UNDERGROUND DESIGN:
PSYCHOLOGICAL ASPECTS

BACHELOR OF ARCHITECTURE THESIS
DON M. ARNOLD
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The psychological aspects of design and the application of those principles are the basis for this thesis project. The thesis book takes one through the basic process for the project. A building type study is used as a concept generator. The development of general psychological concepts and more specific detailed principles follows. The detailed principles are synthesized as they relate to the more general concepts. A decision making model based on these psychological aspects is proposed to create a more structured organization and process for design consideration. The decision making model is applied through two schematic design scenarios. Finally, a conclusion and personal statement on the thesis element of the architectural training is given.
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The purpose of this thesis project is to study the importance and adaptability of psychology in designing underground buildings. Underground buildings represent a growing number of buildings of all types. There exist many potential problems in designing environments for people to live in underground. Apart from the technical problems which can be more easily solved, the perceptual problems that exist between underground environments and building occupants represent a more difficult obstacle to overcome. After living above ground with the flexibility of movement and view, the underground environment represents a confining place to attempt a design. The choice to go underground is often made on an energy or site aesthetic basis. The problem arises when these become the only design considerations. Once the choice to go underground is made, the site aesthetic and energy criteria must become secondary to the psychological aspects when creating a design. The psychological aspects, when considered, can help in designing a habitable underground environment which is not confining or stressful.
to the occupants. The following diagram shows the conceptual relationship between architecture and the inclusion of psychological principles in creating a habitable environment.
BUILDING TYPE STUDY
The building type study was conducted to see what underground and earth sheltered buildings have been designed. Since relatively little actual documentation of research into the psychological aspects was found in the preliminary research, the building type study became very important. Through the study, psychological concepts were developed by analyzing the elements of existing designs which led to a good or bad perception of the building. Since many of the elements of each design were derived by an intuitive design process they must be looked at in an intuitive manner. The ways in which movement, transition, view, and perceived openness were handled are a few of the design elements analyzed in order to develop an understanding of the psychological perceptions in underground spaces.
The study will analyze several buildings and group them by size: small scale, residential; medium scale, institutional; and large scale. Within each group several categories will be used to analyze the placement within the earth. The accompanying illustrations will show the placement categories.

The atrium category represents the most common grouping. The atrium is used as a source of natural light and as a source of visual stimulation. The visual stimulation can be extremely important in smaller underground buildings which are not large enough to provide a high level of interior activity. An atrium can also be a central organizer for circulation or zoning.

The deep subgrade category is one of the least common groupings. It involves placing a building or series of buildings far enough down that a normal exterior view is not possible. Hence, the interior space must provide all the necessary perceptual stimuli necessary for healthy habitation.

The hillside concept maximizes its location within a hill to gain the energy and aesthetic benefits. Likewise it uses its prime site location to maximize a potential for visual stimulation by view away from the hill. Entrance is
usually gained from the open side but not always. Zoning will usually put secondary spaces to the earth side.

The earth bermed concept allows integration with the landscape while maintaining a relatively easy construction process. Minimal cut into landscape is needed; only the placing of dirt where desired is required for completion. Earth bermed structures can easily introduce light where needed.

The near surface concept essentially provides little view at the sides except for entries and small light wells or skylights. The basic idea with this type is to use the roof area for some activity such as parking or a playground.

Two other concepts besides the use of atriums or skylights which will be identified are circulation and zoning. Circulation is not always the prime design determiner but is an integral part of the movement through a space and hence important to the user perception. Zoning is usually a very important concept in the design of underground buildings. The placement of different zones in a building will affect the perception of and use of a space. Often zones that do not require a view are placed at the earthside of a building. This concept, therefore, is normally a major organiser in the
design solution for an underground building.

The building use will also be identified. It is important to note the functions that a building serves. A residence, an office, and a commercial building each have different functional and aesthetic requirements. Each may be more or less adaptable to an underground scenario. Thus it is important to identify the use of each building and its internal requirements.

The afore mentioned concepts will be identified for each building along with diagrams or actual pictures which illustrate the major features of the building. Other less general concepts will be noted for individual buildings. Also, general observations about important points and the perceptual qualities of each space will be noted. The good and bad design merits and elements will be pointed out as well.

NOTE: FOLLOWING CATEGORIES OF ANALYSIS

A. CONCEPT OF DESIGN I.E. ATRIUM
B. CIRCULATION
C. ZONING
D. VIEW
E. USE
F. VENT. & MECH.
A. Atrium Concept.

B. Circulation: Open interior. Entry through atrium.

C. Zoning: Spaces zoned such that all secondary storage and utility spaces are against earth wall.

D. View: Provided to all major areas of house. Important to provide view for interior areas in residence.

E. Small scale - residential.

Simple open plan.

Large floor to ceiling windows might reduce privacy in bedroom but does allow view from one space to another interior space through the exterior atrium.

Major focus for view is the atrium.

The tight atrium essentially only provides a view of sky at above grade level. (Potential Problem)

Interior of average material design. No visually exciting details.
A. Atrium/Patio concept.

B. Circulation: Simple main hall through center of house.

C. Zoning: Living, dining faces patio. Other spaces surround. Laundry, mech. @ rear.

D. View is provided from living by patio/atrium.

E. Small Scale/Residential.

F. Possible flow through ventilation from windows in bedroom.

Stepped slope or atrium provides larger view angle from patio which provides a much less confining atrium space.

Earth bermed walls and earth over living room and bedrooms.

Air-lock solarium off of entry court.

Good arrangement in kitchen with stove facing dining.

Window also provided in kitchen to entry.

Open dining area allows view to all major areas.

Double entry - one @ court and one @ carport reduces feeling of confinement.

As a residence it puts the main activity spaces in a place where view is adequate.
A. Hillside Concept.

B. Circulation: Simple, enter from rear or opposite main view. Enter on upper level, one flight of stairs to lower.

C. Zoning: Major living space adjacent to main view aperture. Auxiliary spaces at rear.

D. As a residence it puts major activity space in the prime location to provide a view.

E. Small scale/residential.

F. Easy flow through ventilation.

Form fits unobtrusively into the hill and actually brings about a certain level of excitement because of the exterior and hence really comes alive once you step inside.

The transition from exterior to interior is such that one is brought down to a small opening and then gradually brought into a beautifully expanding interior.

Variety of organic interior forms provides interesting visual stimulation.
This house design attempts to provide an adequate level of light (natural) and the necessary visual stimulation and contact with the above ground world. The house forms and becomes part of the hill.

It may have been better to place the living room where the kitchen is - here the question arises "Is it more important to provide an atrium view to the kitchen than to the living area?" This could simply resolve itself to personal preference, but should be considered in the design.

It seems awkward to provide a larger more scenic view for a bathroom than for the living room.

The high window in the living room appears too small and too high to do its intended job of bringing in light and certainly does not provide much of a view - reminiscent of a high basement window.

A. - Atrium concept.

B. - Circulation - control entrance and movement from room to room - with open circulation - stairs to upper study.

C. - Zoning - spaces located radially around atrium.
D. - View - provided to all spaces - major view is of atrium.
E. - Small scale/residential.
F. - Possible flow through ventilation.
Although this house is definitely not obtrusive on the environment it is obtrusive on the mind. One problem with living underground is the associations of architectural details with events or places perceived or experienced earlier. No matter how nice you decorate the example below, the form gives the impression of living in a drainage culvert. In actuality that is just what it is, and the perception of living in this form can easily undermine any good points concerning structural stability or energy efficiency. This underground example fails "by association" with a dark, dingy, wet, drainage culvert. "For trolls only".
A. Hillside Concept.

B. Circulation: Very simple with entry from a rear patio space.

C. Zoning: Spaces are placed such that main living spaces are adjacent to view and subordinate spaces are placed on the earthside.

D. Ample view provided by windows facing ocean.

E. Small Scale/Residential.

F. Easy flow through ventilation by virtue of two entries.

Fanning out wing walls facing ocean open up space even more.

Units and courtyard walls are designed to reinforce the landscape.

View provided from bedroom though no actual windows in bedroom walls.

Occupant perceives that he is not very deep underground and hence does not feel dominated by the earth.

As a residence and motel it relies on the nearby ocean for a view.
This particular example of an underground house illustrates the concepts of 1) being a part of the landscape thus beginning to relieve the psychological tension of being beneath the earth; 2) a smooth transition into and out of the underground space to allow freedom of physical movement and visual access to the space.

The ability to see through the central space begins to open the space up and make it feel more normal to an occupant. Variety of views from the interior is offered. Views are of visually stimulating subjects such as the water and the surrounding landscape.
14 lightwells provide illumination to the entire interior office area; the south facing glass provides adequate view for occupants but the subject matter for view is questionable.

The 14 lightwells that penetrate the roof/ground do not allow efficient use of this landscape and begin to contradict the apparent intention to not intrude upon the landscape.

The lightwell design does not make the best use of available sunlight from the north (i.e., north reflector).
A. Atrium Concept

B. Circulation: Entry @ end, and central stairs vor vertical.

C. Zoning: Book racks are at the earth side of building interior.

D. View: Major view provided at atrium where some study areas are desks. Many desks are located in area where main view may not be needed.

E. Moderate Scale/Institutional

F. Total mechanical system control of ventilation because of books.

Book racks create a perceptual barrier to the earth.

Major view from atrium is of a tall campus building which provides a reference point to campus and is not overpowering because it would be viewed at its present angle if one were standing at its base anyway.

Light well at two points reduces feeling of confinement and indicates secondary escape route.

Open interior to allow view access to all levels.
A. Atrium Concept.

B. Circulation: Central path with open circulation to book racks.

C. Zoning: Book rack placed on earth sides of main space. The storage and mechanical are placed at the rear under greatest earth mass and least possible view.

D. View: View is provided of an atrium area from interior spaces. A view of the entry court is also accessible from most of the major zones in the space.

E. Medium Scale/Institutional.

F. Mechanical system does not permit natural ventilation.

This building not only reinforces the landforms but also, due to its size, becomes the major definer of the land form.

Interior lightwell/atrium provides light but lacks imagination - the floor to ceiling glass panes make the lightwell seem like a glass cage. Appears that it is used by people very little - no reason to go out into the lightwell. Lightwell provides view of sky only.

Smooth transition into main entry helps give the appearance of entering a hill - not really going underground.

Good zoning of spaces which do not require a view to the exterior - (earth side) walls.
A. Near surface concept with lightwell.

B. Circular central stairs, dual entry. Open interior.

C. Zoning: Dining space near lightwell. Kitchen zoned to rear.

Potential light problems and confinement in kitchen.

D. View: Major view of exterior is provided through lightwell court area.

E. Medium Scale/Commercial.

Use of concrete provides sense of structural stability but may not be the best material to enhance the lighting qualities.

Most of building is buried in site with very little berming and almost none of the building exposed.

Entry areas provide access at two points in building. This could become extremely important not only in case of emergency but also to the occupant who does not like to be in an area where he has only one means of escape.

From vantage point of picture at left it is nearly impossible to tell that the building is underground.
This building is well concealed beneath the surface; only the entry way is visible. The form at the entry begins to work well as an entry/transition piece but fails where the stair descends because the stairwell is too tight.

Natural light is not used and there are no views of the exterior.

The round form is nice and is structurally stable, however it would be better to place storage areas to the outside wall and provide views to a central atrium space. Zoning is not good.

View and natural light are not necessary in an audio-visual room or a dramatic expression area but lack of exterior view and light in a snack bar may tend to give it a dark dungeon like appearance.
A. Deep subgrade category.

B. Circulation: Simple. Shaft elevator to reach deep office space. Corridor to offices.

C. Zoning: Central main space at elevator.

D. View: Offices are not provided with view, nor are research areas. Assumed that because of activity level in these spaces they do not need to have windows as long as a view is provided nearby in a break area.

View provided by "periscope" apparatus in main atrium.

No view is provided in office. Possible flaw in concept that people will be less inhibited by underground if the space mimics above ground offices which usually don't have extravagant details or windows.

E. Medium scale/institutional.

F. Depth of mechanical service does not allow natural ventilation.

Significant building due to technical innovations.

Attempt at transition aboveground as entry to elevator shaft spirals fown.
A. Near Surface Concept.

B. Circulation: Entry from one end.

C. Zoning: Attempts to place auxiliary spaces at edges but since no windows are provided the importance of zoning for view is obviously minimal.

D. View: The lack of windows has not appeared to have an adverse effect on the students.

E. Moderate Scale/Institutional.

F. Total mechanical system control of ventilation.

The emphasis on task-oriented activities that keep a student busy, reduces the need for exterior visual stimulation and thus makes a windowless environment more appropriate.

There are some skylights for natural light and regular outdoor activities are scheduled for the students.

The reduction of distracting outside noise is extremely important in this school since it is close to an airport.

Roof is used as a playground.

Bright colors important to interior.
A. Atrium Concept.

B. Circulation: A major circulation path encompasses the entire complex at its edge. A central entry node and limited access to central courtyard.

C. Zoning: Central play, middle cell area, edge circulation.

D. Windows were provided in each cell overlooking an enclosed exterior courtyard. This is in contrast to the traditional lack of an exterior view for inmates in many prisons.

E. Large Scale/Institutional.

This facility is a large scale complex of buildings which house inmates (400). By putting the complex partially underground with three sides against earth there was a great energy savings. Also by placing the complex underground, security measures might be easier to meet.

This particular environment is an excellent example of confinement and isolation for extended periods of time. Designing prisons underground has great potential but must be carefully done since the feeling of being buried or confined underground could add to the already high level of stress and tension built up from the continual confinement in the prison environment.
With the high arched form of the subway structure and the lighting techniques used, this space has a light, airy, un-oppressive feeling to it; the light is directed toward the ceiling and lower sides; these areas are often dark in an underground building or cave; these areas do not appear dark and ominous, since a normal distant view is at an angle above the horizon, the ceiling here becomes very important and the lighting technique prevents this view from portraying a long dark tunnel.

The articulated form of the ceiling provides an interesting and visually stimulating pattern of light and shadow but does not become visually "noisy".

Overall there is an adequate level of visual stimulation and attention paid to detail considering the short period of time people actually spend in the subway waiting area.
The arch forms and large sub-grade atrium provide light into interior spaces. The arch forms work toward a smooth architectural transition; however, the stair in central atrium is apparently too long.

A major problem is the low ceiling in main shopping areas which gives a tight confined feeling in contrast to the open atrium spaces.

Also there is a disorienting network of tunnels to recessed parts of the interior which does not have any natural light and view; the disorienting and complex tunnel system has been referred to as "catacomb like". This perceived feeling is a major problem in the design and brings up two points: 1) the importance of being able to accurately relate one's position to the above ground environment; 2) the importance that association with another space, such as a catacomb, has on the occupied space.
A. Concept of Design

Based on the placement and form of the building within the ground, the atrium lightwell category is certainly the most common type. The hillside is also very adaptable for most building types. The deep subgrade is not adaptable to residential applications in most cases because it is difficult and much more expensive to bring light into these spaces and provide an adequate view.

B. Circulation Concept

The most successful circulation concepts are those which have a central node with simple and straight forward movement. The open central circulation allows freedom of movement without constricting or confining the occupants. Circulation must be simple and easy to see from all places. Those buildings with circulation which wound around and was hard to perceive at all levels were not as successful. A direct circulation link between the interior main space, the exterior atrium, and the above ground environment is advised.
C. Zoning Concept

The optimum zoning concept involves the placement of all spaces that do not need a view in those areas of the building where view is not possible. Those buildings which placed activities, elements, or storage spaces, near the earth side of the structure and left the major space open to exterior view were the most successful and active. In deep underground spaces zoning based on view was not as important as zoning based on circulation or the location of a major space. Residential zoning places bathrooms, closets, garage, and storage to the rear or no view portion of a building.

D. Exterior View Concept

Adequate view is imperative to a good underground design. An atrium in a residence is usually located off the living room or entry. It may even provide a view to adjacent bedrooms. In larger underground buildings the view is provided to the major space. View into atriums of small cubic shape are not very adequate. View into atriums with large dimensions, sloped sides, or stepped form sides provide the best
visual stimulation. When view is confined to the sky only, perception problems can result. The best views provide the occupant with a view of all three levels of image: the sky, the surround and the foreground.

E. Use Type

Residences in general require the most light and the most view. Offices do not require as much view because the people are in a task oriented job. Schools are also important examples of buildings where the occupants are task oriented in their work and do not require a view during their work period. As long as a view is provided from some other major rest area the view will be adequate. Libraries need to have an exterior view from a central area but not necessarily from the book reading space.

F. Ventilation and Mechanical Concept

In residences it is often placed beneath the slab to facilitate freedom of location of walls. This is recommend but it should be noted that any future problem with the system might mean breaking up the slab. It is also advisable to allow flow through ventilation. Mechanical systems need to be zoned in locations where they are in a non view area and can be easily serviced.
The following drawings and notes are used to illustrate the psychological design concepts which are important to consider. They were developed by an analysis of existing buildings, adaptations and analogies from other research sources, and finally from personal observations of perceptions in underground buildings. The concepts were derived by making intuitive estimations of how a space might be perceived and the ways in which various design elements can be manipulated to create a space that is not oppressive or confining to be in. The concepts are related not only to the functions of spaces, but also to the depth of space, type of site, degree of confinement, and relationships of interior to exterior environments. Several concepts are grouped together under headings such as zoning, confinement, window placement, visual stimulation and transition.
A basic element in design is the degree of isolation from the outside environment. As isolation increases the degree of confinement becomes very important. When isolation is most severe, the need for alternative perceptual stimulation increases.

No physical barrier between man and environment.
Exterior spaces easily accessible.
Total interaction with nature.
Full effect of environment on man is evident.

Home environment.
Easy visual access.
Physical relationship is seen (perceived).
No direct physical contact with outside environment.
Physical buffer.

Limited visual obstruction.

Exterior environment still accessible.

Exists in large scale projects where physical barrier is extensive but the outside environment is still visible.

No physical contact.

No visual contact.

Normal source of perceptual stimulation has been removed.

Totally interior oriented space exists.

Confinement level - critical.

Psychological design considerations imperative.
Confinement is somewhat different than isolation. Confinement is the restriction from movement or access to sources of stimulation. As volume decreases and enclosure increases the feeling of being confined increases as well.

It is possible to be isolated from the exterior environment without being confined.

The tolerance for confinement may be related to the ease of movement from a confined zone to one of a less confined degree.

As the degree of confinement and time spent in confined areas increase - more time must be allowed in a less confined area.

As the degree of confinement increases the transition element becomes more important.
People in intensive care units in hospitals and those people recovering seem to develop adverse psychological reactions when kept in windowless environments for long periods. The rest/break areas still need views of natural elements and environments.

Tendency of spaces to be more task or attention activity oriented.

In aquariums and theaters occupants are flooded with mental stimulation and don't expect windows to be there.
People in intensive care units in hospitals and those people recovering seem to develop adverse psychological reactions when kept in windowless environments for long periods. The rest/break areas still need views of natural elements and environments. Tendency of spaces to be more task or attention activity oriented. In aquariums and theaters occupants are flooded with mental stimulation and don't expect windows to be there.
Windows provide light, heat, ventilation and view. The psychological impact of taking away these natural sources of stimuli can be extremely detrimental.

Windows can enhance a space not only by providing a source of visual stimulation, but also by increasing the perceived size of a space. This can be critical in an underground space.

Studies show that views with a high information content are preferred over simpler views. Thus being able to see more than one element is important. As one moves away from a window the angle of view decreases and the desire to be close to the window increases. Views of active spaces are preferred over static spaces.

Near objects are perceived in greater detail and thus require a larger window to satisfy the mind's need for information. Far objects appear smaller with less detail and require less window size.
Window placement is important in maximizing the desired psychological impact of light and view in a space.

Small windows are more energy efficient but give a narrower angle of view and require careful analysis of intent.

Place windows to maximize view and light collection.

Try to combine window penetrations to act as both light gatherers and as sources for major visual stimulation and connection with the exterior.

Studies have shown there is a preference for wide windows over tall windows for their quality of information.

Windows at sides may light walls but do not provide view if walls are extended.

Central windows provide strong view.
Windows can be used, as stated before, to increase the perceived size of a space.

The placement of windows at the joint of two walls can serve to make the perceived edge disappear. If the edge of the wall does not extend beyond the glass outside the wall, then the view will not be obstructed and the space will appear to be more open since the corner has disappeared.

An entire window wall will begin to make that edge disappear and decrease the confinement of a specific space. The interior space will appear to continue on until the ceiling and wall planes stop.
Visual stimulation is important to a good design. In a normal exterior environment or a building with windows the eye is constantly receiving a vast amount of information. The mind normally seeks to be stimulated although the acceptable level will vary with the individual. In a space with very little stimulation the eye will be drawn to a single focal point. In a space that has a great deal of visual information coming in from all angles the central focus may be lost. This high level of visual activity certainly may be desired, but it should be considered that it may distract from a given focal point.

It is also possible to reach too high a level of visual stimulation causing a person to feel uncomfortable in that space.
An atrium without some element within it to provide visual stimulation does little more than a skylight would to bring in light and provide a view of the sky.

Elements such as planters in the atrium provide visual stimulation and direct view and attention in a horizontal direction rather than a vertical direction which might be analogous to looking out of a hole in the ground.

To enhance the horizontal direction of view, increase the variety of views. Layering of elements may be used. This layering can reduce the perception of the atrium wall. Layering of elements can also be seen in the interior-exterior-interior transition. Here, a view of adjacent interior spaces through an atrium may serve to reduce the separation of interior and exterior and make the spaces work together as a whole.
The importance of a view of the nearby site may be a function of the content of the subject matter to be viewed. In order for the desire to see the surrounding environment to be high it is necessary to have a visually stimulating environment. The internal environment will become more significant if the nearby land is flat and "lifeless" such as a desert; however, when the underground structure is near a significant site feature, such as a mountain, which provides a beautiful subject for viewing, the restriction of this "known view" will begin to create problems.

If the exterior has a high level of visual activity already it will be impossible to compete with it and even stressful to restrict access to that element.

If the exterior is bland and contains very few worthwhile features the visual stimulation becomes very important on the interior.
Research has shown that task oriented environments such as school classrooms may not require a significant view in order to be a productive work environment.

In lower grades where the activities require less intensive work the view may be necessary for visual stimulation and can also provide a learning experience about the environment. In non-task oriented spaces where attention is not directed to one activity, a view is necessary.

Though windows may be desired in non-task oriented spaces, they may cause a distraction in some cases. This must be taken into account.

As long as windows for view of an exterior environment are provided in a nearby area. The absence of windows in a space should not cause any adverse effects in a task-oriented space.
When a deep and narrow atrium is used view is limited to the sky or very close, tall objects and all light enters space from above. With the only available view being straight up the space begins to be perceived as a hole in the ground with very little relationship to the above grade environment. The placement of an underground building above the surrounding grade level allows for light, view, and ventilation from any or all sides. This facilitates making those connections which will relieve stress arising from an uncertain relationship with the surrounding environment.