R-14.6ci | R-16.7ci | R-16.7ci | R-16.7ci | R-20.9ci | R-20.9ci | R-23ci | R-23ci |
| Joist/framing | R-13 | R-13 | R-30 | R-30 | R-30 | R-30 | R-30 | R-30 | R-30 | R-30 | R-38 | R-38 | R-38 | R-38 | R-38 | R-38 |
| **Slab-on-grade floors** | | | | | | | | | | | | | | | | |
| Unheated slabs | NR | NR | NR | NR | NR | R-10 for 24" below | R-15 for 24" below | R-15 for 24" below | R-15 for 24" below | R-20 for 24" below | R-20 for 24" below | R-20 for 24" below | R-20 for 48" below | R-20 for 48" below | R-20 for 48" below | R-25 for 48" below |
| Heated slabs[g] | R-7.5 for 12" below+ R-5 full slab | R-7.5 for 12" below+ R-5 full slab | R-7.5 for 12" below+ R-5 full slab | R-7.5 for 12" below+ R-5 full slab | R-10 for 24" below+ R-5 full slab | R-10 for 24" below+ R-5 full slab | R-15 for 24" below+ R-5 full slab | R-15 for 24" below+ R-5 full slab | R-15 for 36" below+ R-5 full slab | R-15 for 36" below+ R-5 full slab | R-15 for 36" below+ R-5 full slab | R-20 for 48" below+ R-5 full slab | R-20 for 48" below+ R-5 full slab | R-20 for 48" below+ R-5 full slab | R-20 for 48" below+ R-5 full slab | R-20 for 48" below+ R-5 full slab |

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m², 1 pound per cubic foot = 16 kg/m³.
ci = Continuous Insulation, NR = No Requirement, LS = Liner System.
a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA 90.1 Appendix A.
b. Where using *R*-value compliance method, a thermal spacer block shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.4.
c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-ft² °F.
d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.
e. "Mass floors" shall be in accordance with Section C402.2.3.
f. "Mass walls" shall be in accordance with Section C402.2.2.
g. The first value is for perimeter insulation and the second value is for full, under-slab insulation. Perimeter insulation is not required to extend below the bottom of the slab.

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# 2021 IECC Commercial – Tapered insulation

**C402.2.1.1 Tapered, above-deck insulation based on thickness.** Where used as a component of a roof/ceiling assembly *R*-value calculation, the sloped roof insulation *R*-value contribution to that calculation shall use the average thickness in inches (mm) along with the material *R*-value-per-inch (per-mm) solely for *R*-value compliance as prescribed in Section 402.1.3.

**C402.2.1.2 Minimum thickness, lowest point.** The minimum thickness of above-deck roof insulation at its lowest point, gutter edge, roof drain or scupper, shall be not less than 1 inch (25 mm).

**C402.2.1.3 Suspended ceilings.** Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the minimum thermal resistance (*R*-value) of roof insulation in roof/ceiling construction.

**C402.2.1.4 Joints staggered.** Continuous insulation board shall be installed in not less than two layers and the edge joints between each layer of insulation shall be staggered, except where insulation tapers to the roof deck at a gutter edge, roof drain or scupper.

"…average thickness…"

"…not less than 1 inch…"

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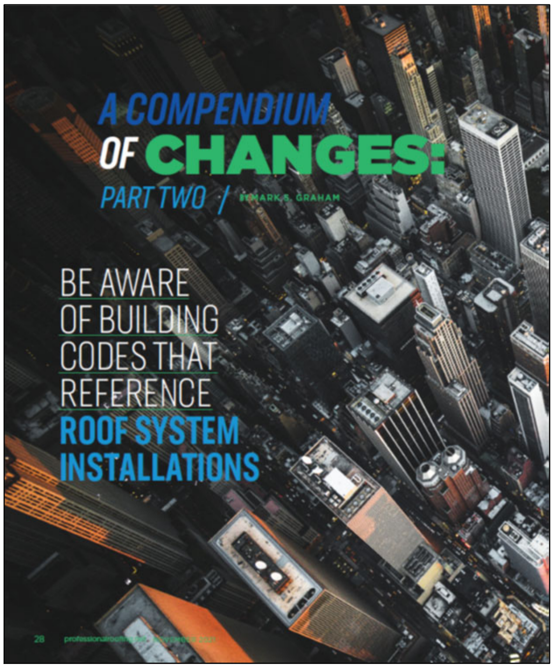


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November 2021

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*Be aware whether and, if so, when your state and local jurisdictions will be adopting the 2021 I-codes*

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## Construction-generated moisture

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**Reflective Roof Coverings:** Experience and limited research has shown that non-adhered membrane roof systems with highly reflective roof surfaces can accumulate moisture while in service to a greater extent than roof systems without highly reflective roof surfaces. This phenomenon appears most pronounced in roof systems with only a single layer of rigid board insulation, which results in "thermal shorts" at the board joints through the thickness of the roof system.

A membrane roof system designed without a vapor retarder layer properly placed within the roof system's cross section may function as a "self-drying" roof assembly. That is, it will likely accumulate small amounts of moisture when the direction of moisture vapor flow is from the building's interior to its exterior and release that moisture or "dry down" toward the building's interior when the direction of vapor flow is from the building's exterior to its interior. Additional information regarding self-drying roof assemblies is provided in Section 2.2—Determining the Need for a Vapor Retarder.

In situations where a membrane roof system has a highly reflective roof surface, the membrane and the roof system's other layers will be cooler than a similar roof system without a highly reflective roof surface. As a result, roof systems with highly reflective roof surfaces will likely not dry down as quickly or to the same magnitude as roof systems without highly reflective roof surfaces.

To account for this phenomenon, NRCA recommends designers use a minimum of two layers of insulation in their membrane roof system designs and the two layers be installed with offset joints to minimize air leakage and movement and thermal shorts.

NRCA also suggests roof system designers consider the use of properly placed air retarders as components of roof systems with highly reflective roof surfaces. Additional information regarding air retarders in roof assemblies is provided in Chapter 4—Air Retarders for Roof Assemblies.

### 1.2 Principles of Moisture Vapor Movement

**Phases:** Water can exist in three phases: solid (i.e., ice), liquid (i.e., water) and gas (i.e., vapor). The phase in which water exists generally depends on its temperature and pressure. At atmospheric pressure conditions, water is generally:

- In its solid (crystalline) phase at temperatures below its freezing point, which is 32 F
- In its liquid phase between 32 F and 212 F
- In its gas phase at temperatures above its boiling point, which is 212 F

Water commonly moves from its liquid phase to its gas phase by evaporation even when the surrounding ambient temperature is less than the material's boiling point. At temperatures lower than the boiling point, heat energy can be transferred to water molecules and cause them to pass from the liquid phase into the gas phase. When water in its gas phase is cooled, it will lose energy and return to its liquid phase (i.e., condense).

When water passes from its liquid phase to its gas phase in the atmosphere, the water vapor is contained in air and it exerts a pressure that is measurable (i.e., vapor pressure).

**Relative Humidity:** The amount of water in its gas phase (i.e., moisture vapor) that can be contained within a given volume of air is a function of temperature. This quantity is described by the term "relative humidity," which is sometimes abbreviated RH and expressed as a percentage. Relative humidity is the ratio of the partial pressure of water vapor in an air-water mixture to the maximum—or saturated—water vapor pressure at the same temperature. Partial pressure is the pressure a substance in its gas phase would have if it alone occupied the available volume. When air at a given temperature has a relative humidity of 100 percent, it is said to be saturated; that is, it cannot hold any more water vapor unless its temperature is raised. Warm air can hold a larger quantity of water vapor than cold air.

For example, a given volume of air will have a relative humidity of 100 percent at 60 F (i.e., dry bulb temperature on psychrometric chart). That same volume of air will have a relative humidity of only about 50 percent if the air is heated from 60 F to 80 F. Using the Psychrometric Chart, this relationship temperature versus relative humidity is illustrated in Figure 1-1 (on page 188).

**Condensation:** When moisture-saturated air is cooled, some of the moisture vapor contained in the air condenses—that is, the moisture vapor returns to its liquid phase. The temperature at which air becomes saturated with moisture vapor and condensation begins to form is referred to as the air's dew-point temperature.

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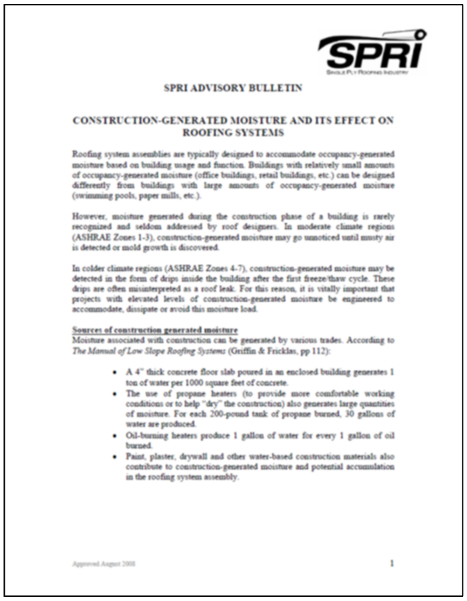

SPRI

SPRI ADVISORY BULLETIN

CONSTRUCTION-GENERATED MOISTURE AND ITS EFFECT ON ROOFING SYSTEMS

Roofing system assemblies are typically designed to accommodate occupancy-generated moisture based on building usage and function. Buildings with relatively small amounts of occupancy-generated moisture (office buildings, retail buildings, etc.) can be designed differently from buildings with large amounts of occupancy-generated moisture (swimming pools, paper mills, etc.).

However, moisture generated during the construction phase of a building is rarely recognized and seldom addressed by roof designers. In moderate climate regions (ASHRAE Zones 1-3), construction-generated moisture may go unnoticed until musty air is detected or mold growth is discovered.

In colder climate regions (ASHRAE Zones 4-7), construction-generated moisture may be detected in the form of drips inside the building after the first freeze/thaw cycle. These drips are often misinterpreted as a roof leak. For this reason, it is vitally important that projects with elevated levels of construction-generated moisture be engineered to accommodate, dissipate or avoid this moisture load.

<u>**Sources of construction generated moisture**</u>
Moisture associated with construction can be generated by various trades. According to *The Manual of Low Slope Roofing Systems* (Griffin & Fricklas, pp 112):

- A 4" thick concrete floor slab poured in an enclosed building generates 1 ton of water per 1000 square feet of concrete.
- The use of propane heaters (to provide more comfortable working conditions or to help "dry" the construction) also generates large quantities of moisture. For each 200-pound tank of propane burned, 30 gallons of water are produced.
- Oil-burning heaters produce 1 gallon of water for every 1 gallon of oil burned.
- Paint, plaster, drywall and other water-based construction materials also contribute to construction-generated moisture and potential accumulation in the roofing system assembly.

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## <u>Some things we know…</u>

Construction-generated moisture

- Cooler temperatures are more challenging than warmer temperatures
  - Cool air holds less moisture
- Some "modern" materials are less moisture tolerant
- Water-based products release moisture; more than solvent-based materials
- Concrete is placed using much more water than is necessary for proper hydration
- Many concrete admixtures slow moisture release

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## Some things we know (cont.)…

Construction-generated moisture

- Temporary enclosures can trap moisture/prevent moisture release
- Temporary heating can be problematic
  - Propane heaters release large amounts of moisture vapor
- Bringing warm, stored materials out into a cold environment can result in surface condensation

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## Recommendations

Construction-generated moisture

- Realize practical (and physical) limitations
- Consider appropriate contract provision language so you don't take on additional liability

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# **Material substitutions**

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RESEARCH+TECH

Considering substitutions

Be aware of potential consequences with product substitution

by Mark S. Graham

With ongoing shortages of building materials and products, substitutions have become more commonplace—but they can have unintended consequences. One issue that has arisen involves substituting European lumber for North American lumber, a decision that could result in unintended consequences.

The situation

At the start of the COVID-19 pandemic, wood product producers were operating under the same uncertainty as the rest of the world. Many mills curtailed production in anticipation of worker shortages and reduced demand. At the same time, many wholesale and retail lumber customers significantly reduced inventory levels. Also, because of the Great Recession, several mills had closed permanently. The American Wood Council reports between 2007 and 2017, mill closures in the South resulted in a lumber capacity loss between 1.7 to 2 billion board feet. Mill closures in the Pacific Northwest represented 10% of the area's mills.

Although the demand for wood products had dipped, it quickly rebounded during the pandemic because of increased remodeling projects and new housing starts spurred, in part, by low interest

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**Questions… and other topics**

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