Cantilevered Floor

Last Updated: 03/14/2016

Scope

Air seal the top, bottom, and sides of a cantilevered floor cavity and ensure that insulation is in full contact with all sides without voids.

- Install a rigid air barrier or other supporting blocking to separate the cantilever from the conditioned space above. Seal all seams, gaps, and holes in the air barrier with caulk or foam.
- Block and seal any open floor joists abutting the cantilever floor cavities.
- Install insulation without misalignments, compressions, gaps, or voids to fill the cantilever floor cavity, making full contact with the top, bottom, and sides of a cantilevered floor cavity.
- Cover the bottom of the insulated cantilever floor cavities with a rigid, weather-resistant solid blocking material such as plywood or house siding.

See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE’s Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
A cantilevered floor is a floor that sticks out past the foundation or supporting wall below. It may be a first- or second-story bump-out, a bay window, or a room over an open porch. Floor joist bays that extend from the house out under the cantilevered floor are sometimes left unsealed and uninsulated by the builder, allowing outside air to flow through the home and conditioned air to escape (Figure 1). Sometimes cantilevered floors are insulated but not air sealed. Air barriers must be put in place across any open floor joist bays to form an air barrier between the cantilever and the rest of the house to prevent air from blowing through the insulation, which renders the insulation ineffective. Blocking material (rigid foam, OSB, plywood, or drywall) should be installed (Figure 2). Plywood subflooring above the cantilever should be caulked at the edges and seams. The cantilever floor cavity must be filled with insulation that completely touches the underside of the floor. Insulating foam sheathing and/or house sheathing or siding should be attached to the underside of the cantilever floor joists as a protective covering. Air sealing and insulation materials may be installed by framers, insulators, and/or siding installers. This task should be included in the contract for the appropriate trade depending on the workflow at specific job sites.

Air barrier effectiveness is measured at the whole-house level. High-performance branding programs and the IECC code require that builders meet specified infiltration rates at the whole house level. See the “compliance” tab for these specified infiltration rates.

When designing the home, HVAC ducts and plumbing pipes should not be located in cantilevered floors.

Figure 1. If these floor joist bays remain open, cold air can flow between the floors of the house.
How to Air Seal and Insulate a Cantilevered Floor

1. Create an air barrier between the house and the cantilever by cutting a rectangle of rigid foam to fit into each floor joist bay cavity (Figure 3). Make a backstop for the foam by tacking furring strips to the joists at the plane with the foundation or house wall.

2. Insert rigid foam pieces into each joist bay, nail in place and caulk to air seal all four edges (Figure 4).

3. Caulk the subfloor to the floor joists at the perimeter of the cantilevered floor and at any seams in the subfloor (Figure 4). Seal any wiring or piping holes through perimeter joists or subfloor with caulk or spray foam.
4. Install unfaced batt insulation in each floor joist bay (Figure 5). Use a thickness that will completely fill the cavity; it must be in contact with the top and bottom air barrier (i.e., the subfloor above and rigid sheathing below) with no compressions or voids. Alternatively, insulate each cavity with open- or closed-cell spray foam that is aligned with the underside of the subfloor above. Install to a depth equivalent to the required exterior wall R-value. In cold climates, use closed-cell foam.

5. Cover the underside of the cantilever with rigid foam insulation (Figure 6). Use caulk and fasteners to attach rigid foam to joists and to air seal at the edges. Tape foam at seams.
6. Cover the rigid foam with siding or with 3/8-inch exterior plywood that is pressure-treated, painted, or primed on all exposed sides (Figure 7).

7. If you have plumbing pipes in the cantilevered floor (not recommended) and live in a cold climate, ensure adequate insulation on the exterior side of the pipes to protect them from freezing. One option is to box in the pipes with a rigid foam box that is caulked to the subfloor to allow warmth from the house to reach the pipes.
Figure 8. Cantilever floor construction detail showing where caulk should be installed in connection with framing and rigid air barriers to provide continuous air blocking.
Ensuring Success

Air sealing of cantilever floor joist bays should be inspected by the site supervisor before the insulation and covering are installed. Blower door testing conducted as part of whole-house energy performance testing may indicate whether air leakage at cantilever floors has been successfully sealed. An infrared camera may also be used to detect air leakage.
Climate

2009 - 2018 IECC and IRC Minimum Insulation Requirements

Install insulation in amounts that meet or exceed code-required levels for your climate zone. Please see this table for the minimum insulation requirements for ceilings, walls, floors, and foundations in new homes, as listed in the 2009, 2012, 2015, and 2018 IECC and IRC.

DOE Zero Energy Ready Home (Revision 07)

Exhibit 2 DOE Zero Energy Ready Home Target Home. The U.S. Department of Energy’s Zero Energy Ready Home program allows builders to choose a prescriptive or performance path. The DOE Zero Energy Ready Home prescriptive path requires builders to meet or exceed the minimum HVAC efficiencies listed in Exhibit 2 of the National Program Requirements (Rev 07), as shown below. The DOE Zero Energy Ready Home performance path allows builders to select a custom combination of measures for each home that is equivalent in performance to the minimum HERS index of a modeled target home that meets the requirements of Exhibit 2 as well as the mandatory requirements of Zero Energy Ready Home Exhibit 1.

Exhibit 2, Insulation and Infiltration) Whole house leakage must be tested and meet the following infiltration limits:

- Zones 1-2: ≤ 3 ACH50;
- Zones 3-4: ≤ 2.5 ACH50;
- Zones 5-7: ≤ 2 ACH50;
- Zone 8: ≤ 1.5 ACH50;
- Attached dwellings: ≤ 3 ACH50.

Footnote 13) Steel-frame ceilings, walls, and floors shall meet the insulation requirements of the 2015 IECC – Table 402.2.6
Footnote 23) Envelope leakage shall be determined by an approved verifier using a RESNET-approved testing protocol.

International Energy Conservation Code (IECC) Climate Regions
Training

Right and Wrong Images

Display Image: ES_TESRC_3.2.2_PG76_115b_102811_0.jpg
CAD FILE: 322_CAD_3-2_cantilever_floor_1_5_in_rigid_foam_5-01020_GBA_1-31-12.dwg
PDF: 322_CAD_3-2_cantilever_floor_1_5_in_rigid_foam_5-01020_GBA_1-31-12.pdf

CAD FILE: 322_CAD_3-2_cantilever_floor_1_in_rigid_foam_5-01019_GBA_1-31-12.dwg
PDF: 322_CAD_3-2_cantilever_floor_1_in_rigid_foam_5-01019_GBA_1-31-12.pdf
Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

ENERGY STAR Certified Homes, Version 3/3.1 (Rev. 09)

National Rater Field Checklist

Thermal Enclosure System.

2. Fully-Aligned Air Barriers. At each insulated location below, a complete air barrier is provided that is fully aligned as follows:

Floors: At exterior vertical surface of floor insulation in all climate zones and, if over unconditioned space, also at interior horizontal surface including supports to ensure alignment. Alternatives in Footnotes.

Footnote 6) For purposes of this Checklist, an air barrier is defined as any durable solid material that blocks air flow between conditioned space and unconditioned space, including necessary sealing to block excessive air flow at edges and seams and adequate support to resist positive and negative pressures without displacement or damage. EPA recommends, but does not require, rigid air barriers. Open-cell or closed-cell foam shall have a finished thickness \( \geq 5.5 \) in. or \( \geq 1.5 \) in., respectively, to qualify as an air barrier unless the manufacturer indicates otherwise. If flexible air barriers such as house wrap are used, they shall be fully sealed at all seams and edges and supported using fasteners with caps or heads \( \leq 1 \) in. diameter unless otherwise indicated by the manufacturer. Flexible air barriers shall not be made of kraft paper, paperbased products, or other materials that are easily torn. If polyethylene is used, its thickness shall be \( \geq 6 \) mil.\n
Footnote 10) EPA highly recommends, but does not require, an air barrier at the interior vertical surface of floor insulation in Climate Zones 4-8.

Footnote 11) Examples of supports necessary for permanent contact include staves for batt insulation or netting for blown-in insulation. Alternatively, supports are not required if batts fill the full depth of the floor cavity, even when compression occurs due to excess insulation, as long as the R-value of the batts has been appropriately assessed based on manufacturer guidance and the only defect preventing the insulation from achieving the required installation grade is the compression caused by the excess insulation.

Footnote 12) Alternatively, an air barrier is permitted to be installed at the exterior horizontal surface of the floor insulation if the insulation is installed in contact with this air barrier, the exterior vertical surfaces of the floor cavity are also insulated, and air barriers are included at the exterior vertical surfaces of this insulation.

Please see the ENERGY STAR Certified Homes Implementation Timeline for the program version and revision currently applicable in your state.

DOE Zero Energy Ready Home (Revision 07)

Exhibit 1 Mandatory Requirements.

Exhibit 1, Item 1) Certified under the ENERGY STAR Qualified Homes Program or the ENERGY STAR Multifamily New Construction Program.

Exhibit 1, Item 2) Ceiling, wall, floor, and slab insulation shall meet or exceed 2015 IECC levels and achieve Grade 1 installation, per RESNET standards. See the guide 2015 IECC Code Level Insulation – DOE Zero Energy Ready Home Requirements for more details.

Exhibit 2 DOE Zero Energy Ready Home Target Home.

The U.S. Department of Energy’s Zero Energy Ready Home program allows builders to choose a prescriptive or performance path. The DOE Zero Energy Ready Home prescriptive path requires builders to meet or exceed the minimum HVAC efficiencies listed in Exhibit 2 of the National Program Requirements (Rev 07), as shown below. The DOE Zero Energy Ready Home performance path allows builders to select a custom combination of measures for each home that is equivalent in performance to the minimum HERS index of a modeled target home that meets the requirements of Exhibit 2 as well as the mandatory requirements of Zero Energy Ready Home Exhibit 1.

Exhibit 2, Insulation and Infiltration) Whole house leakage must be tested and meet the following infiltration limits:

- Zones 1-2: \( \leq 3 \) ACH50;
- Zones 3-4: \( \leq 2.5 \) ACH50;
- Zones 5-7: \( \leq 2 \) ACH50;
- Zone 8: \( \leq 1.5 \) ACH50;
- Attached dwellings: \( \leq 3 \) ACH50.

Footnote 13) Steel-frame ceilings, walls, and floors shall meet the insulation requirements of the 2015 IECC – Table 402.2.6

Footnote 23) Envelope leakage shall be determined by an approved verifier using a RESNET-approved testing protocol.
Self-Adhered Sheet Air Barrier. 2006. Air Barrier Association of America, Walpole, MA. This specification for self-adhered sheet air barriers is developed by a professional association, the Air Barrier Association of America, to provide guidance to the design professional.

Fluid-Applied Air and Vapor Barrier. 2012. Air Barrier Association of America, Walpole, MA. This specification for air barriers that are fluid-applied and also act as vapor barriers is developed by a professional association, the Air Barrier Association of America, to provide guidance to the design professional.

Closed Cell, Medium-Density Spray Polyurethane Foam Air Barrier. 2011. Air Barrier Association of America, Walpole, MA. This specification for closed cell, medium-density spray polyurethane foam air barriers is developed by a professional association, the Air Barrier Association of America, to provide guidance to the design professional.

Fluid-Applied Vapor Permeable Air Barrier. 2012. Air Barrier Association of America, Walpole, MA. This specification for fluid-applied vapor permeable air barriers is developed by a professional association, the Air Barrier Association of America, to provide guidance to the design professional.

2009 - 2018 IECC and IRC Minimum Insulation Requirements: The minimum insulation requirements for ceilings, walls, floors, and foundations in new homes, as listed in the 2009, 2012, 2015, and 2018 IECC and IRC, can be found in this table.

Table R402.4.1.1 Air Barrier and Insulation Installation, Floors: Insulation in floors (including above garage and cantilevered floors) is installed to maintain permanent contact with underside of subfloor decking. A continuous air barrier is installed in the building envelope including rim joists and exposed edges of insulation. Breaks or joints in the air barrier are sealed. Air permeable insulation is not used as a sealing material. Junction of foundation and wall sill plates, wall top plate and top of wall, sill plate and rim-band, and rim band and subfloor are sealed. Corners, headers, and rim joists making up the thermal envelope are insulated.

Table R402.1.1 (Table R402.1.2 in 2015 and IECC) Insulation and Fenestration Requirements – meet or exceed the insulation levels listed in this table.

Retrofit:
Section R101.4.3 (Section R501.1.1 in 2015 and 2018 IECC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

Table N1102.4.2 (N1102.4.1.1 in 2012, 2015, and 2018 IRC) Air Barrier and Insulation Installation, Floors: Insulation in floors (including above garage and cantilevered floors) is installed to maintain permanent contact with underside of subfloor decking. A continuous air barrier is installed in the building envelope including rim joists and exposed edges of insulation. Breaks or joints in the air barrier are sealed. Air permeable insulation is not used as a sealing material. Junction of foundation and wall sill plates, wall top plate and top of wall, sill plate and rim-band, and rim band and subfloor are sealed. Corners, headers, and rim joists making up the thermal envelope are insulated.

Table N1102.1.1 (Table N1102.1.2 in 2015 and 2018 IRC) Insulation and Fenestration Requirements – meet or exceed the insulation levels listed in this table.

Retrofit:
Section N1101.3 (Section N1107.1.1 in 2015 and 2018 IRC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

Appendix J regulates the repair, renovation, alteration, and reconstruction of existing buildings and is intended to encourage their continued safe use.
Case Studies

1. **New Whole-House Solutions Case Study: Tindall Homes: The Legends at Mansfield, Columbus, NJ**
   - **Author(s):** PNNL
   - **Organization(s):** PNNL
   - **Publication Date:** April, 2012
   
   Case study about a new construction building project of 20 luxury homes in northern New Jersey that were more energy efficient than ENERGY STAR and met the 50% energy savings requirements of the federal tax credit for new homes.

References and Resources*

1. **2009 IECC - International Energy Conservation Code**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2009
   
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

2. **2009 IRC - International Residential Code for One and Two Family Dwellings**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2009
   
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2012
   
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

4. **2012 IRC - International Residential Code for One and Two Family Dwellings**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2012
   
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

5. **2015 IECC - International Energy Conservation Code**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** May, 2014
   
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

6.
2015 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: May, 2014
Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

Author(s): International Code Council
Organization(s): ICC
Publication Date: November, 2017
Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems, and service water heating systems in homes and commercial businesses.

8. 2018 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: August, 2017
Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

Author(s): Baechler, Gilbride, Hefty, Cole, Love
Organization(s): Pacific Northwest National Laboratory, Oak Ridge National Laboratory
Publication Date: February, 2011
Guide describing measures that builders in the cold and very cold climates can take to build homes that have whole-house energy savings of 40% over the Building America benchmark with no added overall costs for consumers.

Author(s): Advanced Energy
Organization(s): Advanced Energy
Publication Date: March, 2002
Information sheet containing images and descriptions of cantilevers.

11. DOE Zero Energy Ready Home National Program Requirements (Rev. 07)
Author(s): U.S. Department of Energy
Organization(s): DOE
Publication Date: May, 2019
Standard requirements for DOE’s Zero Energy Ready Home national program certification.

12. ENERGY STAR Certified Homes, Version 3/3.1 (Rev. 09) National Program Requirements
Author(s): U.S. Environmental Protection Agency
Organization(s): EPA
Publication Date: September, 2018
Webpage with links to documents providing the program requirements and checklists for ENERGY STAR Certified Homes (Ver. 3/3.1, Rev. 09).

13. How to Insulate Inside the Basement
Author(s): Natural Resources Canada
Organization(s): Natural Resources Canada
Publication Date: October, 2013
Information sheet providing links and resources for insulating basements in cold climates.

Author(s): Taggart, Sikora, Wiehagen, Wood
Organization(s): NAHB Research Center, National Renewable Energy Laboratory
Publication Date: December, 2011
Research study providing a comparison of selected retrofit activity typically done, versus that same retrofit activity approached from an integrated high performance remodeling and quality management perspective.

15.
Thermal Enclosure System Rater Checklist Guidebook

Author(s): U.S. Environmental Protection Agency
Organization(s): EPA
Publication Date: October, 2011

Guide describing details that serve as a visual reference for each of the line items in the Thermal Enclosure System Rater Checklist.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.

Contributors to this Guide
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