An Analysis of the Structural Characteristics of Environment-friendly Skins of European Housing

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This work was supported by the Korea Research Foundation Grant funded by the Korean Government (MOEHRD)" (The Regional Research Universities Program/Biohousing Research Institute)

ABSTRACT

The purpose of this study is to analyze application methods and structural characteristics of each element of environment-friendly European housing through classification of skin types. The results of the study are following. 1) The skins are classified by three types; single skin with multi layers, double skin with single layer and double skin with multi layers. 2) Most single skins with multi-layer are composed with wooden louvers, sun blinds and insulating windows. There are introduction of atrium and balcony, and variation sectional space composition according to cases. 3) There are two types of double skins; to put cavity between inner skin and outer skin and more extensional spaces such as balconies, corridors and stair halls. Solar walls and mechanical ventilators are often introduced to double skins with multi-layer. 4) The functions of the latest environment-friendly skins are vary from controllers and buffers of indoor environmental elements such as temperature, light, air and sound to equipments to perform essential functions to efficiently operate HVAC systems.

KEYWORDS: Environment-friendly, Skin, Housing

1. INTRODUCTION

1.1 Background and Purpose

The building skin has become increasingly important in recent years in the areas of research and development as a result of a growing awareness of environmentally sustainable forms of living. Comparatively a lot of difficulties are, however, found in realizing the environment-friendly architecture, and most of domestic researches and discussions are also concentrated on high-rise buildings or office buildings. Considering those states of us, this study is to explore features of the "environmentally sustainable building skin" which is now being considered as one of concrete measures for realizing sustainable buildings, by reviewing cases of European environment-friendly multi-family housing per its type according to constructional criteria, so the purpose of this study is to analyze applied techniques of each factor in useful skins of environment-friendly multiple housing and to analyze systems and constructional criteria per the type of skins, from the viewpoint of a designer so that it will present data as a basis of domestic application in the near future.

1.2 Methodology and Scope

This study considers the concept of the building skin and its classification by constructional criteria through literatures, and then classifies the skin into three types from the "skin classification by
constructional criteria" and examines the cases of the European multi-family housing of environment friendliness. Following is the specific way of the examination.

First, it looks over concrete technologies of application of environment friendly factors through analyses on detailed drawings of typical cases per the type showing the application of environment friendly features. Then, it analyzes technologies relating between internal and external spaces by finding out the systems of building skin per the case of each type. Next, constructional criteria of each skin type are presented with analytical diagrams for its composite examination. Finally based on the results drawn from those analyses above, it compares and synthesizes the analytical results per each type of the building skin.

The selection of typical cases are restricted to European environment-friendly housing, which has been completed from in 1996 to the most recent: more detailed, as a time scope, cases presented in regular publications or separate volumes among constructions which have been completed from the time when the development 'sustainable human settlements' was discussed in the 2nd United Nations Conference on Human Settlement (HABITAT II) in 1996 to the recent: as a spatial scope, European cases, based on the fact that the European cities have had high-density characteristics of the housing earlier than those of other regions and according to the situation, there have been active and continuous researches and experimental alternatives on multiple housing.

2. CONSIDERATIONS OF BUILDING SKIN-RELATED THEORIES

2.1 Concept of the Building Skin in the Environment-Friendly Meaning

The environment-friendly building skin is a sieve between inside and outside, that is, it means a filter which is able to react environmentally, beyond the things for covering or protecting from the outer environment. Such a building skin of environmental friendliness aims to provide pleasant environmental conditions and eventually, to have effects of reduction of environmental loading occurring in buildings themselves, through mutual movements and interceptions between inner and outer environmental factors.

2.2 Classification of the “Building Skin”

Werner Lang said that the building skin should be considered in the reciprocal relations of function, form, construction and ecology, not just in the facade itself.

He classifies the building skin by the 4 standards from point of the constructional criteria: that is, the first standard is load-bearing and non load-bearing, the second is single-shell and multi-shell, the third is single-layered and multi-layered and then, transparent, translucent and opaque. These are shown in [Figure 1].

3. APPROACHES TO ANALYZE CASES

3.1 Overview of Cases Selection

By the standard written in the Chapters 1 and 2, the primary cases were 68 multiple housing included in overseas separate volumes and regular publications. Among them, this study selected 16 cases as a final object for analyzing, which represent more concrete applications of environment-friendly factors of the building skin and have detailed drawings or definite conceptual drawings available relating to constitution of the building skin, comparing to other cases (Table 1). The selected cases are located
mostly in the middle Europe, where relatively distinct changes in seasons appear, such as Swiss, Austria, Netherlands, France, Denmark, centering Germany.

Table 1. Selected Cases

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Year</th>
<th>Location</th>
<th>Design/Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Supermarket and Apartment Building, 1998</td>
<td></td>
<td>Muttenz, Switzerland</td>
<td>Nissen Wentzlaff Architects</td>
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<td>2</td>
<td>House in Amsterdam, 2000</td>
<td></td>
<td>Amsterdam, Netherlands</td>
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<td>3</td>
<td>Passive-Energy Terraced Housing in Dornbirn, 2002</td>
<td></td>
<td>Dornbirn, Austria</td>
<td>Johnnes Kaufmann</td>
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<td>4</td>
<td>Housing estate in Kolding, 1998</td>
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<td>Kolding, Denmark</td>
<td>3XNielsen, Arhus</td>
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<td>5</td>
<td>Passive-energy Terraced Housing in Ulm, 2001</td>
<td></td>
<td>Ulm, Germany</td>
<td>Johannes Brucker</td>
</tr>
<tr>
<td>6</td>
<td>Points Blocks in Innsbruck, 2000</td>
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<td>Innsbruck, Austria</td>
<td>Baumschlager &amp; Eberle</td>
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<tr>
<td>7</td>
<td>Housing Development in Zurich, 2003</td>
<td></td>
<td>Zurich, Switzerland</td>
<td>EM2N Architects</td>
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<td>8</td>
<td>Housing Development in Trofaiaich, 2000</td>
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<td>Trofaiaich, Austria</td>
<td>Hubert Riess</td>
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<td>9</td>
<td>Patio Houses in Amsterdam, 2000</td>
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<td>Amsterdam, Netherlands</td>
<td>MAP Arquitectos</td>
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<td>10</td>
<td>Housing Development in Paris, 2000</td>
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<td>Paris, France</td>
<td>Herzog &amp; de Meuron</td>
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<td>11</td>
<td>Housing Blocks in Munich, 2004</td>
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<td>Munich, Germany</td>
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<td>12</td>
<td>Housing Block in Zurich, 2000</td>
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<td>Zurich, Switzerland</td>
<td>Martin Spuhler</td>
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<td>13</td>
<td>Housing Development in Munich, 2000</td>
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<td>Munich, Germany</td>
<td>Munich, Germany</td>
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<td>14</td>
<td>Housing in Ludwigsburg, 1997</td>
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<td>Ludwigsburg, Germany</td>
<td>MAL Arquitectos</td>
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<tr>
<td>15</td>
<td>Tango House, 2002</td>
<td></td>
<td>Malmö, Sweden</td>
<td>Agnta Persson</td>
</tr>
<tr>
<td>16</td>
<td>Klosterenga, 2000</td>
<td></td>
<td>Oslo, Norway</td>
<td>Boligbyggelaget USBL</td>
</tr>
</tbody>
</table>

3.2 Establishment of Units for Analyzing Cases

For the building skin classification by the constructional criteria, based on the 2nd and 3rd classification of Werner Lang's (Figure 1), it is largely divided into the single-building skin and multi-building skin and then according to the singleness or compositeness of layers constituting each unit of the skin, the 2nd classification is carried out.

Figure 2. Types of the Building Skin

3.3 Scope to Analyze the Environment-Friendly Building Skin

Analyzing the environment-friendly building skin is limited by the following 2 points. The skin is constituted largely with a roof and a facade, and each side of the facade faces various directions according to types of buildings.

Firstly, to analyze such a building skin, it is limited to the part directly related to indoor spaces and outside environment, among the surfaces covering buildings. That limit is because that the organization and application of the study, of which purpose is analyze the constituent principles of the environment-friendly building skin and their detailed contents, have been most concretely and compositely shown in the very part where indoor spaces and outside environment have direct relations.

Secondly, as mentioned in the previous parts, the building skin of the modern architecture is able to have facilities to exchange reciprocally environmental factors between outside and inside spaces, and their extent is being increasingly expanding. In this study, thus, the concept of the building skin is considered to include extended elements such as balconies, atria and ventilation systems.
According to the building skin classification as shown in Figure 2, the analysis on each case are assessed being based on the 3 types largely. The recent building skins are showing the tendency that they are not found out as the single-building skin by single-layered from all of the cases analyzed. This study also excludes the type of single-building skins by the single-layered.

4.1 Single Building Skin by the Multi-Layered (Type 1)

(1) Application Techniques of Environment-Friendly Building Skin Factors in "Single Building Skin by the Multi-Layered"

In Housing development in Trofaiach (case #8), the skin mixed wooden louvers and insulating double windows faces the southeast. The building skin of the 2nd floor has two double windows being in upper and lower parts each, and the outer side of the double window in the lower part is covered by the wooden louver. This is to open selectively the upper or lower part windows, according to conditions of outside environmental factors, for the maximization of natural ventilation effects. The wooden louver in the lower serves as the control of solar radiation as well as covering effects from outer eyes. On the contrary, the skin of the ground floor is set-back inside from the side of the 2nd floor's building skin by about 4m. This is a technique that not also provides a passage on the ground covering the circumference of the building, but controls the amount of solar rays by the shadow resulted from the upper floor. Thus, the skin of the ground floor is more simply constituted, comparing to that of the 2nd floor.

As for Passive-Energy Terraced Housing in Dornbirn (case #3), this is a case organized in a way that each household uses two floors and households of 9 units stand in line from east to west. Living rooms of the ground floor and bed rooms of the 2nd floor face the outer spaces, and the constitution of the building skin for getting and controlling solar radiation is shown to be different by those features. The balcony in the 2nd floor, which projects to the south, plays a role of connecting the inside space of a bed room with the outside space, and at a same time, a role of eaves to control the solar radiation of the 1st floor. And the building skin of the 2nd floor is composed of insulating triple windows, and sunblinds which control security and interception of solar radiation changeably. The front side of the 1st floor is a door of insulating triple windows, facing the outside directly and there is no awning facilities for considering solar rays. The wooden sidewall, being standing vertically from the entrance part to the 2nd floor part, serves as considerations for privacy and also as a coverer of solar radiation.

(2) Constructional Criteria of "Single Building Skin by the Multi-Layered"

While many other building skins are constituted by the form of a double building skin, the single building skin tends to apply factors to complement the simplicity of its constitution, such as a balcony projecting to the outside and a vertical louver. Also there are efforts to control solar radiation to be secured or be intercepted, for example, changes in sectional depth or level of the building skin. The building skin has various constitutions according to functions of inner spaces facing directly the skin based on the fact that inner and outer environmental factors make more freely movements, comparing to other types.
4.2 Double Building Skin by Association of the Single-Layered (Type 2)

(1) Application Techniques of Environment-Friendly Building Skin Factors in "Double Building Skin by Association of the Single-Layered"

The double building skin in Housing Development in Paris (case #10) comes under the association of glass and operative louvers. This is a case that is developed in the residential blocks of an existing downtown area and stands in line facing the southeast. The outer skin, as wooden louvers, operates electrically following the aluminum guiding track. The shutters of that wooden louvers are divided per a dwelling unit, so it is possible to use in various forms according to outer climate conditions or types of middle area use between inner and outer skins. This middle area serves as a corridor, as a basis function, and a balcony, that is, when the shutter is shut, the middle area forms a single cavity and when it opens, the area is opened becoming a balcony. The inner skin is organized with doors of insulating double windows, and the balcony is finished with wood both on the floor and on the ceiling so that it gives a visual comfort.

In Housing Block in Zurich (case #12), the outer and inner skins interpenetrate a balcony area, so the balcony is divided into the inside and outside ones. The fabric sun-screen of red color, as an outer skin, is located between balconies is organized to operate following guide rails. The outer balcony in the upper part are equipped with landscaping factors, mostly a flowerpot, while the outer balcony in the lower part actively corresponds to vines and so on rising on the wire mesh. Between the outer skin and the inner skin, as a door being composed of insulating double windows, the inner balcony is located. The dwelling units facing to the south use two floors and the inner balcony, fronting the living room area, is opened to the height of two floors.

(2) Constructional Criteria of "Double Building Skin by Association of the Single-Layered"

The double building skin by association of the single-layered is a form mixed with the inner skin and the outer skin being composed of the single-layered. The spaces between each layer form a cavity, and the cavity has various forms from a simple empty space to functional spaces like a balcony or a corridor, and a room of stairs.

4.3 Double Building Skin by Association of the Multi-Layered (Type 3)

(1) Application Techniques of Environment-Friendly Building Skin Factors in "Double Building Skin by Association of the Multi-Layered"

The skin of Housing Development in Zurich (case #7) is associated with railings made with a vertical awning and perforated steel plate, forming the outer skin while the inner skin is mixed with sunblinds and insulating double windows. The vertical awning made with fabrics of green tone is a significant constituent factor in the constitution of the elevation of the building and also gives a dim shadow of green color. The broad space as a corridor, and, at the same time, as a balcony provides residents the middle area between outer space and inner space, and it plays a role of the space of buffering from environmental factors when the vertical awning is closed. The sunblind of the inner skin also controls more varied environmental factors.
In Housing Estate in Kolding(case #4), between two skins being composed of complicated factors is a cavity equipped with a mechanical guidance system of air flow. Considering the environment-friendly factors constituting the building skin, the outer skin is applied with ventilation flaps for controlling air change, insect screens, solar walls and so on. The ventilation flap controls the intercept or discharge of rising air heated in the inner cavity. The inner skin is organized with concrete walls and insulating materials with the thickness of 80mm. Inside of the cavity is ventilation fans and ventilation ducts with the diameter of 180mm, and these equipment is used for accumulation and reduction of heat and so forth.

(2) Constructional Criteria of "Double Building Skin by Association of the Multi-Layered"

From the cases, the cavity of double building skin by association of the multi-layered performs various functions: for example, it serves as a buffering space from exchanges of environmental factors between the inside and the outside, through varied opening and shutting facilities; and, the thermal energy accumulated in the air of the cavity is changed to the heat energy in the inside space of dwelling units, by returning to heat accumulated mass through the additional mechanical ventilation system.

5. CONCLUSIONS

The following is the key conclusions of the research.
1) In case of the single skin composed of the multi-layered, insulating windows are covered with louvers or sunblinds. Greenhouses, balconies projecting to the outside or other elements are added, or it changes the constitution of sectional spaces so that the simpler constitution of the skin, comparing to the double skin, is complemented by giving modifications in the sectional space organization.
2) As for the double skin by association of the single-layered, a cavity is formed between inner skins and outer skins, and changeable factors are applied to the outer skin while the various spaces are applied to the middle area, as a cavity.
3) As, the double skin by association of the multi-layered is a type that additional sunblind systems are applied to the inner skin, the cavity itself serves as various independent spaces. Also solar energy collectors and mechanical ventilation systems and so forth are applied compositively to the cavity.
4) Most of cases apply sunblind systems to control the getting and intercepting of sun rays, and balconies in the double skin are play a role of cavity between inner and outer skins as well as a role of controller of air change and ventilation, being associated with operative opening and shutting facilities. In some experimental cases, the ventilation system through additional mechanical systems and the solar energy generating system in combination with the skin are found out.

REFERENCES
