Toward a New Direction on Architectural Design Principles of Green Hospitals in Korea

- Focused on cases of Junglim -

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1. Introduction

The discussion on the sustainable green building was initiated in the United Nations Conference on the Human Environment in 1972. In 1999, the study on architecture which has handled environmental problems through the OECD sustainable building project was begun. In 1991, the United Kingdom decided to introduce Building Research Establish Environment Assessment Method (BREEAM) as Green Building Certification Criteria. Since then, the British government has promoted sustainable and environment-friendly architectural planning and development. At present, about 40% of total energy produced on earth is consumed in constructing, maintaining and demolishing buildings. Hence, it is essential to consider environment-friendly aspects in architecture. In particular, sustainable and environment- friendly architecture is especially important in hospitals in which energy consumption is particularly high.

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This study is aimed to investigate how both passive and active design factors were reflected in Pusan National University Yangsan Hospital and Seoul National University Bundang Hospital after examining the principles of the Green Design and analyze the energy saving and environment-friendly design of 'Green Hospital.'

2. Green Architecture

People from around the world have become more interested in environment. We cannot even think of development without considering environment. In fact, urban environment is closely related with a sustainable system. Now, we need to see a building as a sustainable space.

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First, we should understand that construction materials can have an impact on building energy and heat. So far, we have mostly considered short-term profits only in choosing construction materials without considering environmental aspects. However, this kind of attitude can harm both human and environment from the long-term aspect. Second, we need to think over natural design. We should create a sustainable space based on nature-friendly design, not destructive design.

'Green Building'is built based on ecology which studies correlations between an organic body and its inorganic and organic surroundings. It is the architecture in which nature and architectural environment coexist in harmony. In other words, the building created by human is reorganized based on the principles of cycles in the ecosystem, and then the artificial ecosystem is organically integrated with natural ecosystems.

'Green Building' which has been widely spread across Europe (especially in Germany) is a good example of environment-friendly architecture. The specific goals of the green building are as follows:

1) To reduce fossil energy consumption by maximizing and optimizing the use of natural energy

2) To save natural resources through the use and recycling of natural materials

3) To be harmonized with natural landscape

4) To improve human health and amenities[3)]

'Environment-friendly Architecture' may include various concepts such as nature-friendly architecture, ecological architecture, green building, energy-saving architecture, resources-saving architecture, building with minimization of environmental pollutions and local characteristics-specialized architecture. The ultimate goal of the Environment-friendly Architecture is to protect global and local environment and construct a building whose impact on natural ecosystems is minimized.

In addition, the Environment-friendly Architecture can be defined as architecture which saves energy and resources throughout the construction processes from the production of construction materials to the construction, maintenance and destruction, protects natural environment through harmony with natural landscape and pursues human health and pleasant and refreshing environment.[4)]

2.1 Green Design

In green building design, understanding of land characteristics and weather conditions is a top priority. This kind of design is aimed to minimize energy consumption. In case of Korea in which temperature difference between summer and winter is big with distinctive four seasons, for example, passive design would be a good choice in spring and fall. For this, it is necessary to set a goal first. Then, load should be reduced as much as possible to create refreshing indoor environment, and then active design should be applied.[5)]

1) Passive Design

Passive design includes recycling of construction materials and resources as well as energy with a goal of saving energy and creating more refreshing indoor environment.

In other words, passive design is an architectural technique which is aimed to save energy and use natural energy without using facilities and electricity. In fact, passive design has an advantage to strengthen local characteristics and maintain balanced environment.

2) Active Design

In a passive system, cooling and heating systems

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are generally operated in a natural way. In an active system, on the contrary, cooling and heating systems are operated using specific equipment and facilities.

In a passive system, the energy supplied into the building such as solar thermal is fully received. In an active system, on the other hand, it is not operated until a certain temperature is reached. Hence, an active system is greater than a passive system in terms of energy consumption.

To take advantage of the design which includes technical and facility factors, an active design has been chosen.

2.2 Green Design Strategies

Green buildings feature either an active or passive system. In a passive system, for example, the use of windows and doors is maximized without power sources such as electricity and gas. In an active system, the opposite occurs.

1) Envelope

The consideration of building envelope starts with building layout or window and ceiling plan.

In general, it is designed for a building to face to the east or west with windows on the south and north facades to make it easy to get sunlight.

A strategic design can be approached through the use of insulating materials and rice-sheaf structure, double covering and green roofing.

2) Lighting

The sunlight in a building is a critical factor in green design. Daylighting is good energy performance and a key factor for customer satisfaction, productivity and health. In general, successful lighting conditions have a big impact on building mass or zoning activities. Therefore, daylighting should be clearly stipulated in a master plan.

3) Heating

The simplest way of heating a building is to get solar heat (either allowing thermal radiation or storing solar thermal). A well-insulated building with good windows would be a very efficient option to take advantage of the solar energy.

4) Cooling

The most effective way to cool off the machine with the minimum use of energy is to eliminate the necessities to use energy through climate-adapted design. This method is not available all the time, but it can significantly reduce execution time or the size of a mechanical cooling system.

5) Energy Production

The consideration of field energy production starts with the review on an energy efficiency strategy. First, we need to make all possible efforts to reduce demand for energy consumption. Once the demand is decreased, we can reduce the size of a generating system or offset the load of building energy in high percentage.

6) Water and Waste

For decrease of water use, it is necessary to develop and implement a proper strategy. An efficient water management strategy such as low-flow facility or automatic control does not require an additional initial cost. It requires a short compensation period. Other measures such as recycling of wastewater or use of rainfall in construction wetlands cause huge costs.

2.3 Green Architecture Evaluation

In Korea, Green Building Certification Criteria (May 2008) and the specific guidelines (August 2006) on both private and public green buildings were enacted by Ministry of Land, Transport and Maritime Affairs and Ministry of Environment. The City of Seoul also enacted the Green Building Criteria in August 2007 and has actively operated them through certification

agencies such as Korea National Housing Corporation, Korean Institute of Energy Research, Korean Institute of Educational Environment and GreBiz QM.

The subjects of the Green Building Certification Criteria which were enacted by Ministry of Land, Transport and Maritime Affairs and Ministry of Environment are seven buildings including apartment, commercial-residential complex, office building, school, commercial building and accommodations. They are evaluated in 4 categories; transportation: 4, energy, resources and environmental load: 7, ecological environment: 5 and indoor environment: 5 (21 sub-categories in total). Additional scores could be added by category.

In particular, energy consumption is especially high in medical facilities compared to general buildings. Hence, it is urgent to come up with a plan for efficient energy use in hospitals. In Korea, no Green Building Certification Criteria specialized for medical facilities such as LEED[6] for Healthcare are available yet. The additional categories for medical facilities only among LEED HC v2.2 evaluation items are as follows:

- Redevelopment of polluted land or development of land (except for flooded area or land in whichendangered species live) without destructing ecosystems
- Sufficient outdoor shelters for the staff and patients
- Ban on combustions and oil leakage
- Ban on use of water for landscape irrigation or machine cooling and use of condenser or water-saving sensor
- Use of new & renewable energy without using coolant and energy-saving commissioning from the early stage of deign
- Use of energy-efficient medical equipment
- Use of recyclable materials, recycling of furniture and fixtures, flexible planning in consideration of spatial changes and design of endurable buildings
- Ban on the use of the materials and equipment which include harmful materials or heavy metal
- Introduction of a natural air circulation system if natural ventilation is allowed
- Effective noise and vibration control
- Longitudinal study for improvement of building performance and dwellers' health

According to an analysis of green building certifications during 2008 in Korea, most certifications were done in schools. The City of Seoul has offered a variety of incentives to green buildings in addition to tax benefits. For example, the municipal authority has supported the expense for Green Building Certification since April and increased floor area ratio up to 10% in apartments.

3. Green Healthcare

Green Healthcare which includes 'Green Building' refers to all hospital green activities which enhance patient healing and make a contribution to green environment.

In other words, Green Healthcare refers to the supply of green medical services to patients and local community. For example, Green Healthcare activities include construction of a green building with wood, use of green materials such as organic food, decrease in the production of medical wastes and purchase of environment-friendly medical equipment.

The H2E self assessment guide of Practice Green, an American Green Healthcare agency, which is aimed to realize green medical services more easily includes management of general wastes, management of solid wastes, decrease in the production of wastes & recycling, management of medical wastes, hazardous

6) Leadership in Energy and Environmental Design

waste management, purchase of green products and energy saving.

3.1 Concept of 'Green Hospital'

A hospital can be transformed into a space in which healing is carried out under optimized design and environment-friendly atmosphere through Green Hospital. 'Green Hospital' refers to a hospital which targets to save energy by reducing carbon emissions and production of wastes.

A hospital is an essential facility to patients. Even though greenhouse gas emissions and energy consumption have been high in hospitals, they have almost been exempt from energy management restrictions. However, things have changed recently. 'Green Environment' and 'Energy Saving' have been major trends in general hospitals. Korean government has chosen 40 general hospitals to investigate their energy consumption. Five major hospitals (Seoul National University Hospital, Asan Medical Center, Yonsei Sinchon

Severance Hospital, Seoul St. Mary's Hospital and Samsung Medical Center) are included in the said hospitals. As a result, 'Green Hospital' has been the major issue in medical industry.

3.2 Energy saving by low-carbon, green growth hospitals

The Framework Act on Low Carbon and Green Growth promulgated in January 2010 asks for an introduction of 'Target Scheme' to make the firms which emits greenhouse gases exceeding certain levels and consumes a lot of energy should report their greenhouse gas emissions and energy consumption to the government.

Starting this year, Korean government has carried out a pilot project for Target Scheme (Negotiated Agreement) in buildings to reduce energy consumption. According to the project, an energy-saving goal is allocated. After evaluating energy-saving activities, incentive or penalty is applied.

This project has been performed against the buildings which exceed 10,000 Tonnes of Oil Equivalent (TOE) in energy consumption as of 2008. A total of 12 organizations including Asan Medical Centerand Incheon International Airport Corporation have participated in the project. The government plans to accelerate the project with 40 organizations in 2011 and 70 organizations in 2012.

In terms of energy management space, it is in the middle of choosing the subjects of Target Scheme. According to the Framework Act on Low Carbon and Green Growth, the organizations which exceeded 125,000 CO2 in terms of average annual greenhouse gas emissions for the past three years have been chosen. Specifically, a business site which exceeds 25,000 tons of CO2 (12,000 TOE) was selected.

Then, how many domestic hospitals would meet these criteria? In case of a medical foundation which owns general hospitals across the nation, it would be included on the management list provided that its annual energy consumption of all business sites exceeds 60,000 TOE.

Samsung Medical Center, Asan Medical Center	28,000 – 30,000 TOE
Yonsei University Health System	20,000 TOE
Kyung Hee University Medical Center, Boramae Medical Center, Gachon University Gil Hospital, Soonchunhyang University Cheonan Hospital	2,000 TOE

Korea Energy Management Corporation estimates that there are 6 hospitals which exceed 12,000 TOE and 20 hospitals with over 2,000 TOE across the nation. The Green Energy Cooperation Office of Korea Energy Management Corporation has asked the said 20 hospitals with over 2,000 TOE to collect and report the data on greenhouse gas emissions.

3.3 Application of green technology in domestic medical facilities

Since the Framework Act on Low Carbon and Green Growth went into effect in 2010, increase in energy cost would have an impact on business in hospitals. It is likely that Korea would be obligated to reduce greenhouse gas emissions starting 2013 once the Kyoto Protocol expires in 2012.

According to an investigation on 246 hospitals across the nation, major environment-friendly policies include use of green-certified products, construction of water recycling treatment facilities, development of CO2 emission reduction facilities, operation of medical service team and development of alternative energy (solar/wind energy). However, they are not sufficient. According to a study on top five hospitals in terms of energy consumption, the following results were obtained:

1) 24-hour cooling & heating

According to Ministry of Knowledge Economy, the average energy consumption of top 10 hospitals is twice greater than that of general commercial buildings. In addition, the power consumption by hospitals has further increased these days due to introduction of high-tech medical equipment and facilities. According to a study by Korean Institute of Hospital Management, the average fuel & electricity bill per bed in a general hospital is about KRW 2.4 million per year, which accounts for 2.1% of total medical expenses.

2) Green technology

Seoul St. Mary's Hospital which opened in 2009 features Combined Heat & Power Plant and waste heat and rainfall recycling facilities. Depending on the amount of sunlight coming into a room, the cooling and heating system is separately controlled after dividing the rooms into four areas; east, west, south and north. As a result, annual electricity bill has been saved by KRW 4 billion. For 'Green Building,' hospitals generally enhance energy efficiency by reducing energy consumption through the introduction of new & renewable energy and high-efficiency energy facilities. In terms of new & renewable energy, solar thermal energy, photovoltaic energy and geothermal energy are used.

- Asan Medical Center has made KRW 120 million of profit annually since the photovoltaic facility (147kw) was installed on the roof of the new building in 2007.

- Seoul National University Bundang Hospital plans to introduce a geothermal system which is better than a solar thermal or wind power system in terms of energy efficiency. It is likely that the new system would reduce energy consumption for cooling and heating. In addition, an ice storage system in which a chill (ice) is stored at night and used for cooling during daytime will be operated. High-efficiency energy facilities include a heat recovery system. Under the heat recovery system, heat is recovered using a heat exchanger instead of emitting all indoor air and used in cooling and heating.

- Seoul National University Bundang Hospital has saved KRW 300 million annually since the heat recovery system was introduced in 2008.

- Samsung Medical Center has been active in saving energy through boiler cleaning, replacement of cooling tower, introduction of revolving door and installation of energy- saving fluorescent lamps. As a result, it has saved more than KRW 500 million annually. Recently, it plans to introduce a heat recovery system.

- Hallym University Medical Center which is slated to open in 2012 targets to reduce power consumption (by 25% compared to general mold transformer) using a high-efficiency transformer and decrease electricity bill through forced peak demand control.

3) Changes in medical facilities

Gangbuk Jaseng Hospital of Oriental Medicine and Haeundae Jaseng Hospital of Oriental Medicine can

reduce energy consumption by 70,000 KWh annually through introduction of a new MRI which is smaller than the conventional model by 20% and lower by 41% in terms of energy consumption. If estimated by carbon dioxide production, it can reduce 40 tons of CO2 emissions. Seoul National University Bundang Hospital has come up with a computer system in which computer data substituted for papers such as medical records and medical certificates.

4) Building Energy Management System (BEMS)

Hospitals have used a realtime energy consumption measurement system. The BEMS is effective in detecting and correcting energy leakage. For example, energy consumption increases at the peak of outpatients. Therefore, where electric load is present during that time can be analyzed.

– Seoul National University Bundang Hospital makes it possible to monitor BEMS (daily water consumption, temperature, humidity) on the website to properly respond to the Target Scheme. It appears that effective energy management would be possible thanks to energy map and realtime automatic measurement systems.

3.4 Sub-conclusion

'Green Hospital' should be initiated with clear goal orientation and construction plan from the planning and design stage. Green Hospital saves electrical energy through the use of green construction materials, rainwater, natural sunlight and reflected light, PV-based water heating system, recycling of cold air from an operating room and installation of heating pump for recycling of waste heat. In addition, healing environment is improved in organic harmony with external spaces including local communities by eliminating fences through the development of nature-friendly landscape.

For green growth in hospitals, it is urgent to

– develop Green Healthcare-related educational programs;

– actively participate in diverse research and policy projects; and

– raise awareness on Green Healthcare strategies and green vision by discovering the interface between medical technology and hospital management.

4. Case studies

4.1 Pusan National University Yangsan Hospital

Pusan National University Yangsan Hospital, designed in 2005 and opened in 2008, is a general hospital with about 800 acute beds. Its site is located within the new campus of Pusan National University in Yangsan, a newly developed city near Busan.

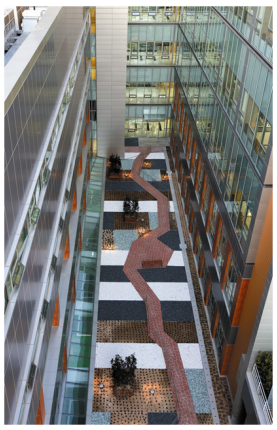
Its master plan starts with the concept of 'Green Hospital.'Green zones are formed in the site, and a circulating pedestrian path is provided. In addition, the hospital is separated from roads and neighboring buildings with parking lots and green areas, which work as a buffer zone.

Since its site area is vast, a dispersed or unbundled type of mass has been selected among many site

planning options. That is, bed tower, D&T (diagnostic & treatment) building and outpatient building are connected horizontally. Those three major blocks of hospital are also horizontally connected with auxiliary facilities such as an administration building and a nursing center.

One of the biggest advantages of a hospital in an unbundled type is that it can customize each building by its structure and systems. For example, the central D&T building requires a huge flexible space in order to include large department such as surgery or radiology. So we provided a universal space with cores such as various stairways, elevators and shafts to the perimeter of the D&T block for efficiency and future adaptability. As buildings are separated by each function, all facilities can have natural sunlight and good ventilation. In addition, way-finding is greatly improved and visitors can find it easy to locate their destination.

The courtyards between buildings are extended to the basement level giving impression that it feels just like the ground floor. Another advantage of the unbundled-type hospital is that elevators to the bed tower can be separated from the visitors to the other pars, especially to the outpatient clinics. As a result, patients' privacy can be protected and nosocomial infection can be greatly reduced.



In particular, a green roof garden on the D&T building is a great outdoor space for both inpatient and their visitors. The green roofing system saves energy by 12-15% for cooling and by 6-10% for heating by blocking solar radiation.

To achieve 'Green Hospital,' the use of alternative energy is also important. Geothermal and solar energy systems are applied to this hospital. The dental building features solar panels on the roof and the geothermal energy system in the basement. The energy produced in these systems is used in cooling and heating of the administration building and the dental hospital building.

4.2 Expansion of New Building of Seoul National University Bundang Hospital

Seoul National University Bundang Hospital is now under construction. It is a new addition to the existing 900-bed general hospital. This new building is scheduled to open in 2012 with 400 beds. This expansion project is aimed to integrate functions with the main building. Therefore the new building and the existing building will function as a single building not only creating synergy effect but also creating seamless harmony with surroundings. In addition, 'Green Outdoor Spaces'will be provided. The Green

Outdoor Space refers to pleasant and comfortable open spaces with various themes; the central plaza in front of the main entrance, an integrated roof garden which extends from the existing building to the new building and the rear garden which is connected to the valley behind the new building.

The piloted space is provided across two floors on the roof to make an airy way. Accordingly, the mountain at the back will not be blocked by the building. After all, this building has been designed for harmony with the nature.

In the lobby, a three-story high atrium gives an open and refreshing atmosphere. In addition, a little indoor garden is provided in the basement level in with direct sunlight can be reached from the atrium.

The health promotion center on the 4th floor has a private entrance from the outside and its clients can be accessed this area separated from other patients. In addition, an indoor garden is designed to give patients not only a simpler circulation but also a positive distraction such as view to the nature while they are waiting for examination.

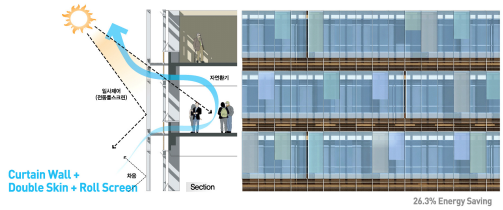
Wards are located from the 6th to the 10th floors with double corridor system nursing unit. While the nurse circulating distance is shortened, patients 'safety and privacy are protected as much as possible in this type of ward.

One of the unique features of this new hospital is double-skin facade which is applied for the first time to a hospital in Korea. In summer, hot air is emitted outside, and sunlight is controlled through louver. In

winter, on the contrary, hot air will be contained inside saving heating energy. Since the bed tower faces southwest, the system would be efficient considering its rather high initial cost.

This building also uses geothermal energy system assisting cooling and heating of the building. To save energy, LED lights have been applied as well. In addition, permeable materials have been used for outdoor floors to recycle rainwater.

Thanks to all these attempts for Green Hospital, New Building of Seoul National University Bundang Hospital is expected to save maintenance cost significantly as well as provide users with more pleasant healing environment.



5. Conclusion

For hospital design, extensive knowledge and experiences are required. So far, a lot of efforts have been made to build good hospital environment for patients. However we need to step further now. ‘Sustainability’ is already a global issue and we, healthcare architects, are facing a daunting challenge to design an energy-saving and nature-friendly hospital. After all, we should help each other and make continued efforts to achieve Green Hospital.

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