building science.com

Building America Special Research Project: Deployment of Advanced Framing at the Community Scale

Research Report - 1004

15 November 2010

Joseph Lstiburek and Aaron Grin

Abstract:

This report investigates the implementation of advanced framing in both production and prototype built homes built in a variety of climate regions across thes USA. This work is part of a large research project on High R-value enclosures. The current industry standard wall is being replaced by a 2×6 frame at 24 inch centers with single top plates, two-stud corners, no jack studs, no cripples and single headers (and in many cases no headers at all). The advanced framing system is cheaper because it uses 5% to 10% less board feet of lumber, and it is faster because it uses 30% fewer pieces. It saves energy because it provides a 60% deeper cavity (which allows 60% more cavity insulation) and because it reduces the framing factor. Advanced framing can save energy, greenhouse gas emissions, and money if properly implemented. Through BSC's experience we have found that builders can save $1000 per house on advanced framing. To maximize cost savings and energy savings for the homeowner, the builder financial savings are best shifted to implementing more energy saving measures.

Advanced Framing Deployment Report

History and Background

The current industry standard wall—a 2×4 frame at 16 in. (400 mm) centers with double top plates, three stud corners, jack studs, cripples and double headers— is being replaced by a 2×6 frame at 24 in. (600 mm) centers with single top plates, two-stud corners, no jack studs, no cripples and single headers (and in many cases no headers at all). The advanced framing system is cheaper because it uses 5% to 10% less lumber (board-feet), and it is faster because it uses 30% fewer pieces. It saves energy because it provides a 60% deeper cavity which allows 60% more cavity insulation and it decreases the framing factor.

The framing elements are farther apart allowing easier installation of services—everything fits more easily making the trades happier—the electrician drills fewer holes and the insulator insulates faster because there are fewer cavities, even though the cavities are wider and deeper. Everything lines up so the load paths are direct, leading to fewer but stronger connections. The lines are cleaner, so it just looks and feels better.

Some of the advanced frame technology goes back to the beginnings of framing—"in-line" framing or "stack" framing where everything lines up is not new (Figure 1). But, the real innovations came from collaboration between the U.S. Department of Housing and Urban Development (HUD) and the National Association of Home Builders Research Foundation (NAHB Research Foundation) in the 1970s. Out of a HUD initiative called Operation Breakthrough the NAHB Research Foundation delivered "optimum value engineering framing" or OVE framing. Today, this is referred to as "Advanced Framing."

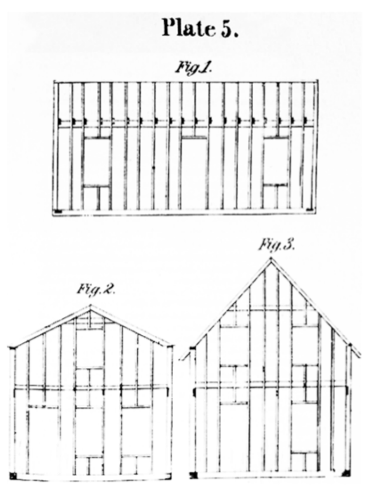

Figure 1 - In-line Framing. (Bullock, 1854)

Figure 2 shows the current expression of advanced framing. Everything lines up so that double top plates are not necessary. No headers in non load-bearing walls. Window openings are clean without jack studs and cripples. Exterior corners have two studs. Gypsum board is supported with drywall clips.

And all of this is code accepted by the model building codes because of the foresight of HUD and the NAHB. Although it's in the code, most code officials (and even fewer builders) are not aware of it.

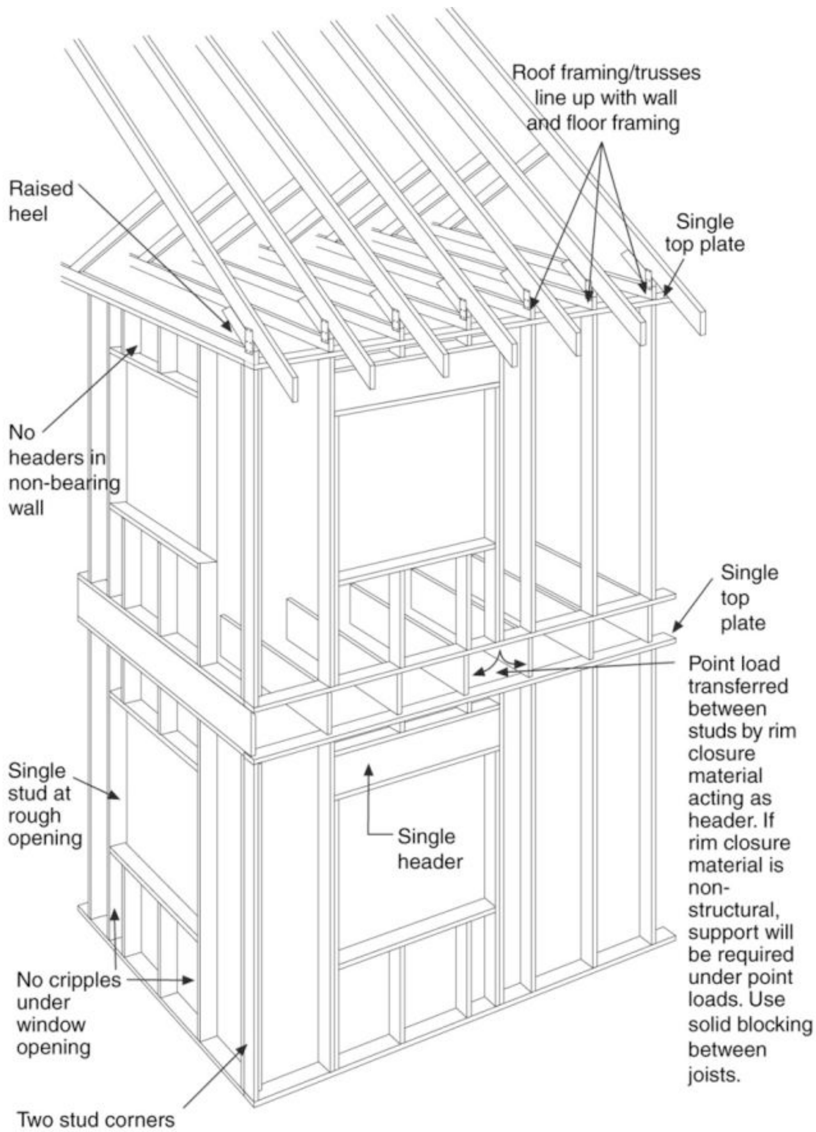

Figure 2: Advanced framing

One of the biggest pushback's from builders and code officials comes from corner support for gypsum board and trim. "Floating corners" reduce drywall cracking and, therefore, are an improvement. Wood always moves because of changing moisture contents. Gypsum board does not want to move. When you attach something that is always moving to something that does not want to move you get cracking. The key to reducing drywall cracking is to attach it less. The easiest drywall clip in the past was to cut a piece of corner bead into 2 in. (51 mm) lengths.

Single top plates seem to be the most difficult to have implemented. Not from a structural perspective or from a constructability perspective but from a perception perspective. There are two ways of making a connection: with a metal plate or with a wood splice. The approach taken is purely one based on preference by the framer.

The real change involving single top plates is that when you are framing an 8 ft (2.4 m) wall the studs have to be 1.5 in. (38 mm) longer. Standard "pre-cuts" don't work. You need 94 inches (2.39 m) not 92.5 inches (2.35 m). Load-bearing walls need headers and advanced framing typically involves using single headers with the header pushed to the exterior of the wall. This keeps the header away from the gypsum board so that boarders can't attach to it, therefore, shrinkage in the header does not result in a crack in the drywall.

The most significant change is the fact that the walls are thicker and we have to figure out what to do with the additional 4 in. (100 mm). Do we make the foundation wider? Do we lose 4 in. (102 mm) to the interior? Do we keep the foundation the same, but cantilever the walls? These are not trivial decisions. In production housing interior dimensions are a big deal and can have effects on kitchen layouts, hallways and stairs. Site setbacks must be considered as well. It typically means that the architectural drawings have to be redone. Taking existing floor plans and redrawing them is a $1,000 to $1,500 cost per plan for a production builder. This is the biggest knock against advanced framing. Of course, this is not a problem if the plans are drawn up from scratch to be advanced framed.

The floor framing is now on 24 in. (600 mm) centers, and that means the floor sheathing has to be thicker. The savings in the floor framing can help cover the cost of the thicker floor sheathing if it is required. The interior walls are also framed on 24 in. (600 mm) centers using 2×4 studs. Almost all of them are non-load bearing hence the connections are pretty much non-structural.

Things get interesting when we add insulating sheathing, although it is not part of advanced framing. Many builders that use advanced framing today also incorporate insulating sheathing. With insulating sheathing the water control layer is the exterior face of the insulating sheathing taped. Insulating sheathing provides no "racking resistance" or "shear" properties. For shear resistance OSB or plywood is required creating "braced wall panels" which are most commonly built into corners.

Techniques and Components of Advanced Framing

Advanced framing consists of a base set of framing features which allows the builder to use 5% to 10% less board feet of wood, use 30% fewer pieces of wood, creating fewer thermal bridges all while reducing costs. BSC recommends the following features:

- Exterior Walls
  - 2" x 6" Studs
  - 24" Stud Spacing
  - 2-Stud Corners
  - Single Top Plate
  - Stacked Framing
  - Single King Studs
  - Single Jack Studs
  - Non-Load Bearing Headers Removed
- Interior Partitions
  - 24" Stud Spacing
  - Single Top Plate
  - Non-Load Bearing Headers Removed
- Floor Framing

        - 24" Spacing
- Roof Framing
        - 24" Spacing

The following figures are photographs from a variety of homes that have implemented advanced framing measures. These details are also documented the drawings provided in Appendix 1.

Figure 2 - Exterior Walls 2" x 6" Studs 24" Stud Spacing

Figure 3 - Exterior Walls 2-Stud Corners

Figure 4 - Exterior Walls Single Top Plate and Stacked Framing

Figure 5 - Exterior Walls Single King Studs without Jack Studs

Figure 6 - Exterior Walls Non-Load Bearing Headers Removed

BSC Advanced Framing Deployment Research

Building Science Corporation incorporates advanced framing in a large number of its Building America homes. Prototype and single homes have been built for decades using advanced framing. It used to be less common to have entire communities built employing advanced framing techniques. David Weekley Homes (DWH) has taken the lessons learned from early prototypes and have fully embraced advanced framing. DWH is in the process of trials and adoption of advanced framing company-wide, in all divisions, in all climate regions proving advanced framing can be deployed on a large scale. The Raleigh, NC division of DWH is in the process of completing the transition to advanced framing by updating their panelized framing plant. All homes built by the Raleigh division will be advanced framed. Similar changes are currently happening with the Houston division as well.

The following table summarizes the number of homes built in various climate regions where BSC has been involved through the Building American program to implement advanced framing.

Table 1 - Advanced Framed Homes per Climate Region up to 2010

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

Although the community builders produce the most total square feet, the prototypes also add to the overall total and provide important implementation lessons for the project.

The most common advanced framing features adopted are the 2×6 frame at 24 in. (600 mm) centers with stacked framing (where possible), single king studs, single jack studs and removal of non-load bearing headers. Exterior insulation is also commonly adopted by builders who move to advanced framing. It is not always possible to incorporate 24" spacing of the floor joists, which leads to the requirement of using double top plates in the walls because the walls and floors are now framed at different spacing. To realize the full benefits and up-front cost savings of advanced framing, the builder and designer(s) should make the decision to adopt advanced framing early in the design process. Early adoption and acceptance of the full framing package allows the designer to select framing systems (joists, trusses, beams, headers etc) that can be used at 24" O.C. and remain within the relevant building code requirements.

Energy and Cost Analysis

Advanced framing has the added benefit of reduced thermal bridging, reduced heat loss and hence energy and cost savings for the occupant. A whole house energy model was utilized to determine the energy savings from implementing advanced framing.

A home representative of the North Carolinian market was modeled in EnergyGauge. The home specifications were as follows:

- 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)

The framing factors of each assembly (wall, roof, floor) were adjusted incrementally. The energy savings of each framing change was added to Table 2. The initial adjustment to 2x6 Framing is shown as two steps, one from 2x4 at 16" OC to 2x6 at 16" OC to show the energy savings of the additional depth of insulation and another step to 2x6 at 24" OC to show the savings from reduced framing factor. This allows a comparison between each of the associate framing factor reductions and annual energy savings.

Table 2 - Energy and Construction Cost Analysis

	Annual Energy Savings (%)	One Time Construction 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%	
Total Cost		-$92

The cost associated with simply using 2x6 framing at 16" OC is not included in the total cost because this would not be done, 24" OC would be used for advanced framing. The high cost of simply switching to 2x6 framing shows that using advanced framing would be more cost effective for the builder. Increasing the stud size to 2x6 without changing the stud spacing was included to show the energy savings associated with the transition to R19 stud space insulation as a separate step from R19 stud space batt with 24" OC construction. This incidentally provided the largest energy savings of any single advanced framing measure. Using 2x6 construction in conjunction with 24" stud spacing shows nearly an 11% annual energy savings. The remaining steps in total increase this savings to 13%. Although the final steps do not account for a large portion of energy savings, they are where a large portion of the construction cost savings are found. As an example, changing the interior stud spacing to 24" on centre saves approximately $240 per house in material cost for this model, but does not affect the energy use of the house. In total, switching to a complete advanced framing package shows an annual energy savings of 13% for the homeowner and a cost savings of approximately $100 for the builder in materials. Although not every step of advanced framing is required, to achieve the most benefit in terms of both energy and construction cost savings, all steps are recommended.

The costs discussed are only those of material costs. Due to the decrease in the number of pieces of material used, eventually labor costs would also decrease. Once all trades are involved each trades cost could decrease as a result of the simplified construction. It has been observed that the cost of the labor does not decrease until the trades have built approximately 5 homes. This seems to be the learning threshold that once 5 homes have been built, working with advanced framing becomes easier for the trades.

Advanced framing has the opportunity to reduce the workload for many trades, not just the framers. This list includes almost every trade associated with the construction of a house - the insulators, drywallers, plumbers, electricians and HVAC installers. Plumbers and electricians have less studs to drill through, HVAC contractors have more space to work, framers have less lumber to handle and insulators have less bays to fill.

There are many cost trade-offs associated to upgrading to advanced framing. For instance increasing the spacing from 16" to 24" of floor joists requires that the floor sheathing be thicker. In BSC's experience this increase in sheathing thickness has an associated cost that roughly matches the cost savings in reducing the board feet of floor joists required. Due to code requirements, some locations also require different sheathing for the exterior shear panels in walls if 24" stud spacing is used. Again, the associated cost increase of additional, rearranged or thicker sheathing is taken away from the savings associated with fewer board feet of exterior wall studs. Interior partitions can be framed at 24"

O.C. and with single top and bottom plates can have a net positive material and cost savings. In certain circumstances, as with the David Weekley Homes Charleston division, a cost savings associated with insulating to R-19 over R-14 was found. The R-19 fiberglass insulation package actually cost less than the R-14 insulation package. Upgrading only the exterior walls to 24" O.C. is a step in the correct direction, but likely will not yield significant savings. Costs reduction can also be seen in from waste savings. The largest savings can be seen if all features of the advanced framing package are utilized. BSC's past experience shows that a builder can save $1,000 per home by implementing advanced framing.

Advanced framing has the possibility to be a cost shifting advantage. As a single measure, the energy savings are relatively low, but the upfront cost savings can be relatively high for the builder. The savings from advanced framing can be used to fund other efficiency options, increasing energy efficiency even further. The cost shifting creates a home that costs the same, but is significantly more energy efficient.

Constructability

Although framing at 24" OC is not new, there are still hurdles to overcome for it to be implemented nationally and several of these were dealt with in BSC's recent research work.

There are issues getting stucco installed over 7/16" OSB on advanced framing, this is not a code compliance or structural issue, it is a matter of completing testing to prove that it is possible. Recently another advanced framing hurdle was overcome in Baltimore code hearings. The code for allowing the use of single headers passed the committee stage. Many other perceived issues are in fact code compliant and it is simply a matter of providing the information to your code official or contractor. Appendix A contains a summary of the compliance of advanced framing to the IRC of 2000 and 2003. Currently 24" 2x6" stud spacing, single top plates, removal of headers in non-load bearing walls and drywall clips are all code approved with specified application stipulations.

Table 3 contains a set of construction concerns and associated resolutions that have been developed for common questions associated with the transition to advanced framing at the community scale.

Table 3 – Construction Concerns and Resolutions

Concern	Resolution
Tile cracking due to floor joist span increased to 24"	This issue is primarily found on main floors. The main floor framing can be either increased in vertical dimension adding to stiffness, decreased in span, or left at 16" on centre. This will not affect the stacked framing as the main floor framing rests on the concrete or block foundation and is fully supported. This problem is rare for the second floor as there are not many tiled locations on the second floor. Where it is an issue additional blocking or support can be added, or the spacing can be left at 16" to accommodate for that area. The wall supporting that floor is usually modified to match the floor joist spacing or employ a second top plate.
Increased joist height on second floor for 20' clear spans.	In order to meet the structural and flexural requirements of the second floor, the joists may need to increase in height ex. - from 12" dimensional lumber to 16" engineered lumber. This can cause issues in determining stair heights and overall rise/run of the current stair plans. If the current stairs do not have enough run to accommodate the rise, additional decisions must be made or plans may need to be altered.
Interior area plans and changes due to loss of interior space	Claimed square footages of the homes are dictated by the exterior dimensions, so the claimed areas will not change, although countertops, closets and other areas designed to fit prefabricated products such as shower stalls and bathtubs must be verified in the plans before construction.
Picture Hanging and Decoration with 24" OC Framing	Although there is a perceived difficulty in hanging photographs or mirrors on studs if the studs are 24" on centre, there are solutions that can be built into the home if attachment to wood substrate is necessary. Many items are not required to be attached to a wood substrate as there are various hanging options that will support more than 75 lbs. If it is known that a wood substrate may be required in a certain area (above a fireplace, where a flat screen TV is rough-in wired) additional blocking or studs can be provided in these areas.
Drywall Support	It is commonly discussed that drywall will have reduced rigidity if it is installed over studs at 24" on centre. If this is a concern thicker drywall may be used if necessary at usually a nominal cost upgrade to the builder. Drywall manufacturers typically have provisions in their installation documents for attachment to 24" on centre studs.
Hurricane and Tornado Areas	Additional structural sheathing, or an increased thickness of sheathing, may be required in these areas. A structural engineer will be able to provide guidance in these areas.
Shifting of Windows and Partitions to accommodate 24" centres	Although optimal, this is not a necessary step. It would decrease material use and thermal bridging, but to maintain the aesthetics and design of the homes, the windows and partitions do not need to be on the 24" centres.

Management, Sales, and Accounting

Table 4 contains a set of concerns and associated resolutions that have been developed for common questions associated with the transition to advanced framing at the community scale in terms of management, sales and accounting.

Table 4 - Management Concerns and Resolutions

Code Compliance	Currently 24" 2x6" stud spacing, single top plates, removal of headers in non-load bearing walls and drywall clips are all IRC approved with specified application stipulations. Appendix A contains a summary of the compliance of advanced framing to the IRC of 2000 and 2003.
Customer knowledge and information	The houses are completely code compliant using 2x6 framing at 24" OC. The homeowner does not need to be informed that there was a change to the way the house was built. The builder may choose to inform the homeowner of the benefits of advanced framing.
Sales and Marketing	Proper, adequate and repeated training may be necessary to train sales and marketing staff to be able to answer questions about the advanced framing methods and benefits to ensure the proper message is given to the homeowner.
Builder In-House Process and Direction	Top-down buy-in from management is the key component which will make any construction change happen without major issues. For example, having the DWH VP of Operations present during planning meetings, supporting the advancements, was key in creating the direction and maintaining the attention of the division.
Does advanced framing save energy?	The analysis conducted as a part of this report finds a savings of up to 13% in annual site space conditioning energy.
Does advanced framing save construction cost?	The analysis conducted as part of this report found a one-time construction material cost savings of almost $100. Through BSC's experience total savings has been found to be closer to $1000 per house. This includes savings found in terms of increased construction speeds of various trades, waste reductions, and improved construction process due to the simplicity of advanced framing.
Do all of the features need to be done?	Although not every step of advanced framing is required, to achieve the most benefit in terms of both energy and construction cost savings, all steps are recommended.
Can advanced framing be deployed at the community scale?	David Weekley homes in partnership with Building Science Corporation and the Building America program has shown that advanced framing can be deployed at the community scale.

Conclusions and Future Research Plans

BSC will continue deployment of advanced framing wherever possible both with its Building America partners as well as private work. David Weekley Homes is to continue production in Raleigh NC panelized framing plant as well as the Houston area and this will allow BSC to gather more accurate production based cost data. David Weekley homes in partnership with Building Science Corporation and the Building America program has shown that advanced framing can be deployed at the community scale. Smaller scale implementation will continue to be completed with other BA builders in a variety of climate zones. Code compliance hurdles, in the few cases they actually exist, have been or are in the process of being overcome. As with every change in construction small difficulties may be encountered in the future and BSC will continue to work to resolve these issues as they arise. There are currently no known constraints which would prevent continued implementation of advanced framing at the community scale.

Advanced framing can save energy, greenhouse gas emissions, and money if properly implemented. Through BSC's experience we have found that builders can save up to $1000 per house by implementing the full set of advanced framing features. To maximize cost and energy savings for the homeowner, the builder's financial savings are best shifted to implementing more energy saving measures. This cost shifting creates a home that costs the same, but is significantly more energy efficient.

References

Bullock, J. “The American Cottage Builder”, Stringer and Townsend, 1854

Neuhauser, K. “David Weekley Homes Comparative Wall Framing Analysis”, Building Science Corporation, 2008

Bazeck. “Advanced Framing”, Presentation – EEBA Conference 2001

Built Green. “Advanced Framing Builds on Love of Wood”, http://www.builtgreen.org, 2007

ENERGY STAR Builder Guide, “Reduce Framing Costs with Advanced Framing Techniques”, Unknown, Unknown

Department of Energy - Technology Fact Sheet, “Advanced Wall Framing”, Office of Building Technology, State and Community Programs Energy Efficiency and Renewable Energy - Department of Energy, 2000

International Residential Code. International Code Council, Inc. Falls Church, Virginia. 2000.

International Residential Code. International Code Council, Inc. Falls Church, Virginia. 2003.

Partnership for Advancing Technology in Housing, “Advanced Framing Techniques”, www.pathnet.org, unknown

Appendix A – Code Compliance

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.

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.

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.

About this Report

This report was prepared with the cooperation of the U.S. Department of Energy's, Building America Program.

About the Authors

Joseph Lstiburek, Ph.D., P.Eng., is a principal of Building Science Corporation in Somerville, Massachusetts. Joe is an ASHRAE Fellow and an internationally recognized authority on indoor air quality, moisture, and condensation in buildings. More information about Joseph Lstiburek can be found at www.joelstiburek.com.

Aaron Grin is a building scientist and researcher with a background in structural Civil Engineering. More information about Aaron Grin can be found at www.buildingscienceconsulting.com/who/grin.aspx.

Direct all correspondence to: Building Science Corporation, 30 Forest Street, Somerville, MA 02143.

Limits of Liability and Disclaimer of Warranty: