Earth-Sheltered Houses
An Energy Factsheet

EEM-01359

An earth-sheltered building is either banked on one or more sides with earth, or built partially or entirely underground. This approach to building is one way to more effectively control a building's interaction with its surrounding environment. Earth-sheltering reduces a building's energy needs for heating and/or cooling by (1) preventing the leakage of air out of and into the building, and (2) placing a barrier between the walls of the building and the extreme outdoor temperatures. In the more temperate areas of Alaska the average ground temperature for depths of 5 to 10 feet below the surface ranges from 35° F at Anchorage to 41° F in Juneau.

Earth sheltering does not need to result in a dark or damp environment. On the contrary, by exposing the south-facing walls and windows to the outdoors and making use of skylights or clerestory windows, an earth-sheltered building can be bright and airy and partially solar heated. The windows must be minimally double pane. These buildings also have other advantages, such as long life expectancy due to their heavy masonry construction, as well as low maintenance, fire resistance (and reduced fire insurance costs), and increased comfort because of minimal temperature swings and few drafts. Earth-sheltering construction is more demanding than above ground structures, and is more costly to build—as much as $10,000 to $40,000 more. All blue-prints and specifications should be certified by a qualified architect or engineer to assure structural soundness. Once the design is complete, leave the basic construction to professionals as a general rule. Concentrate your do-it-yourself efforts to interior finishing and landscaping. Using qualified people also increases the confidence of conservative bankers when financing is sought.

IMPORTANT CONSIDERATIONS

Site

The building site is central to the planning of an earth-sheltered home. Soil and ground water conditions will determine structural and waterproofing requirements. Some soils are more susceptible than others to expansion when wet or frozen, and will place more demands on the strength of the building. Permafrost areas occur in Alaska and special care should be taken during preliminary site preparation to ensure the ground is not disturbed when permafrost is present. Because of this, earth-sheltered homes are not recommended for permafrost areas. Soil testing may be needed at this critical stage in the design phase.

The topography of the site — lay of the land — will affect wind flow and drainage patterns, and will determine how easily the building can be surrounded by earth. A modest slope requires more excavation than a steep one, and a flat site is the most demanding, needing extensive excavation. Buildings on flat ground are bermed more easily on one or more sides. Berming is the practice of banking earth up against the walls of the building.

The design of an earth-sheltered house can be varied to suit the tastes of the occupant while making the best use of the building site. When a house is built almost entirely underground, the first consideration is to provide natural light and passive solar heat to the living and sleeping spaces. An exposed, glazed, south-facing wall is an excellent approach. This approach can be

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modified by building a greenhouse along the south wall. In either case, the floor plan is arranged so that the main living spaces share light and heat from the southern exposure.

Another approach is the central atrium, allowing for a floor plan that surrounds an outdoor space on three or four sides. The strategic use of clerestories and skylights also allow more latitude in the arrangement of interior spaces.

In addition, building codes require fire escape routes from bedrooms. This is essential for the personal safety of you and your family.

CONSTRUCTION MATERIALS

The materials used to build an earth-sheltered house must be able to withstand the stress imposed by the surrounding earth. When soil is wet or frozen, it exerts greater pressure on the walls, ceiling and floors of the building than the pressure that already exists. Pressure also increases with depth, so materials must be selected and used accordingly. The common building materials — concrete and reinforced masonry, wood, and to some extent, steel — are all eligible.

Concrete

Concrete is usually the first choice for construction of earth-sheltered buildings. Not only does it have the strength needed for earth-sheltered construction, but it has the added advantage of durability and fire resistance. Reinforced concrete, poured at the site, is used for footings, floor slabs, and walls.

Concrete will absorb and store solar heat as part of a passive system, and its heat absorbing qualities help to prevent large temperature swings.

Pre-cast Concrete Panels

Pre-cast concrete has all the advantages of poured concrete and more. It meets all structural requirements, and construction proceeds more quickly with pre-cast units. Special care must be taken, however, in making the joints between sections watertight.

Concrete Block

Concrete block, surface bonded with fiberglass, can be used for walls up to two stories but needs reinforcement at depths greater than two feet. Cracks in mortar joints must be sealed carefully, and the porous quality of block demands extra care during the waterproofing process.

Wood

Wood has also been used for walls and roofs of earth-sheltered buildings. It is less expensive than concrete but is not as strong. It needs to be pressure-treated with preservatives that will enable it to endure moist conditions. Conventional framing techniques can be used, and post and beam construction have also proven successful.

Steel

Steel can be used for beams and column supports, but it has been used in other less conventional ways as well. For example, large steel culvert sections have been used to form the shell for dwellings, finished on the interior and waterproofed on the exterior. They have more than adequate strength since they were designed originally for underground use and are also impervious to water seepage. However, they must be treated to prevent corrosion as does any below grade corrosive metal and, as with precast concrete panels, special care must be taken in making the joints between sections watertight.

WATERPROOFING

Waterproofing is extremely important to an earth-sheltered house and must be done right the first time so that major excavation is not necessary to locate and repair leaks. Underground structures must withstand prolonged periods of water pressure. The common waterproofing techniques used for basements, such as coating the exterior walls with asphalt, are not suitable for earth-sheltered dwellings.

The first step in waterproofing occurs during the site selection. The best way to avoid water pressure against underground walls is to choose a site where water will naturally drain away from the building. Survey the site for low spots and areas where water will collect. If possible, build above the water table. If the water table cannot be avoided, drainage systems can be designed to draw water away. Regardless, build with the intent of moving water away from the house via perimeter foundation drainage and wall drainage systems. Building at the top of a hill is usually a good choice because of natural drainage, but a percolation test is advisable to determine how quickly the soil transfers moisture.

After drainage systems have been designed, the actual waterproofing materials for the building can be selected. The limited amount of available data does not establish any one approach as best, but the selection should meet three important criteria: (1) it should have a long life expectancy underground; (2) it should have resealing capacity at underground temperatures; and (3) it should have good crack-bridging capability. Backfilling and construction imperfections can cause undetectable punctures in the waterproofing material, so its ability to reseal is important. Masonry walls always crack during curing and settling, and the waterproofing must be able to bridge these cracks adequately to prevent leaks.

The products being used most widely for waterproofing systems at present are: asphalt and pitch-impregnated membrane, liquid polyurethane, bentonite, and "rubber-like" sheets that are rolled onto the surface over an adhesive coating.

Built-up asphalt or pitch membranes have been used successfully in underground structures for both roofs and walls. The felt products normally used in built-up roofs are not recommended because they tend to rot under prolonged exposure to moisture. Fiberglass fabric should be used in its place. The disadvantage to built-up membranes is that they lack good resealing expansion and crack-bridging qualities.

Bituthene is rubberized asphalt coated with polyurethane. It can be applied directly to walls and roofs and has a long life expectancy.

Butyl Rubber and EPDM membranes are durable rubber sheets that are glued to walls or roofs of the building and have been successful where applied properly. The point of failure in this approach, however, is at seams that are not sealed properly.

Liquid Polyurethanes are often used at points where it is difficult to apply a membrane. They have the advantage of having no seams. However, they do not reseal. Polyurethanes are sometimes used as a coating over insulation on underground structures.

Bentonite is a natural clay that is formed into panels or applied as a liquid spray. The panels are simply nailed to roof or walls. They expand when wet, and seal out moisture. The spray is mixed with a mastic and applied three-eights of an inch thick to roof and walls.

INSULATION

Insulation in underground buildings is as necessary as in conventional buildings, but there are some special considerations. In masonry construction, the insulation will usually be placed on the exterior of the building if solar access is available. This allows the solar energy that is collected and absorbed by the concrete or block to be retained within the building interior. In most cases the waterproofing will be applied to the building first — before the insulation. Because the insulation will be exposed to the earth, it should be a closed cell product such as extruded polystyrene. It must also be able to withstand the pressure of back-filling without being compressed. Some below grade oriented fiber insulation materials help drainage around foundations and walls.

When backfilling against the insulation on the wall itself, a protection board of some kind should be applied to protect the insulation or the wall waterproofing from being punctured by rocks during the backfilling process. Also, backfill material along the wall should have good drainage qualities such as non-frost susceptible gravel.

BUILDING CODES

Building codes have been adopted in some of the municipal areas of Alaska however, that do not specifically take into consideration underground or earth-sheltered home construction. Some obstacles may arise when trying to meet these uniform building codes. For example, the uniform building code requires that habitable rooms have glazed areas greater than one-tenth of their floor area. This may be impossible for a room surrounded on all sides either by earth or other rooms. Another requirement is that bedrooms have a window or door leading to the outside, both for quick exit and access to fresh air to prevent smoke inhalation in the case of a fire. There may be alternate ways to provide safety for occupants, such as smoke detectors or well-planned escape routes, but the burden of proof is on the owner or builder. Be sure to check codes and get building permits!

AIR QUALITY AND VENTILATION

The earth-sheltered home eliminates most of the causes of air-infiltration because of its tight construction. A well designed home should include a ventilation system so that stale air can be exhausted and fresh air added at a reasonable rate. A method that provides ventilation is the air-to-air heat exchanger, which may be connected to forced air furnace systems.

RADON CONSIDERATIONS

No style of housing is more vulnerable to radon penetration than one built with total contact with the soil. Radon-proofing is possible both before and after construction, but **no** underground home should be built in any radon risk area without anticipating radon problems. It is much more difficult to mitigate radon after construction, than to build the home in anticipation of radon. EPA publication EPA/600/8-88/087, *Radon-Resistant Residential New Construction*, should be reviewed thoroughly before beginning construction. It is available at Alaska Cooperative Extension offices in Fairbanks and Anchorage.

SOURCES

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