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Passive Design Elements in the Architectural Planning of the Public Libraries

- Focusing on the Comparison between Site and Building in the G-SEED Pre-certified and Non-certified library -

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ABSTRACT

Purpose: The definition and factors of passive design being the sustainable method of building plan through the preceding research is deducted and the effect of passive design within the public library by applying the deducted factors in the case of built public libraries and further the realization plan of green library aimed to be reviewed in this research. **Method:** This study is to induce common elements of architecture plan for public library and passive design, and assess application level of re-classified elements of sustainable public library in order to analyze present condition of passive design applied on facilities of public library. First, related laws and planning standards of public library will be reviewed, then the definition of passive design will be considered using advanced research. Through advanced research related to planing elements and passive design for library induced from various plans for library standards, a common ground of induced passive design element will be transformed into assessment items and practices to be analyzed. **Result:** Libraries which are and are not preliminarily certified by G-SEED will be compared with each other in order to analyze the effects of passive design on G-SEED. Even though various passive elements such as load reduction of air conditioning and energy efficiency exist, there are no assessment tool within G-SEED. The fact that there are only standards for temporary methods such as utilization of construction material and installation of equipment highlights the challenges in quantitative evaluation.

KEYWORD

친환경 건축
패시브 디자인
공공도서관
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1. Introduction

1.1. Research Background and Purpose

Although sustainable architecture is demanded for all facilities, it, as well as its expansion, is more important for a public library because the public building plays a variety of roles as a community space for local residents such as providing cultural contents, supporting educational activities, offering space for leisure space. Furthermore, a modern library is asked to provide pleasant environment as well as a basic function of lending books. Here 'pleasant environment and space' means not only facility elements, which are provided artificially, but also one that is comfortable enough for people to use the library for a long time and that is offered in harmony with nature in real sense.[1] It means passive design, which can provide pleasant environment and efficient energy by making the most of natural energy, should be most essentially considered at an early stage, so an sustainable library can be built. In this respect, the present study is aimed to identify the evaluation factors for the architectural planning elements of a public library in the perspective of passive design, apply the evaluation factors to cases to examine in this study, and examine how passive design affects G-SEED[2] Certification System and architectural planning elements of a public library. The findings of this study are expected to be basic data in planning an sustainable public library in future.

1.2. Method and Scope

The present study is conducted in the following orders. First of all, public library-related laws and planing standards are reviewed and then precedents studies are examined with care to define passive design. Based on the planning elements derived from the library planning guideline and passive design elements found in the literature review, the present study tries to classify the planning elements of a public library again from the perspective of passive design and uses them for case studies.

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1) Ham Moon-Ju, "A Study on the Eco- Friendly Library's Form, Space, and Equipment System by Using the Low-Carbon Design Method - Focus on the Public Libraries", Master's Dissertation, Inje University, 2011, p.2

2) Green Standard for Energy and Environmental Design

For cases to study, this study selected 6 libraries that acquired a preliminary certification by G-SEED and 6 libraries chosen as excellent architecture by Ministry of Culture, Sports and Tourism. The geographical scope of case study is limited to the libraries established in metropolitan areas. In addition, since it was hard to set temporal scope of study because Excellent Public Library Competition Project stopped after 2012, this study used the certified year of the libraries that acquired green architectural preliminary certification and opening year for ones chosen for excellent construction as criterion for case selection.

It is necessary to consider the elements of passive design overall to realize the efficiency of building performance. However, this study limited the selection and evaluation of the elements to those related to the usage of land on which a building is established and to those related to a building necessary to understand environmental friendliness.

2. Public Library and Passive Design

2.1. Applicable Law and Guideline to Public Library

The laws related to building a public library can be divided into Libraries Act, Building Law, and ordinances related to Sustainable Law. According to Article 2 of Libraries Act [enacted Sept. 28, 2015], public library is defined as a library constructed for the main purpose of enhancing use of information and culture, activities of research, education and culture, and lifetime education for local residents. In article 2 of Building Law [enacted Oct. 7, 2015], library facility is categorized by size into the 1st class neighbourhood living facility with gross floor area of less than 1,000㎡ and education/research facility with gross floor area of more than 1,000㎡.

According to Article 15 of the ordinance of Act on the Promotion of the Development, Use and Distribution of New and Renewable Sources of Energy [enacted March 30, 2015], a building with gross area of more than 1,000㎡ is obliged to the compulsory ratio of new and renewable energy supply. In addition, Article 10 of the ordinance of Green Architecture Support Act [enacted May 29, 2015] stipulates that a building with gross area of more than 500㎡ shall submit an energy conservation plan. Article 13 of Regulations for G-SEED [enacted June 30, 2014] states that when a public building with gross area of more than 3,000㎡ is built or extended with an annex building, it shall acquire higher class of G-SEED preliminary certification and main certification than announced.

Table 1. Construction plan and guideline of pubic libraries

Division	Libraries Act	①Standards of korean libraries(2013)	②A manual on construction and management for public libraries(2013)
Purpose	It is contributed to the cultural development of country and society such as the efficient provision and distribution of data and the improvement of lifelong education, etc.	It is to accomplish and appraise the quantity, quality and range and level of object professional groups of libraries or government authorities establish.	The provision of guideline for the building guideline and space composition for the new building and remodeling of public libraries.
Supervision	Ministry of Culture, Sports and Tourism	Korea Library Association	Ministry of Culture, Sports and Tourism
Enforcement Date	2012	1981(Published The First Edition)	2008(Published The First Edition)
Subject	All Libraries	All Libraries	Public library only
Division	**③ Guideline of the public library operating standards**	**④ A study on development of operation model for gyeonggi-do public libraries**	**⑤ A study on the present status of korean public library space management and standard model**
Purpose	All operation points of libraries are standardized and the preparation of overall guidelines for the facility, the environment and the service.	The proposal of criteria necessary for the building of new library within the province	The policy proposal for the building and facility standard of library and the development of standard model of space operation
Supervision	Seoul city	Gyeonggi-do	Ministry of Culture, Sports and Tourism
Enforcement Date	2012	2013	2007

As mentioned above, institutional efforts are being made toward energy conservation and sustainable building and the coverage for obligation becomes more inclusive. Likewise, applicable laws and regulations also have greater impact on the architectural planning elements of sustainable public library. Not legally binding, library facility guidelines were also issued in consideration of the characteristics of a library (see Table 1). 'Standards of Korean Libraries' and 'A Manual on Construction and Management for Public Libraries' cover all kinds of libraries in Korea and other standards and guidelines regulate the criteria and operational models of public libraries.

2.2. Increase of Social Demand of sustainable Public Library and Precedent Studies

'The 2nd General Library Development Project (2014~2018)' of The Library and Information Policy Council subject to presidential supervision is a comprehensive plan that proposes the promotion targets and task of all kinds of libraries. It puts forth the environmental change and countermeasures related to library. In the plan, 'base

expansion and operational stability for library' and is decided as one of tasks to promote by strategy and 'build 1,100 libraries until 2018' is determined as policy agenda. In addition, the project plans to apply consultation service of experts in field of construction and operation even from the stage of construction in an effort to make the space and facility of a public library efficient. The government already announced that it would support the construction of 69 sustainable and energy efficient public libraries from 2008 to 2012. Like this, the demand for sustainable public libraries is ever increasing, but the standard for sustainable public library, which reflects the characteristics of library facility has been prepared yet.

According to the performance of G-SEED announced as of march 2015, in the homepage of The Ministry of Environment, The current status of G-SEED Certification for public library is as seen in Table 2. The table shows the annual number of public libraries by G-SEED Certification. It is stipulated by law that public facility with gross area of more than 3,000㎡ should acquire G-SEED Certification. Therefore, the number of the public libraries certifications will keep increasing.

Table 2. The Status of G-SEED certified library

Division / Certified Year	Preliminary Certification	Main Certification
2005~2009	4	3
2010	5	0
2011	5	1
2012	2	0
2013	9	5
2014	11	3

Of the studies regarding sustainable library, Korea Culture & Tourism Institute (2010) surveyed energy consumption of 60 cultural facilities and analyzed and calculated the carbon emissions of national cultural facilities.[3] Among those, it is difficult to reduce energy consumption of public libraries because they need to provide users with pleasant environment and rather need more energy to maintain constant temperature and humidity for book storages and computer server rooms. Furthermore, a public library is a facility where many and unspecified persons use, there is a limit to energy saving in terms of operation and management. In other words, since it is difficult to reduce energy load after a library facility opens, it is very important to seriously consider environment friendliness at the stage of design.

And when life cycle cost and energy consumption are considered, it is imperative to consider passive design from the stage of design to build a building with zero energy consumption.[4] However, studies related to sustainable library are not sufficient in Korea. Hong Su-ji (2014) conducted a survey on staffs in library to examine their awareness of establishment and current status of green library. Ahn In-ja and others (2) (2014) examined the academic trend of green library and proposed 5 areas to study in future. Ahn In-ja and others (3) (2012) defined green library and carried out case study with domestic libraries that acquired GBCC Certification and foreign libraries that acquired LEED Certification. Ham Mun-ju (2011) looked into low-carbon design techniques to materialize sustainable library construction and divided them into passive design and active design. And Ham studied Norman Foster's works and derived the elements for low-carbon design techniques.

Like this, studies are not being actively conducted upon domestic sustainable library facility and operation. Therefore, it is now necessary to study the architectural planning elements of library facility so a library building can become environmentally friendly and its efficiency can be secured. Therefore, this study analyzed precedent studies and define passive design. It also discovered the elements of design and applied them to established public libraries (cases) to know the current status of the application of passive design to public libraries and its impact upon public library plan.

2.3. Passive Design in sustainable Architecture

Sustainable architecture is construction that saves energy and resources, preserve natural environment and improve human health and pleasantness.[5] Passive design is one of design techniques that enable sustainable architecture. This study reviewed precedent studies to define 'passive design', which is one of design technique, and the results are as follows in Table 3. From the precedent studies, definitions of passive design is characterized with understanding of relationship between land and climate, use of natural energy, reduction of power load, and provision of pleasant indoor environment. However, it was found that researchers have different opinions on the use of new and renewable energy.

3) Korea Culture & Tourism Institute, "Estimation and Reduction Management of Carbon Emission on Culture Infrastructure", 2010, p.63~p.140 summarized regarding public library

4) Kim Chul, Lee Hye-Won, Han Ki-Jung, "A Study on the Guideline Development for Passive Building Design", Architecture Institute of Korea, 29(6), 2013, p.93

5) Lee Bong, "A study on Integrated Design to Compose Technical Elements of Passive Design to realize Sustainable Architecture", Master's Dissertation, Hanyang University, 2009, p.39

Table 3. Analysis of previous researches

Researcher (Published year)	Passive Design Definition
Kim Chul and Others(2013)	The design method so that residents may maintain the thermal comfort without the equipment help through the architectural design by complying with the domestic climate.
Cho Won-Seok and Other (2013)	The passive design is said to be the sustainable design providing the maximum comfort to the space users by controlling the thermal mechanism of indoor outside space as a design by minimizing the existing energy use that the human being developed.
Yim Su-Hyun and Other (2010)	The passive design is the design method making the energy load less by using the space arrangement, the material or type of building as the meaning of "the passive design" if translated literally.
Lee Bong (2009)	The passive design is the design method introducing the natural energy architecturally without using the equipment facility or the power by inducing the reduction of energy buildings use.
Kim Byul (2013)	The facility, the power and the technology may be used for this as the passive design is the sustainable design concept inducing the energy saving by utilizing the natural energy actively by complying with the ecological environment, even the aesthetic factor should be considered during its process.
Kim Hak-Kun and Others (2014)	The passive design is the architectural design technique pursuing the method utilizing the natural energy actively by minimizing the energy use of buildings for the purpose of use control of fossil fuel.

This phenomenon seems to result from still being locked up in literal meaning and concept of 'passive' and 'active'.[6] However sustainable architecture is possible when natural environment and strategic new and renewable energy are used in harmony. Therefore, the present study defines 'passive design' as follows.

Passive design is an architectural planning technique that maximizes the use of natural energy on the basis of the geographical features of building site. That is, it is "an sustainable design concept that provides users with pleasant space and environment by more using natural energy and less using fossil energy and a design method to consider even the performance of a building as well as the external functions of a building." Therefore, discussion is made on the use of natural energy in terms of passive design to improve building performance. Because of this, passive design exerts a massive power at the stage of plan and design.

3. Architectural Planning Elements of A Public Library in the aspect of Passive Design

3.1. Facility Planning Guideline For Public Library

Passive design is characterized with using a site through the understanding of climate, architectural planning to take advantage of natural energy, and providing pleasant indoor environment by reducing power load. The elements of passive design are largely categorized into 4 areas: use of a site, architectural planning elements, indoor environment, and the use of new and renewable energy. However, this study divided the elements only into the use of a site and architectural building planning elements because the purpose of this study is to examine the impact of passive design at the stage of design. For the use of a site, such elements are included in passive design as layout and direction, preservation of original site, and elements related to mass form. And architectural planning elements include those related to space planning, ventilation, lighting, and indoor green.

Table 4 summarized the detailed standards and guidelines of 5 architectural planning elements of a public library from the viewpoint of the use of a site and architectural planning elements. The introduction of ①Standards of Korean Libraries(2013) explains that 'it is a measure legislated to achieve the quantity, quality, coverage, and level set by special body or a governmental department that supervises libraries and evaluate the progress. It stipulates the identity of a library and presents data and indexes for library facilities by type, which are not designated in law'. Like this, Standards of Korean Libraries is the important basic data for library policy, plan and facility construction by type. ②A Manual on Construction and Management for Public Libraries(2013) is issued by the Ministry of Culture, Sports and Tourism. It says that it is aimed to provide a guideline to 'administrative procedure for the construction and remodeling of a public library, and construction guideline and space composition.' It provides specific and detailed architectural planning elements such as setting construction concept, space size planning, remodeling plan, and environmental facility plan. ③Guideline of the Public Library Operating Standards(2012) is published by Seoul City Government. It is aimed to set standardized work guideline for public library. ④A Study on Development of Operation Model For Gyeonggi-Do Public Libraries(2013) is a study aiming to provide a standard model for operation, construction and cooperation system of a public library. In that study, construction size, necessary space, and sustainable layout plan. Last, ⑤A Study on the Present Status of Korean Public Library Space Management and Standard Model (2007) is a study policy proposal and standard model development necessary to be considered in constructing a new library.

6) Kim byul, "A study on evaluation methods of eco-friendliness for multi-unit dwellings through interpretation of passive design concept", Doctor's Dissertation, Konkuk University, 2013, p.82

Table 4. Detailed contents based on the standards and guidelines of public library

Detail of Plan for Library			Previous Researches					No.
Division		Contents	①	②	③	④	⑤	
SITE	Land use	Topography-Adaptive		●		●		2
		Permeable pavements		●		●		2
		Green-Network		●		●		2
	Layout and direction	Accessibility	●	●	●	●	●	5
		Building orientation		●		●	●	3
BUILDING	Building mass form	Location and scale	●	●	●	●	●	5
		Optimal shape design		●				1
	Floor plan	Efficiency	●	●	●		●	4
		Scalability	●	●			●	3
		Functionality	●	●		●	●	4
		Flexibility	●				●	2
		Adaptability	●					1
	Facade design	Daylight		●			●	2
	Section design	Ventilation		●				1

①Standards Of Korean Libraries②A Manual On Construction and Management For Public Libraries ③Guideline Of The Public Library Operating Standards ④A Study On Development Of Operation Model For Gyeonggi-Do Public Libraries ⑤ A Study On The Present Status Of Korean Public Library Space Management and Standard Model

Reviewing these planning guidelines allowed us to confirm that site has elements of location (area for population), accessibility of public transportation within in certain radius, and identifiability such as night lighting and installation of a sign. And a building has such elements as efficiency that fix walls, columns and partition walls are less used to secure smooth walking line, scalability for securing external space and variable space and functionality for preparing rooms for related facility.

3.2. Passive Design Elements

5 precedent studies were reviewed to derive passive design elements for the use of a site and architectural planning elements. ①Kim byul (2013) extracted natural ecological elements and examined precedent studies and cases later. And the researcher added material and new and renewable energy section and derived passive design elements. ②Koh Gwi-Han (2015) chose 5 items such as climate characteristic, geographical features and layout, formative structure, plane composition, external skin plan and material composition, and illustrated relationship among 5 items. ③Kim Chul and others (2) (2013) analyzed related systems and cases to provide a guideline to passive design and included plan elements and technical elements. ④Yim Su-Hyun and other(1) (2010) divided passive/ active design depending on natural environment element and listed them. And they checked the application status of the list to domestic and foreign cases. ⑤Lee Bong(2011) explained passive design technique and elements as sustainable architecture design.

Table 5 shows the list of passive design elements found from each of those precedent studies. The present study selected the elements with most frequency and analyzed association with library architectural planning elements. And they were chosen as evaluation factors.

Table 5. Evaluation elements of passive design from previous researches

Elements of Passive Design			Previous Researches					No.
Division		Contents	①	②	③	④	⑤	
SITE	Land use	Topography-Adaptive		●		●		2
		Greening of outdoor Space	●			●		2
		Permeable pavements				●		1
	Layout and direction	Southern exposure layout	●	●	●	●	●	5
		Sunlight environment		●	●			2
BUILDING	Building mass form	Ratio of lateral to longitudinal length		●	●		●	3
		Ratio of surface area to volume		●	●	●	●	4
		Buildings mass form		●	●			2
	Floor plan	Daylighting	●	●	●		●	4
		Garden for interior and roof top			●	●		2
		Plan for occupant schedule		●	●		●	3
		Buffer zone		●				1
		Interior spatial plan			●	●	●	3
	Facade design	Louver and shading device	●	●	●		●	4
		Green wall		●	●	●	●	4
		Light-Shelf		●		●	●	3
		Window location	●		●			2
		Window size	●			●		2
		Area ratio of window			●		●	2
		Window type			●	●		2
		Double skin	●		●		●	3
	Section design	Atrium			●	●	●	3
		Light well and light-duct	●		●	●	●	4
		Greenhouse model				●		1
		Piloti				●		1
		Wind path	●	●		●		3
		Cross-ventilation plan	●		●		●	3
		Chimney system of natural ventilation				●	●	2

①Kim byul(2013) A study on evaluation methods of eco-friendliness for multi-unit dwellings through interpretation of passive design concept ②Koh,GwiHan(2015) Study of evaluation model for the analysis of the techniques of passive building ③ Kim Chul and Others(2013) A Study on the Guideline Development for Passive Building Design ④Yim Su Hyun and Other(2010) A Study of Sustainable Architectural Design Elements Based on the Classification of Natural Elements ⑤ Lee Bong(2011) Passive Design for Sustainable Architecture

3.3. Planning Elements of Public Library from the Perspective of Passive Design

Earlier, the common elements of architectural planning elements of a public library and passive design were derived. These common elements were re-classified by calculation method and installation. And the final planning elements of a public library from the perspective of passive design were prepared as seen in Table 6.

For the use of land at the section of site, biotope planning is evaluated to know if ecological environmental area can be secured, and eco-parking space and facility is evaluated for

Table 6. Evaluation criteria of sustainable public library in the aspect of passive design

Division		Criteria	Evaluation Elements	Contents and Score		Evaluation Criteria(Point)					
						5	4	3	2	1	0
SITE	Land use	Creation of ecological environmental area	Biotope planning	Installation of biotope	2	-The acquisition of 1 point scale in assessment depending on with/without the installation of biotope or ecological pond -The acquisition of 2 point scale in assessment depending on both the installation of biotope and ecological pond					
		Landscape ecological green-network in outside space	Eco-parking space	Ground packed onto the grass parking lot	1	The acquisition of 1 point scale in assessment depending on with/without the installation of grass parking space					
	Layout and direction	Accessibility of library for external users	The relationships between road width and accessibility	Roadway infrastructure level for efficient accesses	5	X≤30 m (2sides)	X≤25 m (2sides)	X≤25 m	X≤20 m	X≤15 m	X≤10 m
		Site planning for the direction of an angle for daylight performance	Optimum angles of axis of building facing southern	Building orientation for optimization of natural daylight	5	X≤±15°	X≤±30°	X≤±45°	X≤±60°	X≤±75°	Greater than ± 75°
BUILDING	Building mass form	The building forms considering the cooling and heating loads about on the building energy performance	A/V Ratio*	Surface area to volume ratio on the building energy performance	5	X<0.2	X<0.3	X<0.4	X<0.5	X<0.6	Greater than 0.6
			W/D Ratio*	Interaction heating and cooling load and energy consumption of space width to depth ratio	5	1:1	1<x≤1.5 :1	1.5<x≤2 :1	1: 1<x≤1.5	1: 1.5<x≤2	Greater than 1:2 or 2:1
	Floor plan	Provide a pleasant environment by creating green areas inside the building and the roof.	Horizontal green space	Fixed green roof garden and indoor gardening	2	-The acquisition of 1 point scale in assessment depending on with/without the installation of green roof or indoor gardening -The acquisition of 2 point scale in assessment depending on both the installation of green roof and indoor gardening					
	Facade design	Solar and daylighting strategies for heating and cooling load reduction	Louver and Shading devices	The inflow of direct ray is blocked during the summer time, the security of comfortable city environment as the ray is diffused by cooling and heating loads are reduced by introducing the natural ray and the during the winter time	2	-The acquisition of 1 point scale in assessment depending on with/without the installation of louver or shading devices -The acquisition of 2 point scale in assessment depending on both the installation of louver and shading devices					
			Light-shelf	The reflected light is introduced to the deep indoor by blocking the direct ray.	1	The acquisition of 1 point scale in assessment depending on with/without the installation of light-shelf					
			Green wall	The sunlight load is blocked by introducing the plants in the building façade.	1	The acquisition of 1 point scale in assessment depending on with/without the installation of green wall					
	Section design	Using a sunlight through providing a comfort thermal environment for occupants in the building	Atrium	The natural light is introduced through the glass wall and the provision of comfortable indoor environment	1	The acquisition of 1 point scale in assessment depending on with/without the installation of atrium					
			Light well and Light-duct	The light well is the planning method for floor plan that the sky windows and void slab are located in the straight line so that the sunlight introduced in the sky windows may be delivered to the lower layer; the light duct means to be the device capable of introduction the sunlight to the underground or the deep indoor space.	2	-The acquisition of 1 point scale in assessment depending on with/without the installation of light well or light-duct -The acquisition of 2 point scale in assessment depending on both the installation of light well and light-duct					
Total Score						32					

* A/V : Surface Area to Volume ratio / * W/D : Width to Depth ratio

ecological green-network in outside space. For layout and direction, the relationship between road width (one or two lanes) and accessibility is evaluated for accessibility of library for external users. In addition, optimum angles of main direction (southward) of a building are evaluated for daylight performance, which heavily affects cooling and heating efficiency.

In the section of building, buildings are divided by form. the energy requirement distribution by W/D ratio shows that annual load more reduces as building is more square even for the same volume.[7] Therefore, A/V ratio and aspect ratio, which are the indexes of library shape, are important in architecture design. A/V ratio is the ratio of surface area to volume on the building energy performance. To calculate A/V ratio, this study referred to a building register and multiplied floor area of each floor by hight for volume. External skin area was calculated in 3D model using Sketch Up, which is a modeling program. And the external skin area was divided by the volume and converted into percentage to get A/V ratio. Aspect ratio (W/D Ratio) is calculated in percentage of the width of a building to its depth, which can be obtained in a layout plan. Besides, one point was assigned to louver, shading devices, light well, light duct, and atrium, if there is, to evaluate the natural lighting and natural ventilation of a library. And two points were assigned when two elements wete installed or formed: biotope of land and aqua plant, green rooftop and green indoor, louver and shading device, and light well and light duct. And the highest point 32 was given to the case where these elements were all installed and land environment and architectural planning elements were all applied, say, when a building is laid out southward, close to share shape, and of simple mass.

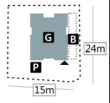
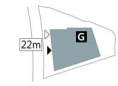
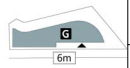
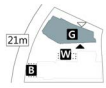
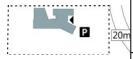
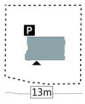
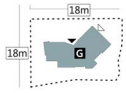
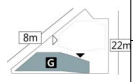
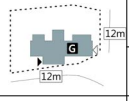
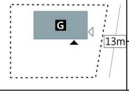
4. Passive Design in Public Library

4.1. Cases of Public Library and Characteristics of sustainable Planning

7) Kim Hak-Kun, Yoon Jong-Ho, Lee Won-Goo, Min Hyeon-Jun, Sustainable Energy Research Institute, "Looking into the practical world of green building design", Goomibook, 2014

G case group consists of public libraries that acquired more than preliminary certification according to G-SEED Certification system from 2011 to 2014, while N case group consists of public libraries without green certification but chosen as excellent public library by the Ministry of Culture and Sports in 2012. This study applied the evaluation index to 6 cases and analyzed them. Table 7 shows the results.

Table 7. Case study of sustainable public library

Div.	Case		Architecture scheme			SITE		BUILDING				Total
						Land use	Layout and direction	Building mass form	Floor plan	Facade design	Section design	
			Location	Site area (㎡)	Site plan	Biotope planning	Road width	A/V ratio	Horizontal green space	Louver / Shading device	Light-shelf	
			Year of opening (Certification year)	Gross area(㎡)		Eco-parking space	Optimize angles	W/D ratio	Green Wall	Atrium	Light well /Light-duct	
			Multi-Use / Certification type	Building size								
G SEED Pre-Iminary Certification	G1		Suwon-si, Gyeonggi-do	7,961		Biotope	24m, 15m	0.35*	Roof garden / Indoor garden	Louver	-	20
			2015. 06 (2014)	3,905								
			—	B1, 2F		Grass Parking lot	27°	1.27:1	-	-	Light well	
	G2		Suwon-si, Gyeonggi-do	3,057		-	22m	0.21	Roof garden / Indoor garden	-	-	17
			2014. 12 (2013)	9,828								
			—	B1, 5F		-	-34°	1.22:1	-	-	Light well	
	G3		Seoul	917		-	6m	0.37	Roof garden / Indoor garden	-	-	9
			2014. 10 (2013)	2,678								
			Multi-Use (Kindergartens)	B2, 5F		-	30°	3.48:1	-	-	-	
	G4		Yongin-si, Gyeonggi-do	5,435		Biotope / Ecological pond	21m	0.25	Roof garden / Indoor garden	Louver	-	16
			2015. 05 (2013)	6,596								
			Multi-Use (Family centers)	B1, 5F		-	-20°	2.60:1	-	-	-	
	G5		Suwon-si, Gyeonggi-do	3,460		-	18m, 15m	0.31	Roof garden	Louver	-	14
			2014. 03 (2012)	2,692								
			Main Certification(2014)	B1, 3F		Grass Parking lot	56°	1.071	-	-	-	
	G6		Seoul	9,949		Ecological pond	18m	0.25*	Roof garden	-	-	10
			2013. 10 (2011)	3,965								
			Main Certification(2013)	B1, 3F		-	-130°	1.14:1	Roof garden	-	Light well	
Outstanding Librar	N1		Yongin-si, Gyeonggi-do	87,722		-	20m	0.29	-	Louver	-	13
			2012. 07	4,360								
			—	B1, 2F		-	-45°	2:1	-	-	-	
	N2		Gimpo-si, Gyeonggi-do	6,313		-	13m	0.25	-	Louver	-	16
			2009. 07	4,080								
			—	B1, 3F		Grass Parking lot	-4°	1.6:1	-	-	Light well	
	N3		Paju-si, Gyeonggi-do	7,000		-	18m, 18m	0.21	Roof garden	-	-	10
			2008. 09	8,546								
			Multi-Use (Art Centers)	B1, 3F		-	180°	1:1.53	-	Atrium	Light well	
	N4		Seoul	3,690		-	22m, 8m	0.32*	Roof garden	-	-	12
			2008. 10	2,032								
			Multi-Use (Sports Center)	B1, 4F		-	-22°	3.18:1	Green wall	-	-	
	N5		Seoul	1,161		-	12m, 12m	0.34*	Roof garden	-	-	6
			2006. 06	3,094								
			—	B3, 3F		-	81°	1.65:1	-	-	-	
	N6		Seoul	17,946		-	20m	0.24	Roof garden	Louver	-	15
			2006, 02	6,526								
			—	B1, 4F		-	1°	1.73:1	-	-	Light well	

* A/V Ratio : If the building located above the sloping ground, it calculated the basement of buildings facades exposed to the outside.
* ▲ : Main entrance, △ : Vehicle, G : Roof Garden, P : Grass Parking lot, W : Ecological Pond, B : Biotope

G1 is located within Ilwol Park and has land plant biotope. Inside, light well and horizontal green are installed as well as louver. G2 uses double external skin and horizontal green facilities such as green indoor and green rooftop are installed inside of each floor. Light well is also introduced inside. G3 had a kindergarten on the first floor and a rooftop garden as well as an open deck on each floor. Other passive design elements are not installed. G4 has a family center within the same site, but the buildings exists as separate unit. A/V ratio is only considered for the library unit. Insides, a courtyard is arranged for natural ventilation and louver is installed. G5 has louver and acquired main certification in 2014. G6 planned and installed a garden on every floor from the 2nd floor to the top (vertical green) and acquired main certification in 2013.

N1 is located in Bora Park and has louver at the facade. N2 has a courtyard and a light well together inside and has louver at the facade. On the top, solar energy generator is installed. N3 is located within Kyoha Jungang Park and has rooftop garden. The atrium installed inside is connected to the library to right to left. N4 has a sports center in the same complex. The library unit and the sports center unit are separated on the level but they are connected by a underground swimming pool. A/V ratio of individual building on the library unit were reviewed. N5 is located near Hongryung Neighborhood Park and has natural experience activity workshop on the rooftop. N6 is located within Onsu Neighborhood Park and light well, rooftop garden, and louver are installed.

Each case was scored according to the evaluation criteria for architectural planning elements of a public library from the perspective of passive design and the results are shown in Table 7. The angles of main axis of a building were calculated with directions described in a layout plan. For the calculation of A/V ratio, basically, mass on the ground was calculated. And only for a building whose external wall of basement floor is exposed over the ground so underground can be accessed from the ground, mass was calculated by adding external wall area. Aspect ratio (W/D Ratio) was calculated with the length of long side of a building as described in the layout, which was divided by the length of short side. As for horizontal green, of which installation needs confirmation, it was divided into rooftop garden and green indoor installed inside a building. For vertical green, only when a garden was introduced at the facade of a building, it was accepted. And louver, shading device, atrium, light shelf, light well, and light duct were checked for installation.

4.2. Case Analysis and Comparison

The total evaluation scores of the certified and uncertified libraries under G-SEED Certification System turned out to be 86 and 72, respectively, and the score of the certified libraries was 14 points higher than the uncertified ones on average. G1 has the largest passive design elements and the score of G3 was lower than the average of the uncertified libraries. In addition, while the uncertified libraries did not have scores both in land and aqua plant biotope, the scores of 2 uncertified libraries were higher than the average.

Of the elements of passive design, the certified libraries had 23 scores from the passive design elements related to land and building such as biotope, louver, shading device, and atrium while the uncertified libraries earned 13 from them, so there was obvious difference. It is because the libraries gained scores (from the items such as biotope and horizontal green) in the process of acquiring preliminary certification. That is, all the cases with preliminary certification installed green rooftop and 4 of them installed green indoor. Furthermore, Biotope was found only in the certified libraries. The second most installation among passive design elements was light well. G1, G2, N2, and N6 were found having a light well of void slabs that were inserted in the lower floors, including the ground floor, from the ceiling. G6 and N3 had a light well on the ground floor so as to light the basement parking lot. Besides, louver was found installed in 5 libraries of the total. Vertical green was found in 2 libraries. For atrium, only one uncertified library had it.

As for 3 evaluation items that require mathematical work to assess such as the angles of the main axis of a building, A/V ratio and W/D ratio, the difference in the total score between the certified and the uncertified libraries was minor (by 2). The entire cases were similar in the score of A/V ratio and rather the score of the uncertified libraries was relatively higher. It is because that most of the libraries are built in a single unit building in a complex and they have similar plane structure both in low-level and high-level floors. Furthermore, it was found that their rooms are layered vertically. The total score of building layout was turned out similar for both groups. For W/D ratio, there was 3 point difference between two groups and the score of the certified building group was higher.

As a result, the total and average score of the certified libraries were higher than those of the uncertified libraries. The gap in the scores stemmed from the installable elements related to land and building (e.g. biotope, louver and shading device). In other words, although two groups showed similar scores in building layout method, direction and vertical expansion in land environment, the certified group accepted passive design elements more actively.

4.3. Relationship Between Evaluation Items of G-SEED Certification System for Public Library and Passive Design

G-SEED Certification System is a tool to certify architecture of its environmental friendliness by saving energy and reducing environmental pollution in the whole process of construction. Judging from the results of this study that conducted the evaluation of passive design adopted by the certified public library, the certified libraries have slightly better than the uncertified libraries. Therefore, this study was impelled to analyze the relationship between G-SEED Certification Standard and passive design elements. G-SEED has 10 standards by building type: apartment housing, complex building for residential purpose, complex building for office, school, business, accommodation (lodging), small residential housing, existing apartment housing, and existing office facility and others. Public library is subject to the standard for 'others'. Therefore, this study carried out a correlation analysis between G-SEED Certification Standard for 'Other Buildings', which was revised on June, and passive the elements of design for the public library. The results are as in Table 8.

Table 8. Analysis to correlation between sustainable public library & G-SEED

Division		Evaluation Elements	Related criteria
SITE	Land use	Biotope planning	6.3.1 Biotope Construction
		Eco-parking space	**None**
	Layout and direction	The relationships between road width and accessibility	**None**
		Optimum angles of axis of building facing southern	**None**
BUILDING	Buildings mass form	A/V Ratio	**None**
		W/D Ratio	**None**
	Floor plans	Horizontal green space	7.3.1 Space planning for rest
	Facade design	Louver and Shading devices	**None**
		Light-shelf	**None**
		Green wall	6.2.1 Biotope Area Ratio
	Section design	Atrium	**None**
		Light well and Light-duct	**None**

As in the results of the case study of public library of Table 7, it turned out that the certified libraries accepted passive design actively to realize sustainable public library. However, as Table 8 confirms, the evaluation items of G-SEED Certification System for passive design elements are sufficient. Therefore, to the certified libraries, introduction of passive design elements is not a tool to acquire certification, but purely use them as sustainable architectural planning elements. That is, passive design elements recommended in G-SEED Certification System should be realistic and plausible so that those passive design elements can be used as architectural planning elements.

Although the standards currently used under G-SEED Certification System include land/aqua plant biotope, indoor water space, planting space, green rooftop, wall green and also have evaluation tools, they have no standards for direct architectural planning elements such as building mass form, layout method, and day light regulating device. Library facility uses such passive design elements as horizontal green and louver most frequently, but G-SEED Certification System does not have such criteria to evaluate. Therefore, it is necessary that the system be more specific and realistic to realize the elements of sustainable architecture of public library by considering the relationship between such elements and energy efficiency and conservation, not only as a tool for institutional certification.

5. Conclusion

The present study compared two groups of public libraries: ones with more than preliminary certification according to G-SEED Certification System and the others without preliminary certification, but chosen for excellent public library by the Ministry of Culture and Sports to examine passive design elements and their relationship with the libraries. The results are as follows.

First, the uncertified libraries have lower scores of design and installation elements than the certified libraries, but similar scores of the elements affected by land environment such as the width of access road, the angle of a main axis facing southward, A/V ratio, and the aspect ratio (W/D Ratio) of a building to those of the certified libraries. This result can be explained by the similarity which both types of libraries have in land environment and vertical layering of individual rooms of a library in a separate building unit.

Second, since the elements of passive design to certify under G-SEED Certification System are not inclusive, quantitative evaluation criteria is not sufficient. Although there are building layout method such as the use of land and the elements that have impact on the reduction of cooling and heating load and building energy performance efficiency such as A/V ratio, aspect ratio (W/D Ratio), and day light regulating device installed according to architectural design plan, there is no evaluation tools of the certification system itself except use of materials and installation of devices.

Third, currently a public library is evaluated by the standards for other types of buildings at G-SEED system.

That is, a public library is categorized in the same group for evaluation with art gallery, hospital, and research center, all of whose energy usage is different. As more and more libraries are built, it is necessary that the evaluation areas for G-SEED Certification System needs to be more specified based on building type.

The present study only analyzed the application of passive design to the sites where library facilities and buildings are located. However, there was limit due to different classification of multiple complex area, size of library, and design guideline.

A public library needs to provide its users with pleasant environment and a public building that can simply ruled up by economic value. Therefore, it should be applied with strict library-related standard for high level of sustainable designed facility and passive design should be applied in initial stage of planning and designing to introduce natural environment more actively. In future, it is expected that public library-related laws and guidelines keep updating and developing and a study is needed upon the quantitative value evaluation of passive design.

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