

The Closed Crawl Space: Making the Transition

Climate Zones 3A & 4A



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What is a closed crawl space?

A closed crawl space includes insulation on foundation walls, a ground vapor retarder, and mechanical ventilation. Some local jurisdictions allow insulation in the floor instead of the wall insulation. Unlike a conventional crawl space, a closed crawl space does not have wall vents and is air sealed to improve energy and moisture performance. A closed crawl space may also be referred to as unvented, conditioned, semi-conditioned, or sealed.

The modern closed crawl space is dry, energy efficient, functional, and practical to build. This TechSpec presents an overview of benefits, code considerations, best practices, and solutions for closed crawl spaces. This information is intended to help home builders transition from a slab-on-grade or conventional vented crawl space, or to improve existing design and construction practices. This TechSpec is consistent with the provisions of the 2012 International Residential Code (IRC), and is focused on warm and mixed-humid climate regions in the southeast (Climate Zones 3A and 4A). Some common local construction practices are also addressed.

Benefits of a Closed Crawl Space

Dry and Durable

Insulation, air sealing, moisture control measures, and conditioned air provide a dry under-floor space.

Marketable to Home Buyers

Raised wood floor homes provide architectural appeal and a warm and comfortable walking surface.

Adaptable to Sloped Sites, Infill Sites, and Challenging Soil Conditions

Crawl space foundations are a cost-effective solution for challenging site and soil conditions.

Simplified Scheduling of Trades and Inspections

Construction and inspection of plumbing and mechanicals does not affect other trades.

Improved Whole-House Energy Efficiency

Closed crawl space temperatures are more stable compared to an attic or a vented crawl space. Locating ducts and mechanical equipment in a closed crawl space reduces heating and cooling loads.

Simplified Installation of Mechanical Systems

Access for installation and maintenance of plumbing and mechanical systems is provided; also changes to floor plans can be accommodated.

Practical

A closed crawl space is built using materials and methods familiar to trades, and allows for a simple transition from either a slab foundation or a vented crawl space.



Easy-to-Install Wood Floor Framing



Mechanical Systems in Conditioned Space



Curb Appeal and Comfortable Home

Closed Crawl Space Design

Closed crawl space considerations addressed in this TechSpec include: foundation walls, height and access, wood floor framing, moisture management, air sealing, insulation, and mechanical systems. Open crawl spaces (a pier and beam foundation without walls), wall-vented crawl spaces, and houses in flood hazard areas are outside the scope of this TechSpec.

Code Compliance

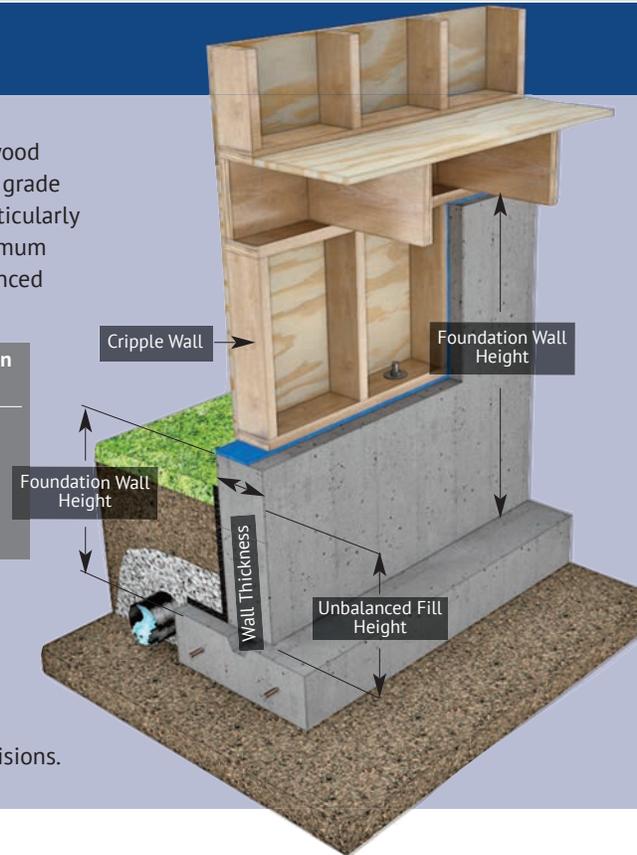
All applicable local building code requirements and all specifications established by the licensed professional for the project must be followed. All products must be installed in accordance with manufacturer's specifications and local building codes. Where required based on local conditions, radon control measures must be implemented in accordance with the governing building code.

Foundation Walls

Foundation walls are constructed with poured concrete, masonry block, or permanent wood foundation systems. Wood-framed walls, referred to as cripple walls, can be used above grade from the top of the foundation wall to the floor framing. Cripple walls are common, particularly on sloped sites in combination with stepped concrete or masonry block walls. The minimum thickness and maximum height of foundation walls is determined based on the unbalanced backfill height.

Foundation Wall	Minimum Nominal Wall Thickness	Maximum Unbalanced Fill Height	Maximum Foundation Wall Height
Masonry block un-grouted	8 inches	4 Feet	5 Feet
Masonry block un-grouted	10 inches	5 Feet	5 Feet
Masonry block (solid unit or solid grouted)	6 inches	4 Feet	5 Feet
Poured Concrete	6 Inches	4 Feet	8 Feet

Cripple walls cannot be used with foundation walls supporting more than 4 feet of unbalanced fill. The cripple wall stud size and spacing is typically the same as for the framed wall above. Where the cripple wall height exceeds 48 inches, however, the studs must be sized and spaced as a full story. Cripple walls must be braced in accordance with the governing building code. It is typical practice to fully-sheath cripple walls on the exterior face with wood structural panels to meet the bracing provisions.



Crawl Space Height and Access

The height of a crawl space is controlled by practical factors such as curb appeal, water table, storage, or access to mechanical equipment. As a best practice, a crawl space height of 44-48 inches is recommended for general access and where mechanical equipment is installed. All appliances located in a crawl space must be accessible for inspection, service, repair, and replacement. Mechanical equipment generally requires a 30-inch minimum clear path height.

Access to all under-floor spaces must be provided from the floor above or through the outside perimeter wall. A through-wall access opening cannot be located below an entrance door.

Minimum Requirements for Access Openings

Access Location	Opening Minimum Size	Minimum Landing
Through the floor	18" x 24"	n/a
Through the wall (entire access above grade)	16" x 24"	n/a
Through the wall (below grade)	16" x 24"	16" x 24" (opening threshold)

Wood Floor Framing

The floor can be framed with dimension lumber joists, wood floor trusses, or wood I-joists, all sized and spaced based on the span. Where additional sturdiness in the floor is desired, shorter spans, deeper members, and closer spacing can be considered. Piers or columns can be installed in the crawl space to reduce the span for girders and joists (see photograph on page 1). Subfloor panels,

rated for the application, should be both nailed and glued to the floor joists to prevent squeaks. Subfloor panels should be spaced 1/8" to accommodate panel expansion. Panel edges may need to be sanded before installation of the finished floor, but many subfloor manufacturers carry products that have a "no-sand" guarantee.

Moisture Management

Exterior Water Management

As with all foundation systems, measures for keeping exterior moisture from getting inside the crawl space include:

- An exterior drainage system
- Dampproofing the exterior surface of the foundation walls (or waterproofing where required)
- Use of gutters & downspouts and proper site grading to direct water away from the house

Ground Vapor Retarder

A ground vapor retarder is installed to minimize transfer of water vapor from the soil into the crawl space.

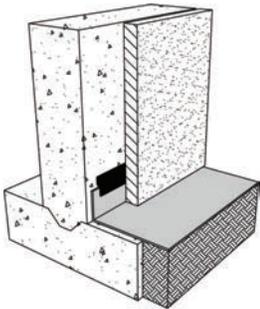
- The earth must be cleared of all vegetation and organic material.
- A 6-mil minimum polyethylene (poly) is required by the IRC.
- The poly can be secured to the ground using sod staples or spikes, or by other means, as needed.
- Poly joints must overlap at least 6 inches, and be sealed or taped, as required by the IRC.
- Poly edges must extend at least 6 inches up the wall, and be attached and sealed to the wall or insulation, as required by the IRC.
- The poly must be sealed at all seams and at all junctions with walls, piers, etc. using tape or mastic
- The poly can be extended the full height of the foundation wall to minimize moisture vapor transfer from the wall. (Poly should not be extended up cripple walls, or be installed over an interior framed wall.)

Best practices include:

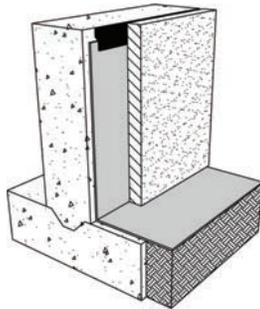
- Roof overhangs to direct water away from walls
- An additional interior drain system with a sump pump
- A capillary break between the footer and wall
- Interior access, or exterior access with a drainage threshold at the landing, to control bulk water
- A 10-mil minimum reinforced ground poly, or non-structural slab over 6-mil poly, is recommended for additional durability.
- A temporary (sacrificial) ground poly can be installed to keep the crawl space dry during construction, and to avoid potential need for repair from punctures during construction.
- Seal ground poly using both tape and mastic

Poly-to-wall Interface Options

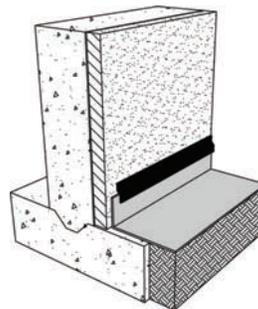
Poly attached and sealed directly to the wall



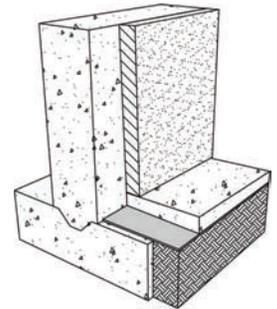
Poly extended the height of the wall



Poly attached and sealed to rigid insulation



Poly capped with non-structural slab



Examples of Homes with Closed Crawl Spaces



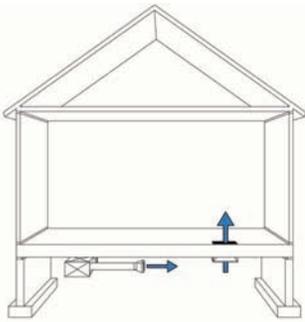
Ventilation

The purpose of ventilation in a closed crawl space is to control relative humidity and maintain indoor air quality. The IRC requires either conditioned air supply (Figure 1) or continuous mechanical exhaust ventilation (Figure 2), at a rate of 1 cubic foot per minute for each 50 square feet of the crawl space floor area. Either option requires an air pathway to the house. As a best practice, the conditioned air supply should have a damper or constant air

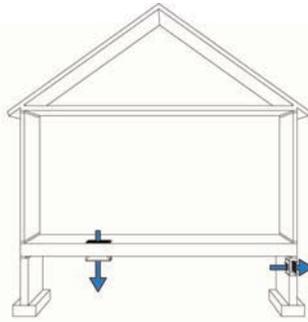
flow regulator to control the ventilation rate. A conditioned air supply with a relief damper to the outside meets the intent of the IRC and minimizes air exchange between the crawl space and house (Figure 3). Some local jurisdictions also allow conditioned air, house air, continuous exhaust, or a dehumidifier, without an air pathway to the house (Figure 4)

Crawl Space Ventilation Options

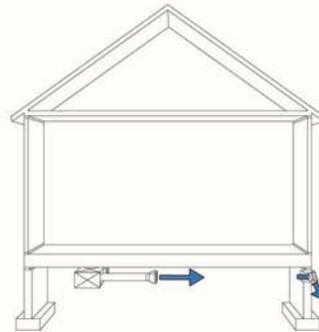
*Figure 1
Conditioned Air Supply with a
Return Air Pathway into House*



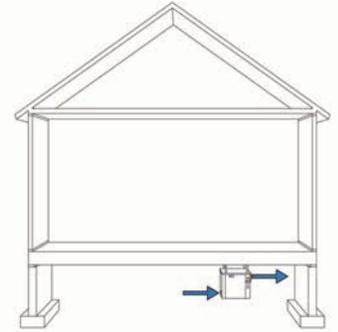
*Figure 2
Continuous Exhaust with an
Air Pathway from the House*



*Figure 3
Conditioned Air Supply with a Relief
Damper to the Outside*



*Figure 4
Local Codes (e.g., dehumidifier)*



Air Sealing

Air sealing a closed crawl space improves energy and moisture performance by limiting infiltration of outside air into the conditioned space. Air sealing also helps meet the maximum air leakage requirements of the IRC for the entire house.

Air Leakage Requirements

Climate Zone	2009 IRC Air Sealing	2012 IRC Maximum Air Leakage
3	7 Air Changes per Hour at 50 Pa (ACH50) OR	5 ACH 50
4	visual inspection of installed air sealing measures	3 ACH 50

The volume of the closed crawl space is included in the volume of the building for the purpose of calculating the air leakage rate based on the blower door test.

Key Areas for Air Sealing a Closed Crawl Space

- Sill plate and foundation wall interface
- Rim board and sill plate interface
- Rim board and subfloor interface
- Rim board joints
- Edge cripple studs and concrete/masonry walls vertical interface (as with step foundations)
- Penetrations through the foundation walls
- For fire safety, the IRC requires that all penetrations through the framed floor be sealed. Some jurisdictions may require a non-porous sealing product.

Strategies for Air Sealing

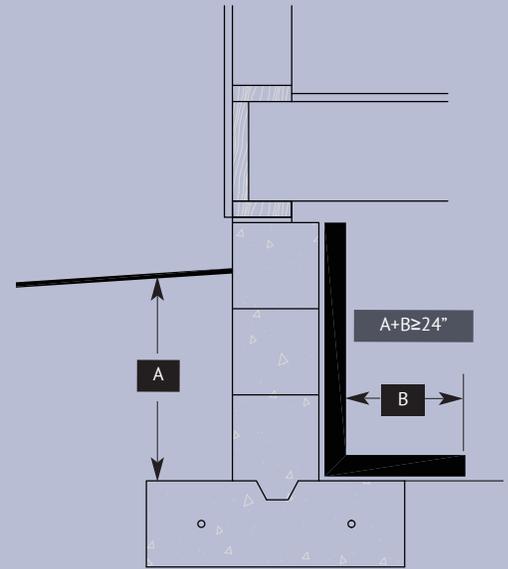
- Elastomeric sealant/caulk at joints, junctures, and penetrations (air sealing function only)
- Closed spray foam (air sealing and insulative functions)
- Sealed and taped exterior water-resistive barrier (WRB) (air sealing and water management functions)

Insulation

The IRC specifies minimum levels of foundation wall insulation based on the climate zone. The wall insulation must extend downward from the top of the foundation wall to the exterior finished grade level and then vertically and/or horizontally for a combined additional 24 inches or more. Insulation installed on the interior of the wall is more common in crawl space applications. Some jurisdictions require a 3-inch gap at the top and/or bottom of the foundation wall to allow for visual termite inspection. Where fiberglass insulation with a facing is used, it is recommended that the facing be perforated to avoid trapping moisture.

Rigid foam insulation installed on the exterior of the wall must be protected from sunlight (UV radiation), physical damage above grade and a minimum of 6 inches below grade, and termites. Rigid foam insulation is not permitted below grade in areas where the probability of termite infestation is designated as “very heavy”.

Cripple walls and rim areas are generally insulated to the same level as above-grade exterior walls. The use of spray foam or sealed rigid foam at the rim minimizes air leakage and reduces condensation potential.



Minimum R-Value for Crawl Space Insulation				
Climate Zone	Continuous Insulation (interior or Exterior)		Cripple Wall and Rim Board	
	2009 IRC	2012 IRC	2009 IRC	2012 IRC
3A	R5	R5	R13	R20
4A	R10	R10	R13	R20

Other levels of insulation are allowed when the house is analyzed to achieve performance-based compliance in accordance with the IRC.

Typical Insulation Materials		
Insulation Type	R-Value Per Inch	Application
Fiberglass (standard)	3.1-3.3	Interior Only
Fiberglass (High Density)	4.2-4.3	
Extruded Polystyrene (XPS rigid foam)	5.0	Interior or Exterior
Expanded Polystyrene (EPS rigid foam)	4.0	Interior or Exterior
Polyisocyanurate (Polyiso rigid foam)	6.5	Interior Only
Closed-cell spray polyurethane foam (SPF)	6.0-6.5	Interior Only

Examples of Interior Insulation Installation



XPS Rigid Foam Insulation



Fiberglass Wall Insulation with Perforated Facing



Spray Foam Insulation

Interior Wall Insulation Fire Safety

Fiberglass: Exposed facings must comply with flame spread and smoke-developed index requirements. Typical fiberglass facing materials include perforated foil-scrim-kraft (FSK) or polypropylene-scrim-kraft (PSK). Exposed kraft paper facings are not allowed.

Foam plastic insulation products must comply with specific fire safety criteria, including ignition barrier and thermal barrier requirements. The IRC exempts spray foam, up to 3.5 inches, installed at the sill plate and the rim joist from the thermal barrier requirement.

Foam manufacturers offer specific products rated for exposed applications (in both rigid and sprayed types) that can be used without additional fire protection.

The factors that impact fire rating include:

- Insulation type
- Insulation brand
- Insulation thickness
- Whether the crawl space is used for storage
- Whether heat-producing appliances are located in the crawl space
- Circulation of crawl space air into the house

Many insulation manufacturers hold proprietary third-party evaluation reports for products in exposed applications validating compliance with fire requirements including any limitations on use. Additional installation requirements may need to be followed (e.g., sealing all joints of rigid foam insulation board with an approved system).

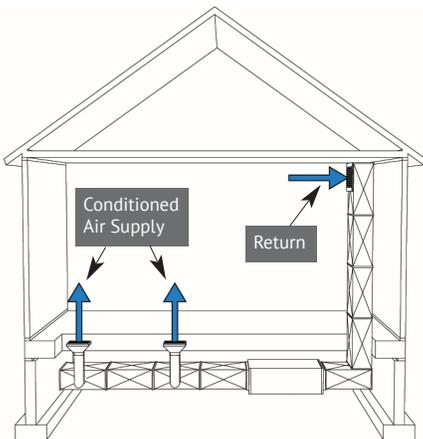
Mechanical Systems

A closed crawl space provides easy access for installation and maintenance of mechanical systems. The conditioned environment of a closed crawl space is more suitable for ducts and mechanical equipment than a conventional vented attic or vented crawl space. Temperatures in a closed crawl space are more stable, resulting in reduced energy loss and reduced condensation potential. In addition, locating ducts in conditioned space result in reduced house air leakage to the outside – an added energy efficiency benefit. Also, locating ducts and mechanical equipment in a dry, enclosed space helps maintain good indoor air quality in the house. With the whole-house fresh-air ventilation requirements becoming mandatory in the 2012 IRC, a closed crawl space can be used to integrate fresh-air ventilation with other mechanical systems.

- It is recommended that all combustion appliances are direct vented (i.e., combustion air from outdoors). This practice is a requirement in some local jurisdictions.
- Ducts and pipes are not required to be insulated in a closed crawl space where wall insulation is installed. As a best practice, ducts and/or pipes may be insulated to R4 to further minimize condensation potential under extreme weather conditions.
- Plumbing installed in a closed crawl space reduces standby heat loss from hot water pipes, and minimizes the risk of pipes freezing, when compared to a vented crawl space or attic.

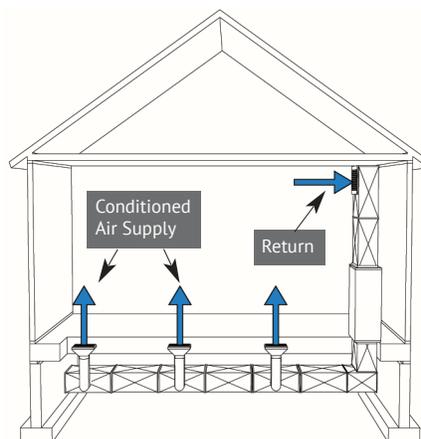
Options for Locating Ducts & Air Handler

Ducts & Air Handler in Closed Crawl Space



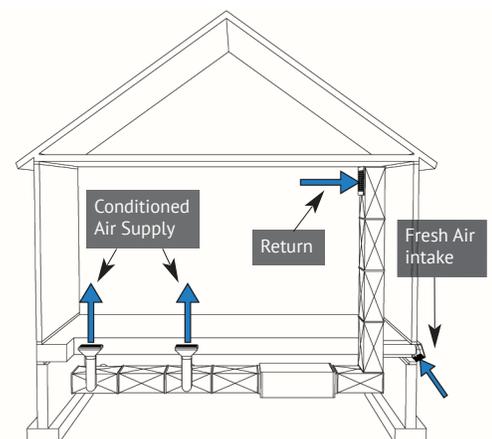
Maximizes use of the living space. Equipment located in crawl space.

Supply Ducts in Closed Crawl Space



By locating the air handler and the return ducts in the main part of the house, the air exchange between the crawl space and the house is minimized.

Integration with Whole-House Ventilation System



As one compliance option for whole-house fresh-air ventilation, a controlled amount of fresh air is supplied to the air handler return located in the closed crawl space.