

CONCRETE MASONRY HOME MODEL DESIGN GUIDELINES

Version 1.0 Published October 2026



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Most jurisdictions require construction documents to be prepared by a licensed design professional for permitting. The involvement of a design professional is recommended for the design, specification, and construction of a concrete masonry home. The content of this design guide is intended for use by design professionals who have the competency and ability to apply the information provided to the design of a residential concrete masonry building.

Acknowledgements

Development of the model home design and accompanying guideline commentary was made possible by funding from the Concrete Masonry Checkoff Program. The following individuals contributed to development of the home design.

Southeast Concrete Masonry Association

James Cain

North Carolina Masonry Contractors Association

Ryan Shaver

Atkinson-Noland & Associates, Inc.

Carlo Citto, P.E.

Micah Heide, E.I.

Michael Schuller, P.E.

Bryce Kelly, E.I.

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Describes the layout of the home and provides options for installing movement joints in walls. Different exterior finish options, such as using textured block, pigmented units, exterior veneer, and stucco, are also discussed.

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Section 9: References

Sources with background information useful for home design are listed.

1 INTRODUCTION AND BUILT EXAMPLES

Building a home with concrete masonry construction makes sense. Concrete masonry is attractive, strong, and long-lasting. In this Guide and the accompanying design drawings, the concrete masonry industry supports development of design options to promote concrete masonry unit (CMU) growth in residential markets and also provides homeowners and builders with quality information to assist them in choosing the premier wall system for their residence. The Guidelines also serve to familiarize designers with a typical concrete masonry home design, optimized to meet code requirements while being as cost effective as possible.

Masonry walls fulfill multiple purposes, contributing to overall efficiency and construction cost-effectiveness. These walls deliver structural stability, serve as external weather barriers, offer thermal insulation, and possess a high fire rating that promotes safety and comfort within residential environments. The primary advantages of masonry walls are outlined below.

- **Attractive.** Smooth-faced blocks deliver a modern, aesthetically pleasing appearance desired for contemporary homes. Concrete masonry units (CMUs) are available in a variety of colors and surface textures, enabling bespoke architectural designs to suit any preference.
- **Strong.** Reinforced masonry construction offers robust strength and ductility to withstand everyday loads as well as high winds and earthquake forces.
- **Durable.** Masonry walls have excellent resistance to environmental factors including moisture, freezing temperatures, and thermal extremes, ensuring longevity without frequent repair or replacement. Routine use does not compromise their integrity.
- **Sustainable.** Concrete masonry units are sourced locally across the United States and composed of natural materials. Their internal pore structure and large surface-area-to-mass ratio facilitate rapid sequestration of atmospheric carbon dioxide compared to other cement-based products.
- **Fire resistant.** Masonry materials are non-combustible and achieve fire ratings that exceed building code requirements.
- **Thermally efficient.** CMU construction featuring integral insulation effectively moderates interior temperatures for comfortable living. The high thermal mass of CMU walls stores heat and releases it gradually, reducing heating and cooling demands and increasing energy efficiency.
- **Sound minimizing.** Concrete masonry walls provide superior sound insulation, exceeding building code requirements for sound transmission and resulting in quieter indoor environments.
- **Insect proof.** Masonry materials do not provide a food source for termites, ants, or other insect life.
- **Mold resistant.** Concrete masonry is inorganic and therefore does not support the growth of mold and mildew.

1 INTRODUCTION AND BUILT EXAMPLES

These Guidelines accompany a separate set of design details and serve as a commentary to the model CMU home design, providing background to the design process and information on design alternatives. The base home design is intended to be applicable to design requirements throughout the majority of North Carolina and South Carolina. Design options are provided that consider areas with high design wind speeds, increased seismic demand, and cold climates.



Phoenix, AZ
Architect: MACKOS
Producer: Superlite Block
Photo courtesy of Arizona Masonry Council



Palm Springs, CA
Architect: o2 Architecture
Producer: Angelus Block Company
Photo courtesy of Lance Gerber



Phoenix, AZ
Architect: Benjamin Hall Design
Producer: Echelon Masonry
Photo courtesy of Logan Havens



Scottsdale, AZ
Architect: Swaback Architects + Planners
Producer: Superlite Block
Photo courtesy of Arizona Masonry Council

1 INTRODUCTION AND BUILT EXAMPLES



Lynchburg, VA

Architect: Studio Møre Designs

Producer: Dominion Block

Photo courtesy of Beauty of Block®



Elk Park, NC

Architect: Collab Architecture

Producer: Johnson Concrete Products

Photo courtesy of Johnson Concrete Products



Columbus, OH

Architect: The Columbus Architectural Studio

Producer: Snyder Brick and Block

Photo courtesy of Seth Myers



San Diego, CA

Producer: RCP Block & Brick

Photo courtesy of RCP Block & Brick

2 ARCHITECTURAL DESIGN

2.1 Home Layout

The model concrete masonry home is thoughtfully designed for a family of four, offering three bedrooms, two full bathrooms, one half bath, and a spacious two-car garage. With its efficient two-story layout, the residence minimizes the building's footprint, providing ample surrounding space for a patio, landscaping, and driveway access.

On the first floor, an open-concept living area encompasses the kitchen, dining room, living room, a utility room, and a storage closet located beneath the staircase. All three bedrooms are situated on the second floor, which also includes a versatile family room at the stair landing. The primary bedroom features a private en-suite bathroom.

All exterior concrete masonry walls, as well as the wall between the garage and first-floor living space, are load bearing. Interior wood-framed walls are not and may be repositioned for flexible space. The second-floor covered deck, supported by three masonry columns, can be accessed from separate entrances in the front bedrooms, or by extending the hallway for a single entry point. The large garage fits two full-size vehicles and provides extra storage, while the overhanging deck protects the garage doors below.

Gross interior square footage	
First floor	625
Second floor	1,245
Total	1,870 square feet
Garage	535
Deck	150

2.2 Movement Joints

Concrete masonry construction shrinks over time as walls dry out and cement-based block, grout, and mortar materials cure. Walls also respond to temperature, expanding slightly during warm weather and shrinking slightly during cool weather. The concrete masonry industry typically recommends installing control joints in all CMU construction to mitigate crack formation. Coupled with horizontal reinforcement designed for the control joint spacing, control joints are effective at allowing movement where it can be properly managed.

The model concrete masonry home uses 9-gauge horizontal joint reinforcement at every other course (16 inches on center), reinforced bond beams at the bottoms of walls, tops of walls, and the second floor line, and reinforced lintels above all door and window openings. Additional joint reinforcement is placed one course below window openings. These crack control strategies do not prevent the concrete masonry assembly from shrinking but instead limit the

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formation of cracks that would be an aesthetic distraction or allow air and moisture to penetrate into the assembly.

Depending on local practices, control joints can be built into the model home for added confidence against cracking. The model home design includes alternative design detail sheets showing control joints (with added vertical reinforcement) at mid-length of the long left and right walls. Control joints may also be placed near building corners. Guidance on design and construction of control joints can be found in CMHA TEC 009-025, *Crack Control Strategies for Concrete Masonry Construction*.

When control joints are used, the reinforcement at the second floor and roof bearing must be continuous through the control joint. Wires of horizontal joint reinforcement, on the other hand, are always cut at control joints.

Control joints add the following items to the overall home construction cost:

- Building with half-length units on each side of control joints breaks up the production work of laying the wall between corners.
- Vertical reinforcement and grout is required on each side of each control joint.
- Backer rod and sealant is used to finish control joints, forming a weather-tight exterior wall.

2.3 Exterior Finish Options

Using smooth-faced concrete masonry units (CMU) is a cost-effective way to provide an attractive, durable finish. Many other exterior finishes are also available to suit different architectural tastes.

Integral color. Pigments are mixed into the concrete during block manufacturing to provide a wide range of colors. Check with your local supplier for available colors and the cost of colored units. See Figure 1.

Texture. Architectural units are available with different surface textures including split face (sometimes called rock-faced, Figure 1), ribbed, ground face, epoxy-finish, or other textures. Textures add to the cost of the masonry unit and make surface cleaning more difficult. Unless sealed, the pore structure is always exposed on any block. If the block is exposed to weather, a post-applied coating is always recommended.

Bond pattern. The base home design uses half-bond running bond throughout. Using single courses of textured units (shown in Figure 1), half-high units, or colored units can enhance appearance. Avoid using different materials such as bricks or stone within the field of the wall: special detailing is required with these materials to accommodate differential movement. Stack bond construction, where head joints align at every course through the full wall height,

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also requires special detailing and additional horizontal reinforcement to satisfy building code structural requirements.



Figure 1. Using texture and color to add interest to a concrete masonry wall.

Paint. It is possible to paint concrete masonry walls, if it is done correctly. Use a special breathable paint made specifically for concrete masonry with a high water vapor transmission rating of 10 perms or more. Mineral paints, including limewash and silicates, have high perm ratings and work well with concrete masonry. Breathable paints let trapped moisture escape, preventing damage, mold, and peeling. Standard epoxy and oil based paints trap water in the wall and must be avoided.

Painting adds costs to your home, and all paints have a limited service life. Painted walls require frequent maintenance to address paint deterioration, as well as sealing cracks or other points of moisture entry. Whereas a concrete masonry wall is essentially maintenance free for decades, most paints require repainting every seven years or so.

Stucco. Cement plaster or stucco can be installed directly over the outside wall surface to provide a smooth, moisture-resistant finish. CMHA TEK 09-03A, *Plaster and Stucco for Concrete Masonry*, provides recommendations for cement plaster mix design and application procedures.

Before applying stucco, make sure the masonry surface is clean and has no dirt, oils, or other materials that inhibit bonding. Hard-coat cement plaster is applied in two layers: the first layer is troweled onto the wall surface and then raked or otherwise roughened before it hardens. A finish coat is then applied to the scratch coat to provide the desired appearance. Cement plaster provides a durable finish that may be integrally colored. If a painted finish is used, follow the recommendations for masonry painting listed above.

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Masonry veneer. Many concrete masonry walls have an exterior masonry veneer covering (Figure 2 and Figure 3). Masonry veneers are commonly built as anchored veneer with an internal drainage space that effectively prevents moisture infiltration into the building. The drainage cavity intercepts any moisture that happens to penetrate through the veneer, collecting moisture at flashing installed at the base of the cavity, and directing that moisture out of the wall system via weep holes atop the flashing. A wider drainage cavity is used in cold climates for placement of 1 to 3 inches of insulation, depending on code requirements for different Climate Zones (see Section 5, Thermal Performance). Concrete masonry and brick veneer is usually 3 to 4 inches thick, whereas most stone masonry veneers range from 4 to 6 inches thick.

Considerations when using anchored masonry veneer include the following.

- Veneer that is 3 or 4 inches thick adds weight, requiring wider footings. Depending on the type of veneer chosen, footing width will have to be increased by 4 to 6 inches with low-capacity clay soils. Sandy or other soils with a higher bearing capacity will require footings to be 2 to 3 inches wider than footings shown for the base home design.
- Veneer is commonly supported on a brick ledge built into the foundation wall. Brick ledges are built by using a 12-inch wide concrete masonry unit as the first course atop the concrete footing. This unit projects 4 inches out from the 8-inch wall above to provide a base for the veneer. It is best to support at least 2/3 of the veneer thickness on the brick ledge.
- Leave a drainage cavity at least one inch wide between the back of the veneer and the face of the CMU wall or the face of cavity insulation. Veneer is connected to the structural wall using metal ties placed periodically in bed joints. Metal tie spacing is prescribed by building codes depending on the type of tie that is used.
- Special detailing is required at windows, doors, and other openings to close off the drainage cavity and prevent moisture infiltration.
- Recognize that clay brick generally expands over time while CMU generally shrinks over time. Brick veneer design must, therefore, consider differential movement between clay brick veneers and CMU backups.

Another option is using adhered veneer, where natural or artificial stone is bonded to the concrete masonry wall using mortar (Figure 4). These thin veneer units range from 3/4 inch to 2 inches thick and are applied directly to the wall without using metal reinforcement or lath. Code requirements for adhered masonry veneer specify an initial scratch coat be applied, followed by setting units into a bond coat, similar to application of cement plaster mentioned above. Note that metal lath is recommended for use in thin brick adhered veneer systems.

Adhered veneer is lighter than anchored veneer. Changes to footings are minimized with adhered veneer, and the footing width would be increased by 1 to 3 inches for construction using this option.

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Figure 2. Concrete masonry veneer installed over a concrete masonry wall. Flashing is placed at the base of the drainage cavity, and rigid insulation board is installed against the CMU wall.

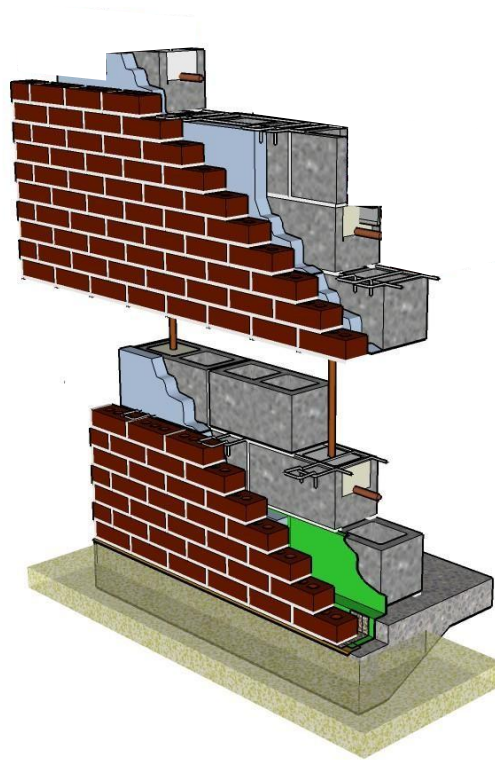


Figure 3. Schematic illustration of a reinforced concrete masonry loadbearing wall, with anchored masonry veneer as the exterior finish (image courtesy of Rocky Mountain Masonry Institute).

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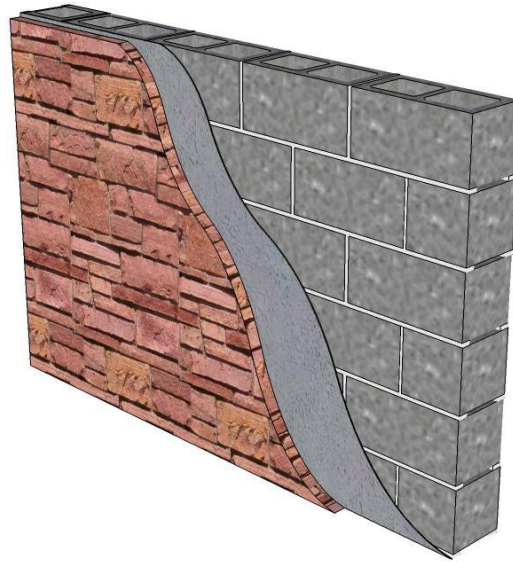


Figure 4. Adhered masonry veneer systems, using mortar scratch coat and bond coat to adhere directly to concrete masonry wall (image courtesy of the Rocky Mountain Masonry Institute).

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3.1 Structural Design Criteria

The model CMU home design represents typical low-rise single-family residential construction applicable to many areas of the country. The design follows codes and standards that are used throughout the United States. Recognize, however, that local building codes often have amendments, minimum (or maximum) requirements, and other conditions that could result in significant changes to the design. Further, local practices may vary from those shown in the design and described herein. Some of the detailing and design options may not be available in your area.

The base home design is intended to be applicable to design requirements in the majority of North Carolina and South Carolina. Design options are provided that consider areas with high design wind speeds and increased seismic demand.

Design codes. Project design followed applicable building codes with North Carolina and South Carolina amendments. North Carolina had planned to adopt the 2021 International Codes in 2024, but this plan was delayed following the devastation caused by Hurricane Helene. North Carolina's 2024 codes, which reference the 2021 International Codes, will be effective sometime after April 1, 2026. South Carolina has already adopted the 2021 International Codes.

Specific codes used during development of design documents included:

- 2021 International Building Code (IBC)
- 2021 International Residential Code (IRC)
- 2018 North Carolina Energy Conservation Code. This code is based on the 2018 International Energy Conservation Code (IECC) with some amendments applicable to the home design included here.
- Minimum Design Loads for Buildings and Other Structures (ASCE 7-16)
- TMS 402/602-16, Building Code Requirements and Specification for Masonry Structures
- Building Code Requirements for Structural Concrete (ACI 318-19)

Loads and design parameters. The design used live, snow, wind, and seismic loads following ASCE 7-16 requirements as listed on drawing sheets as General Notes.

Live Loads (psf)

- | | |
|--|----|
| • Roof: | 20 |
| • Attic: | 20 |
| • 2 nd floor, interior rooms: | 40 |
| • Deck: | 60 |
| • 1 st floor, interior rooms: | 40 |
| • Garage: | 40 |

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Snow Loads (psf)

- Ground snow load P_g : 20
- Flat roof snow load P_f : 14
- Snow exposure factor, C_e : 1.0
- Thermal factor, C_t : 1.0
- Slope factor, C_s : 1.0
- Snow load importance factor, I : 1.0

A ground snow load of 20 psf was used for design as it is the maximum ground snow load applicable to either North or South Carolina for elevations below 2500 ft (See Figure 5). Note that site-specific case studies can be required in the states' western regions for elevations above 2500 ft.

Following ASCE 7, the snow exposure factor of 1.0 corresponds to a partially exposed condition for surface roughness categories B or C. The partially exposed condition was chosen as it is commonly applied to houses in urban areas. Surface roughness categories B and C apply to terrain with closely spaced obstructions and more open terrain with scattered obstructions, respectively. These categories cover most of the conditions that would be typically seen for residential houses.

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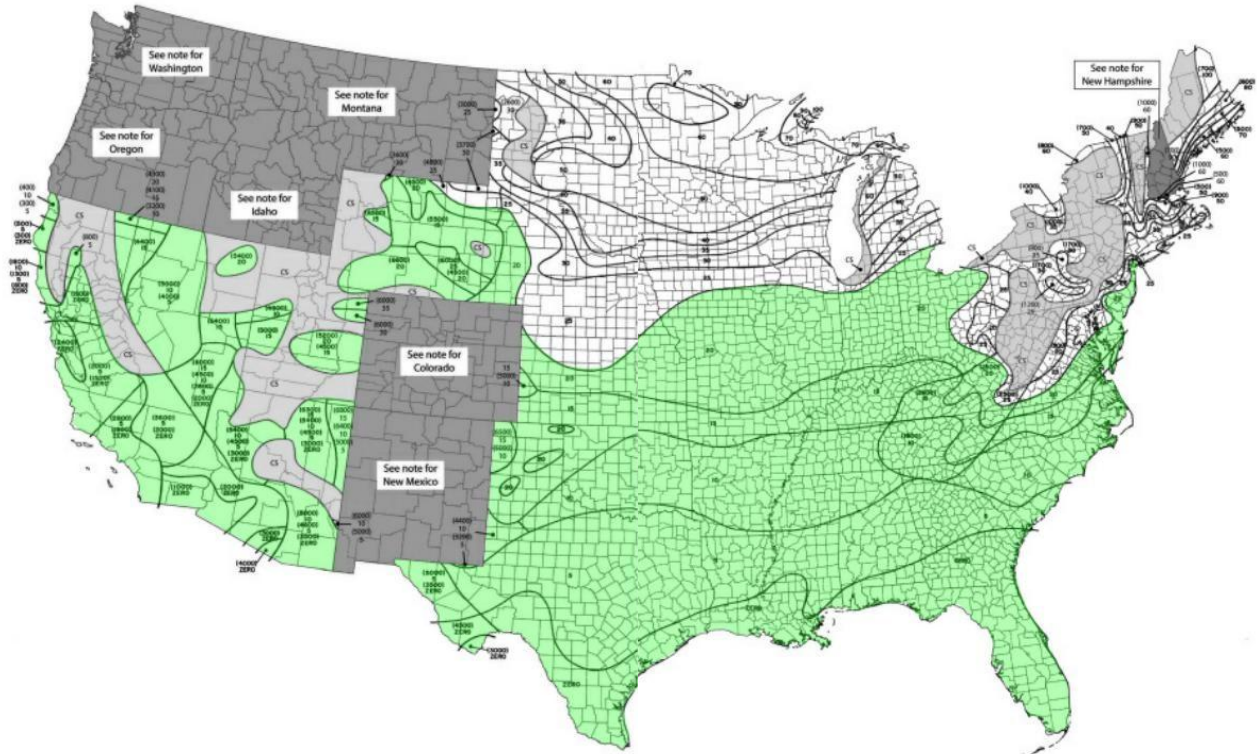


Figure 5. Ground snow load map for the continental United States (2024 South Carolina State Building Code). The home design considers snow loads at green-shaded areas. Areas shaded gray or white have greater snow loads that are not considered by the design.

Wind

- Basic wind speed: 115 mph
- Risk category: II
- Wind exposure: C
- Internal pressure coefficient: ± 0.18
- Topographic factor: 1.0

A basic wind speed of 115 mph was chosen to cover the inland regions of North and South Carolina (See Figure 6). Wind speeds generally increase for sites that are closer to the coast. See the high wind speed design option (Section 3.4) for sites with a higher basic wind speed than 115 mph.

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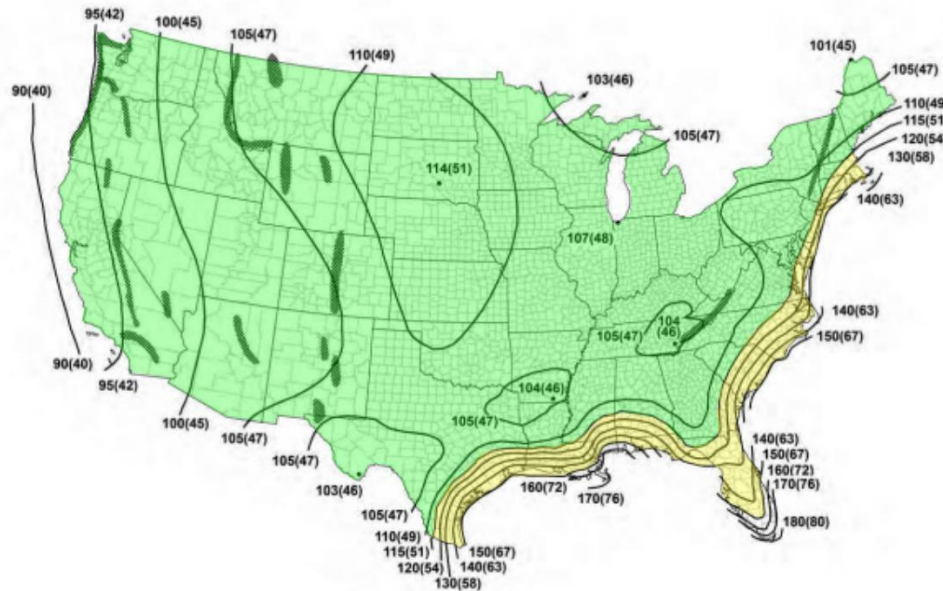


Figure 6. Basic wind speed map for the continental United States (2024 South Carolina State Building Code). The base home design applies to all areas shaded green; the high wind option was developed to address winds in the coastal areas with yellow shading.

Seismic

- | | |
|--|------------|
| • Building risk category | II |
| • Seismic importance factor I_e | 1.0 |
| • Mapped spectral response accelerations | |
| S_S | 0.350 g |
| S_1 | 0.116 g |
| • Site Class | D |
| • Spectral response coefficients | |
| S_{DS} | 0.355 g |
| S_{D1} | 0.183 g |
| • Seismic design category | A, B, or C |

Seismic analysis for the home design followed the equivalent lateral force method and was based on the design parameters listed above. The design intent was to have the base home design apply to Seismic Design Categories A, B, or C, which generally applies to North Carolina, except for the most western point of the state, and most of the western and northern regions of South Carolina (See Figure 7). Note that the seismic design category is dependent on local soils and the site class and will, therefore, vary from site to site within the same region. Site Class D, which corresponds to a stiff soil, was used for this design as a

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conservative assumption. Design for sites that are designated as Site Class E, which represents a soft clay soil, may result in a higher Seismic Design Category. An option for design in Seismic Design Categories D and E is provided later.

Shear walls are considered as “Ordinary Reinforced Masonry Shear Walls” as defined by Code. The base design meets the vertical and horizontal reinforcement requirements for this shear wall type. Additional horizontal joint reinforcement is shown above and below openings, extending 24 inches beyond openings, as required by seismic detailing requirements.

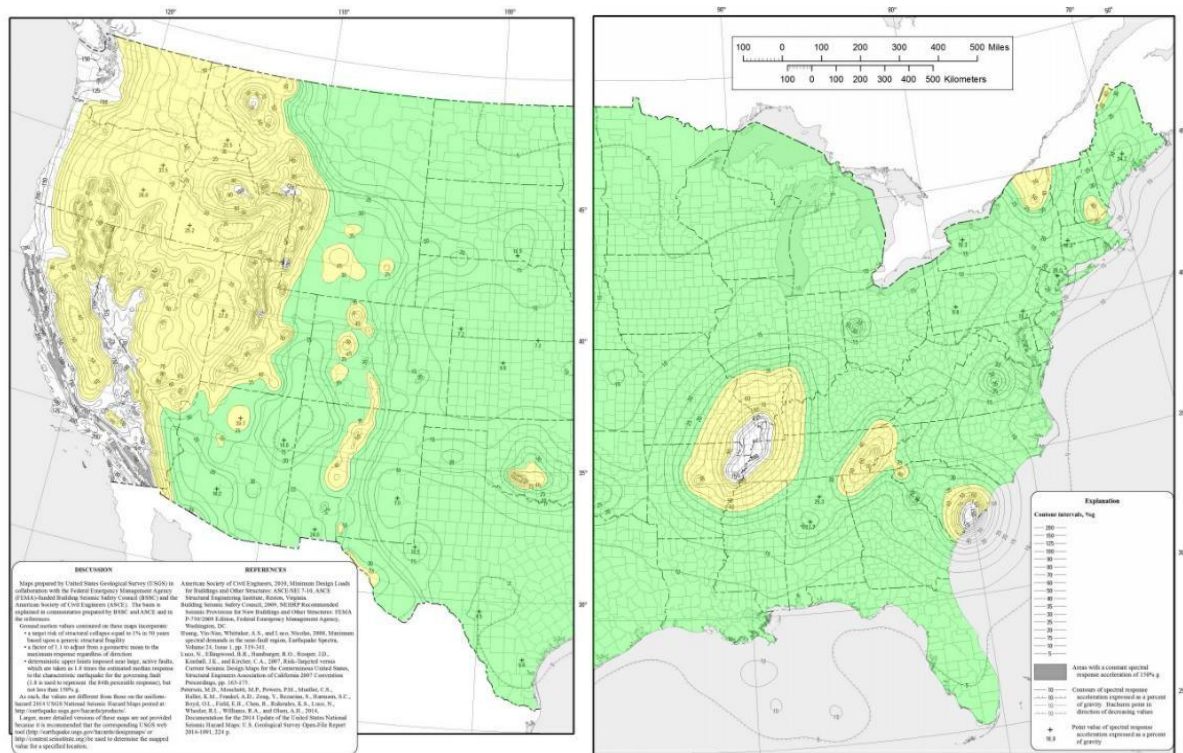


Figure 7. Seismic spectral response acceleration for the continental United States (2024 South Carolina State Building Code). The base home design applies to all areas shaded green, and the high seismic option was developed to address seismic loads in the area shaded yellow. Areas that are shaded gray have exceptionally high seismic loads; these regions require special design and detailing for development of a reinforced concrete masonry home design.

3.2 Materials

Material requirements are described on the drawing sheets as General Notes on the first page.

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- The specified masonry strength f'_m of 2,000 psi represents the strength of the complete masonry assemblage: CMU with mortar and grout. This strength exceeds the code-required minimum of 1,500 psi and is representative of masonry strength provided in the area.
- Concrete masonry unit strength is not specified. However, based on the required masonry strength f'_m of 2,000 psi, the masonry units must also have a strength of approximately 2,000 psi. Lightweight units (concrete unit weight as light as 95 pcf) are used to increase insulating properties and reduce labor costs. Normal weight units are usually cheaper, but installation costs associated with placing heavier normal weight units offset any material cost savings.
- Type S mortar is specified. Pre-blended mortar in accordance with ASTM C1714 is acceptable. Alternatively, following ASTM C270 requirements, typical Type S mortar has volumetric proportions of
 - 1 part portland cement
 - ½ part hydrated lime
 - 3 3/8 to 4 ½ parts masonry sandor
 - 1 part Type S masonry cement
 - 2 ¼ to 3 parts masonry sand
- Grout is used to fill cells at all vertical and horizontal reinforcing bars. Grout strength of 2,000 psi is called for to match the specified masonry strength. Grout must be consolidated by mechanical vibration any time it is placed in lifts of 12 inches or more. Code also requires re-consolidation, about 10 to 15 minutes after placement. Reconsolidation is used to close voids that form as grout mix water is absorbed by surrounding CMU.
- Grade 60 reinforcing bars with yield strength of 60,000 psi are used as horizontal and vertical reinforcement in grouted cells. The 2022 version of the masonry design code has an Appendix for designing with Glass Fiber Reinforced Polymer (GFRP) reinforcement. GFRP reinforcement weighs much less than comparable steel reinforcement and is easier to handle and place within masonry walls. The design code limits using GFRP reinforcement in flexural members, and does not yet include options for using GFRP in load bearing masonry. Future versions of the code are expected to have this option.
- Horizontal joint reinforcement is fabricated of cold-drawn wire with yield strength of 70,000 psi. Ladder-type joint reinforcement is preferred over truss-type: the diagonal rods of truss-type reinforcement often interfere with placement of vertical reinforcing bars and grout. Hot-dipped galvanized joint reinforcement is used, rather than electroplated or mill-galvanized joint reinforcement, to meet durability requirements.

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3.3 Structural Components

3.3.1 Foundations

It is recommended that final design of foundations be based on recommendations provided in a geotechnical report for the actual site where the home is to be constructed. Special foundation systems (not covered here) will be required for homes built in areas with expansive clays, collapsing soils, or locations with a high water table, for example.

For the base home design, foundations are based on the bearing capacity of non-expansive clay soils, with an allowable soil bearing pressure of 1,500 pounds per square foot (psf) and a frost depth of 12 inches. Foundations bearing on other soils including sandy soils, loam, and bedrock, will have much greater allowable bearing pressures, and footing sizes can be reduced.

The design calls for a reinforced concrete spread footing, sized to resist building loads. Walls are connected to the footing with post-installed reinforcing bars inserted into holes drilled into footings and anchored with epoxy. Installing dowels in this manner is usually cheaper and more effective than having the concrete contractor install reinforcement dowels extending up above the footing. Post-installed dowels can be placed precisely where required at all of the wall's vertical reinforcing bars.

3.3.2 Walls

Concrete masonry walls in the home are load bearing, carrying vertical floor and roof loads. Walls also resist lateral wind and seismic loads. Exterior walls were designed using 8-inch CMU. It is possible to construct walls using 6-inch units, but additional vertical reinforcement would be required .

The interior mid-wall carries vertical loads from the second floor and was designed for a lateral pressure of 8 psf. Although no vertical reinforcement was required to resist this lateral load, some reinforcement is included in the wall to meet seismic detailing requirements. This interior bearing wall may be constructed of either 6-inch or 8-inch CMU.

Flexural design of the home's walls considered the interaction of vertical and lateral loads at reducing tension stress across the wall section. The interaction diagram included here as Figure 8 represents the capacity envelope for first story walls, considering vertical loads acting at the same time as lateral loads. Applied axial and flexural forces are represented by the green symbols, all of which lie within the capacity envelope. Even though wall designs were optimized for applied loads, they have considerable reserve capacity should vertical and lateral loads exceed design criteria.

The most effective way to build CMU walls is to place vertical reinforcement at a wide spacing, filling reinforced cells with grout to bond reinforcement with surrounding blockwork. The

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remainder of the CMU cells are left hollow, to be filled later with foamed-in-place insulation. Partially grouted masonry offers excellent fire, sound, and thermal performance, with costs substantially less than fully grouted walls.

Vertical reinforcement is shown at locations where it is required to stiffen walls: at corners, either side of windows, and either side of doors. Once these bars are located, bars are positioned between them at the maximum design spacing of 10 feet (for #5 reinforcing bars). There is only one location at the right elevation where bar spacing is at the maximum of 10 feet. At all other locations bars happen to be spaced closer than the maximum spacing.

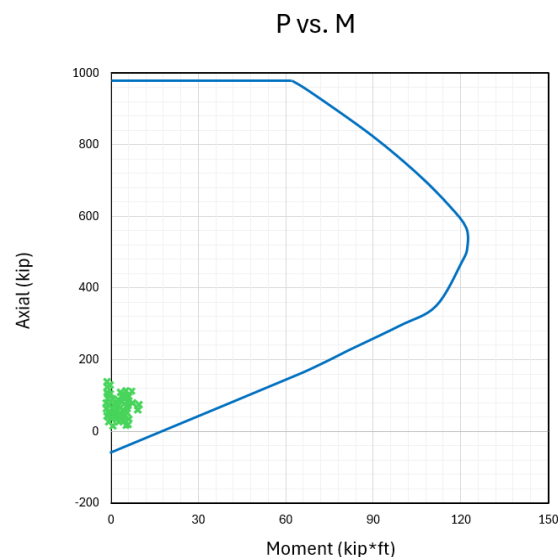


Figure 8. Interaction diagram for first level wall. The blue envelope represents the wall capacity; actions based on design load combinations are shown in green.

Horizontal reinforcement is shown as ladder type with 9-gauge side rods placed at 16" on center in all walls, including the mid-wall bearing wall. Joint reinforcement is used to control width of shrinkage cracks and also serves to meet seismic detailing requirements. As mentioned above, extra joint reinforcement is shown above and below openings and extending 24" beyond opening to meet requirements of Seismic Design Category A, B, and C.

Grouted bond beams are required at the second floor line and roof line, each reinforced with a single #4 bar to act as diaphragm chords and stiffening elements. The masonry industry prefers single bars in bond beams: using 2-bar bond beams interferes with grout and reinforcement placement, especially at lap splices. Bond beam reinforcement must be continuous around corners; continuity is provided by corner bars lapped with longitudinal bars at wall ends.

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Reinforced lintels built with solid-bottom lintel units span over door and window openings, carrying loads to vertical reinforcement at jambs. Structural design requires a single #5 bar for all lintels. Lintels with short spans over doors and windows are designed as single-course beams with one course grouted solid. The long-span lintels over garage door openings could be designed as 2-course lintels, however this lintel would require vertical shear reinforcement to resist applied loads. Installing shear stirrups in masonry lintels is difficult and costly. A better solution is to grout additional courses and have the masonry resist shear in the absence of shear stirrups. This approach was used here: lintels over garage openings use a single #5 longitudinal bar with three courses grouted solid to meet shear demand.

3.3.3 Wall Construction

Walls are best built using low-lift grouting procedures, building walls in lifts to a height of 5'-4" or less. High lift grouting methods may also be used, but the masonry code requires cleanouts at the bottom of each reinforced cell for this approach. In addition, wall bracing is needed for high-lift grouting, rather than relying on the "internal bracing" method described in Section 8.

The construction sequence following low lift grouting is shown in Figure 9. Walls are built up to the top of each bond beam or to a maximum height of 5'-4" before installing reinforcement and grouting. Horizontal joint reinforcement is placed at every other course as the wall is built; bond beam reinforcement and vertical bars are placed when each lift is built. Vertical bars are extended up beyond the top of each lift to lap with vertical bars in the next lift. Once reinforcement is in place, bond beams and reinforced cells are grouted solid. Code requires that grout be consolidated using mechanical vibration with this approach.

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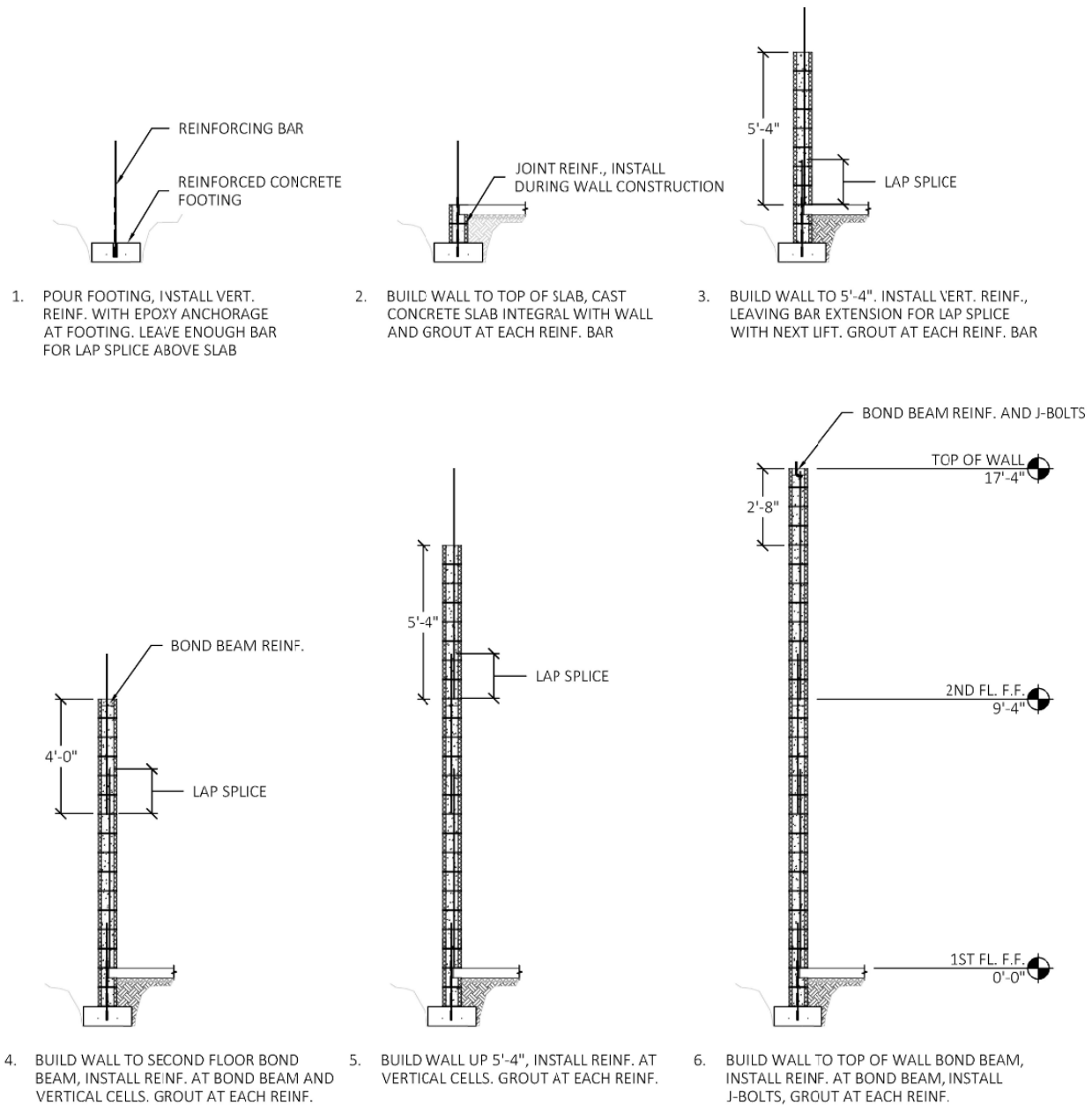


Figure 9. Wall construction sequence.

Reinforcing bars are typically provided in 20 foot lengths and careful planning of reinforcing bar cuts minimizes waste. For our design we have vertical bars, horizontal bars in bond beams, corner bars connecting bond beams around corners, and horizontal bars in lintels. A reinforcing bar schedule should be developed to minimize reinforcement waste.

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3.3.4 Second Floor Framing

Wood trusses are used to span between masonry bearing walls. The advantage of this type of construction is that interior wood-framed walls are partition walls only, and the wall layout can be modified for any internal configuration without worrying about structural requirements. Second floor trusses are designed with a depth of 16 inches to provide enough space for placing mechanical heating and cooling trunk lines at any desired location.

A single course of 12-inch CMU is used just below the second floor line as shown in Figure 10. This “ledger” is grouted solid and provides support for second floor trusses as well as edge support and nailing for the second floor diaphragm sheathing. Constructing in this way eliminates a costly double wood ledger with post-installed anchors. Grout is contained by the solid base of lintel units; hollow units may also be used if grout is contained by using grout-stop mesh or a form board.

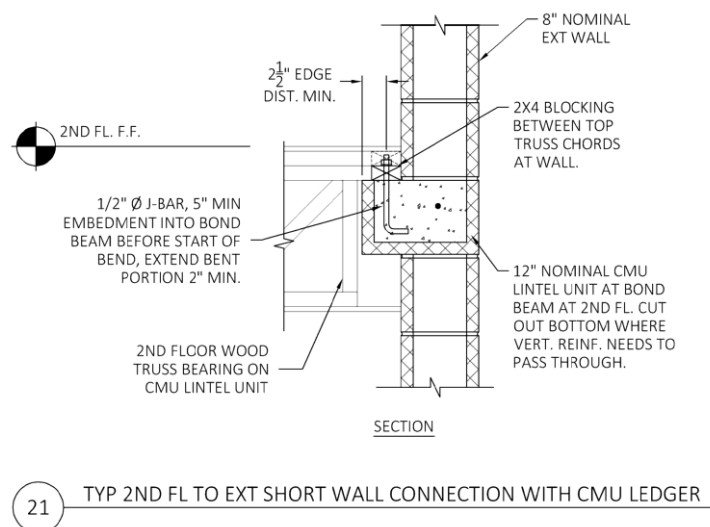


Figure 10. CMU ledger supporting 2nd floor framing.

3.3.5 Roof Framing

Concrete masonry gable walls require a sloped bond beam at the tops of walls, requiring many units be cut to fit. Wood roof trusses were instead designed for a hipped roof profile to simplify wall design and construction. Roof trusses are typically engineered by the truss manufacturer. The shown roof trusses were designed using the loading for the high design wind speed option. The included roof truss designs can, therefore, be used for the base design, high wind design option, and high seismic design option.

3 STRUCTURAL DESIGN

3.4 Design Option: High Design Wind Speed

A design wind speed of 150 mph was chosen for the high wind design option to cover the entirety of North Carolina and South Carolina, including the coastal regions.

- Basic wind speed: 150 mph
- Risk category: II
- Wind exposure: C
- Internal pressure coefficient: ± 0.18

Increasing the design wind speed from 115 to 150 mph effectively increases wind loads by a factor of 1.7 times. Designing for the higher wind speed reduces the vertical reinforcement spacing from a maximum of 10 feet on center to a 7'-4" maximum spacing. The high wind design requires no additional bond beams or horizontal joint reinforcement.

Special connectors are required to tie roof framing to the wall below. Hurricane ties are used at each roof truss, connected to the sill plate and wall below.

The added vertical reinforcement requires steel and grout in what would otherwise be insulated cells. The additional vertical bars required at exterior elevations have a small effect on wall thermal properties and their effect on the insulating properties of the wall section are neglected. Thermal properties are discussed later in Section 5.

3.5 Design Option: High Seismic Design Categories

The design intent was to have the design for high seismic loads apply to Seismic Design Categories D and E, which generally applies to the southern coastal region of South Carolina, centered around Charleston, and the most western tip of North Carolina. This design could also apply to other areas of the United States falling into Seismic Design Categories D and E. There remains a small area of Charleston that may require the design to follow Seismic Design Category F requirements, depending on local soil characteristics.

In addition to vertical and horizontal reinforcement required to meet seismic demand, shear walls for these seismic design categories must follow detailing requirements for "Special Reinforced Masonry Shear Walls" as defined by Code. Vertical *and* horizontal #5 reinforcement spacing cannot exceed 48 inches on center to meet these requirements.

The home design followed the equivalent lateral force method and was based on the design parameters listed below.

3 STRUCTURAL DESIGN

- Building risk category II
- Seismic importance factor I_e 1.0
- Mapped spectral response accelerations
 - S_s 1.0 g
 - S_1 0.311 g
- Site Class D
- Spectral response coefficients
 - S_{DS} 0.733 g
 - S_{D1} 0.415 g
- Seismic design category D or E

The SDC D and E design required more vertical reinforcement and more horizontal bond beams, mainly as a result of prescriptive seismic detailing requirements rather than resist seismic design forces. Both the vertical and horizontal reinforcement spacing cannot exceed 48 inches in these cases.

The added vertical reinforcement requires steel and grout in what would otherwise be insulated cells. The additional vertical and horizontal reinforcement reduces the wall's insulating properties (thermal properties are discussed in Section 5).

Code requirements also require that the design compressive strength for the concrete foundations be increased from 2,500 psi to 3,000 psi for these higher seismic design categories.

Designing for high SDC also requires significant upgrades to framing, including:

- Installing blocking along all sheathing edges, with increased nailing requirements
- Reducing the spacing of connectors where the 2nd floor diaphragm meets exterior walls
- Using heavier connectors to anchor roof trusses to tops of walls.
- Adding vertical reinforcement to the interior CMU mid-wall.

4 MOISTURE MANAGEMENT

Single wythe masonry construction is cost effective. Taking advantage of masonry's ability to perform many different functions, concrete masonry walls provide resistance to structural loads and also act as part of the building's exterior weather enclosure. The masonry's mass helps resist water infiltration, and special materials and products help make single-wythe walls weather resistant. Design and construction practices used to improve single wythe concrete masonry's resistance to moisture infiltration are discussed here.

4.1 Checklist for Single-wythe Masonry

In 2012 the Rocky Mountain Masonry Institute carried out a program to evaluate performance of single wythe concrete masonry walls and develop recommendations for providing weather-resistant construction. Many of the recommendations are relevant to design and construction of our model concrete masonry home.

1. Use integral water repellent in both the concrete block and in the mortar.
2. Apply a breathable spray-applied water repellent to walls after construction and cleaning. Choose a product that is formulated specifically for the type of concrete masonry being used. Breathable water repellents will not "waterproof" the walls but do help shed water that hits the wall surface.
3. Install horizontal joint reinforcement and bond beam reinforcement as designed to minimize cracking.
4. Install control joints (as shown in one design option) to mitigate shrinkage crack formation.
5. Provide head joints and bed joints that are filled to a depth equal to the thickness of the face shell.
6. Tool all mortar joints concave to compress and seal the joint. Do not use other joint tooling styles.
7. Provide sills with drip edges at all windows to direct water off masonry below. Sills may be metal, vinyl, stone, precast, or other impermeable material. Sills are often built integral with windows.
8. Install sealant joints where masonry meets sills to allow small movements to occur without cracking.
9. Use flashing and weep holes above all bond beams, lintels, and other grouted cells, and at the base of walls.
10. Install finish grade around the exterior according to the design. Door thresholds and interior slabs should be at least 4 inches above grade. Slope grade away from the home following the design (see detail excerpt in Figure 11).
11. Do not install vinyl wall paper or other non-breathable coating as interior finishes.
12. Clean newly built walls in a timely manner. Wait 7 to 10 days before cleaning to let the mortar cure. Do not wait more than 30 days or you will have to use aggressive cleaning. Check with your block manufacturer for the right cleaning product to use on your walls. Do not use muriatic acids for masonry cleaning. Do not clean by sandblasting, which can open tiny hairline cracks that let in water.

4 MOISTURE MANAGEMENT

13. Cracks will let water into the wall system. It is a good idea to walk around the home each year and check for cracks. Repair cracks promptly to limit moisture infiltration.

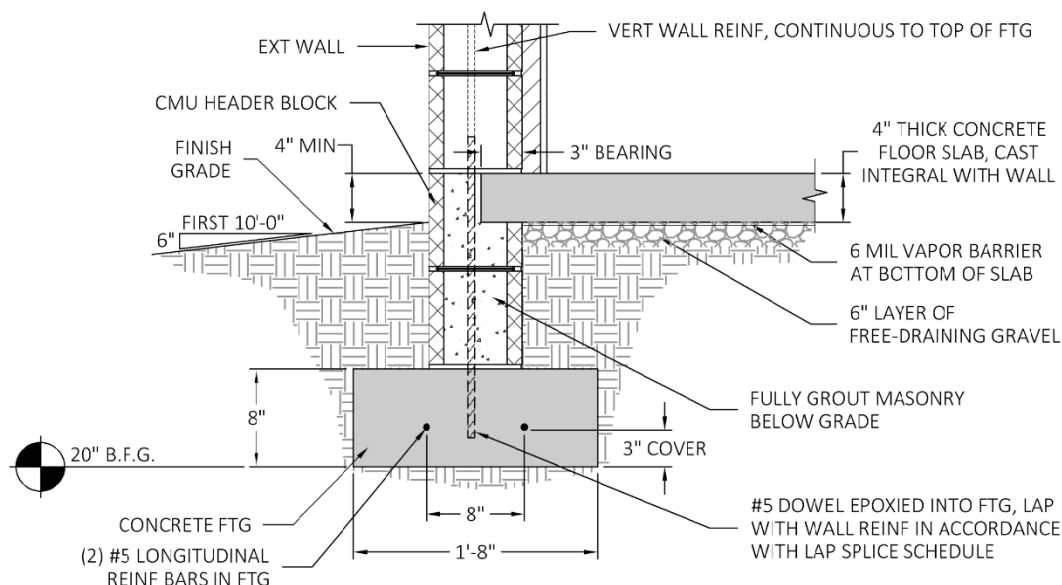


Figure 11. Project design details include holding exterior grading down below the interior slab elevation, and sloping grade away from the home. Both concepts help drain surface water and keep water from entering the home.

4.2 Integral Water Repellent

Project General Notes require an integral water repellent (IWR) to be used in both the concrete masonry units and the mortar. IWR is commonly added to the concrete mixture during manufacturing. Preblended mortars, delivered to the project site in bags or silos, may include an integral water repellent additive. It is also common to have the mason contractor add liquid IWR to each mortar batch.

Integral water repellents help walls shed water and also provide some protection against moisture moving through walls. IWR additives do add cost to concrete block and mortar, but the nominal added cost is a small price to pay for providing good water-resistant performance.

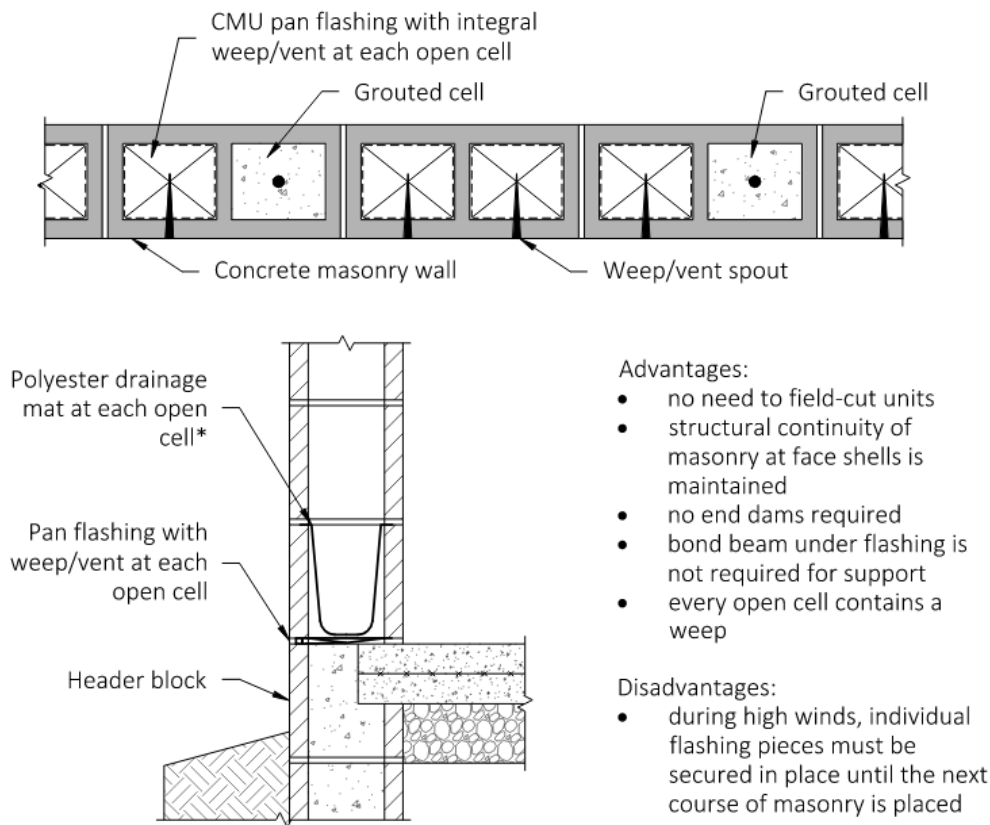
4.3 Flashing and Weeps

Water has a way of finding its way into even the best-built walls. Single wythe walls use a combination of mass and drainage at ungrouted cells to manage moisture infiltration. Cells that are grouted solid provide an effective moisture barrier. At hollow or insulated cells, water getting past the block face shell tends to run downward within the vertical cell space. Flashing

4 MOISTURE MANAGEMENT

and weeps are used at the bottom of all ungrouted cells to collect water and move it out of the wall system.

Flashing for our model concrete masonry home uses a proprietary polymer pan and weep system that is installed at the bottom of all empty cells. See Figure 12 below. These pans are placed at the base of walls and atop all grouted spaces as the wall is being built. Flashing will be built in atop the second floor bond beam.



* There are a variety of products available to keep weeps from being clogged by mortar droppings. The configuration shown is one example.

Figure 12. Pan flashing is installed in single wythe walls during construction. The system includes weeps to collect water and move that water out of the wall system. Image adapted from TEK 19-02B Design for Dry Single-Wythe Concrete Masonry Walls courtesy of Concrete Masonry & Hardscapes Association.

5 THERMAL PERFORMANCE

Thermal performance of wall construction is based on steady-state and thermal mass characteristics. Steady-state performance is described by the wall's U-factor or R-value. In general, walls with lower U-factor or greater R-values have better resistance to energy flow through the wall system.

Thermal performance is based on a number of properties, including:

- Size, type, and configuration of masonry unit
- Density of concrete masonry units
- Number and size of openings in walls
- Type and location of insulation
- Wall cladding
- Building exposure and orientation
- Wall thermal mass

In addition to masonry's inherent insulating properties, masonry walls have high thermal mass. Mass walls absorb and store heat energy during times of thermal gain, releasing that energy slowly during cooling cycles. This thermal mass effect moderates temperature fluctuations in a building by damping heating and cooling extremes. Building codes recognize the benefit of thermal mass at reducing heating and cooling loads by requiring less insulation for mass walls.

5.1 Insulation Requirements

The 2018 North Carolina Energy Conservation Code (NCECC) is based on the 2018 International Energy Conservation Code. These codes require that exterior wall assemblies have minimum insulating properties, depending on the building's climate zone and the assembly's thermal mass properties.

The 2018 NCECC has different requirements for building thermal envelope insulation depending on Climate Zone. General Climate Zones are shown in Figure 13; refer to your local building department or the NCECC for specific requirements of each county.

5 THERMAL PERFORMANCE

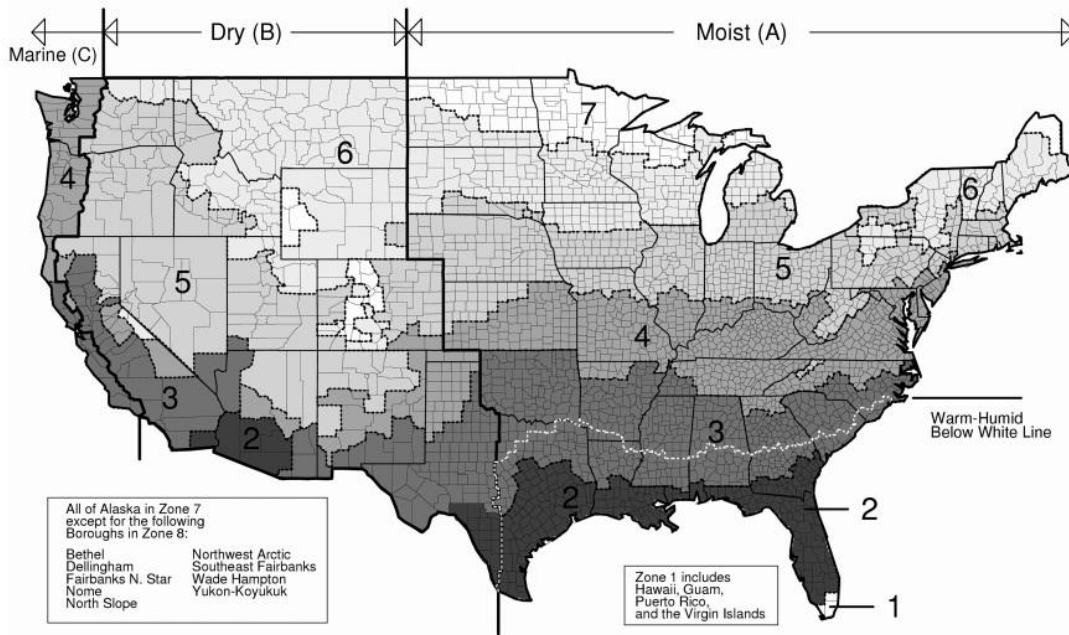


Figure 13. 2018 IECC climate zone map [IECC, 2018].

Climate Zones 3 and 4. The base design considers the home to be built in either Climate Zone 3 or 4. These climate zones apply to all of South Carolina and most of North Carolina. NCECC insulation requirements are the same for Climate Zone 3 and Climate Zone 4. Table 1 lists insulation requirements for exterior mass masonry walls and concrete slab construction. In Climate Zone 4, insulation for monolithic concrete slabs cast integral with exterior walls is to extend to the bottom of the footing but need not exceed 2 feet below grade.

Climate Zone	Mass Wall Insulation, R-Value		Slab Insulation, R-Value
	Insulation in empty cells or at wall exterior	More than ½ of the insulation on the interior of the wall	
3	5	13	0
4	5	13	10
5	13	17	10
6	15	20	10

Design Alternate: Climate Zones 5 and 6. Alternate design requirements are provided for Climate Zones 5 and 6 following the insulation requirements listed in Table 1. A small mountainous area in western North Carolina is designated as Climate Zone 5; this zone is also

5 THERMAL PERFORMANCE

applicable to many areas of the country. Climate Zone 6 requirements apply to northern states and parts of Utah, Wyoming, and Colorado. Insulation requirements for Climate Zone 6 are not listed in the NCECC; values listed in Table 1 are from the 2018 IECC.

Insulation requirements for monolithic concrete slabs cast integral with exterior walls must extend to the bottom of the footing, but need not exceed 2 feet for homes built in Climate Zone 5. For Climate Zone 6, this same requirement applies except the maximum required insulation depth is 4 feet.

5.2 Block Fill Insulation

Energy codes acknowledge the benefit of mass wall construction and require less insulation for concrete masonry mass walls. In accordance with NCECC Section R402.2.5, mass walls are defined as

"above-ground walls of concrete block, concrete, insulated concrete form, masonry cavity, brick but not brick veneer, adobe, compressed earth block, rammed earth, solid timber or solid logs" OR are "any wall having a heat capacity greater than or equal to 6 Btu/ft²".

The model concrete masonry home has walls constructed of lightweight (95 pcf), 8-inch thick partially grouted concrete masonry. This wall type qualifies as a mass wall system as defined by the NCECC.

Many options are available to meet energy code insulation requirements. A simple and cost effective approach with hollow or partially grouted concrete masonry construction is to fill empty cells with foamed-in-place insulation. Aminoplast insulation is chosen for this wall system. This foamed-in-place insulation is cost effective, has good sound insulating properties, and excellent thermal resistance. The insulation is injected into empty cells after the wall is built, where it flows into open cells and spaces. Aminoplast insulation has a hybrid mixture of open and closed cells, and is considered as open cell insulation, effectively permitting moisture vapor transmission and promoting drying of walls should dampness enter the system. The installation provides an insulating R-value of up to 5.0 per inch. An R-value of 4.6 per inch is assumed here for calculating assembly thermal properties.

5.3 Continuous Insulation

The prescriptive requirements of the NCECC imply that continuous insulation, uninterrupted by webs of concrete masonry units or by interior furring, is required for concrete masonry and other mass walls. However, there are several other options to comply with energy code requirements without providing continuous insulation. Mass wall systems with thermal properties meeting the insulation requirements listed above are not required to have continuous insulation.

5 THERMAL PERFORMANCE

5.4 Wall System Thermal Properties

Thermal properties of a wall system are calculated by considering the combined contribution of all wall components, using the series-parallel method as recognized by code. All wall components including finishes, air spaces, internal grout, and insulation contribute to thermal performance. Additional information can be found in CHMA TEK 06-01C, *R-Values of Multi-Wythe Concrete Masonry Walls*, and CMHA TEK 06-02C, *R-Values and U-Factors of Single Wythe Concrete Masonry Walls*.

Walls of the base home design are partially grouted, with grout placed only at cells containing vertical or horizontal reinforcing bars. The remaining empty cells are filled with foamed-in-place insulation taking advantage of the wall's thermal mass properties. The R-value of the wall system is based on the percentage of insulated cells, the percentage of grouted cells, thermal properties of the insulation, and thermal properties of the concrete masonry unit. Webs of concrete masonry units act as thermal bridges; this effect is also considered when calculating insulating properties of the wall system. For our case, grouted/reinforced cells comprise 24% of the total cells, leaving 76% of the cells for insulation. Following the process described in CHMA TEK 06-01C, with lightweight units (95 pcf concrete mixture), the R-value of the partially grouted and insulated wall is 4.52 °F·ft²·h/BTU.

The R-value of the wall assembly is the sum of the individual components:

Component	R-Value
Outside air film	0.17
Concrete masonry wall	4.52
1.5" air gap	1.0
½" gypsum wallboard	0.45
Interior air film	0.68
Total	6.82

The NCECC requires exterior walls to have an R-value of 5 in Climate Zones 3 and 4. Our model home's wall system has an R-value of 6.82, exceeding building code thermal performance requirements by over 35 percent.

The NCECC also requires insulation with R-value of 10 be placed at exterior foundation walls, down to the depth of the footing (or 2 feet, maximum). Extruded polystyrene insulation board provides an insulating value of 5.0 per inch; using 2 inch insulation board as foundation insulation is a common and cost-effective way to meet this building code requirement.

Climate Zone 5 Alternate. The NCECC requires walls to have an R-value of 13 (external insulation) or 17, when more than half of the insulation is placed at the interior wall face. Our base wall system does not meet these requirements and additional insulation must be installed for homes built in Climate Zone 5.

5 THERMAL PERFORMANCE

One option is to add insulation at the exterior wall face, in which case a total R value of 13 is required. Insulation must be protected from weather and is best covered by a masonry veneer or synthetic stucco. Using a nominal 4-inch concrete masonry veneer (95 pcf), the R-value of the wall system is calculated as:

Component	R-Value
Outside air film	0.17
4" concrete brick veneer (95 pcf)	1.43
1" air cavity	0.97
Cavity insulation	x
Insulated partially grouted wall	4.52
1.5" air gap	1.0
½" gypsum wallboard	0.45
Interior air film	0.68
Total	9.22 + x

Hence insulation with an R-value of 3.8 must be placed in the drainage cavity between the concrete masonry veneer and the reinforced wall. An R-value of 3.8 can be obtained using ¾" of extruded polystyrene board (R value of 5.0 per inch) or 1" of mineral wool insulation (R value of 4.0 per inch).

For the exterior veneer option, if the empty cells in the concrete masonry walls are not insulated, the wall R-value is reduced by half to 2.26. In this case cavity insulation with an R-value of 6.0 is required to meet Climate Zone 5 requirements: use either 1 ¼" extruded polystyrene board or 1 ½" mineral wool insulation.

Another option is to add insulation to the interior of the wall, within the furred space. Thermal mass effects are reduced if insulation is placed at the interior face of the wall mass, and the NCECC requires the wall system have an R-value of 17 for this approach. The R-value of the insulated CMU wall is calculated as follows:

Component	R-Value
Outside air film	0.17
Concrete masonry wall	4.52
Insulation	x
½" gypsum wallboard	0.45
Interior air film	0.68
Total	5.82 + x

Hence interior insulation must have an R-value of 11.2 to meet Climate Zone 5 requirements. This can be accomplished with 2 1/2" rigid polystyrene board with wood furring at 24 inches on

5 THERMAL PERFORMANCE

center, or R13 fiber batt insulation. Both of these options require the furred out space be increased by placing 2x4 furring on end rather than flat as shown in detail drawings.

If core-fill insulation is left out of the CMU wall, interior insulation must have an R-value of 13.4. Viable options are using either 2 ¾" of rigid polystyrene board or R15 fiber batt insulation. Both of these insulation options can fit in a 3 ½" furred space.

Climate Zone 6 Alternate. Following the Climate Zone 5 discussion above, the IECC requires walls to have an R-value of either 15 (external insulation) or 20, when more than half of the insulation is placed at the interior wall face. Options for additional insulation are listed below.

5.8 R-value, when placed in the drainage cavity of a concrete masonry veneer system

- 1 ¼" extruded polystyrene board and foamed insulation at empty cells
- 1 ½" mineral wool insulation and foamed insulation at empty cells

8.0 R-value, when placed in the veneer drainage cavity, with no insulation at empty cells in CMU walls

- 1 ¾" extruded polystyrene board, no insulation at empty cells
- 2" mineral wool insulation, no insulation at empty cells

13.2 R-value, when placed in furred out space at the inside face of the wall (empty cells insulated as well)

Furred out space must be 3 ½" wide

- 3" extruded polystyrene board and foamed insulation at empty cells
- R13 fiber batt insulation and foamed insulation at empty cells

15.5 R-value, when placed in furred out space at the inside face of the wall (no insulation at empty cells)

(both of these options require non-standard insulation thicknesses and should be avoided)

- 3.1" extruded polystyrene board, no insulation at empty cells
- R15.5 fiber batt insulation, no insulation at empty cells

6 FIRE PERFORMANCE

Fire rated construction is required by building codes to limit the spread of fires and prevent building collapse, providing time for occupants to escape and for emergency services to respond. Concrete masonry has excellent fire resistance: masonry materials are noncombustible, and its thermal mass slows the rate of heat transmission that occurs during a fire.

Required fire resistance of structural materials and assemblies is covered in Section R302 of the International Residential Code. All single-family residential construction requires that exterior walls have a fire rating of 1.0 hours for homes built near the lot line.

Concrete masonry fire rating is based on the solidity of the masonry units, calculated as the “equivalent thickness,” whether all cells are filled with an approved material (such as grout or aggregate), and aggregate type. The equivalent thickness is essentially the solid thickness that would be obtained if the volume of concrete contained in a hollow unit were recast to be solid without core holes. Interior and exterior finishes such as stucco, cement plaster, or gypsum wallboard will contribute to wall fire rating. The effect of such finishes on fire rating is described in CMHA TEK 01-01D, *Fire Resistance Ratings of Concrete Masonry Assemblies*.

Structural walls of the prototype residence discussed in this guide are constructed with hollow 8-inch (nominal) concrete masonry units. Masonry unit density is specified as 95 pounds per cubic foot assuming expanded clay, shale, or slate lightweight aggregate. The contribution of interior and exterior finishes is not considered in this example.

Fire rating is best calculated following the approach of CMHA TEK 07-01D, *Fire Resistance Ratings of Concrete Masonry Assemblies* with consideration given to aggregate type and equivalent thickness. The TEK note lists the equivalent thickness of a typical 8-inch partially grouted concrete masonry wall as 4.0 inch. A fire rating period of 1.9 to 2.2 hours applies to this equivalent thickness for typical CMU aggregate blends, exceeding building code requirements by approximately 2 times.

Walls built of the same 8-inch hollow unit can have a fire rating ranging from 1 hour 50 minutes (for units made with calcareous or siliceous gravel aggregate), to 2 hours (limestone, cinders, or unexpanded slag aggregate), or as high as 3.0 hours for masonry units having expanded slag or pumice aggregate. Manufacturers will produce block with the aggregate blend necessary to meet the fire rating specified by the designer.

7 SOUND PERFORMANCE

Masonry walls are excellent at reducing noise, and have the mass, texture, and solidity to effectively reduce exterior noise from passing through to the interior. The ability of a wall to minimize *sound transmission* through the wall section is represented by a wall's Sound Transmission Class (STC), measured as decibels (dB) of sound reduction. Construction with higher STC values are better at blocking sound than those with lower STC values. For a given construction typology, the most significant factor influencing the STC rating is its weight: heavier walls generally block more sound. Procedures for determining the STC of concrete masonry construction are described in CMHA Tek 13-01D, *Sound Transmission Class Rating for Concrete Masonry Walls*.

Building codes require certain STC ratings depending on the location and function of the constructed wall. For example, the IBC requires a calculated STC rating of 50dB for walls of corridors or walls separating dwelling units. The IRC does not require minimum STC ratings; however, it has a non-mandatory appendix that recommends a STC rating of 45dB for walls. It is important that all holes, cracks, or voids in walls are filled to achieve the listed STC ratings.

For our prototype home, constructed of 8-inch masonry units with a density of 95 pcf, the walls have a STC rating of 45 dB if left completely hollow. Greater STC ratings are provided for sand-filled units (STC of 53 dB), and for solid grouted walls (STC of 55 dB).

The ability of construction to diminish noise effects is represented by a Noise Reduction Coefficient (NRC), which considers *sound absorption* at a range of frequencies. More porous and open-textured surfaces, such as CMU, absorb more sound than dense, smooth surfaces and, as a result, they have a higher NRC.

8 MASONRY WALL BRACING

The Occupational Safety and Health Administration (OSHA) requires that any masonry wall sections constructed over eight feet in height be braced during construction. Walls under construction must have adequate bracing to prevent overturning or collapse until the walls are connected to structural framing. Once the floor and roof framing are in place and anchored to walls, with floor and roof sheathing installed, the framing provides lateral support and bracing is no longer required.

There are two general approaches to bracing masonry walls under construction:

1. Provide external braces, such as wood braces, steel pipe braces, or tension cables. The Council for Masonry Wall Bracing developed the *“Standard Practice for Bracing Masonry Walls Under Construction”* in 2012 to guide contractors for different external bracing methods. These guidelines are available online and through the Mason Contractors Association of America.
2. Rely on internal bracing, using the strength of the masonry assembly for resistance to overturning and collapse. This concept considers masonry strength development in the first few days after walls are constructed and relies on the mass and strength of the wall to resist short-term wind and seismic forces. The International Masonry Institute (IMI) funded development of the *“Internal Bracing Design Guide for Masonry Walls Under Construction”* in 2013. This guide is available for free online through IMI and other masonry industry sources.

Most contractors use the internal bracing approach for low-rise construction such as our concrete masonry home. Newly-constructed masonry has mass and develops strength in the first hours and days after construction; both of these actions are used to resist lateral loads. The main advantage of the internal bracing approach is cost and simplicity as no external braces are required.

The engineered internal bracing solution requires a “Restricted Zone” be established around the masonry under construction that extends on both sides of the wall a distance equal to the wall height plus 4 feet. Personnel are not allowed in the Restricted Zone when wind speeds exceed 20 miles per hour for newly built walls, or 35 miles per hour after walls have aged for either 12 or 24 hours, depending on design parameters including masonry strength, grout solidity, and lap splice length. A design professional must be involved in the development of a project bracing plan using either external supports or the internal bracing scheme.



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CHMA TEK 06-01C, R-Values of Multi-Wythe Concrete Masonry Walls, Concrete Masonry and Hardscapes Association.

CHMA TEK 06-02C, R-Values and U-Factors of Single Wythe Concrete Masonry Walls, Concrete Masonry and Hardscapes Association.

CMHA TEK 09-03A, Plaster and Stucco for Concrete Masonry, Concrete Masonry and Hardscapes Association.

CMHA TEC 009-025, Crack Control Strategies for Concrete Masonry Construction, Concrete Masonry and Hardscapes Association.

CMHA TEK 13-01D, Sound Transmission Class Rating for Concrete Masonry Walls, Concrete Masonry and Hardscapes Association.

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TMS 402/602-16, "Building Code Requirements and Specification for Masonry Structures", The Masonry Society, Fort Collins, Colorado, 2016.

STRUCTURAL NOTES

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STRUCTURAL NOTES

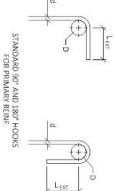
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STRUCTURAL DRAWING LIST

MACHINE UP PLATE (INCHES)			
T ₂ = 2,200 PS			
BAR SIZE	PLS. & MOD.	BEND DMM. D	1.00
#5	19	3.75	7.5

CONCRETE LAP JOINT (CL5) TO (CL6) (INCHES)			
F ₁ = 2,500 psi			
BAR SIZE	CL5 & CL6	MINIMUM LAP	100
#5	30	3.00	7.5

1. C/S CONCRETE LAP SPACE
2. C/S CONCRETE DEVELOPMENT LENGTH
3. TABULATED VALUES ARE PER AISI REQUIREMENTS FOR THE SPECIFIED CONCRETE COMPRESSIVE STRENGTH.
4. WHERE INSTALLATION VARIES FROM THE BAR SIZE LISTED, MINIMUM SPACING AND/OR d , LENGTHS SHALL BE ADJUSTED ONLY WITH THE APPROVAL OF THE EOR.
5. STAGGER LAP SPACES 30" MIN.

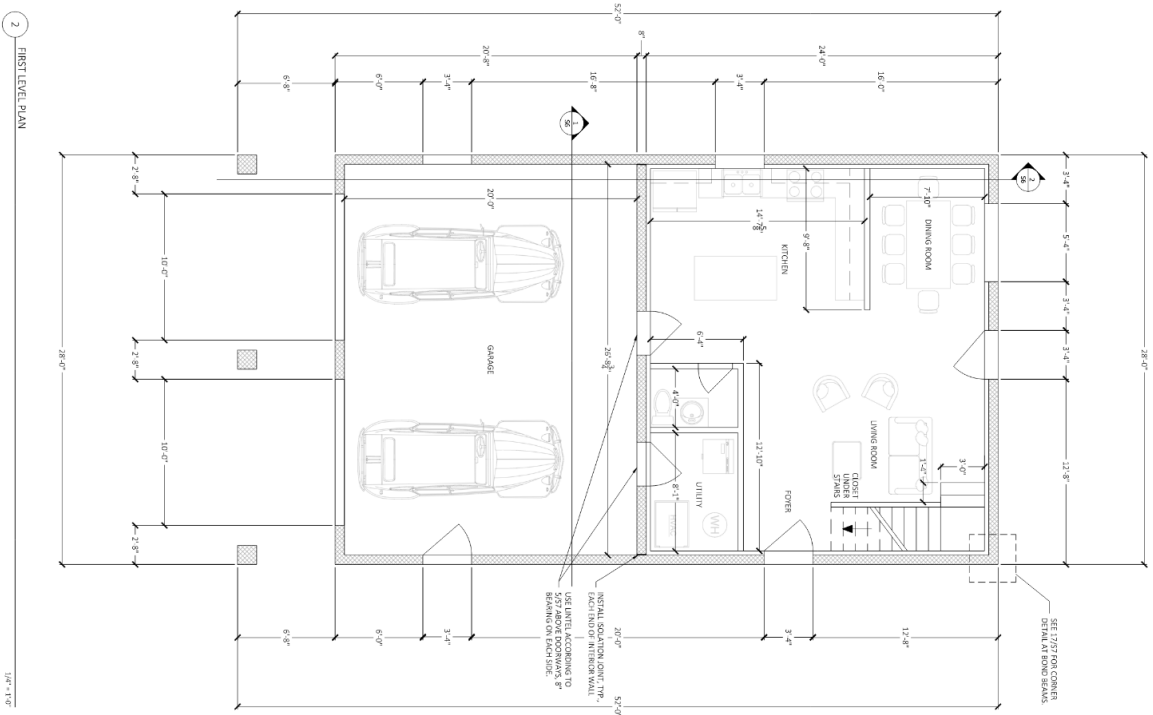
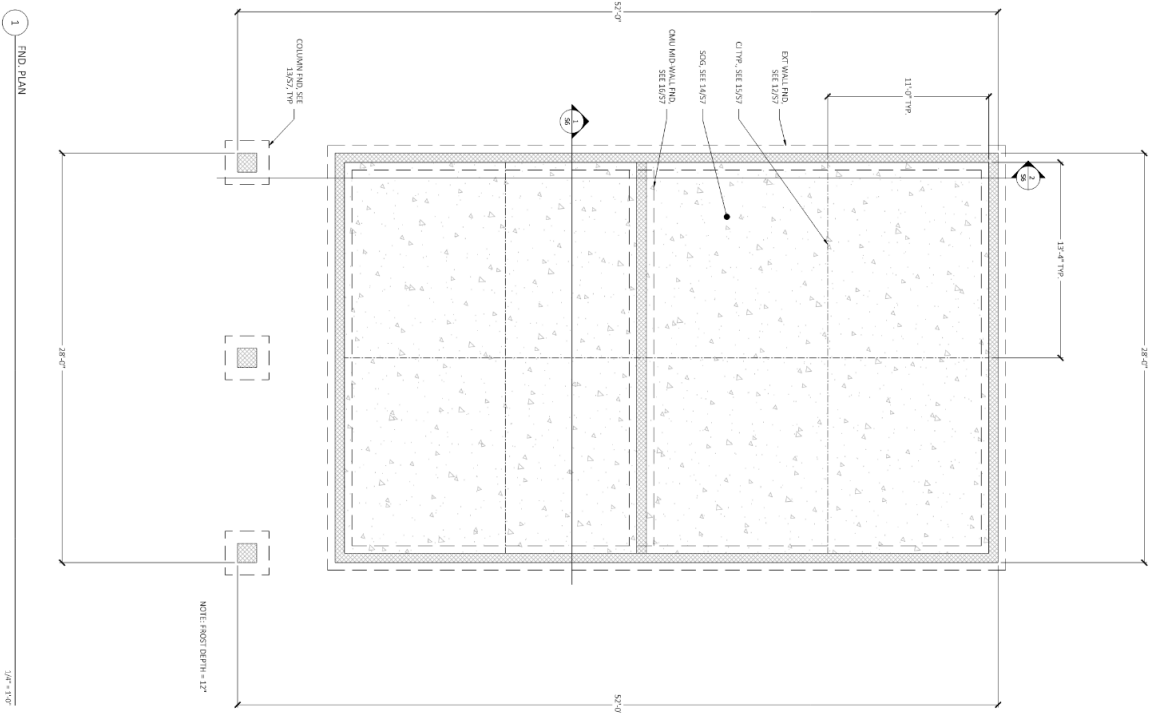


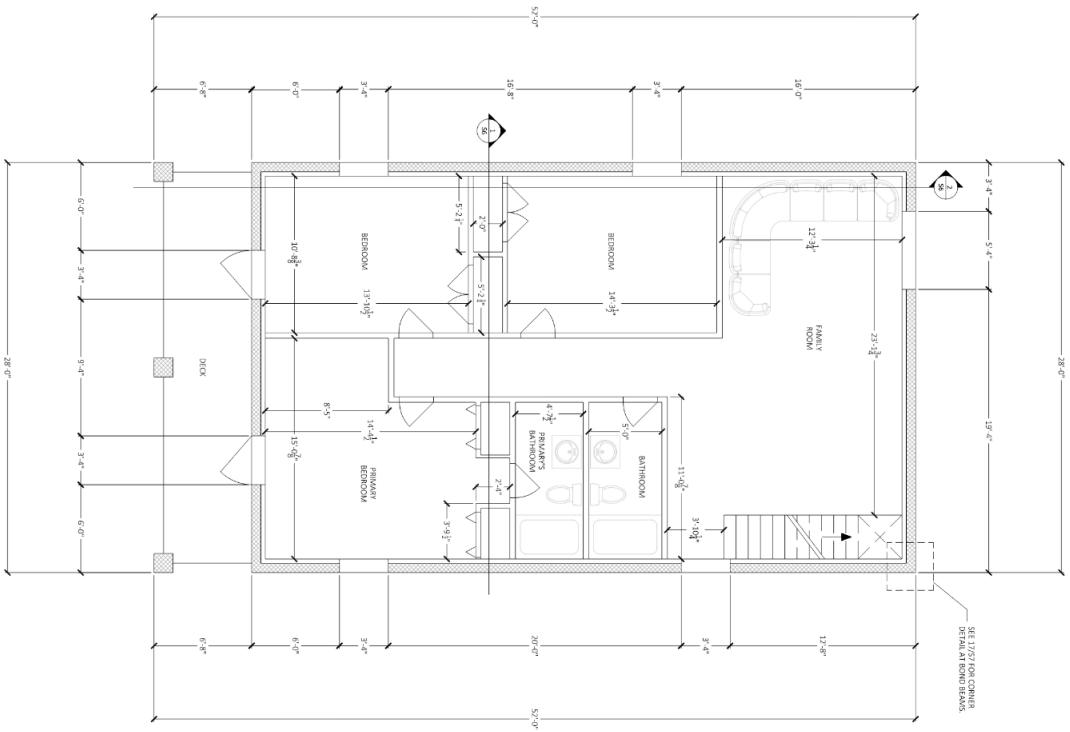
STRUCTURAL DRAWING LIST

50	GENERAL NOTES
51	PLAN VIEWS
52	PLAN VIEWS
53	FRAMING PLANS
54	ELEVATION VIEWS
55	REINFORCEMENT LAYOUT
56	BUILDING SECTIONS
57	DETAILS
58	HIGH WIND DESIGN ALTERNATE REINFORCEMENT LAYOUT AND DETAILS
59	HIGH SEISMIC DESIGN ALTERNATE REINFORCEMENT LAYOUT AND DETAILS
60	CONTROL JOINT ALTERNATE REINFORCEMENT LAYOUT
61	CONTROL JOINT ALTERNATE REINFORCEMENT LAYOUT

ABBREVIATIONS

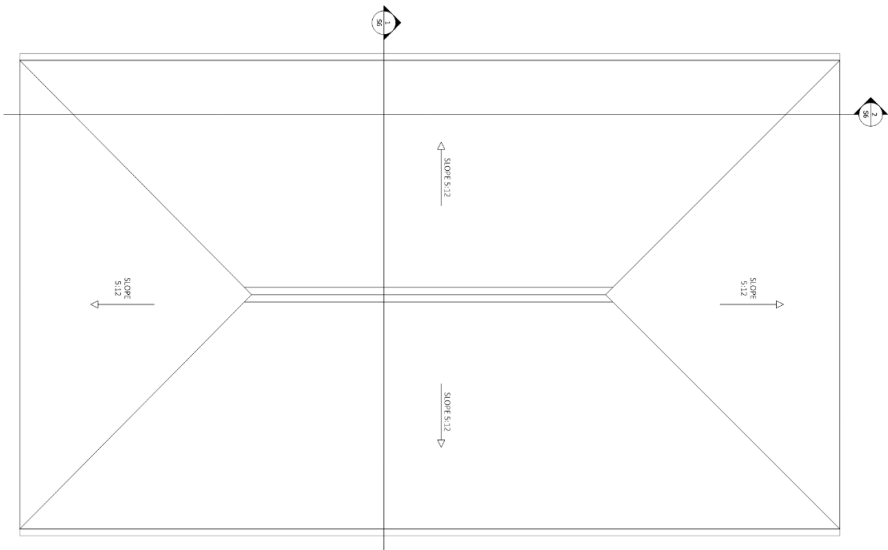
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1 SECOND LEVEL PLAN

1/4" = 1'-0"



2 ROOF PLAN

1/4" = 1'-0"



CONCRETE
MASONRY
HOUSE
DESIGN

DATE: 10/01/2016
PROJECT NUMBER: 25-002
DRAWN BY: MCH
C.D. BY: CAC
REVISIONS:
REV # DATE DESCRIPTION

SCALE:

TITLE
PLAN VIEWS

SCALE: As Indicated

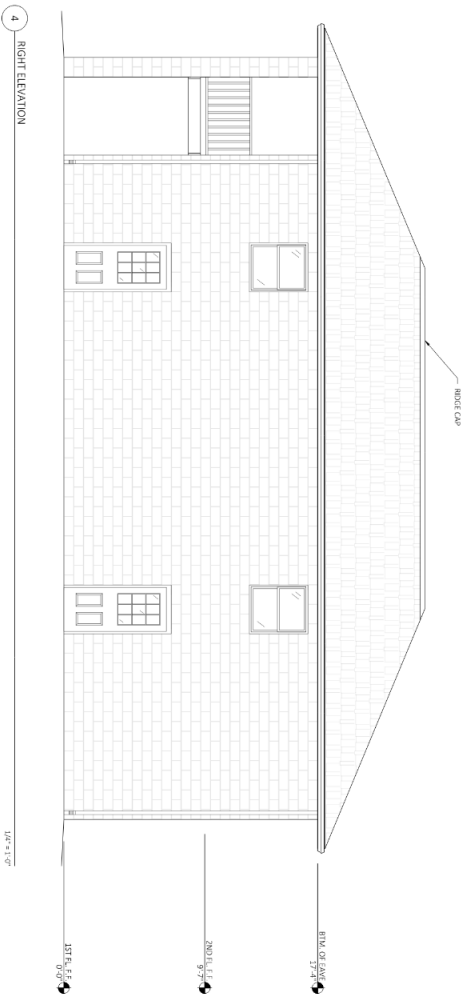
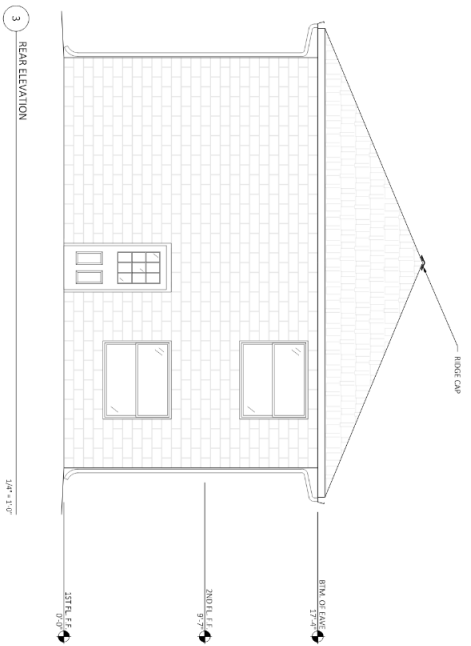
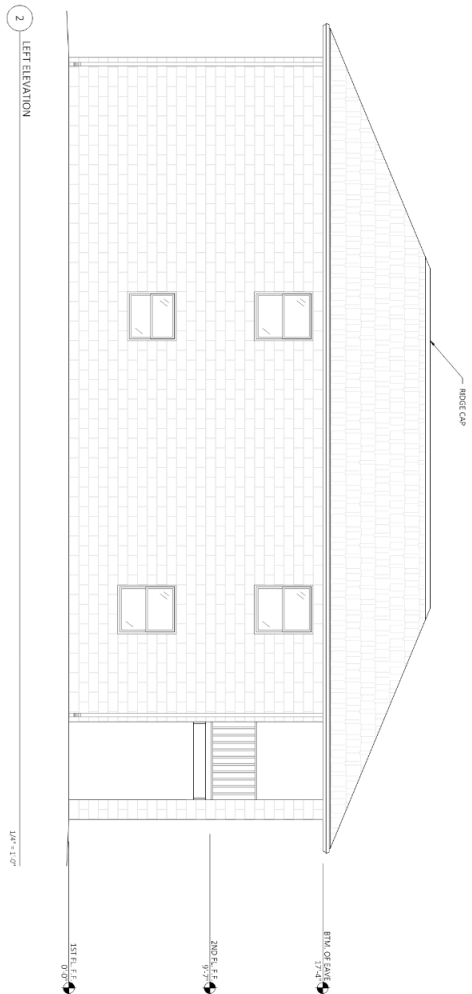
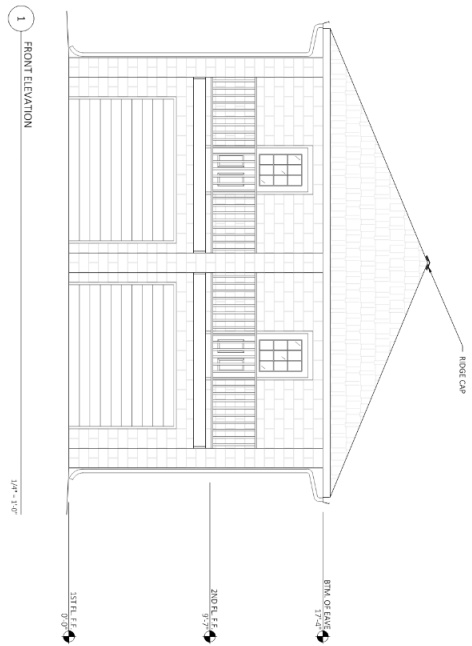
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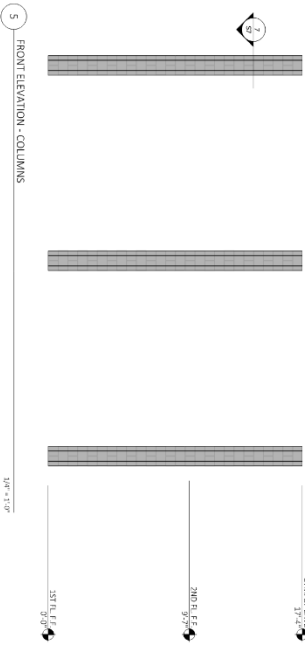
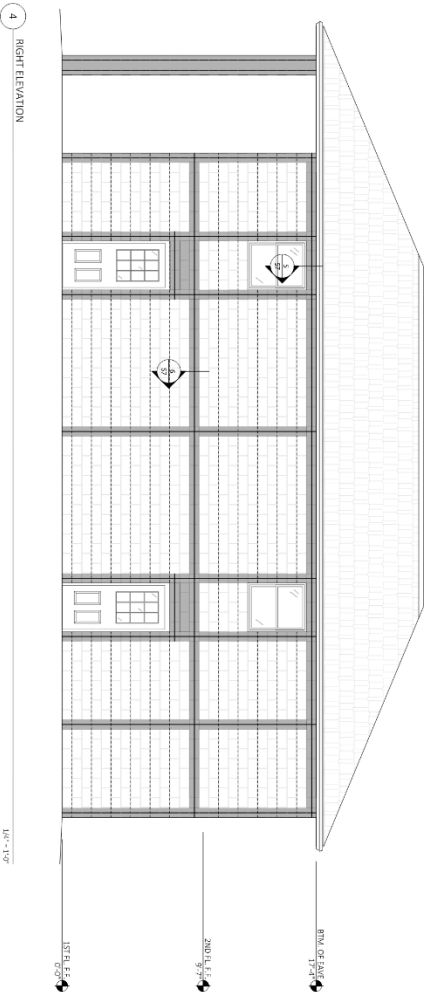
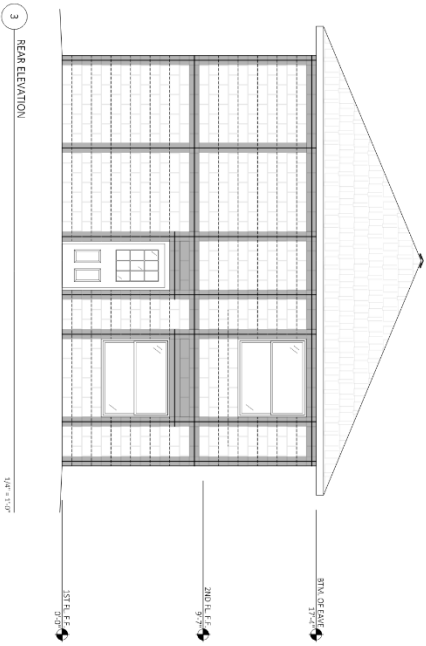
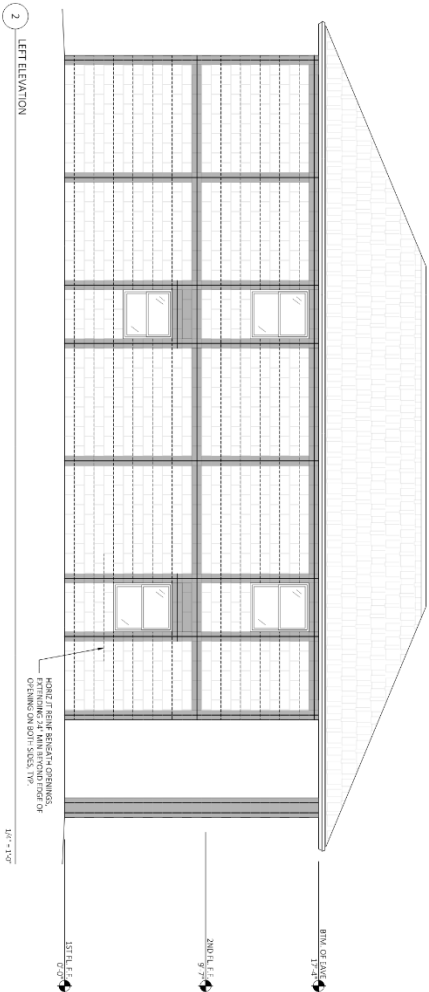
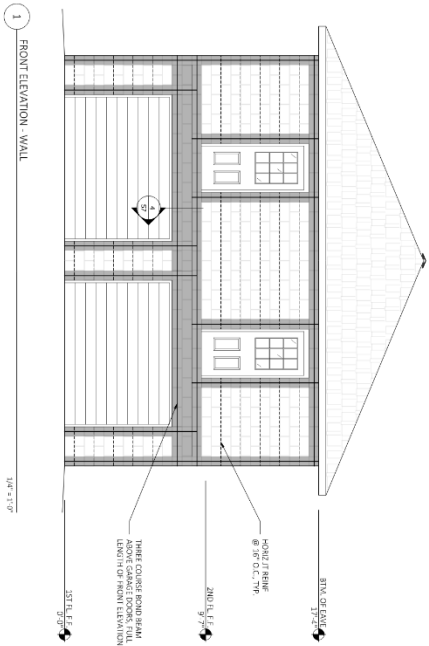
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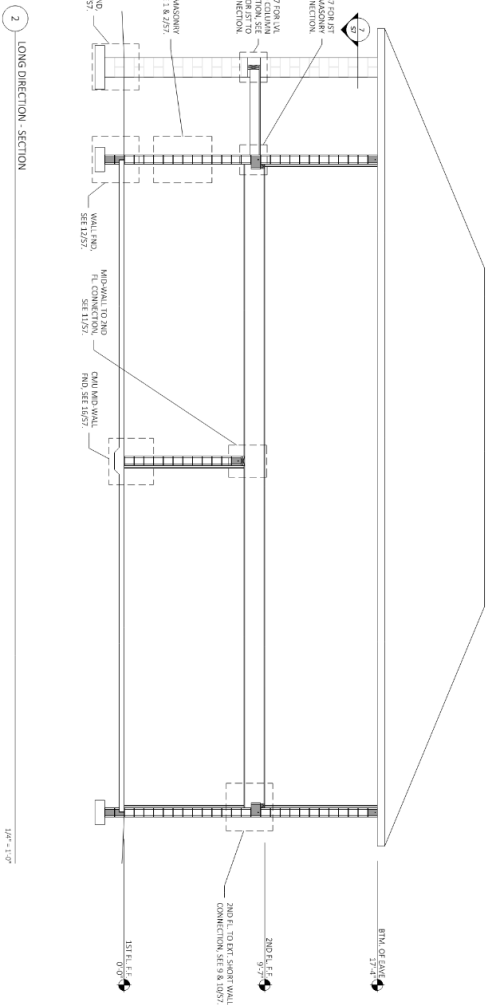
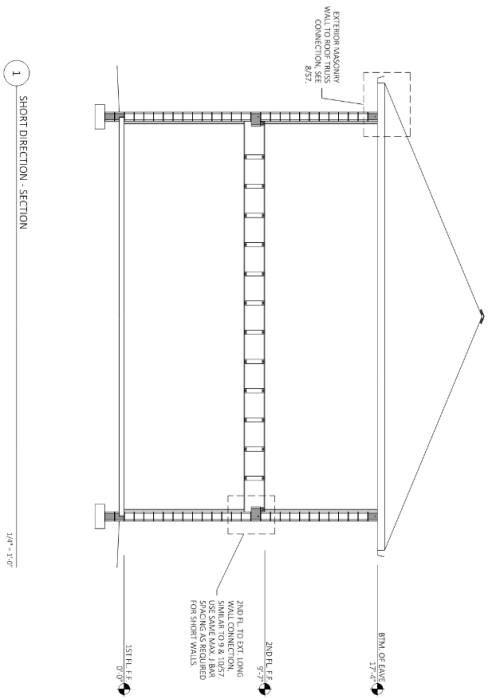


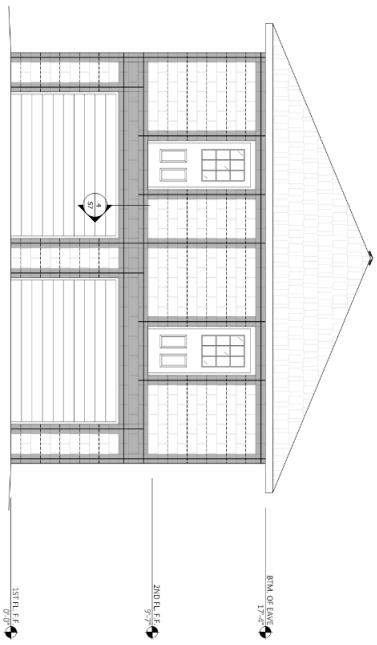
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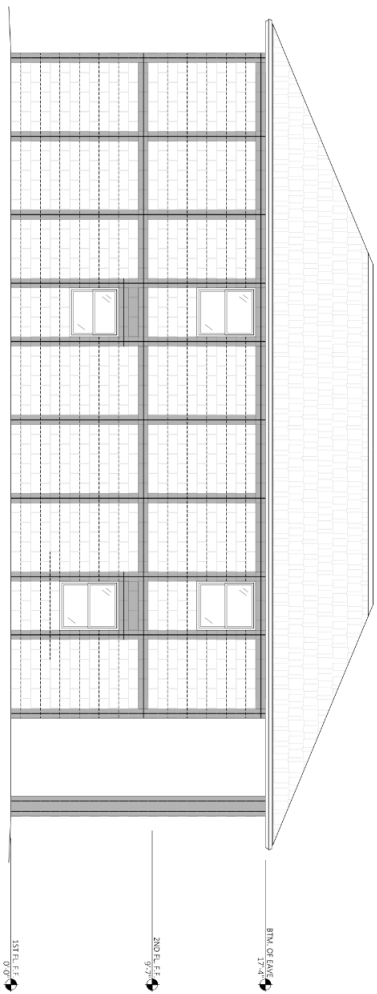




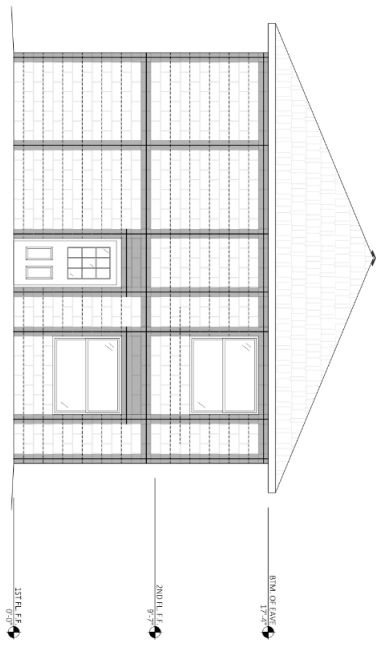




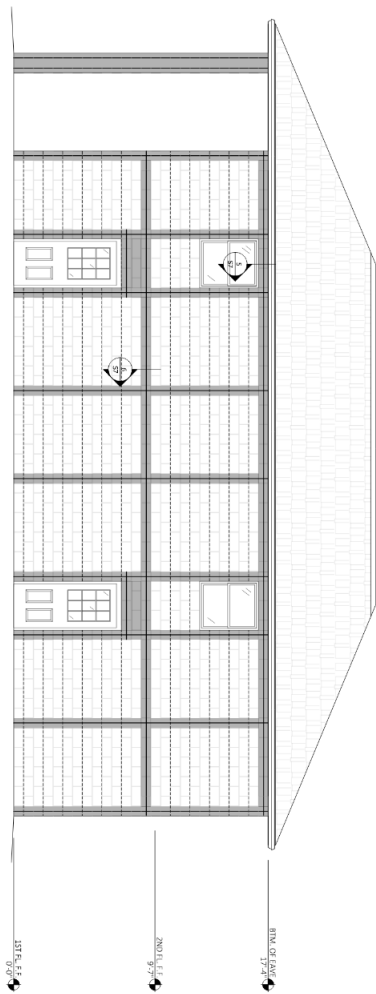
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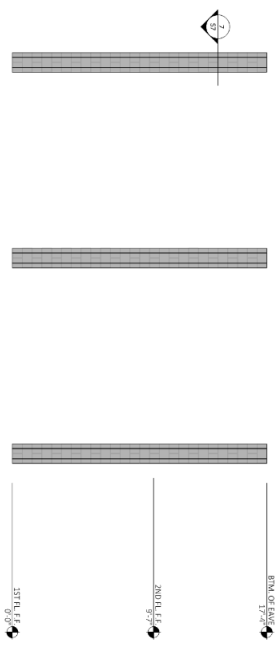
2 LEFT ELEVATION



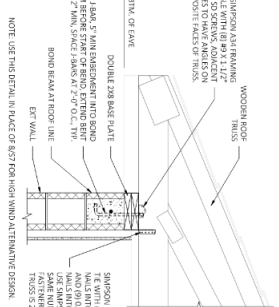
3 REAR ELEVATION



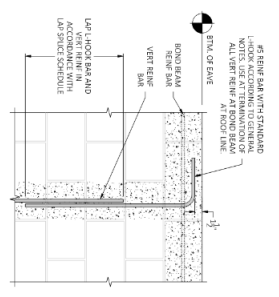
4 RIGHT ELEVATION



5 FRONT ELEVATION - COLUMNS



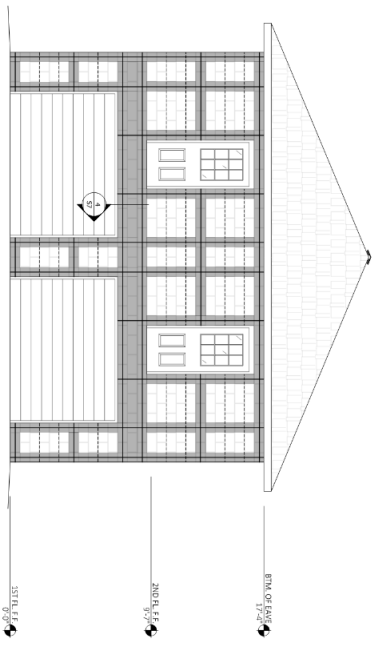
6 TYP. ROOF TO EXT WALL CONNECTION - SECTION



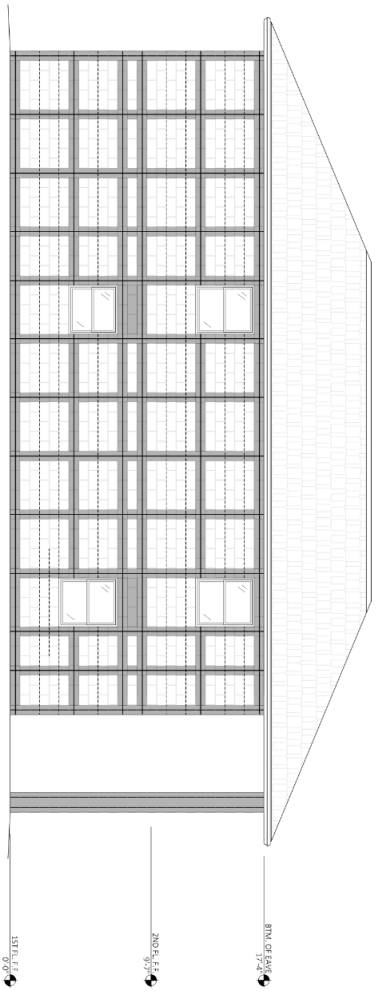
7 TYP. TERMINATION OF VERT REINF. AT ROOF

- REQUIRED MODIFICATIONS FOR HIGH WIND DESIGN ALTERNATIVE
1. VERTICAL REINFORCEMENT IN EXTERIOR WALLS (11.2.2)
 - 1.2. USE FANWIND - HOOKS AT ROOF LINE BOND BEAMS AS SHOWN IN 7138
 2. 1" MAX. TIE SPACING AT LONG WALLS (REINFORCED) FROM 9'-4" TO 7'-9"
 3. 1" MAX. TIE SPACING AT LONG WALLS (REINFORCED) FROM 9'-4" TO 7'-9"
 - 3.1" MAX. TIE SPACING AT LONG WALLS (REINFORCED) FROM 9'-4" TO 7'-9"

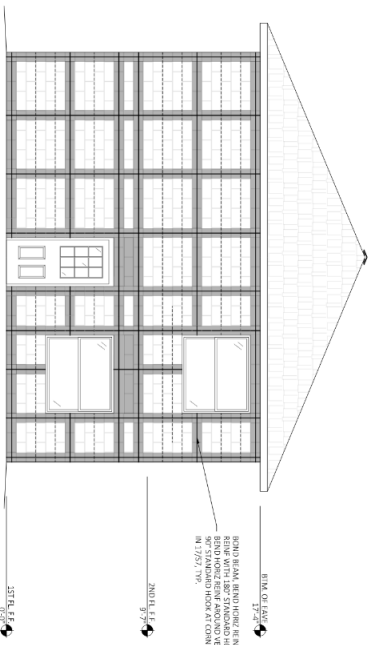
- HIGH WIND ALTERNATIVE DESIGN CRITERIA
- OF WIND DESIGN DATA INCLUDED IN STRUCTURAL NOTES
- | | | |
|----|---------------------------|---------|
| A. | WIND DESIGN DATA | 150 MPH |
| B. | WIND CATEGORY | II |
| C. | WIND PROPOSED COEFFICIENT | 0.018 |



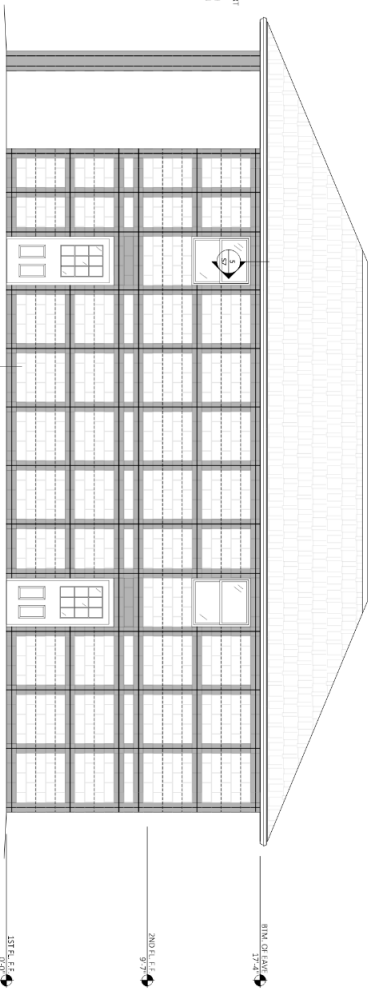
1 FRONT ELEVATION - WALL



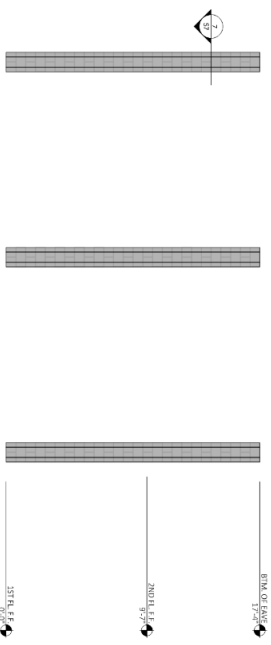
2 LEFT ELEVATION



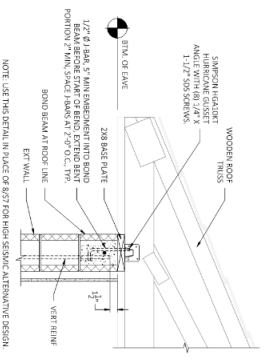
3 REAR ELEVATION



4 RIGHT ELEVATION



5 FRONT ELEVATION - COLUMNS



6 TYP ROOF TO EXT WALL CONNECTION - SECTION

REQUIREMENTS FOR REINFORCED CONCRETE DESIGN. DESIGNER TO VERIFY THAT ALL REQUIREMENTS ARE MET. SEE ALSO REINFORCED CONCRETE DESIGN SPECIFICATIONS, 10th EDITION, 2015, AND REINFORCED CONCRETE DESIGN SPECIFICATIONS, 11th EDITION, 2017.

A. EARTHQUAKE DESIGN DATA	B. EARTHQUAKE DESIGN DATA
- RISK CATEGORY	II
- SEISMIC CATEGORY	1.0
- SEISMIC DESIGN CATEGORY	1.000 E
- EQUIPMENT ANCHOR FORCE	0.111 F

- REQUIRED NOTIFICATIONS FOR REINFORCED CONCRETE DESIGN:
- 2ND FLOOR INTERIOR WALLS
 - 1.1. REINFORCED CONCRETE WALLS, 10" THICK, SPACED AT 12" O.C. WITH 1-1/2" REINFORCEMENT INTO FRAMING AT PANEL EDGES. TOP WALLS SPACED AT 12" O.C. WITH 1-1/2" REINFORCEMENT INTO FRAMING AT PANEL EDGES. REINFORCEMENT INTO TOP CHORD OF FLOOR TRUSSES PRIOR TO APPROVAL OF SETTING TYPE.
 - 2.1. MAX. JOIST SPACING AT GABLE END: REINFORCED FROM 3'-4" TO 7'-0".
 - 3.1. MAX. JOIST SPACING AT GABLE END: REINFORCED FROM 3'-4" TO 7'-0".
 - 4.1. MAX. JOIST SPACING AT GABLE END: REINFORCED FROM 3'-4" TO 7'-0".
 - 5.1. MAX. JOIST SPACING AT GABLE END: REINFORCED FROM 3'-4" TO 7'-0".
 - 6.1. MAX. JOIST SPACING AT GABLE END: REINFORCED FROM 3'-4" TO 7'-0".
 - 7.1. MAX. JOIST SPACING AT GABLE END: REINFORCED FROM 3'-4" TO 7'-0".
 - 8.1. MAX. JOIST SPACING AT GABLE END: REINFORCED FROM 3'-4" TO 7'-0".



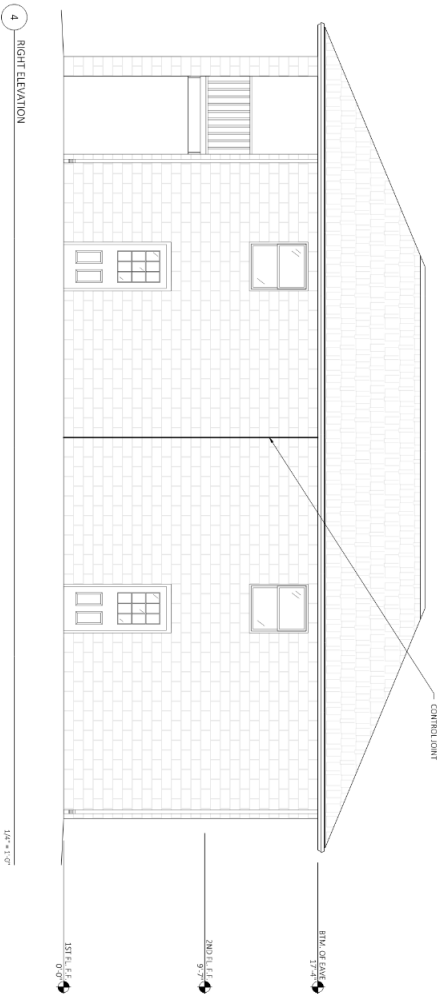
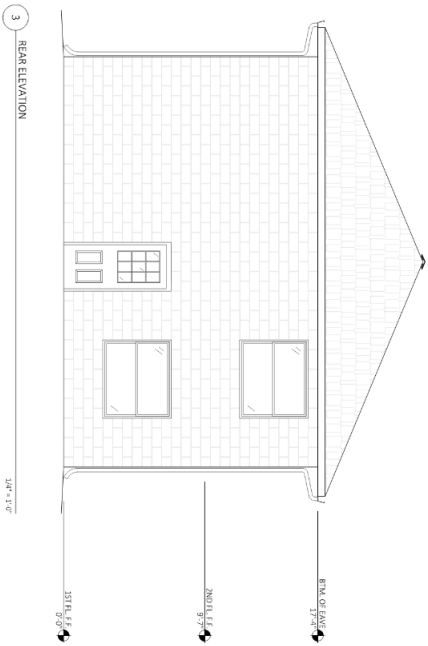
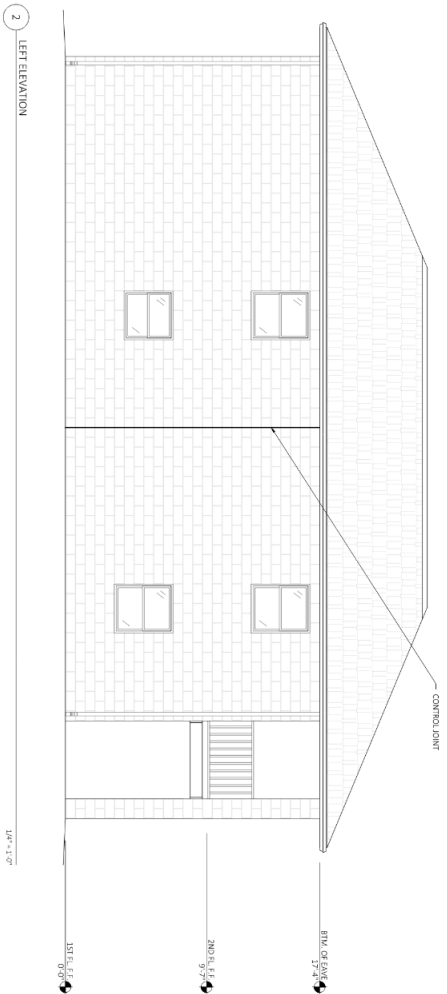
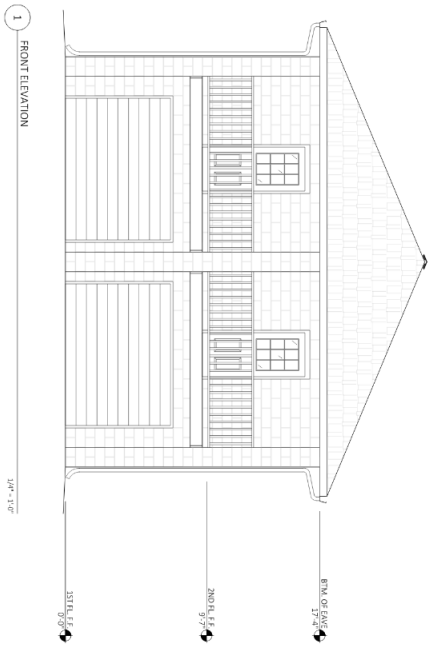
CONCRETE MASONRY HOUSE DESIGN

DATE: 10/08/2016
PROJECT NUMBER: 25-002
DRAWN BY: MCH
CDD BY: CAC
REV # DATE DESCRIPTION

SCALE

TITLE
HIGH SEISMIC
REINFORCEMENT
LANDSCAPE

S9



CONCRETE
MASONRY
HOUSE
DESIGN

DATE: 10/06/2016
PROJECT NUMBER: 25-002
DRAWING BY: MACH
CDD BY: CAC
REVISIONS:
REV # DATE DESCRIPTION

SCALE

TITLE
CONTROL JOINT
ASSEMBLY
ELEVATIONS
SCALE: As Indicated

S10

