International Journal of Advanced Culture Technology Vol.7 No.1 133-142 (2019)
DOI 10.17703/IJACT.2019.7.1.133

IJACT 19-3-20

The Effect on Scenic Impression by Different Construction Methods of Green Wall

Kwang-pyo Hong, Hyuk-jae LEE*

Dongguk University, Department of Landscape Architecture
**Dongguk University, Department of Landscape Architecture*
E-mail: hkp@dongguk.ac.kr, hyuk-jae-lee@hanmail.net

Abstract

This study aims to understand how different construction methods impact scenic preference of green wall and clarify features of each construction method to help select the most suitable construction method for the wanted image of a green wall by providing the basic data for further development and distribution of green wall. Questionnaire developed by the Repertory Grid technique proved that 11 adjectives can be used to describe scenic features of a green wall and 4 preference elements. The result of the Scenic evaluation, the Felt type scored high in 'Aesthetic' and 'Maintenance' meaning that it is the most suitable method when constructing a green wall to improve urban scenery. Regression analysis was conducted to understand the link between the preference elements and scenic impression of a green wall. The result is that the higher the preference is on the design of a green wall, the higher the score is for 'Aesthetic'. Also, the higher the preference is on Bio-Diversity, Design, Growth, the higher the score is for 'Natural'.

The above findings can be important measures and reference for selection of the right construction method when planning a green wall.

Keywords: *Green wall, Scenic Meaning, Repertory Grid Development Method, Factor Analysis, Regression Analysis*

1. Introduction

The term "Wall greening" is used in the Green Design Guide for building architecture published by the Ministry of Land, Infrastructure and Transportation of Korea and is defined as designing of rooftops, walls or interior of building architecture which supports sustainable growth of plants. Also, a term "Wall Planting" is used by The Korea Forest Service on its website which is defined as promoting scenery by making green walls from retaining walls and stone walls. The construction method can vary depending of a purpose of green walls such as reducing urban heat island and securing habitat or to grow plants on the walls by installing media or using climbing plant. Green Wall, Living Wall, Green Façade and Vertical Gardens are also used to describe "Wall Planting" with slightly different meanings. Green wall is derived from Greenroof and is probably the most commonly used term. Green wall also refers to walls indoor and outside, plus freestanding or attached. On the other hand, Green Façade refers to a greening construction method which does not use growing media. Instead, a planter is installed at the bottom or at top of a wall and wires will be installed to grow plants. Vertical Garden is a term coined by a French botanist, Patric Blanc (1953~) which refers to a mixture of plants growing on a wall and is evaluated as a garden with rich bio-diversity and additional designs to greenery which is recognized as something beyond simple greenery. It is sometimes protected with patents.

Manuscript received: January 24, 2019 / revised: February 10, 2019 / Accepted: March 2, 2019
Corresponding Author: hyuk-jae-lee@hanmail.net
Author's affiliation
Department of Landscape Architecture, Dongguk University

As such, green walls have various forms and one can expect that different methods create different scenic impression. One study on the impression of green walls found that green walls create scenery that are natural, familiar, comfortable, beautiful, stable as well as quite, stillness, humble, heavy, gloomy, dark and messy.(Seung-ho Han, 2008). However, such result was based on one construction method only and there has been no study yet into which construction method of green wall generate certain impression more. For a study on the differences created by plant species used, a research by Jeong-ho Kim& others (2015) was conducted to understand the differences created by plant species used in green wall, but this research focused more on performance analysis of building energy. Another study, by Su-young Hwang did comparison analysis on thermal environment of green wall, but there has been no study so far on visual attributes of green wall. Ji-hyun Lee (2011) conducted a study on design attributes of indoor green wall which focused on the impact of color, image, form and plant characteristics on green wall design, but this study did not discuss much on construction methods. In this respect, if one can understand how different construction methods create different scenic impressions, one can select the most suitable construction method to produce the wanted scenery considering characteristics of a given space.

So, this study aims to understand how different construction methods impact scenic preference of green wall and clarify features of each construction method to help select the most suitable construction method for the wanted image when planning a green wall by providing basic data for further development and distribution of green wall.

2. Method

2.1 Construction method and selection of pictures

Websites and brochures of companies domestic and abroad specializing in green walls were examined to understand construction methods of green walls. The methods are continuously improving and in development, so categorization of methods is difficult. However, this study aims to categorize currently available methods up to date. After categorization, features of each construction method were further studied. Then, hearing investigation was conducted on 15 companies specializing in green walls to understand the most common methods used in Korea and to select the target construction methods of the study. 2 places with each of 6 target methods were photographed during May and June of 2018 and 12 photographs were selected as target subjects of the study.

2.2 Extraction of Scenic Elements and Preference Elements

Repertory Grid Developments Technique was used for scenic evaluation to figure out scenic elements impacting images of green wall. 30 Subjects were shown 2 pictures of each of 6 different methods totaling 12 pictures and were asked to sort out these pictures into 5 groups in an order of preference (Highly prefer, Prefer, Neutral, Not preferred, Bad). Subjects were free to choose the number of pictures belonging to each group, then they were asked to compare and freely describe why he/she grouped the pictures the way he/she. Researchers used the laddering process to extract words explaining preference and scenic elements(Adjectives) in the description given by subjects. Laddering is a process of organizing highly related words using lines and present the result in an organized table. Then, the result of the laddering is displayed in a table to extract scenic elements (Adjective) to describe impression of green wall and elements explaining preference.

2.3 Scenic Evaluation by questionnaire

The purpose of the study is to analyze how different construction methods create different scenic impressions based on data collected from the general public. So, a questionnaire was conducted by a survey company with 300 effective participants. A random picture of a green wall was displayed on the website of a survey company along with 4 preference elements and 11 adjectives extracted. A participant is asked to evaluate the displayed picture using 4 preference elements and 11 adjectives and move on to a next picture when evaluation is done.

For 4 preference elements, 7 point Likert scale was used to understand preference on construction methods. For 11 adjectives, 7 Point Likert scale was again used to evaluate scenic features of each construction method. Then, the result of the questionnaire was summed up and translated as 7 points for positive words and 1 point for negative words on a Likert scale for statistical analysis.

For the order of statistical analysis, Cronbach's Alpha Coefficient was calculated to evaluate the consistency of the questionnaire result. Cronbach's Alpha Coefficient is a measure for credibility of data which ranges between 0~1 with the higher coefficient the more reliable. In general, a value between 0.8~0.9 represents high credibility and 0.7 or higher represent reasonable credibility.

Then, average values of the result of the questionnaire were used to conduct a factor analysis. The purposes of a factor analysis are 1) to identify(Group) main factors for scenic evaluation and 2) to confirm meaning of main factors. In this study, adjectives describing scenic impression of green walls were grouped to explain and evaluate the scenery created by each construction method.

For a factor analysis, a number of factors was set to ensure 85% or higher accumulated contribution. Then, Varimax orthogonal rotation was applied as it is known for relatively easy interpretation.

Lastly, a regression analysis was conducted to understand the link between scenic impression and preference elements of each construction method. 11 factor scores were set as object variables for scenic impression by each construction method and 4 preference elements were set as explanatory variables in the regression analysis. Statistic tool used was Excel statistics 2008 by SSRI.

3. Results

3.1. Selection of Construction Method of Green Wall

The result of hearing on 15 companies and surveys on 15 websites show that there are currently 12 construction methods for green wall.(Figure1.) and out of 12 methods, 6 methods are commonly used in Korea. They are 1) Climbing type and 2) Hanging type which have been used mostly commonly from the past, 3) Unit type which allows stable plant growth with added media, 4) Balcony type which comes in module forms for large scale installation, 5) Felt type which is more recently developed to allow more design flexibility and lastly, 6) Pocket exchange type with more convenient maintenance. 2 places with each construction method were selected and photographed as in Figure2.

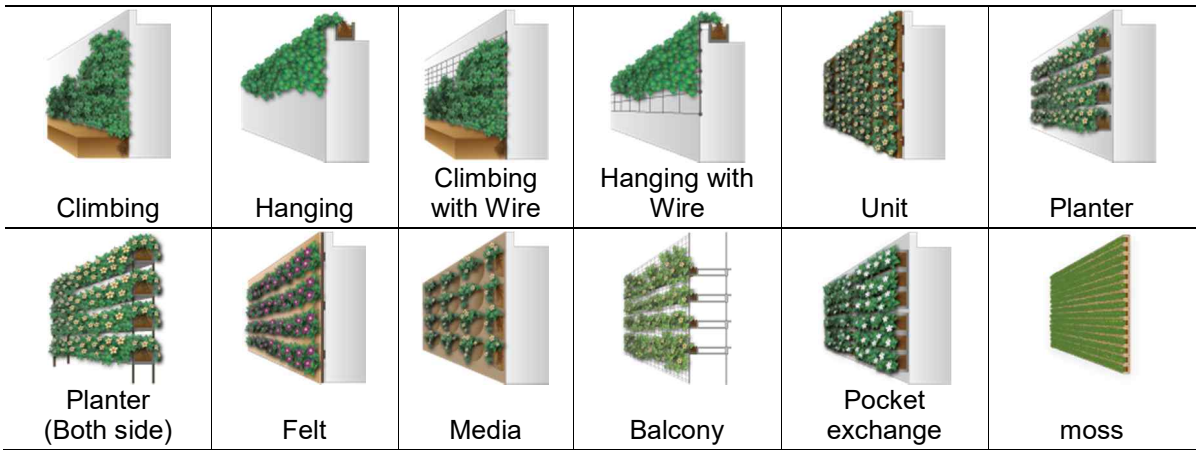

Figure 1. Images of 12 Construction Method of Green Wall

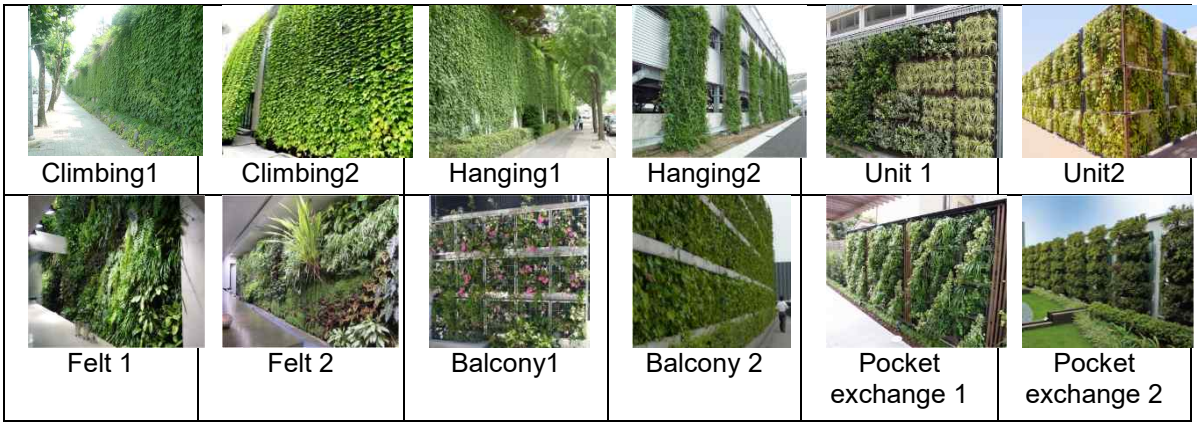

Figure 2. Pictures of 6 Construction Method of Green Wall

3.2 Extraction of Adjectives and Preference Elements

In order to extract adjectives to be used to understand scenic features of green wall, 30 university students majoring in landscape architecture were selected and they took a questionnaire developed using Repertory Grid Technique. All the students who participated in the questionnaire were in 20s with a 50/50 gender ratio. The result of questionnaire was organized into a table to extract adjectives that describe scenic features of green wall. A total of 18 adjectives were extracted and top 11 words were selected as evaluation measure for scenic experiment. Also, 6 preference elements were extracted and top 4 elements were selected for the questionnaire. These are 1) Harmony, 2) Bio-Diversity, 3) Design and lastly, 4) Growth.

Table 1. Extraction of Adjectives and Preference Elements

Adjectives	Frequency	Selection	Preference Element	Frequency	Selection
Natural	28	O	Bio-Diveristy	22	O
Beautiful	27	O	Growth	17	O
Fresh	25	O	Harmony	17	O
Thick	25	O	Design	15	O
Moisture	23	O	Area	8	X
Cozy	22	O	Location	8	X
Luxury	22	O			
Easy	22	O			
Comfortable	21	O			
Elegant	20	O			
Maintained	20	O			
Light	16	X			
Opened	14	X			
Bright	14	X			
Balanced	12	X			
Attractive	12	X			
Regular	10	X			
Neat	10	X			

3.3 Understanding scenic feature of construction method of green wall

A survey was conducted for 5 days to understand image elements with 300 participants. A gender ratio of 50.3:49.7 and 19.3% of participants were in 20s, 21.7% in 30s, 23.7% in 40s, 22% in 50s and

13.3% were in 60s. Gender ratio and age groups for the survey were evenly distributed.

Table 2. 1. Demographic characteristics

Age	Frequency	Participation Rate	Sex	Frequency	Participation Rate
20s	58	19.3%	Men	151	50.3
30s	65	21.7%	Female	149	49.7
40s	71	23.7%	Total	300	100
50s	66	22.0%			
60s	40	13.3%			
Total	300	100%			

Using the average score from the survey, Cronbach's Alpha coefficient was extracted which was 0.877 representing high credibility of the survey result. With items deleted, the alpha value was higher than 0.8.

Table 3. Cronbach's Alpha Coefficient

	Scale Mean If Item Deleted	Scale Variance if Item Deleted	Squared Multiple Correlation	Cronbach's Alpha if item Deleted
Natural	43.416	130.810	0.297	0.884
Easy	45.000	122.727	0.435	0.878
Fresh	43.833	124.697	0.584	0.867
Comfortable	45.416	122.265	0.876	0.855
Moisture	43.166	137.606	0.154	0.889
Cozy	44.166	111.606	0.791	0.851
Thick	42.583	142.447	0.042	0.890
Elegant	44.500	121.727	0.747	0.858
Beautiful	44.166	111.424	0.797	0.850
Maintained	44.583	99.537	0.821	0.848
Luxury	44.166	104.515	0.950	0.837
Cronbach's Alpha = 0.877 (n=12)				

Based on the survey result, a factor analysis was conducted to extract factor axes which is an important element for scenic impression. Accumulated ratio up to factor 3 reached over 85% in the scree plot before Varimax orthogonal rotation and this means that there is sufficient explanation for green wall. Therefore, this study applied 3 factors.

Table 4. Scree Plot

Factor	% of Variance	Cumulative %
Factor1	48.26%	48.26%
Factor2	24.66%	72.92%
Factor3	12.30%	85.22%

Table 5. The amount of factor loads

Adjective	Factor1	Factor2	Factor3
Easy	**0.945**	0.031	0.187
Cozy	**0.937**	-0.106	0.157
Elegant	**0.902**	-0.207	0.175
Beautiful	**0.951**	0.080	-0.003
Luxury	**0.917**	0.118	0.363
Natural	0.089	**0.922**	0.133
Moisture	0.057	**0.942**	-0.183
Thick	-0.199	**0.948**	0.026
Comfortable	0.232	-0.001	**0.767**
Maintained	0.750	-0.056	**0.641**
Fresh	0.558	0.017	0.283

After the Varimax orthogonal rotation, under factor 1 loading, one can see that “Easy”, “Cozy”, “Elegant”, “Beautiful” and “Luxury” have more than +0.9 loading. Thus, factor 1 can be named “Aesthetic”. Under factor 2 loading, “Natural”, “Moisture”, “Think” have more than +0.9 loading and can be named “Natural”. Lastly, under factor 3, “Comfortable” and “Maintained” have relatively high loading whereas “Think” has a negative loading. So, factor 3 is interpreted as “Maintenance”.

Based on the above 3 extracted factors, Factor score was calculated from 6 construction methods with 12 cases and the result is shown in Table 6.

Table 6. The Amount of Factor Score

No.	Factor 1	Factor 2	Factor 3
Climbing1	-0.854	1.107	1.210
Hanging1	-1.185	0.833	-0.582
Unit 1	1.412	-0.420	-1.287
Felt 1	1.325	1.179	0.038
Balcony 1	-0.718	-1.397	-0.311
Pocket Exchange 1	0.776	-0.699	1.337
Climbling2	-0.722	1.174	-0.808
Hanging2	-1.477	-0.150	-1.166
Unit 2	1.234	-0.522	-1.163
Felt 2	1.033	1.204	0.874
Balcony 2	-0.369	-1.519	-0.332
Pocket exchange 2	-0.455	-0.790	2.189

6 construction methods in 12 cases were arranged in 2 dimension axis and the following result was obtained. X axis represent “Aesthetic” with Y axis representing “Natural”. Z axis is for “Maintenance” which was difficult to visualize. So ♦ means + value and X means – value in 3 dimension.

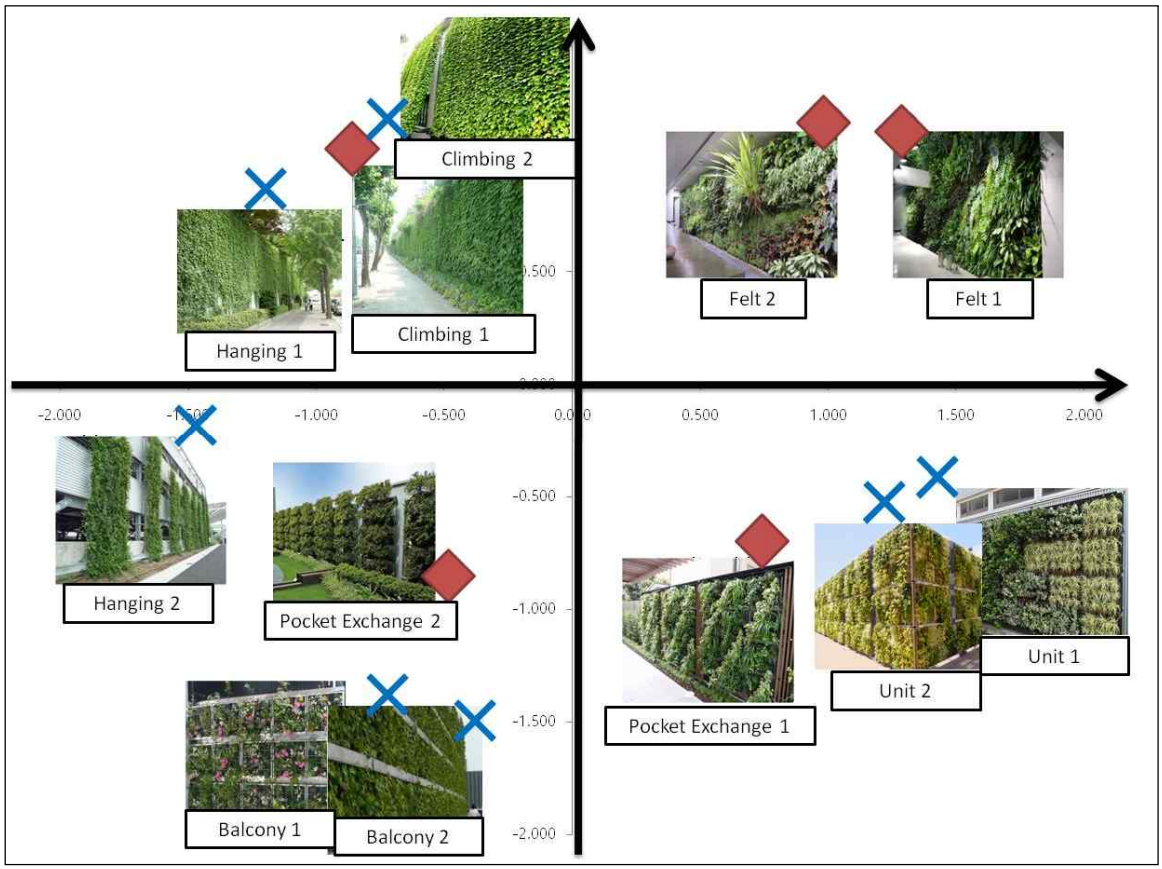

Figure 3. Scene arrangement on the factor axis (x=Aesthetic, y=Natural, Z=Maintenance)

In Figure 3., Felt type 1 and 2 score high in all of 'Aesthetic', 'Natural' and 'Maintenance'. Felt type allows more flexible plantation which probably leads to high scores in "Aesthetic" and in "Natural" as well. Maintaining the felt type green wall is thought to be easy. On the other hand, Balcony type 1 and 2 scored low in all of 'Aesthetic', 'Natural' and 'Maintenance'. The reason is thought to be limited space thus limited design along insufficient plant volume and difficult maintenance of plant. Unit type 1 and 2 scored high in 'Aesthetic', but low in 'Natural' and 'Maintenance'. Unit type allows more flexible design thus scored high in 'Aesthetic', but low plant volume and simple plant pattern probably led to low score in 'Natural' and 'Maintenance'. Climbing type and hanging type scored low in 'Aesthetic' and 'Maintenance', but relatively high in 'Natural'. Climbing type and hanging type use one type of plant which limits design flexibility thus probably leading to low score in 'Aesthetic'. But its relatively high plant volume resulted in high score in 'Natural'. Pocket Exchange type scored low in 'Natural', but high in 'Maintenance'. This type has been developed specifically to allow easy maintenance and has limited design flexibility and low plant volume.

3.4 Link between Preference elements and scenic elements

In order to explore the relationship between explanatory power of Scenic elements(Factor Score) and preference elements of green walls, a linear regression analysis was conducted with 4 preference elements as dependent variables and 3 Scenic elements as independent variables.

The result showed that total explanatory power of 4 preference elements was high at 84% and P-value for Design was below 0.05 which was 0.002 representing its significance. So, the higher the preference element on Design, the higher the "Aesthetic" score. The rest did not have much proven significance thus not much impact on 'Aesthetic' score.

Table 7. Regression Analysis (Aesthetic)

Aesthetic	β		t	P	R^2	F
	B	standard error				
Constant	0.763	2.851	0.267	0.796		
Harmony	-0.009	0.005	-1.733	0.126		
Bio Diversity	-0.001	0.001	-0.753	0.475	0.849	0.001
Design	0.009	0.002	4.520	0.002		
Growth	0.001	0.002	0.693	0.510		

Total explanatory power of 4 preference element for 'Natural' was 71% with P-value 0.02 for 'Bio diversity', 0.02 for Design and 0.01 for Growth which means it is significant variable since P-values are lower than 0.05. In other words, the more people like 'Bio diversity', 'Design', 'Growth', the higher the score is for 'Natural'.

Table 8. Regression Analysis (Natural)

Natural	β		t	P	R^2	F
	B	standard error				
Constant	-12.924	3.808	-3.393	0.011		
Harmony	-1.8E-05	0.007	-0.002	0.998		
Bio Diversity	0.00628	0.002	2.899	0.022	0.717	0.009
Design	0.007	0.002	2.785	0.027		
Growth	0.010	0.003	3.121	0.016		

For 'Maintenance', F-value was 0.122 and P-value was higher than 0.05 for all preference elements, thus no variable was significant.

Table 9. Regression Analysis (Maintenance)

Maintenance	β		t	P	R^2	F
	B	standard error				
Constant	-6.707	6.15	-1.082	0.314		
Harmony	0.010	0.012	0.814	0.442		
Bio Diversity	0.005	0.003	1.520	0.172	0.376	0.122
Design	-0.007	0.004	-1.703	0.132		
Growth	-0.001	0.005	-0.253	0.806		

As explained above, the link between the preference elements and scenic image of green walls is discovered and has proven that 'Aesthetic' of green wall and design preference elements. It is also discovered that in order to enhance 'Natural', 'Bio-diversity', 'Design' and 'Growth' need to be improved as well.

4. Conclusion

This study analyzed features of each construction method of green wall to help select the most suitable method for the desired image when planning a green wall. Also the study analyzed the link

between the preference elements and each construction method in order to collect and provide data to increase satisfaction level of a green wall and to improve urban scenery.

Questionnaire developed by the Repertory Grid technique proved that 11 adjectives can be used to describe scenic features of a green wall and 4 preference elements of 'Harmony', 'Bio-diversity', 'Design', and 'Growth' impact visual preference of a green all.

Using 11 adjectives extracted, 2 pictures of each of 6 different construction methods were shown to general public for ratings on 7 point Likert scale. The result is that Felt type scored high in 'Aesthetic' and 'Maintenance' meaning that it is the most suitable method when constructing a green wall to improve urban scenery.

Climbing type and Hanging type scored low in 'Aesthetic' and 'Maintenance', but high in 'Natural' meaning that it will be most efficient method when constructing a green wall in a space requiring large volume of green. On the other hand, Unit type had high score in 'Aesthetic', but low score in 'Natural' and 'Maintenance' meaning that this type of method is inefficient in enhancing scenery. Balcony type which scored low in all of 'Aesthetic', 'Natural' and 'Maintenance' is discovered to be inefficient.

Regression analysis was conducted to understand the link between the preference elements and scenic impression of a green wall. The result is that the higher the preference is on the design of a green wall, the higher the score is for 'Aesthetic'. Also, the higher the preference is on Bio-Diversity, Design, Growth, the higher the score is for 'Natural'. Lastly, 'Maintenance' was not related to scenic impression of a green wall.

The above findings can be important measure and reference for selection of the right construction method when planning a green wall. That is, these findings help select the most appropriate construction method of a green wall depending on a need for more 'Aesthetic', 'Natural', or 'Maintenance' to allow better design to increase satisfaction and serve as a stepping stone for further development and distribution of green wall to ultimately enhance urban scenery.

However, currently new methods are being developed to minimize visual differences between construction methods. Also, this study was conducted in a cyberspace using internet and results can differ from field. Thus, Additional experiment should take place in the field to obtain more accurate data. Furthermore, environmental factors such as indoor or outside would require different methods and different methods can result in cost differences for construction and maintenance. So, additional experiments would be needed to provide more precise selection standards for construction method. Lastly, in Korea where 4 seasons are distinct, plants lose leaves in winter times and green walls are mostly left bare and empty. Such problem needs to be addressed for continuous distribution and thriving of green wall.

5. Acknowledgement

'This study was carried out with the support of 'R&D Program for Forest Science Technology (Project No. 2017065A00-1719-AB02)' provided by Korea Forest Service(Korea Forestry Promotion Institute)'.

6. References

[1] H.J. Lee and K.P. Hong, "The Impact of Various Wall Greening Methodologies on Landscape Evaluation Structure", *Journal of The Korean Institute of Garden Design*, Vol.3, No.2, pp89-95, 2017

[2] S.H. Han, S.H. Kim, and K.S. Song, "A Study on the Visual Satisfaction of a Panel-type

Facade Planting", *Journal of the Korean Institute of Landscape Architecture* Vol.36, No.2, pp.53-59, 2008.

[3] J.H. Lee, and Y.S. Jang, "A Study on the Characteristic of Indoor Green-Wall Design -With Focused on Preference of Emotional Image Language-", *Korean Journal of the science of Emotion & sensibility*, Vol.14, No.4, pp593-604, 2011.

[4] Bureau of Environment, Tokyo Metropolitan Government. *http://www.kankyo.metro.tokyo.jp/climate/heat_island/green_guidelines.html*

[5] Minuru Sangyo. *http://xn--cjrt5kjv0b8mv.jp/*

[6] H.J. Lee and W.K. Jung, "Study on the Scenic meanings and preferences of fountain", *Journal of The Korean Institute of Garden Design,* Vol.1, No.1 pp.23-29, 2018.

[7] K. Yoshida, H. Takagi, K. Yabe, and S. Asakawa, "Landscape Evaluation of Urban Fringes in Sapporo City, northern Japan" , *Journal of The Japanese Institute of Landscape Architecture*, Vol. 63, No. 5, pp565-568, 1999

[8] J.H. Kim, K.U. Kwon, and Y.H. Yoon, "Analysis of Building Energy Reduction Effect based on the Green Wall Planting Foundation Type Using a Simulation Program" *Korean Journal of Environment and Ecology*, Vol. 29, No. 6, pp936-946, 2015

[9] K.I. Kim, W.P. Kim, and Z.D. Herm, "A Study on the Design Method of Three-Dimensional Planting for the Promotion of Building Appearance and the Expansion of Green Space" *Architectural Research*, Vol22, No.6, pp247-254, 2006