ISSN XXXX XXXX © 2017 IJESC

Research Article Volume 7 Issue No.4

Incorporating Sunlight in Underground Spaces

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Abstract:
The purpose of this research is to study different types of methods and systems which can be incorporated for allowing natural lighting in underground spaces. Existing planning techniques and lighting principles were studied to derive the efficient ways to implement natural lighting performance in underground buildings. The main aim is to develop a lighting system which can be used in underground spaces of commercial buildings. Upper floors unable planning open spaces which are extant techniques for allowing sunlight into underground spaces. Allowing even ambient lighting into deep spaces was an essential matter. This method can help avoiding the planning of large open spaces and increasing the flexibility of design for planning underground spaces. Results show how incorporating natural lighting in underground spaces can improve the living conditions and indoor environment. And how the working conditions enhances in such spaces by the use of these techniques.

Keywords: underground architecture, day lighting, light pipes, shafts, atriums

1. INTRODUCTION:

Stress on the environment created is becoming more and clearer in the form of pollution, environment degradation and the loss of top soil, making the land barren and unusable. So underground can be a great alternative for living and commercial uses. It helps in saving nature. If we provide green roofs over an underground structure it will help in reducing soil erosion, sedimentation, and storm water runoff. These features can be mixed with the contemporary techniques to save energy like solar panels, atriums etc. Underground architecture means constructing properly designed spaces below ground level below ground level which are functional and have all the amenities that an above ground structure have. Spaces lie mostly beneath the ground surface. The surrounding soil provide natural insulation provided by the walls and floors. People living underground feel suffocated or get depressed easily because they just sit in a room without any natural ventilation and light. So to make them comfortable for living, green features like natural ventilation, light, thermal insulation should be incorporated when designing the underground spaces. Therefore the research has focused on the natural lighting environment in underground spaces. The motive is to incorporate methods for introducing natural lighting in underground buildings. Existing underground buildings were studied to recognize the limitations and techniques to be used.

2. UNDERGROUND ARCHITECTURE:

Underground architecture means constructing properly designed spaces below ground level below ground level which are functional and have all the amenities that an above ground structure has. Spaces lie mostly beneath the ground surface. Soil can provide an insulated space in the earth against temperature changes by increasing thickness and it can delay variations of annual temperature due to its great thermal mass. The daily change in temperature is negligible in depths over 0.6 m. In a few meters under the ground level, air temperature remains same during a year, which provides a warm atmosphere in winter and a cold atmosphere in summer. Therefore, there will be minor demand in energy for increasing or decreasing the space temperature and providing convenient conditions for human beings without loads of energy consumption. Furthermore, left over spaces on earth allows the development of more green spaces and more amalgamation and ordination with the environment. Generally compared with architecture above ground, which withstand hard weather conditions, variation of air temperature, effects of humidity on materials, and uncertain conditions, underground architecture can serve intact spaces with thermal comfort.

2.1. DAYLIGHT IN UNDERGROUND SPACES:

Day-lighting is the restrained introduction of natural light-direct sunlight and diffuse sunlight into a building to reduce electric lighting and thus save energy. By giving a direct link to thermodynamic and constantly changing patterns of outdoor lighting, day-lighting helps to create a perceptibly stimulating and generative environment for building inhabitants, while condensing nearly one-third of the total building energy costs. The interiors of underground facilities needs daylight. Some of this demand can be adequately met by favourable architectural design, as the adequate orientation of openings and well apprehend sky lighting.

3. DESIGN FEATURES THAT CAN BE INCORPORATED IN UNDERGROUND SPACES:

Light can access underground spaces from various means, it can be outfitted from ceiling light, an internal yard or atrium, or from different sides of the building. Cases mostly appear where the establishment of high technology may be an efficient tool. Solar optics which operates approved plastic Fresnel optical lenses which trail the sun optically and enables sunlight deep into the interior underground spaces. In extension to daylighting by favourable architectural design and by passive optical systems, production of electricity is an important part of forming a imperishable environment for self-sufficient living. Systems which can be incorporated are:

3.1. LIGHT PIPES:

Light tubes also known light pipes are used for carrying or circulating natural light. In their usage to daylighting they are often known as sun pipes, sun scopes, sky lights or daylight pipes. Basically, a light pipe or tube may address to a tube or pipe used for carrying light to another area, reducing the loss of light, a transparent tube for circulation of light over its

length, either for even distribution along the whole length or for limited light effusion. A tube coated with highly contemplative material leads the light rays over a building, originating from an entrance-point situated on its roof or any outer wall. A light tube is not meant for imaging, thus image distortions makes no problem and are in numerous ways inspired due to the subtraction of 'directional' light. The origin point usually has a dome, which has the task of gathering and reflecting as much sunlight as credible into the tube.

Types of light pipes are as follows:

a. **Open shafts**: This is the most primitive form of light tube. It is basically vacant shaft through which a beam of light can pass. Lenses are used to keep the beam concentrated, but light is diffused as it goes through each lens. Reflective metal pipes are generally idiolized but any off-axis light has to go through numerous reflections, so uncollimated beams will contract after a few meters within the tube.

b. Fibre optics: The fibre optic bundle made of glass or plastic, can have great transmission characteristics. Mostly between 3-16 percent of the light is dissipated per metre cable run. The use of this optic can also enable a flexible solution, with much lesser shaft sizes than an open pipe and the capacity to turn corners.

c. Prismatic shaft: To save the weight associated with solid acrylic rods, the rod can be notched out and the prismatic sides of the tube conduct light in the required direction.

d. **Liquid light pipes**: A latest technology has been refined which carries light through very small diameter liquid light pipes. This system is same as the fibre optic system and can be more flexible.

3.2. SKYLIGHTS:

Skylights implanted horizontally in sloped or flat roofs provide a ceiling height of uniform level. Skylights are generally efficient for the lighting of horizontal tasks. The efficiency of skylights differs under clear skies or overcast skies. Thermal gain is an issue in hot climates. Skylights functions best for one-story buildings.

Figure 1. Skylight in sloped roof

3.3. ROOF MONITORS:

Roof monitor is a high rise structure running along the side ridge of a double sloped roof. Its own runs parallel with the main roof. Clerestory windows or louvers are constructed on the long sides of monitors to incorporate light or ventilate in the area under the roof. Vertical or sloped Glazing may be used accordingly. Monitors should not be placed on east and west orientations.

Figure 2. Roof monitors in commercial building

3.4. SAWTOOTHS:

A saw-tooth roof comprises a row of ridges with two pitches on either side. The sloppy surfaces are glazed. To protect workers and machinery from direct sunlight it is designed away from the equator. This type of roof introduces natural light into an underground building. To provide even, natural light over a large space, without the issue of direct sunlight and its heat, the saw tooth roof is designed with its glass panels facing towards north. It is useful in designing of factories and manufacturing buildings. Structures with saw tooth roofs show apertures with angled or vertical glazing incorporated in a sloped roof plane.

Figure 3. saw-tooth roof

3.5. COURTYARDS:

A confined area, often enclosed by a building or complex that is open to the sky is known as a courtyard. The north orientation should be the open segment to minimize glare and to reduce the necessity for sun control in partly encased courtyards. It is an open space implemented for direct lighting. Ground materials and building facades should reflect daylight and sunlight without booming glare for the users.

Sunken exterior courtyards: On a flat site, utilize sunken exterior courtyards in underground facilities to provide sunlight, view, a connection to the outdoors, and to improve orientation within the facility. Design the courtyard to maximize sunlight penetration, utilize plants and other natural elements, and make the courtyard accessible to people.

3.6. LIGHTWELLS:

A non-roofed exterior space present within the extent of a large building to enable light and ventilation to reach the area that

would otherwise be a dark and poor ventilated area. Lightwells may be coated with glazed bricks to escalate the reflection of sunlight within the area. Lightwells serve to minimize the requirement for electric lighting, provide an internal open space for windows to provide an illusion of having a view outside and add a central space within the building.

Figure 4. lightwell

3.7. ATRIUM:

A huge open air or skylight covered area surrounded by a building is known as 'Atria'. Modern atria are generally several stories high and have a glazed roof or large windows. They are often located directly beyond the main entrance doors. It is used for introducing light and ventilation to the interior. Atria is a prominent design feature because they provide their buildings a feeling of space and light. The atrium has become an important feature of many buildings in latest years. Atria are popular with building users, building designers and building developers. People like atria because they create a effective and appealing interior that provides shelter from the outer environment while maintaining a visual network with that environment. Architects enjoy the contingency to create new types of spaces in buildings. They see atrium as impressive facilities that can improve commercial value and appeal. An important aspect of contemporary atrium design is fire control. Due to elucidation that poorly designed atrium could enable fire to spread more quickly to a building's upper stories.

Figure 5. atium at a shopping mall

Interior atrium spaces:

Create multi-storey interior atrium spaces within underground facilities to provide extended views, visual stimulation, a sense of orientation, sunlight, and a focus of activity within a building. It is one of the most powerful and versatile design pattern available. With respect to orientation and image, the atrium space provide central landmark and is a part of a major circulation path. It provides a major means of relieving feelings of confinements. Long views are available and smaller spaces actually can overlook floor levels below. Advantage of this indoor courtyard is that a summertime environment can be maintained throughout the year. The lively interior atrium is successful in the commercial settings as the major circulation paths pass adjacent or through the atrium.

4. CONCLUSION:

The result of this research can be used to design underground buildings with natural lighting performance. Minimum open spaces are capable to introduce and implement daylight. By applying and modifying the presented lighting system, underground spaces can be planned with more flexibility and also with advanced lighting environment. Underground construction, with proper design, can have a great effect on minimizing electric bills. It is also expected that these design features can be developed in ways to show other environmental features. By developing the results of this research, other environmental functions like air flow and temperature control can also be considered.

5. REFERENCES:

[1].Raymond Sterling, Underground Spaces

[2].F.B. Lembo, F.P.R. Marino, C.I. Calcagno, "Semi-Underground House Models as New Concepts for Urban Sustainable Environment", International Conference on Green Buildings and Sustainable Cities

[3].S.N. Durmisevic, "The Future of the Underground Space"