Wall Systems

Typical residential walls consist of an exterior finish material, sheathing material, structure, insulation, and an interior finish material. All of these wall components have specific roles that, combined, create a wall that is strong, resistant to weather, and durable. Structure is described in more detail under the Framing Systems Chapter in the Structural Component Systems category.

Exterior Finishes

Exterior finish materials are intended to protect the wall system from sun exposure, moisture, and wind. Beyond researching cost and appearance, it is important to learn the manufacturer's installation instructions in order to construct a wall that will withstand extreme weather and be compatible with other components of the wall. Some examples of exterior finish materials found in residential applications include board siding (vinyl, fiber cement, wood, masonite, asbestos), brick, corrugated metal, fiber-cement panels, stucco, magnesium-oxide panels, and fiberglass products.

Sheathing

Sheathing materials tie the framework together to create a structural diaphragm that resists lateral forces against the wall. Generally, the exterior finish materials are installed on top of a vapor barrier, such as Tyvec Housewrap or felt paper, both of which are attached to the sheathing. Typical sheathing materials are 4'x8' sheets of plywood or OSB (oriented strand board). Older homes along the Gulf Coast may have horizontal or diagonal sheathing made of dimensional lumber. Sheathing is usually nailed to stud walls, with a prescribed nail pattern engineered to withstand local wind loads.

(FIG.A) EXTERIOR FINISHES of walls should be well-secured in order to withstand a high wind load. Here, fiber-cement siding is nailed through the sheathing to the framing members, over a vapor barrier.

(FIG.B) SHEATHING creates a rigid building envelope, and helps resist shear forces. OSB sheathing is typically used on the Gulf Coast.

(FIG.C) INSULATION helps maintain the temperature of the conditioned area within a building. This photo shows spray foam insulation sprayed onto existing rigid foam insulation to increase the R-value of the wall.

insulation	required equipment	thermal performance	environmental impact	market exposure	affordability	coastal considerations
fiberglass batt				+	−	+
spray foam	−	+	−		−	+
rigid foam		+	−	+		

exterior finishes	wind resistance	water resistance	lifespan	environmental impact	affordability	coastal considerations
fiber cement siding	+	+	+			+
vinyl siding	−		−	−	+	−
brick	+		+		−	

Insulation
Insulation reduces heat transfer through walls. Insulation is one of the most important factors contributing to the energy efficiency of a building. The unit of measure to determine the performance of insulation is called the R-value. R-value is the rate of thermal resistance of an object or material. Generally, thicker insulation of any type will yield a higher R-value. Insulation is typically placed between vertical framing members. Insulation found in residential applications includes: fiberglass batt, sprayed fiberglass, closed and open cell spray foam, rigid foam, cotton batt, mineral wool, and blueboard.

Interior Finishes
Interior finishes protect the framing and insulation from moisture and damage inside the building. Interior wall finishes are susceptible to mold and rot, if not properly ventilated. As the interior finishes of the building are in close contact with people after construction is complete, it is important to consider the materials used to ensure high indoor air quality for users. Many interior finishes can off-gas VOCs (volatile organic compounds) that lead to respiratory illnesses. Many common interior finish materials are now available with low- or no-VOC options. Examples of commonly used interior finishes include painted drywall, ceramic tile, homasote, tongue and groove wood boards, bead board, polycarbonate panels, and plaster.

(FIG.D) INTERIOR FINISHES influence the comfort and versatility of walls. Tongue and groove pine boards (above) are durable and provide additional shear strength for the building. (photo © Alan Karchmer)

FURTHER INFORMATION

- Toolbase (www.toolbase.org)
- USGBC Green Home Guide (www.greenhomeguide.org)
- National Association of Home Builders (www.nahb.org)
- International Code Council (www.iccsafe.org)

OTHER TYPES OF WALL SYSTEMS

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7 WALLS

subjects

(Fig.1) Masonite siding should be painted every few years to protect from water damage, mold, and rot. Special attention should be paid to the bottom edge of the exterior lap, where damage often occurs.

Exterior Finishes

Overview: Exterior finish materials protect the structure from sun exposure, moisture, and wind. Beyond cost and appearance, it is important to research each material and the manufacturer's installation instructions in order to construct a wall that will withstand extreme weather and be compatible with other components of the wall system. Some examples of exterior finish materials found in residential applications that are discussed in this section include: board siding (vinyl, fiber-cement, wood, Masonite), brick veneer, corrugated metal, fiber-cement panels, and stucco.

INSTALLATION

Construction Process: Typically, finishes such as board siding, corrugated metal, and fiber-cement panels are applied to the exterior side of the sheathing material over a moisture barrier. Nail patterns are specified by the manufacturers to meet local wind loads. Stucco may be applied directly to a masonry wall or to a wood-framed wall using wire mesh or lath. Brick veneer is laid in courses with mortar joints and tied to the structure with steel ties.

Speed of Construction: The installation time of exterior finishes depends on the size of the project and the skill level of the builder. Typically, siding and panels can be installed relatively quickly. Brick installation time depends mostly on the experience level of the mason. Stucco may be the most time-intensive, as multiple layers must be applied, and the material is sensitive to humidity levels in the air.[1]

Delivery Method: Siding materials generally come in 8', 10', and 12' units, and can be delivered on a flatbed truck or trailer. Large quantities of brick may need to be delivered with commercial trucks or trailers. Stucco is mixed on site.

(Fig.2) Vinyl siding is designed to mimic wood planks, and is easy to install.

(Fig.3) With an experienced mason performing the installation, brick can be laid in a variety of patterns.

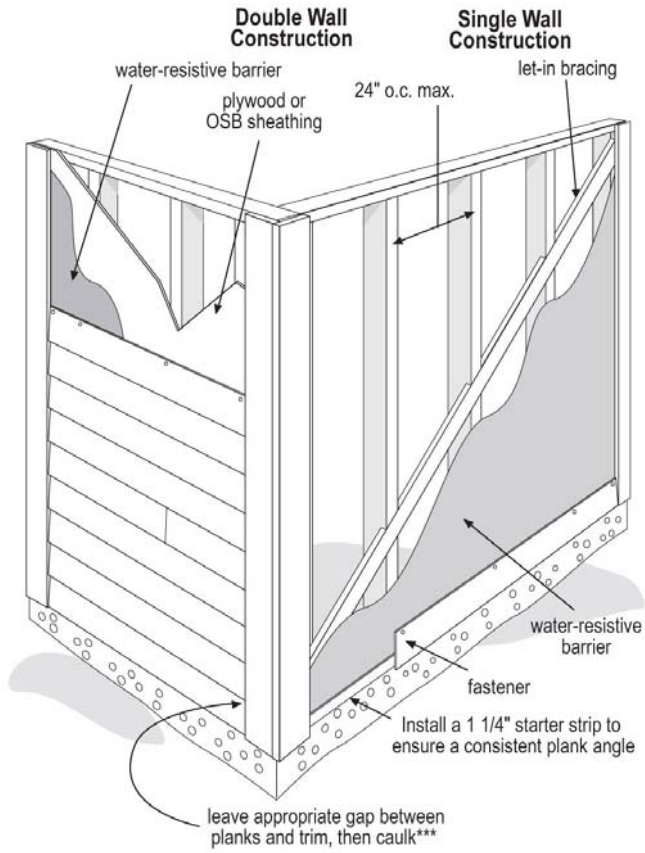
Required Equipment: Fiber-cement boards and panels can be cut on-site by scoring and snapping, using shears, or using a saw with a carbide blade or a blade designed for cement-fiber products.[2] Vinyl siding is easy to cut on-site with shears or utility blades. Wood and Masonite siding can be cut with regular framing saw blades. These exterior finishes can be installed using screws or nails, as per the manufacturer's instructions. A water-level or transit may be necessary for accurate siding installation. Brick finishes require typical masonry equipment (mixers, trowels, spades, and masonry saws). Stucco finishes require some form of reinforcement to reduce cracking, such as wire or plastic mesh. All exterior finish applications may require scaffolding for taller buildings.

Specialized Labor: No specialized labor is necessary for installation of siding. Masonry finishes may require experienced masons, depending on the pattern and size of the project. Stucco is difficult to apply evenly if the builder is not experienced in the trade.

PERFORMANCE

Wind Load: The wind load capacity of fiber-cement siding and panels are dependent on the nail pattern and type of nail used. Typically installed 8" fiber-cement siding can withstand wind loads between 110 and 150 mph.[3] Wood and Masonite siding have similar wind load capacities, if installed properly. Brick finishes, if tied to the frame properly, can withstand up to 150mph winds (when ties are spaced every 10" vertically and every 16" horizontally).[4] Vinyl siding has the lowest wind resistance, as the material is lightweight, prone to cracking and tearing, and adhered to the exterior surface of the building loosely.

Water Resistance: Manufacturers claim that fiber-cement siding is non-porous and is therefore resistant to mold and rot.[5] According to the 2000 ICC Legacy report, James Hardie fiber-cement products allow 1.54 perms, which is slightly less than wood siding.[6] Masonite siding, if properly painted and sealed, is similarly water resistant. Vinyl products are highly water resistant. However, because vinyl siding breaks and cracks easily, water can leak into the wall cavity and cause damage. Brick veneer is porous, necessitating a 1" gap between the veneer and the structure of the wall so proper ventilation can occur if water penetrates the exterior surface. In addition, weep holes (vents within the brick) and flashing must be properly installed so that moisture that does get in can escape the wall cavity.[7] Stucco has a very low resistance to water and is prone to mold and rot in humid climates.



(Fig.4) This drawing shows the preferred method of installation for HardiePlank siding, a fiber-cement siding product. Wood and vinyl siding are installed similarly.

(Fig.5) Stucco can be applied in a variety of textures. Above, a smooth finish is used for the exterior wall, while a rough finish is applied to the window trim.

Energy / Thermal: Generally, exterior finish materials provide negligible thermal resistance. Fiber-cement products, wood and Masonite siding have similar thermal properties, with R-values between 0.12 and 0.8. Stucco has an R-value of 0.2 per inch of thickness (most stucco applications are approximately 1/2"). Brick has an R-value of 0.11 per inch of thickness; common bricks are 4" thick. Vinyl products have an R-value of 0.61. Vinyl siding is available with an additional layer of insulation that can increase the R-value to 4.[8]

Life Span: Life spans of exterior finish materials vary greatly, depending on the level of maintenance and the local climate. Products like fiber-cement siding and vinyl siding come with a manufacturer's warranty of up to 50 years.[9] Masonite and wood siding must be painted every few years in order to seal the material from water damage. Brick, if properly installed and tied to the structure, has a long lifespan with little maintenance required.

Common Failure: Masonite siding and stucco have been known to rot and mold if not properly maintained (painted and sealed every 2-3 years).[10] Vinyl siding will most commonly fail in high-wind environments. Also, vinyl is extremely susceptible to failure in high heats, and emits toxic fumes when it burns.[11] The common failures of brick are related to poor installation of ties. Any exterior wall system will fail if moisture is allowed past the exterior surface and is not properly ventilated or wicked to the exterior.

(Fig.6) Fiber-cement vertical panels are used above in a cabin addition. 1x battens are used on the vertical joints between panels. Many fiber-cement products are primed at the factory.

DESIGN

Environmental Impact: The production of fiber-cement products and the raw materials for stucco (cement products) require high levels of embodied energy. If these products are manufactured with fly-ash, an industrial by-product, the impact is lower. Vinyl (polyvinyl chloride) products are particularly dangerous to manufacture; prolonged exposure during the manufacturing process is linked to certain cancers and respiratory problems. Additionally, vinyl releases VOCs during its lifespan and can also affect air quality if incinerated.[12] The impact of wood siding is dependent on the type of species used and where it was grown. Masonite siding has a fairly neutral environmental impact, as it is produced with wood by-products.

Versatility / Flexibility: All of the exterior finish materials described in this section can be used in combination with each other. Masonite, wood, fiber-cement, and vinyl siding are primarily designed to adhere to wood-framed buildings. Also, most alternative wall systems (SIPs, ICF, etc.) are designed to easily accept siding materials. Stucco is easier to apply and maintain if adhered to a masonry

(Fig.7) Fiber-cement lap siding has the finished look of wood siding. Here, it is used in combination with fiber-cement window trim.

wall. Brick can be coupled with most wall systems; however, it is difficult to change or remodel a brick wall after it is built.

Market Exposure: All of the above products are extremely common and easy to obtain in the United States.

Code Approval: Each of the exterior finish materials addressed here is accepted as an exterior cladding by the International Code Council (ICC) Evaluation Service. Code compliance is inspected by local building inspectors either during the framing or final phases of construction.

Affordability: Prices for exterior finishes vary, depending on location. In general, wood siding is more expensive than fiber-cement siding or masonite. Vinyl is generally the cheapest material. Brick and stucco have negligible differences in material cost, but usually cost more to install.

Coastal Considerations: High wind loads and prolonged exposure to heat and moisture are the most important factors to consider when choosing an exterior finish material on the Gulf Coast. With any siding application, check with the manufacturer and local building officials to determine the proper nailing pattern to reduce the risk of damage during a high-wind event (up to 140 mph winds). Materials such as stucco, Masonite, and brick that are particularly sensitive to moisture will likely require more maintenance and repair than in other parts of the country because of the humid climate.

(Fig.8) Cedar is a popular wood species used in siding. It is highly resistant to rot and moisture.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Retailers in the Gulf Coast Area include:

Nearly every building supply retailer along the Gulf Coast carries or can order any of these materials.

Manufacturers being used in the area include:

- James Hardie (fiber-cement)
- CemPlank, Inc. (fiber-cement)
- CertainTeed Corp. (fiber-cement)
- Dura-Bilt (vinyl)
- Georgia Pacific (vinyl)
- Masonite International Corporation (Masonite)

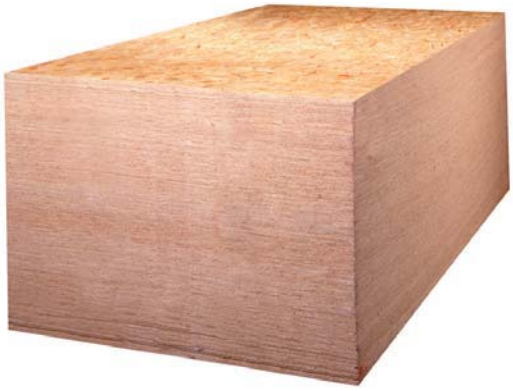
(Fig.9) Vinyl siding has a very low melting point. Here, a house fire caused the vinyl siding to melt, releasing toxic fumes.

(Fig.10) Brick is used to accent the cypress siding above. Cypress is another popular wood species used in siding because it is water resistant.

Sheathing

Overview: Sheathing is a material used to tie a building's structural framework together, creating a structural diaphragm that resists horizontal forces against the wall. Typical sheathing materials are 4'x8' sheets of plywood or OSB (oriented strand board), although sheets with 9' and 10' lengths are also available for higher ceilings. Sheathing is an essential component of construction.

In hurricane-prone areas, alternative sheathing materials include full-height OSB and sheets with pre-affixed weather barriers. Older homes along the Gulf Coast may have horizontal or diagonal sheathing made of dimensional lumber.



(Fig. 11) Plywood and OSB can be purchased at almost every building supply retailer and can be delivered on a trailer.

INSTALLATION

Construction Process: Sheathing is nailed to stud walls, with a prescribed nail pattern engineered to withstand local wind loads. Generally, the exterior finish materials are affixed to the sheathing, with a vapor barrier between them, such as Tyvec Housewrap or felt paper. Joints should be appropriately spaced at 1/8" or as defined by local code.

Speed of Construction: The process of sheathing is fairly swift once the framing is complete. An experienced crew can sheath a one-story house in a day. Sheathing can be further expedite by using full-height materials.

Delivery Method: Plywood and OSB can be purchased at almost every building supply retailer and can be delivered on a trailer. Boards should be kept flat to reduce warping before installation.

Required Equipment: Hammers and nails or nail guns, circular saw.

Specialized Labor: Aside from basic carpentry knowledge, no specialized labor is needed.

(Fig. 12) Aside from basic carpentry knowledge, no specialized labor is needed for sheathing a house.

PERFORMANCE

Wind Load: Sheathing is nailed to stud walls, creating a structural diaphragm that resists horizontal forces against the wall. It is affixed to the studs with a prescribed nail pattern engineered to withstand wind forces appropriate to the region, and should be carefully monitored to ensure proper installation.

Water Resistance: Wood sheathing is prone to rot and mold and should be kept dry on site and inspected before use to ensure quality.

Energy / Thermal: Sheathing itself has low thermal resistance. However, it can be a large determining factor in how the wall performs, based on proper installation and sealing of seams, and depending on the material used.

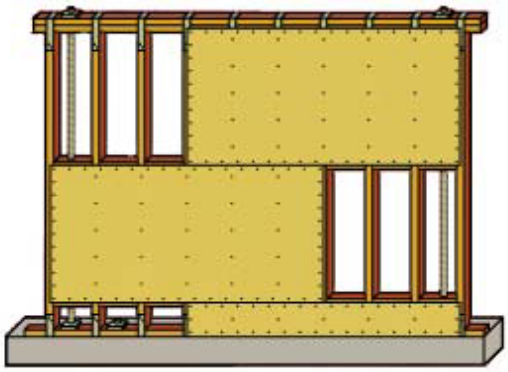
Common Failure: Failure in sheathing may result from improper nailing in the case of a high wind event. More likely is rot or decay from excessive moisture due to leaks in the building envelope. This can be prevented by properly sealing panel systems per manufacturer specification, as well as the proper application and installation of house wrap in the case of a conventionally sheathed OSB or plywood wall.[13]

DESIGN

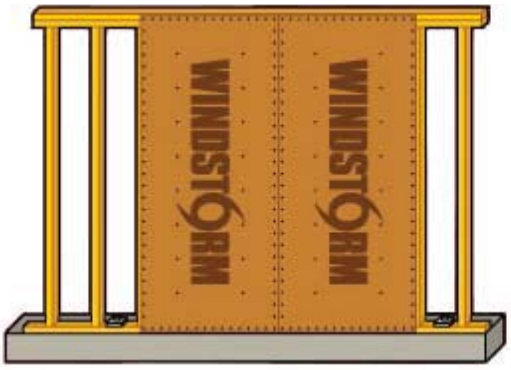
Environmental Impact: Plywood manufacture uses more mature wood than OSB or hardboard alternatives. The key to minimizing impact with plywood is to optimize material use and reduce waste.

OSB, in contrast, is made from short rotation or re-used chip products, but uses petrochemical binders in its manufacturing process. Builders can look for products with minimal binders and maximum recycled content.[14]

Versatility / Flexibility: Sheathing is manufactured in a variety of different material compositions and lengths and provides a wide array of choices for the builder. Increased lengths allow builders to connect the sill and top plate with one panel, resulting in increased resistance to uplift and wind shear.[15]



(Fig. 13) When not using full-height sheathing, panels should be properly spaced and overlapped, and affixed according to specified nailing patterns.



(Fig. 14) Full-height sheathing can increase the shear strength of the wall system.

(Fig. 15) Properly nailing and wrapping the sheathing with a moisture barrier is essential to prevent rot and mold in hot and humid climates.

Market Exposure: OSB and plywood remain the predominant materials for sheathing but a number of alternatives are available, including pre-wrapped panels such as Huberwood's ZIP System or Georgia Pacific's Nautilus wall sheathing.

Code Approval: Sheathing should be properly installed per manufacturer specifications and local building codes regarding nailing patterns. Structural sheathing should be used in coastal regions to provide proper shear strength.

Coastal Considerations: There are a number of factors to consider when sheathing on the Gulf Coast.

Proper nail patterns are essential in high wind areas. Without the required nail spacing and pattern, the sheathing wind resistance will be diminished, which can result in failure of the wall system.

Full-wall height sheathing is another option that is strongly encouraged. This increases strength by linking the top plate to the sill and rim joist with a continuous surface.

Sufficient moisture control is another essential element of coastal construction. This includes ensuring seams are properly sealed; ensuring house wrap is overlapped and wrapped at corners; using tools properly; and making sure nails are driven to proper depths to prevent puncturing the moisture barriers.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Retailers in the Gulf Coast Area include: Nearly every building supply retailer along the Gulf Coast carries or can order any sheathing material.

Additional Info and Further Reading:

- National Association of Home Builders Research Center, http://nahbrc.org/
- Toolbase Services, http://toolbase.org/
- Oikos Green Building Source- http://www.oikos.com/

Information on pre-wrapped panels can be found at:

- http://www.huberwood.com/ - ZIP System
- http://www.gp.com/ - Nautilus Wall Sheathing

Information regarding Windstorm OSB can be found at:

- http://www.windstormosb.com/

(Fig. 16) Nautilus wall sheathing by Georgia Pacific is an alternative to OSB and Plywood. It is produced with a moisture barrier pre-affixed and has begun to gain favor among builders.

(Fig.17) The ZIP system by Huberwood.

Insulation

Overview: Insulation is one of the most important elements contributing to the energy efficiency of a building. The unit of measure of insulation performance is called the R-value (the rate of thermal resistance of an object or material). Generally, the thicker the insulation, the more resistance it will have to heat flow, and the higher its R-value. Thermal bridges, which reduce the efficiency of a wall, occur wherever a material directly contacts both the interior and exterior finishes (for example, at every stud in a wood-framed wall). This creates a path for the conduction of heat or cold through the wall. The insulating performance of the wall decreases with each thermal break.

FIBERGLASS

Material: Fiberglass insulation is a composite material made of silica sand with additives such as boron and binders such as phenolformaldehyde. It is sometimes produced in rolls that are sandwiched between kraft paper for fire-proofing and vapor retarding. This is the most common type of insulation found in residential applications.[16]

Installation: Fiberglass insulation is manufactured to fit between studs and joists that are spaced 16" or 24" on center. Face-masks and gloves should be worn while handling the material, to avoid respiratory and skin irritation.

R-Value: Fiberglass batt insulation has an R-value of about 3.7 per inch.[17] This method of insulating creates many opportunities for thermal bridging, as the insulation is placed between studs.

Environmental Impact: Most fiberglass insulation is produced with a minimum of 20-30% recycled content. After the packaging industry, fiberglass insulation has the second largest market for recycled bottle glass. Glass fibers are potential human carcinogens, while formaldehyde is a confirmed human carcinogen. Most fiberglass insulation manufacturers have products certified as low-emitting by Greenguard, a third-party non-profit committed to improving indoor air quality.[18] Consumers should look for this certification when choosing fiberglass insulation.

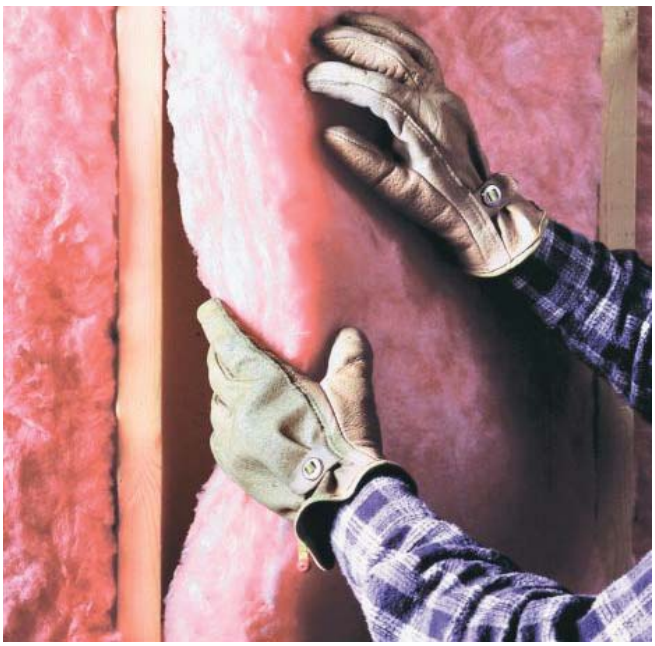
Affordability: Fiberglass batt insulation is approximately $0.70 per square foot of coverage(R-19). Skilled labor is not required for installation.[19]

Coastal Considerations: Fiberglass batt insulation is not water-resistant. Proper ventilation is required for roof and ceiling installation (by using ridge vents, attic vents, vented blocking, and vented soffits in the assembly of the house). Similarly, an elevated house with fiberglass insulation in the floor should have vented covering.

SPRAY FOAM

Material: Spray-foam insulation is a plastic product that is sprayed into cavities as a liquid and expands as it cures to create a tighter seal than typical batt insulation. There are two types of spray foam: open-cell (made of isocyanurate) and closed-cell (made of polyurethane).[20] Open-cell spray foam is more flexible than closed-cell and is less likely to crack or fail as a house expands and contracts.

Installation: A liquid polymer is combined with a foaming agent as the material is sprayed through a nozzle. A professional spray-foam contractor should perform installation to ensure personal safety and thorough application.



(Fig. 18) Fiberglass batt insulation should fit snugly between studs without any compression of the material.

After the foam dries, excess is trimmed from the cavity and a thermal barrier such as drywall or sheathing is installed as a covering.[21]

R-value: Open cell pray foam insulation typically yields an R-value of 3.8 per inch of thickness. Closed-cell polyurethane performs slightly better than open-cell applications.[22]

Environmental Impact: Installers of spray foam insulation have been required to reduce or eliminate the use of HCFCs (ozone-depleting gas). Many companies are producing soy-based spray foam insulation to reduce the risk of releasing VOCs over the lifetime of the product.[23]

Creating a tighter seal of insulation with spray foam applications will yield increased energy efficiency within buildings.

Affordability: Spray foam insulation costs between $1.25 to $2.25 per square foot (for material and installation).[24] This is one of the more expensive methods for insulating a building. However, many studies have shown that the initial cost is recovered over a few years of low heating and cooling costs associated with better thermal performance. Oftentimes, spray foam insulation is combined with fiberglass batt insulation to reduce the cost, while increasing the R-value of the wall.

Coastal Considerations: Spray foam insulation is typically more moisture resistant and mold resistant than fiberglass batt or other blown insulation materials.[25] Closed-cell spray foam is considered a vapor barrier, while open-cell is a vapor retardant. In residential construction, closed-cell foam being a vapor barrier can be problematic as its location traps moisture in the wall instead of keeping moisture from entering the wall.

(Fig. 19) Above, open-cell spray foam insulation is installed by a professional. The excess foam will be trimmed and discarded.

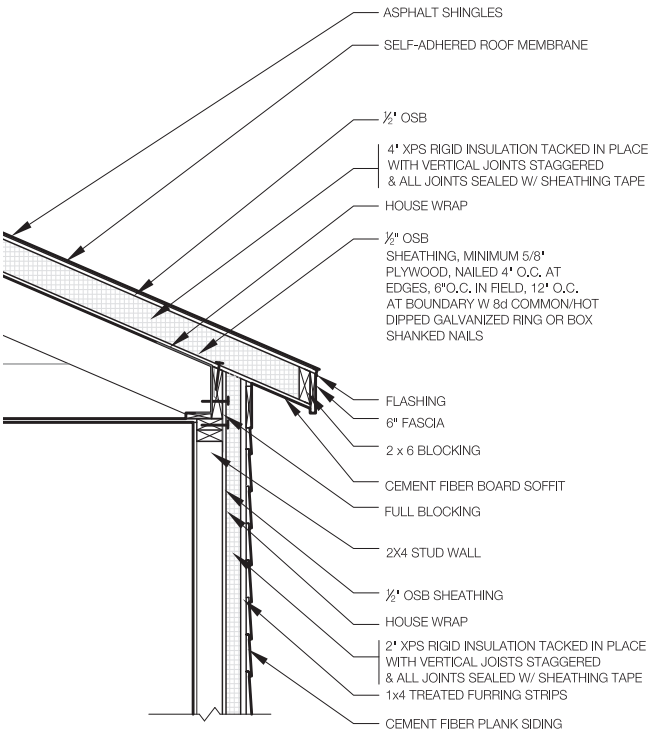
RIGID FOAM

Material: Rigid foam insulation refers to plastic foams made of either XPS (extruded polystyrene) or EPS (expanded polystyrene). The plastic is manufactured in sheets that vary in thickness. Rigid foam insulation can be used with stud walls, or to make ICFs (insulated concrete forms) and SIPs (structurally insulated panels).

Installation: Rigid foam insulation can be cut and installed between studs and joists. Alternatively, it can be adhered with screws or nails to the exterior or interior of a stud wall or masonry wall to create a seamless layer of insulation with little or no thermal bridging. Also, it can be used to supplement existing insulation in older homes. No skilled labor is required for installation.

R-value: XPS rigid foam has an R-value of 5 per inch of thickness; EPS rigid foam has an R-value of approximately 4 per inch of thickness.[26]

Environmental Impact: Both XPS and EPS are produced from petrochemicals. XPS foam is currently produced with HCFCs (ozone-depleting gas), while EPS is produced using pentane (non-ozone-depleting gas). There are health concerns related to the continued off-gassing of VOCs (residual monomers and brominated flame retardants may be released over time).[27] Code requires that all rigid foam insulation is covered with a material, such as drywall, to minimize this risk.



(Fig. 20) With proper detailing of the entire wall assembly, rigid foam can perform with little or no thermal breaks.

Affordability: The material costs for XPS and EPS foam are relatively comparable to fiberglass batt insulation. 2" XPS foam (R-10) is $0.54-$1.12 per square foot. 2" EPS foam (R-10) is $0.40-$1.12 per square foot.[28]

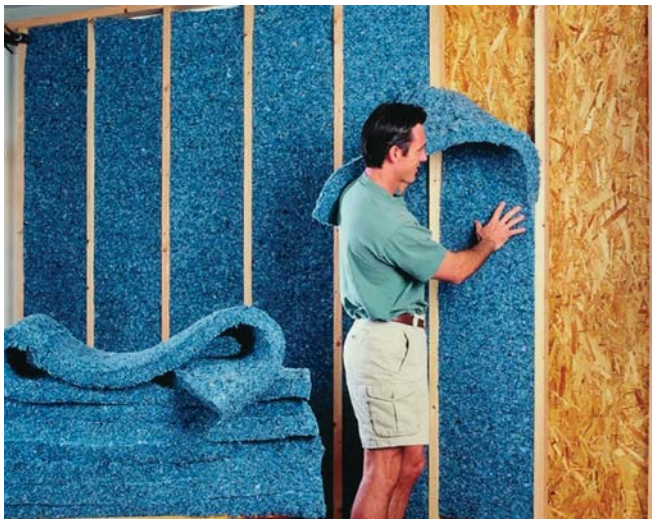
Coastal Considerations: If using EPS or XPS foam on the exterior of a stud wall, it is extremely important that the exterior sheathing and finishes are adhered firmly to the frame of the building because of high wind loads. Depending on the thickness of the insulation, higher gauge nails or screws may be required. Similarly, if using an ICF system, check the exterior finishes to ensure that they are compatible with foam for adhering.

COTTON BATT

Material: Cotton batt insulation is manufactured with 70-100% pre-consumer cotton, generally from recycled trimmings from denim factories. Boric acid (low-toxic) and/or ammonium sulfate is added to the insulation as a fire retarder and mold and insect repellant.[29]

Installation: Cotton batt insulation is installed in rolls between studs and joists, similar to fiberglass batt insulation. No skilled labor is involved in installation, and the material is safe to handle without any special protective equipment.

R-value: Cotton batt insulation is typically produced to yield an R-value of 3.7 per inch of thickness.[30] A 2x4 wall will have an R-value of 13, while a 2x6 wall will have an R-value of 19. Some manufacturers offer higher R-value cotton batts of up to R-21 for 2x6 applications. Like fiberglass batt insulation, cotton batt insulation creates many opportunities for thermal bridging, as the insulation is discontinuous at every stud within a wall.



(Fig. 21) Cotton batt insulation can be installed without any special equipment or specialized labor.

Environmental Impact: Because this insulation is made with plant-based, recycled material not known to off-gas harmful VOCs, cotton batt is considered to have very low environmental impact. Some question whether cotton is as safe as its manufacturer's advertise, because little research has been done regarding the use of pesticides during the manufacture of the raw material.[31]

Affordability: R-19 cotton batt insulation is about $1.20 per square foot.[32]

Coastal Considerations: Homeowners and builders should check with the manufacturer of any cotton batt insulation regarding the amount of mold and insect resistance the product provides.

MINERAL WOOL

Material: Mineral wool refers to either slag wool (a product made of iron-ore blast-furnace slag, an industrial by-product), or rock wool (a synthetic material made of basalt or diabase). Both are naturally resistant to fire, mold, and insects. Mineral wool can perform equally well when wet. Additionally, because of the high density of this type of insulation, both types offer high levels of acoustical insulation.[33]

(Fig. 22) Rock wool, as shown above, is extremely resistant to fire.

Installation: Mineral wool is produced in batts that are installed between wall studs and joists, or it is blown loosely into wall and ceiling cavities. Skilled labor is not necessary for installation; gloves and face-masks should be worn to lower the risk of temporary upper respiratory and skin irritation from loose fibers. As with any insulation described here, a material such as drywall should be installed over the insulation.

R-value: The R-value of mineral wool is slightly higher than fiberglass batt insulation; a batt designed for a 2x4 wall will have an R-value of 13.5.[34]

Environmental Impact: Mineral wool is made primarily (approximately 75%) of post-industrial recycled materials.[35] There is some debate as to whether mineral wool decreases the level of indoor air quality when installed; like any fibrous material, some fibers will enter the air. The North American Insulation Manufacturers Association (NAIMA) claims that there are no health risks related to the use of mineral wool.

Affordability: The cost of typical mineral wool insulation is approximately $1.07 per square foot.[36]

Coastal Considerations: Mineral wool, while very similar to fiberglass batt insulation, is naturally resistant to mold, which makes it a slightly better choice for the climate of the Gulf Coast.

CELLULOSE

Material: Cellulose insulation is made of post-consumer recycled paper products such as newspapers and telephone books, with borates and ammonia sulfates added for moisture, fire, and insect resistance.[37]

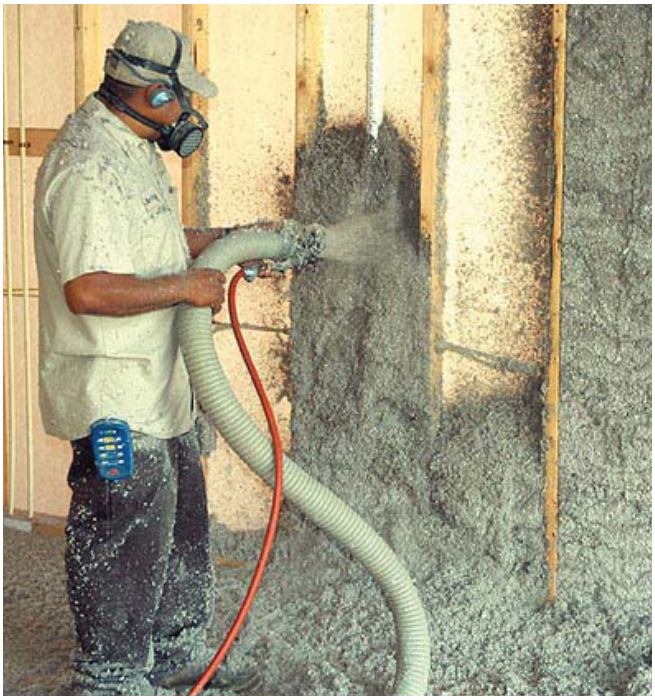
Installation: Cellulose insulation comes in four different forms: dry (loose fill), spray-applied (wet-spray), stabilized, and low-dust. Dry cellulose is typically used in retrofitting applications. Spray-applied cellulose is used for new construction. Water is mixed with the material and sprayed into the wall between studs. Stabilized cellulose is used in attic and high-sloped roofs. Small amounts of water and adhesive are mixed with the stabilized cellulose to create a lightweight insulation. Low-dust cellulose is used in applications where dust or paper-fiber allergies are a concern for the installers. This cellulose insulation has oil or some other dampener added to the mixture.[38]

R-value: The R-value of cellulose insulation is approximately 3.6-4.0 per inch of thickness. A 2x4 wall with cellulose insulation has an R-value of 13. Depending on the installation method, cellulose insulation has lower occurrences of thermal bridging.[39]

Environmental Impact: Cellulose insulation has low-embodied energy, as it is made with a high percentage of readily available post-consumer waste. A greater level of flame retardant is necessary compared to cotton batt or fiberglass insulation, as cellulose is inherently combustible. VOCs from printing inks were a concern in the past, but today most printed paper products use soy-based ink that does not release VOCs.[40]

Affordability: R-19 spray-applied cellulose insulation is approximately $1.20 per square foot.[41]

Coastal Considerations: Cellulose is considered a good choice for coastal applications because the performance of the material does not change if the insulation is wet. In studies done by the Cellulose Insulation Manufacturers Association (CIMA), cellulose-filled wall cavities remained mold-free after weeks of water saturation.[42]



(Fig. 23) A professional installs spray-applied cellulose insulation in the wall cavities. A relatively large amount of the material is wasted during this type of installation.

Interior Finishes

Overview: Many finish materials are available for the interior walls of a house. Finish materials are chosen primarily for their appearance and affordability; however, durability, environmental impact, and even acoustic qualities are important considerations. In the United States, gypsum board is the most common interior finish material; other panel materials available include fiber-reinforced plastic and magnesium oxide. Wood paneling is available in both modern and traditional styles. Plaster, tile (ceramic, glass, or porcelain), stone, and brick are additional options.

GYPSUM BOARD

Gypsum board, is used worldwide and is the most common interior finish in the United States. Also known as drywall or gypsum wallboard (GWB), gypsum board is "made of a layer of gypsum plaster pressed between two thick sheets of paper, then kiln dried."[43] When properly installed, gypsum board creates a smooth finish that is ready for painting or texturing.

Installation: Gypsum board usually requires professional installation for the best appearance, although many homeowners can make small repairs or modifications themselves. Gypsum board comes in sheets, usually 4' wide and between 8' and 12' long, although longer and wider sizes are available. These sheets are attached to the wall structure using drywall screws or nails.

The finished surface is created in a process known as "tape and float." Gypsum board can be finished to a level between 0 (no finish) and 5 (best finish). Typical residential gypsum board is finished to level 3 or 4: the joints between panels are sealed with drywall tape set in joint compound and concealed with 1-2 additional coats of joint compound, and nail or screw holes and any imperfections are concealed with 2-3 coats of joint compound. Once dry, the joint compound is sanded to create a smooth surface.[44]

Performance: Gypsum is a fire-retardant material; standard 1/2" drywall is rated as a 30-minute fire barrier, while 5/8" "Type X" drywall is rated as a 1-hour fire barrier.

Some homeowners dislike gypsum board's hollow feel and its lack of texture and character. Gypsum board is susceptible to damage, but can accept small nail and screw holes for hanging light objects. Heavier objects must be anchored to the wall structure (such as a stud).

Environmental Impact: According to the California Integrated Waste Management Board, "the U.S. produces approximately 15 million new tons of drywall a year... [and] approximately 12 percent of new construction drywall is wasted during installation."[45] The energy used in the manufacture of gypsum board, mostly in the form of natural gas, accounts for 1% of U.S. energy emissions.[46] Measures to reduce waste and encourage recycling can help reduce the environmental impact of gypsum board. Look for gypsum board made using a high percentage of recycled content. Gypsum can be up to 99% recycled while the paper facing can be up to 100% recycled from newspaper and other sources.[47]

Affordability: Gypsum board is an inexpensive material. However, cost estimates should include joint compound, tape, fasteners (screws or nails), corner bead (metal strips used to finish drywall corners), and the various tools used to hang and finish drywall. The cost of professional installation will vary depending on the size of

(Fig. 24) Gypsum board finishing (taping and floating) is the process in which panel joints, screw and nail holes, and other imperfections are concealed to create a smooth surface.

the job and the speed and skill of the workers. Estimates for materials and installation range from $0.85 to $1.15 per square foot to upwards of $2 per square foot in some cases.[48]

Coastal Considerations: Gypsum board's susceptibility to moisture is a significant disadvantage in coastal areas. If not protected from moisture, the paper facing of gypsum board can develop mold. Gypsum board exposed to leaks or flooding is prone to extensive mold growth and decay.

"Green board" is a type of gypsum board made with water-resistant paper facing and is suitable for use in areas subjected to some splashing (around sinks, for instance). However, green board is not suitable for showers, tubs, and other areas where it could be exposed to water for extended periods of time. Choose a water-resistant cement-based board for these areas.

Related System: Plaster

Plaster was widely used before World War II as an interior finish similar to gypsum board. Plaster was commonly applied over a series of wooden strips in a method known as "lath and plaster."[49] Alternatively, plaster can be applied over metal mesh to make a surface of any shape. Due to the ease and affordability of gypsum board, plaster is less common in residential construction today. Skilled plasterers may be hard to find. In some cases, its sculptural qualities are used to create architectural detailing.

NON-GYPSUM WALLBOARD

In addition to drywall, a number of other wallboard products are available today. Two of the most promising materials are magnesium oxide and fiberglass-reinforced plastic.

Magnesium oxide board (known as "MgO," after its chemical formula) is a durable, high-performance alternative to drywall, most commonly used in Asia, where the majority of magnesium oxide deposits are found.

Fiberglass-reinforced plastic (FRP) is made of high-strength glass fibers bonded with a resin. The result is a lightweight, strong, easy-to-clean board suitable for use in kitchens, bathrooms, and other sanitary areas.

Installation: Magnesium oxide board can be scored and snapped, cut, and drilled in much the same way as drywall, although it is a harder material and therefore somewhat more difficult to work. It is also heavy; a 4'x8' sheet of 11/16" MgO board manufactured by Dragon-Board weighs 106 pounds.[50] MgO can be used in applications drywall cannot: as structural sheathing, tile backer board, exterior wallboard, fascias, soffits, and more.

FRP panels can be installed using adhesive, fasteners, or a combination of the two. Refer to manufacturer installation instructions.

Performance: Magnesium oxide board has numerous advantages over drywall. Its structural strength and impact resistance are greater. Therefore, thinner sheets can be used. For instance, a 3/8" MgO sheet can be used in place of a 5/8" drywall sheet.[51] Because it has no paper covering and magnesium oxide is not harmed by water, MgO board is resistant to moisture and mildew. When used in exterior applications, it should be painted, like

(Fig. 25) Gypsum Board with mold growth caused by flooding.

(Fig. 26) Magnesium oxide panels are considered to be more mold resistive then typical drywall.

cement board, to prevent water absorption. Finally, MgO is nearly impervious to fire. As with drywall, any penetrations through fire-rated walls must be firestopped.

Fiberglass-reinforced plastic has several advantages: it is strong, lightweight, water-resistant, and easy to clean, making it a suitable choice for kitchens, bathrooms, and other sanitary areas. FRP is more common in commercial and institutional construction.

Environmental Impact: Magnesium oxide is manufactured from magnesite, which is mined in China, the Middle East, and Canada. "Deposits in the US are negligible."[52] Due to its weight, the costs and emissions produced by transporting MgO or magnesite may be high. However, because MgO is manufactured at room temperature, little energy is consumed during production.[53] In addition, magnesium oxide board is highly durable and contains no VOCs or toxins.

Affordability: FRP and MgO panels are more expensive than drywall. For instance, a 4'x8' sheet of 3/8" MgO board can cost $35, whereas a 4'x8' sheet of 1/2" drywall can cost $7-8.[54,55]

Coastal Considerations: Based on their strength and resistance to moisture and mildew, both FRP and MgO have potential for use in coastal construction.

Gulf Coast Availability / Local Manufacturers:

Substance Distributing
- Austin, TX
- Sells "Dragon Board" magnesium oxide wallboard and "Strong-Enviro Board" magnesium oxide board.
- www.substanceproducts.com / (512) 385-4326

Dragonboard
- Dallas, TX; Miami, FL
- Sells "Dragon Board" magnesium oxide board for walls, subfloor sheathing, and more. Available thicknesses range from 1/8" to 3/4".
- www.dragonboard.com / (800) 214-4551

Magnum Building Products
- Tampa, FL
- Sells "Magnum Board" magnesium oxide board for interior wall and ceiling sheathing, underlayment, exterior sheathing, fascia, soffit, and more.
- www.magnumbp.com / (813) 314-2202

(Fig. 27) Magnesium oxide panels are used as the subfloor in this building.

(Fig. 28) Magnesium oxide panels are used as the exterior sheathing in this building.

(Fig. 29) Magnesium oxide panels are used as the exterior sheathing in this restaurant.

WOOD & WOOD PANELING

Wood can create an aesthetically pleasing finish for walls or ceilings. Wood finishes come in many forms, including solid wood and wood veneer. Veneer products imitate the appearance of solid wood using a thin layer of real wood or vinyl or paper facing bearing a printed pattern. Beadboad and other types of textured and patterned wood paneling are used for some applications. For instance, wainscoting is a traditional application in which wood paneling is used on the lowest 3′ - 5′ of a wall.

Installation: Solid wood boards and wood panels are often installed using interlocking tongue-and-groove joints. These boards can be cleanly installed using finish nails concealed in the joint. Larger pre-made wood panels may simply be installed flush with one another using finish nails, screws, or concealed fasteners.

Performance: Dents and damage in wood paneling can be difficult to repair. Some woods must be sealed to protect them from moisture and water damage. Low-quality veneers can warp or peel, especially if exposed to moisture or improperly installed.

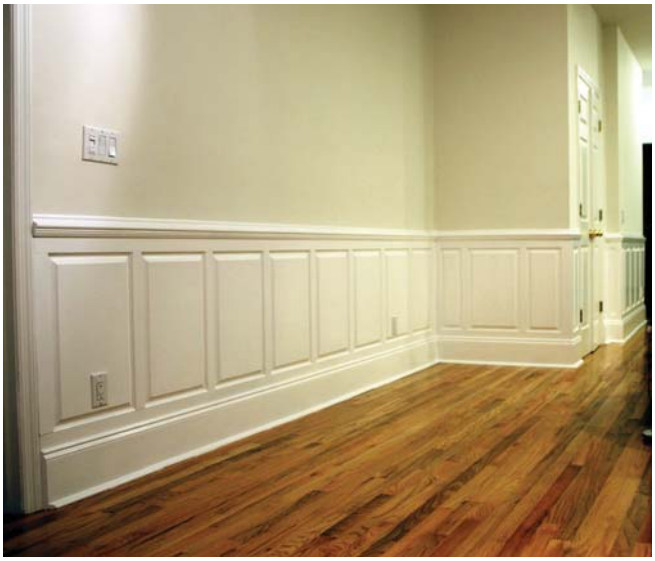
Environmental Impact: Wood veneer or imitation wood paneling are produced using a thin veneer applied over a substrate of plywood, medium-density fiberboard (MDF), or other composite wood materials. These materials can be manufactured using waste lumber, reducing the amount of raw lumber needed to produce wood paneling.

If stains or sealants are used to finish the wood or protect it from decay, select a product that will not off-gas and release harmful VOCs into the house.

Affordability: Wood paneling comes in a range of styles and prices, but can be an affordable option. MDF-based veneer with imitation wood grain is an inexpensive option but may be of low quality. Solid wood or high-quality veneers using real wood, while more expensive, offer better value due to their quality and durability. Wood paneling is generally more expensive than drywall and can be more costly to install.

Coastal Considerations: If using solid wood, consider durable, water-resistant woods such as cypress or cedar. Many woods must be stained or sealed to protect them from moisture. Termites can attack wood wherever it is used in the home; proper construction techniques should be followed to resist termite intrusion.

(Fig. 30) Wood paneling can add warmth to a residential interior.



(Fig. 31) Wainscoting is a traditional application in which wood paneling (often painted) is used on the lowest 3′ - 5′ of the wall.

(Fig. 32) Solid wood, such as this 2x6 tongue-and-groove southern yellow pine, is a durable and natural finish for a room.

TILE

Ceramic, porcelain, and glass tile can be used not only for flooring but also for walls, countertops, and other areas in bathrooms, kitchens, and elsewhere. Tile is highly durable, easy to clean, and can be used to create attractive designs that vary in their detail and complexity.

Ceramic tile is made primarily of clay. Regular ceramic is a porous material and ceramic tiles are usually glazed to make them waterproof and impart their finished color and appearance. Porcelain tile is a type of ceramic made with more refined clay and fired at higher temperatures. This makes porcelain denser, stronger, and much less pervious to water.[56] Glass tile is a third option that can come in a variety of styles.

Installation: Tile requires care and preparation to install, but it can be done by unskilled homeowners as well as skilled builders. The surface to be tiled is generally sheathed with a tile backer board, often a cement-based, water-resistant board. Tiles are set into a layer of mortar or other adhesive that has been spread on the wall using trowels. The joints between the tiles are filled with grout to create a finished surface.

Performance: Tile is a durable material which should last for many years. If not sealed and regularly cleaned, grout can accumulate grime and mildew. Extensive use of tile throughout a room can create unpleasant acoustic effects.

Environmental Impact: Because tile is heavy, it requires more energy to transport. Products that originate closer to the building site will require less energy to transport.

"Some manufacturers claim to use recycled materials," according to architect Cassandra Adams, "but those are mostly post-production (not post-consumer) wastes." One alternative is glass tile, which can include significant post-consumer recycled material.[57]

If grout sealer is used, select a product that will not off-gas and release harmful VOCs into the house.

Affordability: Ceramic tile comes in a range of styles and prices, but is generally an affordable option. Porcelain and glass tiles and specialty tiles may be more expensive.

Coastal Considerations: The warm, humid coastal climate can make maintenance especially critical. Sealing the grout will help reduce the development of mildew and grime.

(Fig. 33) Tile used for a kitchen backsplash creates a durable and attractive surface and protects the wall from grease and moisture.

(Fig. 34) A ceramic tile mosaic creates a artistic effect using small tiles or, in this case, broken pieces of tile in a random or pictorial pattern.

(Fig. 35) Ceramic tiles are set in a layer of mortar. In this case, magnesium oxide panels are used as the tile backer board.

MASONRY

Stone, brick, cast stone, and other types of masonry block can be used to create an attractive finish that adds character to the interior of a house.

Stone comes in nearly infinite varieties. Types of natural cut stone commonly used as decorative finishes include granite, marble, travertine, slate, limestone, and sandstone.

Cast stone is a manufactured concrete product, usually used as a veneer, that can replicate or nearly replicate the appearance of natural cut stone.

Brick is a ceramic block made of fired clay. Brick comes in a wide variety of shapes, textures, and colors.

Installation: Stone, brick, and other masonry finishes are most commonly installed as a non-structural veneer. The veneer layer can be applied directly to the structural wall using mortar or be attached by metal ties or other means. Individual masonry units are typically bonded to one another with a layer of mortar and the exposed joints filled with grout. The mortar joint between units can be reduced to create a "dry stack" look.

Performance: Quality brick or stone, professionally installed, is extremely durable.

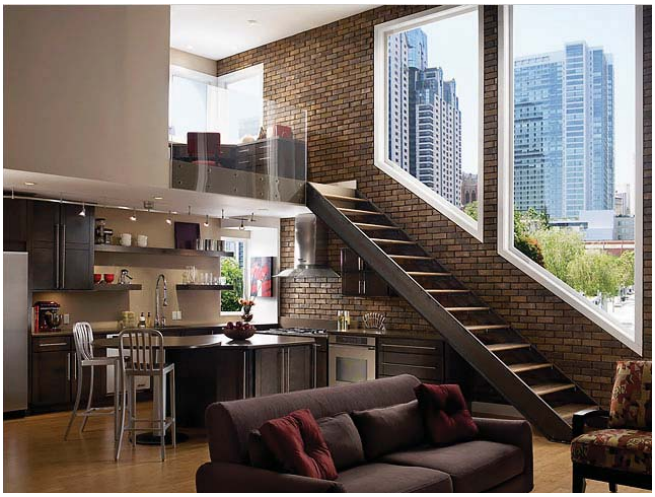
Environmental Impact: Depending on their source, brick, stone, and other earth-based materials can have a significant environmental impact. Additionally, they are heavy and therefore energy-intensive to transport. Choosing materials extracted and processed as close to the building site as possible can reduce the energy needed for transportation.

Affordability: The quality of workmanship and materials determines the cost of masonry. Stone can be very expensive, particularly hard, rare, or highly sought-after types such as marble. Cast stone can provide an affordable alternative to natural cut stone. Brick, too, can be affordable, although prices vary. In all cases, the skilled labor required can raise the cost of masonry finishes.

Coastal Considerations: Brick and stone are not prevalent in traditional coastal architecture. However, both are widely available and currently used in some coastal residential construction.

(Fig. 36) Cast stone is made to replicate the appearance of natural cut stone.

(Fig. 37) Natural stone and cast stone can provide attractive finishes for spaces such as fireplaces or outdoor spaces.



(Fig. 38) Faux brick adds texture and character, but is easily distinguished from real brick if not detailed right.