

# Earth-Sheltered Housing

Earth-sheltered housing is one option many people consider in their search for more energy efficient homes. In areas with temperature extremes—bitter cold winters and sweltering summers—an earth-sheltered house, combined with passive or active solar heating, can be a good investment. In most parts of Oregon, however, temperatures don't fluctuate widely enough to warrant the extra costs of building an earth-sheltered house.

## What is an earth-sheltered house?

There is no legal definition for an earth-sheltered house. Most people consider a house "earth-sheltered" if more than 50 percent of its surface area comes in contact with soil. Earth-sheltered houses use the soil as a buffer to moderate heat flow in and out of walls. An earth-sheltered house can be built on level ground with the earth packed around and over the structure, in a sloping site, or on a flat site which is fully or partially below grade.

The chief advantage to an earth-sheltered house is its thermal stability. Soil protects the house from prevailing winds and thus the air filtration which can cause heat loss in the winter and heat gain in the summer.

The earth doesn't insulate the house well. Heat is still transferred both in and out. However, because soil temperature generally fluctuates less than outside air temperature, the soil slows the rate of heat transfer.

In the winter, for example, when the outside air is colder than the soil, the earth moderates the heat flow from the house interior. With its slower heat loss, an earth-sheltered house requires less energy for heating.

In the summer, when the outside air is warmer than the soil, the earth slows the rate of heat transfer from the outside to the house interior. Variation and rate of heat flow are greater near the soil surface where soil temperatures are more responsive to outside air conditions.

In addition to lower energy requirements, earth-sheltered houses blend into the environment more than conventional houses do. They also afford greater privacy and protection from outside noise, require less maintenance, and are less susceptible to storm damage and burglaries.

## How much does it cost to build an earth-sheltered house?

Construction costs for an earth-sheltered house are usually higher than for a conventional house. With land and site improvements, an earth-sheltered house will probably cost 10 to 35 percent more than a comparable sized above-ground house.

Research indicates a wide variation in the life cycle costs for an earth-sheltered house, however. Energy costs, insurance rates, and maintenance expenses, for example, are usually lower.

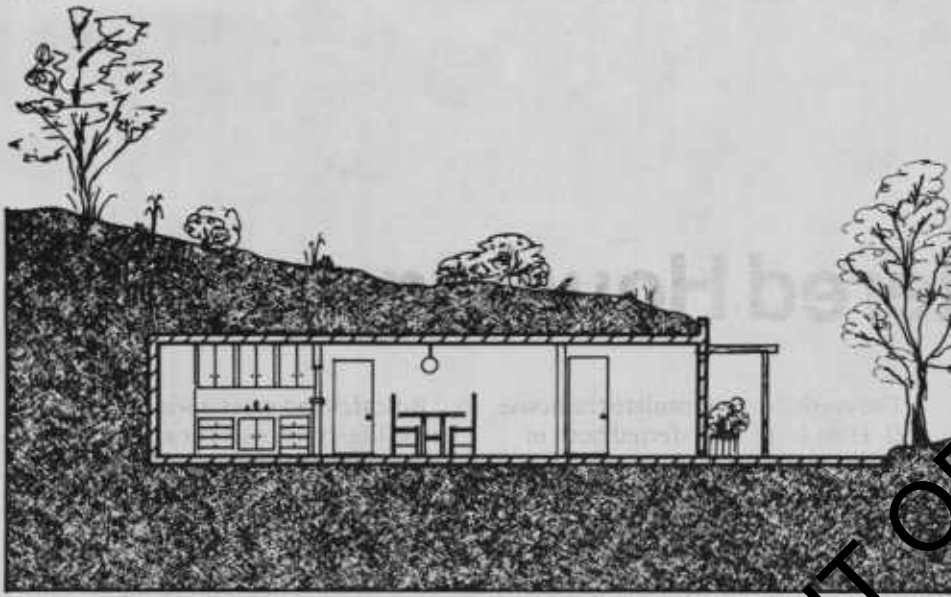
Because earth-sheltered houses are unconventional, financing may be difficult, especially if you're the first person in your community to build one. However, the Federal Housing Administration, the Veterans' Administration, and the Federal Land Bank are now approving loans for earth-sheltered houses. Since mortgage lenders generally follow trends started by these agencies, financing should be available as more earth-sheltered houses are built.

## Building an earth-sheltered house

*Site selection*—Soil conditions affect the cost of construction, the feasibility of the building site, and the longevity of the house. Information about the physical properties of the soil on which you intend to build is essential.

The compressive strength or load-bearing capacity of the soil (how much weight it will hold) affects the footing size. Percolation rate (how fast the soil will drain moisture), density, and location of the water table also affect design and construction costs. The Soil

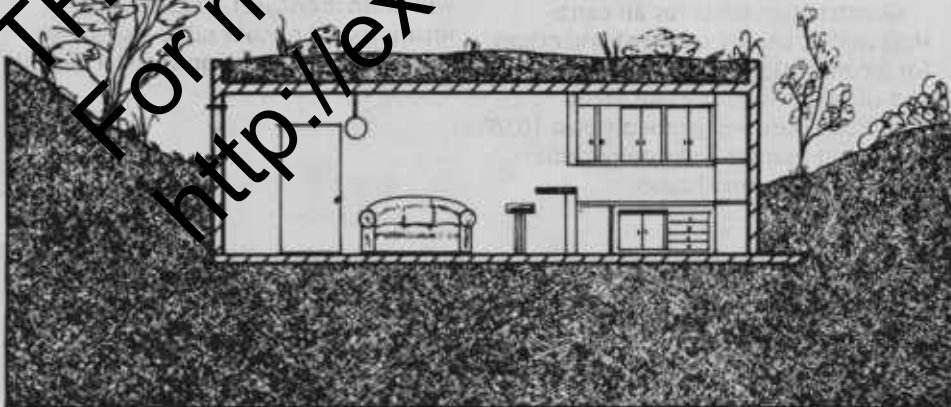
Three earth-sheltered house shapes



*Elevational*—one wall is exposed



*Atrium*—walls open onto below-grade courtyard



*Penetrational*—portions of two or more walls are exposed

Conservation Service, local soil scientists, or structural engineers can give you this information. These experts can also recommend design values for foundation loads and lateral earth pressures.

Different soil types exert different pressures on the walls of earth-sheltered houses. An engineer or architect will make allowances for this when designing the strength of the walls. Areas with loamy sand, peat, or highly organic soils make earth-sheltering difficult—and probably not worth the extra cost and effort. Earth-sheltering suitability of various soils is given in Table 1.

**Orientation**—Location of the earth-sheltered house on the building site is important because you want to make the best use of solar energy. The exposed wall of the house should face true south to allow for maximum solar heat gain in the winter. In the summer, more solar energy will fall on the roof, east, and west sides of the building.

**Construction factors**—Earth-sheltered houses are usually constructed of poured-in-place concrete, precast concrete panels, or concrete blocks. Some builders have also had success with pressure-treated wood structures. Highway-sized culverts have even been used to form curved walls and roofs.

When designing the structural strength of the walls, engineers and builders make provisions for outside soil pressures. If the roof is to be covered with soil, these experts must consider the soil weight as well as the state minimum snow load of 25 pounds per square foot in the roof's structural strength. In some areas where the snow load is much higher, the design load will be much higher. With an earth-covered roof, internal nonload-bearing walls should be constructed after the roof is loaded to avoid damage to interior walls.

**Moisture and drainage**—Moisture in a house comes from both indoor and outdoor sources. Since the soil may become saturated during certain periods of the year, drainage of external moisture sources is very important.

An earth-sheltered house needs foundation drains just below the footing in a large bed of gravel to carry away ground water. One or two feet of gravel against exterior walls will ensure rapid drainage of exterior moisture.

The terrain around earth-sheltered houses on hillsides can be altered either by creating a swale to divert water around the structure or building gravel trenches with drain tiles. On flat sites, the earth surrounding the house should slope away from the structure on all sides. A slope of one to five percent will provide gentle drainage.

Waterproofing the foundation and floor is an important step in the construction of an earth-sheltered house. A waterproof membrane or barrier will prevent water leakage from the soil into the house. Table 2 lists several readily available products. Remember to waterproof footings also.

Indoor moisture comes from activities such as cooking, bathing, and breathing. Due to the tight construction of an earth-sheltered house, you may need a dehumidifier to remove this moisture.

Roof sag will change with moisture content and other external load factors. Roof sag may be prevented by building a camber (a slight convex curve) in the roof structure. Some designers leave expansion space at the top of interior walls to allow for roof fluctuations.

**Insulation**—Insulation in earth-sheltered houses is usually applied to exterior walls. This allows the thermal mass of the walls to radiate heat into rooms.

Concrete walls provide ideal thermal mass for storing solar heat gains. Insulation used below grade should be water-resistant and placed either inside or outside the waterproof membrane.

**Windows**—You can ensure natural light and ventilation in an earth-sheltered home through proper orientation and placement of windows. An exposed south facing wall, for instance, will admit both natural light and wintertime solar heat.

In totally recessed houses, skylights and window wells serve several purposes. Besides admitting natural light and providing ventilation, a window well can serve as the emergency exit required by building codes. Some recessed earth-sheltered houses leave enough top wall and roofline exposed to allow for above-ground windows.

If you have an above-grade earth-sheltered house, you can make an opening anywhere in the soil to provide for natural light or a special view. Retaining walls or culvert tile can also penetrate the soil to admit a shaft of light.

**Ventilation**—Ventilation is important to provide fresh air and remove gas and vapor buildup from smoke, cleaning products, woodstoves, and other indoor activities.

If enough natural ventilation isn't available, you'll need to install a mechanical ventilation system such as an air-to-air heat exchanger. Air-to-air heat exchangers provide necessary air exchange while recovering 60 to 70 percent of the heat from outgoing air. Electrostatic air filters will remove pollutants attached to dust particles.

**Building codes**—All building codes are designed to protect your health, safety, and welfare. There are certain requirements for exits, window sizes, ventilation, and materials. You'll need to have a local building code official check your plans and issue a permit before you can start to build.

Most building officials require an earth-sheltered house be designed by an architect or engineer registered with the state. The earth-sheltered house must be able to resist external forces on the walls and roof. All bedrooms must have an emergency exit and every habitable room must have natural light.

### Other considerations

Investigate the advantages and disadvantages of earth-sheltering in the area in which you want to live. Remember, an earth-sheltered house is not cost-effective in areas where the temperatures are moderate throughout the year. Also, because earth-sheltered houses are uncommon, consider the difficulties of both financing and regaining your investment should you later decide to sell your house.

### For more information

Several books about earth-sheltered housing are now on the market. They include how-to manuals, workbooks, and photographic essays about the pleasures and pains of earth-sheltering. You should be able to find the information you need in your local bookstores or public library.

**Table 1.—Soil suitability for earth-sheltering.**

Type	Qualifiers	Suitability
gravel sands	very loose to loose medium dense to very dense	good drainage, but may need to be compacted for adequate bearing excellent—good drainage, good bearing, and low lateral pressures
silty sands		depends on whether cohesive or cohesionless elements dominate behavior; should generally be workable unless soft or loose conditions prevail
silts and clays	very soft to soft	requires careful evaluation
	medium stiff to hard	should present no problems structurally; drainage of high water requires granular backfill; may cause problems for septic tank system
	expansive	avoid
highly organic soils	for example—peat, humus, and swamp soils	would probably require extensive soil replacement or special foundation techniques

**Table 2.—Waterproofing methods.**

Waterproofing method	Adhesion	Ability to bridge cracks	Water pressure tolerance	Resealing ability	Seam-sealing problems	Cost
build-up membranes	fair	poor	occasional	poor	overlapping	low to med.
bitumene	fair	good	occasional	poor	overlapping	low to med.
butyl rubber EPDM neoprene membranes	mastic	good	continuous	poor	vulcanization	high
benzoflate	good	good	continuous	good	none	med. to high
liquid applied membranes	good	good	occasional	poor	none	low to med.
polyethylene embedded in mastic	good	fair	occasional	poor	overlapping	low to med.

The Oregon State University Extension energy program offers education, training, and technical assistance on conservation and renewable resources to help Oregonians solve energy-related problems.

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