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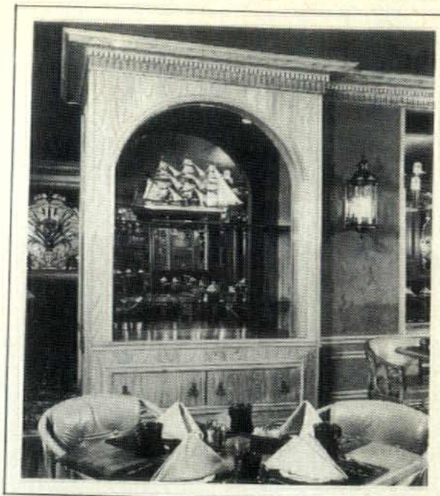

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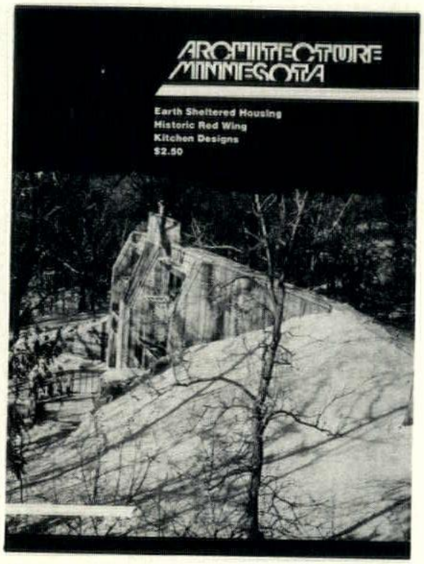
Vol 6 No. 2
April 1980

A Regional Review of Design and Architecture

Contents



Cover: Earth sheltered home in Burnsville designed by Tom Ellison and John Carmody for Ellison Design and Construction, Station 19 Design Offices, Minneapolis. For more on this HUD-award winning home, *see pp. 42–44.*

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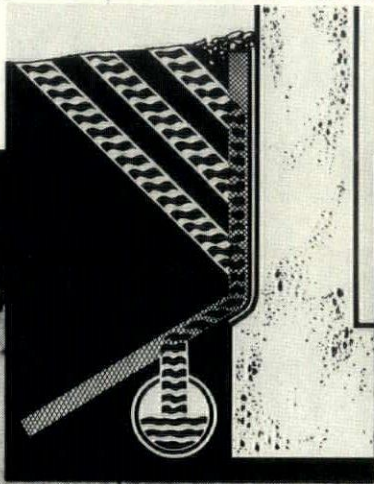

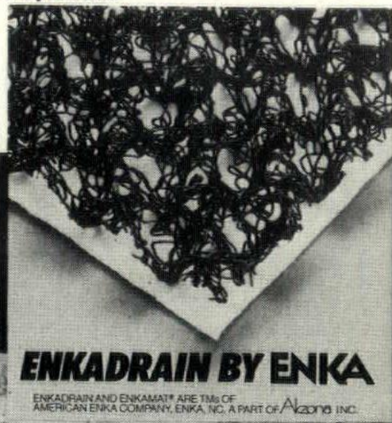

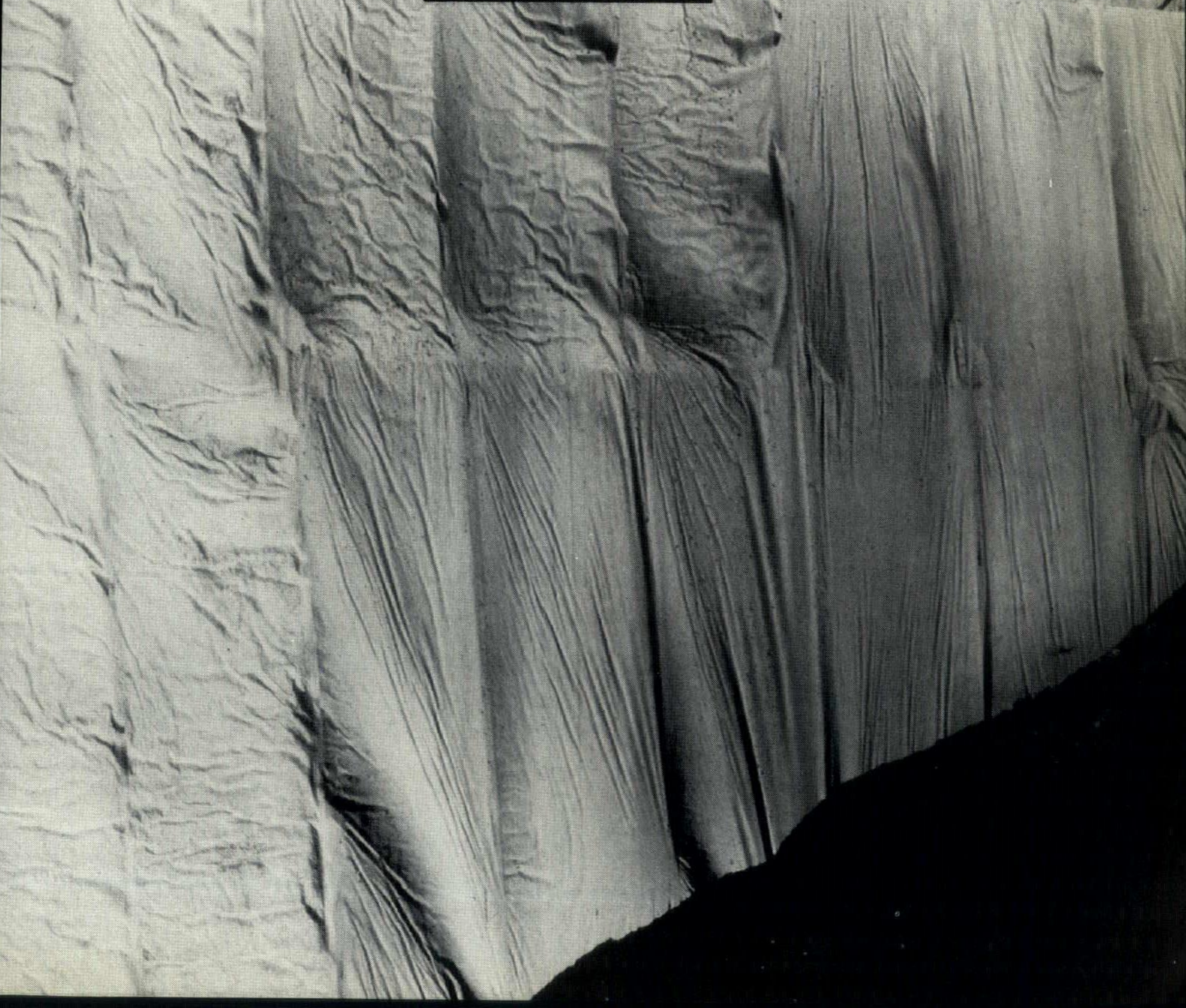

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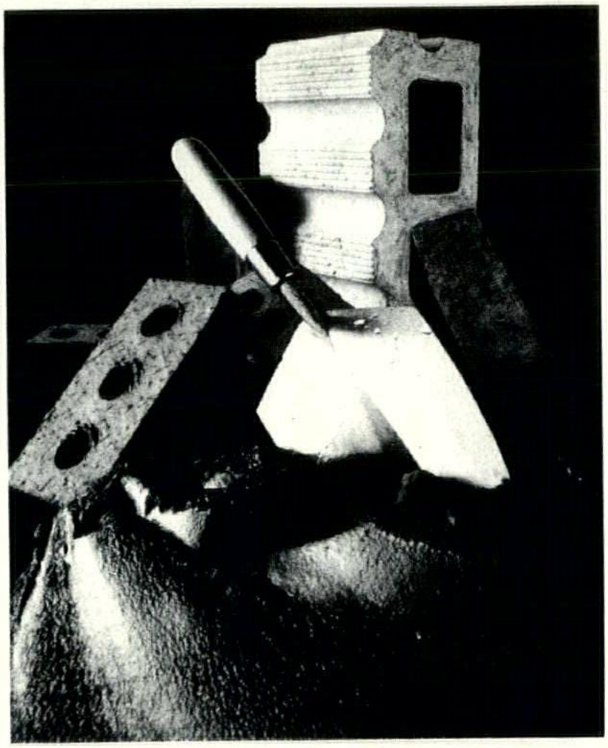

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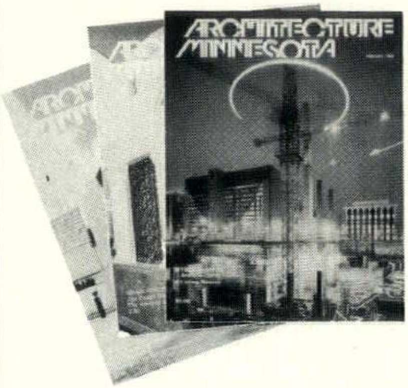

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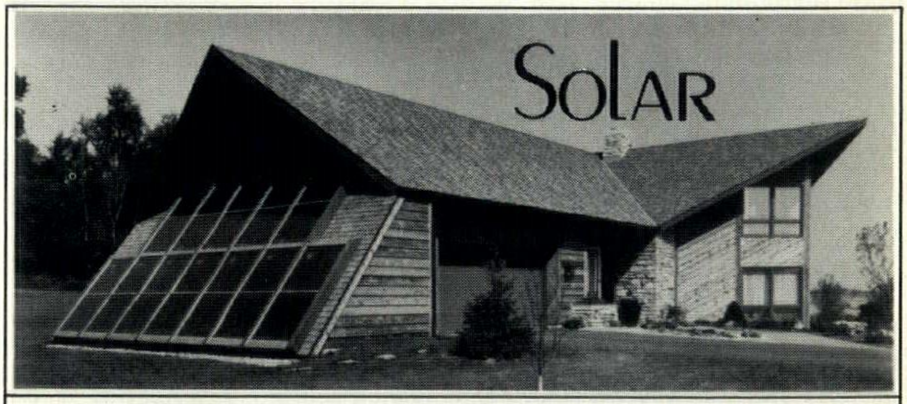

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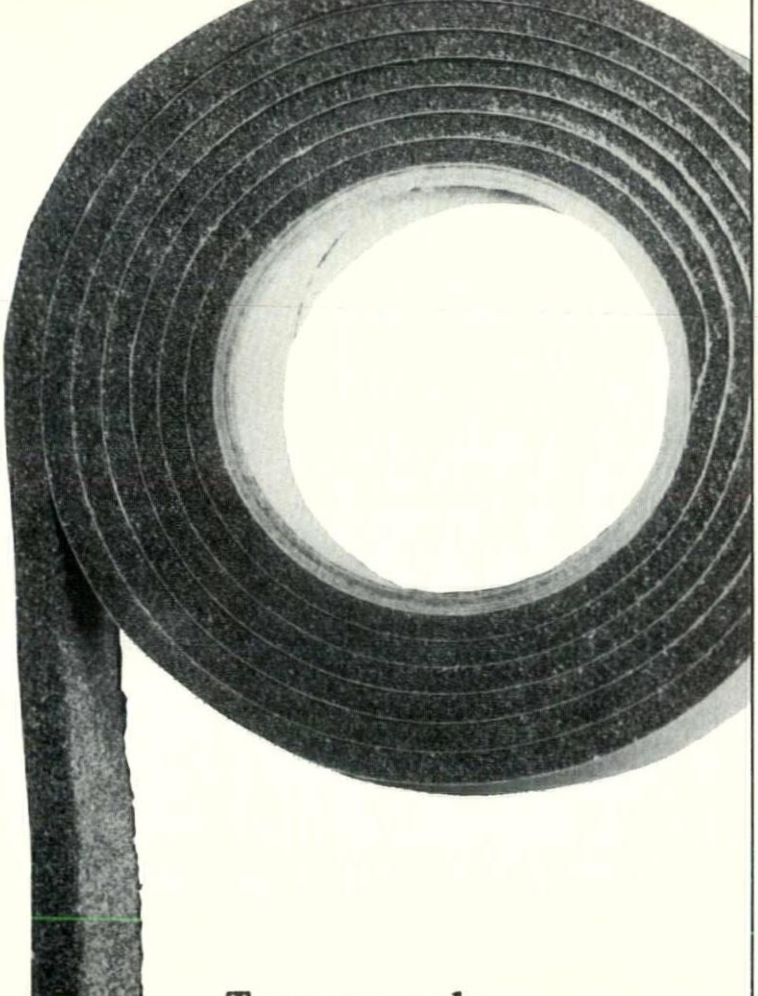

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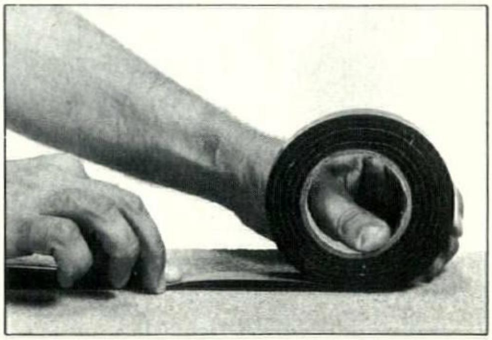

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The Need For A Congruous Approach

Minnesota leads the way in the area of underground/earth shelter research and construction. What is needed, however, is the State Legislature's wholehearted commitment.

Earth sheltered and underground construction is proliferating throughout the nation. The rapidly accumulating wealth of empirical and academic research is overwhelming. In less than four years, what was at best an esoteric concern has now become a vital and widely shared interest. The intensifying energy/fuel related crisis, greater ecological sensitivity, a good share of Tom Wolfe's "me-ism" and—not least of all—the challenge of problem-solving, have accelerated the developments in earth-sheltered construction beyond anyones expectations. The space program, even with presidential mandate, was quite slow by comparison.

We in Minnesota can be proud to have been the leaders in the development of so much of this knowledge and also the construction of so many outstanding earth-sheltered underground structures. No state has had one of its public agencies, such as the Minnesota Housing Finance Agency, sponsor and administer earth-sheltered demonstration projects. No state university has received legislative support and encouragement equal to that received by the University of Minnesota. The University of Minnesota's Underground Space Center is widely known as the leader in thought and research in this area. Williamson Hall, the underground admissions and records/bookstore building, has attracted international attention. The Civil and Mineral Engineering Building, now under construction, will further advance the frontiers of knowledge and research.

It is ironic that on the one hand, a progressive and enlightened Legislature has given encouragement and support to agencies and institutions towards the development of earth-sheltered/underground and solar construction. They have even gone so far as to support a National "Terratectural" Competition. But, on the other hand, the Legislative has not yet been able to bring itself to vote for the construction of the winning design.

In 1973 the Legislature authorized preliminary studies for a Capitol Building Annex. As a result of this mandate, the Capitol Area Architectural Planning Board conducted the National Terratectural Competition in 1976—Minnesota II. The unusual aspect of the competition was that the proposed building was to be entirely underground. The integrity of the State Capitol was to be maintained and in order not to interfere with the view of the building, the proposed addition was to be built adjacent—in front of the Capitol and below the grade.

The winning design by C. F. Murphy Associates of Chicago is a definitive piece of underground architecture. As stated earlier here, the building sets high standards for the consideration and respect it gives the State Capitol Building and the Capitol Approach. It shows that it can work with and interpret civic symbols. It also shows that an underground building need not be a cell, cave, or bunker. It can be a very humane environment, resplendent with all the spatial drama, interest and vistas of aboveground buildings. It also illustrates that architecture can have an interior quality which need not be projected, that external symbols are not mandatory.

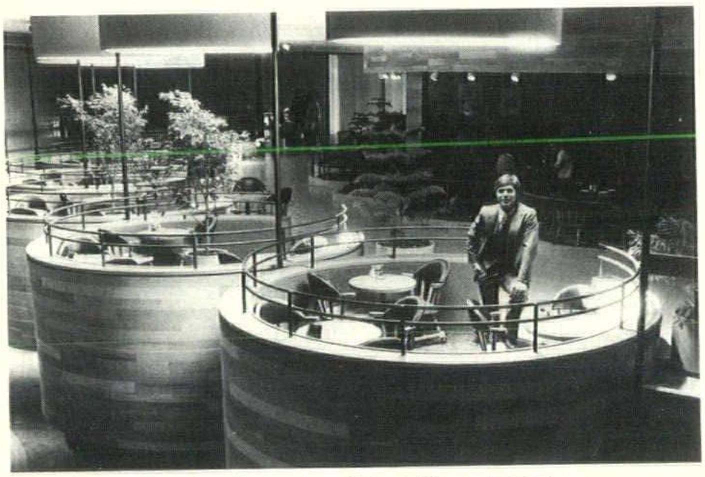
From the point of view of the building as architecture, from the point of view of the interpretation of civic architecture, from the point of view of the technical environmental resolutions of underground construction, the winning design for the Capitol Annex Building leads the way.

It is ironic and incongruous that the Legislature, which can be so sensitive and daring in legislative matters, has not seen fit to fund the construction of the Capitol Annex Building. On the other hand, it will be very congruous and in keeping with Minnesota's leadership role to build this underground structure and for our Capitol to point the way, both symbolically and in reality.

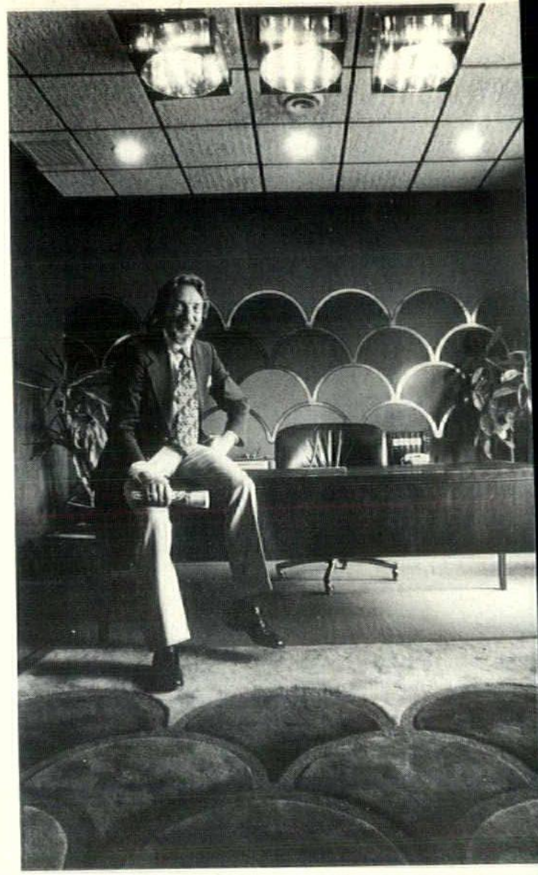
–Bernard Jacob

Commercial Wallcoverings from Hirshfield's.

Controlled use of pattern.
Bold use of texture and color.



Executive Wood wallcovering at Fresh Fin restaurant is planked natural white oak.
Hirshfield's representative: Jeff Lien.



Winfield Graphic sets pattern for custom carpet in Meshbesher, Singer & Spence law offices.
Designer: Don Sewell.

Georgetown Print provides pattern accent to dark w
at Green Mill Too restaurant, Minneapolis.

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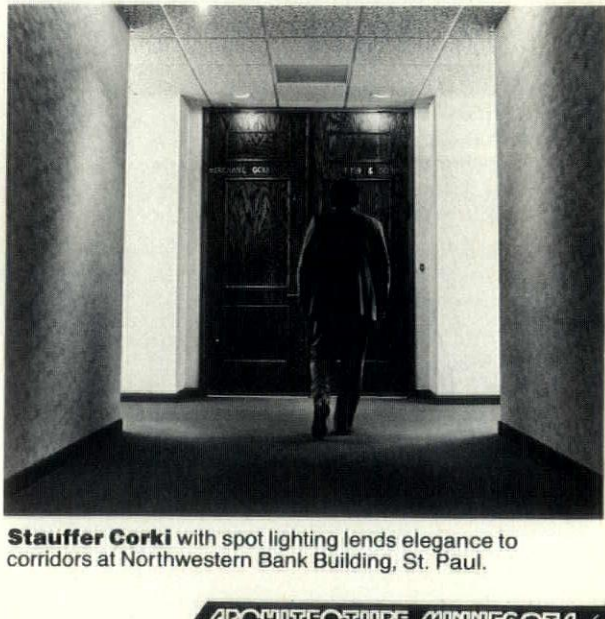
Shenandoah Suede walls enhance setting at Dayton's Commercial Interiors.
Designers: Renee Savage and Patti Hiatt.

Stauffer Vinyls in vivid colors brighten corridors at 3M Company.
Designer: Wendy Patterson.

Hirshfield's representative: Bob Katchmark, left.
Architect: Lanny Oxton, Hill District Design.

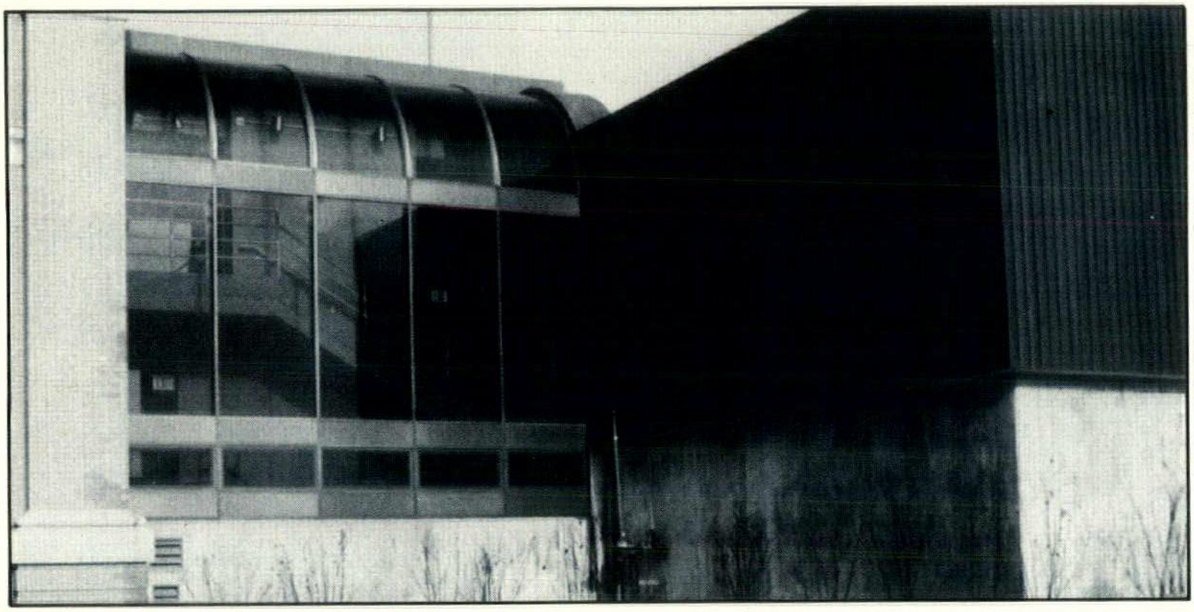
"Niji" Oriental Wallcovering adds natural texture to walls at Main Hurdman & Cranstoun accounting offices.
Designer: Marsha Wilkins, left, Dayton's.
Client: Patty Ursin, Main Hurdman.

French Woven Fabric wallcovering provides dramatic backdrop for Ken Meshbesher's law office.

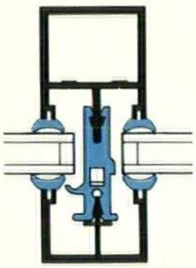


Stauffer Corki with spot lighting lends elegance to corridors at Northwestern Bank Building, St. Paul.

Go Straight To Cronstroms When Your Design Calls For Curves



Lake Superior Maritime Museum, Architect: Architectural Resources, Inc., Hibbing, MN; Army Corps of Engineers

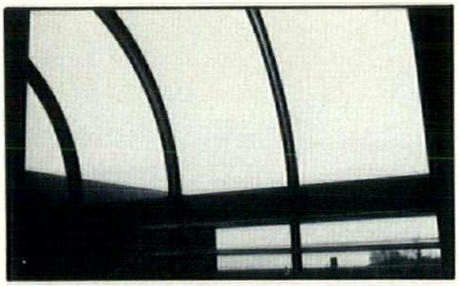


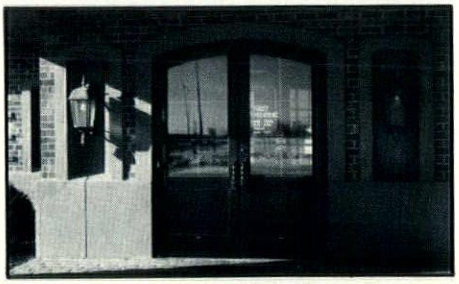
Even though energy efficiency is the watchword in public buildings today, that doesn't mean you have to shackle yourself to time worn designs. Instead, consider the benefits of Cronstroms CTS thermal barrier system. Its energy-saving design eliminates metal-to-metal contact in curved or straight designs. And that means no frost or condensation, even at temperatures of -30°F. Of course, that's something you'd expect from Cronstroms. Cronstroms was the **first** to develop this thermal break system 14 years ago.

You'd also expect to find unusual applications of the CTS system. You will.

At the Lake Superior Maritime Museum located on Minnesota's waterfront in Duluth, a location buffeted by winter's bone-chilling gale force winds, the architect specified Cronstroms CTS thermal barrier energy saving walls and windows for a new addition linking two sections. Notice the bent mullions of the upper section.

You'll find another distinctive CTS design at First Federal Savings and Loan where curved mullions frame the glass entry doors.





First Federal Savings and Loan, Architect: Gene Hickey & Associates, Minneapolis, MN

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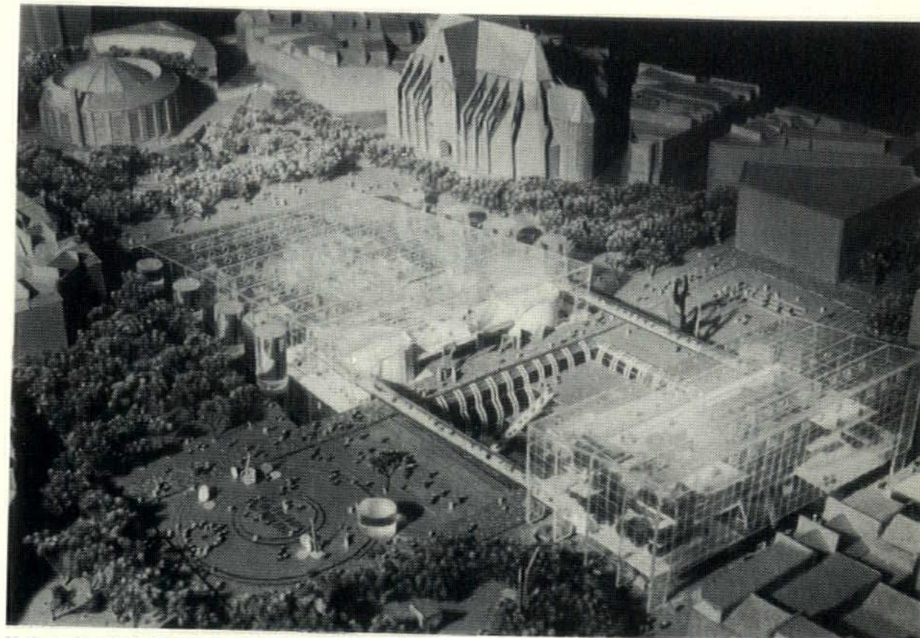


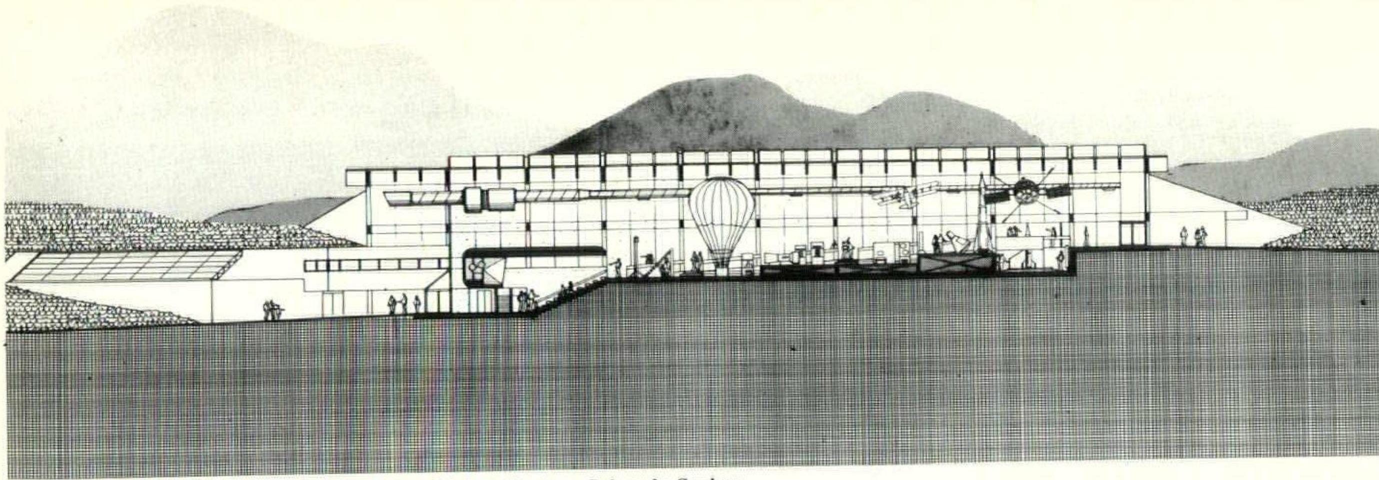
University of Minnesota architecture students' prizewinning re-design of Les Halles.

A **French design competition** to redesign Les Halles market quarter in Paris has been won by a team of five University of Minnesota architecture students. The five seniors are: **Ngu Aloysius Bongwa,** 23, of the United Republic of Cameroon; **James Dahlberg,** 24, Coon Rapids; **Timothy Dray,** 28, Elmore; **Richard Ness,** 24, Bloomington; and **Shi-Ming Tam,** 23, Hong Kong. The students worked together to create the design as a class project and tied for first place with four other entries from New York, Atlanta, Italy, and France. The competition was conceived by a group of French architects in protest of a government decision to turn Les Halles into a park. The students' design for the site included a World Information Center with laser communications and an international computer center. The design was intended to bring the marketplace concept back to the area.

Construction is underway on a new two-level shopping plaza that will double the number of stores and retail space in the Lowry Medical complex in downtown St. Paul. The shopping mall, to be called **Carriage Hill Plaza,** will include 24 new stores, and will increase retail shopping space in the building to 55,000 square feet. Twelve new stores will be added to the main level and 12 more to the second level. Three entrances will lead to the main level stores, one on St. Peter Street, one on Wabasha, and one on Fifth Street. The second level stores will line corridors that will lead to skyways linking the complex with Hotel St. Paul and the St. Paul City Hall. Architect for the $2 million project is **Winsor/Faricy Architects, Inc.** of St. Paul and the general contractor is Kraus-Anderson of St. Paul. It should be completed in the summer of 1980.

A new landscape architecture and site planning firm, **Sanders and Associates,** has been formed. **William Sanders,** recently appointed Advisor to the Capitol Area Architectural and Planning Board by the State Arts Board, is the firm's principal. **Larry Wacker** and **Jeffrey Westbrook** are Associates. The firm is located at 1150 Northern Federal Building, St Paul.

Myers and Bennett Architects/ BRW, Minneapolis, has been selected as the architect for the United States Air Force Academy Visitor Center in Colorado Springs, Colorado. Myers and Bennett, well known for their work in the area of earth sheltered architecture, were chosen out of a field that included such firms as Skidmore, Owings & Merrill of Chicago, Phillip Johnson, New York, and I. M. Pei,



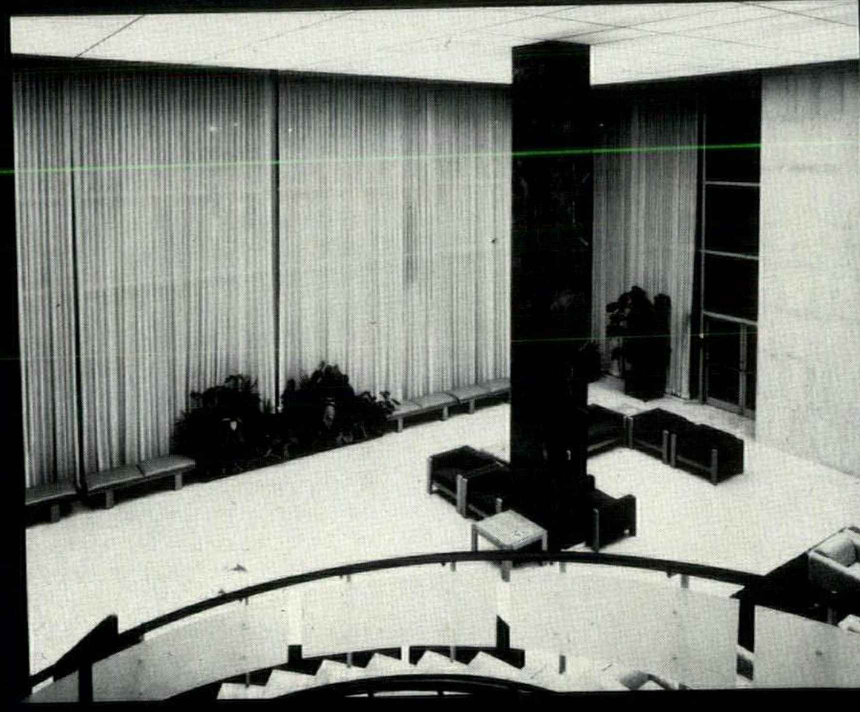
Plan for United States Air Force Academy Visitor Center, Colorado Springs
Myers & Bennett, BRW, Minneapolis

New York. The earth sheltered design for the structure is an assembly of vaults, platforms and retaining walls, organized to mold a part of the natural topography with the Center's specific program functions. Its most vital characteristic is that the exhibit space is a tunnel through the hill connecting the visitor arrival and parking area to the Cadet area. Using the tunnel concept, the visitor is conveyed in the course of the exhibit sequence from the wilderness setting of the arrival area to the man-made setting of the Academy grounds. The combination of solar collectors and the inherent energy saving characteristics of the earth sheltered building will make the Center extremely energy conservative. The $3 million project will be completed by 1982.

---

800 LaSalle Avenue in downtown Minneapolis, a site cleared by fire last year, is being rebuilt as a one-story retail center by the longtime owners of the property, the Abbay Company. Formerly the home of Duff's and Martin/Williams Advertising Agency, the project will have about 10,000 square feet of retail space and cost about $500,000. No leases have yet been signed for the building, which will have a brick and glass exterior. Architects for the project are **Hills, Gilbertson, Fisher/Centrum Architects.** Occupancy is scheduled for March, 1980.

25′ floor to ceiling, 12′spans 200′ long at the crossroads of the business world.



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BWBR Architects, St. Paul, has been selected by the Girl Scouts of America as the architect for their new headquarters facility near Pleasantville, New York. The National Learning Center will be designed along the lines of BWBR's earth-sheltered, energy efficient Girl Scout Regional Headquarters in St. Paul. It will occupy a 400 acre site in Mount Pleasant, New York and serve as a conference/learning center.

The Underground Space Center of the University of Minnesota will present a three-day **Conference on Earth Sheltered Housing** from April 9–11 at the Leamington Hotel in Minneapolis. It will feature selected papers by experts from all over the country, practical workshops, a display of the products and services of some 50 firms involved in various aspects of earth sheltered construction, a design competition, and tours to earth sheltered dwellings. The Minnesota Society American Institute of Architects is co-sponsoring the conference with the American Underground Space Association and the Minnesota Society of Professional Engineers. Conference times (open to registrants only) are from 8:30 to 5:30 daily. The exhibition area (open to the public for $5.00) is open from 7 to 9 p.m., April 9 and 10. This issue of *Architecture Minnesota* is devoted to the Conference and subjects covered therein.

The Minnesota Society American Institute of Architects will sponsor a General Session called "The Physical Plant Needs a Physical Exam: Opportunities for Energy Conservation," at the **1980 Upper Midwest Hospital Conference** at the Minneapolis Auditorium on Thursday, May 8, 9—11 a.m. A panel of architects and engineers who specialize in energy conservation will explore the architectural and engineering opportunities for energy conservation within medical facilities. The primary focus will be on the steps necessary to achieve this and how to fund it especially through grant funding. For further information, contact Upper Midwest Hospital Conference, 1375 Willow Street, Minneapolis, MN 55403, (612) 871-5522.

The Sixth Annual Minnesota Energy Conference will be held April 8–9 at the Radisson South Hotel, Bloomington. The conference is aimed at commercial, industrial and institutional energy users from Minnesota and will include exhibits of energy conservation equipment and materials.

For further information contact: Ronald Griffith, Chairman, Minnesota Energy Conference, 414 Nicollet Mall, Mpls., MN 55401; tel. 330-5696.

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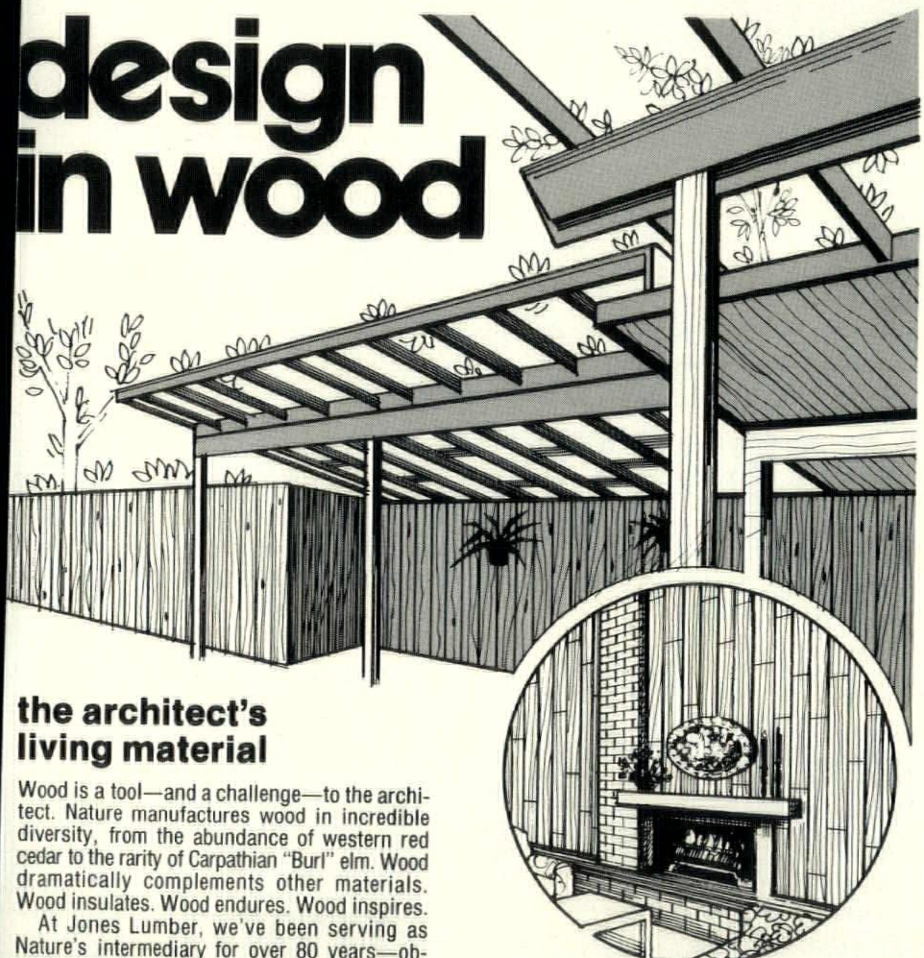

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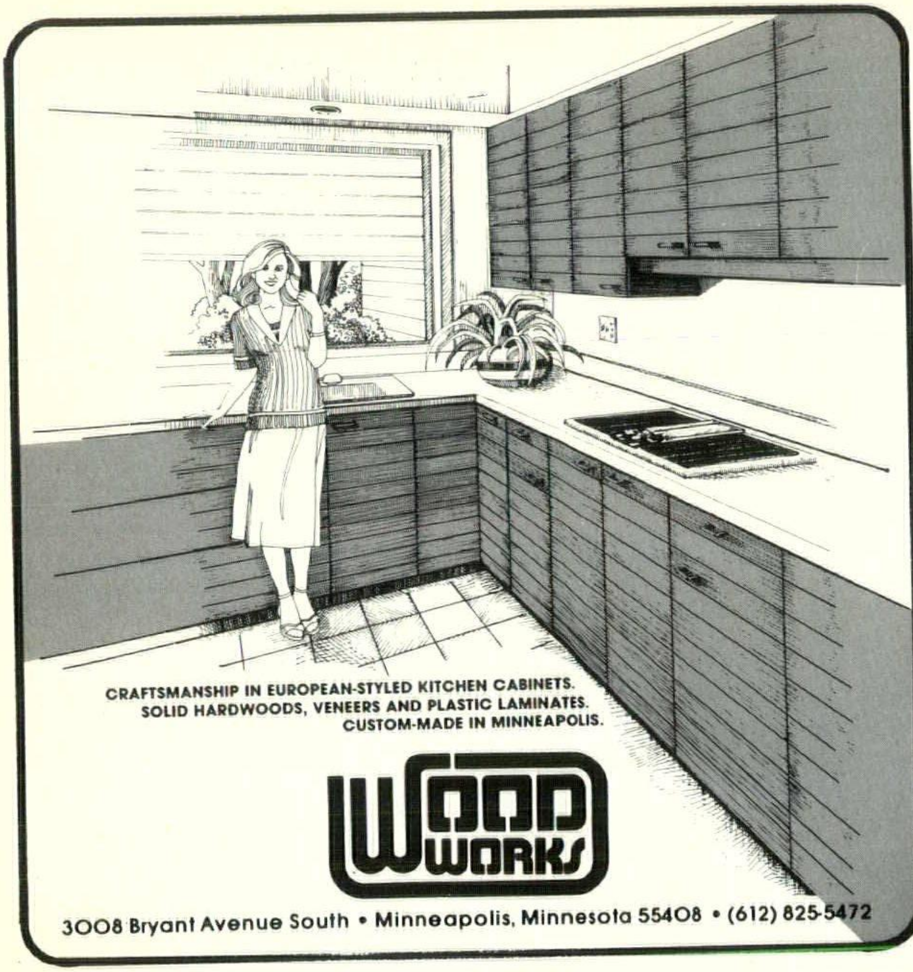

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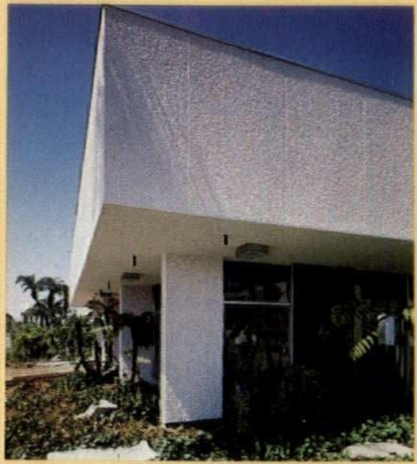
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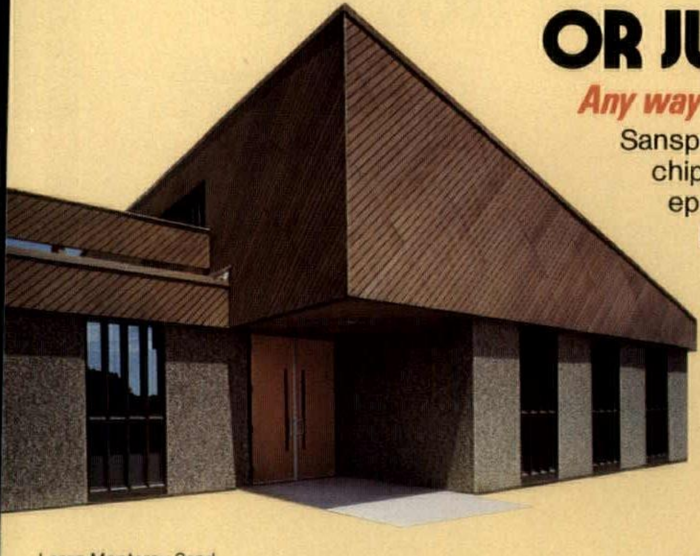
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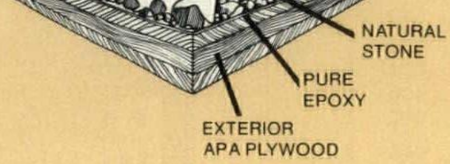

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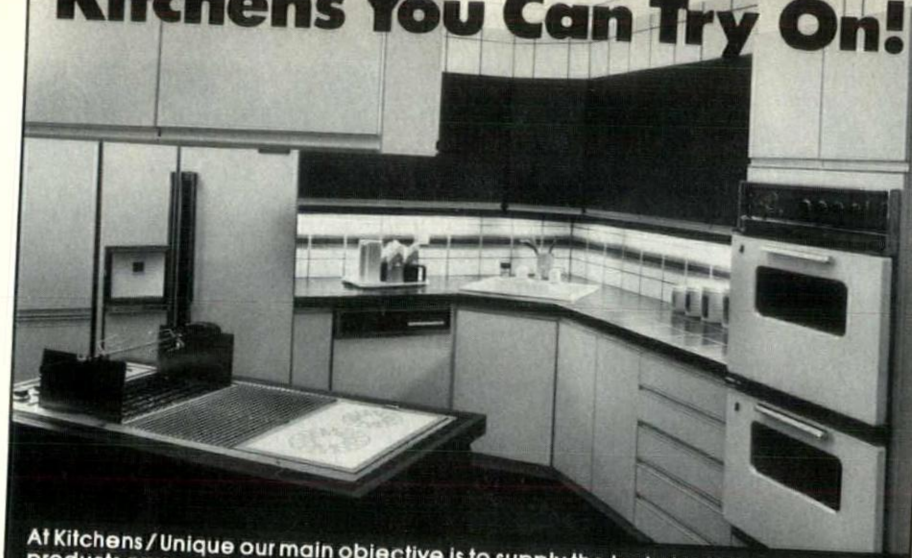

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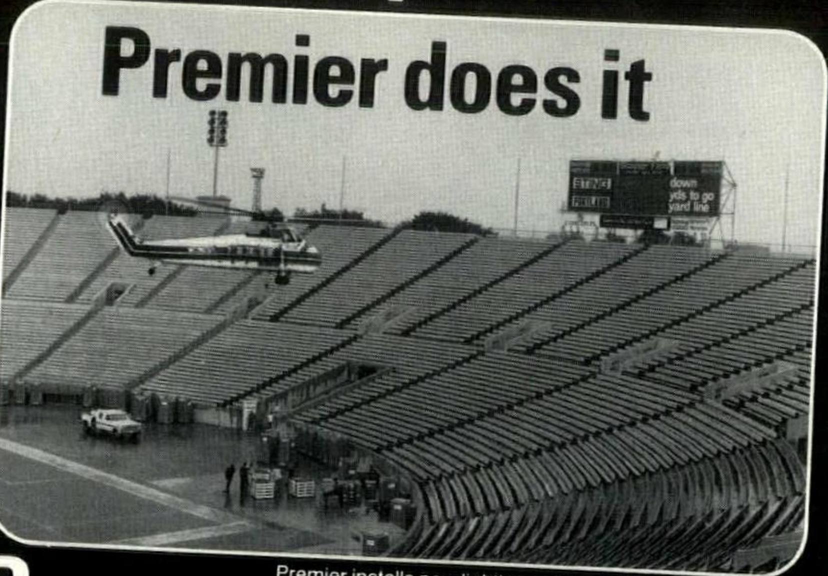

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Noel Residence, Wayzata
Designer: Design Consortium, Inc., Minneapolis

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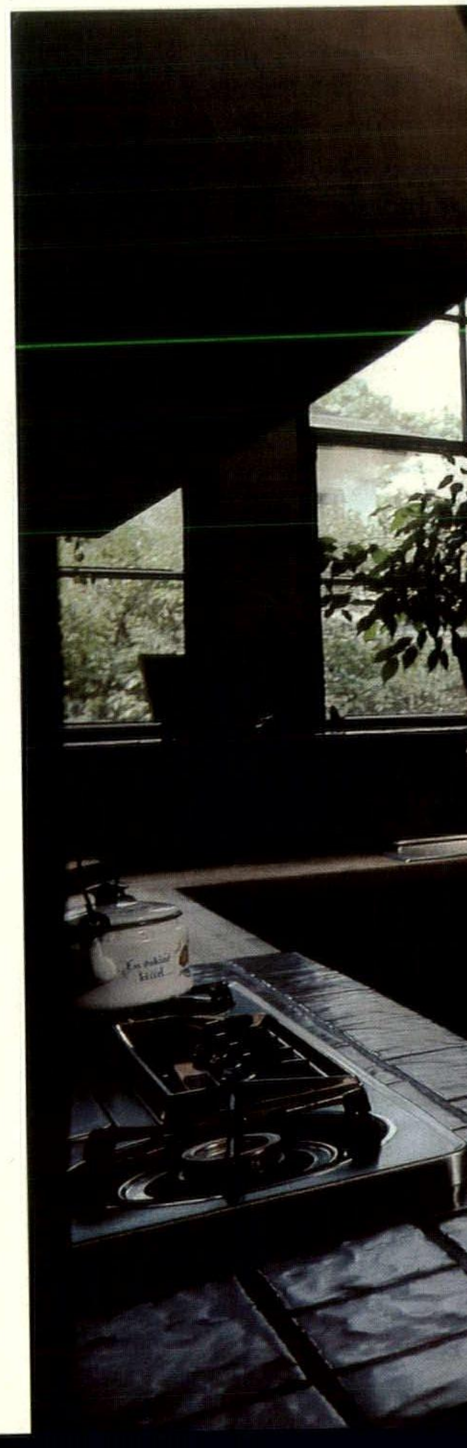

Dahlstrom Residence, Minneapolis
Kitchen designer: John Idstrom
This large English Tudor style home on Mount Curve Avenue was built in 1930. The kitchen was renovated in 1975 to accommodate the needs of a large family with four children. To retain the character of the house, Idstrom designed a country kitchen which gets its rustic look from rough plaster coated walls, fir floors, a brick woodburning fireplace hearth and wood storage area, and custom built cabinets which match those in the butler's pantry.

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Photography: Roger McBr

Winton Residence, Minnetonka
Kitchen Designer: John Idstrom
The Winton home in Minnetonka is Minnesota's only Phillip Johnson-designed residence. The kitchen in the 25-year old house needed updating to meet contemporary technological and storage needs, but the designer also realized the importance of maintaining the basic design quality of the space. A pair of French doors lead to the windowless kitchen which gets natural light from five skylights. The whiteness of the kitchen is offset by the teakwood which surrounds the cooking island.

Cabinetry: Mutschler Kitchens

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EARTH SHELTERED HOUSING CONFERENCE & EXHIBITION

April 9, 10, 11, 1980 The Leamington Hotel, Minneapolis, Minnesota

CONFERENCE

The focus of this conference and exhibition is HOUSING, both single and multi-family. Major conference presentations will primarily consist of selected papers and practical sessions. Technical sessions will include research exploring such issues as heat transfer, building codes, and attitudes about living in earth-sheltered homes. Practical sessions will provide experiential, hands-on advice on insulating, waterproofing, financing, etc. Master Classes will provide an opportunity to consult with a "master" (an experienced architect, engineer or builder) on earth-sheltered building plans. These sessions in combination with tours of earth-sheltered buildings and time spent in the exhibit hall, will bring you the Underground Space Center's most comprehensive earth-sheltered housing program to date.

EXHIBITION

For the first time anywhere, an earth-sheltered housing EXHIBITION will be held to provide an opportunity for architects, engineers, contractors and suppliers to display their products or services related in any way to earth-sheltered construction. The exhibition will be held at The Leamington during the conference: it will be open free to all registrants and to the interested public for an admission fee.

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For details and site plan contact Underground Space Center.

Registration Fee:	\$95.00 — before April 8th	\$125.00 — at door	\$ 45.00 — daily rate

For further information, call or write: Underground Space Center, 11 Mines and Metallurgy, 221 Church Street, S.E., Department of Civil and Mineral Engineering, U of M, Mpls., MN 55455, (612) 376-1200

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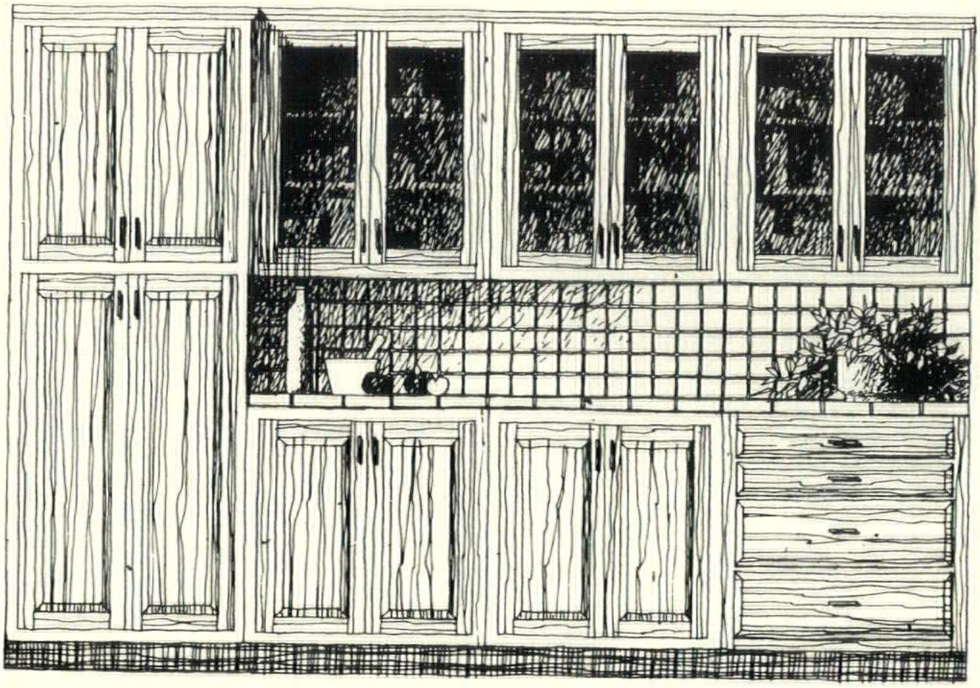

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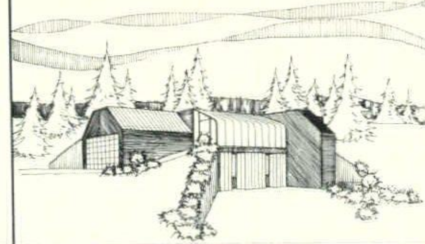

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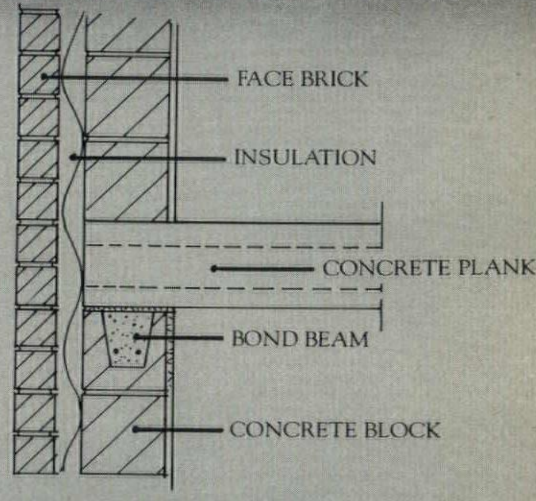

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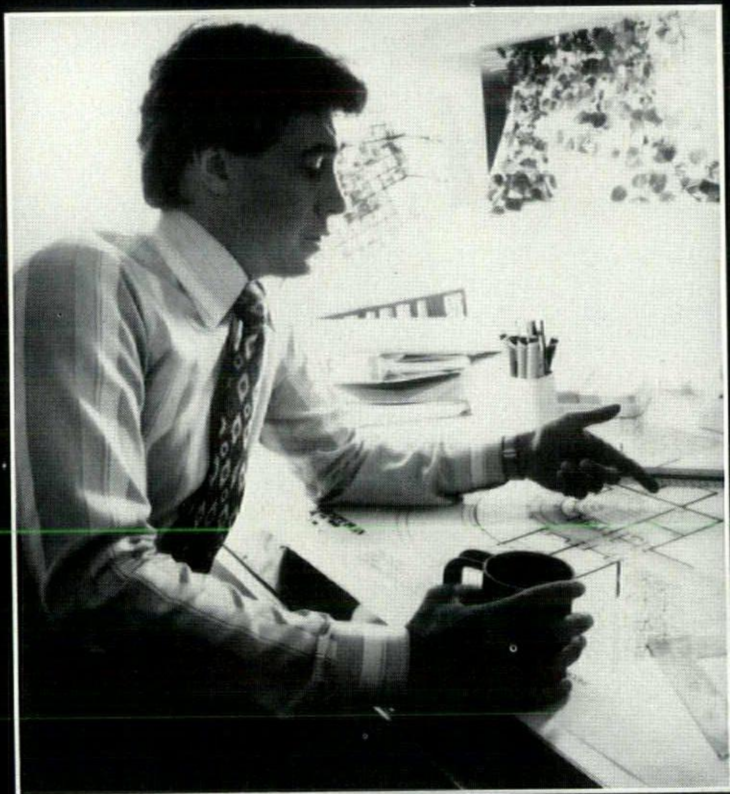

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Is Earth Sheltered Housing Entering The Mainstream?

Mary Rollwagen

"Going Under To Stay On Top" . . . "Down-To-Earth Solution To The Energy Crisis" . . . "The Great American Cover-Up" . . . It appears that the ingenuity and inventiveness that is sending designers and builders underground is matched and sometimes surpassed only by the wit of headline-writers and phrase-makers who write or teach about earth sheltered construction. No other evidence is really required to document the fact that earth sheltered construction, ancient though its roots may be, is still regarded by much of the public as new, relatively untried, and likewise unproven.

And yet proof of its worth exists, all over the country. The pioneering stage, at least in the central United States, is nearly over. The technology is available, and many of the mistakes have already been made, to be repeated fewer and fewer times. Solar technology, in contrast, requires extensive research and development now and in the future in order to be widely useable and cost-effective, but earth sheltering is basically made up of familiar design and construction techniques that are simply applied in new ways.

The challenge presented by the earth sheltered and underground option, then, is not primarily to the researcher and technician, but to the whole spectrum of the practicing design-construction-regulation-financial-real estate communities, and ultimately, of course, to us, the consumers. The challenge is to our attitudes, our traditional views of what "shelter" is and looks like.

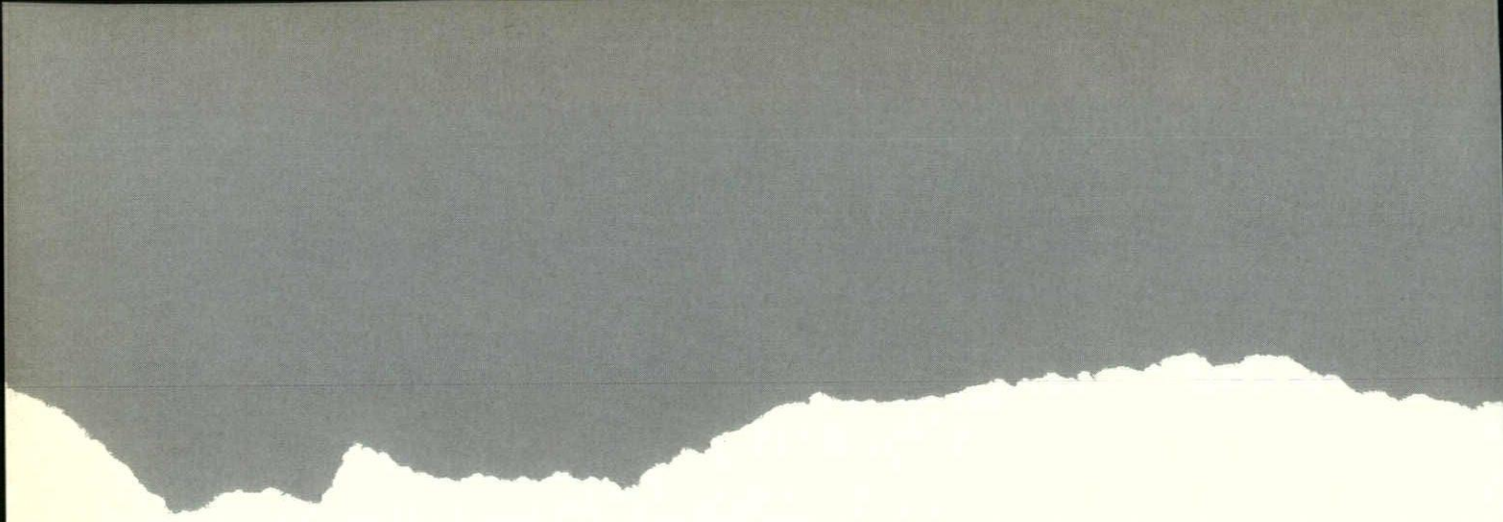
The extent to which we are able to lessen or shift our paradigms of shelter governs, in each of us, the extent to which we will embrace unfamiliar ideas of shelter. Vague visions or ideas behind "red flag" words like "underground" may govern attitudes more than the actual looks, sometimes unconventional, of earth sheltered houses. In fact, most of them don't look funny. We need to shift our mental images of underground space, then, even more than our shelter images.

The energy crisis is forcing such a shift. The notion of the need for energy conservation has entered our way of thinking. We are only beginning to modify our behavior, but the consciousness of the need to do so is already here.

The new awareness of the need to conserve energy is the engine that has driven the earth sheltered idea so far and so fast in the past several years, but the idea was first broached and tried for reasons having nothing to do with energy.

When architects like Malcolm Wells, Don Metz, John Barnard and others began looking at the sub-surface as a resource, they saw it as a way to reduce human impact on the land. Earth sheltering was an aesthetic that disturbed the natural environment as little as possible.

Concurrently, engineers in Sweden and America began looking at the deep underground as a resource that provided safety and security, and also saved valuable surface land for other uses. Using tunnelling technology borrowed from subway construction and mining, new uses were devised for underground space: uses that included storage and manufacturing space as well as the more traditional transit and utility corridors.



Large institutional buildings began to go underground—at first for aesthetic and land conservation reasons also. For example, Williamson Hall, the widely known bookstore and office facility at the University of Minnesota, was designed by its architect, David Bennett, to go down instead of up in order to preserve circulation patterns and retain views of other buildings in a densely built campus.

Today these goals of lessened impact on land, security, and saving surface space are joined by the goal of energy efficiency. Much has been learned about the energy savings to be had through the moderated temperatures of the sub-surface, and precise documentation is just beginning to be available.

In the meantime, public attitudes are changing. Public interest increases with every month. To cite a few examples: while word-of-mouth and other information networks have spread notice of the concept, a great thirst for hard information has fueled book sales to phenomenal levels. The Underground Space Center (USC) at the University of Minnesota printed, somewhat nervously, an initial run of 5,000 copies of *Earth Sheltered Housing Design*, a book that remains the most comprehensive source available for specific information. Having gone through several successive printings, the book is now a best seller, professionally published and distributed to bookstores all over the country, with approximately 200,000 copies in print.

People's interest propels them to go and see for themselves—the experience of the builders of two earth sheltered houses that are part of a Minnesota demonstration program shows that. Built on speculation to demonstrate their marketability, these two houses were open to public view for approximately a month. An average of 4–5,000 people went through each during that time—each sold promptly to the first interested buyer. Other builders report the same experience.

Information and research centers which, like the Underground Space Center, study earth sheltered housing, have grown up in other universities; none is more than a few years old. There are other such centers in Washington state, Texas and Oklahoma; others investigating deep space utilization are in Wisconsin and Missouri.

The books being published, the lengthening bibliography of articles in popular and professional periodicals, the conferences being planned—all attest to the rapidly increasing interest in earth sheltering.

It can probably be safely said, however, that the continuing momentum of *attention* can drive an idea past the pioneering stage only if the idea enters the economic mainstream; in other words, if it is profitable.

That earth sheltering is beginning to enter that mainstream is evidenced by the emergence of entrepreneurs; the builders, designers, engineers and other professionals who are developing a new industry, and doing so without much government subsidy. A healthy young professional association like American Underground-Space Association attests to the birth and growth of profitable earth sheltered and underground ventures.

One can't escape the feeling that the momentum behind earth sheltering exists. It is hard to resist the temptation to assert that the idea is entering the mainstream just in time. If it is true, as stated recently in a MASEC (Mid-American Solar Energy Complex) newsletter, that one-half of the housing units that will exist in the year 2000 have yet to be built, then earth sheltering, for reasons of aesthetics, safety, security, land conservation or energy efficiency, is vitally important to learn about and to foster.

Mary Rollwagen is a senior associate at TLH Associates, Inc.

Frequently asked Questions on Earth Sheltered Housing

Charles A. Lane

This essay briefly answers some of the most frequently asked questions regarding earth-sheltered housing design. It deals with topics such as: site selection; structural systems; energy-use criteria; heating, ventilation, and air-conditioning (HVAC); waterproofing; insulation; and factors affecting constructing costs.

1

How many earth-sheltered houses have been built (or are currently under construction) in the United States?

In early March 1978, the University of Minnesota's Underground Space Center published a book entitled *Earth Sheltered Housing Design*. At that time, only an estimated 30 to 40 earth-sheltered homes had been built in the U.S. Although it is difficult to determine how many of these homes are being built at present, I would estimate that 2000–3000 earth-sheltered homes are now either completed or in some phase of planning, design, or construction. This number is increasing at a rapid rate. . .

The idea of using the earth for shelter from the elements is not new, of course. One can discover from reading a good history book that the use of earth-sheltering for human habitation has ancient beginnings. The popularity of the concept today can be described accurately as the rebirth of an old idea. However, the timing of the attention now focused on earth-sheltering is closely linked with the expected decrease in the availability of cheap energy sources.

2

What things should be considered in selecting a site for an earth-sheltered home?

To date, most earth-sheltered homes have been built in rural or semi-rural areas on larger, open sites. The prevailing attitude is that a buildable site should be a large, five-acre plot on a south-sloping hill facing a beautiful view protected by a forest of pine trees to the north. Although ideal, such a site is far from essential.

A good exposure to the south, however, is necessary to obtain maximum solar heating and natural light. North exposure should be kept to a minimum. No direct solar heat gain, only diffuse natural light, is available from the north.

As with any conventional above-grade home, landscaping and planting can be designed to maximize privacy and wind/sun protection. Other site considerations such as vehicle and pedestrian access, utility hookups, easements, wells and septic systems usually pose no special problems for the earth-sheltered home builder.

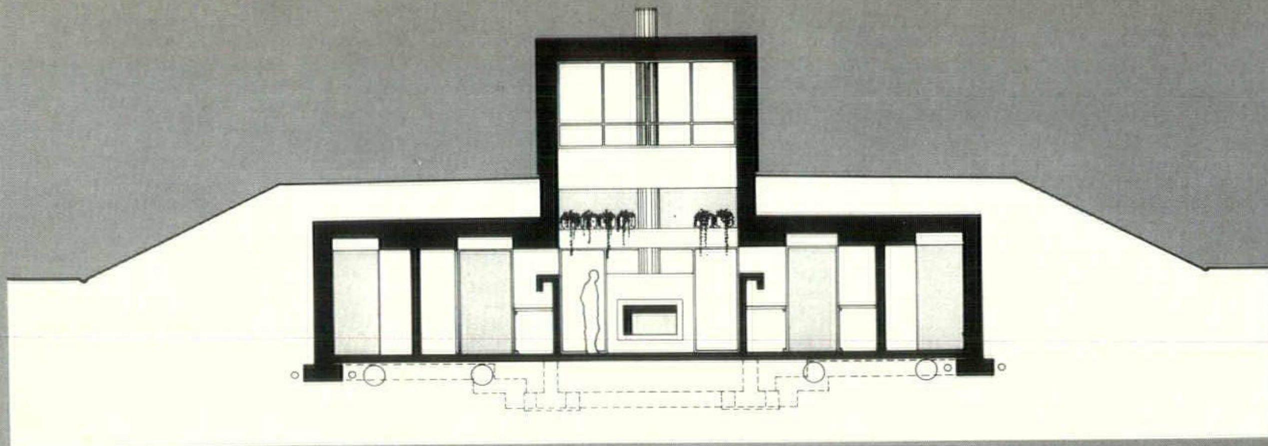
A good knowledge of soil and groundwater conditions is very important in planning an earth-sheltered house, but often prospective builders will choose a site without any knowledge of where the groundwater table is located, how the soil transfers moisture (the percolation rate), the soil composition (sands, gravels, clays, peat, fill, etc.), and the chemical characteristics of the soil. Sometimes soil conditions can be approximated by contacting neighbors on adjacent lots, or by obtaining soil surveys for the immediate area. If these methods do not yield sufficient information, it is advisable to invest in a thorough soils test from a reputable soil testing firm.

In earth-sheltered housing, the surrounding soil is a functional part of the house, and not merely a design afterthought. A builder should be familiar with the properties of the soil, just as he would be familiar with the properties of the other construction materials.

Under optimum conditions, the soil should provide good load-bearing strengths, good drainage characteristics, and a sufficient distance between the house structure and the highest point of any groundwater table. A wise builder should probably avoid building in a flood plain area, in humic soils, or in extremely expansive clays.

Earth-sheltered homes are proving highly adaptable to the urban setting as well as the rural setting. Conditions of adjacent sites and structures are more important in urban than rural sites: care must be taken that adjacent structures do not shade the site. In some earth-sheltered house designs, the soil-berming may require a fairly large lot, thereby making some smaller urban lots unacceptable.

On the other hand, urban sites considered undesirable for conventional homes may be ideal for earth-sheltered


Plans for Earth House, Waseca
Architect: Design Consortium, Inc.

construction, as soil-berming can be used effectively to block out unwanted views and noises. . .

Urban sites may also become more popular as automobile transportation costs continue to rise. With reductions in the costs of both transportation and home energy use, earth-sheltered home owners can significantly lower their energy expenses.

3

What structural systems and materials should be considered in planning an earth-sheltered home?

The structural parameters of an earth-sheltered home are probably among of its least understood aspects, especially for the nonprofessional, individual home builder. Yet, surprisingly, it is the area in which many novice builders seem least willing to seek professional help.

The stresses produced on an earth-sheltered house are far greater than those on a conventional above-grade, platform-framed house, and are far greater than a novice builder may suspect. The structural design of a conventional home allows more flexibility in precision and in the use of materials. Thus, detailed structural engineering is usually required in designing an earth-sheltered house.

Structural systems and materials vary widely, and have included: cast-in-place reinforced concrete, reinforced masonry, precast concrete, post-tensioned concrete, treated wood foundations, wood beam roofs, fiberglass reinforced masonry, fiberglass, reinforced wood panels, concrete silo block, and steel and concrete drainage units. Little standardization in construction of earth-sheltered housing has yet been developed, and as a result, builders are faced with the uncertainty that accompanies any prototype design. This lack of standardized construction techniques makes builders reluctant to invest their efforts in earth-sheltered house construction, and can add to construction costs once the decision to build is made.

Care must be exercised to use the materials properly. In flat roof structural systems, roof clearance spans will vary with the type of material used. Wood beam roofs obviously will require limited shorter spans than will a concrete material roof. To resist stresses developed by earth-bermed walls, shear walls should be designed and integrated into the house plans. In two-story earth-sheltered homes, the greatest stresses developed by earth-bermed walls are located at the intermediate floor. Too often, novice builders overlook this fact and plan for a wood joist intermediate floor system; in some cases, a wood joist floor system is inadequate to safely transfer these lateral wall stresses.

Another major class of structural systems, arches and shell shapes, can transfer heavy loads very efficiently. It is important, however, not to seriously alter these simple shapes in a house design, therefore the placement of openings such as doors, windows and atriums in arches and shells should be done by a competent architect and engineer.

At present, professional builders need to develop a better knowledge of loads and stresses caused by earth-berming. As builders develop more confidence and variety in their products, the number of cost-competitive designs available to the consumer should increase.

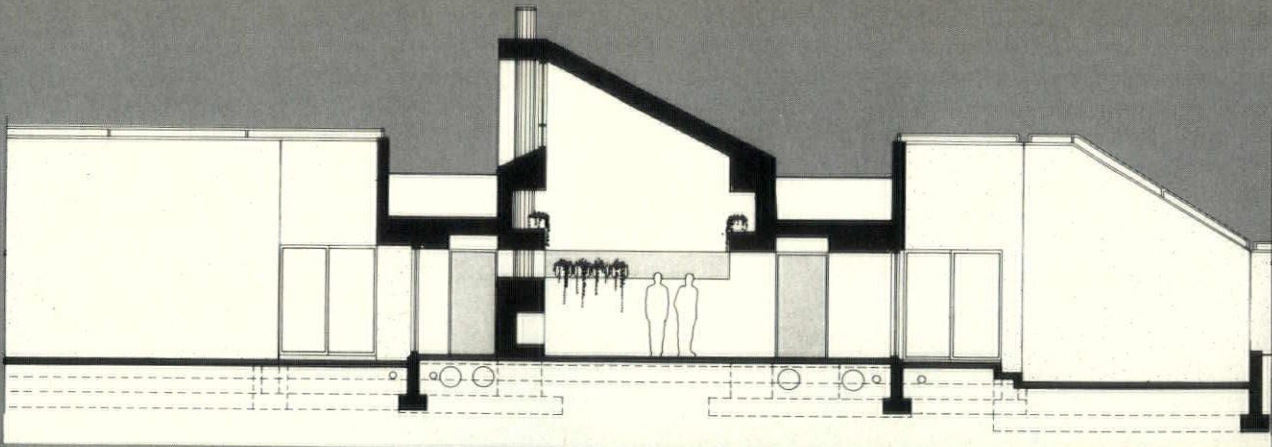
4

What information is available on energy savings afforded by earth-sheltered homes?

Most earth-sheltered building enthusiasts are convinced that by berming portions of the structure and by maximizing south orientation with properly shaded and insulated glazing they can conserve energy. Proper insulation will reduce the steady-state conductive heat transfer, and soil berming will effectively moderate the skin temperatures of the structure, resulting in a much narrower range of temperature extremes in the soil berm in comparison to the ambient air temperatures.

The total energy consumption of a house should be budgeted to the different use components, including the energy requirements of heating/cooling; interior lighting; exterior lighting; household appliances; hot water heating; and treating make-up air ventilation.

Extensive research is needed to determine how the various components of an earth-sheltered house contribute to overall energy losses. For example,



the effects of opening doors and windows or not insulating glazing need to be quantified; and the thermal behavior of soil on walls, roofs, and under floors should be examined.

Most reports of the energy-saving properties of existing earth-sheltered homes have been non-scientific surveys by the homeowner. No quantitative data-gathering studies have been completed...

5

Why must the roof of an earth-sheltered house have an earth cover? Can't a well-insulated conventional type of roof be used instead?

Many prospective earth-sheltered home builders have considered the option of using a conventional roof. It does seem that many design headaches could be avoided by not placing earth on the roof. For example, structural loads on the walls could be reduced, and roof drainage, waterproofing, and landscape uncertainties would diminish. With the possible cost-savings from conventional construction, one could afford to insulate heavily (to a minimum R-value of 50 or 60).

However, by not earth-berming the roof, the builder is paying another kind of price. Reducing heat transfer through the roof is a two-pronged attack. First, insulation should be used on the roof to retard steady-state heat transfer. Contrary to common belief, the earth is a very poor insulator. Soil is *not* placed on the roof to insulate; one would need many feet of earth to equal the insulating properties of just a few inches of rigid insulation, and such earth loading would impose impractical demands on the structural system.

Second, soil is used on the roof as a temperature moderator. Because of its density and specific heat properties, earth has a fairly good heat capacity, or thermal mass. This thermal mass allows the soil on the roof to retain and dissipate large amounts of excess heat energy, resulting in reduced temperature fluctuations of the soil adjacent to the roof structure. Rapid temperature changes in the outside air are not "felt" as quickly by the soil on the roof. In fact, the roof soil shelters the house from a harsh climate (very cold and/or very hot) and places it in a much more moderate climate. The earth cover on the roof combines with good insulation to comprise the total roof system.

Earth-sheltered home builders also must determine how much earth should be placed on the roof. Here, a compromise between a large thermal mass and structural consideratons must be made, generally for flat roof systems 1.5 to 2 ft of soil seems optimum. In cold climates, it is not necessary to try to berm to below the frost line (in northern portions of the country, a depth approaching 4 ft). The exact temperatures and thermal characteristics of roof soils are not yet understood, but it is unlikely that the bottom soil layers will freeze, since heat transferred through the roof continues to warm the soil.

If a builder still chooses to use more roof soil, arch and shell structures can be used. These shapes are better suited to transfer the stresses produced by high soil loading.

6

What are the best methods of meeting Heating, Ventilation, and Air Conditioning (HVAC) requirements in earth-sheltered houses?

Closely allied with the energy behavior of an earth-sheltered house are the Heating, Ventilation and Air Conditioning (HVAC) requirements. Since thermal loads are less than those for a conventional home, smaller HVAC units can be used. Data compiled from earth-sheltered demonstration homes will enable HVAC engineers to properly size the design the mechanical systems: extensive research and design work by mechanical engineers is necessary, as most existing earth-sheltered homes have incorporated standard HVAC designs.

Research into the integration of other backup energy systems with earth-sheltered housing also is in demand. Because heating/cooling loads are small, systems such as active solar can be cost-effective as backup. Other systems: include passive designs such as "earth pipes," trombe walls, heat storage, natural ventilation, solar gain systems, wind, and the use of renewable resources such as wood burning and alcohol fuels. Properly designed earth-sheltered homes should have heating loads well within the capabilities of an efficient wood stove

Interior of the Earth House
Photography: Phillip MacMillan James

even in very cold climates with an excess of 8000 degree days per year.

Generally, mechanical air-cooling systems have not been necessary in properly designed earth-sheltered houses. Because the temperature of the surrounding earth is almost always cooler than the inside of the house, excess specific heat will flow from the house into the soil. Initial fears regarding condensation and high indoor relative humidities have not materialized. Good air circulation usually will control most high-humidity situations, and in extreme cases a small portable dehumidifier should suffice to control humidity.

As knowledge of the energy performance becomes accessible, mechanical engineers should be able to effectively standardize and size systems to perform the necessary HVAC functions for an earth-sheltered house. Ideally, the systems will incorporate the good design of current HVAC systems and the best of new, energy-efficient solar-energy and passive-energy techniques. Such a system would be a great boon to the earth-sheltered housing industry.

7

What waterproofing systems are most appropriate for earth-sheltered homes?

The most frequently asked questions about earth-sheltered housing concern waterproofing. The possibilities of leaks in an earth-sheltered house inspire fear in the minds of professionals and lay people alike.

Unfortunately, sound knowledge and experience in applying waterproofing systems to earth-sheltered homes are scarce. Experts offer ample opinions but very few facts. Extensive, independent testing of current waterproofing systems and the development of new products is imperative.

At present, five major products are being used for waterproofing earth-sheltered homes: asphalt and pitch products; bituthene; liquid polyurethanes; butyl and EPDM (Ethylene Prophylene Diene Monomer) membranes; and bentonite products. Each product has advantages and disadvantages; none can be described as universally "the best." These products should be distinguished from dampproofing products, which only restrict vapor transmission. In addition, good surface drainage practices and proper backfill are essential for an adequate waterproofing system.

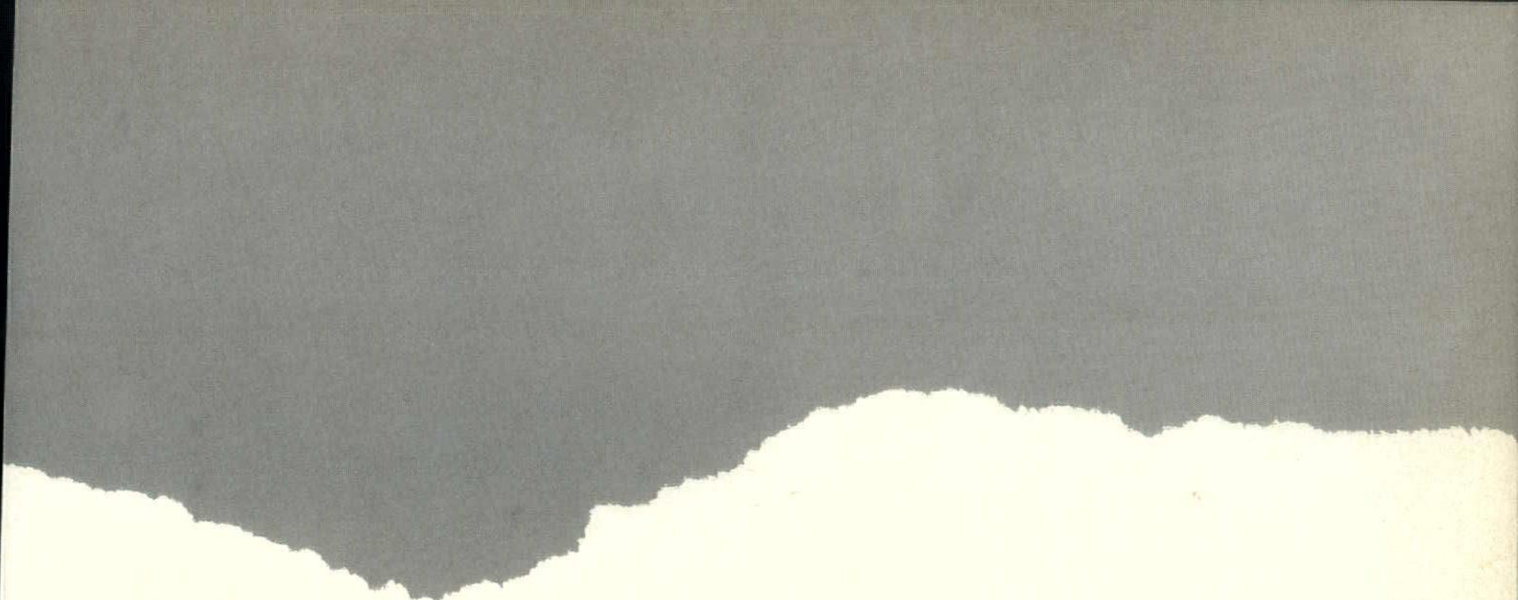
Regardless of which waterproofing system is used, the product should: (1) have a long service life underground; (2) have good crack-bridging capabilities; and (3) ideally be able to reseal itself at underground temperatures. The third requirement can prove to be the most demanding. Products will range from good resealing properties to none at all. Be sure to consult the manufacturer's test data on this. Performance test results of a product should be available from the product manufacturer or from independent testing sources; any product that appears weak in one or more of the abovementioned areas should be eliminated. No matter what type of structural material is used, there will always be some settling and possible structural cracks, so the waterproofing must have the ability to bridge the cracks and protect the house from unwanted moisture. During construction, it is easy to scrape off, tear or rip the waterproofing product once applied. Nails, sharp rocks, work boats and careless backfilling can take their toll.

When used in conventional above-grade structures, some waterproofing products will reseal quite well. This is primarily due to the warm extremes in air temperature: heat will cause the material to soften and then allow it to reseal. Asphalt products are especially adaptable in this way.

Below grade, however, temperatures are lower, ranging from 35 to 70°F, far below the high temperatures of 150–180°F that can be reached on an above-grade, built-up roof system. Most products specify that during application air temperatures be above 40°F; otherwise the bonding or curing processes will be retarded.

On the other hand, repeated thermal expansion of a material is one of the greatest forces leading to wear. It may be argued that the narrow thermal spectrum of underground temperatures will aid in the durability of product material, yet to answer this quantitatively, much research on underground waterproofing systems is needed.

Finally, whichever waterproofing system the builder chooses, quality control is essential. Even the best material



can prove a disaster if improperly installed. It is questionable whether the novice, do-it-yourself, earth-sheltered home builder should attempt to install waterproofing himself or herself. The job is better left to a waterproofing contractor who knows the product. Only with repeated application experience can one know how to cope best with unexpected problems and their consequences. It is best not to make your house your guinea pig.

In waterproofing, extra care must be taken at the seams (if any) and points where the flashing projects from the building. Water has a way of finding the weak link in a waterproofing system. Skylights can cause problems if the mechanical details are not well designed, though some apparent leakage attributed to skylights has actually been due to interior condensation problems rather than to a failure in the exterior waterproofing system.

8

What properties should be considered in choosing insulating materials for earth-sheltered homes?

The other product (i.e., besides waterproofing) usually applied to the exterior of the structure is insulation. This is necessary when the structural system is that of high thermal mass such as concrete. A large amount of concrete used in the structure represents a potentially large thermal storage mass, which must be insulated to work effectively.

Placing insulation on the outside exposes it to moisture and soil conditions. Usually the insulation is placed outside of the waterproofing system because most waterproofing systems need a smooth, dry, stable base, such as the concrete structure for application. Except for butyl sheets, waterproofing products should not be applied over the insulation. There is too much potential movement of insulation, whether it be rigid board or polyurethane liquids, to form a stable base for the waterproofing. Placing the insulation over the waterproofing also will protect the waterproofing during backfilling.

9

What are the necessary properties for exterior applied insulation?

First, they must have good compressive strength to resist earth pressures. Second, they should be a closed cell product that will not absorb excessive moisture. This is an important requirement since water-absorbing insulations rapidly lost their R-value (the ability of a material to resist heat flow).The most commonly used insulating product that fulfills the above criteria is extruded polystyrene. It is a closed cell, rigid board insulation with good long-term thermal performance. It should also be distinguished from expanded polystyrene, which is basically an open cell product. Open cell insulation will absorb moisture from the ground over an extended period of time. Two different production processes are used in producing extruded and expanded polystyrene.

Another concern regarding insulation placed on the exterior is the possibility of rodent and insect damage; both time and possible research into this area should reveal whether or not this concern is warranted.

Insulation placement should be maximized under roof soil and upper portions of the walls. These areas are most susceptible to temperature fluctuations of the outside air. Nonbermed house portions, such as a south wall, should be conventionally framed and insulated. . .

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Pergamon Press Ltd. 1979.

Deciding to Build an Earth Sheltered Home

Mary Tingerthal

For many who entertain the idea of building an earth sheltered house, such a venture will be the first time they have approached the purchase of a house without the assistance of a realtor. Furthermore, many of these same people have never been involved in the purchase of a custom-built house. Now, most would-be earth shelter dwellers will be forced to face both of these matters. First, there are virtually no realtors in the business of selling earth-sheltered houses. Second, there are few builders who are building earth sheltered houses on a speculative basis. While some are building from stock plans, even these are being built on a pre-sold, custom basis. Because of this, a person wishing to build an earth sheltered house must face not only the uncertainties of a new type of construction, but must also take on the roles of realtor and construction client as well.

It is with these current market constraints in mind that the following list of suggestions for potential earth sheltered home owners has been developed. Many of the suggestions are items which must be considered regardless of the type of home being constructed. However, the importance of these factors—particularly personal financial resources—may be increased if the lender considers earth sheltered construction to be a risky proposition.

Personal financial assessment

One of the two major factors that a lender considers in determining whether or not to make a mortgage commitment is personal creditworthiness. It is for this reason that any decision to build an earth sheltered house should include a thorough analysis of a person's individual or family financial history, current situation and potential. At a minimum this analysis should include:

Investigation of current lending industry underwriting standards—This will tell a borrower how much of his income can be assigned to debt service. It will provide a framework within which the borrower can consider how much house he can afford.

Assessment of downpayment and monthly payment ability—Within the framework determined earlier and using standard mortgage payment tables (available in bookstores), the borrower may determine the amount of equity (downpayment, land owned free and clear) and the monthly cash available. This determination should set the price range of the house to be built.

Assessment of credit history—Serious credit problems, such as chronically late mortgage payments, could have a negative impact on mortgage approval.

Assessment of employment history—Major fluctuations, periods of unemployment, and/or frequent job changes could have a negative impact on mortgage approval.

Site assessment

Aspects of the site selected for the project can affect the project througn two major factors—appraised value and cost of construction. Careful assessment of the site can help to avoid or at least anticipate such site-specific costs. An analysis of the site should include at least the following:

Location—Besides the obvious considerations of proximity to school, work and services, the borrower should also consider the impact that the location may have on the appraised value of the completed project.

Compatibility of house with surrounding neighborhood—Locating a house where it is clearly visible to neighbors and obviously imcompatible with other structures will have a negative effect on its marketability and therefore on its appraised value.

Zoning and building codes—If current zoning and/or building codes do not allow earth sheltered construction, it may be both time-consuming and costly to obtain the necessary variances.

Services—If public sewer and water are not available, it may add to construction costs. Services may also have an impact on the appraised value.

Physical characteristics — Many factors, should be considered in this area including soil type, drainage, vegetation and site access. Certain physical aspects of a site can have a tremendous effect on the cost of the project.

Design assessment

The design of a project is certainly the biggest factor in controlling the cost of the project. It can also play a large role in the initial appraisal of the project, which is the second major factor in receiving a commitment for mortgage financing. Some design factors which should be considered include:

Comparability to conventional designs—A design which compares favorably with conventional houses will tend to have a greater market acceptance and marketability, and may therefore receive a more favorable appraisal.

Architectural and/or engineering consultation—There are enough factors about earth sheltered construction which remain unknown or untested that consultation with a registered architect and/or engineer is highly advisable in order to ensure the structural integrity of the design. Standard, pre-engineered plans may offer an alternative to individual consultation.

Engineering certification—Regardless of whether or not any design consultation takes place, it is likely that both the lender and the building official will require certifications by a registered engineer on at least the structural system and the waterproofing system.

Compliance with building codes—In most cases, it is easier to design the structure in compliance with applicable building codes in order to avoid the need for variances.

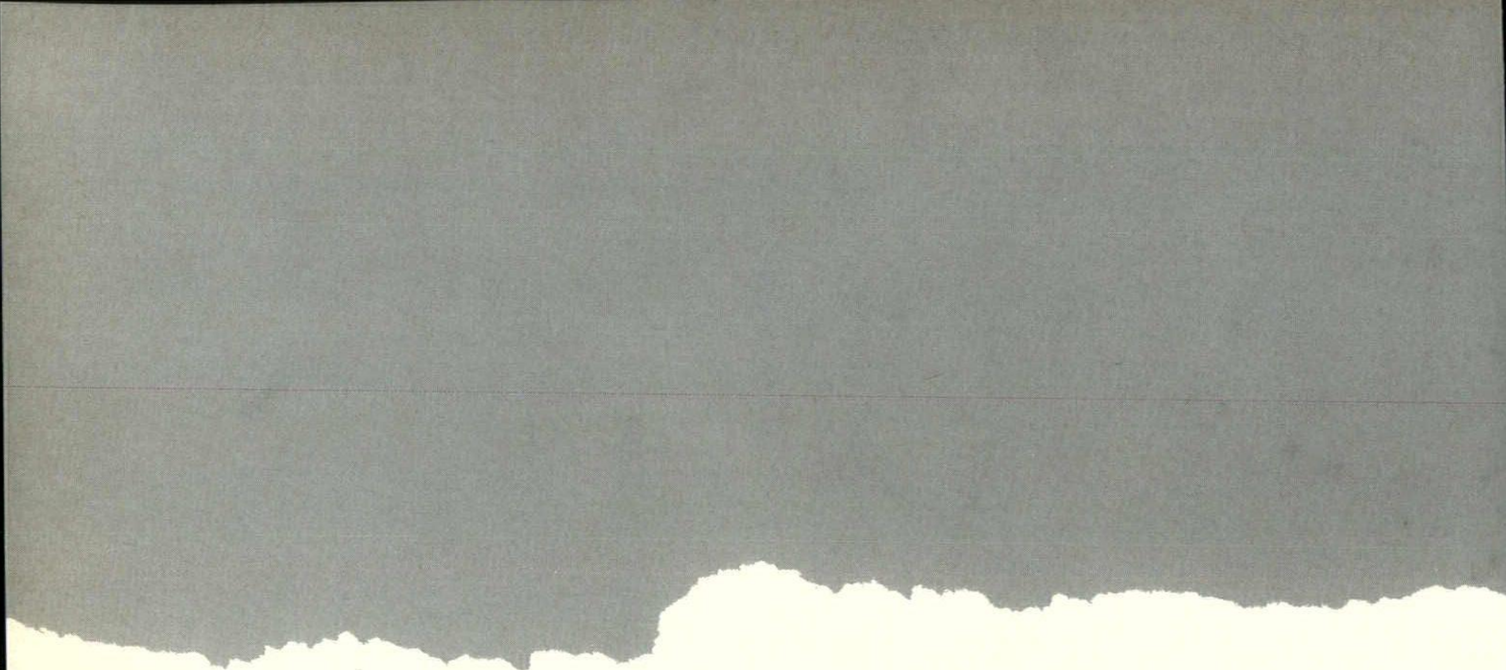
Builder assessment

Most lenders simply will not consider financing an owner-built construction project unless the owner-builder is himself a proven construction contractor. Individuals who wish to construct their own houses will probably find it necessary to finance the project with personal funds. Therefore, in most cases the borrower will find it necessary to select a builder. The following issues should be considered in selecting a builder:

Experience with earth sheltered construction—While such experience will be difficult to find, it may be helpful to find a builder who is at least familiar with the products and techniques specified in the plans.

Reputation—The builder should be reputable within the community and should be willing to allow checking references and viewing previous projects.

Ability to obtain construction financing—Most construction loans are made on the basis of the reputation and reliability of the contractor for completing projects within the prescribed time and cost. Inexperienced contractors may find it difficult or impossible to obtain construction financing.



Enthusiasm for the project—Because earth sheltered construction is still relatively new, it is likely that problems will be encountered during construction. A builder who is not enthusiastic about the project may overlook problems or insist on costly increases.

In addition to the careful assessment of these and other aspects of the project the potential borrower should make some final preparations before approaching a lender, including the following:

Basic mortgage lending knowledge
If the borrower has not previously sought a mortgage without the assistance of a realtor, it may be useful to gain a basic understanding of mortgage lending practices, including underwriting standards, appraisals, documents and mortgage insurance. Several books are available on the subject.

Checklist of required items
In setting an appointment to apply for a mortgage commitment, the borrower should inquire about required materials such as plans, specifications, certifications, employment and credit information, cost estimates and information about the contractor. The borrower should develop a checklist of these items and be sure to provide everything that is requested.

Background and supporting material
The borrower should develop a package of informational material for the lender, including photos and locations of other earth sheltered projects in the area, names of other lenders who have written loans on earth sheltered projects and basic instructional materials on earth sheltering (explanation of the concept, projections of energy savings, material or waterproofing, etc.).

In conclusion, it is important for the prospective borrower to remember that the decision of the mortgage lender to commit funds to finance any house, earth-sheltered or not, is a determination of risk. Many factors enter into the formula for calculating that risk, including: personal credit worthiness, appraised value of the project, percentage of equity or down-payment, credibility of the construction contractor and type of project. It is also important to be aware that different insitutions will give various weights to these many factors. Some may even reduce their risks by eliminating certain categories of loans entirely. It is therefore possible that some lending institutions will prohibit loans on earth-sheltered structures.

If the borrower understands this concept of risk assessment, several major areas emerge which must be addressed in the process of seeking a financial commitment for an earth-sheltered house:

Preparation: careful assessment of the feasibility of the project and attention to project detail prior to approaching the lender.

Education: providing information to the lender to assist him in becoming familiar and comfortable with the concept of earth sheltering.

Perseverance: willingness to approach several lenders, if necessary.

Flexibility: willingness to modify certain aspects of the project to better address the risk concerns of the lender.

The borrower who attends to these concerns should find that obtaining a mortgage for an earth sheltered house is not an impossibility.

Investigating Soils

Brent Anderson

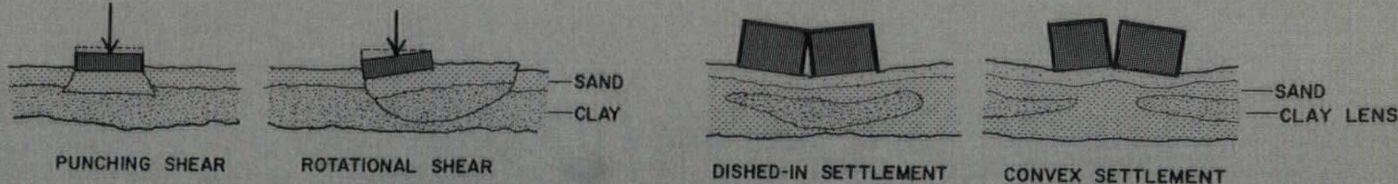


FIG. 1 Types of Failure

Soil analysis for earth sheltered home design seems to be a subject that most homeowners take for granted. For the aboveground portion of a conventional house the loadings are relatively light compared to an earth sheltered house. Typical values for footing loads may run about 2700 plf, while an earth sheltered home may have values of 7000 to 12000 plf, depending on the span and soil depth. From this simple comparison we can see that a ratio of two to four exists in the loadings. One may now hypothesize that the footings must be two to four times the size of the conventional ones. A few questions arise at this point: 1) What is the bearing capacity of the soil? 2) What are possible settlements that might occur? 3) What are the code requirements for size and depth of footings in that area? As a homowner, builder, or the designer you may now see the importance of soil borings. It seems that you are now left with 2 choices: 1) Design footings that may be undersized and suffer any consequences due to excessive settlement like structural cracking of walls, or 2) Overdesign the footings to assure minimal settlement and cracking but pay the extra cost for the materials and labor to pour the larger footings.

A local builder had the problem mentioned above. The builder drew plans for an earth sheltered home in a low, swampy area. After completion of the plan he went to his sub-contractor for an approximate bid. After review, the subcontractor bid the 250 feet of wall and footings at $20 per foot or $5,000. The city required an architect's seal on all plans in the area for homes of this nature. When the architect received the plans he was told the soil was a clay in a low, swampy area. Being very prudent he used a bearing capacity of 1500 psf for his calculations. The walls and footings were redesigned after assuming a bearing capacity of 1500 psf. When the builder received his plan he noticed the footings were over twice as large as before and the walls were heavily reinforced with steel. The builder took his plan back to the subcontractor for another bid, since the structural elements had changed in size. After careful analysis, the subcontractor gave a new bid of $12,000 for the project. This came as a surprise to the builder, so he turned to a soil testing agency to procure more accurate information about the soil. After the soil analysis was completed the results showed a bearing capacity of 3000 psf and the walls and footings were again redesigned. The subcontractor now was given the drawings to submit a new bid. The final bid was for $6,800. The cost of the soil borings were about $500 and the consulting fee for the engineering was $200. By doing the soil borings and determining the true bearing capacity, the builder saved $4,500.

As mentioned earlier, the aboveground portion of a conventional house has loadings that are relatively light compared to earth sheltered homes. Hence, the load paths by which snow and wind loads are directed to the ground are not generally crucial to the design. There are many rules of thumb to use in the structural design of conventional homes, which have been developed through decades of practice. For a conventional basement, the burial depths are generally less than five to seven feet of earth. For these depths of burial it has been found that unreinforced poured concrete, concrete block, or treated wood foundations are, in almost all cases, quite adequate structurally. Because the burial depths are low and the earth pressures are small, there is little to be saved in the structure by determining the exact soil type.

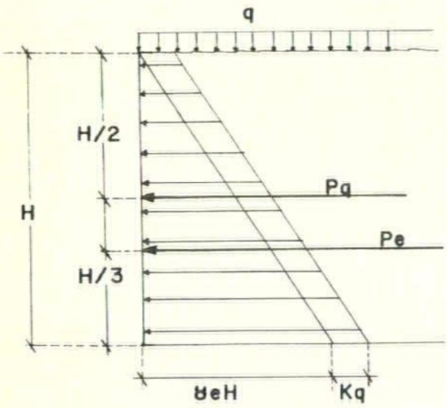
In contrast to the conventional house, the earth sheltered house has large depths of burial. The earth on the roof is a very significant load, approximately 100–125 psf for each foot of depth of earth cover. The structural form of the house can have a significant impact on the ease with which the heavy loads can be carried. In standard methods of construction there is some flexibility in the design. But the requirements of the structural system must be considered or a price will be paid in unnecessarily high structural costs. Because of the heavier loads, the orientation of openings in the structural members must be designed with more care.

Table 1
Presumptive Bearing Capacities (PSF)

Soil Description	Bear Capacity
Clay, very soft	500
Clay, soft	1,000
Clay, ordinary	2,000
Clay, medium stiff	2,500
Clay, stiff	3,500
Clay, hard	6,000
Inorganic silt, compact	2,500
Sand, loose and fine	3,000
Sand, compact and silty	3,000
Sand (loose and coarse, or sand-gravel mixtures, or compact and fine)	5,000
Gravel, loose, and compact coarse sand	8,000
Sand-gravel, compact	10,000
Hardpan, cemented sand, cemented gravel	15,000
Soft rock	16,000
Sedimentary layered rock (hard shale, sandstone, siltstone)	20,000
Bedrock	150,000

FIG. 2

Pe = ½ · 8e · H²
Pq = K · q · H
H = unsupported height of wall, ft.
q = surcharge, lbs/ft.²
8e = equivalent fluid pressure, pcf
K = lateral earth pressure coefficient



UNRESTRAINED WALLS $K = \frac{1 - \sin \phi}{1 + \sin \phi}$

RESTRAINED WALLS $K = 1 - \sin \phi$

1.1 Soil Site Investigation

Knowledge of the underground conditions at a site is prerequisite to the economical design of any substructural elements of any appreciable size. For a new structure the soil-site investigation should provide data on the following items:

1) Location of groundwater level to the extent where it could cause problems
2) Bearing capacity of the soil
3) Selection of alternative types and/or depth of foundation
4) Data on soil parameters and properties so that earth pressures and construction methods may be evaluated
5) Settlement predictions
6) Potential problems concerning adjacent property
7) Percolation tests or results

1.2 Foundation Soils

Foundation design is a means of transmitting the loads from a structure to the underlying soil without a soil shear failure or excessive settlement. Shear failure occurs when there is a plastic flow and/or a lateral expulsion of soil from beneath the foundation. Excessive settlements of the soil under the imposed loads can cause the walls to tilt and form unsightly cracks. The walls may even collapse if the differential settlements induce enough overstress in the critical membrane. Table 1 shows some typical bearing values, Fig. 1 has examples of settlement processes.

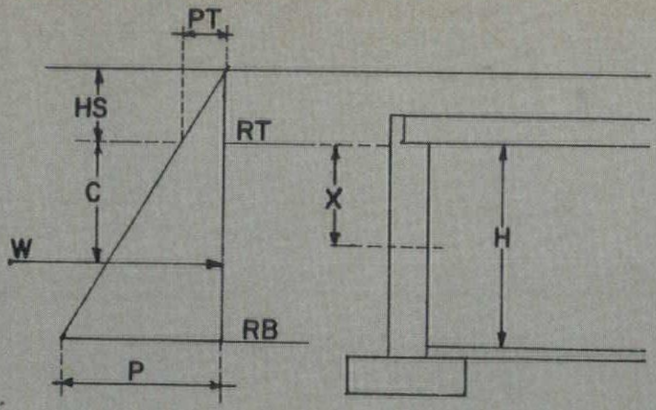
Soil settlements are of two general permeability-dependent natures. Immediate settlements take place from zero to seven days after loading. Sands and gravels with a high coefficient of permeability have this characteristic. Some silts and clays with a low degree of saturation also have immediate settlements. Consolidation-settlement analysis is generally appropriate for saturated, or nearly saturated, fine grained soil deposits where k, the coefficient of permeability, is approximately 0.0001 cm/sec or less.

The footings or foundation should be constructed below areas which may cause soil settlements. Factors to consider in foundation design are:

1) the frost line
2) zones of high volume change due to moisture fluctuations
3) topsoil or organic material
4) peat or muck
5) unconsolidated material such as abandoned garbage dumps and similar filled in areas

1.3 Lateral Earth Pressures

The magnitude and distribution of lateral earth pressures acting on the walls will depend upon the type of backfill, method of placement, magnitude and distribution of surcharge behind the wall, backslope behind the wall, drainage and wall rigidity. Fig. 2 presents lateral earth pressure criteria for a vertical wall with surcharge, q. The criteria assume a fully drained condition with a sand and gravel backfill.



$$PT = w \cdot HS;\ \text{where } w = \text{equivalent-fluid wt of soil}$$

$$HS = \frac{\text{surcharge (lb./sq. ft.)}}{\text{weight of soil (lb./cu. ft.)}}$$

$$P = w(H + HS)$$

$$W = \frac{H(P+PT)}{2},\quad C = \frac{H(2 \cdot P+PT)}{3(P+PT)},\quad RT = \frac{H(P+2 \cdot PT)}{6};$$

$$RT = \frac{H(2 \cdot P+PT)}{6}$$

Maximum Shear: $V = RT = \frac{H(2 \cdot P+PT)}{6}$

Point of Maximum Moment:

Solve for X in equation: $\frac{P-PT}{H}(X^2+2 \cdot PTX-2 \cdot R) = 0$

Maximum Moment:

$$M = \frac{X}{6H}[H^2(P+2 \cdot PT) - 3 \cdot H \cdot PT \cdot X - X^2(P-PT)]$$

FIG. 3.

Design pressures are presented for two conditions of wall rigidity: 1) The wall is totally restrained at the top when the backfill is placed; and 2) The wall is free to deflect at the top.

If the wall is totally restrained at the top, lateral strain is prevented and the lateral earth pressure approximates the "at rest" condition. If the wall is permitted to move away from the soil and the magnitude of deflection of the top of the wall is equal to or greater than about the values given in Table 2, the free-standing height, the earth pressure approximates the conventional "active pressure" state.

Figure 3 is a simple analysis that determines the maximum shear and moment on a wall of a typical situation for an earth sheltered home, that is, one story in height.

The analysis of Figure 2 and Figure 3 is for a granular soil. Special consideration must be given in an analysis of clay backfills. When excavating into a clay area the walls will generally stand by themselves. Based on this, one might think the soil does not exert any pressure. But in actuality, the wall will stand as long as the moisture levels are low and a slip line does not develop. Water usually will activate the soil and eventually the whole wall will collapse. The point is that clay generally exerts a soil pressure with time. The value of this pressure is not easily defined. Based on the way things are done in practice, an equivalent fluid pressure of 60 psf per foot seems to be a first time analysis approach.

At this point an architect should have a soils analysis performed. We may be overdesigning and adding additional construction costs, yet in many cases the pressure could be more than 60 psf per foot and the problem could be underdesign. Generally, the architect must try to find out what has been the accepted practice for that local area where clay could be a problem. In Minnesota, most of the clay soils are mixed with glacial tills. Lateral pressures are about 40 psf per foot. Typical bearing values of the clays with glacial till are approximately 3000 psf and lateral pressures are in the range of 30 to 40 psf per foot. One of the single most important procedures to design in the foundation and wall system is proper drainage. The drainage system should be at the base of the footing with at least 16 inches of aggregate around the drain tile with, if possible, a granular backfill on top.

In summary, soil borings will cost about $350 to $500 for two holes approximately 20 feet deep. The cost will be higher if more and deeper holes are required. The cost will increase slightly if the travel distance generally exceeds 50 miles from the lab. The soils report will include all the important parameters that the architect needs to know for design purposes.

Table 2

Soil and condition	Amount of translation
Cohesionless, dense	0.001 to 0.002H
Cohesionless, loose	0.002 to 0.004H
Cohesive, firm	0.01 to 0.02 H
Cohesive, soft	0.02 to 0.05 H

Earth Sheltered Houses: Two Case Studies

Tom Ellison and John Carmody

Although interest in earth sheltered housing has been significant for only a relatively short time, there are numerous examples of it in the Minnesota region and the rest of the country. The ever-increasing number of earth sheltered housing projects are built for a wide variety of reasons with a broad divergence in costs. The two houses presented here were designed and built with three goals in mind. The primary objective was to conserve energy by the use of earth sheltering and insulation in conjunction with passive solar heating. The second intention was to remain within the limits of reasonable construction costs; and the third was to integrate good design with energy efficient, cost effective housing.

Tom Ellison works with energy efficient buildings for Ellison Design and Construction, Station 19 Design Offices, Minneapolis.

John Carmody is currently doing research on earth sheltered/underground buildings at the Underground Space Center, University of Minnesota.

Earth Sheltered House #1

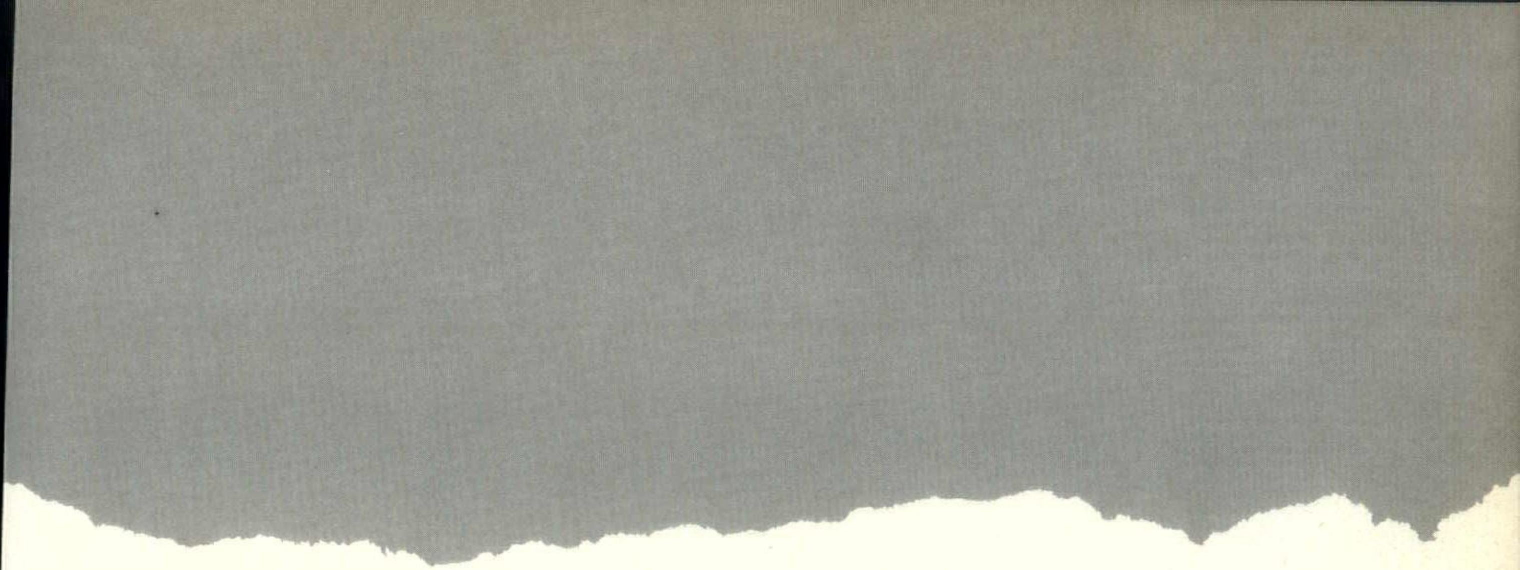
A major factor in the design of this house was the difficult, steeply sloping, heavily wooded site. The house is placed into an east-west ridge which slopes away to the north and south. The use of earth sheltering on the roof and walls allows the house to blend into the surrounding land forms. By opening both to the north and south sides, a more public entry and driveway area on the north is separated from the outdoor spaces on the south side which open off of the living spaces. Although the living spaces are raised above grade in this two level plan, exit to grade is provided at the east end of the house where an outdoor deck is located in order not to interfere with the sunlight.

The two story configuration of this house is compact, which minimizes the area of exterior building envelope and the amount of internal circulation. All of the rooms in this 2,000 square foot house have large window areas which face south to maximize solar gain. The usually warmer living spaces are on the upper level with the majority of the glazing area while the cooler bedroom spaces are on the lower level. The only spaces which open to the north side are the entry and the attached garage. The roof is completely covered with earth as are most of the east, west, and north walls.

Reinforced concrete block walls are used in this structure to support the pre-cast concrete roof and intermediate floor. The planks span across two bays in the east-west direction so that the south wall is a wood frame non-bearing wall. All the utilities are consolidated into a mechanical core in the center of the house so that no roof penetrations through the concrete plank and waterproofing are necessary. The color of the treated timber retaining walls and planters blend with the rough cedar siding used on the exterior.

The passive solar system employed in this house is often referred to as a direct gain system in which the living spaces act as a solar collector. The roof is sloped to allow greater penetration of sunlight into the living spaces. The large clerestory windows provide additional solar heat gain as well as a substantial amount of natural light. The primary surface for absorbing the solar radiation is the concrete floor which is covered with dark brown, unglazed ceramic tiles. This intermediate floor can then release heat into spaces on both levels of the house. The massive concrete structure and the surrounding earth help to moderate the temperature. The additional heating requirement is provided by an efficient centrally located fireplace and an electric forced air system. The blower portion of the air system can also be used simply to circulate warm air from the upper level/fireplace area into the lower level spaces.

In the summer, the direct sun is kept out of the house by the use of sunshades over the windows as well as the tall deciduous trees on the south side of



the house. As in winter, the surrounding earth helps to moderate the hot summer temperatures. The north entry and the clerestory windows can be opened to provide natural ventilation through the house.

This house was partially funded by a grant from the Minnesota Housing Finance Agency for passive solar/earth sheltered demonstration houses and also received a Passive Solar Design award from the Department of Housing and Urban Development.

Earth Sheltered House #2

The site for this house is rather steeply sloping to the south, heavily wooded, with vehicular access limited to the south side. It was decided with the owner to detach the house from the garage and move it up the hill to enhance view, increase usuable outdoor space, and receive adequate sunlight for passive heating. The north side of this one level house is set fully into the hill with the earth sloping down on the east and west sides to meet grade on the south. The entrance to this 1900 square foot house and all of the major living spaces open to the south and have excellent views and substantial natural light. The family living and eating spaces are at the center of the plan with the children's bedrooms at one end and the adult bedroom and private spaces at the other. The outdoor space to the south of the living spaces is designed so that a greenhouse and a screened patio can be added.

The walls which retain earth on the north, east, and west sides of the house are reinforced concrete block. On the exposed south side is a 2×6 stud wall covered with styrofoam sheathing. The floor is a concrete slab on grade. The roof structure of this house consists of 20″ truss joists which span the entire width of the house and leave space for a substantial amount of insulation.

Again, a direct gain passive solar system is used. The sloping roof and large clerestory windows in every room maximize the penetration and amount of solar radiation. The concrete floor and 16 inches of compacted sand are isolated from the earth by a layer of styrofoam insulation to form the primary storage mass for the house. Secondary heat storage masses are the rock face concrete block walls which will remain exposed at the east and west ends of the house. The direct sun is controlled by the use of sunshades over the windows which pivot to allow maximum sun penetration in the winter and eliminate heat gain in the summer. The earth against a significant portion of the wall area moderates the outdoor temperature in both the summer cooling and winter heating seasons. The heating system of the house is comprised of an electric forced air system with supply ducts below the floor slab. The air return duct runs continuously at the peak of the roof in order to collect and redistribute the warm air as shown in Section A. The high air return can also be used automatically with the furnace blower to redistribute warm air from either the fireplace/wood stove or from the solar heat gain. Another energy saving feature of this design is the air lock entry which reduces infiltration.

This house was designed and is presently being built for a private client.

Design Comparison

Although both of these houses use passive solar and earth sheltered techniques to conserve energy, the two designs differ in some fundamental ways. These include the one versus two level design, the north versus south entry, and the earth covered versus well-insulated roof without earth. Each of these differences can affect the total construction costs, ease of construction, total energy use, as well as the overall design.

The advantage of a two level design with respect to energy use is that it has less exterior surface area than an equal sized one level house. For these two earth sheltered houses, however, the two level house proved to be more complicated to design and build. With greater soil depths, the structure of the walls had to be considerably stronger. In addition, there was a greater vertical drop between the earth on the roof and the grade on the south side of the house with the two level design. This contributed to more sitework, retaining walls, and more complicated sequence of construction. These drawbacks were more apparent due to the particularly difficult and restricted site used for House #1, although it seems they would be present to some extent with any two level design. The two level design has the advantage of raising the living spaces higher off of the ground, giving a more expansive view than the one level design. The one level design provides more direct access to the outdoor spaces, however.

Usually the side of the house on which the entry occurs is determined by the location of roads and other physical features on a particular site. For earth sheltered houses in which the south wall is exposed and the remaining walls are covered, the entry location can have some significant effects. Naturally, the simplest type of entry to construct for an earth sheltered house is on the south wall. By limiting openings to the south side only, protection from winter winds is maximized, thus reducing heat loss due to infiltration. A disadvantage of a south entry is that the more public entry area of the house is on the same side as the private outdoor living spaces. In House #2, these two functions were separated by the plan arrangement and by the use of plantings and level change. An entry on the north side, as occurs in House #1, alleviates this problem by providing a completely separate public entry area. Such an entry requires additional structure/retaining and landscaping which proved to be more costly than a south entry. Energy uses may be affected since a small portion of wall area is exposed on the north side.

The placement of earth on the roof on House #1 has certain cost and energy implications in comparison to the well-insulated roof without earth on House #2. Even with deep truss joists spanning the width of the house and 18 inches of fiberglass insulation, the roof without earth was less expensive than the earth covered roof and simpler to build. The structure to support the additional weight of the earth, the butyl rubber waterproofing system, and the styrofoam insulation contributed to the higher costs on House #1. The energy use which can be attributed to these two types of roofs is not a simple thing to evaluate. Although the r-value of the roof without earth is actually higher than the earth covered roof, this is only one aspect of how the two roofs may actually perform. The thermal mass of the earth covered roof, its ability to diminish daily temperature fluctuations, and the ability of the snow to contribute to the total r-value will enhance the energy performance to some extent. Although some computer simulations of these factors have verified these effects, they have not been adapted for simple hand calculations. In the summer, the earth covered roof definitely performs better than the conventional roof in maintaining cooler temperatures. In comparing earth covered and well-insulated roofs without earth, naturally there are factors other than cost and energy performance which may be considered. These include noise reduction and protection from winds experienced with earth covered roofs, as well as aesthetic and environmental considerations.

In general, it is interesting to note that in spite of many significant differences in design, the projected energy use for these two houses is roughly equivalent. Perhaps this is due to the fact that the similarities are more important than the differences. Both houses are relatively simple in layout, they are well insulated, have a substantial earth mass around them, and have virtually all the glazing on the south side used in a direct gain passive system.

Naturally, the actual energy performance of these houses will be affected by many variables including the lifestyle of the residents and any important modifications made to the spaces. For example, at the time of construction of both houses, a suitable cost effective insulated shutter system was not considered to be available on the market. Although the energy use of both houses is relatively low without the shutters, over half of the heat loss occurs through the windows. As fuel prices continue to increase, insulated shutters may become cost effective or less expensive systems may become available. The installation of shutters is a primary example of a future modification which can further improve the energy performance of these houses. The emphasis on conservation in these houses through the use of substantial amounts of insulation and earth sheltering actually increases the relative effectiveness of the passive solar systems and other energy saving devices such as insulated shutters.

MHFA Solar/Earth Sheltered Demonstration Housing Program: Seven Case Studies

Mary Tingerthal

Residence, Burnsville
Architect: Carmody and Ellison Design and Construction, Minneapolis

In 1978, the Minnesota Housing Finance Agency (MHFA) developed its Solar/Earth Sheltered Demonstration Housing Program in response to a mandate from the Minnesota Legislature that the agency demonstrate various energy conserving techniques in housing. With a $500,000 appropriation, MHFA designed a demonstration program which would examine various aspects of active and passive solar and earth-sheltered housing construction. This largely untested subject area provided the possibility for a program with many and varied goals.

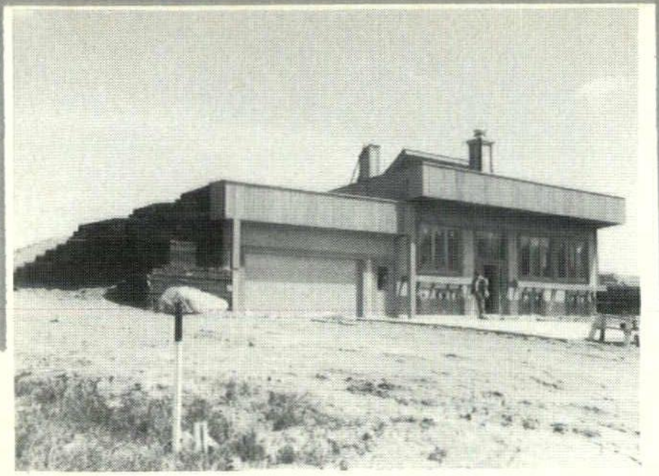
The first set of program goals was related to the need for reliable data. Of particular importance was the need to accurately determine energy consumption of solar and/or earth sheltered houses as compared to conventional houses. Accurate data was also needed on construction costs, construction techniques and experience, public response, and response by institutional participants, such as lending institutions and building and zoning code officials.

A second set of goals for the program dealt with public awareness and visibility. In 1978, the concept of earth sheltered housing was relatively unknown. It was felt that a program which provided good public visibility and awareness would lead to increased public acceptance of the concept.

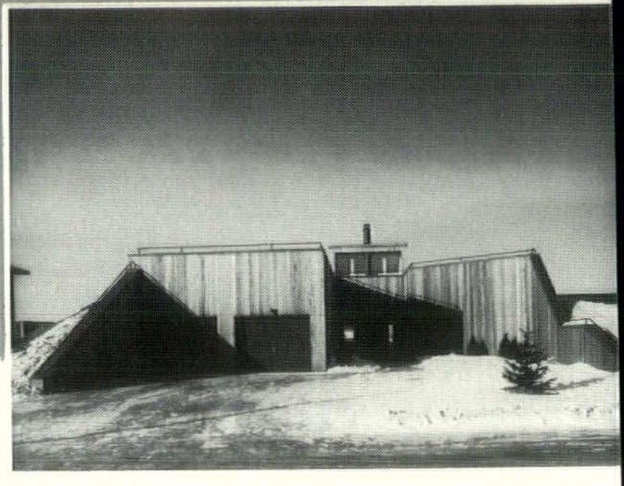
The program which was designed to meet these goals has resulted in the construction of seven earth-sheltered structures, including six single-family houses and a twelve-unit townhouse project. Three of the houses and the townhouse project were privately financed and constructed, and were available for sale on a speculative basis. Builders of these projects received grants of $17,000 from MHFA to help defray extraordinary costs. The remaining three houses were constructed by the State, are located within State parks, and will serve as residences for park managers. All of the houses have been equipped with monitoring devices and will be monitored for energy performance for a minimum of two years.

Private Sector Demonstration Projects
Architects and Builder: Carmody and Ellison Design and Construction
Project Location: Burnsville, Minnesota

This project was under construction in August, 1978 and was completed in April, 1979. It is a bedroom, two-story design with 2,000 square feet of living space and an attached two car garage. A high, sloped ceiling provides a very spacious feeling on the upper floor. The house includes many passive solar design features and is extensively earth-covered, with 100% of the roof and 60% of the wall area in contact with earth. Over 5,000 people visited the house during the ten week open house period. Public reaction to the house was generally favorable, with the only negative comments indicating that the house seemed small. A buyer for the house was identified shortly after the house was completed and the house sold for the asking price of $110,000.



Residence, Willmar
Architect: Genesis Architecture, Willmar



Earth House, Waseca
Architect: Design Consortium, Inc., Minneapolis

Photography (upper right): Phillip MacMillan James

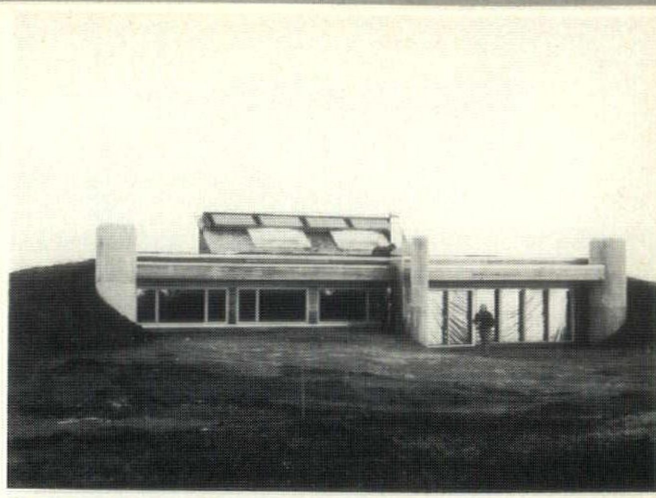
Project: Willmar Area Vocational Technical Institute
Architect: Genesis Architecture
Builder: Willmar Area Vocational Technical Institute
Project Location: Willmar, Minnesota

One of the more unusual projects, this house was contructed primarily by second year carpentry students from the Willmar AVTI. Coinciding with the school year, construction began in September, 1978 and was completed in May, 1979. It is the only house in the demonstration program which uses a poured concrete wall system. The house was well received by the community with over 4,000 visitors during the open house period. With 85% of the roof and 72% of the walls earth-covered, the design uses a light monitor to bring light into the kitchen area on the upper floor. Passive solar design techniques are employed in the house including the use of both exterior overhangs and interior window shutters. The three bedroom design contains 1,850 square feet of living space and an attached two car garage. The house sold for the asking price of $81,500 to a buyer who expressed interest shortly after the house was completed.

Project Sponsor and Builder: Associated Lumber Marts, Inc.
Architect: Design Consortium
Project Location: Waseca, Minnesota

The Waseca project provides an interesting contrast to the rest of the structures in the program in its design. While all of the other projects are an elevational design type, this house uses an atrium design. The center of the house is used as a living room with light provided by a large light monitor over the space. A second unusual feature about this project is its location on an urban-type lot in an area which is fully developed with conventional housing. A number of construction problems caused delays in the completion of the project which took place in January, 1980. At the time of this writing, a buyer for the project had not yet been identified.

Seward West Redesign, Minneapolis
Architect: Close Associates, Minneapolis



Park Manager Residence, Camden State Park
Architect: The Architectural Alliance, Minneapolis

Project Sponsor: Seward West Redesign, Inc.
Architect: Close Associates
Builder: Kraus-Anderson of St. Paul
Solar Contractor: Solar Dynamics, Inc.
Project Location: Minneapolis, Minnesota

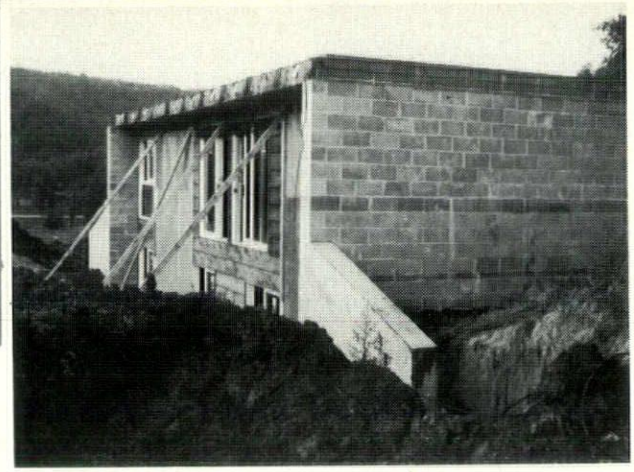
This project is certainly the most complex of all of the projects in the demonstration program. Five financial concerns combined their resources to provide the project construction loan. In addition, the project received grant funding from both MHFA and the HUD Cycle 3 Solar Demonstration Program. Three revisions of the construction plans were necessary in order to make the project economically feasible. Construction finally began in March, 1979 and was completed in September, 1979. The project contains three three-bedroom units at a sale price of $76,400 and nine two-bedroom units at a sale price of $66,500. As of this writing, Seward West has obtained final sales contracts on five of the units. The energy conserving features of townhouses include: a virtually 100% earth covered roof; active solar space heating and domestic hot water system; and passive solar design, including exterior rolling insulating shutters. Over 4,000 visitors have toured the model unit.

Park Manager Residences

Project Location: Camden State Park (near Marshall, Minnesota)
Architects: The Architectural Alliance
Builder: Bladholm and Hess Construction, Inc.

The smallest of the houses in the program, this house has 1,640 square feet of living space in a compact, one-story design which includes three bedrooms. Built on a relatively flat site which is characteristic of the surrounding area, the house provides an interesting contrast to the site. The house includes many passive solar design features including a thermostatically controlled, automatic interior shuttering system. It also includes an active solar system for domestic hot water. A challenge in the design of any earth sheltered house is the effective use of the inevitable retaining walls. An interesting solution employed in this house uses pre-cast concrete tubes for both retaining walls and an entrance tunnel. This house is one of two which will have an extensive monitoring package. The house was completed in November, 1979 and opened to the public in January, 1980.

Park Manager Residence, Wild River State Park
Architect: McGuire/Engler



Park Manager Residence, Whitewater State Park
Architect: Close Associates, Minneapolis

Project Location: Wild River State Park (near North Branch, Minnesota)
Architects: McGuire/Engler
Builder: Herb Larson Construction

The Wild River house is the only house in the demonstration program which uses a wood deck for the earth covered roof structure. While this house does not make use of an active solar system, it does include a simple fan-driven circulation system which is designed to collect warm air from the high ceiling area and draw it down to a rock storage bed located beneath the floor of the lower level. The heating system is designed to make use of this stored heat when it is available. Also included in the house is a wood furnance system which is designed to take advantage of abundant wood in the surrounding area. The 1,920 square foot house has three bedrooms and is a two story structure. Construction began in April, 1979 and the project should be completed in Spring, 1980.

Project Location: Whitewater State Park (near St. Charles, Minnesota)
Architect: Close Associates
Builder: Wolter Lumber Company

This 2,200 square foot, three bedroom house combines the main entrance to the upper level of house with a two car garage located on the north side of the structure. The house is set near the base of a south facing slope and takes full advantage of its southern orientation. In addition to a passive solar design, the house uses active solar systems for both space heating and domestic hot water. Collectors for the space heating system are mounted vertically on the south elevation on the structure in order to take advantage of the additional light-reflected from the snow-covered ground. Collectors for the domestic hot water system are mounted on a light monitor which is located at the rear of the structure. Skylights are also housed in this structure to provide natural light to the rear portion of the house. Construction began in June, 1979 and completion is anticipated in Spring, 1980.

The Cape Cod Cottage and the Earth Sheltered/ Passive Solar Home

John E. Barnard, Jr.

***Cost Analysis**

	Conventional		Earth Sheltered
Construction—1530′ ² @ $45. =	$69,000.	1781′ ² @ $31. =	$55,200.
		Shutters	2,000.
			$57,200.
Annual			
Mortgage, Interest & Principal—30 yrs. @ 12¾%	$ 9,000.		$ 7,200.
Depreciation—25 yrs.	2,750.	50 yrs.	1,140.
Insurance, full coverage	520.		370.
Exterior painting	125.		—0—
Real Estate Taxes	1,466.		1,215.
Heat	727.		273.
	$14,588.		**$10,198.**
Initial Savings—			**$11,800.**
Annual Savings—			**4,490.**

* The cost analysis was estimated on the basis of current non-union labor in Southeastern Massachusetts. Also the garage and solar green house of the earth sheltered house and the garage of the Cape were not included in any of the computations.

Having been raised on Cape Cod under the tutelage of an architect-father whose forte was colonial reproductions and conventional design, I advocated the Cape Cod Cottage as a practical and low-cost housing plan for many years. This, however was before the increased urban population density of the '60s. Combined with the formation of OPEC and the subsequent spiraling fuel costs of the '70s it seems to me that a happy solution to both these problems is the earth sheltered house.

The following is a comparison of two houses: one is a side hill south-facing linear design which utilizes passive solar; the other is a traditional above grade Cape Cod Cottage. This comparison makes it evident that the earth sheltered design is the practical house for now and the generation to follow.

The actual savings in dollars are important, but there are many other advantages. Some of these advantages are:

- The esthetics of a house that fits into the land rather than sitting on top of it.
- The natural quiet in rooms below grade.
- The ability to plant the roof replacing O_2 producing greenery so important in today's suburban sprawls.
- Natural protection from nature's severest blows.
- Elimination of the extremes of heat and cold, thereby saving on energy needs.
- Minimization of the amount of escaping energy from exposed surfaces.
- No exterior maintenance such as gutters to clean, wooden trim to paint, etc.

Most important of all are the energy saving abilities of the earth sheltered house.

Although it is well known the earth is not as good an insulator as many man-made products, it does provide a stabilizing effect. Actually, 12 to 18 inches of earth cover is sufficient as more depth builds of dead loads at a fast rate.

Because the earth does not react to temperature changes as quickly as the air, the temperature variations below grade are far less than above. The earth sheltered house therefore requires far less energy to maintain an even temperature. This lag produces a benefit known as a thermal fly wheel effect. The earth and subsequently the walls will naturally reach a peak about three months behind the air, thus requiring far less energy to heat in the above grade coldest months or to cool during the summer heat.

The earth sheltered house containing some 2454 cubic feet of concrete and insulated on the outside provides a heat store of approximately 85,000 BTUs per degree F. This means that in the cooling down process it will liberate to the house in usable heat nearly the equivalent of a gallon of #2 fuel oil per degree F, which has a great stabilizing effect.

The fuel costs used in the cost analysis chart were derived by computing the number of BTUs needed to maintain an interior temperature of 70° F. based on 5570° days for the Boston area. These were then converted into gallons and priced at the current cost of #2 fuel oil. Naturally another fuel source would be figured in the same way.

The Cape Cod house had a heat loss of 78,900,000 BTUs minus a solar gain through the windows of 9,600,000 BTUs resulting in a heat requirement of 69,300,000 BTUs or approximately 700 gallons of fuel oil.

Using the same method of loss and gain for the earth sheltered house there was a net requirement of 27,000,000 BTUs or approximately 275 gallons of fuel oil.

The low fuel requirements of this house are due in part to the use of fiber glass covered styrofoam shutters that slide across the glass panes at night.

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The use of a pre-stained red wood grape arbor is another energy saver. The high summer sun is shielded from the interior by the leaves and trellis bars to cut down on unwanted summer solar heat gain. The low angle winter sun is not affected by the now bare vines.

There are a great many concerned individuals who immediately responded to the energy crisis and are dedicated to the cause of conserving non-renewable energy. Far more, unfortunately, adopted a laissez-faire attitude. But the one crisis that evokes a response and change of life style in nearly everyone is inflation.

The above comparison of two houses, one earth sheltered and one above grade, proves beyond question that the earth sheltered house with passive solar is not only less expensive to build and less costly on an annual basis but also requires 60% less non-renewable fossil fuels. This is one of the most important factors in a world of decreasing energy resources.

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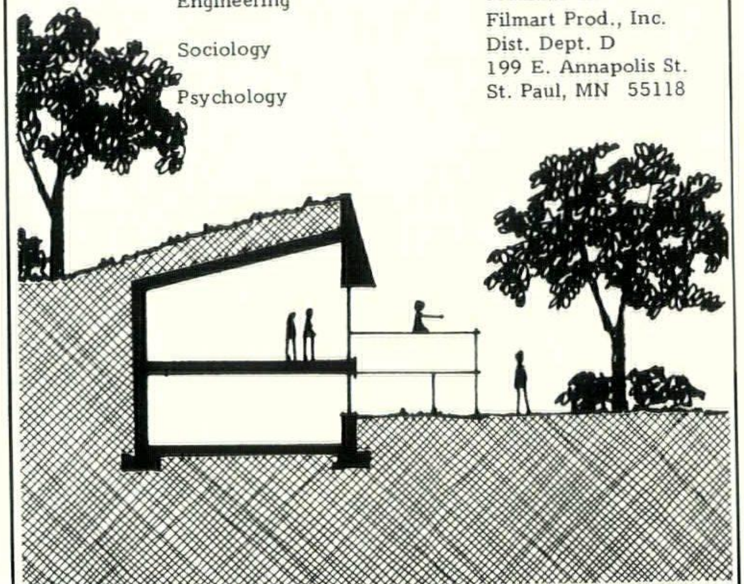

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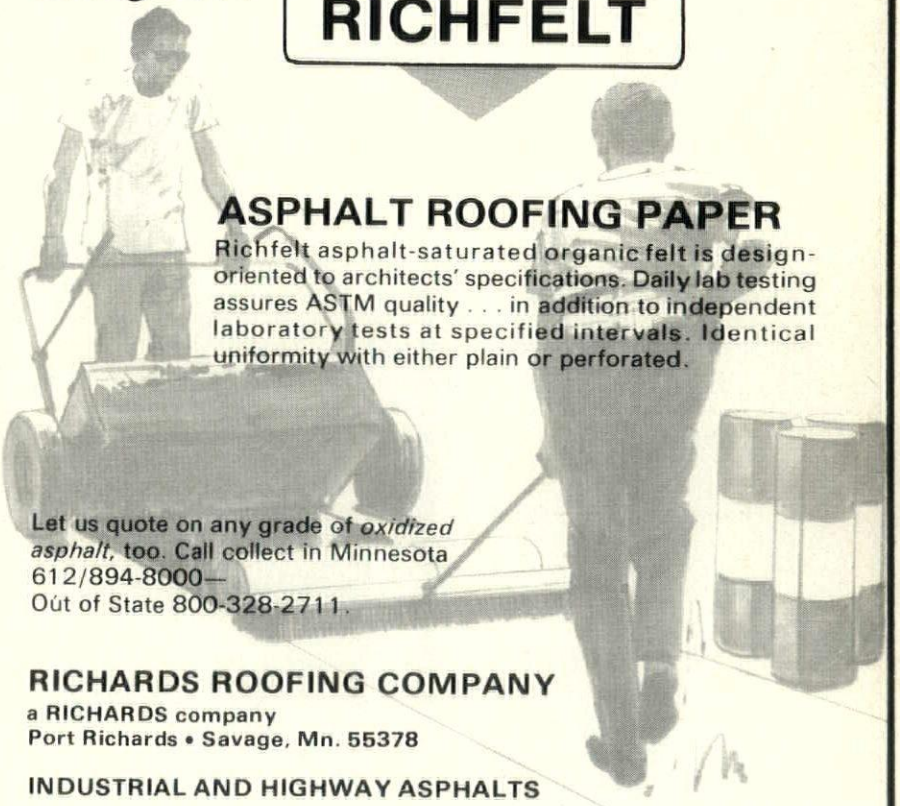

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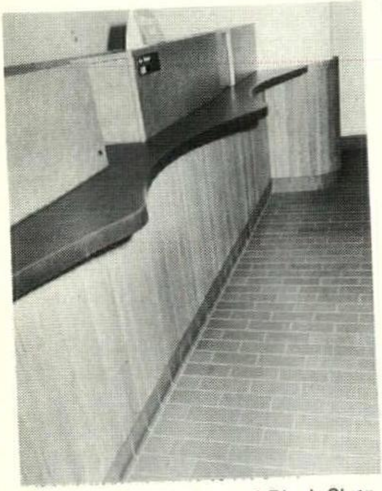

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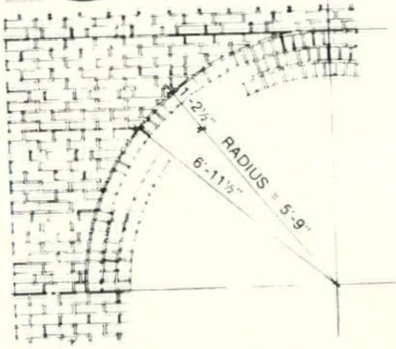

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Earth Sheltered Housing Resource Index

Susan Taylor

Programs and Centers

The American Underground-Space Association
Thomas C. Atchison, Executive Director
Department of Civil and Mineral Engineering
University of Minnesota
221 Church Street, S.E.
Minneapolis, MN 55455
612/376-5580

The AUA is the professional association dedicated to promoting the wise use of underground space. Membership in AUA includes a subscription to the Association's journal, **Underground Space.** Reprints of articles and information on the full spectrum of earth sheltered and underground uses can be obtained by contacting Thomas C. Atchison, Executive Director.

Office of the Assistant Secretary for Policy Development and Research
Division of Energy, Building Technology and Standards
Department of Housing and Urban Development
Washington, DC 20410
202/755-0640

HUD recently completed an earth sheltered housing study focusing on codes, zoning and financing that was conducted by the Underground Space Center, University of Minnesota. HUD has also granted about 25 earth sheltered home loans under their Section 233 insurance program.

Dr. Lester Boyer
Professor of Architecture
103 Architecture Building
Oklahoma State University
Stillwater, OK 74074
405/624-6043

Included under Oklahoma State's two-year graduate program, "Environmental Control", is earth sheltered/passive solar design. Short courses are offered on earth sheltered building design and lighting/energy design. Send a self-addressed, business-sized envelope to Dr. Boyer to receive the school's packet of earth sheltered materials.

Dr. Ernest Kiesling
Professor and Chairman
Department of Civil Engineering
Texas Tech University
Lubbock, TX 79409
806/742-3523

The Department of Civil Engineering offers a graduate research program in earth sheltered housing. The school will answer inquiries and are currently preparing a booklet for the Department of Energy, "Introduction to Earth Sheltered Housing", which can be obtained from the Department of Engineering for $4.00. The faculty consult with the private sector on design, construction and demonstration of earth sheltered houses and offer seminars.

The Underground Space Center
University of Minnesota
11 Mines and Metallurgy
221 Church Street, S.E.
Minneapolis, MN 55455
612/376-5341

A research and information center on underground space use, the Center can provide information on many subjects including earth sheltered housing, finance and code issues, and large scale underground construction. Their book, *Earth Sheltered Housing Design*, is the definitive text on earth sheltered design and construction techniques. They offer an annual series of introductory and in-depth conferences on various facets of earth sheltered construction and finance.

Dr. Truman Stauffer
Department of Geosciences
300 Geology-Physics
University of Missouri
Kansas City, MO 64110
816/276-1334

The emphasis at the University of Missouri is deep storage. A three-hour credit course is offered through Geosciences entitled, "Occupants and Use of Underground Space". The same material is also covered in a yearly short course given during the first two weeks of June. Dr. Stauffer recently completed an 8-volume reference manual containing papers on underground space utilization; it can be purchased from Dr. Stauffer for $52.50, including postage.

Dr. Nolan Aughenbaugh
Chairman, Dept. of Mining
Petroleum and Geological Eng.
University of Missouri Rolla, MO 65401

Dr. Aughenbaugh and his associates have been working with local contractors on earth sheltered house construction and have done a demonstration project that showed an earth sheltered house's insensitivity to outside temperature fluctuations.

The Clearing House for Earth Covered Buildings
School of Architecture and Environmental Design
The University of Texas at Arlington
Arlington, TX 76019
817/273-3083

The Clearing House established by Frank Moreland will provide reading lists and information on general earth sheltered questions. They have held two conferences in the past four years; the transcript from the 1975 meeting is available. The faculty also consults with federal agencies on earth sheltering.

Professor Gabor Karadi
Chairman, Department of Civil Engineering
University of Wisconsin P.O. Box 784
Milwaukee, WI 53201

The school has an institute for Underground Space Utilization Studies which was established under the National Science Foundation program for Research Initiation and Support. Their emphasis is on research in deep space utilization.

David Scott
Assistant Dean
College of Engineering Room 136/Dana Hall
Washington State University
Pullman, WA 99164
509/335-5593

Over 800 students have gone through Mr. Scott's earth sheltered program in the past 18 years. Students study both residential and nonresidential applications. Dr. Scott participates in seminars, has produced 8 television shows on the subject and has lived in his own earth sheltered residence for 10 years.

Periodicals

Earth Shelter Digest and Energy Report, WEBCO Publishing Inc., Bi-monthly, $15.00 per year. Available from WEBCO Publishing Inc., 479 Fort Road, St. Paul, MN 55102

The only popular magazine available devoted to a comprehensive look at earth sheltered construction. Features include case studies of earth sheltered residences and commercial structures from across the country, plus practical articles on a wide range of topics including: construction data, building materials, codes and financing. Articles are accompanied by drawings and full color photographs. **Earth Shelter Digest** has been in circulation for one year and has become a relied upon source for the latest information on earth sheltering.

Underground Space, the official journal of the American Underground-Space Association, Pergamon Press, Bi-monthly. Available to individuals as part of AUA membership ($30.00 per year) or from the publisher for $40.00 per year. Pergamon Press, Maxwell House, Fairview Park, Elmsford, NY 10523

Underground Space is devoted to the broad technical, legal and social aspects of expanding the use of this important resource. The Senior Editor is Charles Fairhurst, Head of the Department of Civil and Mineral Engineering at the University of Minnesota and the Journal's Board of Editors is composed of 12 experts representing the many different professional areas concerned with the underground. Back issues of the journal and individual reprints of articles are available through the publisher and Tom Atchison, Executive Director of the AUA.

Many other periodicals carry articles on ea sheltering with some regularity. Check y local library for back issues of these magazin You will find a more comprehensive bibli raphy of earth sheltered and solar articles

Earth Sheltered Housing Design
Alternative Sources of Energy
American Institute of Architects Journa
Both the national journal and regional journ carry earth sheltered articles
Architectural Record
The Futurist
Mother Earth News
Popular Mechanics
Popular Science
Progressive Architecture
Solar Age
Architecture Minnesota

Books and Reports

Alternatives in Energy Conservation: The use of Earth Covered Buildings, NSF/RA-760006 Proceedings and Notes of Conference held in Fort Worth, Texas, July 9–12, 1975, $3.25. Available from U.S. Govt. Printing Office, Washington, DC 20402 Stock No. 038-000-00286-4

This book contains a large collection of papers on the use of underground space. Several underground projects are reviewed as well as possibilities and problems discussed. Contains an extensive bibliography.

The Architectural Use of Underground Space: Issues and Applications, Ken Labs, 1975, 160 pages, $20.00. Available from Ken Labs, 147 Livingston Street, New Haven, Connecticut 06511

The three-part thesis discusses the emergence of underground architecture, emphasizing (1) the role and potential implications of subsurface design practice, (2) issues in the design, use, and response to both windowed and windowless underground environments, and (3) specific problems related to structure, regional climatic suitability, the soil/building environment, and landscaping. The thesis is addressed to the designer who is assessing the appropriateness of the underground alternative either conceptually or for a specific site and building program. Technical appendices, taxonomy, and bibliography are included.

Earth Integrated Architecture, 1975, Edited by and available from, James W. Scalise, College of Architecture, Arizona State University, Temple, AZ

A collection of student research and design projects on earth integrated architecture. It contains detailed information on some of the fundamental determinants of earth integrated architecture, and also contains a section of examples and a bibliography. It places a special emphasis on the climate and conditions of the southwest.

Earth Integrated Building Construction, Portland Cement Association, June 1978, 24 pages. Available from PCA, 5420 Old Orchard Road, Skokie, IL 60077

This pamphlet provides background information on earth sheltering and several examples of projects in the planning and completed stages. The publication also includes construction guidelines for a single-family house and lists sources of other information.

Earth Sheltered Housing: Code and Financing Issues, U.S. Department of Housing and Urban Development, Division of Energy, Building, Technology and Standards, 1980, approximately 160 pages. Contact HUD for copies; no price set as of this writing.

This study has been recently completed for HUD by the Underground Space Center, University of Minnesota. The purpose is to consolidate current information on earth sheltered housing, identify known advantages and disadvantages and relate this information to impediments to earth sheltering in the areas of finance, building codes and zoning ordinances. Recommendations for alleviation of unnecessary barriers are made.

Earth Shelter Housing Design: guidelines, examples and references, The Underground Space Center, 1978, 310 pages, $11.00. Available from The Underground Space Center, 11 Mines & Metallurgy, 221 Church Street, S.E., University of Minnesota, Minneapolis, MN 55455

A definitive exploration of all facets of earth sheltered housing design and construction. The report is intended to assist people in the layout and design of earth sheltered houses as well as covering public policy issues like codes, zoning and financing. Plans and sections of 20 earth sheltered houses are included, with both interior and exterior photographs.

The $50 and Up Underground House Boo Mike Oehler, 1978, 112 pages, $6.00. Ava able from Mole Publishing Co., Rt. 1, Box 61 Bonners Ferry, Idaho 83805

Owner/builder Mike Oehler has written a ve personal account of building his own earth sh tered home by the PSP (post/shorin polyethylene) system. Amid quotes fro American Indians and gentle philosophy abo preserving the earth, he provides a detailed a count of building a truly handmade home.

Underground Designs, Malcolm Wells, 197 87 pages, $6.00. Available from Malco Wells, P.O. Box 1149, Brewster, MA 02631 some bookstores.

This book contains plans and illustrations Wells' many underground designs (18 home d signs). Not all of the designs were actually bu but they provide a valuable idea book of sol tions to the problems of designing undergrou buildings. The book also contains short sectio dealing with selecting a site, choice of structur building code problems, waterproofing, insul tion and landscaping.

Underground Houses: How To Build Low-Cost Home, Robert L. Roy, 1979, 1 pages, $5.95. Available from Charles C Nurnberg, Sterling Publishing Co., Inc., 2 Pa Avenue, New York, NY 10016

Mr. Roy describes the full process used in buil ing his earth sheltered block home. Picture sketches, charts and calculations help the read understand, in precise detail, how the home w built with the surface bonding technique. He i cludes many tips to potential builders based up his experience.

Underground Utilization: A Reference Ma ual of Selected Works in 8 Volumes, Edited b Truman Stauffer, 1978, Geographic Public tion, $52.50 including postage. Available fro Materials—Stauffer, Department of Ge Sciences, University of Missouri, Kansas Cit MO 64110

Dr. Stauffer has compiled a combination of r printed and new articles on all aspects of unde ground construction.

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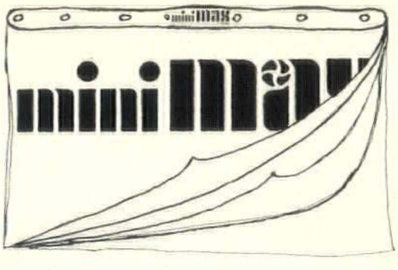

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Red Wing Minnesota: The Architecture at Third and Hill Streets

Robert T. Mooney

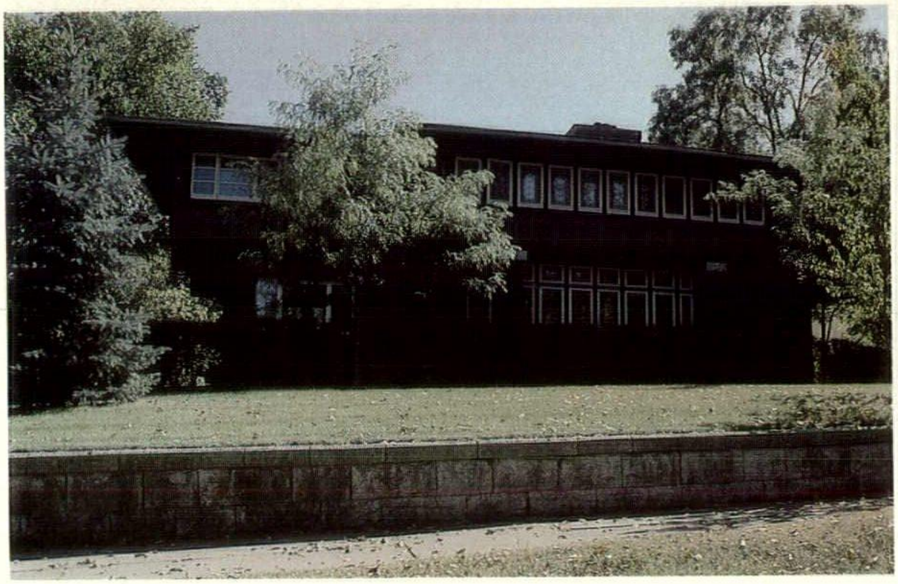
Photography: Robert T. Mooney

Hoyt House (1913)

Sprague House (1867)

The history of the development and expansion of the American midlands is inexorably intertwined with the Mississippi River. Though that history is more often written than visual, the shorelines of the river have provided, over the centuries, handsome sites which are even today graced with magnificent examples of nearly 200 years of American architecture. Evidence of 18th, 19th and early 20th century architectural design is scattered and isolated along the length of the River. Occasionally it can be found cloistered in the protected environment of total community restorations. Regrettably, some river architecture has been subjected to tasteless restoration and preservation purely for the sake of architectural tourism. But even in these cases a knowledgeable observer can glean vivid images of times past.

With the passage of time, one finds but a few dwindling examples of architecture which are both historically significant and a part of the river culture. Those special few are the essence of Mississippi River architecture. They have aged gracefully with continuous care and the acknowledgement of the splendor of their proportions, sensitive textures, dignity in scale and sense of place in the lives of their inhabitants and in the history of the communities of which they are a part.



Hoyt House (1913)

From time to time, one may happily come upon a superb example of the union of architecture and river. Along the quiet, tree-lined gothic avenues of Red Wing, Minnesota, the intersection of Third and Hill Streets offers what may well be the most spectacular presentation of 19th and early 20th century residential architecture along the length of the river. Encompassing 56 years of residential design, the earliest example is the Lawther Octagonal House (1857). It was built three years before Longwood at Natchez, Mississippi, perhaps the most well known and grandiose octagonal house among many of that form along the River corridor. The octagonal house was invented by Orson Squire Fowler in about 1848 following his investigation of the octagonal form in a concrete hotel in Milton, Wisconsin, 1845. Fowler designed and built his own octagonal house in 1850. Because Fowler's original idea for the octagonal form involved its use by the average man, the Lawther house is probably truer to that concept than Longwood. The southern flamboyance, classic revival and eastern influence so readily apparent in Longwood must be attributed to the wealth of the builder, Dr. Haller Nutt. The Lawther house is much smaller in scale, devoid of detail and nicely joined with a small bluff, appropriate for its residential setting in Red Wing.

On a second corner, diagonally opposite the Lawther House, a delicately articulated Victorian mansion, the Sprague House (1867) rises, gracefully above the towering trees. Among examples of the French Second Empire Style, it is virtually without peer along the River. Other Second Empire houses found along the upper Mississippi River (in Quincy, Galena or DuBuque for example) are important in their own right, but do not enjoy the same proximity to the river nor the elegance of spatial separation which so pleasantly protects the Sprague House from other structures in the neighborhood. The Lawther House and the Sprague House contrast dynamically in form and style, yet share a common denominator of craftsmanship in detailing, appropriate landscaping and sensitivity to scale.

The Hoyt House (1913), an example of the Prairie School by the office of Purcell, Feick and Elmslie, shares the same intersection with the Lawther and Sprague houses. That office was prolific in the expression of the Prairie School along the Mississippi below Minneapolis-St. Paul and it seems appropriate that the Hoyt House join at the same intersection as those two earlier and dynamic examples of architectural thought. Along with other Prairie School houses, the Hoyt House is important in design development along the Mississippi. The time of the Prairie School simultaneously signaled the end of serious architectural design along the length of the River corridor and the beginning of the end of urban-river interface.

Weak zoning, heavy industry, slum development and lack of design awareness have rendered null and void the viability of what were once classic river towns. There are a few communities along the River like Red Wing which accept and cherish their architectural heritage. The River edge of Red Wing is not a thing of beauty, but its bluffs still retain a certain grandeur. A walk along its streets today isn't much different than it was more than a century ago. In addition to the three great houses at Third and Hill, Red Wing offers fine examples of other styles—among them Eastlake, Queen Anne, Greek Revival, Gothic, Italianate and even Beaux-Arts Classicism. There is something timeless and clean about the general nature of Minnesota villages along the Mississippi, such as Winona and Hastings. Among them, Red Wing is of singular importance in having recognized the priceless treasures of its architectural heritage. ▰

Robert T. Mooney is the Associate Head, Department of Architecture, University of Illinois, Urbana-Champaign Campus. He has extensively studied the architecture of the Mississippi River during the past two years with funding from the University of Illinois Research Board.

Building for the Future with Historic Resources: A Review of the Irish Row House Case, Red Wing

Donald J. Heffernan

The Minnesota State Supreme Court's willingness to examine our historical environment recently saved the 100-year old Irish Row Houses in Red Wing, Minnesota from demolition. Writing the unanimous decision for the State Supreme Court on October 12, 1979, Justice Rosalie Wahl noted:

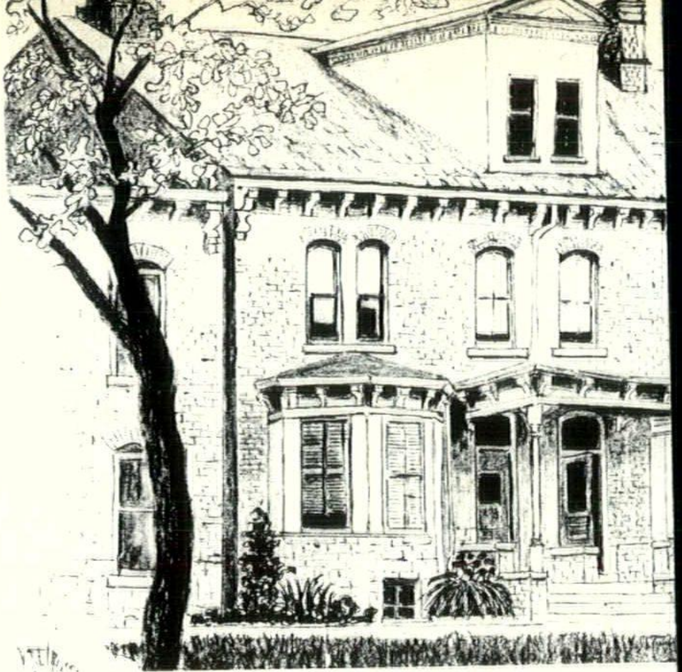
> **. . . Because of this State's paramount concern with the protection of its natural resources, demolition is not consistent with the public health, safety, and welfare.**[1]

In this case, the owner of the buildings wanted to demolish them to make additional parking spaces available for his adjoining retail business. The main State Statute applicable here was our Minnesota Environmental Rights Act[2], commonly used in disputes involving natural resources protection. "Historic resources" are included in that law's protection as being part of our protectable natural resources.

This was the first historic preservation case[3] decided by the Minnesota State Supreme Court and provides some guidance to those concerned with the planning, building, and designing of our future living environment. Factors considered by the Court in determining that the row houses were historical resources were: who built the structure; who lived in it; its location; its architecture; unique materials; quality of workmanship; the structure's association with the builders or important people or events in the area; and its interaction with other buildings.

The buildings, located in Red Wing's Heritage Mall Preservation District, were structurally sound. They had been occupied as rental properties until the summer of 1978, when the owner closed them preparatory to demolition. A concerned group of Red Wing citizens brought the injunction action to save them in August of 1978. They, along with another local group, the Friends of History, provided the necessary local support to insure the continuation of the case through the District Court (where it was lost) and into the Supreme Court (where it was won). As a result, the row houses survived their hardest year and stood for their centennial birthday. This local dedication was an essential factor in the preservation effort. Thereupon, assistance was provided by the Minnesota Historical Society and the Attorney General.

The process of historical preservation involves many people. The legal machinery is only a part of the ongoing process. Helpful architects provided support throughout this case. They will be the final interpreters of this decision on the face of the land. In all cases, as was done in this one, a partnership between historic preservation and business must be explored and attempted. As George Bernard Shaw once stated, "the only absolute is—there is none." As in all cases, the facts have their own unique quality. Drastic conclusions on either side, based on the Red Wing Row House decision, should be avoided. A brief review of the historical background of



Lawther House (1857)

the Irish Row House structures was given in testimony by Mr. Russell Fridley, Director of the Minnesota Historical Society:

> **The north row house was built in 1870 by James Lawther, an Irish immigrant, who was highly successful in real estate. Lawther had a tremendous impact on building in Red Wing and was one of the town's greatest philanthropists. The south house was built in 1882 by Silas Foot, a mayor and famous civic leader of Red Wing, who was involved in the Foot Tanning Company. The style of the houses, although common in other parts of the country during the 19th century, was unusual in Minnesota. The row houses also occupy a position on the mall and act as a buffer between the highway and the Heritage Preservation District. The row house and the District would be eligible for nomination to the National Register.**

In Mr. Fridley's opinion, the row houses are historical resources because of their age, their construction and their association with local historical events.

Feasible and Prudent Alternatives to Destruction

Beyond proving that a candidate structure or area is a historical resource, a second question must be addressed under our Environmental Rights Act. It is a step that cannot be accomplished without the aid of architects, engineers, planners, and related experts. Once it is determined that a particular resource is an "historical resource" the burden of proof is on the one who wants to destroy it or impair it. That burden includes the requirement that feasible and prudent alternatives to the resource's destruction or impairment be explored and attempted. What this means for the designers and planners is a creative opportunity to weave the old with the new as has been done successfully in other parts of the country and the world.[4] Our Court concluded that the owner-developer did not meet this burden of proof in the Red Wing case:

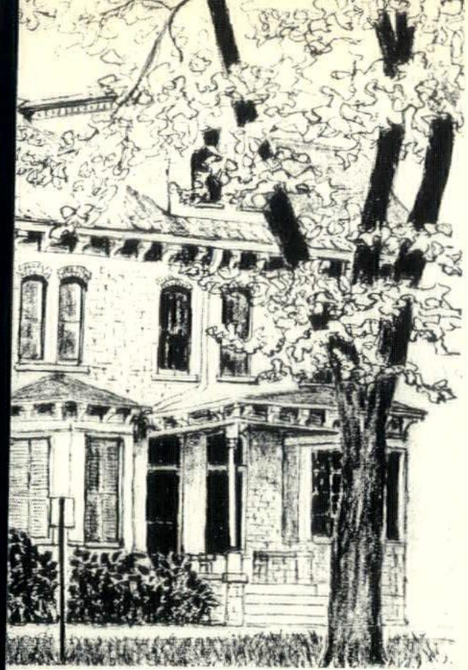
> **Not only have defendants not sustained their burden of proving no feasible and prudent alternative, they have not sustained their burden on proving that demolition is ". . . consistent with and reasonably required for promotion of the public health, safety, and welfare *in light of the state's paramount concern for the protection of its . . . natural resources from pollution, impairment, or destruction.*" (emphasis added.) Minn. St. 116B.04.**

Such alternatives, for example in the Red Wing case, should have involved the consideration of various parking and building plans, zoning variances, landscape and restoration options. Although those concerned about preserving desirable historical structures can offer such options, as the Friends of History and the citizens of Red Wing did in the Irish Row House case—it is incumbent upon the developer to do so. An example of a developer pursuing those required alternatives is often cited in the recent Oxford Development in Minneapolis, dealing with the preservation of the Art Deco interior of Scottie's.[5]

In the future, the Irish Row Houses will face what similar structures face—the need for restoration. It should be accomplished by the present owners or by an interested party who can acquire the buildings. A great deal of education for owners, contractors, and builders is needed in this preservation area. Often, the special economic advantages in owning or rehabilitating properties that are historic resources or in an Historic District are overlooked. Low cost loans are available for construction. The IRS Code allows for highly accelerated depreciation. Building and Fire Code requirements can be appropriately adjusted and property tax relief reduction may be available. In federally listed properties, the U.S. Government assists with rentals from U.S. Government agencies or units seeking rental space. Current real estate market trends show that buyers and renters value the historic nature of such properties and are willing to pay for it. It is also to the good of the entire community to preserve a community resource, rather than to destroy it.[6]

Conclusion

What is needed is a partnership approach between developers and those concerned with weaving the old with the new in building and construction. There are many historic resources in this state. The construction industry



Donald Heffernan is a lawyer with the firm of Donald J. Jeffernan and Associates, p.a. He is legal counsel to the Ramsey Hill Associates, St. Paul, and the Friends of History. He was the lawyer for the plaintiffs and Friends of History in the Irish Row House case, Red Wing.

will usually touch on them when building or planning in or near state or federally listed Historic Districts, state or federally listed buildings, districts and buildings, that have not been listed, but are pending, and other buildings that have not yet been surveyed for formal listing. When the builder is considering construction that affects the historic resource, the builder must plan design and construction so as not to impair the resource. Wisely and artfully incorporating the historic resource into the project in a compatible manner should be strongly suggested to the owner. It can be proven to the owner that such a course is an economic improvement.

When asked to design and build on owner-developed property that is either in an historic District or contains the site of an historic building and the contract calls for demolition or impairment of an historic resource, the designer and builder must explore the "feasible and prudent" alternatives to that demolition/impairment with the owner. This is easier done out of court during contract negotiation time. Most owners will not be aware that there are alternatives to the demolition/impairment of the historic resource that can be implemented into the design and structure of the new project. Refusal to explore alternatives or the attempt at a "footrace" can often lead to unnecessary cost and material overruns due to work stoppage and lawsuits.

Following the Irish Row House case in this State and the Penn Central case decided by the U.S. Supreme Court in 1978, preservation guidelines are now becoming clear and standards can now be explained to clients. In the Penn Central case, the U.S. Supreme Court dealt directly with historic resources for the first time. Penn Central Railroad wanted to build an office tower on Grand Central Station, a property they had owned for many years. The office tower would radically change the appearance and character of the station, a valuable historic resource in New York City. A building permit was refused to Penn Central. Penn Central contended that this was an unconstitutional taking of their property (deprivation of the right to build the office tower) without just compensation. The U.S. Supreme Court ruled against Penn Central and pointed out that Penn Central had a reasonable return on their present use of the property. Penn Central, therefore, had no rights to contravene the City of New York's Preservation Law in order to turn the station into a *new* use. The Court reasoned that it was, therefore, not a taking of property without just compensation. The Court further made strong statements upholding public policy to protect resources for present and future generations. Local citizens notice and feel strongly about their historic environment. If the Irish Row Houses were torn down on that City's Heritage Mall area, a local citizen suggested that it "would be like a front tooth being knocked out." Similar comments were made in New York City about the proposed tower there. At first, professionals and builders may fail to recognize the citizens' concern, but it is encouraging that we are all learning the process of weaving the old with the new.

It has been most truly said that old buildings do not belong to us only: that they belonged to our forefathers and they will belong to our descendants unless we play them false. They are not in any sense our property, to do as we like with them. We are only trustees for those who come after us.

William Morris, 1887

Footnotes

1. Quotation from the case of *State of Minnesota, by Edward Powderly, Martha Wasmund and Maxine Pfleuger*, Appellants and *Friends of History, Inc.*, a Minnesota non-profit corporation, Intervenors, -vs- *Claire Erickson, Erickson Diversified Corp.*, and the *City of Red Wing*, Respondents. No. 49708 State Supreme Court of Minnesota, decided October 12, 1979.
2. Minn. Statute 116B.04 et seq.
3. There was an earlier case in 1977 that went to the Supreme Court, but only for temporary relief in the trial court process, the case was No. 47608 *State of Minnesota, ex rel Ramsey Hill Association -vs- Macolm Lien, the City of St. Paul, et al* involving the construction of a duplex on Summit Avenue, St. Paul, in the area between the Cathedral and the University Club.
4. *The Economic Benefits of Historic Preservation*, Thomas D. Bever U.S. Department of Interior (May, 1978) with references to Boston, New Orleans, Atlanta, Dallas, Denver and San Francisco, to name a few.
5. This case may be reviewed by our State Supreme Court.
6. *Making History Pay: Economic Incentives for Reuse of Old Buildings*, a conference sponsored by the Ramsey County Historical Society and Lowertown Redevelopment Corporation (October 11, 1979). Tax Incentives for Rehabilitating Historic Buildings, Office of Archeology and Historic Preservation, U.S. Department of Interior, Washington, D.C. (1979).

CICC
Retainage Recommendations*

4.6.1

General and Supplementary Conditions

October 1, 1978

RETAINED PERCENTAGE

The use of retainage against progress payments has traditionally been recognized by all segments of the construction industry as a primary method of protecting the ability of the Owner to complete his project. Although some segments of the industry nation wide are suggesting zero (0) retainage, CICC of Minnesota recommends continued use of retainage; however, at a lower but uniform percentage rate throughout the project rather than a high starting rate and a reduced or zero (0) retainage rate as completion nears. It is recommended that the Article 9 of the AIA General Conditions be modified by adding the following supplementary condition:

Refer to Subparagraph 9.5.1 Add:

There shall be retained 5% from each progress payment until the work is substantially complete, at which time the Architect may recommend release of retained sums in accordance with paragraph 9.8, or final payment in full in accordance with paragraph 9.9.

It should be recognized that the retained percentages represents money that has actually been earned by the Contractor and the withholding results in a hardship for he is deprived of the use of funds. To alleviate this hardship, yet provide the protection the retention offers the Owner, it is recommended that the following paragraph be added:

Refer to Subparagraph 9.5.1 Add:

Prior to the start of construction the Owner and Contractor shall select an escrow agent to receive the retained percentage and enter into an escrow agreement. When each progress payment becomes due, the Owner shall issue two (2) checks. One, in the amount due the Contractor, shall be issued to the order of the Contractor. The other, in the amount of the retention, shall be issued to the order of the escrow agent. The interest and principle shall accrue to the Contractor. In accordance with the provisions of the contract the escrow account shall be released to the Contractor under the provisions of Article 9.7.

When the escrow provisions for retainage apply to a contract, it is recommended that sub-contract agreements provide for a distribution of accrued interest to all major subcontractors and suppliers according to their interests.

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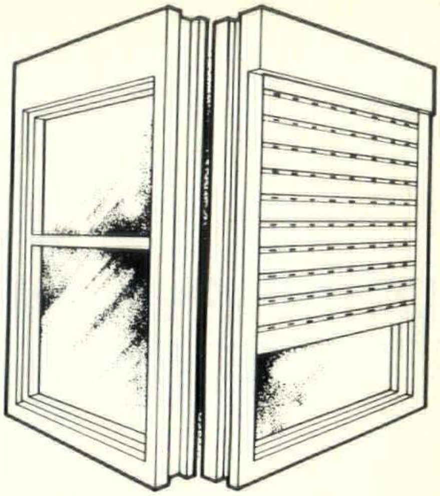

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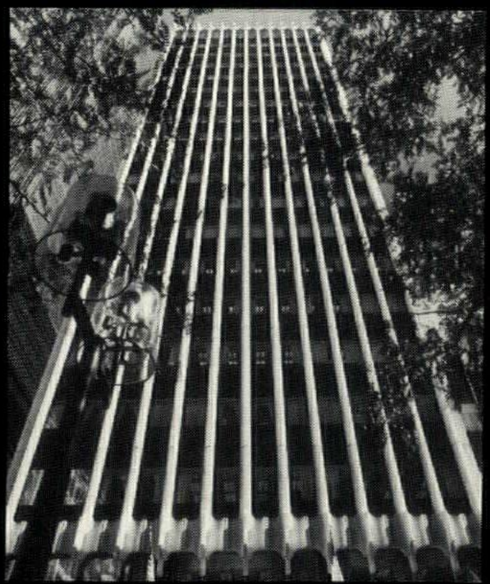

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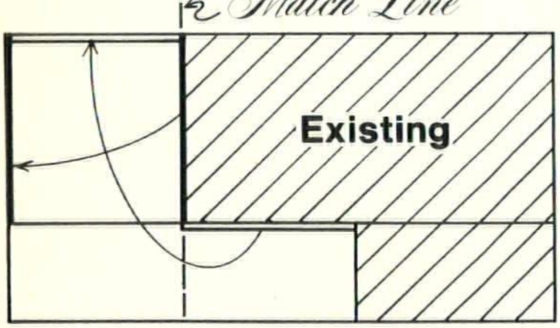

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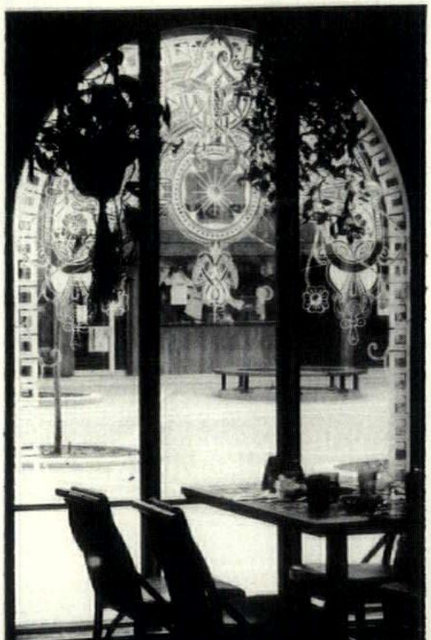

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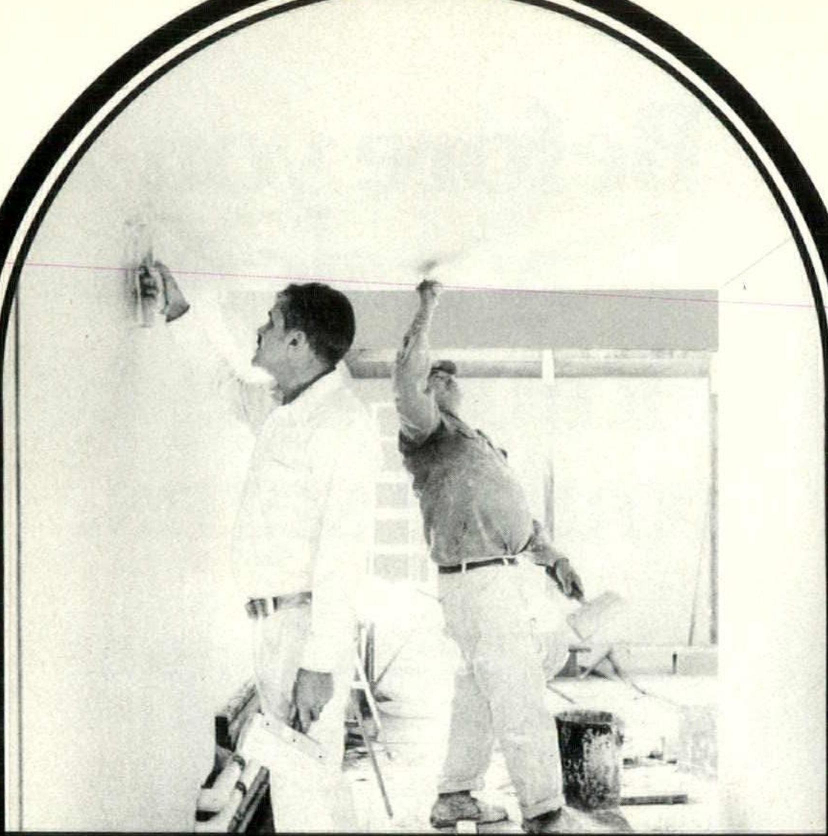

The new dormitory under construction at St. Olaf College, Northfield, follows the crest of a point of land. Main entry is at the top of three levels. Rooms for 243 students step down the slope on three sides. Groups of dorm rooms share common study lounges, forming family clusters. Sovik-Mathre-Sathrum-Quanbeck, Northfield, architects. Kratochvil Construction Co. Inc., New Prague, general contractors.

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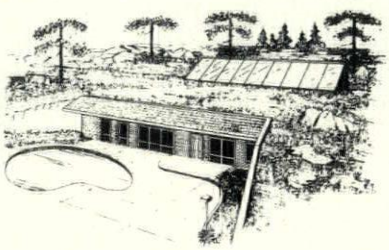

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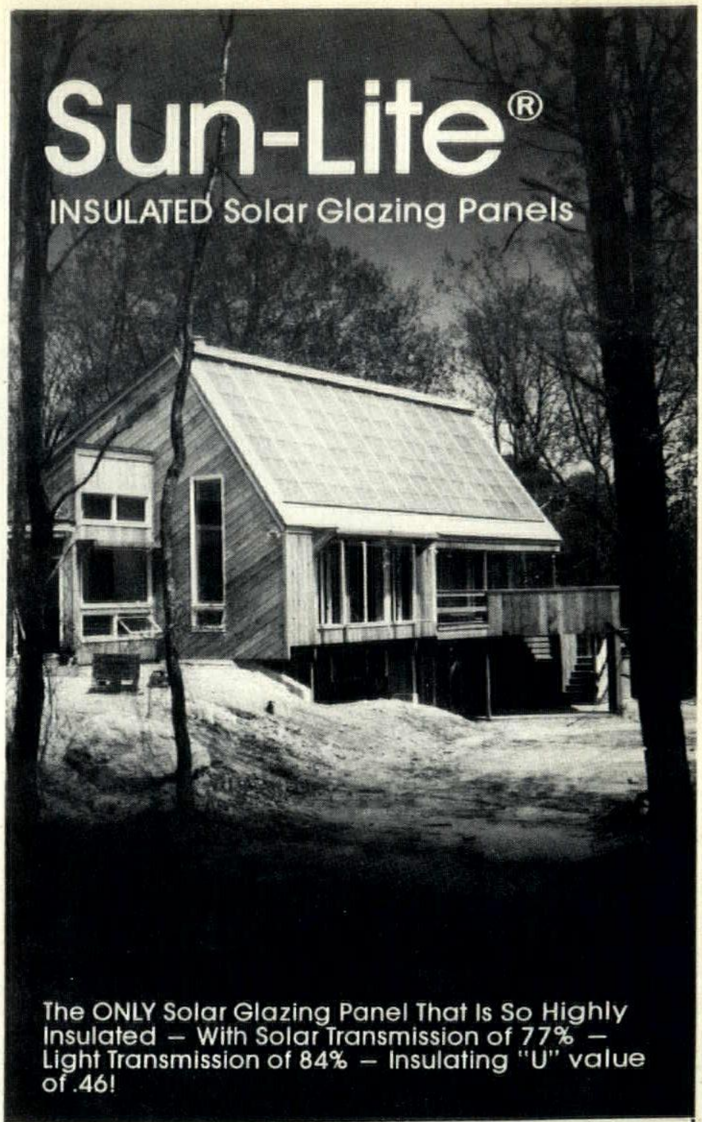

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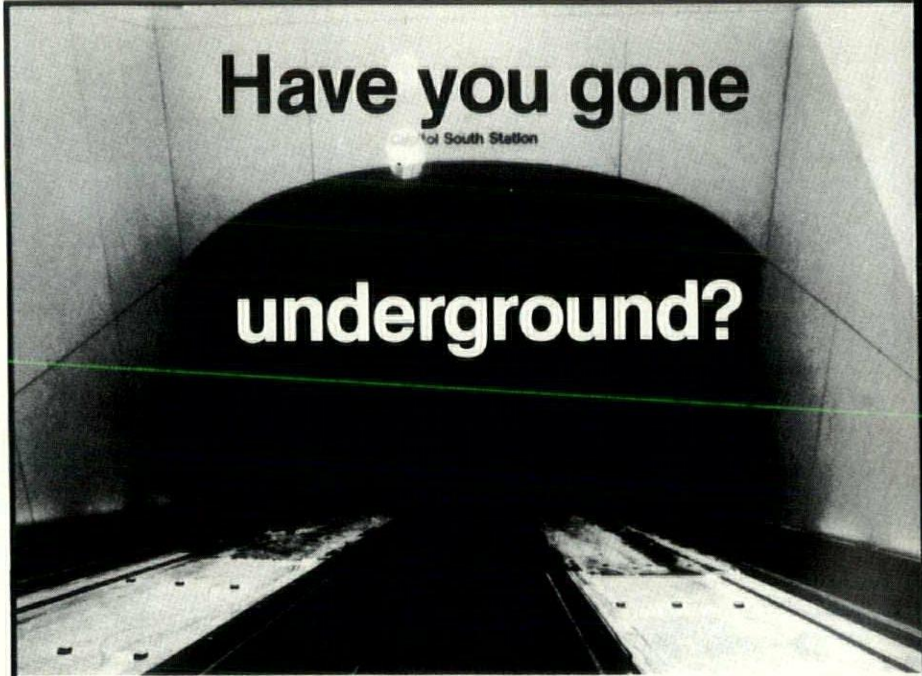

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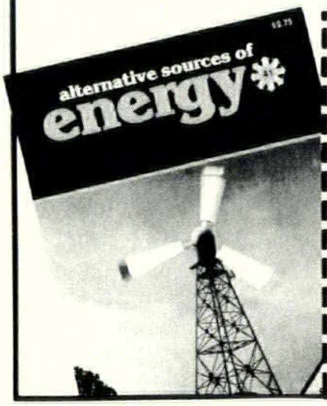

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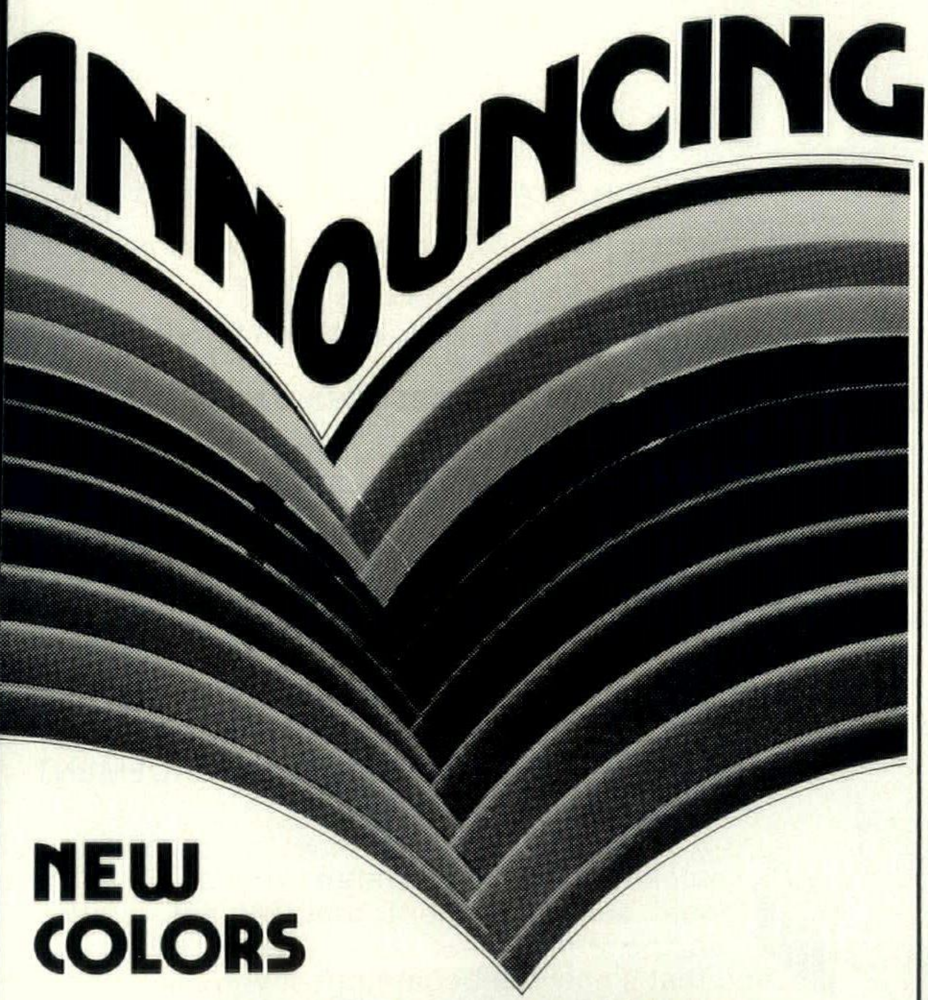
Correction

In the February 1980 issue of Architecture Minnesota, the photographs on page 31 were credited to Phillip MacMillan James. The photographs should have been credited to Stuart West. The photos on top of page 32 were James's.



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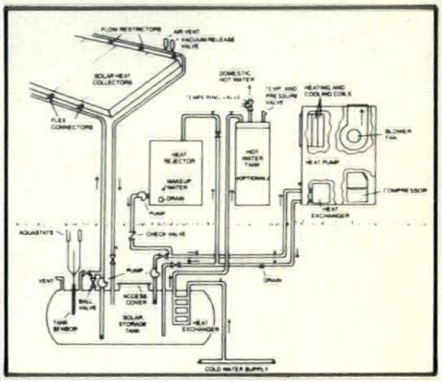

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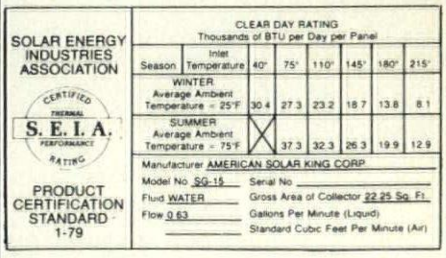

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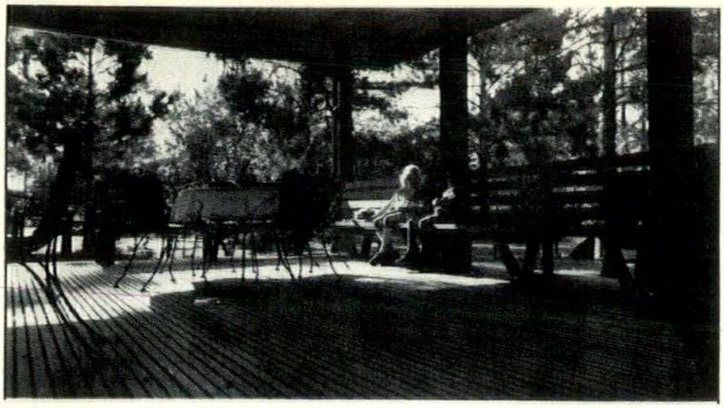

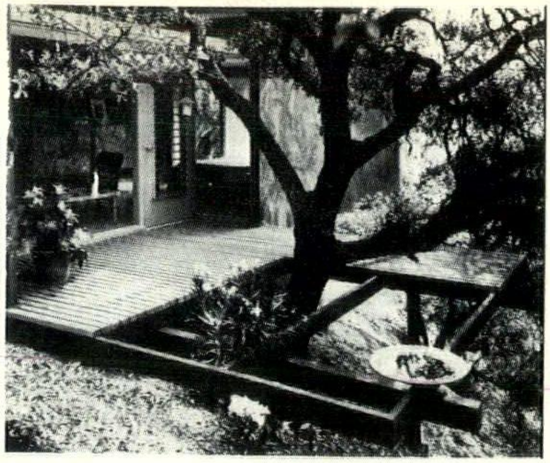

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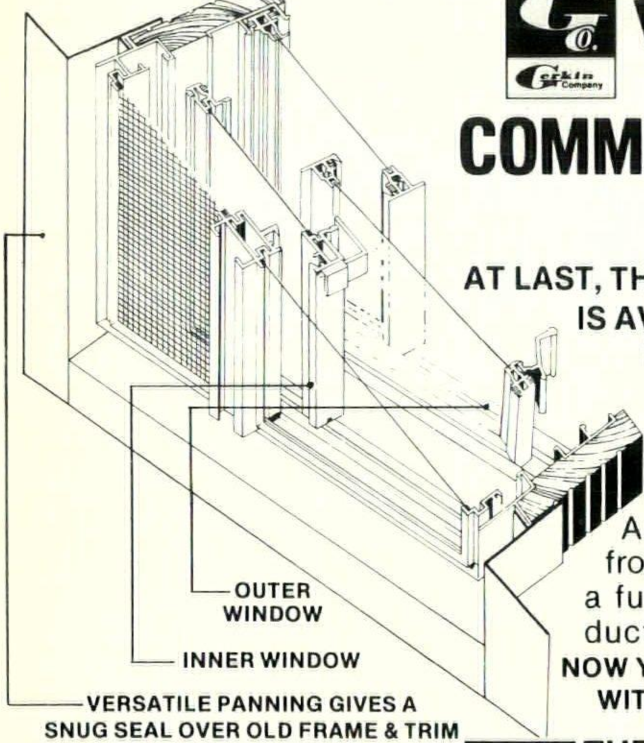

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Underground Designs, Malcolm Wells, $6.00.

HUD Study on Earth Sheltered Housing: Code and Finance Issues. Focuses on codes, zoning and financing. Study conducted by Underground Space Center. No price set as of this writing.

Introduction to Earth Sheltered Housing, Department of Engineering, Texas Tech., $4.00. Prepared by D.O.E.

Alternatives in Energy Conservation: Use of Earth Covered Buildings. Proceedings and Notes of Conference held in Fort Worth, Texas, $3.25.

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St. Paul, Minnesota 55104

Friday, April 11, 1980

Registration: 8:15-9:15 a.m.

Tuition: $95.00

Marquette Inn
Marquette Inn Ballroom
701 Marquette Ave.
Minneapolis, Minnesota

Lawyers, architects, engineers, contractors, and owners will benefit from this practical seminar about the issues that frequently arise during construction projects and which can lead to delay, expense, and litigation if not anticipated and managed competently.

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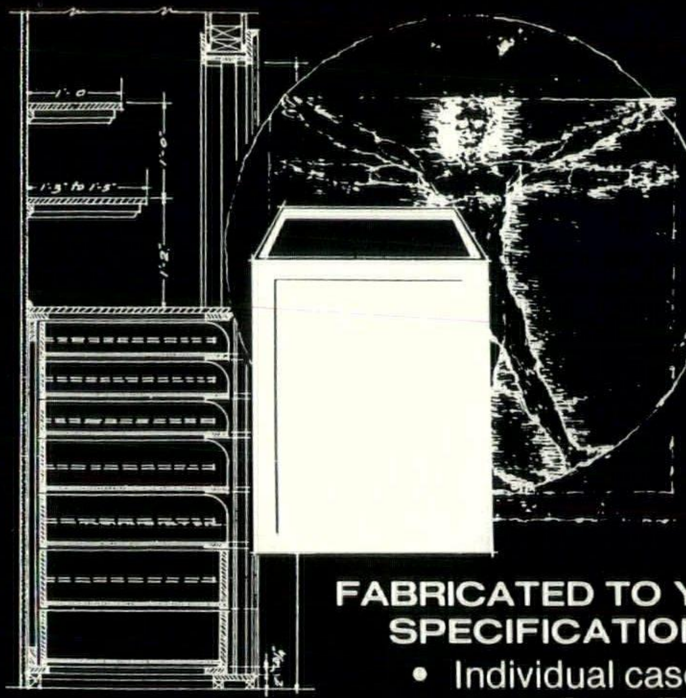

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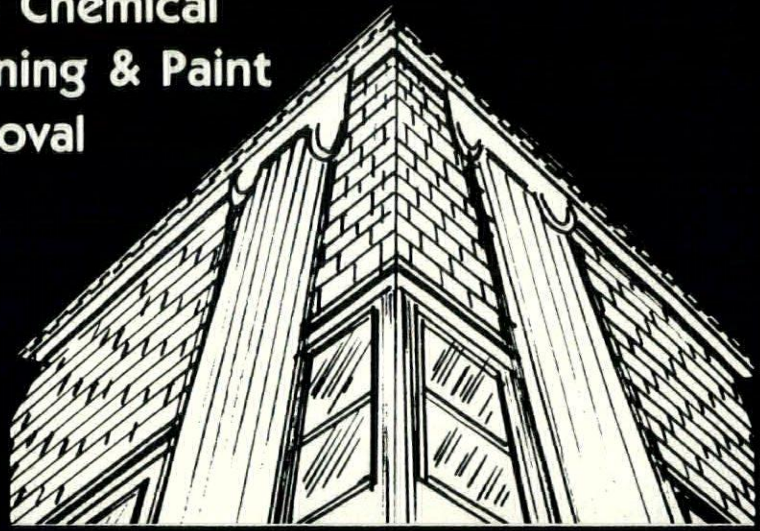

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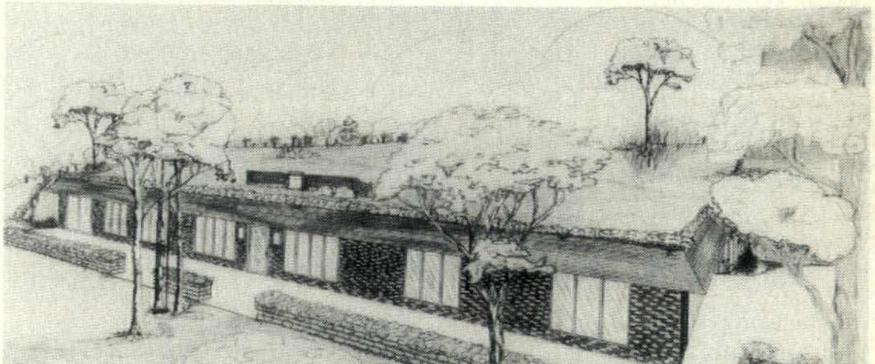

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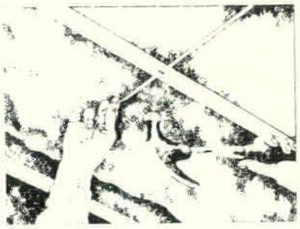

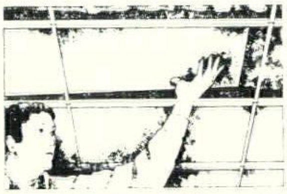

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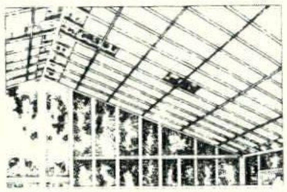

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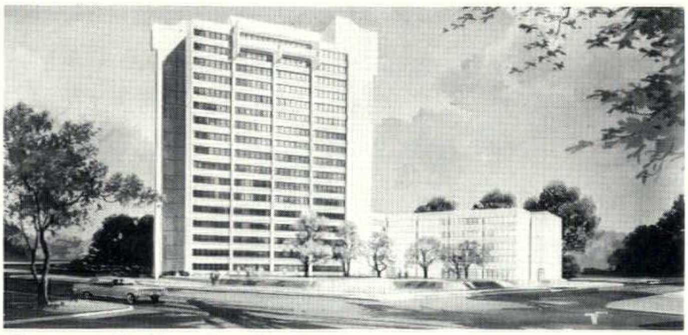
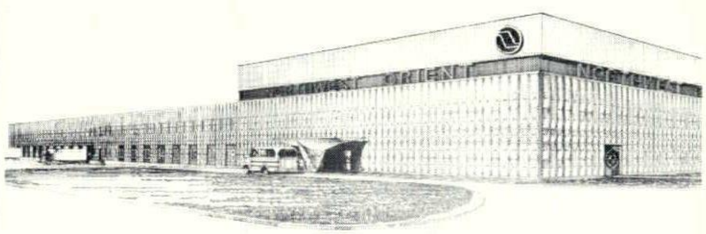


Minneapolis Housing Redevelopment Authority (Housing for the Elderly which became a model for future retirement facilities). 635 - 17th Avenue NE Minneapolis, Minnesota.



Northwest Orient Airlines, Inc. (Flight Services Facility demonstrated the wide applicability of Prestressed Concrete). Minneapolis International Airport, Minneapolis, Minnesota.

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