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Passive control of architectural environment based on the design method of Korean traditional architecture with reference to "*Young-am House*"

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Abstract

The examination of the "Young-am House", a traditional folk house located in the middle region of the Korean peninsula, aims to analyze and to inform the bio-climatic design of the building and interior spaces based in the traditional architecture of Korea. As a consequence of the examination, it was evident that bio-climatic design performed an important part in creating a natural environment for comfortable living by taking consideration of the changing local climatic conditions. In the case of the "Young-am House", it is remarkable to see how efficiently the comfort requirements are met comprehensively through the design of the building by incorporating passive measures with a direct effect, such as passive heating and cooling, shading, natural ventilation, etc. Changes of temperature and thermal zones were taken into consideration in the planning of the functional layout of the plan and sections. Also, the skin's function in permeability and transparency is capable of being controlled and modified to react accordingly to the changing local climatic conditions.

THEORIES OF ENVIRONMENTAL ARCHITECTURE

Industrial revolution heralded the pursuit of progress and innovation dictated by a human desire to do away with our dependence upon natural constraints and to overcome and dominate nature. Rather than working with particular environmental qualities, buildings have increasingly come to represent enclosed, isolated boxes in which the internal environment is artificially controlled. Structures are maintained at temperatures deemed comfortable according to the purpose of the building: whether the temperature outside is –20 or 35, the internal temperature remains constant. Achieving this comfort necessitates considerable energy consumption.

The level of energy use is largely dependent upon technologies applied in design and construction, and this may be considered at three levels.

1. Technology determines how much energy is required to operate the services in a building.
2. Technology determines what kind of energy is utilized, and how efficiently.
3. Technology determines how this energy is generated or harvested.

How technologies are employed in building design is the ultimate responsibility of the architect and engineer. They are responsible for dictating the energy requirements of their designs.

For the environmental architecture, it is strongly recommended to study and utilize the design principles of traditional architectures, because most of the traditional architectures in the world have been developed with relation to their climatic environments.

PRINCIPLES OF KOREAN TRADITIONAL ARCHITECTURE

In Korean traditional architecture, buildings were situated to optimize the natural geography to maximize the comfort condition of the building. Korea has a warm temperate climate with a cold strong wind during the winter months, with winds blowing mostly from the north. The wind comes over the mountains and is stopped and circles in the valleys. Therefore the slope is the ideal location to live. This principle is repeated in residential layout.

A residence usually consists of at least two building levels with space (courtyard) between, where the wind gets trapped. The front façade of the building faces almost to the plain with a southeast or southwest orientation. At the rear of the buildings which being the highest location trees and/or walls are arranged. In the summer, cool air created by the shades of the trees in the backyard with the help of narrow path of back wall creates wind of high velocity. With the solar radiant in the center courtyard helps to create a "Venturi effect" to cool the house, creating a comfortable atmosphere even in the hot summer climate. In the winter, the trees and the wall act as a thermal buffer to block out the cold wind blowing from the north.

PASSIVE CONTROL DESIGN MEASURES OF *YOUNG-AM HOUSE*

The *"Young-am House"* is located in the middle region of the Korean peninsula, Chungcheong-Namdo, in a Preservation District for Traditional Buildings.

Young-am House was built around 1880, during the middle period of the Chosun-Dynasty. This residence represents a typical Ban-ga (a house of the Korean nobility).

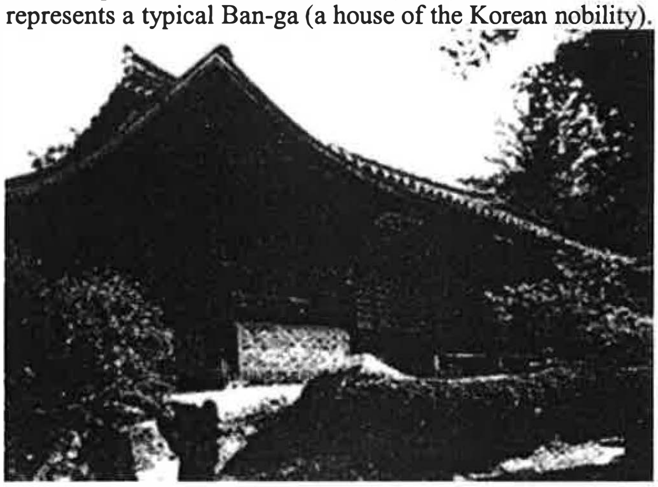

Figure 1. Front view of Sarang-chae, *Young-am House*

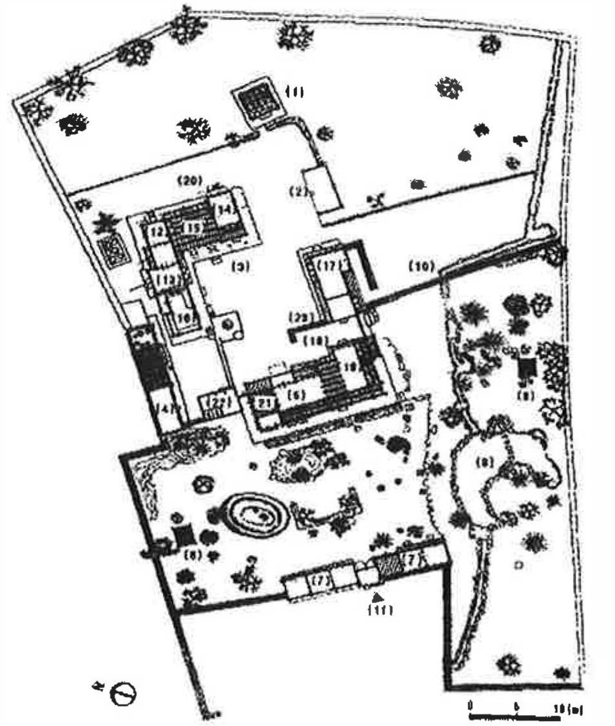

Figure 2. Site of *Young-am House*

In the case of *Young-am House*, the site planning measures were taken into consideration. The residence is divided mainly into two blocks, one being the Sarang-chae (Men's Quarter) and the other the An-chae (Women's Quarter). The orientation of the building faces southwest. It has open field to the front southeast of the house with a pond and a central courtyard in between the two sets of buildings with a narrow backyard located in the northwest and enclosed by a wall surrounded with trees. The buildings were also individually built to optimize passive design measures. The Korean traditional architecture has been developed by adapting to distinctive climatic conditions of four seasons and has dual structural system for summer and winter.

Also the building roof skirt, the Chuma, is designed with what appears to be a random organic curve yet its angle has been deliberately calculated at an angle of 60 degrees when measured from the center column line. This angle working in conjunction with the depth works with the altitude of the cross meridian to casts a shade during the summer solstice and to allow the light to penetrate into the interior space during the winter solstice. Chuma also protects the outside walls and windows from rain and snow.

Wall and roof are made of renewable materials since they are made out of layers of mud plaster. And on the roof is finished with clay tiles or thatched roof. In the summer, the walls and the roof act as insulating elements to keep the heat out. And also it absorbs humidity to make the indoor environment cooler and drier especially during the monsoon season. In the winter, these materials have high heat capacity; sunlight is absorbed during the day (by isolate effect of solar radiation) and cooled down with a time-lag effect to create a warmer comfortable indoor environment.

The openings made out of lattice wood frame with rice paper, also of renewable material, act as skin's function in permeability and transparency. In the winter, the openings are of double layer system and have an insulating effect to reduce the heat loss as well as preventing outside cold air from entering the interior space. In the summer, these opening are designed to fully open to the nature. Some wooden frame doors are hung types that can be folded, lifted and fixed up on the hanger at the ceiling level, away from the main living space to produce maximum cross ventilation. Others are sliding type that seems to vanish into the wall to optimize the opening space. The rice paper on the wooden frame acts as a sunscreen effect and produces pleasant physical and mental environment for the users of the interior space by letting in diffused sunlight as well as effectively blocking out the cold wind.

The flooring method and material also are designed with passive control in mind. The wooden floor of the Daechung (main room) is a plank system, which is elevated with a crawl space of about 45cm in height. In the summer, this system is effective in reducing the indoor day temperature by radiant cooling as well as inducing constant natural air flow, especially cool air, which originates from the back yard, moves through the floor space to the center courtyard. This type of convective cooling makes one feel comfortable on the floor. The Ondol, Korean under floor heating system is used in the inner room to use in the winter to heat. Sometimes it is used during the monsoon season when the humidity rate is too high to dehumidify the interior space.

heat source for the Ondol is often generated from the hen. Thus the wood burned for cooking serves a double ction by also heating the room. This is one of the hods of traditional architectural design to conserve the ited natural resources. The Ondol is a system of layers of vel placed on the bare ground. Above it, large stone slabs placed and clay is plastered above. As a finishing layer, flooring material is of paper, which has been oil treated. effectively using the natural tendencies of the rising heat, od is burned at the stove in the kitchen. The stone under er has a highly efficient thermal storage effect. In a mal winter day, even it is heated only twice a day -in the rning and in the evening- the interior temperature nains comfortable throughout the day and night.

The overall floor plan of the each building is that it is de up of several layers of buffer zone to control the ironmental functions. In the summer, this type of laying out creates different temperature making the inner space coolest. In the winter, it prevents direct penetration of cold wind and thus making the inner space the warmest. en though the exterior temperature fluctuates the interior nperature can be maintained at a fairly uniform nperature to meet the comfort of the users.

MEASUREMENT AND ANALYSIS

the summer of 1994 between August 23 to 27, *Young-am ouse* was analyzed for physical elements such as mperature, humidity, and airflow which affect the thermal ivironment of the house were measured in the main rooms the house. From the analysis, the effect of convective oling was found to be an important factor determined by e layout, site, and landscape. The result revealed that the mperature of the floor fluctuated between 22 and 29.9 0cm above the floor surface: mean temp. 25.95: temp. inge 7.9) while outdoor temperature ranged between 28.9 id 35.1. Therefore the fluctuation of outdoor airflow iuses the airflow to sore with the solar radiant in the center iurtyard, which moves the air from the backyard cooled by ie shades of trees to the front garden. The input of the icoming air to the Maru space has a high velocity rate aused by the narrow path of back wall.

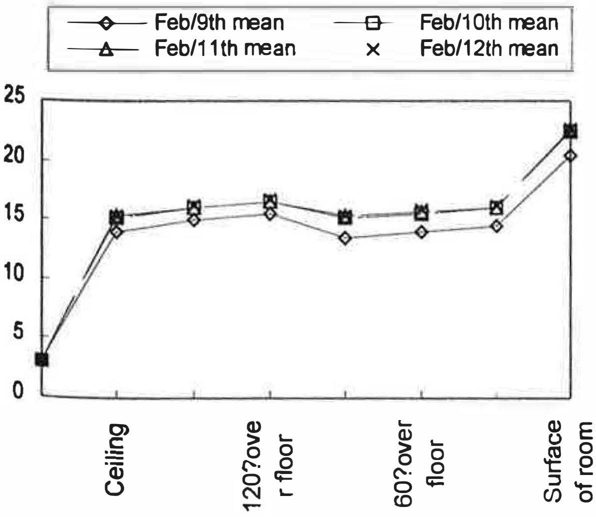

Figure 3. Distribution of vertical mean temperature in the Anbang

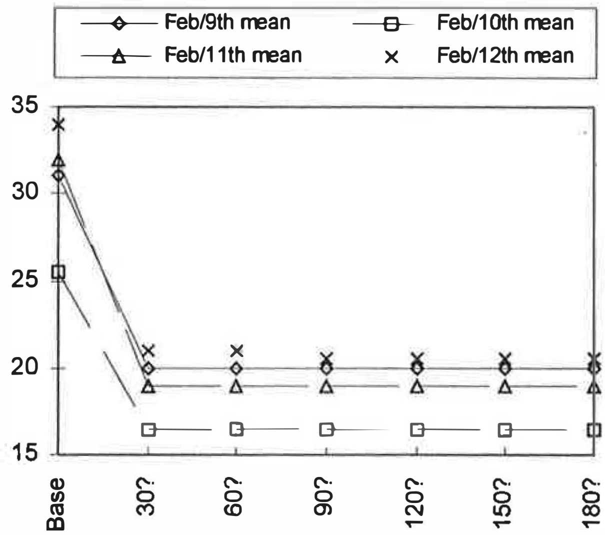

Figure 4. Distribution of vertical mean temperature in the Sarangbang

The façade elements play an important row in the airflow properties. The result found that the temperature under the floor ranged from 20.8 to 29.2 (mean temp. 25, temp. range 8.4) and temperature in the yard from 19.3 to 29.7 (mean temp. 24.5, temp. range 10.4), which is relatively low. The result found that the door/wall ratio of this house was 20.4%, while 20% is the optimum environment. The cooling effect by the difference between the inlet and the outlet of air improves when the area of inlet is smaller than that of outlet. The outlet of this house exceeds that of the inlet by 130%. And the convective cooling effect on and under the floor is increased by the infiltration through the floor. During the daytime, while the temperature on the roof's surface may change as much as 31.6 (between 17.8 and 49.4, mean temp. 33.6), the temperature of the floor space showed minimal change.. The mud layers on the roof effectively work as a thermal mass causing the temperature of ceiling at a nearly constant rate, ranging between 25.7 and 28.6 (mean temp. 27.15, temp. range 2.9) . The result found the front yard's temperature ranged between 18.9 and 35.1 (mean temp. 27, temp. range 16.2), while the backyard's temperature ranged between 19.3 and 29.7 (mean temp. 24.5, temp. range 10.4). Therefore, the sinking of the cold air at the backyard and the rising of the warm air at the front yard create solar radiant phenomenon of the natural air convection in the Maru space.

In the winter of 1995 between February 8 to 12, the *Young-am House's* main rooms were again analyzed for the thermal properties. When the floor surface's temperature was measured, the temperature of Anbang's floor surface showed a great deal of fluctuation ranging between 16.4 and 38.9. The temperature of Sarangbang's floor surface was ranging between 13.5 and 33.5, while outdoor temperature changed from -5.1 to 14.9. By the thermal control function of buffing space around Sarangbang, such as Kolbang and Numaru made indoor temperature stable. The temperature in Sarangbang changed from 17 to 23.2 (mean temp. 20.1). The distribution of floor temperature in Sarangbang, where Ondol exists, the maximum temperature (38.1) reached one hour after heating and the temperature only dropped to 17, even after eleven hours have passed. The Ondol of the Sarangbang has a time-lag effect of thermal keeping capacity.

ADAPTATION OF TRADITIONAL ARCHITECTURAL THEORY IN MODERN ARCHITECTURE

Such an attempt to apply design principles extracted from vernacular architecture is one of the best ways to create a more comfortable and healthy building environment and thus help to solve the global environmental problems. The Korean traditional architecture's Passive Control Design Method can be used as models to adapt to Modern Architecture. This can be helpful to restore the environment control function of architecture that has gotten lost with the development process of Modern Architecture. And moreover it always should be remembered that sustainable or environmental architecture does not mean solely making the buildings more energy efficient but also considering diminishing the energy embodied in a building. Embodied energy is that needed to extract and manufacture materials from them into building components and to assemble them.

A number of goals and objectives for more efficient building design can be proposed by Korean traditional architecture:

1. Buildings should only need to use artificial mediators inside when the prevailing conditions externally make human activities uncomfortable.
2. Buildings should avoid restricting natural conditions reaching their internal spaces that would be of positive benefit to their occupants.
3. Buildings should be designed to assist in the collection and storage of received energy sources, particularly solar energy, and then utilize this when and where required. Buildings should also be environmentally responsive to their local surroundings. Not only should they minimize internal energy consumption; they should also aim not to create external demands or induce negative environmental effects.

To achieve these goals, we need to learn from our pre-industrial history and to reconcile the relationship between nature and human activities. Our first dwellings provided "shelter" as a basic protective enclosure. It is a fairly a recent phenomenon for the majority of people to spend much of their lives indoors. The commitment to preserve the built and unbuilt environment should reflect upon successful historical examples and aim to revive and refine many of these lost and neglected principles. Recognizing the dependency of human activity upon maintaining a sustainable relationship with the natural environment should stimulate greater understanding of construction in nature.

REFERENCES

1. Kyung Hoi Lee, '*Architectural Environment Science*'. (Seoul Munundang Publication, 1988)
2. Kyung Hoi Lee, '*Passive Environmental Control Method of Environmental Character in Korean Folk House*', in Architecture (Seoul: 1986)
3. Kyung Hoi Lee, '*Some Problems in Designing Building Envelope in Korean Climate*', in Proceedings of the 10th International PLEA Conference. (Auckland: 1994)
4. Bo Ung Jang, '*A Cultural Geographical Study of Folk Houses in Korea*'. (Seoul: Bojinjae Publication, 1986)
5. Saehan Architectural Culture Research Institute, '*Asan Oiam Village Preservation Plan Academic Survey Research Report*' (Asan-Kun: 1990)
6. Donald Watson, '*Climatic Design*'. (New York: McGraw-Hill, 1983)
7. Yung Hoon Shin, '*The Traditional Residence of Korea*'. (Seoul Yolhwadang Publication, 1983)
8. Ken Yeang, '*Designing with Nature*'. (New York: McGraw-Hill, 1995)