Materials, Structure Design and Thermal Energy Management for Green Building

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Abstract. This essay will introduce an increasingly popular topic: Green building. We list 3 important fields of green building technology, which are materials, structure design and energy. In each part we will introduce some advanced technologies and evaluate them with some principles.

Key words: Solar energy, Greenhouse material, Structure design, Thermal energy.

1. Introduction
The Green building is one of the most important academic nouns in the construction field. In modern society, the use of green building technology inside buildings is a way to save natural resources and protect the environment. The general aspects that are used to evaluate a building whether it is green building are the green material, structure design, and required energy. In this essay, we are going to introduce the functions, theories, and details about green building technologies with reliable information. In addition, we introduce some practical devices and buildings that already been created by experts as examples.

2. Green House Materials

2.1. Insolation Material
Heat preservation material is to point to heat coefficient is less than or equal to the material of 0.12 commonly. Thermal insulation materials develop rapidly, and the use of good thermal insulation technology and materials in industry and construction can often have twice the result with half the effort. For every ton of mineral cotton insulation used in a building, one ton of oil can be saved per year.

2.2. Solar Cell Material
Solar panels are devices that convert Solar radiation into electric energy directly or indirectly through photoelectric effect or photochemical effect by absorbing sunlight. The main material of most Solar panels is silicon.
First, mono-crystalline is a good choice. Its photovoltaic efficiency is about 18%, with the highest reaching 24%. This is the highest of all kinds of solar cells, but it is so expensive to make that it cannot be widely used. The production process of polysilicon solar cells is similar to that of mono-crystalline silicon solar cells, but the photovoltaic conversion efficiency of polysilicon solar cells is much lower, which is about 16%. In terms of production cost, compared with mono-crystalline silicon solar cells are cheaper, the material manufacturing is simple, save power consumption, the total production cost is lower, so it has been developed in large quantities. In addition, the service life of polysilicon solar cells is shorter than that of mono-crystalline solar cells. In terms of performance-to-price ratio, mono-crystalline solar cells are slightly better.

2.3. Degradable Material
Biodegradable materials are materials that are thermodynamically and dynamically degradable over a period of time. According to the external factors of degradation, it can be divided into photodegradable materials, biodegradable materials, etc. The main influencing factors are temperature, molecular weight, material structure, etc.

3. The Structure Design of the Green Building
Structural design refers to the realization of certain requirements like reducing energy consumption of buildings by changing the geographical location and layout of a building.

3.1. Orientation of the Building
Orientation of building refers to the direction of lighting surface. A good building orientation can maintain comfortable temperature and ventilation, which reduce using of electrical devices like air conditioner. There are 2 major factors that influence the choice of orientation. One is Sunlight. The principle of selection is to obtain more sunlight in winter and avoid excessive sunlight in summer. The other is dominant wind direction. Dominant wind direction refers to the most frequent wind direction during a certain period of time. It will affect the indoor heat loss in winter and natural ventilation in summer. For houses located in northern hemisphere, it is better to choose south-directed orientation. Since sunlight shine from south in winter to provide warmer temperature. And at summer, roof can avoid sunlight to keep temperature cool.

![Figure 1. Different sunlight path in winter and summer](image)

3.2. Greening
Greening refers to plants grown to improve environment and it is also a part of green building design. Proper greening can bring many benefits to the surrounding environment. Plants can Absorb harmful gases from the atmosphere. For example, greening can effectively reduce the nitrogen oxides in automobile exhaust. Plants can also help adjust the temperature. In process of transpiration, plants evaporate water to reduce temperature.
3.3. Windows
Rooms exchange heat and air with the outside world mainly through windows. So a proper position of windows and styles can make room more livable.

Usually, a window with area between 1/3 to 1/4 of wall can provide enough sunlight for illumination. North-South facing windows can provide more comfortable temperature for human. But good ventilation has a disadvantage. When using energy to heat or cool room, windows can waste about 25 percent energy through heat conducting. Careful placement of windows to protect them from sunlight and wind can reduce this energy waste. In addition, doors and windows facing east or West wasted twice as much energy as those facing north or south. Besides, reducing size of windows can also reduce energy loss. [2]

4. The Thermal Energy
Heat is considered a low-grade form of energy. While less useful than other forms, thermal energy storage allows it to be captured, stored and used later. One of the most challenging tasks for green buildings is to find the best way to store the thermal energy inside or around the building with minimum costs. Thermal storage is using PCM (Phase Change Materials) to store energy, and PCM has multiple but specific advantages and disadvantages.

4.1. Sensible Heat Storage
The sensible heat storage stores thermal energy in a heat storage medium whose temperature change is the result of the addition or removal of heat. The capacity of sensible heat storage is determined by its specific heat and the mass of the heat storage medium as well as the allowed temperature change in operation. The figure 2 below shows the example of the process of Sensible heat storage works.

![Figure 2. The example of using Sensible heat storage [3]](image)

4.2. Thermal Chemical Storage
The term "thermal storage" encompasses a wide variety of technologies, but most currently fall under sensible heat storage. Thermal-chemical energy storage is a new technology which provides the advantage of high storage densities and minor thermal losses. This makes the technology attractive for low-temperature long-term storage as well as for high-temperature storage. The storage mechanisms range from physical adsorption to reversible chemical reactions, some of the storage materials are available. New materials are under development to further improve the material properties regarding storage quantity and heat transfer. The figure 3 below is an example that shows the process of how Thermal-Chemical Storage works. The thermal-chemical storage is now more and more popular than them in the past, which means the buildings that currently constructing are mostly using this method.
4.3. The Equation of the Efficiency on Thermal Engine
The basic formula on efficiency is known as Carnot efficiency.

\[ \eta = \frac{W}{Q_H} \]  

\( W \) is the useful work and \( Q_H \) is the total heat energy input from the hot source. There are a lot of devices that use thermal energy for a certain purpose in families, which rise a problem that how we can use the thermal energy in the most efficient ways. Scientists and engineers are struggling with this issue in creating new green building technologies. As we all know that the more efficient using energy a device can be, the more energy can be saved from doing the same amount of works. To find an efficient way of using thermal energy, we need to understand what affect efficiency.

Heat engines often operate at around 30% to 50% efficiency, due to practical limitations. From the figure 4 above shows, heat engines can't achieve 100% thermal efficiency (\( \eta = 1 \)) according to the Second law of thermodynamics. As figure 4 shows, there is always some wasted energy on the thermal engine.

4.4. The Example of Efficient Devices on Using Thermal Energy
One example of reducing the input of the energy is Smart Thermostats. [5] Although programmable thermostats, which allow you to set different temperatures for different times based on a day-to-day schedule, can help to reduce wasted energy, smart thermostats are even more energy efficient. What makes a smart thermostat so special is the number of options it provides users for the entire building.
5. Conclusion

In conclusion, the following points should be considered when considering the technology used in a building. First, the technology should be energy efficient, sustainable and not harmful to humans. Second, the appropriate technology should be chosen according to people's requirements. Last, the appropriate technology should be selected according to the geographic information of different regions.

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