Efficient Earth-Sheltered Homes

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If you are looking for a home with energy-efficient features that will provide a comfortable, tranquil, weather-resistant dwelling, an earth-sheltered house could be right for you.

There are two basic types of earth-sheltered house designs—underground and bermed.

Underground Earth-Sheltered Homes

When an entire earth-sheltered house is built below grade or completely underground, it's called an underground structure. An atrium or courtyard design can accommodate an underground house and still provide an open feeling. Such a house is built completely below ground on a flat site, and the major living spaces surround a central outdoor courtyard. The windows and glass doors that are on the exposed walls facing the atrium provide light, solar heat, outside views, and access via a stairway from the ground level.

The atrium design is hardly visible from ground level, creates a private outdoor space, and provides good protection from winter winds. This design is ideal for building sites without scenic exterior views, in dense developments, and on sites in noisy areas. Passive solar gain —heat obtained through windows—is likely to be limited because of the position of the home's windows, and courtyard drainage and snow removal should be carefully thought through during design.

Bermed Earth-Sheltered Homes

This house in Tempe, Arizona, uses earth-sheltered construction methods to help decrease cooling costs. | Photo by Pamm McFadden

A bermed house may be built above grade or partially below grade, with earth covering one or more walls. An “elevational” bermed design exposes one elevation or face of the house and covers the other sides—and sometimes the roof—with earth to protect and insulate the house.

The exposed front of the house, usually facing south, allows the sun to light and heat the interior. The floor plan is arranged so common areas and bedrooms share light and heat from the southern exposure. This can be the least expensive and simplest way to build an earth-sheltered structure. Strategically placed skylights can ensure adequate ventilation and daylight in the northern portions of the house.

In a penetrational bermed design, earth covers the entire house, except where there are windows and doors. The house is usually built at ground level, and earth is built up (or bermed) around and on top of it. This design allows cross-ventilation and access to natural light from more than one side of the house.

Advantages & Disadvantages

Like any home design, earth-sheltered houses have advantages and disadvantages.

On the plus side, an earth-sheltered home is less susceptible to the impact of extreme outdoor air temperatures than a conventional house. Earth-sheltered houses also require less outside maintenance, and the earth surrounding the house provides soundproofing. In

addition, plans for most earth-sheltered houses "blend" the building into the landscape more harmoniously than a conventional home. Finally, earth-sheltered houses can cost less to insure because they offer extra protection against high winds, hailstorms, and natural disasters such as tornados and hurricanes.

The principal downsides to earth-sheltered houses are the initial cost of construction, which can be up to 20% more than a conventional house, and the increased level of care required to avoid moisture problems, both during construction and over the life of the house. It can also take more diligence to resell an earth-sheltered home, and buyers may have more hurdles to clear in the mortgage application process.

Site-Specific Factors for Earth-Sheltered Home Design

Before deciding to design and build an earth-sheltered house, you'll need to consider your building site's climate, topography, soil, and groundwater level.

Climate

Studies show that earth-sheltered houses are more cost-effective in climates that have significant temperature extremes and low humidity, such as the Rocky Mountains and northern Great Plains. Earth temperatures vary much less than air temperatures in these areas, which means the earth can absorb extra heat from the house in hot weather or insulate the house to maintain warmth in cold weather.

Topography and Microclimate

The site's topography and microclimate determine how easily the building can be surrounded with earth. A modest slope requires more excavation than a steep one, and a flat site is the most demanding, needing extensive excavation. A south-facing slope in a region with moderate to long winters is ideal for an earth-sheltered building. South-facing windows can let in sunlight for direct heating, while the rest of the house is set back into the slope. In regions with mild winters and hot summers, a north-facing slope might be ideal. Careful planning by a designer familiar with earth sheltering can take full advantage of the conditions on your particular site.

Soil

The type of soil at your site is another critical consideration. Granular soils such as sand and gravel are best for earth sheltering. These soils compact well for bearing the weight of the construction materials and are very permeable, allowing water to drain quickly. The poorest soils are cohesive, like clay, which may expand when wet and has poor permeability.

Professional soil tests can determine the load-bearing capability of soils at your site. Soil radon levels are another factor to consider, because high concentrations of radon can be hazardous. There are, however, methods for reducing radon buildup in both conventional and earth-sheltered dwellings.

Groundwater Level

The groundwater level at your building site is also important. Natural drainage away from the building is the best way to avoid water pressure against underground walls, but installed drainage systems can be used to draw water away from the structure.

Construction Materials and Considerations for Earth-Sheltered Homes

The construction materials for each earth-sheltered structure will vary depending on characteristics of the site and the type of design. Materials must, however, provide a good surface for waterproofing and insulation to withstand the pressure and moisture of the surrounding ground.

Concrete is the most common choice for constructing earth-sheltered buildings, because it strong, durable, and fire resistant. Concrete masonry units (also called concrete blocks) reinforced with steel bars placed in the core of the masonry can also be used, and generally cost less than cast-in-place concrete.

Wood can be used in earth-sheltered construction for both interior and light structural work. Steel can used for beams, bar joists, columns, and concrete reinforcement, but must be protected against corrosion if it is exposed to the elements or to groundwater. It is also expensive, so it must be used efficiently to be economical as a structural material.

Other Construction Considerations

Waterproofing

Waterproofing can be a challenge in earth-sheltered construction. Keep in mind these three ways to reduce the risk of water damage in your house: choose the site carefully, plan the drainage both at and below the surface of the house, and waterproof your house.

Waterproofing systems to consider include:

- Rubberized asphalt combines a small amount of synthetic rubber with asphalt and is coated with a polyethylene layer to form sheets. It can be applied directly to walls and roofs and has a long life expectancy.

- Plastic and vulcanized sheets are among the most common types of underground waterproofing. Plastic sheets include high-density polyethylene, chlorinated polyethylene, polyvinyl chloride, and chlorosulfonated polyethylene. Suitable vulcanized membranes or synthetic rubbers include isobutylene isoprene, ethylene propylene diene monomer, polychloroprene (neoprene), and polyisobutylene. For all these materials, the seams must be sealed properly to guard against leaks.
- Liquid polyurethanes are often used in places where it is awkward to apply a membrane, and are sometimes used as a coating over insulation on underground structures. Note that weather conditions must be dry and relatively warm during their application.
- Bentonite is a natural clay formed into panels that are nailed to walls or applied as a liquid spray. When the bentonite comes in contact with moisture, it expands and seals out moisture.

Humidity

Humidity levels may increase in earth-sheltered houses during the summer, which can cause condensation on the interior walls. Installing insulation on the outside of the walls will prevent the walls from cooling down to earth temperature, but can also reduce the summer cooling effect of the walls. Careful planning by a designer familiar with earth-sheltered home design can keep humidity from becoming a problem.

Insulation

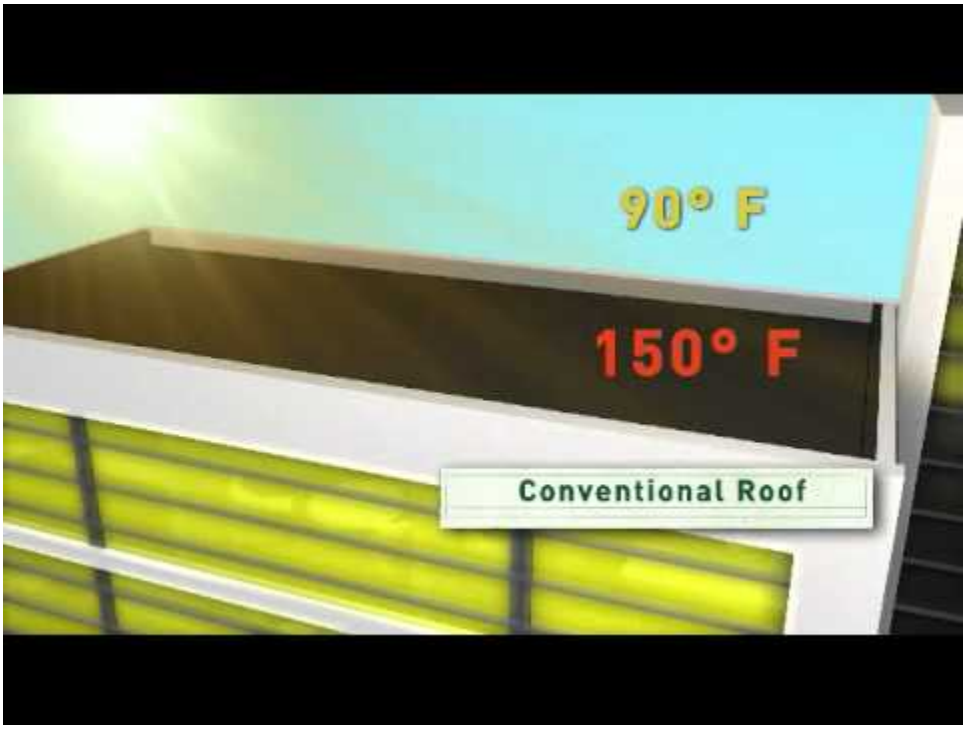
Although insulation in an underground building does not need to be as thick as that in a conventional house, it is necessary to make an earthen house comfortable. Insulation is usually placed on the exterior of the house after applying the waterproofing material, so the heat generated, collected, and absorbed within the earth-sheltered envelope is retained inside the building's interior. If insulating outside the wall, a protective layer of board should be added to keep the insulation from contacting the earth.

Air Exchange/Air Quality

Adequate ventilation must be carefully planned in an earth-sheltered house. Combustion appliances should be sealed combustion units that have a direct source of outside air for combustion and vent combustion gases directly to the outside. In addition, avoiding indoor pollutants such as formaldehyde from foam insulation, plywood, and some fabrics can help keep indoor air healthy. An energy recovery ventilator, which exchanges heat in the outgoing exhaust air with incoming fresh air, minimizes heat loss while ensuring good indoor air quality and is a useful addition to any energy-efficient home.

Energy 101: Cool Roofs

Video Url



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Learn how switching to a cool roof can save you money and benefit the environment. U.S. Department of Energy

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