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Building AMERICA
U.S. Department of Energy
Building for Energy Efficiency – Part 2
Advanced Framing Workshop
Aaron Grin
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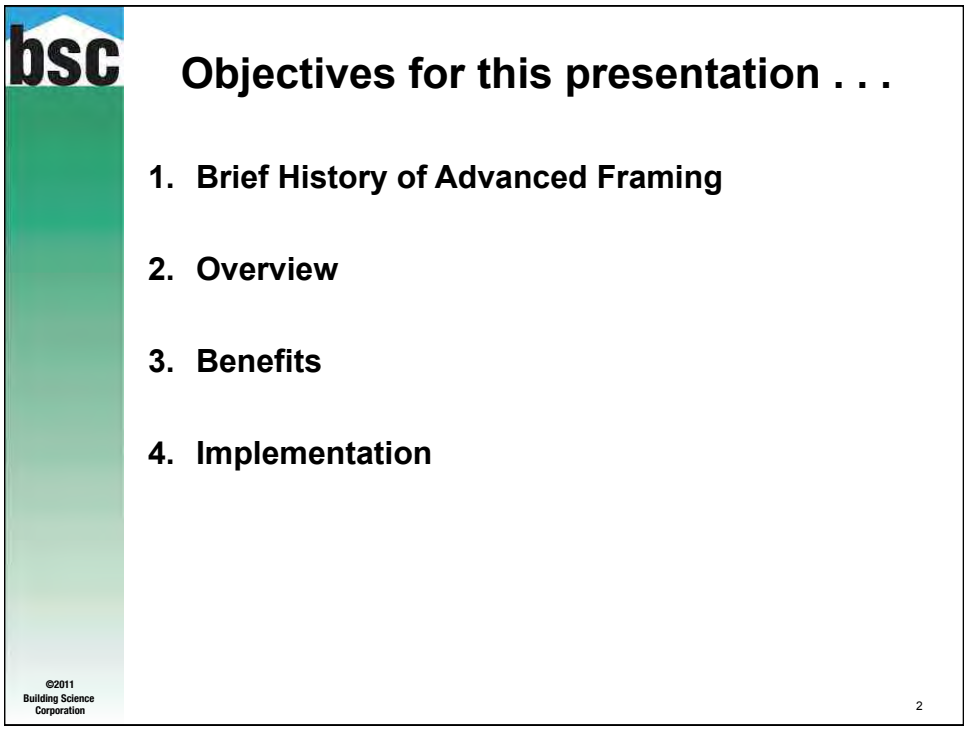
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Objectives for this presentation . . .
1. Brief History of Advanced Framing
2. Overview
3. Benefits
4. Implementation
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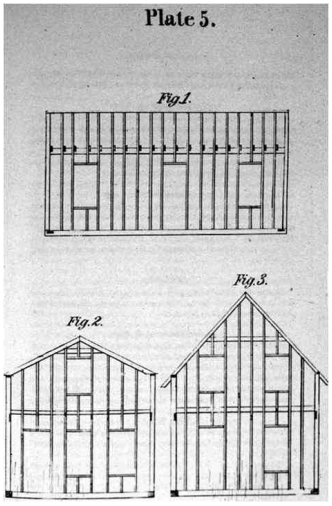
History

The Year – 1854

The Book – The American Cottage Builder



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History

1970s

U.S. Department of Housing and Urban Development

NAHB Research Foundation

Operation Break-through delivered "optimum value engineering framing"

Today this is "Advanced Framing"

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Overview

What is Advanced Framing?

- Framing system on 2' centers
- Reduce Framing Material Use
- Increases Insulation Volume
- Improves Energy Performance
- Reduces Labor Costs (eventually)

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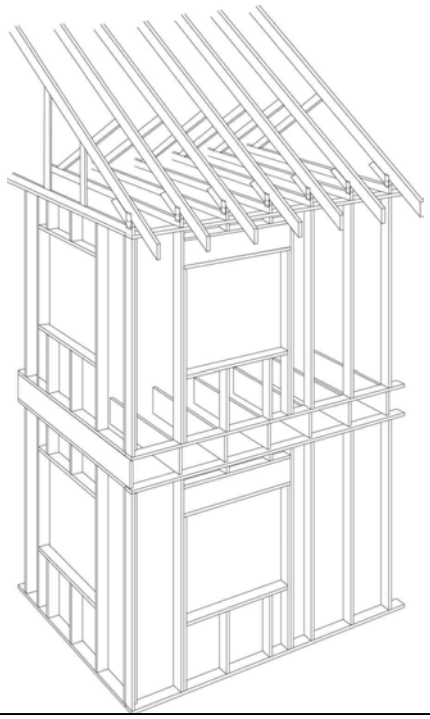
- 24" Centers Inline Framed
- No Headers in non-load bearing walls
- Single Studs at Rough Openings
- No Cripple studs under windows
- Two Stud Corners
- Single Insulated Header
- Header Hangers
- Single Top Plate



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Overview

Advanced Framing and The Building Code

Within the IRC the following are permitted:

- **24" On Centre Framing**
- **Single Top Plates**
- **24" On Centre Interior Partitions**
- **No Headers in Non-Load-Bearing Walls**
- **Interior and Exterior Wall Covering on 24" On Centre**
- **Drywall Clips**
- **Single Headers**

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Overview

Advanced Framing and The Building Code

Single Top Plate

IRC 2000 AND 2003, IN SECTION R602.3.2 TOP PLATE

EXCEPTION: A SINGLE TOP PLATE MAY BE INSTALLED IN STUD WALLS – WITH PROV

24" On Centre Interior Walls

IRC 2000 AND 2003, IN SECTION R602.5

INTERIOR, NONBEARING WALLS SHALL BE PERMITTED TO BE CONSTRUCTED WITH 2-INCH-BY-3-INCH (51 MM BY 76 MM) STUDS SPACED 24 INCHES (610 MM) ON CENTER

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Overview

Advanced Framing and The Building Code

No Headers in Non-Load-Bearing Walls

IRC 2000 AND 2003, SECTION R602.7.2

NONBEARING WALLS. LOAD-BEARING HEADERS ARE NOT REQUIRED IN INTERIOR OR EXTERIOR NONBEARING WALLS. – WITH PROVISIONS

Exterior Covering over 24" On Centre Framing

IRC 2000 AND 2003 SECTION R703 EXTERIOR COVERING

STRUCTURAL SHEATHING AND SIDING REQUIREMENTS ARE BASED ON TABLE R703.4. NOTE THAT FOOTNOTE "A" SPECIFIES THAT THE TABLE IS BASED ON 16 INCHES ON CENTER AND THAT STUDS-SPACED-24-INCHES-ON-CENTER SIDING SHALL BE APPLIED TO SHEATHING APPROVED FOR THAT SPACING.

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Overview

Advanced Framing and The Building Code

Drywall Installation over 24" On Centre Framing

IRC 2000 AND 2003 TABLE R702.3.5 MINIMUM THICKNESS AND APPLICATION OF GYPSUM BOARD

ALLOWS THE USE OF 24-INCH-ON-CENTER FRAMING FOR FASTENING GYPSUM BOARD WITH EITHER FASTENERS OR ADHESIVE 1/2 INCH THICKNESS OR GREATER.

Use of Drywall Clips for Drywall

IRC 2000 AND 2003, FIGURE R602.3(2)

NOTE: A THIRD STUD AND/OR PARTITION INTERSECTION BACKING STUDS SHALL BE PERMITTED TO BE OMITTED THROUGH THE USE OF WOOD BACK-UP CLEATS, METAL DRYWALL CLIPS, OR OTHER APPROVED DEVICES THAT WILL SERVE AS ADEQUATE BACKING FOR THE FACING MATERIALS.

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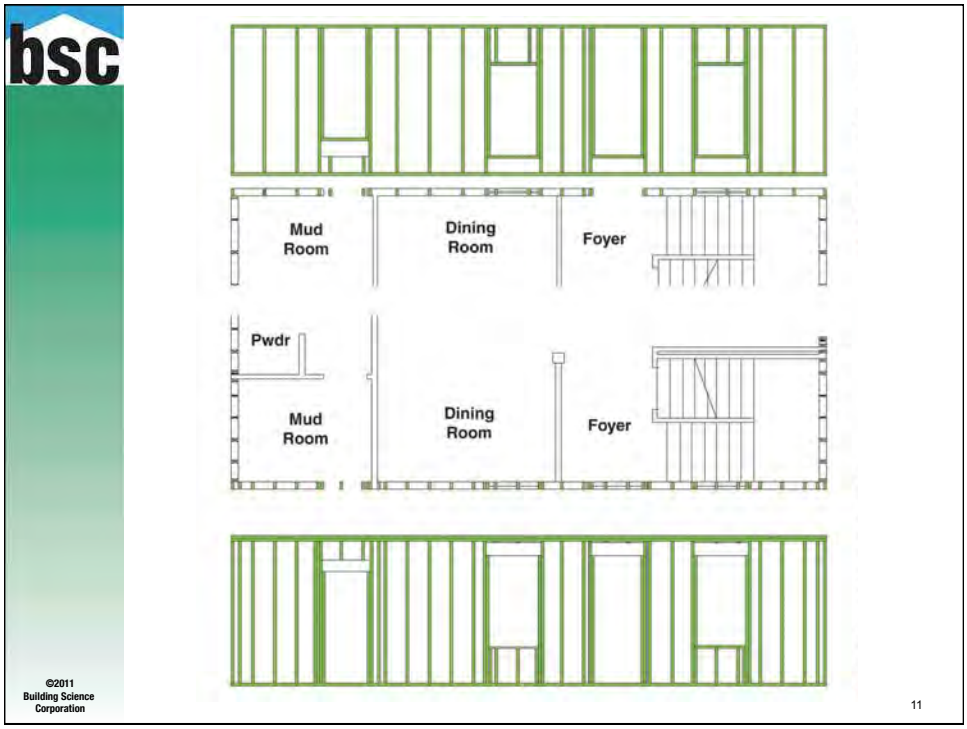
Mud Room
Dining Room
Foyer
Pwdr
Mud Room
Dining Room
Foyer
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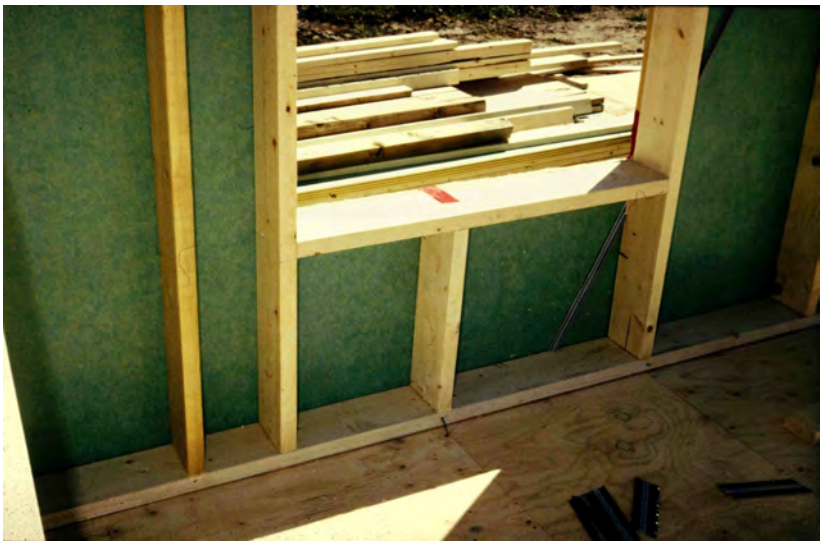

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Benefits

Reduced Framing Material Use

Lower Construction Costs

Reduced Number of Framing Members

Reduces Labor Costs and Increases Speed

Increased R-Value

Lower Operating Costs

Improved Energy Performance

Reduces Emissions from Space Conditioning

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Benefits

Case Study – Residential House – Material

Standard Framing

	8'Studs	Board Feet
Exterior Wall	467	1634
Exterior Plate	95	331
Interior Wall	715	2502
Interior Plate	126	446
Header		273
Total	1403	5186

Advanced Framing

	8'Studs	Board Feet
Exterior Wall	238	1312
Exterior Plate	63	347
Interior Wall	279	977
Interior Plate	85	298
Header		148
Total	665	3082

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Benefits

Speed of Construction

- Usually Takes 5 Houses to Gain Familiarity
- Fewer Pieces of Lumber to Handle
- Fewer Holes to Drill
- Less Framing to Work Around
- Larger Areas to Work

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Benefits

Fewer Pieces of Lumber to Handle

- Less to Load
- Less to Unload
- Less to Move
- Less to Fasten

Primarily Helps Framers

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Benefits

Fewer Holes to Drill

Less Framing to Work Around

Larger Areas to Work

HVAC Installer !

Electrician !

Plumber !

Drywaller !

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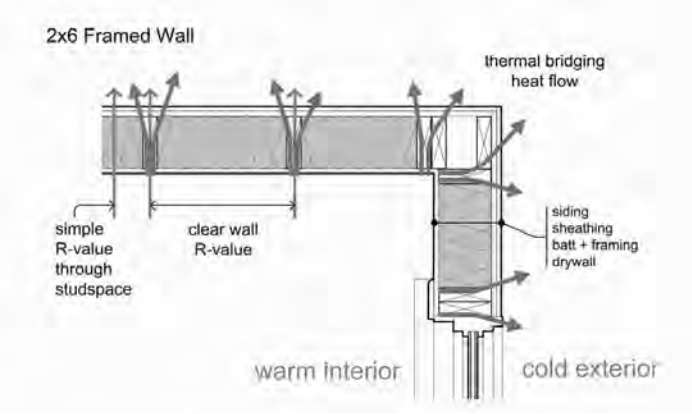
Benefits

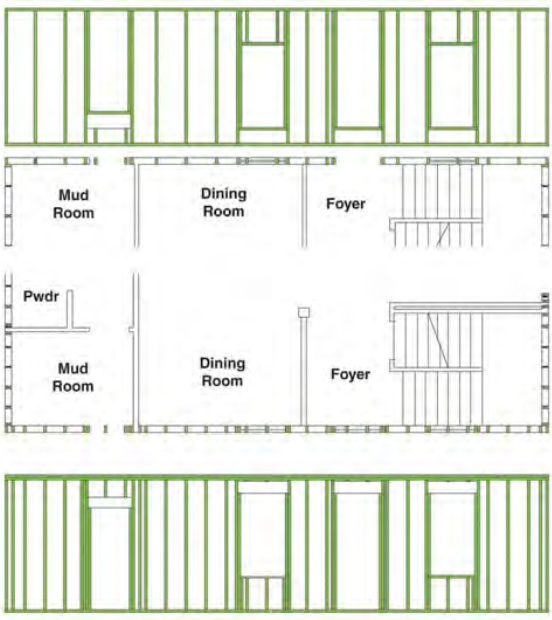
The Truth about R-VALUE

Wood is More Conductive than Insulation



Less Framing Means Higher Overall R-Value!

24



Wall 1 (2x6 24"o.c.)

Plate	36'-0"	2
Stud	8'-0"	20
Jack	7'-9 1/4"	6
Jack 2	6'-8 1/2"	2
Cripple 2	1'-2 3/4"	2
Cripple 3	2'-1"	3

Gross wall area	327 ft²
Window area	74 ft²
Opaque area	45.17 ft²
Cavity area	207.83 ft²

Wall 1 (2x6 16"o.c.)

Plate	36'-0"	3
Stud	8'-8 1/2"	29
Jack	7'-8 1/2"	6
Jack 2	6'-8 1/2"	2
Cripple 1	0'-2 3/4"	6
Cripple 2	1'-2 3/4"	2
Cripple 3	2'-1"	8

Gross wall area	327 ft²
Window area	74 ft²
Opaque area	65.60 ft²
Cavity area	181.40 ft²

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Benefits

Case Study – Residential House 1 – Energy

- 2,800 ft^2
- Slab on grade
- 2-story, detached single family house
- R-13 Walls (2x4 Construction)
- R-38 Ceiling
- 90% AFUE Furnace
- 14 SEER Air Conditioner
- BSC Building America target enclosure airtightness
  (0.25 CFM/ft^2)

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Benefits

Case Study – Residential House 1

	Annual Energy Savings (%)	One Time Construction Material Costs
Exterior 2x4 Framing at 16" OC	0.0%	$0
Exterior 2x6 Framing at 16" OC	9.2%	$1,177
Exterior 2x6 Framing at 24" OC w/2 Stud Corner	1.7%	$143
Exterior Single Top Plate	0.9%	$54
Exterior Opening Framing (Sills, Kings, Jacks)	0.2%	$89
Exterior Single Headers with Insulation	0.9%	-$27
Interior Stud Spacing at 16" OC	0.0%	$0
Interior Stud Spacing at 24" OC	0.0%	-$238
Interior Single Top Plate	0.0%	-$83
Interior Opening Framing	0.0%	-$31
Floor Joist Spacing at 16" OC	0.0%	$0
Floor Joist Spacing at 24" OC	0.2%	$0
Roof Rafter Spacing at 16" OC	0.0%	$0
Roof Rafter Spacing at 24" OC	0.0%	$0
Total Energy Savings	13.0%	

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Implementation

BSC Houses Built with Advanced Framing

Climate Zone	Number of Homes
2	679
3	417
4	7
5	10
Grand Total	1113

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Implementation

Typical Implementation Steps

Optimally the architect and designer would start fresh and design with Advanced Framing

1. 2 x 6 frame at 24” centers
2. Single king studs
3. Single jack studs
4. Removal of non-load bearing headers
5. Stack framing (align all joists, studs and rafters)
6. Single top plates (where possible)
7. Exterior insulation for a more than 25% increase in R-value

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Implementation

Common Issues Found

1) Construction

2) Management

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Implementation - Construction

Concern

Tile cracking on floors with 24" o.c. joists

Resolution

This issue is primarily found on main floors

Increase Joist Size

Additional Blocking

Decrease Spans

Decrease Spacing (main floor does not NEED to be stack framed)

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Implementation - Construction

Concern

Second floor joist depths for large clear spans

16" o.c. 2x8 lumber increased to

engineered lumber for 24" o.c construction

Resolution

Check interference with stair runs with new rise

Additional Blocking

Decrease Clear Spans

Re-orient Joists in an Alternate Direction

Decrease Spacing (may require double top plates on some main floor walls)

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Implementation - Construction

Concern

Reduced interior area vs Claimed interior area

Resolution

Claimed floor area does not change

Other Items that may need to change:

- **Countertops**
- **Cabinets**
- **Bath and Shower areas**

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Implementation - Construction

Concern

Picture Hanging and Decorating with studs at 24" o.c.

Resolution

Drywall anchors available to support up to 75 lbs.

Additional blocking can be provided in required areas

- **Above Fireplaces**
- **Logical Television Locations**
- **Behind Cabinets etc.**

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Implementation - Construction

Concern

Inadequate Drywall Support

Resolution

Generally a perceived issue

Manufacturers have provisions for ½" drywall

Increased drywall thickness if necessary

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Implementation - Construction

Concern

Hurricane, Tornado and Seismic Requirements

Resolution

Additional Sheathing

Increased Thickness of Sheathing

Variety of Shear Panels available

Consult your Structural Engineer

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Implementation - Construction

Concern

Building windows and doors on 24" units

Resolution

Provides an optimal solution

Maximizes savings in material and energy efficiency

Not a necessary step for Advanced Framing

Architects and Designers may prefer other spacings

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Implementation - Management

Concern

Code Compliance

Resolution

Within the IRC the following are permitted:

24" On Centre Framing

Single Top Plates

24" On Centre Interior Partitions

No Headers in Non-Load-Bearing Walls

Interior and Exterior Wall Covering on 24" On Centre

Drywall Clips

Single Headers

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Implementation - Management

Concern

Customer Knowledge and Information

Resolution

Advanced Framed homes are completely code compliant

Builder may choose to inform the homeowner about the benefits of AF

The homeowner does not need to be informed of the change

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Implementation - Management

Concern

Sales and Marketing

Resolution

Training will be necessary to inform the Sales and Marketing staff

Once trained, staff will be able to properly answer home buyer questions and concerns

Sales tools and documentation can be developed to help inform the homebuyer of the benefits of advanced framing.

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Implementation - Management

Concern

Builder in-house process and direction

Resolution

Top-down buy-in from management is the key component

Management direction ensures necessary changes are made

41

Implementation - Management

Concern

Does Advanced Framing Save Construction Costs?

Resolution

Case study of material use showed $100 per house savings

Building Science Corporation experience with David Weekley Homes nationwide has shown cumulative savings of $1000 per house

Increased Rate of Construction

Waste Reductions

Improved Process

Design simplifications for multiple trades

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Implementation - Management

Concern

Does Advanced Framing Save Energy?

Resolution

Case study of energy use showed 13% space conditioning energy sav

Additional exterior insulation improves savings further

Additional air sealing details improve savings further

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Implementation - Management

Concern

Do all of the features need to be used?

Resolution

Not every step of advanced framing is required

Each additional step for exterior walls improves energy savings and construction cost reductions

Advanced framed interior partitions save construction costs

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Implementation - Management

Concern

Can Advanced Framing be used at the Community Scale?

Resolution

Building Science Corporation has been involved in the construction of over 1000 homes, both prototype and large scale production homes

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Implementation

Construction Methods

Construction Photographs

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Reduce Unnecessary Thermal Bridging

Where 4 is Good

47

Reduce Unnecessary Thermal Bridging

Where 5 is Better

48

Reduce Unnecessary Thermal Bridging

10 Has to Be Just GREAT!

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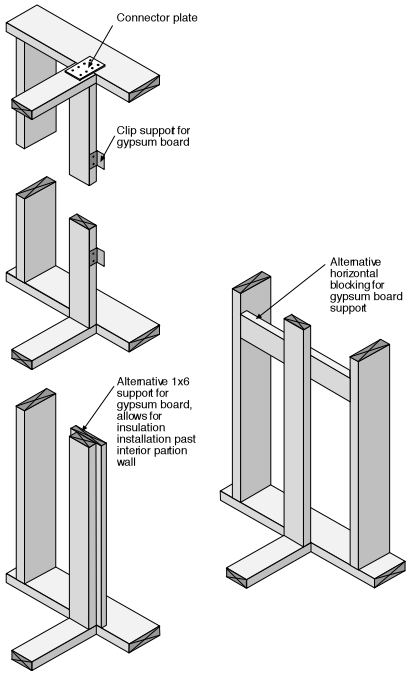

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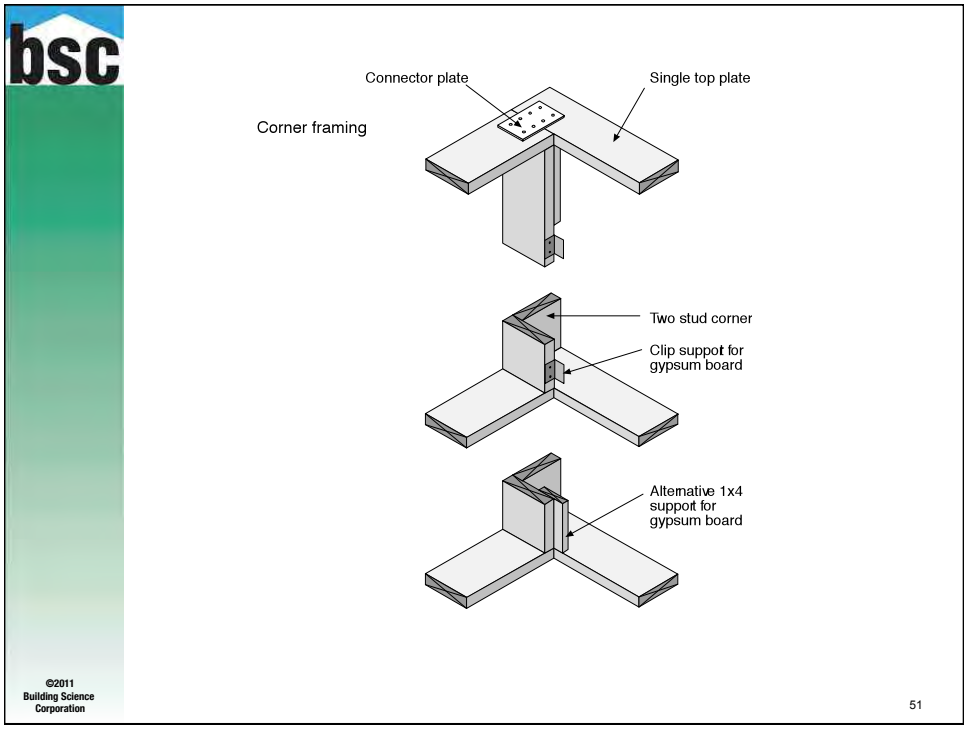
Connector plate
Single top plate
Corner framing
Two stud corner
Clip support for gypsum board
Alternative 1x4 support for gypsum board
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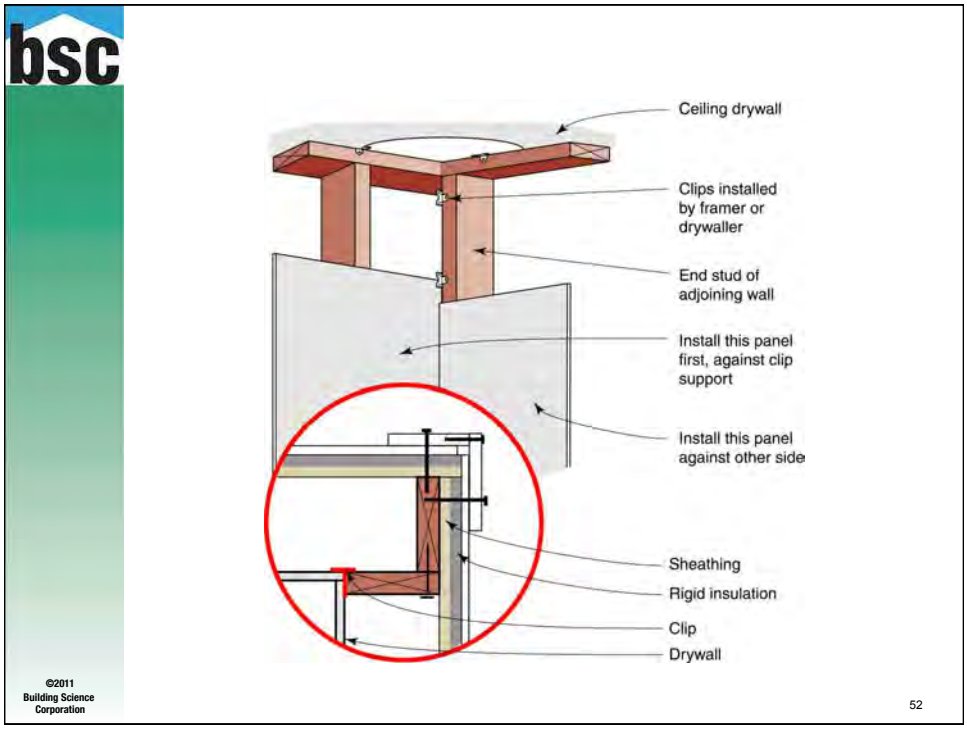
Ceiling drywall
Clips installed by framer or drywaller
End stud of adjoining wall
Install this panel first, against clip support
Install this panel against other side
Sheathing
Rigid insulation
Clip
Drywall
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Two-Stud Corner with Tie-Downs

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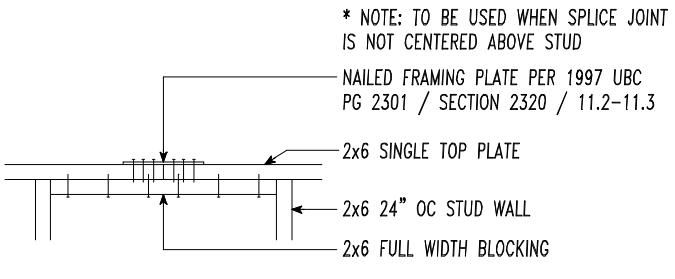

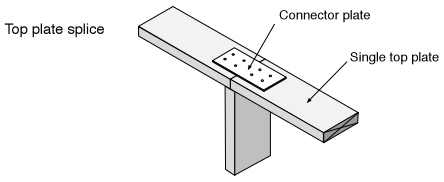

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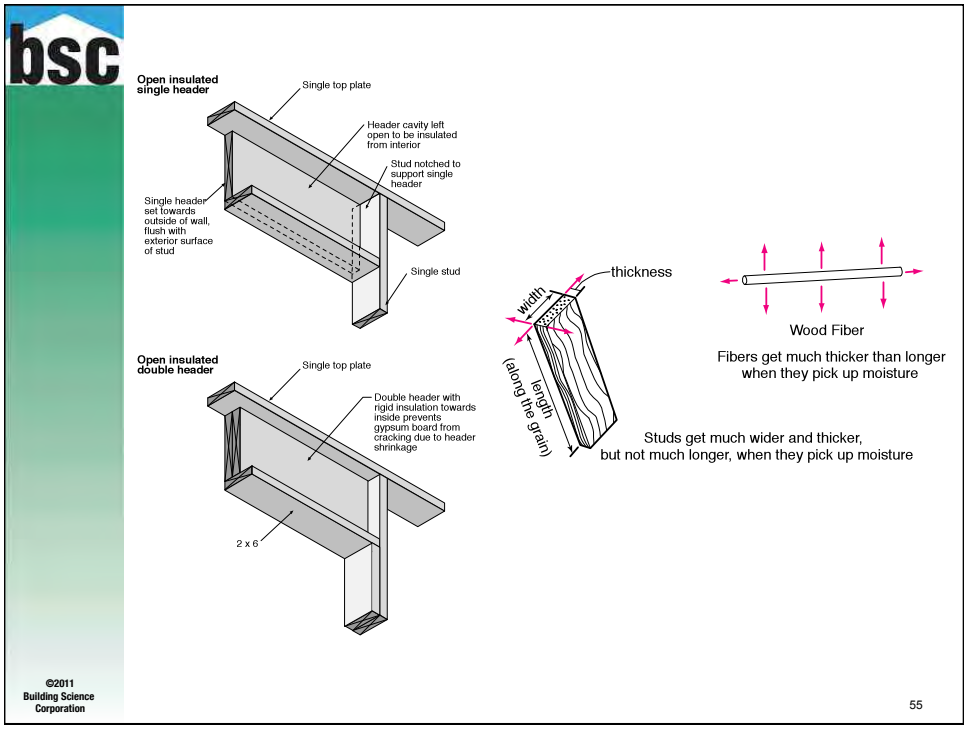
Open insulated single header
Single top plate
Header cavity left open to be insulated from interior
Stud notched to support single header
Single header set towards outside of wall, flush with exterior surface of stud
Single stud
Open insulated double header
Single top plate
Double header with rigid insulation towards inside prevents gypsum board from cracking due to header shrinkage
2 x 6
thickness
width
length (along the grain)
Studs get much wider and thicker, but not much longer, when they pick up moisture
Wood Fiber
Fibers get much thicker than longer when they pick up moisture
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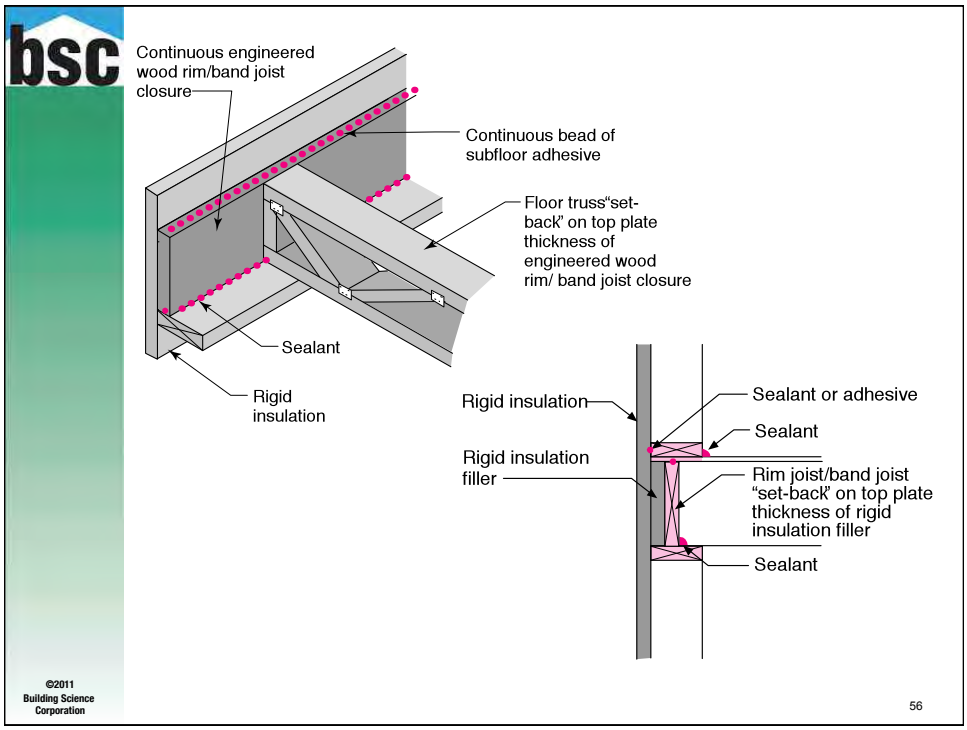
Continuous engineered wood rim/band joist closure
Continuous bead of subfloor adhesive
Floor truss"set-back" on top plate thickness of engineered wood rim/ band joist closure
Sealant
Rigid insulation
Rigid insulation
Rigid insulation filler
Sealant or adhesive
Sealant
Rim joist/band joist "set-back" on top plate thickness of rigid insulation filler
Sealant
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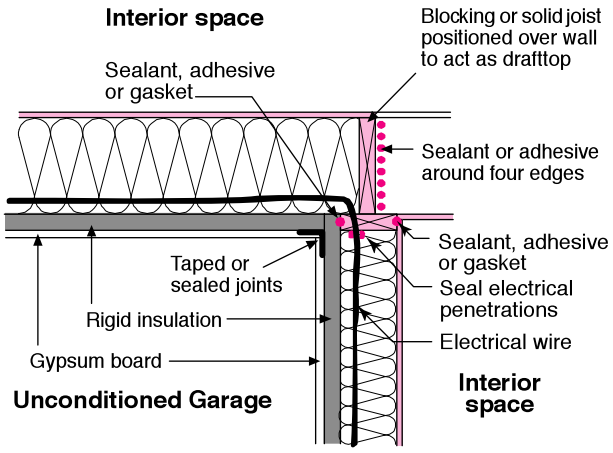
Floor Over Unconditioned Garage



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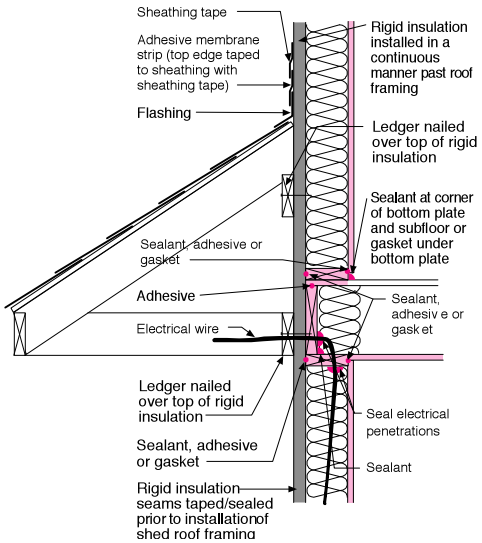
Shed Roof at Exterior Wall



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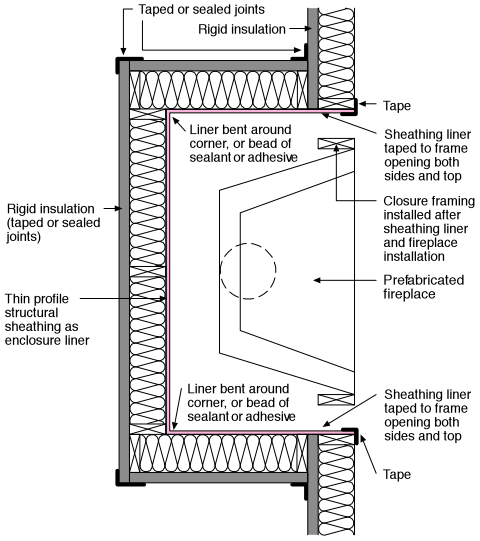
Air Barrier Continuity At Fireplace



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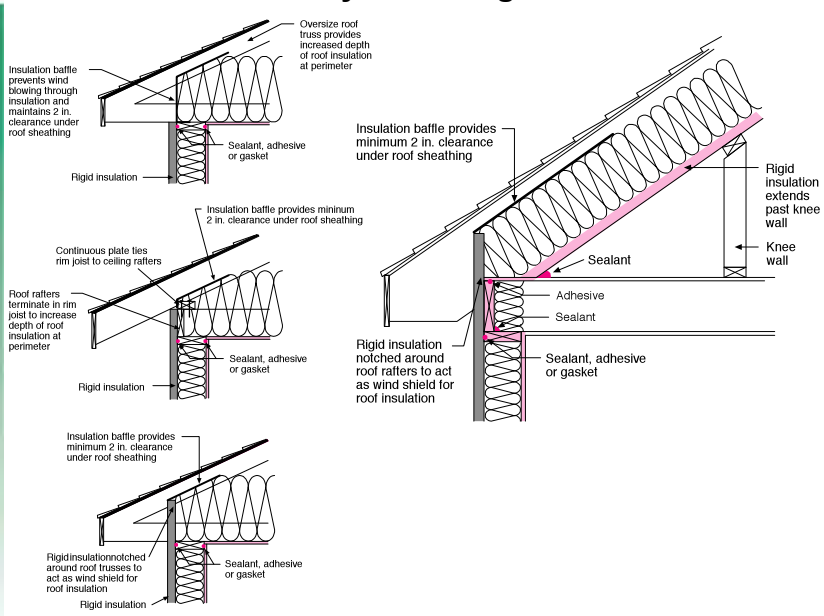
Air Barrier Continuity At Ceiling



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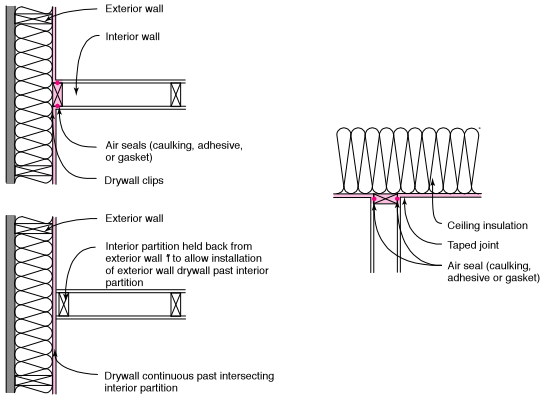
Air Sealing Interior Partitions



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Air Sealing Electrical

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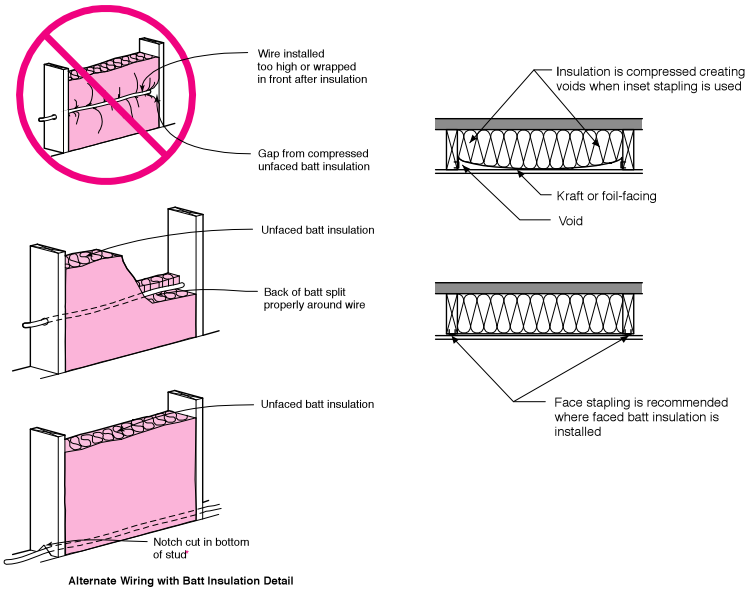
Properly Insulating



Alternate Wiring with Batt Insulation Detail

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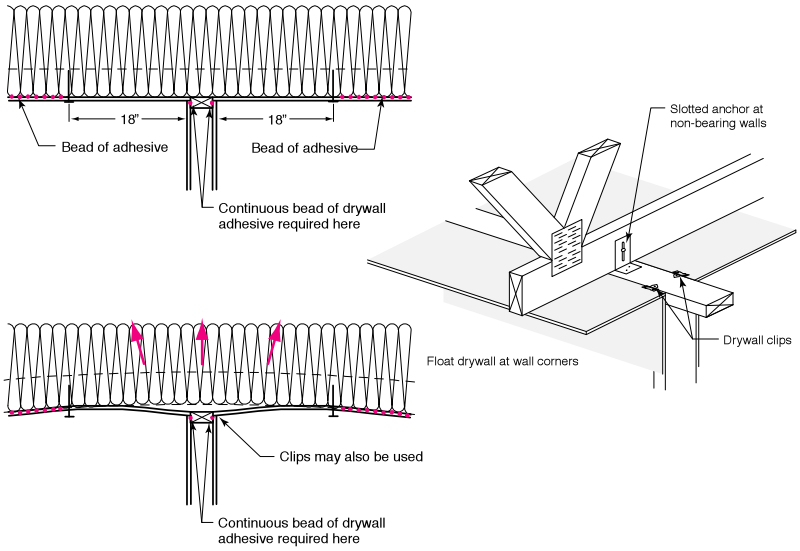
Truss Uplift and Floating Corners



65

Truss Uplift and Floating Corners

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Truss Uplift and Floating Corners

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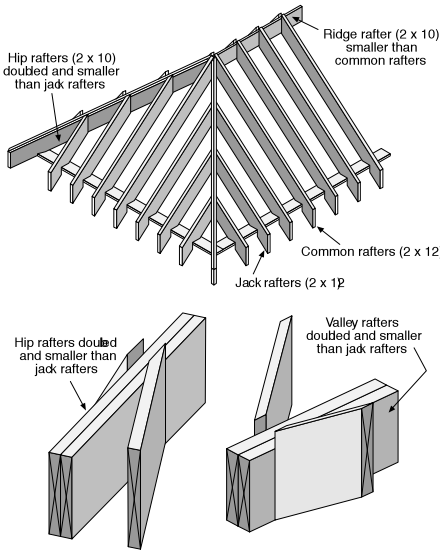
Framing Vented Hip Roof



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Framing Vented Hip Roof

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Shear Panels with Exterior Insulating Sheathing

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Shear Panel

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Shear Strapping with Exterior Insulating Sheathing

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Shear Strapping with Exterior Insulating Sheathing

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Ladder Blocking and Extra Blocking

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Non-Load-Bearing and Load-Bearing

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Advanced Framing and Spray Foam

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Advanced Framing and Cellulose

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Advanced Framing and Cellulose

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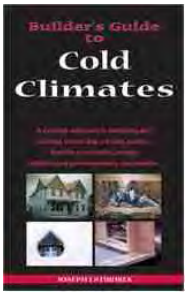
Resources

- **Builder's Guide to Cold Climates**



- **Information Sheet 201**
  Common Advanced Framing Details
- **Building Science Insights 030**
  Advanced Framing
- **Special Research Report 1004**
  Advanced Framing Deployment

find all of this at:

www.buildingscience.com

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Advanced Framing and The Building Code

- SINGLE TOP PLATE
- IRC 2000 AND 2003, IN SECTION R602.3.2 TOP PLATE
- EXCEPTION: A SINGLE TOP PLATE MAY BE INSTALLED IN STUD WALLS, PROVIDED THAT THE PLATE IS ADEQUATELY TIED AT JOINTS, CORNERS, AND INTERSECTING WALLS BY A MINIMUM 3-INCH-BY-6-INCH BY 0.036 INCH-THICK (76 MM BY 152 MM BY 0.914 MM) GALVANIZED STEEL PLATE THAT IS NAILED TO EACH WALL OR SEGMENT OF WALL BY SIX 8D NAILS ON EACH SIDE, PROVIDED THAT THE RAFTERS OR JOISTS ARE CENTERED OVER THE STUDS WITH A TOLERANCE OF NO MORE THAN 1 INCH (25.4 MM). THE TOP PLATE MAY BE OMITTED OVER LINTELS THAT ARE ADEQUATELY TIED TO ADJACENT WALL SECTIONS WITH STEEL PLATES OR EQUIVALENT AS PREVIOUSLY DESCRIBED.
- IRC 2000 AND 2003, IN FIGURE 602.3(2)
- THE FIGURE LABEL STATES "SINGLE OR DOUBLE TOP PLATE."
- IRC 2000 AND 2003, IN SECTION R602.5
- INTERIOR, NONBEARING WALLS SHALL BE PERMITTED TO BE CONSTRUCTED WITH 2-INCH-BY-3-INCH (51 MM BY 76 MM) STUDS SPACED 24 INCHES (610 MM) ON CENTER OR, WHEN NOT PART OF A BRACED WALL LINE, 2-INCH-BY-4-INCH (51 MM BY 102 MM) FLAT STUDS SPACED AT 16 INCHES (406 MM) ON CENTER. INTERIOR, NONBEARING WALLS SHALL BE CAPPED WITH AT LEAST A SINGLE TOP PLATE. INTERIOR, NONBEARING WALLS SHALL BE FIREBLOCKED IN ACCORDANCE WITH SECTION R602.8.
- IRC TABLE R602.3(1)
- FOR TOP OR SOLE PLATE TO STUD (END NAIL), TWO 16D FASTENERS ARE REQUIRED.
-
- NO HEADERS IN NON-LOAD-BEARING WALLS
- IRC 2000 AND 2003, SECTION R602.7.2
- NONBEARING WALLS. LOAD-BEARING HEADERS ARE NOT REQUIRED IN INTERIOR OR EXTERIOR NONBEARING WALLS. A SINGLE, FLAT 2-INCH-BY-4-INCH (51 MM BY 102 MM) MEMBER MAY BE USED AS A HEADER IN INTERIOR OR EXTERIOR NONBEARING WALLS FOR OPENINGS UP TO 8 FEET (2438 MM) IN WIDTH IF THE VERTICAL DISTANCE TO THE PARALLEL NAILING SURFACE ABOVE IS NOT MORE THAN 24 INCHES (610 MM). FOR SUCH NONBEARING HEADERS, NO CRIPPLES OR BLOCKING IS REQUIRED ABOVE THE HEADER.
- IRC 2000 AND 2003 TABLE R702.3.5 MINIMUM THICKNESS AND APPLICATION OF GYPSUM BOARD
- ALLOWS THE USE OF 24-INCH-ON-CENTER FRAMING FOR FASTENING GYPSUM BOARD WITH EITHER FASTENERS OR ADHESIVE 1/2 INCH THICKNESS OR GREATER.
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- IRC 2000 AND 2003 SECTION R703 EXTERIOR COVERING
- STRUCTURAL SHEATHING AND SIDING REQUIREMENTS ARE BASED ON TABLE R703.4. NOTE THAT FOOTNOTE "A" SPECIFIES THAT THE TABLE IS BASED ON 16 INCHES ON CENTER AND THAT STUDS-SPACED-24-INCHES-ON-CENTER SIDING SHALL BE APPLIED TO SHEATHING APPROVED FOR THAT SPACING.
- IRC 2003 SECTION R602.10.2 SEISMIC DESIGN CATEGORY D2
- IN SEISMIC DESIGN CATEGORY D2, CRIPPLE WALLS SHALL BE BRACED IN ACCORDANCE WITH TABLE R602.10.1.
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- DRYWALL CLIPS
- IRC 2000 AND 2003, SECTION R602.3 DESIGN AND CONSTRUCTION
- EXTERIOR WALLS OF WOOD-FRAME CONSTRUCTION SHALL BE DESIGNED AND CONSTRUCTED IN ACCORDANCE WITH THE PROVISIONS OF THIS CHAPTER AND FIGURES R602.3(1) AND R602.3(2) OR IN ACCORDANCE WITH AF AND PA'S NDS. COMPONENTS OF EXTERIOR WALLS SHALL BE FASTENED IN ACCORDANCE WITH TABLE R602.3(1) THROUGH R602.3(4). [EXCERPT]
- IRC 2000 AND 2003, FIGURE R602.3(2)
- NOTE: A THIRD STUD AND/OR PARTITION INTERSECTION BACKING STUDS SHALL BE PERMITTED TO BE OMITTED THROUGH THE USE OF WOOD BACK-UP CLEATS, METAL DRYWALL CLIPS, OR OTHER APPROVED DEVICES THAT WILL SERVE AS ADEQUATE BACKING FOR THE FACING MATERIALS.
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TABLE R602.3(5)
SIZE, HEIGHT AND SPACING OF WOOD STUDS[a]

STUD SIZE (inches)	BEARING WALLS					NONBEARING WALLS	
	Laterally unsupported stud height[a] (feet)	Maximum spacing when supporting a roof-ceiling assembly or a habitable attic assembly, only (inches)	Maximum spacing when supporting one floor, plus a roof-ceiling assembly or a habitable attic assembly (inches)	Maximum spacing when supporting two floors, plus a roof-ceiling assembly or a habitable attic assembly (inches)	Maximum spacing when supporting one floor height[a] (feet)	Laterally unsupported stud height[a] (feet)	Maximum spacing (inches)
							
2 × 3[b]	—	—	—	—	—	10	16
2 × 4	10	24[c]	16[c]	—	24	14	24
3 × 4	10	24	24	16	24	14	24
2 × 5	10	24	24	—	24	16	24
2 × 6	10	24	24	16	24	20	24

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 square foot = 0.093 m².

a. Listed heights are distances between points of lateral support placed perpendicular to the plane of the wall. Increases in unsupported height are permitted where justified by analysis.

b. Shall not be used in exterior walls.

c. A habitable attic assembly supported by 2 × 4 studs is limited to a roof span of 32 feet. Where the roof span exceeds 32 feet, the wall studs shall be increased to 2 × 6 or the studs shall be designed in accordance with accepted engineering practice.

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