# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Program</strong></td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>2</td>
</tr>
<tr>
<td>Underground</td>
<td>3</td>
</tr>
<tr>
<td>Solar energy</td>
<td>4</td>
</tr>
<tr>
<td>Site analysis</td>
<td>5</td>
</tr>
<tr>
<td>Slope orientation</td>
<td>6</td>
</tr>
<tr>
<td>Vegetation</td>
<td>7</td>
</tr>
<tr>
<td>Percentage slope &amp; drainage</td>
<td>8</td>
</tr>
<tr>
<td>Topography</td>
<td>9</td>
</tr>
<tr>
<td>Sections</td>
<td>10</td>
</tr>
<tr>
<td>Synthesis</td>
<td>11</td>
</tr>
<tr>
<td>Issues</td>
<td></td>
</tr>
<tr>
<td>Scope</td>
<td>12</td>
</tr>
<tr>
<td>Client</td>
<td>13</td>
</tr>
<tr>
<td>Non-traditional facts</td>
<td>14</td>
</tr>
<tr>
<td>Growth and change</td>
<td>15</td>
</tr>
<tr>
<td>Critical issues</td>
<td>16</td>
</tr>
<tr>
<td>Functions</td>
<td>17</td>
</tr>
<tr>
<td><strong>Design process</strong></td>
<td>19</td>
</tr>
<tr>
<td>Concept</td>
<td>20</td>
</tr>
<tr>
<td>Schematic</td>
<td>22</td>
</tr>
<tr>
<td>Final design</td>
<td>25</td>
</tr>
<tr>
<td>Presentation</td>
<td>26</td>
</tr>
<tr>
<td>Model</td>
<td>34</td>
</tr>
<tr>
<td>Details</td>
<td>48</td>
</tr>
<tr>
<td>Conclusion</td>
<td>53</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>54</td>
</tr>
<tr>
<td><strong>Appendix</strong></td>
<td></td>
</tr>
<tr>
<td>Building Types Study</td>
<td>A</td>
</tr>
<tr>
<td>Climatic data</td>
<td>B</td>
</tr>
<tr>
<td>Solar project</td>
<td>C</td>
</tr>
<tr>
<td>Design development</td>
<td>D</td>
</tr>
</tbody>
</table>
abstract

The object of this thesis project was to explore the potential of underground dwellings on a community basis, and in conjunction with this, to maximize the usage of passive solar energy.

Because of the lack of previous examples, a project of this sort has, as a result, prototypical implications. In my design process, I attempted to design for more than just an isolated situation. The project wouldn't be feasible in all circumstances, but, allowing for adaptations to specific site situations, the project could be used in a variety of areas.

This project deals with a variety of factors—factors that simultaneously restrict and offer unlimited design opportunities. The major ones were:

a. Subterranean dwellings—combating all negative associations with underground living
b. Passive solar energy—southern orientation required
c. Development of a community—separating vehicular from pedestrian circulation

In the development of these ideas, the project divided itself generally into 3 different scales:

a. The total site—developed into a community, maximizing the topography of the site
b. Clusters (of 3 to 5 units) which make up the community, and relationship of units in the cluster
c. The living unit

Working with these factors and breaking it down at various levels, I tried to develop a design that would provide a comfortable living environment within the community framework.
program
introduction

The project on which I will be working is an underground housing development and supportive community facilities. This project would include in its basic goals and design:

a. Subterranean building—earth as insulator and temperature stabilizer (low energy usage)
b. Passive solar energy—southern exposure
c. Conservation, to the greatest possible extent, of existing ecological environment
d. Provision of a working, living environment within the boundaries outlined

There is no specific client or site for this project, but it has come into consideration by various groups for many of the reasons I have enumerated above. For this reason, I intend the project to act as a preliminary research study on the various aspects of housing of this sort. The funding, needs, changes, etc. will be incorporated into a given program. The prototype unit can then penetrate the market and assess the specific needs of a given area (site, clientele, etc.) and amend to accommodate that input.

There have been many singular projects which encompass many of the ideals I would like to incorporate into a development of this sort, ranging from libraries and museums to single family residences. Each of these included important information concerning use of materials and maximizing environmental assets.
underground

There are only a tiny percentage of today's architecture that are built underground, but the number is increasing each year. History shows us that for early man it was the most practical way to keep warmer in the winter and cooler in the summer. However, with today's sophistication, the idea of living underground seems absurd to most people. The negative associations of dampness and darkness seems to overcome any evidence of the opposite. In fact, subterranean living can offer many amenities that conventional living cannot. A few of these are:

- Insulator
- Temperature stabilizer
- Acoustical barrier
- Little or no exterior maintenance
- Wind buffer
- Little or no infiltration

Aside from energy savings, a building of this sort offers limitless potential for design with the landscape, rather than apart from it.
Solar energy

Solar energy is becoming a highly popular innovation in today's energy-conscious market. In reality, many designs were reliant upon passive solar energy long before it became a technological term. It is just that, the acknowledgment and usage of the solar energy that is available, that I wish to incorporate into my project. For this I will use no mechanical methods of utilizing the sun's heat. With the usage of passive solar heat I will use:

Shading methods:
   a. Roof overhang
   b. Deciduous trees

Solar wall (glass)
   a. Direct gain
   b. Tile floor--delayed gain
   c. Shutters to retain heat at night

Trombe wall
   a. Usage of thermal lag through concrete wall in areas that would use heat during the night more so than during the day.
site analysis

The site for this project is one of about 20 acres located in southern Indiana. My main purpose in choosing a specific site was to work with a variety of realistic site conditions and temperate climate, rather than to relate to nearby cities, highways, etc.

In studying all the aspects of the chosen site, I found the following to have the most significance with regard to design:

a. Slope orientation—S, SE, SW exposure best
b. Degree of slope—dealing with slopes ranging from approximately 0° to 30°
c. Drainage areas—design along with natural drainage patterns
d. Vegetation—maximum preservation of existing trees

Other areas having input in the design were:

a. Latitude—winter and summer sun angles
b. Average annual temperatures
c. Etc.
issues
SCOPE

The scope of the project would be:

40 units--residential
Central green or park area
Recreational facility
Supportive commercial facilities:
   Small grocery store
   Beauty shop
   Laundromat
   5¢ & 10¢ store/cards
   Coffee shop/restaurant

The site would be approximately 20 acres,
ranging in topography from level to moderate slopes.
The client for this project would most likely be private/speculative. Because of the nature of the project, the philosophy of the organization would be:

a. Promotion of environmental concern
b. Energy conservation--
   Earth as insulator and temperature stabilizer
   Solar energy

Several assets intrinsic to a project of this nature are:

a. Good acoustic control
b. Virtually no exterior maintenance
c. Visual privacy

Goals of the organization:

Creation of a community:
   a. Allowing both individual privacy and communal activities to exist
   b. Promoting conservation of the natural environment
   c. Promoting energy conservation
NON-TRADITIONAL FACTS--

Effects of physical environment:
- Light--Limited
- Color--natural landscape
- Circulation--environment will dictate limits
- Acoustics/sound--noise barrier

Exterior image and customer buying patterns:
- Image of "buried home" or "home in natural environment" will effect acceptance of underground development.

Effects of centralization vs. decentralization
- Privacy intrinsic to underground housing may change previous attitudes towards density.

Relationships between natural land features and settlement patterns of high income families:
- Entire development designed to retain as much as possible of the natural land features.
GROWTH AND CHANGE--

At present, there are comparatively few projects of this nature being built, however, much research is being done. Faced with environmental issues, this type of building is becoming much more practical:

1. Running out of land—natural vegetation
2. Little is being done about conservation
3. Energy shortage
   a. Solar energy
   b. Earth as insulator and stabilizer
   c. Protection from north wind (on southern slopes)

This project being prototypical in many aspects, the theory used is practical in application in a wide variety of climates. Underground housing is used in the northern parts of China as well as in desert areas. General adaptations would have to be made for specific climates and sites, but the same general theory applies in both extremes. It is this versatility that makes the project a feasible one for the immediate future.
critical issues

Orientation
a. Units can be built on southern, southeastern, or southwestern slopes
b. For solar energy, units should be south or 10° west of south

Drainage of soil
a. Will determine the location of units within the site

Soil depth to solid rock & water table
a. Will determine if the project is feasible in an area, or if berming would be an alternative

Soil type
a. Loose porous soils are best for maximum heat retainage and drainage of soils

Slope of site
a. Will deal with slopes ranging approximately from 0° to 30°

Vegetation
a. Prevention of erosion
b. Preservation of existing
# functions

The prototype development combines the following residential and supportive community facilities:

<table>
<thead>
<tr>
<th>Residential (40 units)</th>
<th>sq. ft.</th>
<th>Community facilities</th>
<th>sq. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2 and 3 bedroom units, 20 each)</td>
<td></td>
<td>Central green/park</td>
<td></td>
</tr>
<tr>
<td>Living</td>
<td>280</td>
<td>Tennis court</td>
<td>(60x120)</td>
</tr>
<tr>
<td>Kitchen</td>
<td>120</td>
<td>Basketball court</td>
<td>(84x50)</td>
</tr>
<tr>
<td>Dining</td>
<td>144</td>
<td>Pool</td>
<td>960</td>
</tr>
<tr>
<td>Bath</td>
<td>60-90</td>
<td>Playground</td>
<td></td>
</tr>
<tr>
<td>Bedroom</td>
<td>192</td>
<td>Recreational facility</td>
<td></td>
</tr>
<tr>
<td>Family</td>
<td>280</td>
<td>Restrooms (2)</td>
<td>100 each</td>
</tr>
<tr>
<td>Storage</td>
<td>24-70</td>
<td>Activity rooms</td>
<td>850</td>
</tr>
<tr>
<td>Utility</td>
<td>24-45</td>
<td>Vending</td>
<td>50</td>
</tr>
<tr>
<td>Circulation</td>
<td>(10%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 bedroom unit</td>
<td>1480-1600</td>
<td>Commercial</td>
<td></td>
</tr>
<tr>
<td>3 bedroom unit</td>
<td>1780-2000</td>
<td>Small grocery store</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beauty shop</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Laundromat</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5¢ &amp; 10¢ store/cards</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coffee shop/restaurant</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manager/maintenance office</td>
<td>400</td>
</tr>
</tbody>
</table>

4640
These facilities were not intended to make the community a totally self-supporting system, but instead to provide adequate recreational facilities and basic commercial outlets needed for convenience at short notice, and thereby reasonably assured of financial capability.

To insure functional success, this project requires the basics needed by any other community, that is, nearby business, commercial and industrial organizations.

Within the system itself lies a different range of relationships:

a. Those of the Living Units as private entities:
   L.U. functions—
   Sleeping
   Living/recreation
   Eating
   Personal hygiene
   Requirements—
   Privacy
   Natural light and artificial
   Heating and cooling (passive solar & auxiliary units)

   b. Those of the L.U.'s as a part of the total community
   Access to:
   Main thoroughfares
   Central green/park area
   Commerce
   Other Living Units

Yard or terrace area
Carport
Security
design process

In this section I will try to outline the process that took place in designing this project. A general outline would contain the following:

I. Process
A. Site input
   1. Slope orientation
   2. Degree of slope
   3. Drainage areas
   4. Vegetation
B. Building Types Study
   1. Subterranean
   2. Solar
   3. Communities
C. Synthesis
   1. Housing
   2. Commercial
   3. Recreational
   4. Circulation
D. Concept
   1. Public and private
   2. Community
   3. Cluster
   4. Individual units
E. Schematic
   1. Variables (possibilities and restraints
      a. Structure (underground)

1. Arch/vault
2. Grid
3. Amorphic form
b. Solar
   1. Single story
   2. Multi-story
c. Privacy
   1. Atrium (enclosed)
   2. Courtyard (semi-enclosed)
   3. Terrace (open)
The concept for this project is patterned after the basic organizational factor of the typical community in society. First of all, there is a progression from public to private to public again. This differs from the typical community by total separation of vehicular and pedestrian circulation. This progression could be broken down into these steps:

1. outside the community
2. outer circulation
3. parking
4. courtyard
5. living unit
6. terrace
7. community green space/park
8. recreation
9. commercial

This too, can be further diagrammed at three different scales. The most general would be the concept for the entire community, that of peripheral circulation, access to a number of clusters of units, which in turn open onto a central green space which would continue on to a central commercial area. The commercial area would also be accessible from the major circulation route.
This could be broken down further to the scale of the cluster (3 to 5 units). From parking one would enter a courtyard which would lead to the subsequent entries of each unit.

Ultimately, there is the scale of the individual unit. Each has its own entry, and the sequence is from light to dark to light again. The unit is divided into areas of maximum and minimum light, public and private. All have a central or organizing factor, that of the outdoor space, of which they become an integral part.

At each scale there is a central or focus point bordered by peripheral elements. The scale of the overall project broken down to accommodate the individual at each level.
final design

In the final design, the use of man-made (geometric) and natural (amorphic) was to be both blended and contrasted throughout the project. It offers a variety of interesting possibilities:

a. Land acting as a bridge over the man-made
b. Creates a new topography that reflects the existence of dwellings, in turn sheltering and exposing different spaces.
c. Reversing indoor and outdoor spaces
   --Indoor spaces focusing on the outdoor, fusing with them.
   --Outdoor spaces treated as indoor spaces, sheltered by the landforms created by the subterranean spaces
grading plan
courtyard

entrance
terrace

interior
VIEW OF CLUSTER FROM THE SOUTHWEST
VIEW OF CLUSTER AND COURTYARD
VIEW OF COURTYARD
View from the north

View from the south

View from the east

View from the west
View of parking from north

Entry to courtyard

Berms around parking

View of courtyard from east
Entry to courtyard

View from the south

View of courtyard

View of courtyard and surrounding units
View from southeast

View of B unit SE

View from the southwest

View of units from southwest
VIEW OF B UNIT AND PARKING BEYOND
VIEW OF BERMING AROUND PARKING
VIEW INTO COURTYARD
VIEW OF CLUSTER FROM THE SOUTHWEST
BLOW-UP OF COURTYARD

B unit SW

courtyard