



MULTI-YEAR ADVANCED RESIDENTIAL BUILDING SYSTEMS RESEARCH

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**Revisions to Quality Management
Products: Four Scopes of Work for High
Performance Homes**

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High Performance Scopes of Work Package Mixed-Humid Climate

INTRODUCTION

Scopes of Work

A Scope of Work is a description of the work that a trade contractor will perform for a builder. Every contract, including those executed with only a handshake, incorporates a Scope of Work, even if only implied. After all, if a builder did not need a task accomplished and did not describe that task to the trade contractor; there would be no basis for initiating an agreement. However, without a clear, detailed, written agreement between the builder and trade contractor, both parties can have significantly different expectations of the work.

Yet despite the problems caused by vague scopes of work, many documents in use today meet only the minimal legal and production requirements for the day-to-day new home construction operation. In addition, many builders and trade contractors often view revising scopes of work as more trouble than it is worth. However, the cost of the status quo can be high. Small mistakes that must be found and corrected before progressing to the next trade cause inefficiency, expensive delays, and increased cycle time. Other mistakes, if left undiscovered, can be concealed in a closed assembly and create long-term consequences, which are often insidious and very costly.

High Performance Homes

High performance homes, according to the U.S. Department of Energy's Builders Challenge, are those that "deliver comfort, quality, durability, and a healthy indoor environment consistent with the Department of Energy's Building America performance criteria." Years of research and practice by the Building America program and the construction industry at large have led to the establishment of best practices for the production of high-performance homes.

However, it is challenging for builders to convey the non-standard construction details that are critical to building high-performance homes. It is even more difficult to relate how the trade contractor—who is typically responsible only for his trade without concern for the others—and his work fits into the construction of a house that functions as a system. When building high-performance homes, unambiguous design and construction details, as well as information regarding the interconnectedness of the trade contractors, become crucial to ensuring the home's superior performance.

High Performance Scopes of Work

High Performance Scopes of Work include unique requirements for design, specification, installation, and inspection and testing that, together, facilitate the construction of high performance homes. These scopes highlight the interconnectedness of each trade contractor's work and encourage trade contractors to consider their work as part of a systematic process to build a home that exceeds minimum requirements.

High Performance Scopes of Work differ from conventional scopes of work in that they include:

- Industry-recommended best practices for design and specification based on the best available research,
- Builders Challenge Quality Criteria,
- Coordination and integration between trade contractors, and between contractors and the designers or engineers, when required, and
- Performance testing whenever possible, tied to successful job completion.

High Performance Scopes of Work—Applicability

This document introduces four sample High Performance Scopes of Work for builders and trade contractors wishing to build high performance homes. Although the High Performance Scopes of Work contained herein are limited to four areas of the building process in the Mixed-Humid climate (as shown in Figure 1 and Figure 2), the intention is to, over time, expand the scopes to encompass other climate regions and other trade contractor responsibilities. For now, when applying the sample High Performance Scopes of Work to other climate regions, details must be adjusted to reflect best practices for the climate.

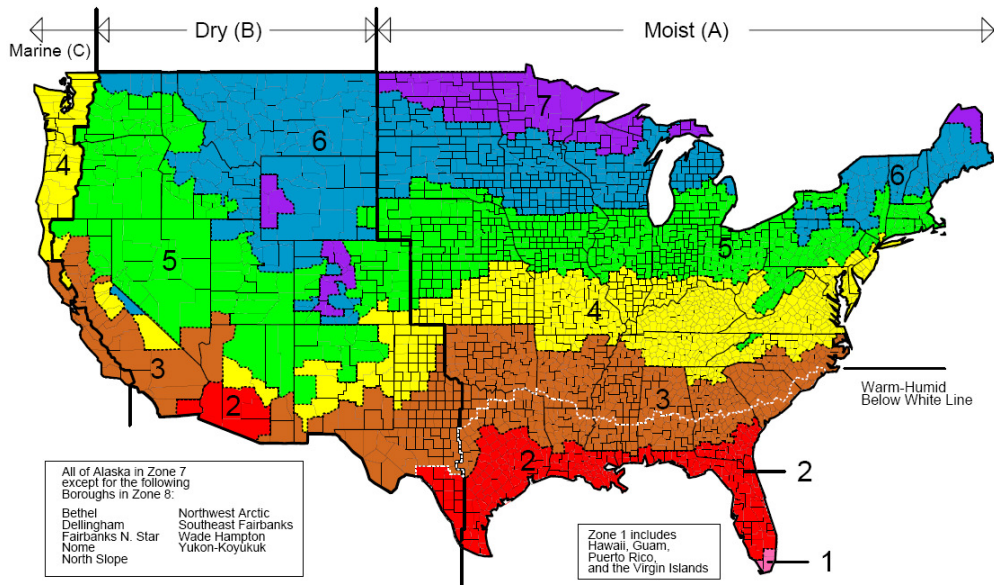



Figure 1. Climate Zone Map of North America, Courtesy of the U.S. Department of Energy



Mixed-Humid

A mixed-humid climate has moderate conditions much of the time. However, weather conditions similar to those found in neighboring climate zones are also frequent. Homes in the mixed-humid climate are faced with a substantial heating season with monthly average outdoor temperatures dropping below 45°F. Summers in the mixed-humid climate can have high humidity.

http://www1.eere.energy.gov/buildings/residential/printable_versions/mixed_humid.html

Figure 2. Mixed-Humid Climate

These High Performance Scopes of Work do not replace builder and trade contractor code requirements, OSHA Safety Requirements, or any local, state, or national codes or laws. Implementing High Performance Scopes of Work does not guarantee compliance with any legal requirements associated with any part of the construction process. The sample High Performance Scopes of Work assume relatively moderate or standard engineering conditions only. Where extreme soil conditions, high wind, or seismic loads exist, the user should consult a professional engineer. Although the 2006 International Residential Code and the 2006 International Energy Conservation Code were referenced during the development of these sample scopes, local building code requirements should always be reviewed in conjunction with the implementation of any scope of work.

These High Performance Scopes of Work are intended to assist builders and trade contractors to build high performance homes efficiently and cost-effectively. They may be adopted and used in whole by a builder or trade contractor. These scopes may also be customized according to geographic region, construction methods, company size and culture, or other unique company characteristics.

High Performance Scopes of Work—Organization

The High Performance Scopes of Work consist of five sections with each intended primarily for use by office or field personnel. Field and office documents are separated in order to succinctly provide instructional information to installers without including the legal and contractual elements necessary for the office. However, it is extremely important for both field and office personnel to be aware of the provisions contained in all the documents.

The five sections of each High Performance Scope of Work and the personnel to which the section most directly applies are outlined in Table 1 and described in detail below.

Table 1: Sections of a High Performance Scope of Work

Section	Office	Field
Design and Specification Prerequisites	X	
Job Ready Checklist		X
Detailed Job Requirements and Tolerances		X
Addendum to the Trade Contractor Agreement	X	
Job Complete Checklist		X

Design and Specification Prerequisites (Office)

The Design and Specification Prerequisites section includes all design work as well as material and equipment specifications that must be documented before trade contractor installation work can begin. Typically, design and specification work is completed by designers, architects, and/or engineers rather than by field installers. Often, it is necessary to include information from this phase in construction documents so that the trade contractor can correctly install high performance measures.

Note: High performance design and specifications are based on best practices developed under the Building America program. For more information about best practices for the Mixed-Humid climate, refer to Building America Best Practices Series Volume 4: Mixed Humid Climate, available from www.nrel.gov/docs/fy05osti/38448.pdf. For list of climate zones by U.S. county, see www.eere.energy.gov/buildings/building_america/pdfs/ba_climate_regions2_column_rev_03.pdf.

Job Ready Checklist (Field)¹

The Job Ready Checklist, to be completed jointly by the site supervisor and trade contractor, includes all items that must be installed or prepared on the jobsite by other trade contractors before work can begin. Although items in the Job Ready Checklist are not directly under the trade contractor's control, they directly affect the trade contractor's ability to successfully and efficiently carry out the work.

The Job Ready Checklist is an essential part of a High Performance Scope of Work because it highlights the ways in which one trade contractor's work is connected to another's and, thus, encourages trade contractors to think of their individual work as part of a larger whole.

The Job Ready Checklist creates accountability for trades since each trade contractor's finished product is reviewed with the builder and by the next trade in preparation for the next phase of work. At this point, incomplete or missing work can be identified and corrected before the next phase starts. The Job Ready Checklist provides a method for ensuring that the work of previous trades is completed to the satisfaction of the builder so that the jobsite is ready for the subsequent trade contractor.

Detailed Job Requirements and Tolerances (Field)

Detailed Job Requirements and Tolerances set builder-specific standards for safety, jobsite cleanliness, subcontractor coordination, and completion benchmarks. This section may also include performance tolerances that must be met. This section is used to augment architectural drawings and to standardize material specifications and installation instructions. The Detailed Job Requirements and Tolerances section highlights critical elements that must be implemented in the field in order to achieve a high performance product. Industry-recommended best practices, coordination between trades, recommended tolerances, and ranges of acceptable performance test results, where applicable, are included. This document also includes diagrams and photos of correct installation techniques for clarity. Builders are urged to use the high performance strategies contained in this document as a starting point and to enhance the document with the input of their trade partners.

Addendum to the Trade Contractor Agreement (Office)

The Addendum to the Trade Contractor Agreement is intended for the office and contains the legal, contractual, and business-related aspects of the agreement between the builder and the trade contractor. Elements typically included are:

¹ It may be preferable for the Trade Contractor to develop the Job Ready Checklist in order that there is consistency within his/her company. However, the Builder should review the Job Ready Checklist to ensure that it captures the critical elements of his Scopes of Work Packages and his work flow.

- Insurance requirements
- Payment conditions
- Change order procedures
- Schedule conditions
- Penalty clauses
- Re-work and/or damage clauses

The Addendum is not addressed in this set of documents because it is typically specific to a company's business management structure, legal concerns, local practice, and market conditions. A builder will usually have this type of document already in place; if not, it should be developed by the builder in consultation with an attorney.

Job Complete Checklist²

The Job Complete Checklist provides the mechanism by which the trade contractor certifies that work has been completed and the builder and trade contractor agree that the work meets the expectations set forth in the Detailed Job Requirements and Tolerances. To verify that the high performance features of the home were constructed correctly according to the Scope of Work, performance testing is often part of a Job Complete Checklist.

The Job Complete Checklist holds both the builder and the trade contractor responsible for proper implementation and appropriate inspection of the high performance Scope of Work. Properly defined and implemented the Job Complete Checklist functions as:

- Part of the Job Ready Checklist for subsequent trade contractors, and
- A field authorization of payment for the completed work.

Since the Builders Challenge Quality Criteria from the DOE Building America Program have been incorporated into these Job Complete Checklists, a builder may also use the checklists to verify that the Builders Challenge criteria relevant to each trade contractor have been completed by each trade partner. Builders Challenge items are indicated throughout the individual scopes of work by gray shading on those items.

High Performance Scopes of Work— Implementation Notes

As a general practice, anytime Scopes of Work are updated or created, it is essential to have participation, review, and feedback from all affected parties, including builder's staff, trade partners, and suppliers to avoid unanticipated problems. Trade partners and suppliers, especially, are essential to the process because they are usually directly and indirectly impacted by changes. Even if a trade contractor or supplier is not directly affected by the scope, they may be indirectly impacted by a change in the construction process. Often, these indirect impacts can be difficult to predict and can affect trade partners, suppliers, or the builder in ways are rarely foreseen, except by the affected company.

² It may be preferable for the trade contractor to develop the Job Complete Checklist to provide consistency within the company. However, the builder should review the Job Complete Checklist to ensure that it captures the critical elements of his Detailed Job Requirements and Tolerances document.

Note on Implementation: A company will most efficiently and effectively implement high performance practices when it has a business management system in place that assures connection between all phases of design, construction, sales, and warranty; provides the necessary training to consistently perform the work correctly; and verifies proper installation and performance at every stage. A company must also have a process in place to identify and correct the cause of problems in order to prevent them in the future – not simply a punch list that marks the defect after the fact. Therefore, these documents are best suited for incorporation into a documented quality management program that stresses continuous improvement.

As materials change and construction techniques evolve, Scopes of Work must be regularly reviewed and revised in order to remain current. All builders are urged to review and revise their Scopes of Work into useful working documents that are not merely appendices to a standard trade contract.

High Performance Scopes of Work—Development

The High Performance Scopes of Work are based on best practices developed under the Building America program.³ The Scopes of Work developed and included in this package include: Excavation and Backfill for Basement Foundations, Poured Concrete Foundations, Framing, and HVAC.

There were two distinct steps in developing the High Performance Scopes of Work. The first step was to develop the content using industry resources and experts, which resulted in a final draft version of four sample High Performance Scopes of Work. More specifically, this process included:

- Review existing scopes of work from high performance builders, industry standards, and Building America best practices
- Compare content and format typically used by builders for existing scopes of work
- Design a template for the Building America High Performance Scopes of Work
- Develop rough drafts of High Performance Scopes of Work
- Identify and locate graphics and pictures to supplement the Scopes of Work
- Review of the draft Scopes of Work by industry experts and professionals including builders and Building America teams
- Develop final draft Scopes of Work, incorporating feedback of industry professionals as appropriate

The second step in developing the content of the scopes was to have builders and trade contractors review the final draft High Performance Scopes of Work and provide feedback regarding their usefulness in the field. In addition, this step incorporated the Builders Challenge into the Scopes of Work. The result was the final High Performance Scopes of Work. This step included the following items:

- Review final draft Scopes of Work by high performance builders and trade partners to determine usability

³ Building America Best Practices Series Volume 4: Mixed Humid Climate, www.nrel.gov/docs/fy05osti/38448.pdf.

- Review internally and edit to include feedback from the builders and trade contractors
- Incorporate Builders Challenge Quality Criteria into the final High Performance Scopes of Work

Resources

When seeking information about best practices, Building America program information was supplemented with residential construction performance guidelines⁴ and by consulting experts in the trades addressed by this effort.⁵ In addition to consulting leading industry resources, multiple existing High Performance Scopes of Work used by high performance builders were reviewed. The Builders Challenge Quality Criteria from the Building America Program was also incorporated. The final draft High Performance Scopes of Work were then drafted by the Research Center and reviewed by Building America Teams⁶.

Rough Draft Feedback from Industry Professionals and Building America Teams

Once the final draft scopes were complete, Building America teams and other industry professionals provided review. Most of the feedback from these reviewers was very positive. Some reviewers expressed concern that the High Performance Scopes of Work did not have the look and feel that industry professionals expect of Scopes of Work. For example, the High Performance Scopes of Work include Job Ready and Job Complete inspection checklists, which are not included in most builders' scopes. Some also felt that the High Performance Scopes of Work were too detailed; that they included information that could be found in other places, such as on the plans or architectural drawings.

Though it was clear that the level of detail and amount and type of content is greater than that which is typically found in scopes, the Research Center felt that it was important that High Performance Scopes of Work include an expanded level of detail and content. The details were seen as critical to the performance of the finished product. Also, provided that builders are able to download and modify the documents, it is easier to omit items that are not applicable than it is to add detail. Using the information from the initial review by Building America teams and industry experts, the Research Center finalized the scopes of work into a final draft version.

Review of Final Drafts by High Performance Builders and Trade Contractors

After the initial creation and internal review, the scopes were reviewed externally by builders and trade contractors to determine how to make the scopes effective and useful in the field. The validity of this approach was confirmed by the very positive feedback from the builders and trade partners who reviewed the final draft versions. Builders and trade contractors were given the following questions as a guideline for their review:

- Are the scopes useful for the builder or trade partner?
- Are there any parts of these scopes that are especially useful, such as illustrations or checklists?

⁴ NAHB, *Residential Construction Performance Guidelines 3rd Edition*.

⁵ See *Acknowledgements*.

⁶ NAHB Research Center, Building Science Corporation, and IBACOS staff and consultants reviewed these Scopes of Work for accuracy, applicability, and usability for high performance builders

- How do these scopes compare with the builders' current scopes?
- Are they too complex, sufficiently detailed, or are there any items that should be added or changed?
- Would a builder use these Scopes of Work as is, or just as a reference to revise their current scopes?
- Is the Introduction adequate to prepare the reader for how to use and apply the "model" Scope of Work?
- Other general comments or suggestions.

Two builders, Ideal Homes of Norman, Oklahoma, and a builder in Madison, Wisconsin, reviewed the High Performance Scopes of Work. They were selected because of each firm's production capacity of about 500 homes per year combined with each company's design flexibility gave them the dual perspective of production and custom builders. Furthermore, both builders have been recognized for their commitment and implementation of quality management systems by earning NHQ Builder Certification and for their overall quality of operations by winning the National Housing Quality Award (NHQA). Trade contractors who were either trained to become, or who were certified as NHQ Certified Trade Contractors, also provided review. Finally, a construction and quality professional, Denis Leonard, PhD, provided an additional review perspective.

General Feedback from Builders and Trades

Overall, the builders stated that the final draft High Performance Scopes of Work were ideal as is, pointing out that their level of detail was necessary and appropriate to high performance building. As one builder put it, "We cannot afford not to have this sort of standard used. Many trades complain to us about paperwork and detail, but we have responsibilities and they do as well. The level of detail in these Scopes of Work help drive that responsibility." (Builder)

Builder and Trade Partner Usage of Scopes

Builders and trade partners said they would use the Research Center's final draft Scopes of Work to improve their existing scopes. In addition, they felt that the scopes would be particularly useful for training and contracts. Several reviewers made favorable comments about the first page of each scope, which states the goal, or purpose of the scope. Reviewers also recommended including an intended use commentary at the start of each scope to clarify that the scopes should not in any way be considered a replacement for any building codes, OSHA requirements, or other legal requirements.

Checklists

Reviewers felt the checklists in the final draft High Performance Scopes of Work were useful for highlighting "hotspot" items that commonly create problems during construction.

Graphics

The reviewers found the illustrations to be both excellent and beneficial, especially since high-quality graphics are not commonly available. They described the pictures and diagrams as being particularly valuable when English is not an individual's first language. The builders expressed interest in obtaining the graphics and pictures for use in training presentations.

Need for Customization

While the reviews were very positive of the final draft High Performance Scopes of Work, reviewers also acknowledged that scopes will need to be modified to accommodate a variety of factors including the builder's geographic location, company size, annual home sales, and construction methods and materials. "These scopes will serve as a template for a best practice for some builders; for other builders they are a starting point from a non-existent Scopes of Work." (Builder)

Reviewers felt these final draft High Performance Scopes of Work provide an outstanding template from which to begin, and can be adapted and personalized to each builder or trade by modifying, adding, or deleting content as appropriate for the organization. The reviewers suggest the final draft High Performance Scopes of Work be readily available to builders in an easily downloadable and customizable format to meet their unique needs.

Feedback on each High Performance Scope from Builders and Trades

In addition to the general feedback on the final draft Scopes of Work, the builders and trades provided specific reactions to each individual scope. The feedback is included below.

Excavation and Backfill for Basement Foundations and Poured Concrete Basement Foundations Scopes

Feedback from one trade contractor regarding the Excavation and Backfill Basement Foundation and the Poured Concrete Basement Foundation Scopes of Work was that the scopes cover the basic requirements. In addition, the reviewer felt "it matches up with our Scope of Work for the most part, and it would be applicable to any part of the country because of the basic format." The format content and structure of the High Performance Scopes of Work led one trade contractor to comment that it could work well as an outline for a basic Scope of Work "for someone who is starting from scratch." Another reviewer stated that the scope "has details that are essential for this Scope of Work." A builder liked that the scope includes a Job Ready Checklist because "it immediately sets expectations for the trade."

Framing Scope

One builder found the Framing Scope of Work easy to read and follow because the details of the framing process are well sequenced. A builder reported that, "The scope format does differ from our Scope of Work; it is better. We can learn from this scope, and so can our Drafting and Estimating Departments, especially in regard to the OSB layout for the walls and roof."

HVAC Scope

One trade contractor described the HVAC Scope as "very complex...closer to what a LEED Scope of Work would be than a basic starting point. There are many items which go beyond code and would add greatly to the cost of doing the job." One builder was very pleased to see that the scope had incorporated the equipment startup performance form. Another builder expressed a desire for the format to be more like that of the framing Scope of Work, which "describes the process from the beginning of framing to the final cleanup."

Excavation and Backfill for Basement Foundation

Design and Specification Prerequisites

Site Preparation, Excavation, Backfill, Rough Grade, Final Grade including Foundation Waterproofing and Drainage

INTRODUCTION

Excavation and Backfill is an extremely important element of high performance home construction. Site conditions such as soil type, water table, and contours must form the basis of the foundation design and, often, of the building itself. Construction methods such as waterproofing and backfill procedures play a critical role in the performance and longevity of the foundation.

PURPOSE OF THIS HIGH PERFORMANCE SCOPE OF WORK

A High Performance Scope of Work for the Excavation and Backfill trade is designed to achieve the following:

- Proper footing and surface drainage,
- Coarse, well-drained soils adjacent to the foundation to ensure a dry and structurally sound basement,
- A minimum of 8" distance between final grade and wood members of the building, and
- Minimized land disturbance.

BUILDERS CHALLENGE

A builder may also use the scope of work to verify that the Builders Challenge criteria relevant to each trade contractor have or have not been completed by each of their trade partners. Builders Challenge items are indicated throughout the scopes of work and checklists. They are denoted by a gray highlight. In addition, a note in italics accompanies the provision noting which Builders Challenge Quality Criteria the item addresses. For example, *[BCQC-2]* stands for Builders Challenge Quality Criteria item number 2.

DESIGN AND SPECIFICATION PREREQUISITES

In order for the Excavation and Backfill contractor to properly execute his job requirements in a safe, efficient, and professional manner, the following *Design and Specification Prerequisites must be in place*:

- Roof designs will not deposit runoff in enclosed areas such as walled patios,
- Limits of excavation and areas of vegetation to be protected are clearly demarcated on site plan,
- Benchmark, elevations, and contours are clearly identified on site plan,
- Specifications for driveway, walkways, and patio pads are located on the site plan,

- Recommended specifications for driveway (to be provided by Architect/Engineer):
 - Width of pad
 - Depth of excavation for pad and gravel
 - Type and size of gravel
 - Crown of pad
- Soil conditions that form the basis of the site and foundation design are characterized on plans,
- A detailed soils analysis has been conducted where problematic soils/sites exist, including expansive soils, high water table, wetlands, potential bedrock within depth of excavation, previous brownfill sites or potentially contaminated soils,
- Specifications for backfill material by professional engineer are included with the site plan, but at minimum shall be, “Type SM, ML, or better as classified by ASTM D 2487”, to within 24” of grade (per *ACI 332.1R-06*),
- Specifications for structural soils by professional engineer are included with site plan,
- Specifications for topsoil material are included with site plan,
- Specifications for foundation waterproofing material are included on architectural plans. Options include:
 - Spray-on water-based polymer-modified asphalt coating
 - Liquid rubber membranes
 - High density polyethylene membranes
 - Drainage boards
 - Capillary breaks
- Material specifications for drain tile are included on architectural plans. Available options include:
 - PVC Schedule 30 thin-wall perforated pipe
 - Drainable concrete forms
 - Code-approved composite foundation drainage system (Polyethylene black “coil” flexible piping shall not be used for exterior basement foundation drainage nor buried deeper than 4’ below surface or grade)

Excavation and Backfill for Basement Foundation

Job Ready Checklist

Site Preparation, Excavation, Backfill, Rough Grade, Final Grade including Foundation Waterproofing and Drainage

Prior to commencement of work, the trade contractor and site supervisor must both complete this form and make plans to resolve any missing or incomplete items. The trade contractor shall ensure that the Builder, the Construction Manager, or other designated representative of the Builder's management team has a final copy of the completed checklist.

All Phases of Site Work

Builder and trade contractor verify that:

Trade Builder N/A

- Building permit is clearly posted
- Sign identifying lot number is in place and clearly legible from street
- Site is clear of debris
- Silt fence is in place
- Builder has provided a complete set of lot-specific site plans, including lot survey, site plan showing septic or sewer location, buffers, easements, elevations, and any areas to be protected
- Architectural plans showing details pertinent to foundation drainage, sump pump outfall, gutter discharge, backfill specifications, and final grade have been obtained. Location of house, pads for HVAC or other equipment, and outbuildings has been clearly defined on the plans [BCQC-2]
- Appropriate underground utility locating agency has been called and all existing underground utilities within 20 feet of the area to be excavated have been clearly marked with paint, tape, or flags
- Erosion control measures are in place as shown on site and grading plans and have been approved by local building official
- Barriers and/or other tree/vegetation/wetlands protection measures are in place, if applicable
- Property pins are in place and clearly marked with paint, tape, and/or flags
- Dumpster is on site, as applicable

Excavation and Backfill for Basement Foundation - Job Ready Checklist (cont.)

Incomplete Items	Date Completed
_____	_____
_____	_____
_____	_____
_____	_____

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature: _____

Date: _____ (Excavation)

Date: _____ (Backfill)

Date: _____ (Final)

Builder Company Name: _____

Trade Contractor Signature: _____

Date: _____ (Excavation)

Date: _____ (Backfill)

Date: _____ (Final)

Trade Contractor Company Name: _____

Site Address: _____

Excavation

Job Ready Checklist

Builder and trade contractor verify that:

Trade Builder N/A

- Full accessibility to lot is established, including temporary driveway
- House is properly staked in accordance with site plans and architectural plans
- Setbacks from property line are accurate and conform to local codes

Incomplete Items

Date Completed

_____	_____
_____	_____
_____	_____
_____	_____

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature

Date:

Builder Company Name

Date:

Trade Contractor Signature

Date

Trade Contractor Company Name

Site Address

Foundation Waterproofing and Drainage

Job Ready Checklist

Builder and trade contractor verify that:

Trade Builder N/A

- Building permit is clearly posted
- Foundation wall is complete and cured sufficiently to be waterproofed (at least 7 days or as recommended by manufacturer of waterproofing product)
- Finish grade line is marked on foundation wall(s)
- Area around foundation is clear of trash, debris, and forming materials

Incomplete Items

Date Completed

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature

Date:

Builder Company Name

Date:

Trade Contractor Signature

Date

Trade Contractor Company Name

Site Address

Backfill and Rough Grade

Job Ready Checklist

Builder and trade contractor verify that:

Trade Builder N/A

- Foundation walls, basement walls, and/or retaining walls have been poured and cured a minimum of 10 days
- Basement slab has been poured
- Foundation walls are adequately braced and/or first floor deck framing is in place
- Waterproofing, drainage board, and/or exterior insulation are installed as specified on architectural plans
- Foundation drainage system is installed as specified on architectural plans *[BCQC-2 Verification]*
- All termite treatments necessary before backfill have been made
- Building code official has inspected and signed off on footing, foundation, and foundation drainage and waterproofing
- Area around foundation is free of all debris
- Retaining walls are in place and properly tied to ensure that final slopes shall not exceed 50%
- Water meters, wells, and/or septic tanks are clearly flagged as applicable
- All forms and layout stakes have been removed
- Available backfill on site or on order meets Specifications provided by Builder and/or Soils Engineer as applicable

Incomplete Items

Date Completed

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature	Date:
Builder Company Name	Date:
Trade Contractor Signature	Date
Trade Contractor Company Name	
Site Address	

Final Grade

Job Ready Checklist

Builder and trade contractor verify that:

Trade Builder N/A

- All underground utilities, sewer lines, water lines, and geothermal pipes if applicable have been installed, backfilled, and compacted
- All flatwork and paved areas such as driveways, patios, and walkways are in place and at elevations as specified on plans. All form boards and layout stakes have been removed
- All flatwork and paved areas have been inspected for any damage and the Builder has acknowledged that damage, if any
- Area to be graded is clear and free of impediments such as stockpiled building materials, dumpster, portable toilets. No wood has been disposed of close to structure that would attract termites
- Soil available on site or on order to be used as final grade material meets Specifications provided by Builder and/or Soils Engineer as applicable

Incomplete Items

Date Completed

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature

Date:

Builder Company Name

Date:

Trade Contractor Signature

Date

Trade Contractor Company Name

Site Address

Excavation and Backfill for Basement Foundation

Detailed Job Requirements and Tolerances for the Field

Site Preparation, Excavation, Backfill, Rough Grade, Final Grade including
Foundation Waterproofing and Drainage

GENERAL PROVISIONS FOR ALL PHASES

- Complete Job Ready Checklist for each phase of work in conjunction with Builder or Builder's representative
- Perform all work within the guidelines specified in the contract, applicable building codes, plans, and the Detailed Job Requirements
- Notify Builder or Builder's representative in writing immediately if any part of the specifications/plans do not meet the locally adopted building code
- Complete all work in a manner that respects the efforts and materials of other Trades. No broken, damaged, or incomplete work will be concealed. Any damaged work must be reported to the Builder
- Protect sidewalks curbs, streets, and other paved areas during all phases of clearing, excavation, backfill, and grading from damage due to heavy equipment
- Do not excavate or trespass outside the identified and flagged no cut/no fill areas
- Maintain erosion control measures as required by code and shown on drawings throughout all phases of site work. Report any damage to erosion control measures immediately to the Builder.
- Protect benchmarks, sewer tap markers, and property lines set by Builder.
- Do not trespass on adjacent property
- Notify Builder of any property pins displaced during clearing, grading, excavation, backfill, and/or final grading
- Clean up all litter, trash, and construction debris resulting from Trade Contractor's activities. Deposit in designated area or remove from site. Keep streets clean and free of dirt and debris at all times

CLEARING – ROUGH GRADING PROVISIONS

- Verify the following with Builder's Site Superintendent
 - Location for trash disposal and temporary stockpiling of debris and brush
 - Location(s) to stockpile topsoil and subsoil from excavation
 - Location of pad for delivery and storage of materials
 - Need for removal of excess dirt or provision of additional material
 - Location of concrete truck access
 - Proper location of Hub stakes in accordance with site plan

- Locations of curb cuts, easements, and water boxes
- Procedures for protecting site against weather conditions
- Provide temporary access roads as required for site clearing, grading, and storm drainage
- Remove from the site or chip on-site cleared trees and debris prior to excavating
- Do not bury or burn debris or trash
- Protect neighboring property, adjacent trees, and people when clearing trees and brush
- Cut and fill areas per site plan and specifications to meet foundation elevations. No slopes to exceed 50%
- Topsoil is stockpiled on site at Builder-specified location
- Disturbed area of lot to be subgraded 6" or more below final grade
- Provide level (within 4") pad to accommodate building footprint and required area for basement foundation excavation
- Subgrades provided for all driveways, patios, and sidewalks as shown on plans
- Set offset corner stakes as necessary to complete grading and clearing work
- Install temporary driveway in location specified on site plan

EXCAVATION PROVISIONS

- Cut basement to accommodate house footprint per site plan and architectural plan.
- Excavate footing/foundation to depth as shown on site plan and architectural plan; hold level to within 2" of lines and grades indicated on site and architectural plans.
- Basement slab excavation shall be to a depth 4" below top of footing and shall be level with maximum variation ± 1 " of lines and grades shown on architectural plans.
- Trade Contractor is responsible for any overdigs on the interior of the foundation and shall provide and fill the area with pea gravel, at Trade Contractor's own expense, to achieve specified slab subgrade.
- On foundation exterior, over-excavate at least 2', (per OSHA requirements), but no more than 3', around the perimeter to allow working clearances needed to install foundation walls, waterproofing, and drainage. It is the Trade Contractor's responsibility to supply and install additional gravel and backfill material for overdigs in excess of 3'.
- Slope wall around foundation or bench-step the excavation to prevent soil cave-ins. Slope must be no steeper than 1' vertical to 1 1/2' horizontal per the *NAHB-OSHA Jobsite Handbook*⁷ or as specified by professional engineer.
- Depth of foundation shall not exceed 7' 6" unless additional cave-in protection is installed.

⁷ *NAHB/OSHA Jobsite Safety Handbook, Second Edition*, published by Home Builder Press of the National Association of Home Builders, 1999.

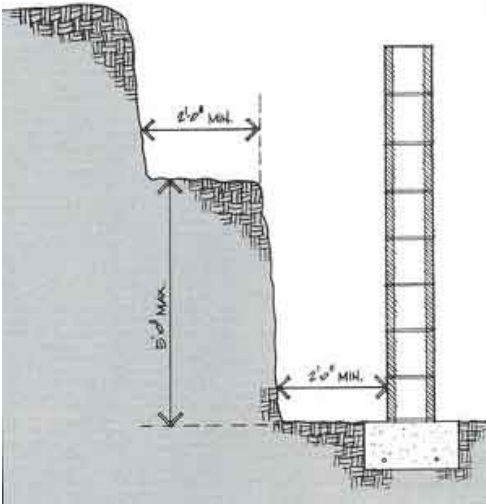


Figure 3: Properly Benched Foundation Trench
NAHB-OSHA Jobsite Safety Handbook



Figure 4: 1' Vertical to 1 1/2' Horizontal Slope
NAHB-OSHA Jobsite Safety Handbook

- Cut drainage path to sump area daylight (if possible) at base of basement slab excavation
- Excavate for stemwalls for garage and porches to accommodate dimensions as specified on plans. Depth of excavation is per local jurisdiction and/or must be sufficient to provide adequate frost protection for climate
- All soils beneath footings, slabs, and stemwalls should be undisturbed or compacted. Compaction of filled areas should be performed in 6" lifts and achieve 95% compaction by means of Standard or Modified Proctor Compaction Test (ASTM D-698 or ASTM D1557). Soils should be moisture conditioned as necessary for compaction
- Excavated area shall be free of loose soil
- Notify Builder if unsuitable soil conditions or groundwater is encountered. Examples of unsuitable conditions include, but are not limited to, less than 2000 psf soil, expansive soils, heavy clay soils, excessive water infiltration, and/or bedrock layer above specified excavation depth
- Provide access route and/or build ramps for access into excavated area by concrete contractor

Garage, Porch Stemwalls and Slab Areas

- Excavate for garage and porch stemwalls to depth within 2" of that shown on architectural plans. Base of excavated area to be level within 2"
- Excavate garage and porch slab areas to depth that allows for 4" to 6" gravel beneath slab. Excavated area to be level within 2"

FOUNDATION WATERPROOFING AND DRAINAGE PROVISIONS⁸

Waterproofing

- Sweep and brush foundation wall and top of footing to “broom clean” condition
- Apply waterproofing membrane to all below grade basement walls. (See Specifications for recommended materials). Membrane should extend from footing up to final grade line on foundation wall.
- Lap membrane over wall/footing joint
- Membrane shall be applied in an even, continuous layer with no gaps or voids
- Shingle-lap all horizontal and vertical joints, as applicable, with a minimum of 6” overlap

Perimeter Drainage [BCQC-2]

- Lay geo-textile fabric around perimeter of footing at base of trench to wrap gravel/stone bed and drain tile
- Install 4” (depth) of washed gravel or #1 and #2 stone around entire basement foundation prior to installing perforated drain tile. Stone should extend approximately 12” from footing.
- Install 4” perforated drain tile around entire basement foundation with holes facing downward. Bottom of pipe must be below the top of the footing, e.g., the bottom of the basement floor slab.
 - Alternate: Install drainable concrete form system in accordance with manufacturers’ instructions
- Install drain tile level or with slight pitch (~1/2” in 4’) with outfall to daylight, a drywell, or to a sump hole on the interior of the basement. A vertical clean-out pipe with an above-grade capped end is recommended to flush out the system for maintenance.
- When outfall is to daylight or a drywell, run perforated tile for the first 10’ from the foundation. Use solid pipe thereafter
- When run to an interior sump, use solid pipe beneath the basement slab
- On top of pipe, install a minimum of 10” of washed gravel or #1 and #2 stone
- Prevent dirt or silt from clogging pipe and stone by wrapping pipe and stone bed with geo-textile filter fabric on top as well as both sides

⁸ This work may be performed by Builder or by other Trade Contractor.

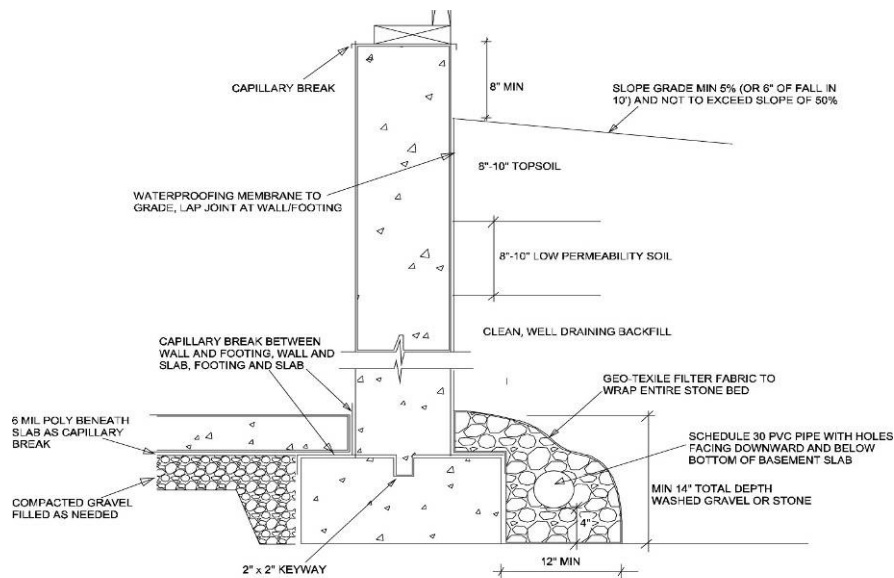


Figure 5: Perimeter Foundation Drainage and Backfill

BACKFILL AND ROUGH GRADE PROVISIONS

- Take care not to damage foundation wall, drain tile, or waterproofing during backfill.
- Ensure that end of drain tile remains exposed.
- Do not operate heavy equipment parallel to foundation walls
- Follow municipal or county dust control procedures during backfill
- Backfill with clean material to within 18" of final grade – no large stones, roots, limbs, construction trash, or organic material. Material should be coarse-grained material that drains well. Do not use heavy clay soils or very silty soils for backfill within 3' of foundation wall. Do not use frozen material for backfill
- Place approximately 8-10" low permeability soil on top of porous backfill to aid in diverting water away from the foundation
- Use stockpiled or trucked-in topsoil for top 8"-10" of backfill and final grade
- Compact backfill in 8" lifts with a mechanical device such as loader or tamper to 95% by means of Standard or Modified Proctor Compaction Test. Soils should be moisture conditioned as necessary for compaction
- Do not leave low areas where water can collect against foundation. Rough grade area to provide positive drainage away from foundation – 5% slope or 6" in 10'
- Locate swales as necessary to drain lot, per the site drainage plan
- Upon completion of backfill, restore temporary driveway to original location and specification per site plan

- Window wells – Provide 2” fall from window to buck. Place 4” of well-graded sand, pea gravel, or 1½” stone at base of window well. Tie this stone base to foundation drain system via sand/gravel or drain tile

Garage, Porch Stemwalls and Slab Areas

- Fill interior and exterior of stemwalls concurrently to maintain equal pressure against wall
- Fill interior areas where concrete slab is to be poured in 8” lifts and compact to 95% by means of Standard or Modified Proctor Test. Soils should be moisture conditioned as necessary for compaction
- Spread 4” to 6” gravel over entire slab area and compact to 95% by means Standard or Modified Proctor Test

FINAL GRADE PROVISIONS

- Place and spread a minimum of 6” of topsoil or more as specified over entire lot to attain proper grade, elevation, and contours as shown on the site drawings and specifications
- Topsoil should be a loam or silty loam free of sticks, roots, and stones larger than 1” ; all particles should be capable of passing through a 1” screen
- Topsoil should be used from stockpiled material on site if appropriate
- Follow municipal or county dust control procedures during grading. Provide sufficient water on every truck for dust control
- Establish final grade to carry water away from foundation to at least 6” of fall in 10’ (5%) and not to exceed slope of 50%
 - Where lot lines, walls, fences, walkways, or other physical barriers prohibit 6” fall over 10’, use slopes and swales to ensure positive drainage away from structure
- Prepare finish grades for pads required for HVAC equipment per architectural plans
 - Do not block drainage paths around foundation with equipment pads or fences, or walls
 - Provide drainage underneath or beside obstructions such as HVAC pads
- Finish grade height must cover established grade line on foundation wall and be at least 8” below foundation sill plate
- Finish grade to be 1½” lower than adjacent flatwork
- Ensure proper drainage to the street or appropriate drainage easements with no standing water. Standing water is defined as “puddling” for more than a 24-hour period
- All finish grading shall be performed to maintain a maximum variation of $\pm 1\frac{1}{2}$ ” from elevations shown on plans. Proper finish elevations shall be verified using transit
- Leave site ready for landscaping, requiring no more than hand raking for landscape installation.
 - Leave site clear of trash, debris, and any rocks larger than 1”

Excavation and Backfill for Basement Foundation

Job Complete Checklist

Site Preparation, Excavation, Backfill, Rough Grade, Final Grade including Foundation Damp-Proofing and Drainage

This list is to be reviewed by the Builder/Superintendent and the Earthwork Contractor to verify that the job site is ready for Trade Contractor work—subsequent to the Earthwork Contractor work—to begin.

NOTE: Many if not most of the items called out below would be accomplished by following the plans or the building code. Items are called out in the Job Complete Checklist as further verification of proper completion because many of these measures have proven to be problematic and, therefore, require a double check.

Clearing and Rough Grading

Builder and trade contractor verify that:

Trade Builder N/A

- Trees and brush cleared per site plan. All debris removed from site, chipped and stockpiled on site, or per Builder's specifications
- Topsoil removed and stockpiled on site
- Level building pad prepared that accommodates building footprint per site and architectural plans
- Corner stakes replaced to mark all corners of building and garage
- Temporary driveway is installed
- No damage has occurred to neighboring property
- Subgrade for driveway, patio, and sidewalk or other flatwork has been created per plans
- Subgrade is 6" or more below final grade
- No slope is greater than 50%

Incomplete Items

Date Completed

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature

Date:

Builder Company Name

Date:

Trade Contractor Signature

Date

Trade Contractor Company Name

Site Address

Excavation

Job Complete Checklist

Builder and trade contractor verify that:

Trade Builder N/A

- Basement foundation has been cut to accommodate house footprint as shown on architectural plans and drawings with 2' to 3' overcut
- Footing and foundation has been excavated to a depth within 2" of that indicated on plans
- Basement area has been cut to 4" below top of footing for slab and within ±1" of lines and grades on plans
- Overdigs on the interior of the foundation have been filled with pea gravel to achieve specified subgrade
- On foundation exterior, site has been over-excavated at least 2' but no more than 3'. Overdigs in excess of 3' have been filled with approved gravel and backfill material
- Slope of embankment around foundation complies with Table V-2-1 of the *OSHA Technical Manual* per soil type or as specified by professional engineer
- Drainage path to daylight is cut at base of basement slab excavation where possible
- Stemwalls for garage and porches are excavated to depth and dimensions as shown on architectural plans and drawings
- Soil beneath footings, slabs, and/or stemwalls is undisturbed or compacted to 95% by means of Standard or Modified Proctor Test
- Excavated area is free of loose soil
- Builder has been notified of any unsuitable soil conditions and if groundwater was encountered
- An access route or ramp has been provided for access by concrete contractor

Incomplete Items

Date Completed

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature	Date:
Builder Company Name	Date:
Trade Contractor Signature	Date:
Trade Contractor Company Name	
Site Address	

Foundation Waterproofing and Drainage

Job Complete Checklist

Builder and trade contractor verify that:

Waterproofing

Trade Builder N/A

- Waterproofing membrane installed to final grade lines on foundation walls with no gaps or voids
- Waterproofing membrane laps foundation wall/footing joint by 12"
- Horizontal and vertical joints shingle-lapped a minimum of 6"
- Waterproofing membrane is applied evenly and without voids

Perimeter Drainage [BCQC-1 Verified]

Trade Builder N/A

- 2-4" of washed gravel or #1 and #2 stone surrounds entire basement foundation beneath drain tile material and extends 12" from footing
- 4" perforated drain tile installed around entire perimeter of basement foundation and run, with slight pitch of about 1" in 8', to daylight, drywell, or sump hole
- If outfall is to daylight or a drywell, perforated pipe is run for the first 10' from the foundation and solid pipe is run thereafter
- Drain tile is placed with holes downward and so that holes are below the top of the footing/bottom of basement slab
- Pipe run to an interior sump is solid pipe
- Pipe is covered by a minimum of 10" of washed gravel or #1 and #2 stone that extends 12" from footing
- Pipe and gravel bed are wrapped with filter fabric

Incomplete Items

Date Completed

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature

Date:

Builder Company Name

Date:

Trade Contractor Signature

Date

Trade Contractor Company Name

Site Address

Backfill and Rough Grade

Job Complete Checklist

Builder and trade contractor certify that:

Trade Builder N/A

- Backfill material meets specifications of Soils Engineer or as identified in material specifications
- Verification provided for compaction of backfill material to 95% by means of Standard Proctor
- Cut and fill areas prepared per site plans with no slopes exceeding 50%
-

Garage, Porch Stemwalls, and Slab Areas

Trade Builder N/A

- Stemwalls for garage, porches have been backfilled
- Slab areas for garage and other exterior flatwork has been prepared with 4 to 6" gravel and compacted to 95% by means of Standard Proctor

Incomplete Items

Date Completed

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature

Date:

Builder Company Name

Date:

Trade Contractor Signature

Date

Trade Contractor Company Name

Site Address

Final Grade

Job Complete Checklist

Builder and trade contractor certify that:

Trade Builder N/A

- Minimum of 6" topsoil has been spread over lot as indicated on site plan
- Characteristics of topsoil meet Builder's specifications
- Final elevations are within $\pm 1\frac{1}{2}$ " of those specified on site plan
- Finish grade is at least 8" below foundation sill plate or siding
- Grade is established around perimeter of foundation to achieve at least 5% (6" of fall within 10'). Grade shall not exceed 50% (5' of fall in 10')
- Site is clear of trash, debris, and rocks larger than 1"
- Finish grade prepared for HVAC equipment
- Finish grade is $1\frac{1}{2}$ " lower than adjacent flatwork and $\pm 1\frac{1}{2}$ " from elevations on plans
- Window wells installed per plans with 4" of $1\frac{1}{2}$ " stone base
- Proper site drainage ensured (no standing water)
- Site is ready for landscaping

Incomplete Items

Date Completed

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature

Date:

Builder Company Name

Date:

Trade Contractor Signature

Date

Trade Contractor Company Name

Site Address

Poured Concrete Basement Foundation

Design and Specification Prerequisites

INTRODUCTION

The long-standing standard practice of specifying concrete footings and poured concrete basement walls that meet minimum code requirements and the specific requirements of the builder is good practice only so long as the required construction activities are carried out in full. Using code minimum provisions for specifying concrete footings and poured concrete basement walls can result in oversized foundations and unnecessary costs. Typically, code provisions have large factors of safety built into their design tables. On top of that, certain code design requirements depend on the local jurisdiction or code official to characterize soil type and conditions; and, since very few local code officials are soil experts, this often results in overly conservative design.

Although engineered foundations can provide the optimum design for the location, the engineering process can be costly and time-consuming. An engineered foundation requires soil testing and analysis, increased design fees, control of materials to assure that specified materials are delivered to the site, and adequate field supervision to assure proper implementation of the design. Furthermore, the code official must often be convinced that the engineered design is adequate and meets the intent of the code. Therefore, it has become the norm to use building code provisions and apply “worst-case” scenarios to every foundation design. This practice frequently results in overbuilt foundations that cost more, and use more materials, than necessary.

For a small, scattered site, semi-custom builder, it may be most expedient and cost-effective to simply rely on building code requirements rather than engineer every single foundation. However, for the production builder, the time and expense of an engineered foundation that will be repeated in a subdivision may well be worth the investment.

PURPOSE OF A HIGH PERFORMANCE SCOPE OF WORK FOR CONCRETE BASEMENT FOUNDATIONS

There are two primary and, perhaps obvious reasons for developing a High Performance Scope of Work for Poured Concrete Basement Foundations: 1) The foundation provides fundamental support for the above-grade portion of the structure. Failure of the foundation ultimately results in failure of the entire structure; 2) Repairs to the foundation are difficult to execute and usually, very costly. It can be argued that this is the part of a structure where it is most important to “do it right the first time.”

BUILDERS CHALLENGE

A builder may also use the scope of work to verify that the Builders Challenge criteria relevant to each trade contractor have or have not been completed by each of their trade partners. Builders Challenge items are indicated throughout the scopes of work and checklists. **They are denoted by a gray highlight.** In addition, a note in italics accompanies the provision noting

which Builders Challenge Quality Criteria the item addresses. For example, [BCQC-2] stands for Builders Challenge Quality Criteria item number 2.

DESIGN AND SPECIFICATION PREREQUISITES

In order for the contractor to properly execute his job requirements in a safe, efficient, and professional manner, the following *Design and Specification Prerequisites must be in place*:

Notes/Office Files Include the Following

- Design calculations justifying the specified foundation for locally prevalent soil conditions, the loads calculated for the greatest load case and specified backfill materials

Architectural Plans Include the Following

- Footing and wall concrete to a minimum 28-day compressive strength of 2500 psi or that specified in the local building code, whichever is greater
- Footing and wall design and specifications based upon actual soil conditions at the site, including bearing capacity, drainage capability, and lateral loading characteristics
- At a minimum, foundation and site plans include:
 - Compressive strength of concrete for footings and walls and maximum slump permitted
 - Specifications for acceptable and unacceptable admixtures
 - Location of control joints
 - Height, width, and depth of all footings and poured walls. Base of footing to be at least 12" below undisturbed ground and below frost depth for local jurisdiction or in accordance with design provisions for frost-protected shallow foundations (ASCE 32-01 or locally adopted building code)
 - Provision for uplift tie-down hardware – type, size and placement diagram
 - Size, spacing, and installation specifications for steel reinforcement as well as specification for reinforcement when footings span utility trenches
 - Recommended: reinforcement for crack control in poured walls - two no. 4 bars running continuously 2 inches below top of wall and above and below window openings
 - Provision for bracing walls in excess of 30'
 - Site plan showing existing and finish grade contours, curb and street elevations, finished basement slab elevation, finished 1st floor elevation, and utility hookup locations
- All footings specified with a continuous keyway with a minimum dimension of 2"x 2"

- A capillary break the width of the footing should be specified between the wall and the footing and the footing and the slab (6 mil poly minimum; sprayed applied elastomeric compound or self-adhesive high density polyethylene membrane preferred) [BCQC-2]

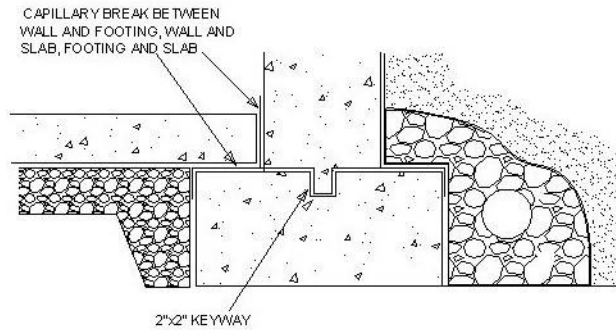


Figure 6: Keyway and Capillary Break

- All wall and footing steel reinforcement bars specified to be rust-free prior to pouring and encapsulated by concrete after the wall concrete is placed

Poured Concrete Basement Foundation

Job Ready Checklist

Prior to commencement of work, the trade contractor and site supervisor must complete this form together. The trade contractor shall ensure that the Builder, the Construction Manager, or other designated representative of the Builder's management team has a final copy of the completed checklist.

Builder and trade contractor verify that:

Trade Builder N/A

- Building permit is clearly posted
- Sign identifying lot number is in place and clearly legible from street
- Notice of commencement/lien waiver is posted
- Silt fence is in place
- Builder has provided the Trade Contractor with a complete set of architectural plans, Scope of Work, and site plan that include setback lines, elevations, foundation layout including optional features, and tie-down hardware placement plan
- Builder has provided the Trade Contractor with complete set of specifications for required compressive strength of concrete, allowable admixtures, required slump, and any on-site sampling or testing that must be done
- Builder has conducted an on-site review of the job specific items with the Trade Contractor or the Trade Contractor's representative
- At least two (2) corners are clearly staked
- Location of sleeve for utility (sewer/water/electric/gas) lines is verified and marked
- Water meter location is marked and visible
- Finished elevation of top of foundation wall is clearly indicated on the lot by benchmark stake
- A washout area for the concrete trucks has been designated by Builder
- All Builder-supplied materials are on site
- Full accessibility to house is established, including gravel entrance pad
- 24"-36" clear excavation outside the wall line provided to ensure safe and workable access to install and strip forms
- Excavation is within ± 2 " of site plan elevation
- All slopes laid back per Table V-2-1 of OSHA Technical Manual or as specified on plans

Poured Concrete Basement Foundation - Job Ready Checklist (cont.)

Trade Builder N/A

- Drainage path cut to sump pit or daylight for all in-ground basement sites where site conditions allow [BCQC-2]
- This lot will ___ or will not ___ require concrete pumping. It is agreed that the cost of a pump is ___ - or is not ___ included in the contractor's contract
- Builder has provided documentation that a design/technical professional has confirmed the existing soil is suitable for the proposed construction

Incomplete Items

Date Completed

_____	_____
_____	_____
_____	_____
_____	_____

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature	Date:
Builder Company Name	Date:
Trade Contractor Signature	Date
Trade Contractor Company Name	
Site Address	

Poured Concrete Basement Foundation

Detailed Job Requirements and Tolerances for the Field

GENERAL PROVISIONS

- Complete Job Ready Checklist for Poured Concrete Basement Foundation in conjunction with Builder or Builder's representative
- Perform all work within the guidelines specified in the contract, applicable building codes, plans, and the *Detailed Job Requirements and Tolerances for the Field*
- Notify Builder or Builder's representative in writing immediately if any part of the specifications/plans do not meet the locally adopted building code
- Determine acceptable admixtures and location, if any, of control joints for shrinkage control in conjunction with Builder or Builder's representative
- Complete all work in a manner that respects the efforts and materials of other Trades. No broken, damaged, or incomplete work will be concealed. Any damaged work must be reported to the Builder
- If applicable, confirm that required local inspections have been passed before any concrete pour
- Schedule and take part in any inspection(s) required for the completion of work
- It is the responsibility of the Trade Contractor to ensure that the streets are clean and clear of mud and dirt from the trucks
- Clean up all materials, litter, and construction debris and deposit in the designated area
- Trade Contractor is responsible for the quality and completion of the job regardless of the weather or time of day
- Wash out all concrete trucks at the Builder-designated washout area

CONCRETE PLACEMENT PROVISIONS

- Trade Contractor is responsible for purchasing, scheduling, and placing the concrete
- Avoid pouring when the temperature is dropping to below freezing (32°F) within 24 hours. Trade contractor is responsible for protecting the concrete from rain, sub-freezing temperatures, and excessive heat, sun, and wind
- The use of calcium additive requires Builder approval
- Water shall not be added to concrete on the jobsite unless the water/cement ratio is below the maximum allowable at the time of batching as indicated on the delivery ticket
- Turn in all concrete delivery tickets to the Builder
- Builder must approve conveying or pumping equipment as specified in the Job Ready Checklist

- Provide ready access to Builder's engineering consultant for concrete slump tests and preparation of concrete test cylinders
- Protect all concrete cylinders from movement or damage until removed by Builder's engineering consultant
- Protect all adjacent work from concrete splatter

FOOTING PROVISIONS

- Size and construct footings and poured walls per foundation and site plans and all applicable local building codes
- Trench and/or form footings as shown on foundation and site plans
- Install steel reinforcement per foundation plan and local building code requirements
- Remove loose soil or unsuitable material from footing excavation and replace with granular material, pea gravel or #1 stone, or concrete that has been compacted to specified bearing capacity
- Schedule and take part in inspections of footing excavation and steel reinforcement , if applicable
- Protect footing excavation from soil cave-in or standing water. If conditions warrant, Trade Contractor will pump out rainwater and allow excavation to dry prior to continuing with pour
- Footings shall be of uniform depth, straight alignment, clean and cut to size, level (tolerance of 1/2" in 20') and diagonally square (tolerance of 1" or as needed to provide projection of at least 2" on each side of foundation wall)
- Secure sleeves prior to pouring footings or walls
- Footings shall not be cast on frozen, saturated, or loose ground.
- Pour footings with continuous 2"x2" keyway

WALL PROVISIONS

Note: Wall corner location pins on the footings will be provided by the builder after footings are complete

- Inside wall surface to be smooth __-, or brick pattern ____
- Outside wall surface to be smooth ____, or brick pattern ____
- 4" Brick ledge locations and dimensions per plan elevation dated: _____
- Brick ledge elevation must remain below top-of-wall elevation at all times
- Brick ledges to be level within 1/4" in 10'

- Provide capillary break between the wall and the footing as specified on foundation plan. [BCQC-2]

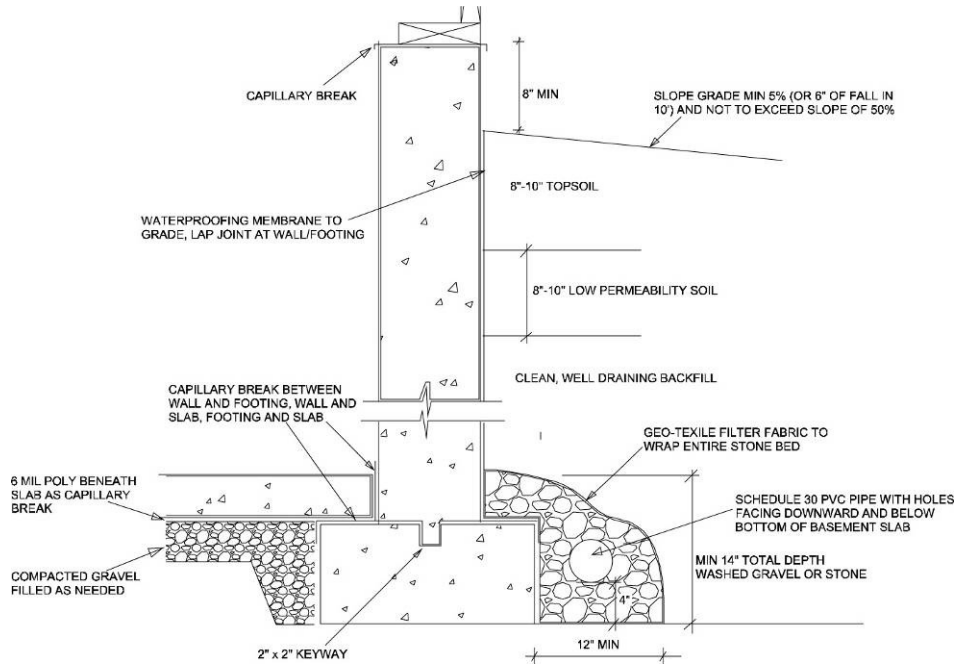


Figure 7: Poured Concrete Foundation Wall: Capillary Break and Foundation Damp Proofing

- Install and brace wall forms to maintain a straight edge (tolerance of $\frac{1}{2}$ " in 40'), level (tolerance of $\frac{1}{4}$ " in 20'), plumb (maximum deviation $\frac{1}{4}$ " in 8') and diagonally square (tolerance of $\frac{1}{2}$ "
- Ensure all rebar is installed as specified on architectural plans and in accordance with American Concrete Institute (ACI) 332-04
- Place concrete continuously around the perimeter of the wall forms in maximum lifts of 3'. Vibrate and compact concrete to eliminate all honeycomb areas
- Install tie-down hardware according to design and manufacturer's specifications immediately after concrete is poured. Spacing shall be per foundation plan
- Where anchor bolts are used, bolts shall be at least $\frac{1}{2}$ " diameter and spaced according to local building code, but no further than 6' apart (for $\frac{1}{2}$ " bolts) or more than 1' from any corner or plate break. Anchor bolts shall be embedded at least 7" in concrete
- Finished foundation wall is square, level, and plumb to tolerances specified above. Top-of-wall depressions not to exceed $\frac{1}{8}$ " in 32"
- Any over-pour must be moved away from the slab and footings
- Strip all forms and break off form ties once concrete has reached adequate compressive strength to be self-supporting, typically 500 psi. Forms should be left in place for at least 12 hours after pour

- Point and patch all vertical surfaces prior to job completion. Any honeycombed areas shall be patched according methods specified in ACI 332.1R-06 Guide to Residential Concrete Construction. All sleeves are to be clean and clear of obstructions
- Trade Contractor to provide a finished product within the tolerances and specifications listed above and in the contract or bear the cost of repair/replacement

Note: samples and testing are the obligation of and occur at the expense of the builder. Trade Contractor is hereby advised that unacceptable results, as defined below, will require remediation by the trade contractor, as directed by an engineer selected by the builder and paid by the trade contractor.

PERFORMANCE TESTING PROVISIONS

Trade Contractor agrees that full compliance with this scope of work requires demonstrating that the completed work meets the Builder's requirements using the following tests:

Performance Test 1: Slump tests during any concrete pour operation – ACI standard slump tests will be completed and evaluated on-site by the Builder's engineering consultant. Concrete slump during any pour shall not exceed 5 inches.

Performance Test 2: Compressive strength of concrete – Three concrete cylinder samples will be prepared by the Builder's engineering consultant as directed by the Builder from each concrete order. Additional samples may be made from any continuous pour exceeding 50 cubic yards.

- Test samples will be removed from the jobsite after 48 hours by the Builder's engineering consultant.
- Trade Contractor is to protect cylinders from movement or damage until removed.
- Testing of all cylinders will be conducted in accordance with ASTM C873-04 after 7 days and after 28 days. Tested compressive concrete strength must exceed 2000 psi after 7 days, and at least 2500 psi (or as required by local code) after 28 days. One cylinder from each sample will be maintained by the testing lab as a backup.

Poured Concrete Basement Foundation

Job Complete Checklist

(Including Performance Testing)

This list is to be reviewed by the Builder/Superintendent and the Foundation Contractor to verify that the job site is ready for Trade Contractor work—subsequent to the Foundation Contractor work—to begin. The trade contractor shall ensure that the Builder, the Construction Manager, or other designated representative of the Builder's management team has a final copy of the completed checklist.

NOTE: Many if not most of the items called out below would be accomplished by following the plans or the building code. Items are called out in the Job Complete Checklist as further verification of proper completion because many of these measures have proven to be problematic and, therefore, require a double check.

Builder and Trade Contractor verify that:

Trade Builder N/A

- | | | | |
|--------------------------|--------------------------|--------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Footings and walls meet the size and construction per plans |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | All forms have been removed and materials are stacked |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Finished work has been checked for straight, square, level, plumb as follows: <ul style="list-style-type: none">• Measured diagonals: _____ x _____• 4 main corners confirmed plumb within ____" in ____'• String lines on walls confirm on-line within ____" in ____'• String lines on walls confirm level within ____" in ____'• Note: Concrete contractor is responsible for the cost of any corrections needed for framing adaptations due to concrete work that does not meet tolerances described in the Detailed Job Requirements and Tolerances. |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Capillary break installed between footing and foundation wall [BCQC-1 Verifier] |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Builder received concrete delivery tickets |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Conveying and/or pumping equipment approved by Builder |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | No overpour is near foundation or footing |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Streets are clean and free of mud from concrete trucks |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | If brick ledge is present, it is below the top-of-wall elevation and level within 1/4" in 10' |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Vertical surfaces have been rubbed smooth, and patched if needed |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | All wall ties have been knocked off below wall surface |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Tie-down hardware installed per plans (both spacing and position on wall) |

Poured Concrete Basement Foundation - Job Complete Checklist (cont.)

Trade Builder N/A

- As applicable: anchor bolts plumb with ____” exposed above top of wall/ straps positioned and nailed per manufacturer’s specifications
- Backfill limitations (height, materials, bracing, and wait time) have been provided to Superintendent
- Materials, litter, and construction debris, have been cleaned up and deposited in the designated area
- Slump tests have been performed and results comply with Design Specifications
- Compressive strength test cylinders confirmed with ____ PSI at ____ days

Incomplete Items

Date Completed

_____	_____
_____	_____
_____	_____

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature	Date:
Builder Company Name	Date:
Trade Contractor Signature	Date:
Trade Contractor Company Name	
Site Address	

Framing

Design and Specification Prerequisites

INTRODUCTION

High performance framing and high performance HVAC design and installation are closely inter-connected. Many elements of a high performance framing plan will reduce the home's space conditioning loads and, thus, the required size of equipment. By coordinating the development of the structural framing design and layout with the forced air distribution system, structural members can be appropriately sized to facilitate duct installation that will assure proper air delivery. Likewise, the plumbing distribution and waste layout must also be coordinated with the structural framing design during the design phase in order to prevent conflicts and delay during construction.

GOAL OF THIS HIGH PERFORMANCE SCOPE OF WORK

The goal of a High Performance Scope of Work for Wood Framing is threefold: 1) to assure adequate structural integrity based upon sound engineering principles and reasonable safety factors, 2) to minimize unnecessary material use, and 3) to assure proper coordination with other systems in the home to maximize thermal performance and moisture management.

BUILDERS CHALLENGE

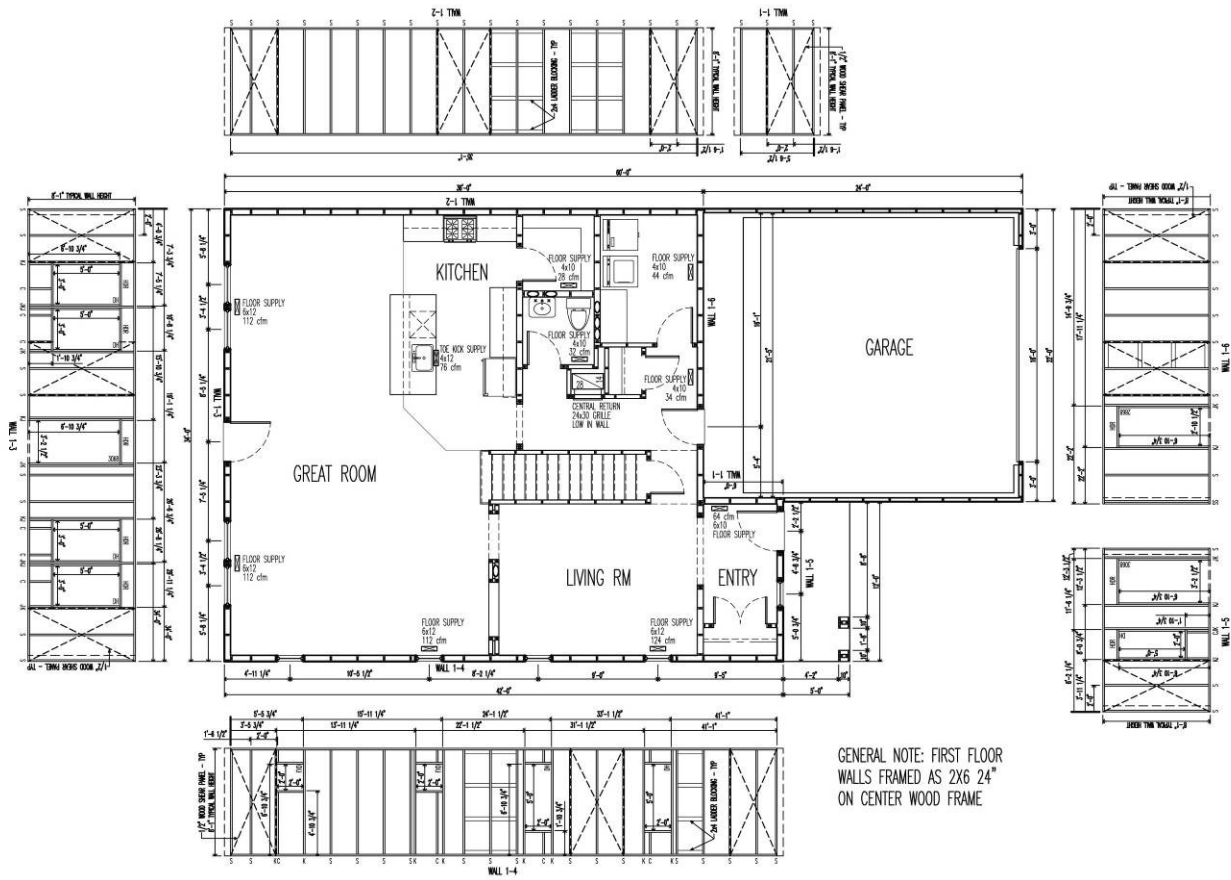
A builder may also use the scope of work to verify that the Builders Challenge criteria relevant to each trade contractor have or have not been completed by each of their trade partners. Builders Challenge items are indicated throughout the scopes of work and checklists. **They are denoted by a gray highlight.** In addition, a note in italics accompanies the provision noting which Builders Challenge Quality Criteria the item addresses. For example, *[BCQC-2]* stands for Builders Challenge Quality Criteria item number 2.

DESIGN AND SPECIFICATION PREREQUISITES

In order for the framing contractor to properly execute his job requirements in a safe, efficient, and professional manner, the following *Design and Specification Prerequisites must be in place*:

Design

- Structural framing of the exterior walls follows as many advanced framing techniques as is structurally possible (eliminating non-structural studs, cripples, and full-stud drywall backing and replacing them with smaller dimension lumber and/or cavity insulation).
- All exterior wall framing layouts are part of the construction documents. A detailed framing plan showing all exterior wall framing is in the Architectural Drawings. A detailed framing plan shows every stud, cripple, plate, and header as shown in Figure 8, Figure 9, and Figure 10.



FIRST FLOOR PLAN / DETAILED WALL LAYOUT
SCALE 1/8" = 1'-0"

Figure 8: Detailed Wall Framing Layout Example
Courtesy of Steve Baczek

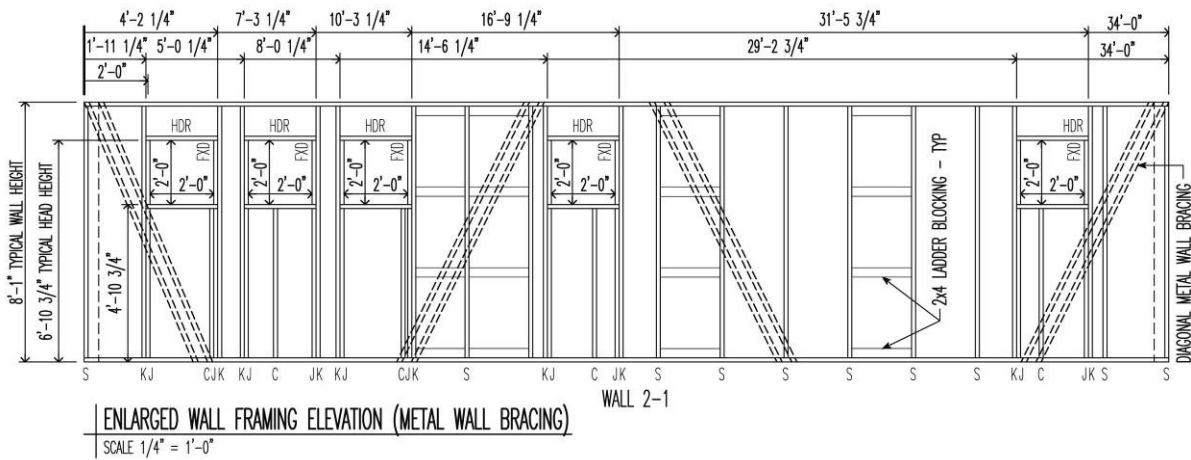


Figure 9: Braced Wall Panel – Diagonal Metal Bracing
Courtesy of Steve Baczek

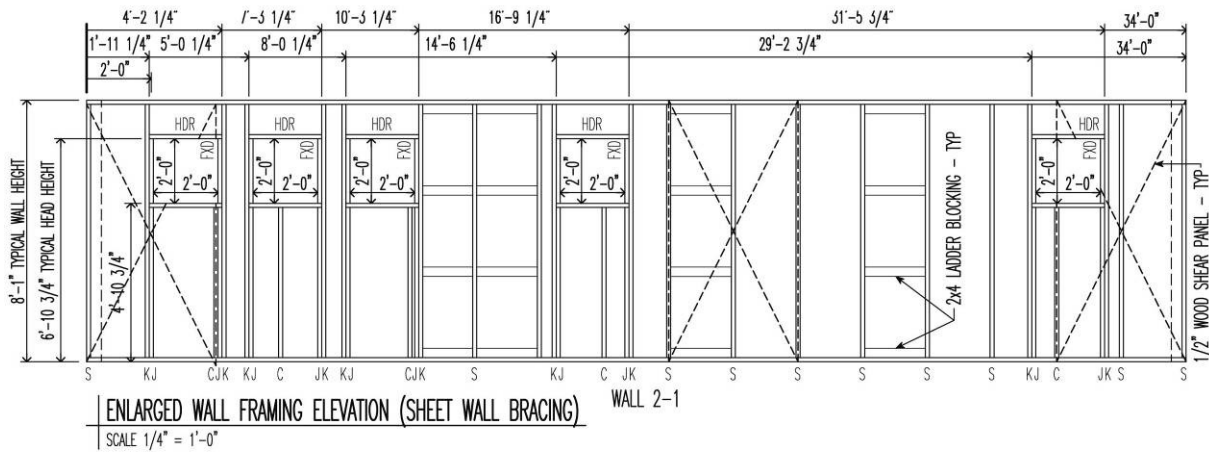


Figure 10: Braced Wall Panel – Intermittent Bracing
 Courtesy of Steve Baczek

- All sheathing that is intended to enclose cavity insulation on all six sides (except top-floor ceiling/attic cavity insulation) is identified and shown on the Architectural Drawings and complies with the EPA ENERGY STAR[®] Thermal Bypass Checklist.
- All chases for ductwork are shown on Architectural Drawings. Construction documents showing sheathing and/or gypsum board are required to be installed by framer behind chases and/or above bulkheads, tray ceilings.
- Complete floor framing layouts are part of the construction documents, with all HVAC chases and runs identified and sized with the appropriate floor framing members (i.e., open web floor trusses as required for the actual duct size running through the floor framing).

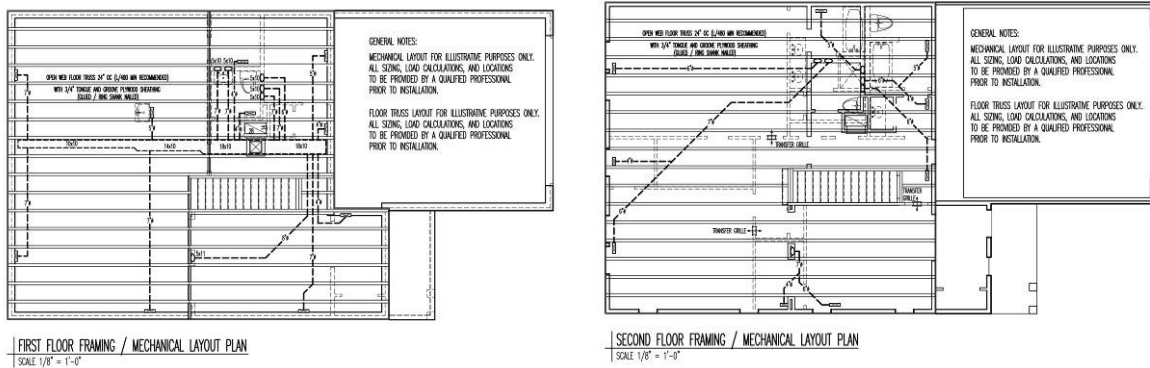


Figure 11: Detailed Floor Framing and Mechanical Layout
 Courtesy of Steve Baczek

- The HVAC engineer or contractor has sized all elements of the HVAC system. See Scope of Work Design and Specifications Prerequisites for HVAC contractor.

Recommended Specifications

- Frame (2x4 or 2x6) and sheathe exterior walls with minimum ½” insulating sheathing plus any structural sheathing or other shear resistance method that is required by local code to provide layer of continuous insulation and enhance air tightness of wall assembly
- Use a capillary break such as 6-mil poly, 15# felt paper, asphalt coating, rubber membrane, or foam sill sealer between all framing and concrete or masonry material [BCQC-2]
- If the HVAC layout assumes that open web floor trusses will be used, the free and clear linear dimensions within the truss webs must be sufficient to accommodate the duct diameters indicated in the HVAC layout. Shop drawings from the truss manufacturer can be used to verify the free and clear linear dimensions. Alternately, the architect and HVAC engineer/HVAC contractor can determine that this specification is met
- To be verified at Startup Meeting:

Trade Builder N/A

- | | | | |
|--------------------------|--------------------------|--------------------------|---|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Plans are complete and show critical dimensions |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Plans include wall and floor framing layouts showing all components—studs, cripples, headers, plates, drywall stops [BCQC-3] |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Wall bracing method and materials are clearly shown on architectural plan [BCQC-3] |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Wall framing layouts include air sealing details for all thermal bypasses per the EPA ENERGY STAR® Thermal Bypass Checklist [BCQC-16] |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | All chases for ductwork, bulkheads, and tray/coffered ceilings are shown on Architectural Drawings with provisions for air sealing specified [BCQC-6] |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Floor framing layout includes all HVAC duct runs [BCQC-6] |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Framing measurements on the floor plan match the foundation plan |

Framing

Job Ready Checklist

Prior to commencement of work, the trade contractor and site supervisor must complete this form together. The trade contractor shall ensure that the Builder, the Construction Manager, or other designated representative of the Builder's management team has a final copy of the completed checklist.

Builder and trade contractor verify that:

Trade Builder N/A

- Building permit is clearly posted
- Readable sign identifying lot number and street address is in place
- Full accessibility to the site is established, including gravel pad or clear driveway
- Silt fence is in place
- Site is clear of debris
- Concrete basement, slab, garage, and porches are complete
- Foundation/slab has been checked for level and square. Any foundation or slab more than ¼ inch out of level must be repaired by concrete contractor before work can continue. (No shimming exceeding ¼ inch is permitted.)
- Form boards have been removed
- Plans are complete and show critical dimensions. Any redline changes have been incorporated into a final plan set. Verify that last revision to plans, specs, and options is current
- Manufacturer's garage door installation instructions are onsite and available to trade contractor
- Placement of sub-slab plumbing or drainage pipes, anchor bolts, and hold down layouts match the plans
- Any anchor hold downs mistakenly placed in doorways have been removed without damaging the foundation wall
- Temporary electrical service is available
- Sewer, water, electrical, and gas laterals are complete
- An area has been designated for lumber delivery and stacking
- Lumber drop is located to be easily accessible to the framer, about 5 to 6 feet from the house foundation, and out of the way of other work in progress
- Enough lumber has been delivered for framer to work for at least 1 to 2 days

Framing - Job Ready Checklist (cont.)

Trade Builder N/A

- Stockpiled lumber and other framing materials are protected from damage, theft, and weather. Top sheets of plywood may be nailed or bundled together to prevent theft
- An area designated for trash and debris has been identified
- Construction waste management plan has been consulted and proper handling of clean wood waste is known
- There is no damage to curb/road or existing foundation/utilities

Incomplete Items

Date Completed

_____	_____
_____	_____
_____	_____
_____	_____

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature	Date:
Builder Company Name	Date:
Trade Contractor Signature	Date:
Trade Contractor Company Name	
Site Address	

Framing

Detailed Job Requirements and Tolerances for the Field

GENERAL REQUIREMENTS AND TOLERANCES

- Verify completion of the *Job Ready Checklist for Framing*
- Perform all work within the guidelines specified in the contract, plans, applicable building codes, appropriate span charts, and the *Homeowner Handbook* (or applicable warranty program of the builder)
- Notify Builder or Builder's representative in writing immediately if any part of the specifications/plans do not meet the locally adopted building code
- Perform all work in accordance with the following high performance design intents, as expressed on the plans:
 - Maximize cavity insulation by framing exterior walls according to the wall framing layout plan [BCQC-3]
 - Facilitate the installation of a continuous air barrier by framing details related to air sealing according to the wall framing layout plan and in compliance with the EPA ENERGY STAR™ Thermal Bypass Checklist (see: http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/ThrmByChklist_12006.pdf) [BCQC-16]
 - To accommodate ducts within conditioned space, frame all HVAC chases and soffits according to the framing layout plans and employ open-web floor trusses if called out in the framing plans [BCQC-6 (partial)]
 - Complete all work in a manner that respects the efforts and materials of other trades
- Verify that all framing materials, whether builder-supplied or trade contractor-supplied, are in accordance with the size, grade, and species of lumber and sheathing identified on architectural plans and in material specifications. Call any discrepancies between specified size, grade, and species of lumber and lumber on site to the attention of the Builder or Builder's representative
- All delivered lumber has been verified to match size, grade, and quantity listed on the delivery ticket
- Moisture content of lumber, by weight, is 16% or less (verified through random sampling using a probe-type moisture meter, minimum 2 readings per pallet)
- All floor, wall, and roof framing layouts shall be in accordance with the detailed framing layout plan. All framing layouts shall be coordinated with plumbing and mechanical systems. Where discrepancy exists or where no detailed framing plan has been provided, trade contractor shall coordinate layout with the builder or builder's representative [BCQC-3]
- Wherever possible, preserve grade stamp and make stamp visible as lumber is cut and installed
- Where directional stamps exist, all materials shall be installed accordingly. Where directional stamps do not exist, all members shall be installed "crown up" or crown to the outside

- Designate any lumber with unacceptable knots, checks, splits, crooks, bows, twists, or other defects to be used for blocking, bracing, or backing. Bows and twists in dimensional lumber shall not exceed $\frac{1}{2}$ " in 8'; bows and twists shall not exceed $\frac{1}{4}$ " in 8' in window, door, and cabinet framing areas; splits shall not exceed $\frac{1}{4}$ " in width
- Use fastener type and schedule for all structural members as specified on framing plan
- Clean up all materials, trash, and construction debris resulting from the job and deposit in the designated area
- Where a construction waste management plan is in place that requires materials separation for recycling, handle all clean wood waste per the plan

SILL AND FLOOR FRAMING

- Install capillary break and air seal between top of foundation wall and treated sill plate such as foam sill sealer or water impermeable material (rubber membrane, asphalt coating) combined with air seal detail such as silicone caulk [BCQC-2, BCQC-16]

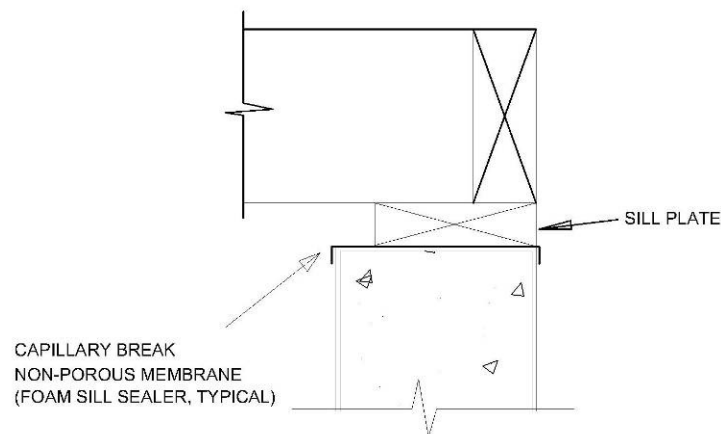


Figure 12: Capillary Break and Sill Sealer

- All flooring joist and other sub-floor framing is to be coordinated with the mechanical systems as well as stair block-outs, fireplace installations, and future deck installations according to framing layouts in the plans
- Verify layout so that joists are not placed under toilet installations
- Shim sill plates and/or band joists as needed to achieve a floor deck level within $\pm 3/8$ " in all directions. All shims shall be metal shims
- Attach straps to the sill and foundation per manufacturer requirements and the local code. Where anchor bolts are used, holes shall be accurately drilled and not exceed bolt diameter by more than $\frac{1}{4}$ "; washers and nuts shall be installed on each bolt
- Splices in built-up beams should occur directly over bearing posts. Proper nailing patterns and nail sizes should be used, according to local codes
- Beams and girders must be straight and level to within $\pm 1/8$ " in 10' or in accordance with manufacturer's specifications

- Joists are to have a minimum bearing of 1½” on wood, and 3” on masonry
- Cuts, notches, or holes bored in solid lumber beams and joists shall be in accord with local building code provisions
- Cuts, notches, or holes bored in engineered beams and trusses are not permitted except as allowed by manufacturer.
- Double trimmer and header joists when span of the header exceeds 4’
- Support the ends of header joists with metal anchors or hangers where they do not bear on a beam, partition, or wall
- Detailing of all floor framing in accordance with the EPA ENERGY STAR® Thermal Bypass Checklist [BCQC-16]

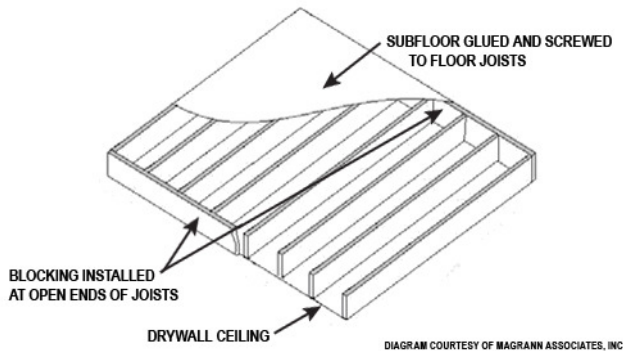


Figure 13: Blocking for Floor over Garage

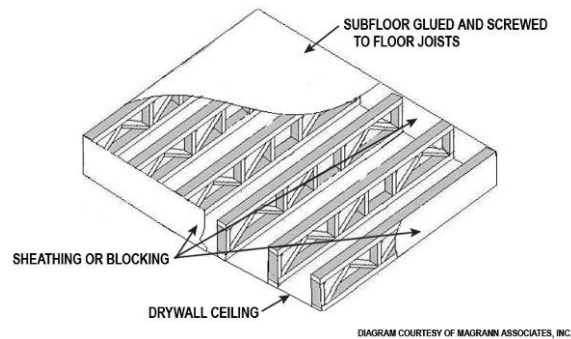


Figure 14: All Edges of Open Web Floor Truss Enclosed

- Where floors are cantilevered, floor framing cavities shall be fully insulated and air sealed using blocking at perimeter and sheathing on underside of joists. Seams and joints to be sealed with caulk, foam, mastic, or tape

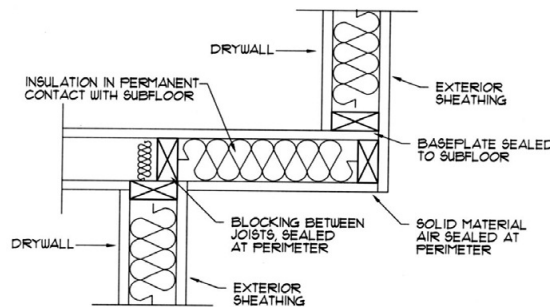


Figure 15: Insulation and Air Barrier Detail at Cantilevered Floor
Diagram courtesy of MaGrann Associates

- Support joists longer than 4’, attached to beams or double headers, with metal anchors or hangers or 2” x 2” ledger strips
- Lap joist framing from opposite sides of a beam, girder, or partition at least 3”
- Install and brace floor trusses in accordance with engineered design

- Stagger subfloor joints; align all subfloor panels to break on the center of a joist; ensure that the ends of all subfloor panels are fully supported
- Glue subflooring at all fastening lines with construction adhesive and space wood screws 6" o.c. on the edges and 12" o.c. in the field. Follow local building code and/or manufacturer requirements for screw specification and fastening pattern where available. Assure proper performance of adhesive by following manufacturer's instructions regarding fastening time, temperature and moisture conditions
- If subflooring is not tongue-and-groove, allow a 1/8" gap around perimeter of subflooring to allow for swelling

WALL FRAMING

- Use dimensional lumber of species, grade, size, and spacing specified on framing plan
- Where walls sit directly on concrete slab:
 - Use pressure treated plate material for bottom plates
 - Use foam sill sealer or other non-porous material, such as rubber membrane, 15# felt, 6-mil poly, as capillary break between concrete and framing material. (NOTE: This detail applies to vertical framing in contact with concrete at all steps in the foundation) [BCQC-2]
 - Where straps are specified, attach straps to the pressure treated bottom plate with two-8d nails into the edge of the plate, and four-4d nails into the top of the plate. Nails shall be stainless steel or triple galvanized
- When a single top plate is used, tie wall sections together with a 3"x6" galvanized steel plate with six 8d nails into each section or as specified by local building code [BCQC-3]
- Brace walls during the course of construction
- Jack studs must be cut accurately to fit tightly against headers. Any space should be shimmed with metal shims to ensure proper bearing
- Install properly sized headers per specifications on framing plans and in compliance with local code requirements [BCQC-3]
- Wind-brace walls per framing plans and in compliance with local code requirements for shear resistance
- Nail wall sheathing per manufacturer's specifications and local building code requirements. Wood-based sheathing must be gapped 1/8" at all seams
- Install rigid insulating sheathing in conjunction with structural panelized sheathing or structural diagonal bracing as specified on framing plan
- If plans indicate that insulating sheathing is to serve as a continuous exterior air barrier, tape all seams with manufacturer-specified taping material [BCQC-2, BCQC-16]
- Walls shall be plumb and square to within $\pm 1/8$ " per 8'
- Door openings shall be plumb and square to within $\pm 1/8$ " per 8' and sized within 1/8" of dimensions specified on framing plans

- Window openings shall be plumb and square to within $\pm 1/8$ " per 4'. Openings shall not be smaller than the dimensions specified on framing plans and shall not exceed those dimensions by more than $1/4$ "
- Fire-block chases and fur-downs between floors per local building codes
- Install garage door trim and backing to mount door rails and spring per garage door manufacturer installation requirements. Garage door openings to have double jack studs on each side
- Frame the tub/shower area to prepare for the unit size specified on framing plan. All walls must intersect at true right angles
- On exterior walls, sheathe the interior of the framing members behind the shower or tub enclosure with a solid material that blocks airflow such as fibrous laminated sheathing to provide a stop for loose fill insulation and to create a six-sided enclosure for the continuous air barrier of the building envelope. If cavity will be inaccessible for installation of insulation, install insulation prior to enclosing the framing cavity with sheathing [BCQC-16]

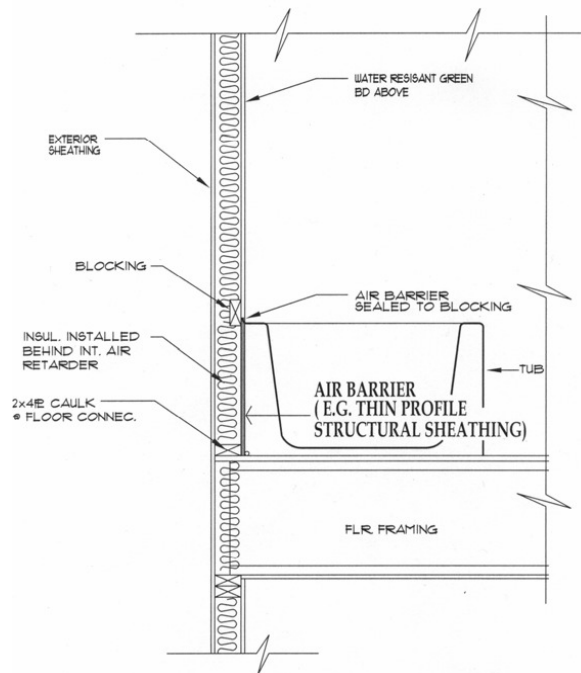


Figure 16: Air Barrier Behind Tub on Exterior Walls
Diagram courtesy of MaGrann Associates

- Provide continuous vertical load path beneath all point loads
- Place multiple studs under load bearing beams or girders as indicated on framing plan
- Install purlin bracing mid-span on walls greater than 9 feet in height
- Exterior wall behind framing for fireplace insert is fully insulated and air sealed with all joints caulked, foamed, or taped [BCQC-16]

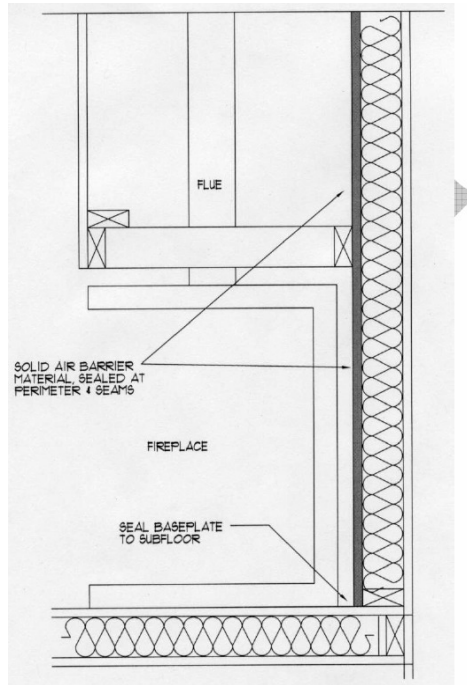


Figure 17: Fireplace Air Barrier and Insulation System
 Diagram courtesy of MaGrann Associates

- Install sheathing on back side of knee walls adjoining attic space and continuous top and bottom plate. Tape, caulk, or use adhesive to seal sheathing at perimeter and seams [BCQC-16]

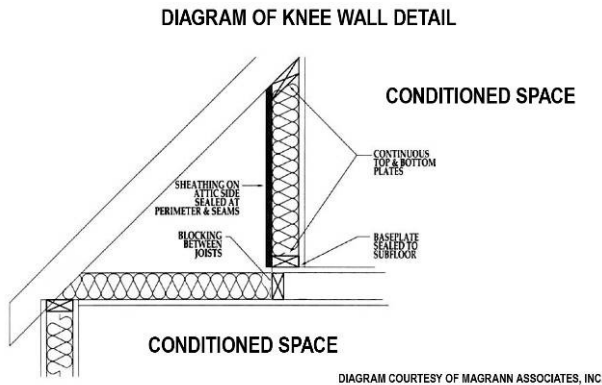


Figure 18: Knee wall Air Sealing Detail

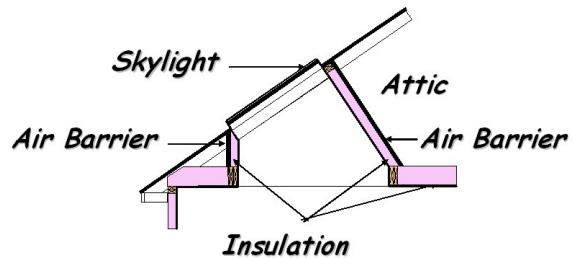


Figure 19: Skylight Well Air Sealing Detail

- Where stairway abuts an exterior wall, install air barrier below stairs, gypsum board typical. Base of air barrier to be taped/sealed at subfloor and all joints sealed [BCQC-16]

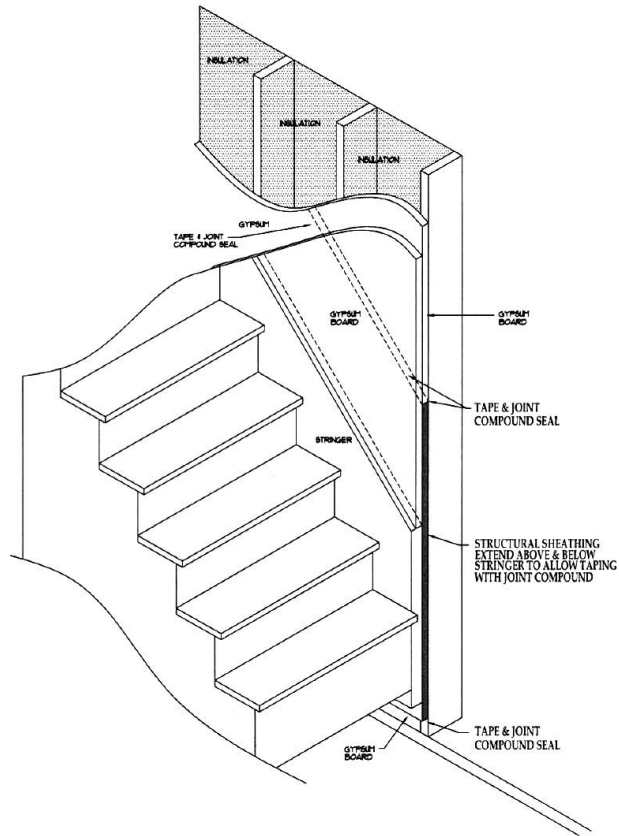


Figure 20: Staircase Air Barrier Detail
Diagram courtesy of MaGrann Associates

- Install deck bands in the proper location per the framing plan. Deck bands should be attached to solid rim joists with carriage bolts and nuts and washers per local codes
- Deck bands must be flashed to prevent water damage to all adjacent framing; see Deck Band figure for possible techniques which include building the deck structure independent of (unattached to) the house structure or by supporting the deck band with posts and then using spacers to separate the deck band from the house rim joist
- Complete plant shelves, half walls, knee walls, and pony walls per framing plan. The first stud of a half wall must extend through the floor and be securely attached to a floor joist for added strength
- Provide blocking for cabinet and handrail supports at 36", 54", and 72". Handrails blocked at 36"-38" above finished floor

STAIRWAYS

- Provide stairway(s) between floors as shown on architectural plans. Where stairs or balcony are open to floor below, a temporary railing must be installed
- Where stairs are adjacent to a wall, nail wall studs to stair stringers
- Permanent stairways shall be constructed in accordance with local building code with specified dimensions and tolerances

CEILING FRAMING

- Plumb, straighten, and brace walls before setting ceiling joists
- Install properly sized ceiling joists as specified on the framing plan and the local building codes
- Provide continuous vertical load path beneath all point loads
- Install correct size and type of metal anchors or hangers for ceiling joists as specified on framing plan
- Fire-stop chases and fir-downs at the ceiling/attic level
- Provide air barrier at dropped ceilings, coffered/tray ceilings, and soffits at underside of ceiling joists and to interior face of studs in exterior wall [BCQC-16]

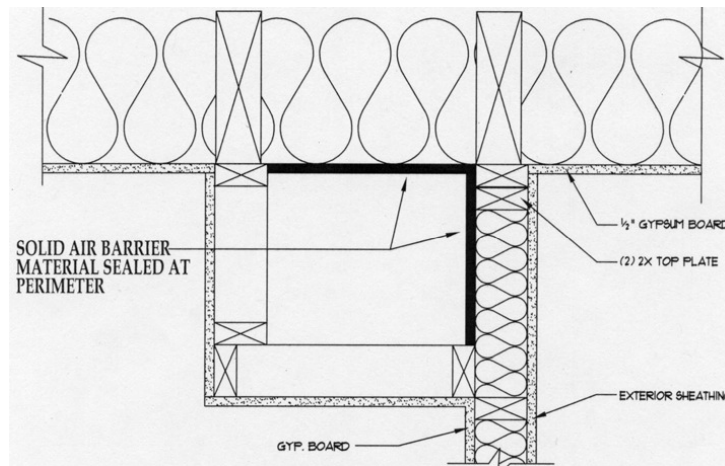


Figure 21: Soffit Capped by Air Barrier
Diagram courtesy of MaGrann Associates

- Install 2x4 and 2x6 L-shaped strong backs at the center of all ceiling joists having spans over 10'. Strong backs must extend gable wall to gable wall
- Tie ceiling joists securely together where they meet at center wall (3-10d nails). Tie ceiling joists securely to parallel rafters at exterior walls (3-10d nails). Tie ceiling joists securely to walls upon which they rest (3-8d nails)
- Size rough opening for attic access or stairs per the framing plan and local building code
- Provide adequate nailing surface for drywall or verify that drywall clips will be used

ROOF FRAMING

- Plumb, straighten, and brace walls before setting roof trusses or rafters
- Install temporary bracing to keep trusses and rafters from racking while installation is in process
- Install permanent bracing as indicated on truss manufacturer drawings
- Install diagonal bracing on gable-end walls that extends from the roof peak to a bearing wall

- Set trusses and rafters/ridge board to maintain straight line at roof ridge and fascia along eaves
- Cut rafter tails to the style and length of overhang specified on architectural plan
- Provide ridge, hip, and valley framing members that are 2" deeper than rafters and jacks to allow for full bearing
- All rafters must bear fully on the top plate
- Brace ridge, hips, and valleys to a load-bearing wall, at both ends, and every 8' or as specified on framing plan. Brace all splices in rafters, ridges, and valleys to a load-bearing wall
- Install purlins per code and support by T-brace 48" on center to load bearing wall at 45 degree maximum angle
- Tie parallel rafters and ceiling joists together where they join at exterior walls (3-10d nails). Tie rafter to plate (toenail – 2-16d nails or hurricane bracing as specified on structural plans)
- Connect perpendicular rafters and ceiling joists with rafter ties
- Brace and support rake overhang by securing outriggers to first standard truss and extending them out over a "reduced height" gable end truss

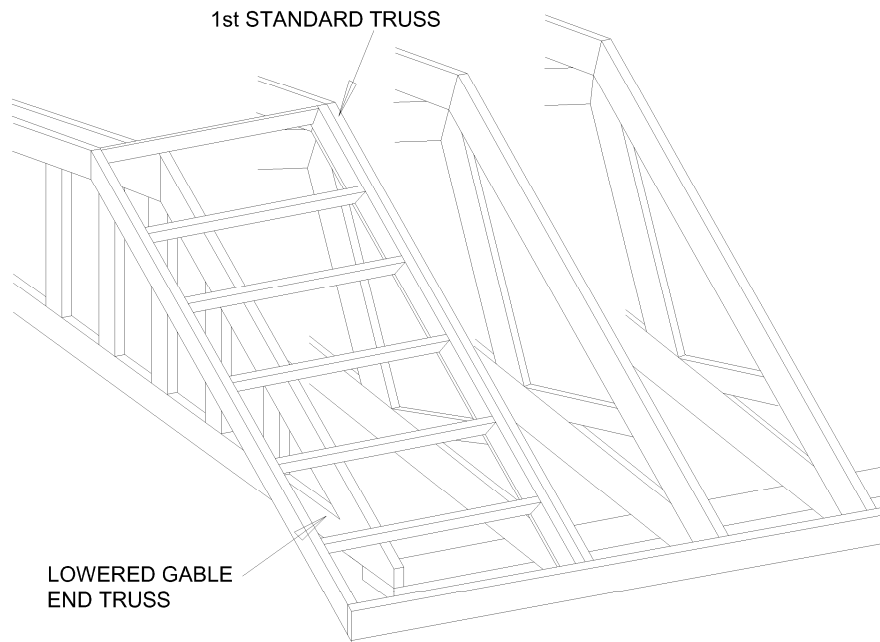


Figure 22: Rake Overhang Detail

- Nail roof sheathing with a minimum of 8d common or galvanized box nails, with spacing as required by local code per wind speed and seismic area. Keep nails at least 3/8" from the edges of the panels

- Use H-clips to support mid-span edges of sheathing where rafter spacing is greater than 16". Ensure sheathing is gapped to meet manufacturer's instructions.
- Provide a 1½" – 2" gap in the sheathing at the peak of the roof when ridge vents are specified. Top course of roof sheathing shall be no less than 12" in width
- Roof ventilation is cut in per architectural plans in the upper one-third of the roof unless insulated attic and unventilated roof are specified
- Install fire blocking for chases at rooflines, between floor levels, at intervals not exceeding 10', and/or as specified by local building code. Chases must be adequately braced and anchored
- Install roof saddles or crickets on the upper side behind chases or chimneys
- Verify roof deck surfaces are dry and free from ridges, warps, or voids. Broom clean surfaces
- Install roofing underlayment over roof sheathing and on top of drip edge within 24 hours of roof sheathing installation or prior to any significant precipitation, whichever comes first

Framing

Job Complete Checklist

This list is to be reviewed by the Builder/Superintendent and the Framing Contractor to verify that the job site is ready for Trade Contractor work—subsequent to the Framing Contractor work—to begin. The trade contractor shall ensure that the Builder, the Construction Manager, or other designated representative of the Builder's management team has a final copy of the completed checklist.

NOTE: Many if not most of the items called out below would be accomplished by following the plans or the building code. Items are called out in the Job Complete Checklist as further verification of proper completion because many of these items have proven to be problematic and, therefore, require a double check.

Builder and trade contractor verify that:

Trade Builder N/A

- All loads are fully transferred to the concrete foundation or basement floor footer pads as indicated on the plans
- Any and all basement load bearing walls are located per the plans
- Any and all basement load bearing walls have a capillary break, such as rubber membrane, 15# felt, 6-mil poly, between the bottom plate and the concrete slab including wherever vertical studs are in contact with concrete at steps in foundation wall [BCQC-1 Verifier]
- All piers have proper shimming; i.e., shimming that has at least the compressive strength as the beam bearing on the shim
- All headers are sized per the framing plan; i.e., as large as is required for the load but no larger than is required [BCQC-3 Verifier]
- All headers are at correct height for rough opening
- All walls are flush with floor systems at two-story foyers and stairs
- The EPA Thermal Bypass Checklist has been completed for the job [BCQC-16 Verifier – also review completed TBC]
- All fire stops, particularly at the chimney, have been installed
- All garage door openings have double jacks
- Any garage stairs are in place and clearance for cars is verified
- Shear bracing (structural panels or other techniques as indicated on the plans) is in place and nailed off per the pattern required on the plans
- All structural flooring is sufficiently planar to meet the needs of finish flooring with underlayment, particularly at direction changes in the floor framing
- All kitchen and bath wall framing is plumb within a 1/8" in 8' tolerance for cabinets

Framing - Job Complete Checklist (cont.)

Trade Builder N/A

- Any kitchen windows are centerlined correctly in terms of subsequent cabinetry and finish plumbing layout
- Stairs have finished uniform riser heights, taking into consideration finished treads and flooring
- Stair stringers are fully supported per the plans
- Full finished head height at stairs is a minimum of 6'-8"
- All capillary breaks called out on the plans have been installed [BCQC-1, BCQC-23 Verifier]
- No unapproved material substitutions have been made in the frame of the building

Incomplete Items

Date Completed

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature

Date:

Builder Company Name

Date:

Trade Contractor Signature

Date

Trade Contractor Company Name

Site Address

HVAC

Design and Specification Prerequisites

INTRODUCTION

In a high performance HVAC system, designing an HVAC system that performs well by efficiently delivering conditioned air where it is needed, maintaining consistent temperatures throughout the house, providing adequate dehumidification, and maintaining a high level of indoor air quality is equally as important as selecting high-efficiency equipment. Further, to ensure a high level of performance, system design and equipment selection must employ the latest industry standards and information about high performance equipment so that a minimum amount of energy is used to produce the maximum amount of comfort. One such industry standard is the latest version of ANSI ACCA Standard⁹, that, though not a scope of work is a valuable resource for acceptable specifications, procedures, and protocols related to designing, installing and testing the HVAC system.

GOAL OF THIS HIGH PERFORMANCE SCOPE OF WORK

The goal of a High Performance HVAC Scope of Work is to facilitate the design and installation of an HVAC system that delivers the maximum performance using the minimum amount of energy. Maximum performance is defined as temperature and humidity levels within the home that achieve occupant comfort at reasonable cost.

BUILDERS CHALLENGE

A builder may also use the scope of work to verify that the Builders Challenge criteria relevant to each trade contractor have or have not been completed by each of their trade partners. Builders Challenge items are indicated throughout the scopes of work and checklists. **They are denoted by a gray highlight.** In addition, a note in italics accompanies the provision noting which Builders Challenge Quality Criteria the item addresses. For example, *[BCQC-2]* stands for Builders Challenge Quality Criteria item number 2.

DESIGN AND SPECIFICATION PREREQUISITES

In order that the HVAC contractor can properly execute his job requirements in a safe, efficient, and professional manner, the following *Design and Specification Prerequisites must be in place*:

System Design

- Room-by-room heating and cooling load calculations have been performed using industry accepted practices (e.g., ACCA Manual J or equivalent) *[BCQC-5]*
- Equipment has been sized and selected according to industry accepted practices (e.g., ACCA Manual S) *[BCQC-6]*

⁹ ACCA Standard Number: ANSI/ACCA 5 QI-2007. This standard is updated every five years and is available online at www.acca.org.

- Cooling equipment capacity does not exceed the calculated cooling load by more than 15% (25% for heat pumps when heating load exceeds cooling load) [BCQC-5]
- Gas heating equipment is sized as closely as possible to the calculated heating load, with a maximum capacity of 140% of total heating load. If single-stage gas furnace equipment within this size range is not available, then multiple-stage gas furnace equipment having a variable speed indoor fan motor shall be used
- Indoor and outdoor coils are matched and listed in the CEE-ARI Directory of Certified Equipment (www.ceehvacdirectory.org)
- Equipment is selected to meet the design sensible load at not more than the ASHRAE 1% cooling design outdoor conditions and not less than the indoor conditions of 75°F dry bulb and 50% relative humidity (also see ACCA Manual J for heating and cooling design temperatures). Heating design conditions should be based on and not higher than the ASHRAE 99% heating design outdoor conditions. [BCQC-5]
- Air distribution equipment is located within conditioned space whenever possible [BCQC-15]

System Design–Configuration

- Architect and HVAC contractor have agreed and produced an HVAC layout, in accordance with *ACCA Manual D* and *ACCA Manual T* or equivalent, that clearly indicates [BCQC-5, BCQC-6]:
 - HVAC equipment location
 - Location and sizing of the following air delivery components:
 - Plenums
 - Trunks
 - Ducts
 - Registers
 - Grilles
 - Location of thermostat(s) [BCQC-6]

System Design–Ducts

- As much as possible, the air distribution system is contained within the conditioned envelope of the home. Any ducts outside the conditioned space must be insulated to at least applicable code levels with special care taken to seal all joints and connections with code approved mastic or UL 181A/B approved foil tape [BCQC-15]
- Complete floor framing layouts are part of the construction documents, with all HVAC chases and runs identified and sized with the appropriate floor framing members (i.e., open web floor trusses as required for the actual duct size running through the floor framing) [BCQC-6]

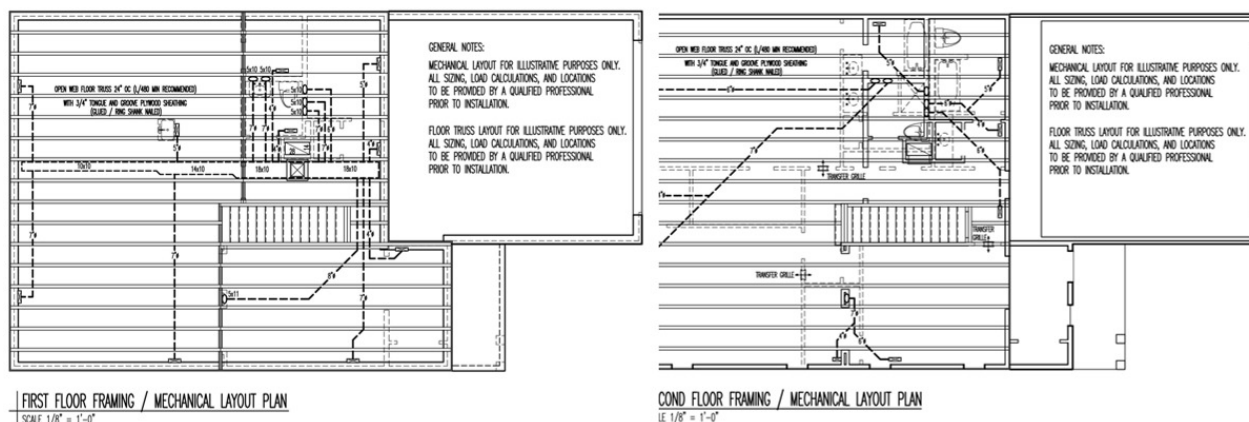


Figure 23: Detailed Floor Framing and Mechanical Layout

Courtesy of Steven Baczek

- All chases for duct work are shown on Architectural Drawings [BCQC-6]
- No duct is located within an exterior wall cavity unless equivalent insulation is installed and detailed air sealing is performed behind ductwork
- The entire air distribution system, including supply and return ducts, is “hard” ducted. Panned joist or wall cavities do not serve as air ducts
- Any portion of the duct system that is outside of the conditioned envelope shall be insulated to at least local code levels. R-8 duct insulation is recommended
- Where access is feasible, manual blade dampers will be located at the takeoffs to facilitate more precise airflow balancing than is possible with supply register adjustments
- The duct system includes:
 - At least one ducted return for each story of a multi-level home
 - Transfer grilles or jump ducts between each room having a door and the central area having a return duct. (Normal door undercuts of about 1/2” are expected, but undercutting interior doors will not provide sufficient return airflow.)
 - A ducted return for each room, which has a door and more than 250 cfm of supply air. A dedicated return will eliminate the need for the large jump duct needed to accommodate more than 250 cfm (which would be larger than 12” diameter and may create aesthetic issues)
- If ducts are located in a vented attic, do not bury them directly under full insulation. This practice has been shown to cause moisture problems due to condensation on the outside surface of the duct during warm-humid outdoor conditions
- Select and size air distribution components (e.g., return and supply grilles, registers, and diffusers) using *ACCA Manual T: Air Distribution Basics for Residential and Small Commercial Buildings*

System Design–Refrigerant Lines

- Diameter and length of lines are sized to meet manufacturer specifications. Lines should be no longer than 50 feet horizontal or 20 feet vertical without specifically consulting the manufacturer's specifications

Cooling and Heat Pump Equipment

- Air conditioning equipment components are matched and listed at the CEE/ARI directory <http://www.ceedirectory.org/ceedirectory/pages/cee/ceeSearchMain.aspx>. For higher efficiency rated equipment see the CEE directory at <http://www.ceeHVACdirectory.org/ac.php>. For ENERGY STAR rated equipment see http://www.energystar.gov/index.cfm?c=cac.pr_central_ac for a list of qualifying ENERGY STAR rated central A/C units.
- Minimum SEER 14-15, HSPF 8.2-9.0 recommended for heat pumps
- Air handler airflow should be 350-400 CFM/ton for the mixed-humid climate
- Variable speed air handlers are recommended, particularly for humid climates

Thermostat

- A 7-day programmable thermostat bearing the ENERGY STAR™ label should be installed

Combustion Equipment

- Gas furnaces recommended to be direct vent condensing furnaces labeled by ENERGY STAR™
- Minimum recommended AFUE rating of gas-fired heating equipment: 90%
- Minimum recommended AFUE rating of oil-fired furnaces: 83%

Humidity Control

- Supplemental dehumidification for high-performance homes in the mixed-humid climate should provide between 40 and 90 pints per day of latent cooling capacity (a maximum of 60% RH). Systems can be stand-alone or integrated into the heating and cooling system [BCQC-7]
- Duct system humidifiers are recommended for use during heating season and should be controlled by a humidistat

System Installation

- Installation procedures in accordance with the ACCA HVAC Quality Installation Specification or similar should be specified [BCQC-8]
- A copy of training and qualifications of trade contractors and technicians (e.g., certificates) should be included within the trade contract documentation

HVAC Rough-In

Job Ready Checklist

Prior to commencement of work, the Builder/Superintendent and Trade Contractor verify that:

Site Conditions

Trade Builder N/A

- | | | | |
|--------------------------|--------------------------|--------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Building permit is clearly posted |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Readable sign identifying lot number and street address is in place |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Full accessibility to house established, including gravel pad or clear driveway |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | House is clean and free of debris |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | House is dried-in and roofing is installed |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Electricity is available |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Plumbing rough-in is complete and plumbing lines for HVAC are in proper location |

Documentation Required

Trade Builder N/A

- | | | | |
|--------------------------|--------------------------|--------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Purchase order |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Mechanical permit, if required |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Current set of plans (Record date on plans: ___/___/___) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Final framing plan |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | HVAC plan including the following, clearly marked |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | HVAC equipment location |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Location and sizing of air delivery components <i>[BCQC-6 Verifier]</i> <ul style="list-style-type: none">• Plenums• Trunks• Ducts• Registers• Grilles |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Location of thermostat(s) |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Documentation of room-by-room load calculations (e.g., ACCA Manual J report or equivalent) <i>[BCQC-5 Verifier]</i> |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Copy of CEE-ARI and/or GAMA certificate/certification record of matched HVAC equipment |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Locations of indoor and outdoor equipment are clearly marked and accessible |

HVAC Rough-In - Job Ready Checklist (cont.)

Documentation Required (cont.)

Trade Builder N/A

- Equipment locations allow adequate clearance from walls and other equipment for cleaning, filter replacement, and repairs
- Outdoor unit location is away from dryer vents, decks, and windows as well as away from eaves where excessive snow and ice is likely to fall
- Specified locations of indoor and outdoor units have been accounted for in the appropriate sizing of refrigerant line according to manufacturer's instructions
- Duct chases have been framed in allowing adequate space for duct installation
- Approved supported equipment pad is level and in place for outdoor unit placement. (Phase 2 Finish)

Incomplete Items

Date Completed

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature	Date:
Builder Company Name	Date:
Trade Contractor Signature	Date:
Trade Contractor Company Name	
Site Address	

High Performance Central Forced Air Heating and Cooling System

Detailed Job Requirements and Tolerances for the Field

GENERAL PROVISIONS

- Notify Builder or Builder's representative in writing immediately if any part of the specifications/plans do not meet the locally adopted building code

PROVISIONS SPECIFIC TO HVAC ROUGH-IN

Framing

- When it is necessary to cut into engineered framing lumber, manufacturers instructions must be followed explicitly. If manufacturer's instructions are not available, approval of a registered design professional is required
- Notches or holes in any load-bearing, solid framing member must follow the constraints specified in the locally adopted building code or those of the International Residential Code (IRC 2006 Section R502.8)

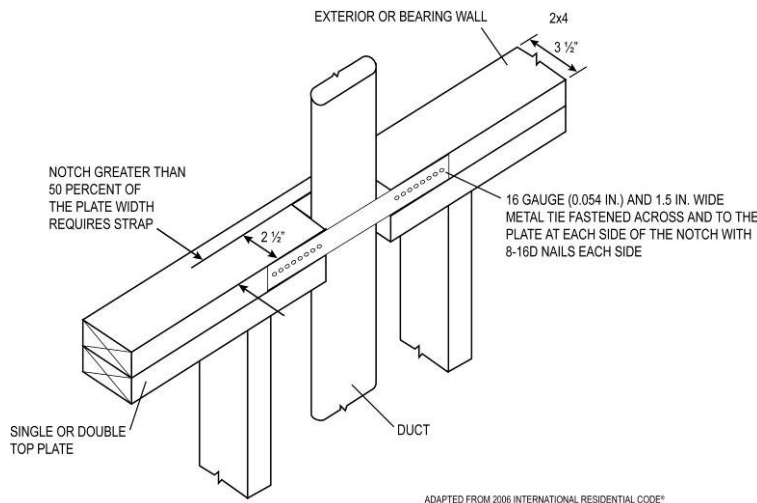


Figure 24: Proper Notching of Wood Framing Members

- In concealed locations where copper or plastic piping is installed through holes or notches in a framing member and piping is less than 0.75 inches from the edge of the member, protect the pipe with a steel shield plate that is at least 0.062-inch-thick. Any shield plate should extend a minimum of 2 inches above sole plates and below top plates

Exterior Penetrations

- Any exterior wall penetrations must be properly flashed and air sealed. Flashing should be installed in a shingled manner integral with the drainage plane. Foam or caulk should be used to seal the over-cut area of the hole.

PROVISIONS SPECIFIC TO DUCT INSTALLATION

- Consult with designer/site supervisor for any deviations from the duct layout plan
- The duct layout plan should use the following guiding principles:
- The entire air distribution system must be formed with approved air duct materials—panned joist or stud cavities are prohibited

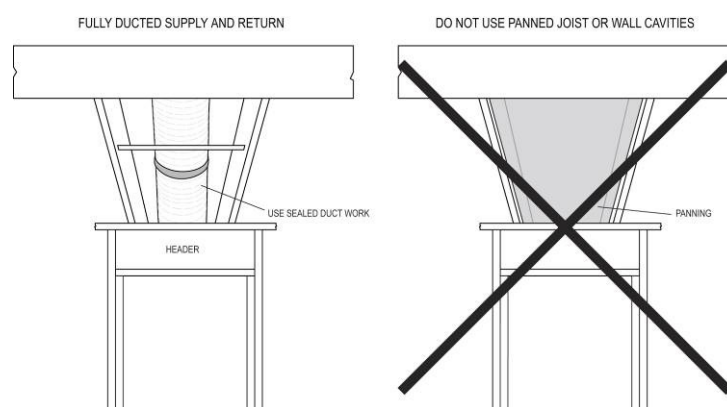


Figure 25: Fully Ducted Air Distribution System

- Use the straightest and smoothest path possible to get from point A to point B. Avoid bends and extra duct length, whenever possible. When using insulated flexible duct, make sure that the inside liner, through which the air flows, is pulled to its full extent to prevent excessive air flow resistance
- Total duct leakage should be limited to 10% of the conditioned floor area at 25 Pa pressure with respect to the house [BCQC-15]
- Duct leakage to unconditioned space should be limited to 5% of the conditioned floor area at 25 Pa pressure with respect to outside (unless all ducts are in conditioned space (i.e. within the air barrier of the house) [BCQC-15]
- Supply airflow to each room should be within 20 CFM of the cooling design value

Flex Duct

- Ducts should be accurately measured and cut to length to minimize slack
- Support flex ducts at least every 4 feet with bands that are at least 1½ inches wide
- Support straps should not constrict the inner core of the flex duct or cut the outer jacket of the flex duct

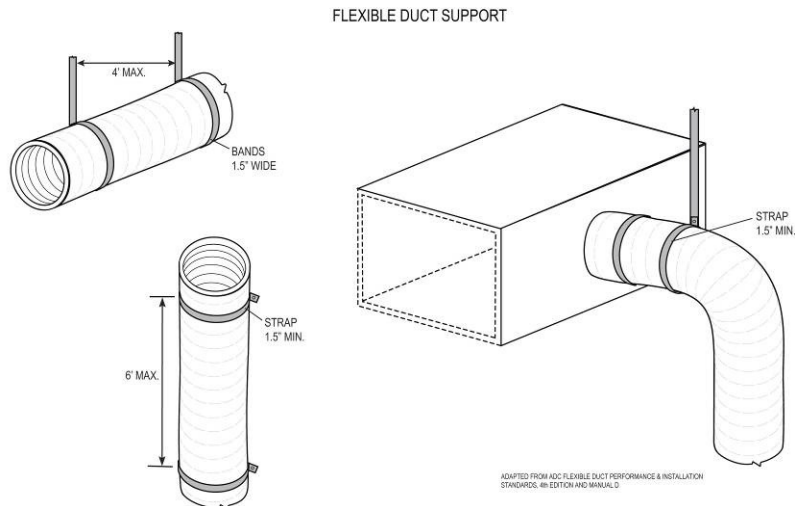


Figure 26: Proper Flexible Duct Support

- Any bend radius should be greater than one duct diameter and no bend shall be greater than 90 degrees

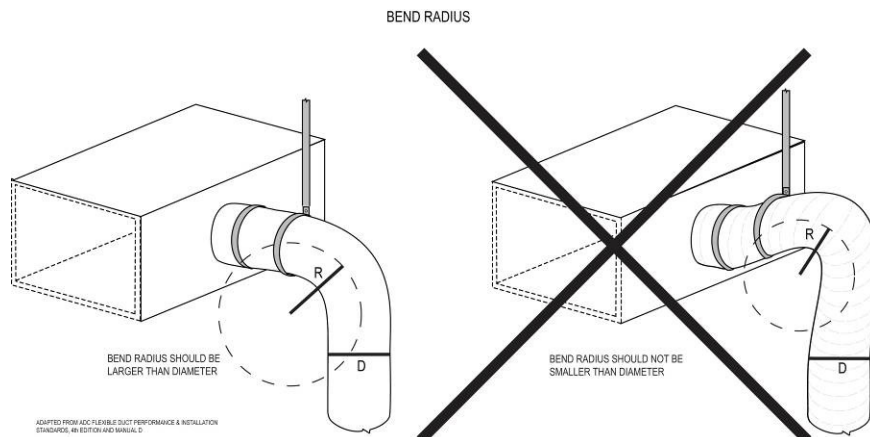


Figure 27: Proper Bend Radius for Flexible Duct

- If possible, install accessible volume dampers at each supply take-off
- Flex duct connections must have mastic, UL 181 A/B foil tape (hereafter referred to as “code-approved foil tape”), or Butyl rubber backed foil tape (also called “foilmastic”) connecting the inner duct to the connecting collar. Wrap tape at least two times around the duct touching at least 1½” of the collar and 1½” of the inner flex duct. Otherwise, install mastic continuously around the collar and secure inner core to collar with nylon duct tie. Secure the insulation and outer vapor retarder to the collar with a duct tie and/or code-approved foil tape

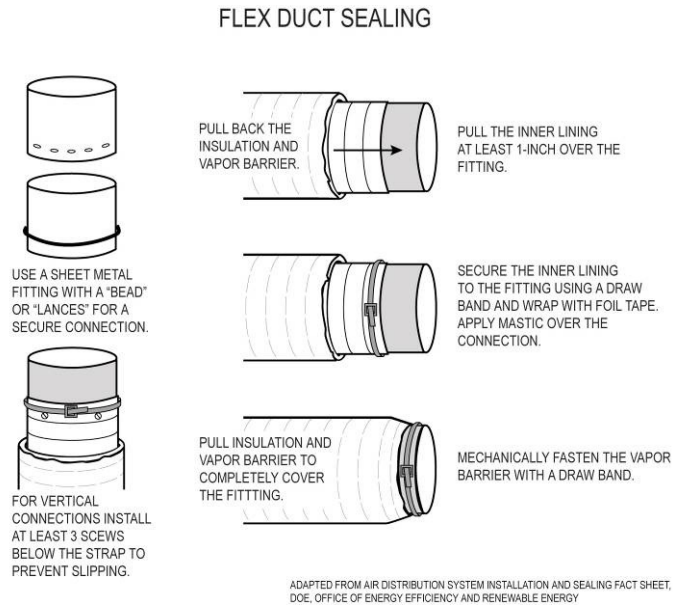


Figure 28: Flexible Duct Connection and Sealing

Fiberglass Duct Board

- Joints in fiberglass duct board should be sealed with code-approved-foil tape and coated with a thin layer of fibered mastic to make sure the tape stays in place

Rigid (sheet) Metal Ducts

- Horizontal sheet metal ducts should be supported at least every 6 feet.
- Mechanically fasten all rigid metal duct joints
- Seal all duct joints and seams using mastic or code-approved foil tape

Jump Ducts or Transfer Grilles

- Install jump ducts or transfer grilles in each bedroom that does not have a dedicated return [BCQC-26]
- Room pressure should not be more than ± 3 Pa with respect to the common area [BCQC-26]

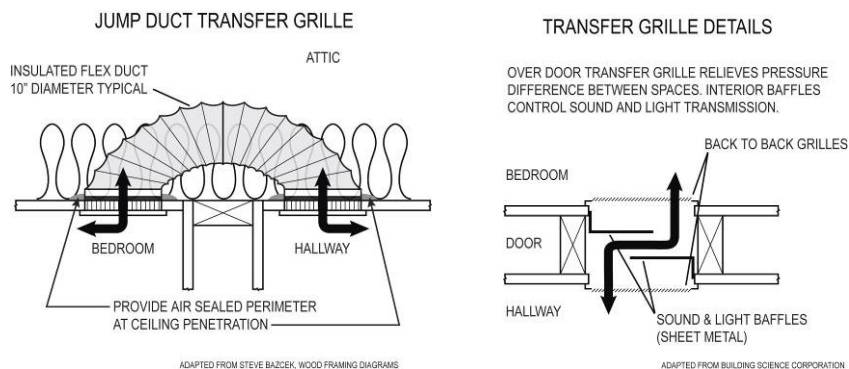


Figure 29: Jump Duct and Transfer Grille Details

Duct Boots

- All duct openings should be square with wall and cut such that finish grilles will fit flush with floor, wall, or ceiling (depending upon location)
- Seal duct boots with caulk or foam sealant to the subfloor or drywall before the register is in place. Material used for sealing the duct boot should not interfere with installing or removing the register

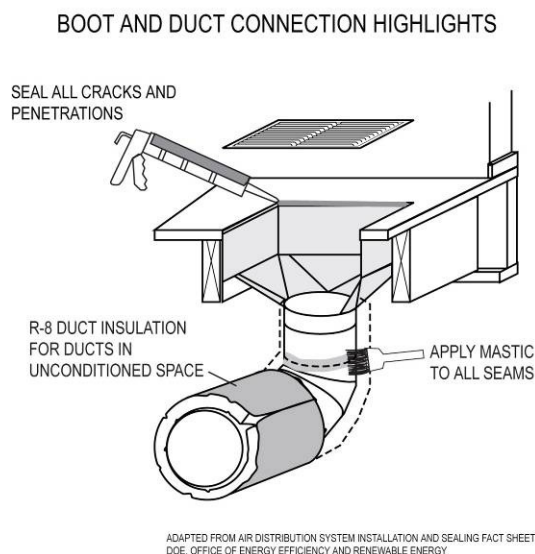


Figure 30: Ductwork and Boot Connections/Insulation

- Seal any seams in the duct boots or elbows with mastic
- Cover all duct boots during construction to keep the ducts clean. Wide tape products, such as those commonly used during duct leakage tests or for protecting carpets, works well for this

PROVISIONS SPECIFIC TO REFRIGERANT LINE INSTALLATION

- Refrigerant line sizing for both liquid and suction lines must be done per manufacturer's instructions. Refrigerant line length, elevation change between indoor and outdoor units, number of bends, and equipment capacity should be taken into consideration
- If possible, do not conceal refrigerant piping in walls and partitions, underground, or under a floor
- Cut refrigerant piping accurately to measurements established at the site, and install without springing or forcing. Installed piping shall be sufficiently flexible to allow expansion and contraction caused by temperature fluctuation inherent in its operation
- When bending, use long sweep bends
- Insulate suction lines with at least 3/8" closed-cell, pipe insulation
- Do not insulate liquid lines

- Insulated lines exposed to the weather must have a waterproof covering that protects against moisture and UV radiation
- When sweating fittings, use solder with 15% silver, and allow a small amount of nitrogen gas to flow inside to prevent carbon scaling
- Leave roughed-in lines with a 150 psi charge of nitrogen gas to keep the lines clean and dry until the indoor and outdoor units are set
- Install refrigerant piping in accordance with ANSI/ASHRAE Standard 15

Condensate Line

- Primary condensate line must be trapped with a clean-out provision and run to an appropriate drain or pump or outside to daylight. When passing through unconditioned space, this line should be insulated with at least 3/8" closed-cell pipe insulation to avoid condensation
- Secondary condensate line must be trapped with a clean-out provision and run to an outside location that will alert the occupants to a primary condensate drain problem

Thermostat

- Choose a thermostat location that will be representative of the space conditions that the system is serving. That location is most commonly on an interior wall away from direct sunlight, direct supply airflow, or other heat source that will adversely affect the temperature measurement. Seal around the thermostat wiring cable where it penetrates the wall to avoid hot or cold drafts that will adversely affect operation

PROVISIONS SPECIFIC TO EQUIPMENT INSTALLATION

Outdoor Unit

- Ensure that unit is per material specifications
- Install unit on level equipment pad placed over compacted soil or stone. Elevate unit to prevent snow blockage for heat pumps or wherever standing water may occur
- Avoid the following locations when placing unit:
 - Beneath eaves where excessive snow or ice is likely to fall
 - Near dryer vents where lint may accumulate
 - Near decks and windows where noise may be problematic
- Provide 36" of clearance to service panel for access
- Provide 12" horizontal and 48" vertical clearance around unit for air to circulate freely

Indoor Unit

Air Handler

- Ensure that air handler is per material specifications

- Provide minimum of 30” of clearance to service panel for access
- Use mastic, code-approved foil tape, or putty to seal any unused holes, wire penetrations, and refrigerant and condensate line penetrations in the air handler cabinet
- Seal access panel seams with code-approved foil tape
- Seal joints between air handler and main supply and return plenums with mastic. If necessary, remove the access panel and seal area from the inside
- All HVAC equipment sealed from the garage by a thermal and air barrier [BCQC-22]

Power-Vent/Direct Vent Equipment

- Follow manufacturer’s instructions and local code requirements for sizing and location of combustion air vents and clearances for exhaust and supply vents

Air Filter

- Locate air filter as close to indoor air coil as possible
- Air filter must be easily accessible by occupants
- Clearly mark air filter location and size
- Air filter housing should have a gasketed cover
- Install minimum MERV 8 filter (account for any additional pressure drop in the duct design) [BCQC-17]

PROVISIONS SPECIFIC TO SYSTEM START-UP

- Using a vacuum gauge capable of reading vacuum level in microns Hg, evacuate the refrigerant loop to the level recommended by the manufacturer (300 to 500 microns Hg is typical) to remove moisture. Shut off vacuum pump and isolate it from the refrigerant loop with valving. Record the system pressure once per minute for at least five minutes in the table below:

Table 2: System Pressure Measurements

	Test 1	Test 2 (conduct only if Test 1 fails)	Test 3 (conduct only if Test 1 and Test 2 fail)
Initial reading (Microns Hg)			
Minute 1			
Minute 2			
Minute 3			
Minute 4			
Minute 5			

Table 3: Commissioning Space Cooling System

Test Result	Test Status	Action
Readings do not rise above 1000 microns	Pass	With system evacuated, add refrigerant charge by weight per manufacturer's specification if necessary to account for actual line set length, then release pre-charge from outdoor unit into system.
Pressure rises above 1,000 microns before stabilizing	Fail	Continue pumping to remove moisture. Repeat test.
Pressure continues to rise within the 5 minute period, does not stabilize	Fail	System has a leak; Fix leak and repeat test.

- If necessary, remove refrigerant by weight per manufacturer's specifications to account for actual line set length
- Operate system for at least 15 minutes and test refrigeration charge using superheat test for fixed orifice metering devices or sub-cooling test for TXV devices. Other methods, such as checking for a cold-to-the-touch suction line entering the outdoor unit, or using rules of thumb about what the pressure gauge readings should be are not sufficient to determine adequate refrigerant charge
- Verify that total air handler airflow is between 350 to 400 cfm per ton of total cooling capacity

SUPPLEMENTAL DEHUMIDIFICATION

Supplemental dehumidification can assure that indoor relative humidity can be controlled below 60% RH year round, which is good for comfort and health. Adequate capacity to achieve 50% RH can be important if the homes occupants are sensitive to dust mites and other allergens. During swing seasons, rainy summer periods, and some summer nights in the Mixed-Humid climate, conventional cooling equipment may not be able to control indoor humidity without either overcooling the space or adding some form of reheat. This problem can be pronounced in very energy efficient homes because the sensible heat load is reduced more greatly by the building's efficiency than is the latent heat load.

- Supplemental dehumidification, in the form of centrally integrated equipment or stand-alone equipment, should provide between 40 and 90 pints per day capacity to meet excess latent load
- Any stand-alone dehumidification equipment should be coupled with cycling of the central air handler to allow mixing of dry air throughout the house

VENTILATION

Scope of work for local and whole-house ventilation is contained in a separate document.

HVAC

Job Complete Checklist

This list is to be reviewed by the Builder/Superintendent and the HVAC Contractor to verify that the job site is ready for Trade Contractor work—subsequent to the HVAC Contractor work—to begin. The trade contractor shall ensure that the Builder, the Construction Manager, or other designated representative of the Builder's management team has a final copy of the completed checklist.

NOTE: Many, if not most, of the items called out below would be accomplished by following the plans or the building code. Items are called out in the Job Complete Checklist as further verification of proper completion because many of these measures have proven to be problematic and, therefore, require a double

Builder and trade contractor verify that:

Framing

Trade Builder N/A

- Notches and holes in lumber are within constraints of local code

Exterior Penetrations

Trade Builder N/A

- Flashing at exterior penetrations is in place correctly

Duct Installation

Trade Builder N/A

- Duct layout plan has been followed. Note deviations from plan: _____
- No ducts are located in exterior wall cavity
- All air distribution is "hard ducted"
- Joints and connections sealed with UL-listed 181A/181B foil tape and/or mastic or foilmastic
- Ducts outside conditioned space are insulated to R-8
- At least one ducted return is provided for each level of the home
- Any ducts in attic are NOT buried under attic insulation
- Duct leakage to the exterior is less than 5% of conditioned floor area or total duct leakage is less than 10% of conditioned floor area when all ducts are in conditioned space [BCQC-15]

Record results:

Conditioned Floor Area _____ square feet

Air handler flow _____ cfm

Total Duct Leakage _____ @ 25 Pa

* Duct Leakage to the Exterior _____ cfm

* Note: For duct systems with ducts in unconditioned space

HVAC - Job Complete Checklist (cont.)

Trade Builder N/A

- Airflow to each room is within 20 CFM of design. Complete the following table:

Table 4: Register Air Flows

Room	Design Airflow	Tested Airflow	Difference (Design-Tested)
Master Bedroom			
Master Bath			
Bedroom2			
Bedroom3			
Bedroom4			
Living room			
Den/Family Room			
Kitchen			
Office			
Bath1			
Bath2			
Bath3			
Basement			
Other			
Other			
Other			

Flex Duct

Trade Builder N/A

- Flex duct is supported at least every 4 feet with bands that are least 1½” wide
- The inner core of the flex duct is not constricted
- Bend radii are at least one duct diameter; no bend is greater than 90 degrees
- Flex duct connections are constructed according to the *HVAC Detailed Job Requirements and Tolerances for the Field*

Fiberglass Duct Board

Trade Builder N/A

- Joints are sealed with code-approved-foil tape, which is coated with fibered mastic
- Butt joints are sealed with code-approved foil tape, which is coated with fibered mastic

Sheet Metal Ducts

Trade Builder N/A

- Horizontal sheet metal ducts are supported every 6 feet

HVAC - Job Complete Checklist (cont.)

- Joints are mechanically fastened
- All joints are sealed with UL-181A/181B foil tape and/or mastic, or with foil mastic

Air Balancing

Trade Builder N/A

- Jump ducts and/or transfer grilles are used to balance pressure for rooms that do not have a dedicated return duct. Record pressure test below [BCQC-26]:

Table 5: Room-by-Room Pressure Diagnostics

Central area	Room	Room pressure with respect to central area (must be ± 3 Pa)	Pass/Fail

Duct Boots

Trade Builder N/A

- Duct openings are square with walls and floor
- Registers are flush with wall, floor, and/or ceiling
- Duct boots are sealed to the subfloor or drywall
- Seams in the duct boots and elbows are sealed with mastic
- Duct boots were covered during construction and are clean

Refrigerant Lines

Trade Builder N/A

- Liquid and suction refrigerant lines sized per manufacturer’s instructions
- Installed piping is sufficiently flexible to allow expansion and contraction caused by temperature fluctuation inherent in its operation
- Bends are long sweep bends
- Suction lines are insulated with 3/8” (or greater) closed-cell pipe insulation. A waterproof coating is on exterior lines
- No insulation is on liquid lines
- Solder with 15% silver was used
- Refrigerant piping installed in accordance with ANSI/ASHRAE Standard 15

HVAC - Job Complete Checklist (cont.)

Condensate Line

Trade Builder N/A

- Clean-out trap on primary condensate line is run to an appropriate drain or pump or outside to daylight. If in unconditioned space, condensate line is insulated with at least 3/8" closed-cell pipe insulation
- Secondary condensate line is trapped with a clean-out provision and run to an outside location that will alert the occupants of a primary condensate drain problem

Equipment Installation

Outdoor Unit

Trade Builder N/A

- Unit is per material specifications
- Unit is installed on level equipment pad placed over compacted soil or stone. Unit is elevated if necessary
- 36" of clearance is available to access service panel
- 12" horizontal and 48" vertical clearance is available for air to circulate freely around unit

Indoor Unit

Air Handler

Trade Builder N/A

- Air handler is per material specifications
- There is 30" of clearance to access service panel
- Unused holes, wire penetrations, and refrigerant and condensate line penetrations in the air handler cabinet are sealed
- Air handler is sealed (thermal and air barrier) from garage [BCQC-22 Verifier]
- Access panel seams are sealed with replaceable sealant
- Joints between the air handler and main supply and return plenums are sealed with mastic

Power-Vent/Direct Vent Equipment

Trade Builder N/A

- Manufacturer's instructions and local code requirements have been followed regarding sizing and location of combustion air vents and clearance for exhaust and supply vents

HVAC - Job Complete Checklist (cont.)

Air Filter

Trade Builder N/A

- Air filter is located close to the indoor air coil, easily accessible, clearly marked, and has a gasketed cover
- Minimum MERV 8 filter installed [BCQC-17 Verifier]

Incomplete Items

Date Completed

_____	_____
_____	_____
_____	_____
_____	_____

By signing below, builder and trade contractor acknowledge that all above items have been completed and the job is ready to start.

Builder/Superintendent Signature	Date:
Builder Company Name	Date:
Trade Contractor Signature	Date:
Trade Contractor Company Name	
Site Address	

