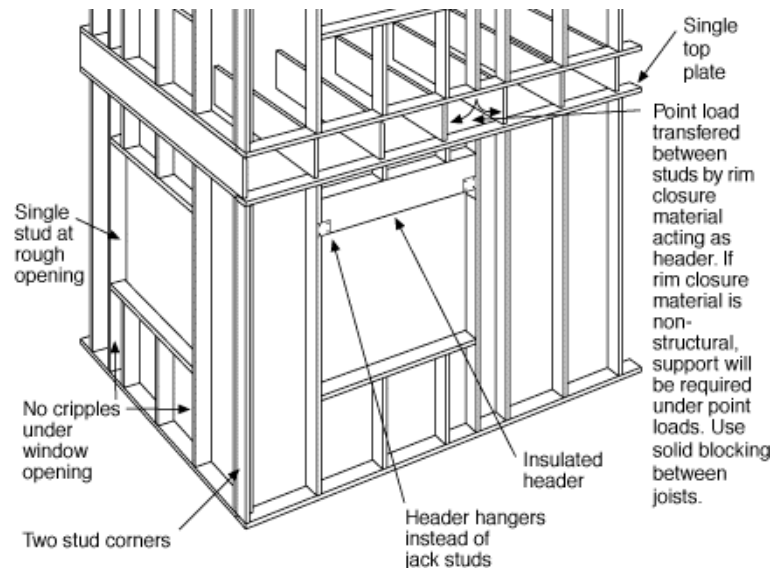


## Advanced Framing

Advanced framing, or Optimal Value Engineering (OVE), is a systems approach to the design, engineering, and construction of wood-framed structures that reduces lumber use, minimizes wood waste, and maximizes a structure's thermal efficiency. While maintaining structural integrity and meeting building codes, an advanced framing approach:

1. Considers energy efficiency when designing the structural system
2. Optimizes layout for efficient material use
3. Uses structural-rated wood materials to their full approved capacities
4. Eliminates structural materials where non-structural materials are adequate
5. Reduces the structural redundancies inherent with conventional stick framing



Advanced framing is a collection of techniques that are most effective when implemented holistically. However, advanced framing need not be “all or nothing”—many techniques can be adopted independently. In fact, for a design team new to this approach, it may be smartest to undertake just a couple of new measures per project.

### Benefits

#### Save money

For the builder, advanced framing techniques can save significant money. For every piece of unneeded lumber, builders pay three times: once to purchase, once to move around, and once to recycle or send to the landfill. From studies conducted in the 1990s, the National Association of Homebuilders (NAHB) found that advanced framing techniques generate cost savings of \$0.24 to \$1.20 per square foot, or up to \$2400 for a 2000 sq. ft. home.

In addition, many techniques simplify air sealing and reduce drywall cracking, saving on labor and call-back costs.

#### Protect the environment

Smart wood use saves trees and forests. Conventional logging practices can damage forests and the larger environment by causing erosion, eliminating habitat, reducing biodiversity, and reducing air and water quality. Much of logging is fueled by our huge demand for housing: new U.S. homes are about double the size of those built in the 60s and most of them are built with traditional wood framing techniques, accounting for 40%



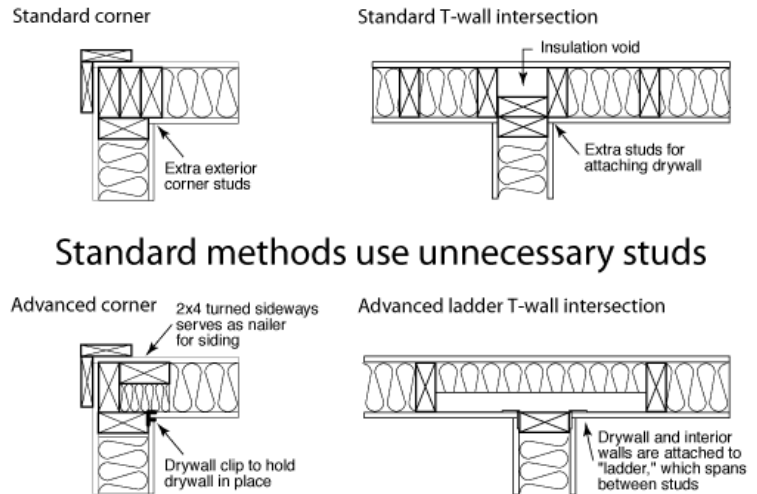
of all wood consumed in the U.S. (almost an acre's worth of wood for a 2000 sq. ft. home). Almost 20% of that wood is wasted and hauled away. The National Resources Defense Council (NRDC) estimates that efficient design and construction can reduce wood use by up to 35% in homes.

### Increase energy efficiency

Eliminating unnecessary wood framing increases thermal efficiency of the exterior envelope by allowing for more insulation to be installed. Heat moves through wood four times faster than standard insulation materials, causing thermal bridging (hot and cold spots). Conventional stick framing also leaves numerous insulation voids and makes air sealing difficult. According to the U.S. Department of Energy, advanced framing methods can improve a wall's effective R-value (resistance to heat flow) up to 30% and save 3-5% on heating and cooling costs.

Advanced framing is simply a smart, common-sense way to design and build homes. Read on to learn about specific measures and practical considerations with implementing them.

## Standard Framing Versus Advanced Framing Cross-section



### Standard methods use unnecessary studs

Comparison	Standard	Advanced
Insulation Voids	3%	0%
Framing factor	15-25%	10-15%
Batt R-value	R-13	R-13
Sheathing R-value	R-0.5 to 2.0	R-2.5
Effective Average R-value	R-11.1	R-14.6 (30% higher)

Source: U.S. Department of Energy

## General Considerations

### Misconceptions

To some people, "value engineering" equates to "cheap and low quality". Some believe that more wood must make for a better, stronger home. Or that 24 inches on center (o.c.) framing is not compatible with seismic and other structural requirements, or that 1/2" drywall will be too flimsy on 24 inches framing. However, codes ensure that implementation of advanced framing techniques still achieves structural and architectural requirements just as with conventional methods—albeit with less waste and redundancy.

- **Architects** may be apprehensive about designing on a module if they feel it limits their creativity or design options. By educating architects on the merits of this measure, they might instead view it as a challenging design parameter to embrace.
- **Engineers** might prefer structural redundancy or purposely overdesign, having seen substandard construction quality control or knowing that field changes will



occur. Some are apprehensive about relying on gravity connectors or designing with engineered wood products if they've traditionally worked with solid lumber. To demonstrate that advanced framing is not substandard but rather is an acceptable, quality approach, engineers need to be thoroughly educated on the measures. They might also be enticed by talking to other engineers experienced with these materials and techniques. Finally, the project manager must require the engineer to have adequate on-site presence to ensure structural specifications are followed in the field.

- **Builders** like to keep inspectors on their good side, and they often don't want to implement a new technique given the risk of slowing down the project. By having code references and stamped construction drawings on hand, this risk can be largely avoided.
- **Clients** may be resistant to paying added upfront costs unless they are educated on how those will generate overall cost savings and provide long-term added value to the building. Investment in additional design, engineering, and coordination are required to fully realize the benefits of advanced framing.

### Overcoming inertia

Compounding these challenges is the fact that building professionals are busy and often resistant to change. Architects might be partial to a linear process and apprehensive about a collaborative approach. Engineers might not want to change their existing approach or provide additional plans and details. Builders might prefer to work with their typical subcontractor framer rather than a new sub who is willing to be trained on new techniques. All parties will likely be unsure of how to best budget time and money for additional training, project coordination, and construction quality control.

Ultimately, not everyone will be willing to try advanced framing. It might take many phone calls and interviews to assemble a project team that is dedicated to a collaborative approach and ready to spend the extra time and effort required to come up to speed with new processes, techniques, and materials.

### Project coordination

In the typical project, the full team—owner, architect, engineer, builder, supplier, and trades—rarely meet to collaborate on the design of a home. This can result in lack of adequate space to run ductwork and plumbing, creative engineering to accommodate architectural features, misplaced blocking for finish components... the list goes on. Additional labor is thus needed to fix problems from lack of planning, and the finished product is often much more resource intensive and less energy efficient than would have been possible given an integrated approach to the design.

- While not every advanced framing measure requires **added planning and coordination**, it's preferable to integrate many measures to achieve maximum benefits. While a learning curve is inevitable, most builders report the team is up to speed after just a few jobs. To ensure the smoothest process, schedule design/pre-construction meetings to encourage collaboration, provide the opportunity for every party to have their concerns addressed, and discover potential downstream issues.
- For many measures, it's critical that **drawings be properly detailed and reviewed** by all affected parties. To reduce the likelihood of trades needing to alter or move structural members due to unforeseen space conflicts, the designer



should provide locations and details for ducts, plumbing, vents, and wiring on the drawings. The engineer or designer should detail non-standard connections and show *every framing and blocking member* on both plans and elevations. This will make it much more likely the techniques will be applied in the field and also simplify lumber take-offs and improve their accuracy, optimizing wood use and reducing waste even more.

### Building codes

Some advanced framing practices involve layout, details, or coordination that is independent of structural requirements. Other techniques are alternatives to standard practices and are expressly allowed and specified in the prescriptive requirements for "Conventional Light Frame Construction" in the 2007 California Building Code (CBC), which is based on the 2006 International Building Code (IBC). Finally, some practices require engineering of members or systems that might otherwise have been addressed prescriptively.

Providing adequate calculations and documentation will help to gain building officials' support and approval of any unfamiliar practices. Code references are included in the following detailed discussions of advanced framing measures.

## Design & Layout

### 19.2 inch and 24 inch on center framing

California builders are accustomed to framing all walls on 16 inch centers, but this is often overkill as shown in the CBC's Conventional Framing provisions for bearing walls:

Stud Size	Maximum stud spacing for laterally unsupported studs not exceeding 10 feet in height		
	Supporting roof & ceiling only	Supporting one floor, roof & ceiling	Supporting two floors, roof & ceiling
2x4	24	16	Not permitted
3x4	24	24	16
2x5	24	24	Not permitted
2x6	24	24	16

*Adapted from CBC Table 2308.9.1*

2x4 studs not more than 10 feet in height are allowed to be spaced at 24 inches for top-level bearing walls (ie, carrying as much as the roof and ceiling). 2x4 studs can also be spaced at 24 inches for walls supporting one floor only. Where 2x4 studs at 16 inches are required, 2x6 studs at 24 inches are always acceptable (ie for walls supporting one floor, roof and ceiling). Depending on window and door placement, this substitution may not substantially reduce volume of lumber used but will significantly improve energy efficiency by reducing thermal bridging and providing more depth for insulation.

When the framing system is engineered, spacing can often be widened to 19.2 inches (1/5 of an 8' sheet). Per CBC 2308.9.2.3, interior non-bearing walls and partitions can be framed with flat studs (long dimension parallel to wall) up to 28 inches o.c. For very high wind loads or tall walls, stud size and spacing will need to be engineered; 2x6 or engineered studs (eg LSL) are often the optimal solution.



In general, use the smallest stud with largest spacing possible based on the code or engineer's calculations. Related considerations:

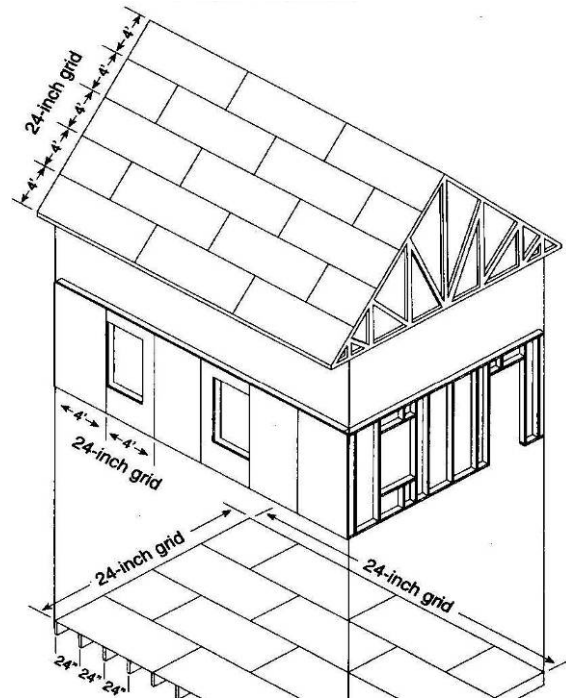
- 2x6 walls will require extension jambs if drywall returns are not used
- Exterior cladding and interior finish materials must be specified to span the added dimension without undesirable deflection
- Though ½ inch drywall on 24 inch framing is acceptable to most homebuyers, if there are concerns with deflection or waviness use 5/8 inch drywall or higher-grade (and straighter) lumber, or place studs to ensure any bowed edges are in line
- Some batt insulation products are not available for 19.2 inch spaced framing, which will require changing the brand or type of insulation for exterior walls

For added economy, combine this strategy with modular layout and in-line framing as discussed below.

### Modular layout

Laying out a building on a two foot module maximizes the efficiency of 24 inch framing and 4x8 sheet goods. It can significantly reduce not only the amount of materials that need to be purchased, but also associated labor and waste. Implement these measures to maximize economy:

- Set the building dimension for the direction parallel to the roof and floor framing to be evenly divisible by four feet
- Set the building dimension for the direction perpendicular to the roof and floor framing to be evenly divisible by two feet
- Alter the roof pitch and overhang widths to achieve a two foot module (factor in space for ridge vent if applicable)
- Keep plans simple; minimize odd dimensions and small offsets in the plans
- Size and place door and window openings per the module
- Provide framing elevations to guide the framing crew



Since many standard architectural dimensions and components—such as hallway widths and bathtub sizes—are not modular, it's impractical to optimize for all situations. Prioritize exterior structural dimensions to maximize use of framing and sheathing materials.

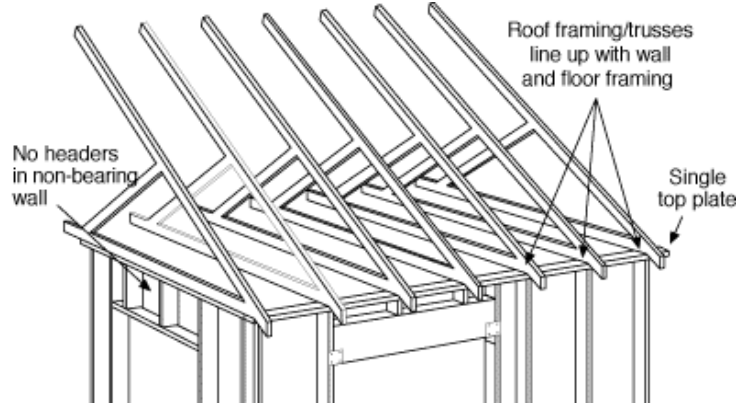
### In-line framing

By using the same spacing for studs, floor joists, and roof framing, structural members can be vertically aligned. Stacked framing provides better overall structural integrity since gravity loads bear directly on members below. And in many cases in-line framing allows



for a single top plate, eliminating at least 30 studs worth of lumber for a two-story 2000 sq. ft. home.

For bearing and exterior walls, top plates cap and connect wall segments, facilitate connections of diaphragms and finish materials, transfer gravity loads from framing above to adjacent studs, and collect wind and earthquake loads for distribution to shear panels. While double top plates are standard practice, single top plates are allowed per conventional framing provisions (CBC 2308.9.2.1) provided they are adequately tied at joints, corners, and intersecting walls. Minimum 19 gauge 3x6 galvanized steel plates are required, and rafters, joists, and trusses must bear over studs within one inch of center.



Single top plates are not always compatible when designing in high wind or seismic zones, as engineers often rely on double top plates to drag shear forces or provide adequate connection for trusses. Also, this measure might inspire questions from building officials.

Since floor joists must align with the roof and wall framing, they will likely be designed for 19.2 or 24 inch spacing as opposed to more common 16 inch floor framing. To account for the wider spacing, the joists might need to be made deeper, and the subfloor and finishes must be specified to span the added dimension without undesirable deflection.

Related considerations:

- Bracing may be needed to steady erected walls until lateral support is provided by the floor or roof above
- Requires longer studs, which could cause jobsite confusion
- Single top plates can be time-consuming to splice

### **Zone framing**

For best value and performance, and to maintain the ideal of using structural-rated materials to their full approved capacities, use both conventional lumber and the stronger engineered products depending on structural requirements or architectural needs. For example, use engineered studs on very tall walls and engineered headers for longer spans. For areas where potential wood shrinkage or warping could be particularly problematic, such as where tiling or hanging cabinets, consider engineered products to provide a flat, stable, true surface.

## **Systems & Materials**

### **Engineered wood products**

Structural engineered wood products are composites made with smaller wood pieces (veneers, chips, particles, strands, etc) and adhesives. They are generally made with smaller, younger trees and can utilize small parts that would otherwise be unusable,



reducing demand on older trees. Finished products are engineered to precise specifications and are straighter, stiffer, and stronger than their solid wood counterparts. They can allow for members of a smaller cross section, providing more space for insulation—and longer floor framing spans, possibly eliminating the need for mid-span supports. They can eliminate construction waste from unusable solid lumber and reduce hours of added labor from having to deal with bowed or twisted wood.



Direct the engineer to design all or portions of the framing system with I-joists and other engineered products such as glued laminated timber (glulam), laminated veneer lumber (LVL), laminated strand lumber (LSL), parallel strand lumber (PSL), finger-jointed studs, and oriented strand board (OSB). Manufacturers provide code-approved evaluation reports and load tables to facilitate proper specification and installation. Engineered lumber has long been accepted by building officials and should not cause concern. It is covered in CBC 104.11 - Alternative Materials.

## Trusses

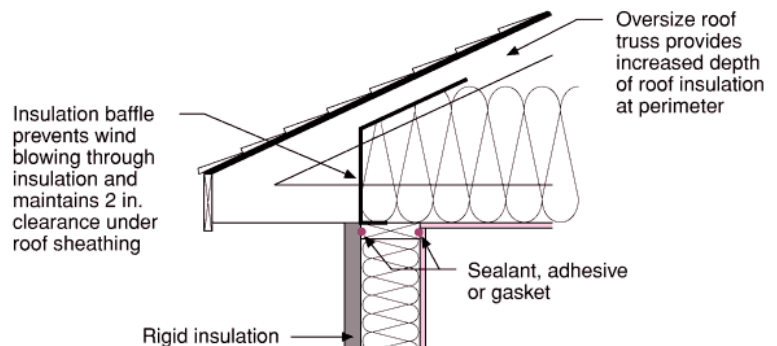
Trusses make efficient use of materials by assembling members into triangular forms, enabling gravity forces to be carried primarily by tension and compression rather than bending components. Trusses are substantially lighter than structurally comparable solid beams, and trussed roofs are generally much less expensive than stick-built roofs. Trusses can also be used to frame floors, and they facilitate installation of ductwork, wiring, and other components.

Pitched roof trusses taper towards each end, so there is generally not adequate height to provide full-depth insulation near where trusses bear on exterior walls. This perimeter band of shallow insulation covers a significant percentage of the attic and can significantly compromise energy efficiency. In cold climates, this can also cause ice dams and associated leakage and shingle damage.

To ensure integrity of the insulation envelope, request energy heels (raised heels) or oversized trusses from the truss manufacturer to increase the height of the trusses at exterior walls. Specify to allow for at least 75% of the average insulation depth to be provided. Also, to ensure that ductwork is installed within the conditioned space, coordinate with the HVAC designer to specify trusses with a raised center section to accommodate ductwork. Trusses are typically inexpensive, and these features usually have nominal cost impacts.



*Raised heel roof trusses*



Related considerations:

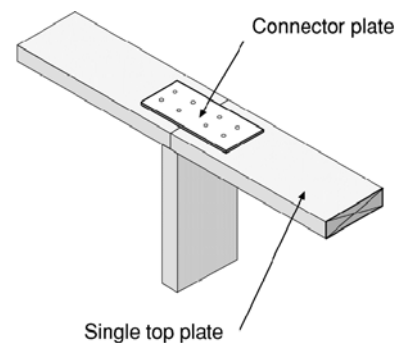
- Raises height of roof peak, which may not be compatible with local zoning regulations
- Requires additional exterior sheathing and finish materials
- May require additional engineering and labor to prevent truss rolling and ensure proper load transfer from the roof, especially in high wind or seismic zones

## Framing Techniques

### Single top plate at interior non-bearing walls

Per CBC 2308.9.2.3, any non-bearing wall or partition can be built with a single top plate. The plate must be continually tied at joints with solid blocking or metal ties. In a typical home, the equivalent of 30 studs is likely to be saved.

Bracing may be needed to steady erected walls until lateral support is provided by the floor or roof above. If this measure is used along with standard double top plates for bearing and exterior walls, two lengths of stud will be required on the job and require careful coordination.



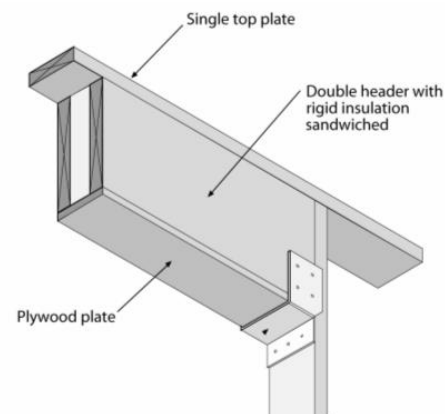
### Headers sized for load

It is not uncommon to find massive 4x12 headers over every opening, no matter the span or whether the wall is actually carrying load. This makes it easy on the framers since they only have to work with one header size and do not have to install cripples for headers that are 12 inches deep. Also, oversized members can accommodate point loads or other structural elements that fall unexpectedly over an opening due to field changes or lack of coordination. Unfortunately, lumber of this size is very resource-intensive and displaces insulation.

CBC 2304.3.2 states that "Headers, double joists, trusses or other approved assemblies that are of adequate size to transfer loads to the vertical members shall be provided over window and door openings in load-bearing walls and partitions." Instead of specifying a single header that accommodates the worst-case condition, require the engineer to design each header (preferably with engineered lumber) and develop a header schedule with at least three different sizes that are practical to implement. Specifying too many variations will likely cause mistakes in the field.

The engineer must also clearly designate which openings do not require headers. While not installing headers where they're not required might seem like common sense, out in the field it's not always obvious to framers which walls are non-load bearing. Ensure that drawings clearly indicate which walls are bearing and which are not.

Another equal or better option is to build a standard size insulated box (or sandwich) header for all conditions, which ensures energy efficiency but avoids challenges of framing with various size





headers. Box headers are lighter than solid wood headers, provide much better insulation, reduce drywall cracking since they shrink less than solid wood, and provide a nailing surface on both faces. They can make use of otherwise wasted wood and insulation scrap and be assembled efficiently when made all at once. They are typically constructed with rigid insulation sandwiched between 2x or engineered lumber faces, and OSB or plywood plates on the top and bottom.

Related considerations:

- Training of framing crew may be required
- Careful reading of plans, construction quality control, and tight coordination around field changes are essential
- Might require different size cripples over headers
- Per the code, all openings over 8 feet in non-bearing walls require headers

### Header hangers

Headers are typically supported by vertical members called jack studs. However, when framing anchors (header hangers) are adequate to carry the load, jack studs can be eliminated. Anchors must be attached to a full-height wall stud and to the header. They are generally adequate for spans up to three feet, or when replacing a single jack stud at each end.

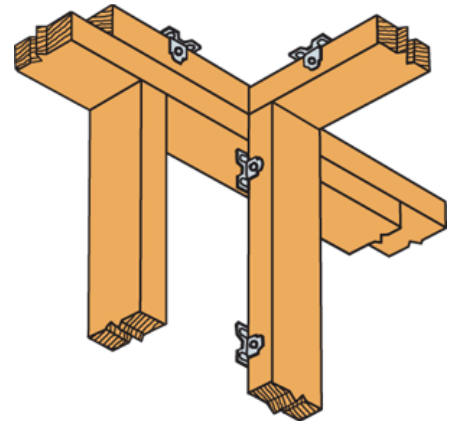
In summary, ensure that jack studs are installed only when required to carry loads or provide nailing surfaces for finishes.

### Open wall corners

Typical wall intersections are constructed with three or even four studs to accommodate attachment of finish materials. But this wastes structural materials where non-structural materials are usually adequate, reduces space for insulation, makes voids that are often left uninsulated, and contributes to nail pops and drywall cracking.



Instead, use a two-stud detail with non-structural backing to support the drywall as allowed per CBC 2308.9.2. Backing can be wood, specified sheathing or panel materials, and “other approved devices”.



In structural zones, materials such as additional studs, holddown posts, sheathing, blocking, and connectors are independent of this measure and must be installed as specified. However, eliminating studs in many areas will be independent of the structural design and thus relevant to this measure.

Metal or plastic drywall clips can be used to replace the third stud at a corner, backing studs at T-intersections, and nailers in a ceiling. Instead of drywall being rigidly attached to wood, which itself shrinks and expands with temperature and moisture changes, clips allow for small movements in drywall and can greatly reduce drywall cracking, nail pops, and contractor call-backs. Eliminating studs also makes for easier—and better—insulating.



The savings in studs, blocking, and labor can offer significant savings. Drywall clips themselves are very inexpensive: a typical 2000 sq. ft. home will require 300 to 400 clips if used in walls and ceilings and cost as little as \$100 for some products.

Related considerations:

- Drywall clips at ceilings don't provide nailing for crown molding
- Most subs have not used drywall clips and will require education and training
- Clear communication between framers and drywall subs is required to coordinate installation of clips

Products include:

- The Nailer, [www.thenailer.com](http://www.thenailer.com)

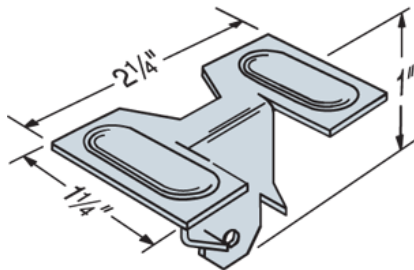


*100% recycled HDPE plastic or galvanized steel*

- Prest-on Corner-backs, [www.prest-on.com](http://www.prest-on.com)



- Simpson DS (Drywall Stop), [www.strongtie.com](http://www.strongtie.com)





## Green Building Guidelines References

This strategy may align with specific measures, points, or credits in various Green Building Guidelines and Rating Systems:

### **New Home Construction Green Building Guidelines (Build It Green)**

- A3 – Recycle Job Site Construction Waste
- D1 – Apply Optimal Value Engineering
- D2 – Use Engineered Lumber
- D6 – Design Energy Heels on Trusses
- D7 – Design Roof Trusses to Accommodate Ductwork

### **Home Remodeling Green Building Guidelines (Build It Green)**

- A3 – Recycle Construction and Demolition Waste
- D1 – Apply Optimal Value Engineering
- D2 – Use Engineered Lumber
- D6 – Design Energy Heels on Roof Trusses

### **Multifamily Green Building Guidelines (Build It Green)**

- B1 – Construction and Demolition Waste Management
- B2 – Construction Material Efficiencies
- C4 – Engineered Lumber or Steel Studs, Joists, Headers and Beams
- C5 – Optimal Value Engineering Framing
- C8 – Raised Heel Roof Trusses

### **LEED-H Rating System (U.S. Green Building Council)**

- ID1 – Integrated Project Planning
- MR1 – Material-Efficient Framing

### **LEED-NC Rating System (U.S. Green Building Council)**

- EA Prereq 2 – Minimum Energy Performance
- EA Credit 1 – Optimize Energy Performance
- MR Credit 2 – Construction Waste Management

**To learn more** about these Green Building Guidelines & Rating Systems, visit:

[www.builditgreen.org/guidelines-rating-systems](http://www.builditgreen.org/guidelines-rating-systems)



## Resources

**Building Science Corporation** – experts in whole-systems design. Wealth of resources including [Using Wood Efficiently: From Optimizing Design to Minimizing the Dumpster](#), a *must-read* 31-page research report:

- [www.buildingscience.com/documents/reports](http://www.buildingscience.com/documents/reports)

and publishers of the [Builder's Guides](#), essential printed manuals for designers, engineers, and builders. Select "Mixed-Humid Climates" for most of California. Also available from Amazon and local bookstores:

- [www.buildingsciencepress.com/store](http://www.buildingsciencepress.com/store)

**Natural Resources Defense Council (NRDC)** – publishes the detailed [Efficient Wood Use in Residential Construction](#) online or printed handbook:

- [www.nrdc.org/cities/building/rwoodus.asp](http://www.nrdc.org/cities/building/rwoodus.asp)

**ToolBase Services** – NAHB Research Center portal offering design & construction guides, best practices, performance reports, case studies, and more:

- [www.toolbase.org](http://www.toolbase.org)

For current **product, manufacturer, and supplier information**, search the Green Product Directory: [www.builditgreen.org/products](http://www.builditgreen.org/products).

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