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Investigating Architectural Techniques for Designing and Creating Sustainable Spaces

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Abstract
The impact of architecture on the environment has turned out to be an important issue for which much research has already been conducted. Although the earth (soil) constitutes a major part of the environment, its use in creating sustainable architecture has not yet been precisely studied. The article focuses on earth (soil), as one of the oldest ecological building materials, and presents new ideas and technologies regarding its use. As a result, the use of earth in creating sustainable architecture will be discussed.
Keywords: Ecological building materials, building, energy, environment, sustainable architecture

Introduction

From ecological point of view, buildings are considered to be detrimental to the environment. Today, there exists a great number of building materials and, accordingly, a wide variety of new ideas. The characteristics of the ecological building materials can be defined as follows:

- They should provide the health of the consumers; natural materials enjoy such characteristics.
- Their transportation needs less energy and they produce less pollution; local materials enjoy such characteristics.
- Their production, likewise, needs less energy; again natural materials enjoy such characteristics.

New building materials and techniques should be eco-friendly, recyclable, and reusable at least once, or several times (Pearson, 1989). Traditional building materials have been good samples of ecological materials, and innovative use of them is observable in new constructions. To provide consumers' health, the building materials should have the following features, as well:

- They should be free from pollution and toxic components.
- They should not make annoying noises.
- They should be resistant to radio-active and electromagnetic radiation (Randall, 1992).

The research investigates the advantages and disadvantages of the earth (soil) and its impact on the environment.

Research Method

Based on former studies, the research investigates the characteristics of the earth (soil) and its application as one of the oldest building materials. Through observation, different styles of using earth (soil) in architecture in order to reduce energy consumption will be studied.

Findings

In order to evaluate the environmental impacts of building materials, different issues including energy consumption, energy resources, global warming, toxic and acid rain are taken into consideration. The amount of energy needed to produce different materials is as follows:

Very high: aluminum, plastics, copper, stainless steel, 100-250 GJ/ton

High: steel, zinc, glass, cement, 10-60 GJ/ton

Medium: limestone, clay brick, tile, gypsum, 1-3.56GJ/ton

Low: sandstone, volcanic ash, 0.5 GJ/ton

In case the production process of a material is lengthier, the requiring energy is higher, and more waste is remained by its production. Therefore, the more the materials are close to their natural state, the less the energy required for their production.

On the other hand, the durability of the materials is of great importance. In fact, the more a material is durable, the less the building affects the environment, since there will be a reduction in energy consumption as well as in pollution (Roaf, Fuentes, & Thomas, 2007).

Earth (soil) is one of the oldest natural building materials which is available everywhere. While being harmless to human health, earth (soil) consumes a very low amount of energy without leaving any pollution.

Earth sheltered buildings

Earth sheltering is an architectural experience in which the outdoor building walls are covered with earth (soil) so as to reduce heat loss and to keep a steady indoor air temperature. In modern times, earth sheltering is embraced by advocates of passive solar systems and sustainable architecture. Earth sheltered buildings reappeared after the 1973 oil crisis due to scarcity and expensiveness of energy resources (Randall, 1998).

In most buildings, space heating is the main energy consumer. Two major causes of heat loss are infiltration and heat transfer by conduction. In earth sheltered buildings, infiltration is reduced because the wind is separated from the building structure by the earth cover. Without direct contact between walls and wind, the outside air cannot infiltrate the building. In addition, the conduction is reduced because the earth covering acts, to some extent, as insulation.

Earth (soil) has also other advantages. It is a good insulation for noise, and few vibrations can pass through it. It is also fire resistant like other materials used for building structures such as concrete and stone. Storms cannot affect buildings constructed by such materials.

Passive solar buildings need materials with high thermal inertia, but in earth sheltered buildings, the thermal fluctuations are reduced by earth (soil) coverage. In ordinary buildings, the exterior walls absorb an excessive amount of solar heat in summer, but in earth sheltered ones, the heat slowly moves within the walls. The temperature of each consecutive layer of the wall should be changed before the heat moves toward the next layer; thus the slow process prevents the heat flow (Pearson, 1989). The external temperature fluctuations have trivial effects on the temperature of the inside spaces and keep it relatively stable. Earth sheltered buildings are almost warmer in winter and cooler in summer.

The building patterns are as follows:

- Soil (earth) is placed and packed against the exterior walls sloping downward. The roof may be fully covered by soil. The buildings above ground have rarely the moisture problem. If there is such problem, it can easily be removed.
- In natural or artificial hills, the houses are mostly built on the slope side. The ideal situation is when the slope is southward (or northward in southern hemisphere).

• Underground architectures are made by excavating the ground. An atrium is necessary for light and ventilation.

Although the advantages of earth sheltered buildings are numerous, the earth (soil), as a thermal mass, has potential disadvantages as well:

• Moisture may appear due to water penetration. The waterproofing can be threatened by the water infiltrating from around the ventilation pipes.

• Indoor air may have a poor quality and a high condensation. For this reason, there should be enough ventilation.

• The materials for earth sheltered buildings are not biodegradable, such as plastics for waterproofing and concrete for the construction.

Studies to find materials which are more eco-friendly are being conducted. Excavating the site is also time consuming and needs manpower. The price of earth sheltered buildings is less than ordinary ones, since they need less finishing and their maintenance is more economical.

For earth sheltered buildings, the site planning is a necessary part of the design. Many factors should be taken into consideration when investigating the landscape of the site. The site's topography shows flat land and the direction of different slopes. The climate of the region is also of great importance. The main issues for cool and temperate climates are retaining heat, preventing infiltration, receiving winter sun heat, using thermal mass, and preventing wind in winter, and shading and ventilation is summer. Earth sheltered buildings are ideal for the regions with excessive warm summers and very cold winters. In humid regions, there should be greater precautions to avoid air condensation.

There cannot be an absolute notion for earth sheltered buildings. In all the buildings with a basement, the situation of the basement causes a further protection by the soil, and there is more glass surface on the southern side.

A green roof is the roof of a building which is completely or partially covered with soil and plants over a waterproof membrane. Such roof may have additional layers like root barrier layer, drainage layer, and irrigation layer (Figure 1).

Figure 1: A green roof

Conclusion

Designing is based on the principle that considers the building to be a part of the surrounding nature. According to this principle, the building acts as a part of ecosystem and life cycle. The negative effects of building activities should be reduced through using less-toxic and recyclable materials. From the ecological point of view, the earth (soil) architecture is the most eco-friendly architecture. The earth materials, in form and meaning, are consistent with human's nature. The potential characteristics of the soil (earth) and using it as a building shelter can be introduced as a designing strategy for a significant reduction in energy consumption, thus providing a better living environment for human health and welfare.

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