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# Preference of User Groups on Facade Elements of Remodeled Factories in Korea

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**Abstract** The transition from manufacturing to service-based economies in highly developed societies during the post-industrial period resulted in the decline of the industrial landscape, leaving it abandoned or underutilized. In pursuit of revitalizing the obsolete industrial space, innovative design techniques based on adaptive reuse are applied to retrofit modern functions to create a new cultural space and preserve the historical, symbolic, and cultural importance of the abandoned industrial facilities. Design considerations based on facade redesign have proven to be one of the most adopted techniques that can help in recreating a new function for the vacant industrial buildings and integrating them into the present-day urban fabric. This paper examines the facade renovation elements used for the adaptive reuse of 15 abandoned industrial buildings presently used as multi-purpose facilities in South Korea. Through a questionnaire survey, this study analyzes the respondents' preference for different facade renovation elements in the 15 sites according to age and gender. The study found that both genders showed similar preference patterns between most elements. But on some elements, females were keener and expressed a stronger opinion than males. There were much more females than males who perceived color and material as the most important exterior elements. The findings of this study can be used for the adaptive reuse of industrial buildings according to user preferences for different facade renovation elements.

*Keywords: Industrial heritage, Old factory buildings, Facade Study, Facade elements, Remodeling*

## 1. INTRODUCTION

Economic development, the transformation of commercial centers, and advancement in production technology have resulted in rapid urban expansion. However, traditional industries in inner-city areas have gradually declined over the recent decades. The supporting infrastructure and environmental quality of these former industrial sites reflect low imageability and no longer contribute to the economic growth of cities. As a result of the downward trend of industrial development and sluggish economic growth, most of the old factory buildings were shut down in the past few years, leaving the industrial landscape abandoned. With the outward expansion of cities, these industrial sites formerly located in the suburban areas have gradually become a part of the city center. Consequently, the dilapidated factory sites have led to the poor quality of life in the surrounding physical environment.

Most countries across the globe are experiencing similar problems regarding abandoned industrial sites and have taken measures to renovate/remodel and preserve them as industrial heritage. However, the renovation and remodeling plans fail to address the importance of local context in the preservation/conservation practices. In few cases, demolition in the name of renovation has resulted in the loss of industrial heritage. Shen (2014) even when renovated, unsuitable methods and techniques used for redesigning has often been used. The renovated industrial buildings remain unused as they fail to attract visitors or commercial investment. Due to these negative impacts, the renovated heritage remains vacant and abandoned, returning to the same situation. Considering the current situation, it is necessary to identify an optimal and suitable method for renovation/remodeling by comprehending people's perception.

The study investigates how to improve the utilization rate of old factory buildings and increase the economic efficiency of the surrounding areas through renovation/remodeling. Previous studies examine interior renovation and structural renovation of industrial heritage. In contrast, studies related to exterior renovation remain under-explored and require further

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attention. To address this research gap, this study will focus on investigating methods for exterior renovation and remodeling used for revitalizing abandoned industrial sites in Korea. During the site selection process, younger generations or the elderly were the prominent users of the renovated buildings. While women were the predominant users of renovated buildings adaptively reused as coffee shops. Considering these observations, this paper will also analyze the preference of facade elements based on the age and gender of the user in order to optimize the use of the renovated buildings.

The study investigates 15 renovated industrial sites to identify exterior renovation and facade elements commonly used in Korea. These elements were categorized and used for preparing a visual survey questionnaire. The user preference data obtained through the questionnaire survey was statistically analyzed using gender and age as independent variables. The findings in this study contribute to the existing literature on the exterior renovation of old factory buildings that can provide an additional reference for future studies. The study also examines the impact of changing social patterns and economic and industrial structures of the city on renovated old factory buildings. Despite applying multi-functional design approaches, the buildings remain unused and abandoned. This paper includes case studies of abandoned old factory buildings renovated by considering cultural preservation. The present study confirms previous findings on these cases, published in magazines and research articles, and contributes additional evidence on the current situation. This research has been conducted as a part of master's degree thesis by corresponding author (Yuanzhao Liu)from 2018 to 2021.

## 2. LITERATURE REVIEW AND ELEMENTS OF BUILDING FACADE

### (1) Literature Review

Prior studies mainly focus on categorizing different design elements used for the facade renovation of historic buildings in Korea (as mentioned in Table 1). Kim (2017) classifies facade elements based on aesthetics (form, material, volume, and color) and analyzes their importance in facade construction using design principles of unity, rhythm, and proportion. Lee (2006) and Oh (2008) have listed structural (exterior walls, form, access and movement, doors, and windows) and decorative (exterior signage, window typologies, illumination) facade elements used in retail and commercial buildings. Subsequently, Choi (2011) broadens the list of structural elements by including pillars, interior walls, and balconies against the backdrop of commonly used facade modeling elements. Studies have also listed architectural form elements such as vertical, horizontal, projecting, or sunken components used in the building structure and the color combination used for blending these elements with the outdoor signage to create an aesthetic harmony (Y. Cho, 2011). Additionally, phenotypic characteristics such as pattern, material, texture, and color have been considered (Seo, 2011). However, much of the research has been limited to the evaluation and classification of different facade elements based on aesthetics and physical appearance but fails to specify the users' visual perception of these elements. In view of this gap, this study will explore commonly used categories of facade elements in building renovation as mentioned in previous research and evaluate them based on the users' perceptions.

Table 1. Literature Review

| Researcher | Research method | Constituent elements |
|---|---|---|
| Kim Hyun-Jung (2017) | Systematize the elements and principles of the facade | 1.Components-form, texture, style, color<br>2.Composition principle-unity, coordination, balance, symmetry, proportionality |
| Lee Su-Jin (2006) | The article divides the form, material, color, and the relationship with the surrounding into two parts: structural and decorative | 1.Structural elements-Various structural changes<br>2.Decorative factors-parts of various performance changes<br>3.Modeling elements-stereotypes, non-stereotypes |
| Oh Yeon Soon (2008) | Classification of elements in the facade composition system | 1.Structural elements-wall, shape, entrance part<br>2.Decorative elements-signs, windows, posters, lighting |
| Choi Young Shin(2011) | The architectural elements are divided into structures and horizontal facilities according to their types, and the outdoor advertising objects on the facade are divided into forms, materials, and colors for analysis. | 1. Order phenotype elements-patterns, materials and textures, colors<br>2. Architectural elements-pillars, windows/walls, balconies, doors |
| Seo Ji Young (2011) | Distinguish the types in the facade composition system. | 1. Form-horizontal type, vertical type, protruding type, pillar type<br>2. Decoration-materials, signs, signatures, text |

With reference to prior studies, this study will examine selective facade elements structured in five categories of "form", "location", "material" and "color" (see Table 1).

### (2) Elements of Building Facade

Bian (2012) identifies different facade elements and analyses them under three categories of aesthetics, geometry, and color. This study will consider Bian method to classify and analyze building facade elements based on the building shape, exterior walls, roof structure, entrance, doors, and windows. These categories were further subdivided into sub-categories using letters and numbers as shown in Table 2.

Table 2. Element Classification

| Element | Property | Type | Number |
|---|---|---|---|
| Building shape | Basic form | Cube | A1 |
| | | Cylindrical | A2 |
| | | Triangle | A3 |
| Exterior wall | Overall colored | Red | B1 |
| | | Orange | B2 |
| | | Yellow | B3 |
| | | Green | B4 |
| | | Cyan | B5 |
| | | Blue | B6 |
| | | Purple | B7 |
| | | Gray | B8 |
| | External material | Concrete | C1 |
| | | Brick | C2 |
| | | Stone | C3 |
| | | Glass | C4 |
| | | Wood | C5 |
| | | Steel | C6 |
| | | Other | C7 |
| Roof | Roof form | Accessible flat roof | D1 |
| | | General flat roof | D2 |
| | | Single pitch roof | D3 |
| | | Double pitched roof | D4 |
| | Roof material | Stone tile | E1 |
| | | Steel | E2 |
| | | Wood | E3 |
| | | Glass | E4 |
| | | concrete | E5 |
| Entrance | Entrance and internal connection | Flat entrance | F1 |
| | | Recessed entrance | F2 |
| | | Protruding entrance | F3 |
| | Proportion on the facade | Big(30%~50%) | G1 |
| | | Middle(20%~30%) | G2 |
| | | Small(10%~20%) | G3 |
| | Border around the entrance | Transparent | H1 |
| | | Opaque | H2 |
| | Entrance canopy | With canopy | I1 |
| | | Without canopy | I2 |
| | Entrance location | Middle of building | J1 |
| | | Both sides of the building | J2 |
| Door | Opening types | Swing door | K1 |
| | | Sliding door | K2 |
| | | Special doors | K3 |
| | Door material | All wooden | L1 |
| | | Wood + Glass | L2 |
| | | All metal | L3 |
| | | All Glass | L4 |
| | Door height | High(2.8m~3.2m) | M1 |
| | | Middle(2.4m~2.8m) | M2 |
| | | Low(2.0m~2.4m) | M3 |
| Window | Window form | Whole floor window | N1 |
| | | Large horizontal window | N2 |
| | | Large vertical window | N3 |
| | | Small horizontal window | N4 |
| | | Small vertical window | N5 |
| | | French windows | N6 |
| | | without | N7 |
| | Opening types | Casement window | O1 |
| | | Sliding window | O2 |
| | | Hanging window | O3 |
| | | Closed | O4 |
| | | Folding window | O5 |
| | | Without | O6 |
| | Window ratio | Big(60%~90%) | P1 |
| | | Middle(30%~60%) | P2 |
| | | Small(0~30%) | P3 |

Based on detailed field investigations, all the elements were categorized accordingly. "Building shape" category includes cube, cylindrical and triangular shapes. "Exterior colors" were categorized as using RGB color model complimentary primary-secondary combinations of red, cyan, green, violet, blue and yellow. Based on the overall buildings style, climatology, structural system, "Exterior materials" were defined as reinforced concrete, brick, stone, glass, wood and metal. Two types of "Roof form" namely flat roof and pitch roof were considered and further sub-categorized based on "Roof materials" including stone, metal sheet, wood, glass, and concrete. Considering the front structure and overall composition of the building, the "Building Entrance" category includes flat entrance, protruding entrance and recessed entrance. The study examined three types of "Doors" i.e. swing doors, sliding doors, and special doors. This category was subdivided based on the door materials (only wood, wood-glass combination, only metal, and only glass). "Windows" includes casement windows, sliding windows, hung windows, fixed windows and folding windows.

## 3. RESEARCH METHDOLOGY

### (1) Case Studies

Renovated old factory buildings in industrial heritage sites were selected from recently published research articles, architectural magazines, and internet archives. Photographs of facade elements used for exterior renovation of these buildings were obtained through online sources. The Facade study of the selected sites included comparative analysis of structural elements such as Shape, Entrance, Roof, Doors, and Windows and decorative elements such as materials and colors.

Based on the findings from the initial investigation, a visual survey questionnaire for all the 15 selected sites was prepared. Read through relevant past research and record the cases that appear in the research. Then search these cases through "Google Keywords" and select the top 20 cases. Delete 5 cases with low relevance to this paper, so as to control the number of researched cases to 15.

The sites selected for the study: F1963 (Busan), Daelim Warehouse (Seoul), Samtan Art Mine (Gangwon-do), Kim Chung-Up Art Museum (Anyang), Incheon Art Platform (Incheon), Art Bunker B39 (Bucheon), Samnye Cultural Art Village (Wanju County), Palbok Art Factory (Jeonju), Mapo Cultural Depot (Seoul), Geumcheon Art Factory (Seoul), SeMA Nanji Residency (Seoul), Sinan Salt Museum (Sinan County), Anthracite (Seoul), Insa 1-gil Culture Space (Seoul), and Cheongju Culture Factory (Cheongju).

Table 3. Case Study (*author's own photograph, ;3: Samtan Art Mine; 4: 2020 Anyang Foundation for Culture Arts; 5: Jjw's photograph in2019; 6: 2021 Vmspace; 7: 2018 Samuye Culture Art Village; 8: 2017-2020 Jeonju Cultural Foundation Palbok Art Factory; 12: Sinan County Office; 15: Urban regeneration new deal)

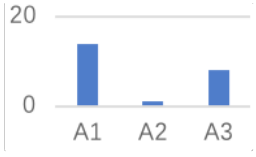
| No | Photo | Name | Year | Use | |
|---|---|---|---|---|---|
| | | | | Before | After |
| 1* |  | Busan F1963 | 2016 /9 | Wire Factory | Cultural Factory |
| 2* |  | Daelim Warehouse | 2016 /5 | Ware-house | Cafe, Complex Culture |
| 3 |  | Samtan Art Mine | 2013 /5 | Rock Mining Com-pany | Cultural Arts Center |
| 4 |  | Kim Chung-up Museum Of Archi-tecture | 2014 /3 | Yuyu Pharma-ceutical Plant | Kim Chung-Up Art Museum |
| 5 |  | Incheon Art Platform | 2009 /9 | Ware-houses | Culture and Arts Creation Facility |
| 6 |  | Art Bunker B39 | 2014 | Garbage dump | Culture and Arts Exhi-bition Space |
| 7 |  | Samnye Culture Art Village | 2013 /6 | Grain storage | Cultural Facilities |
| 8 |  | Factory of Contempo-rary Arts | 2018 /3 | Tape factory | Art Factory |
| 9* |  | Mapo Cultural Base | 2017 /9 | Oil storage tank | Cultural Reserve |
| 10* |  | Geumcheon Art Factory | 2009 /10 | Tele-phone coils Factory | Exhibi-tion and Creative space |
| 11* |  | Nanji Art Creation Studio | 2006 /10 | Leachate Water Treatment Facility | Art Creation Space |
| 12 |  | Sinan Salt Museum | 2015 | Stone Salt Storage | Salt Museum |
| 13* |  | Anthracite Café | 2009 /9 | Shoe Factory | Café |
| 14* |  | Insa 1-gil Culture Space | 2017 /11 | Pagoda Furniture Factory | Complex Culture and Commer-cial Space |
| 15 |  | Cheongju Tobacco Manufac-turing Plant | 2018 /12 | Tobacco Factory | Art Center |

### (2) Findings from Initial Investigation

During the initial investigation, the facade elements of 15 selected sites were analyzed based on the various categories (as mentioned in section 2.2). An overall comparative analysis of the selected sites showed that "cube" was the commonly used building shape. "Concrete" appears to be the commonly used exterior material. In the case of roof form, flat roofs and double-pitched roofs were commonly used and were mostly made of "steel". Most of the buildings had a flat entrance which were reported to be small (10-20%), made of glass, covered by a canopy, and included corner doors. Swinging flush doors made of glass and a medium height of 2.4m-2.8m were commonly used. For windows, large horizontal fixed windows along the front facade and the proportional size were relatively small (0-30%) in most of the cases.

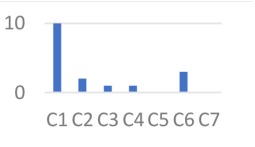
Table 4. Analysis on the Facade Elements of Case

| Building shape | | | Exterior wall(Overall color) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A1 | A2 | A3 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 |
| 14 | 1 | 8 | 8 | 0 | 2 | 1 | 2 | 2 | 0 | 7 |





| Exterior wall(materials) | | | | | | | Roof | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | C2 | C3 | C4 | C5 | C6 | D1 | D2 | D3 | D4 | E1 | E2 | E3 | E4 | E5 |
| 10 | 2 | 1 | 1 | 0 | 3 | 3 | 6 | 0 | 6 | 4 | 6 | 0 | 2 | 9 |

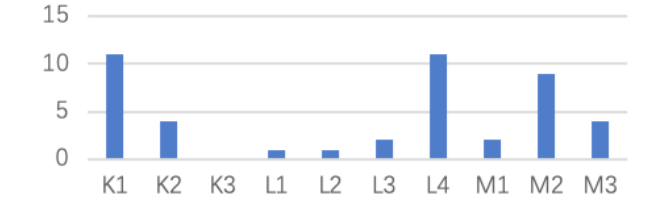



**Entrance**

| F1 | F2 | F3 | G1 | G2 | G3 | H1 | H2 | I1 | I2 | J1 | J2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 1 | 6 | 2 | 4 | 9 | 11 | 4 | 12 | 3 | 4 | 11 |

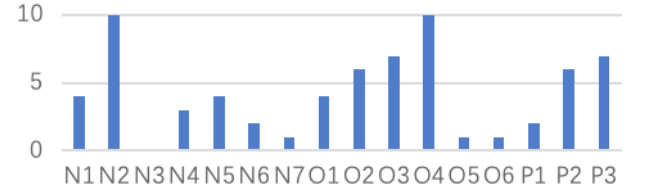
**Door**

| K1 | K2 | K3 | L1 | L2 | L3 | L4 | M1 | M2 | M3 |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 4 | 0 | 1 | 1 | 2 | 11 | 2 | 9 | 4 |




**Window**

| N1 | N2 | N3 | N4 | N5 | N6 | N7 | O1 | O2 | O3 | O4 | O5 | O6 | P1 | P2 | P3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 10 | 0 | 3 | 4 | 2 | 1 | 4 | 6 | 7 | 10 | 1 | 1 | 2 | 6 | 7 |




**(3) Questionnaire Design, Sampling and Data Collection**

This study investigates user preferences and opinions of different facade elements used in the renovation of industrial buildings in South Korea based on the data collected from a visual questionnaire survey. Overall, 200 samples from participants of various age groups and gender were collected.

Only foreign participants were selected to avoid similar responses and to understand an outsider's point of view on the facade elements used in the adaptive reuse of Korean industrial buildings. Most of the respondents selected for the survey are currently living in Korea and have prior knowledge regarding the selected industrial sites. The survey includes various photographs of the building exterior and specific facade elements used for renovating the building. Based on the photographs, the respondents evaluated six categories of elements, including building shape, entrance, facade color, openings (windows and doors), and the overall color combination used for blending the facade elements on a 5-point Likert scale: 1- Excellent, 2 - Good, 3 – Neutral, 4 – Poor and 5 – Very Poor.

The study considered simple random sampling method in order to collect a diverse sample of different age groups and gender with non-architectural or design background. Assuming that the respondents might not be aware of the history of these industrial sites, a visual survey questionnaire with simple evaluation criteria was used for data collection. This helped the respondents to evaluate the sites based on the physical appearance and aesthetics.

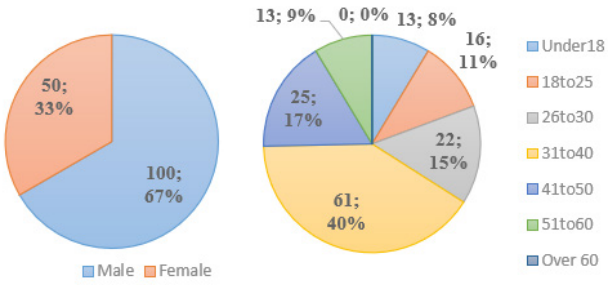



Figure 1. Gender and Generation Distribution in the Questionnaire

Out of 200, 50 responses were excluded from the analysis due to misleading information or inadequate responses. The final data set included responses from 100 male participants (66.67%) and 50 female participants (33.33%) i.e. 2:1 ratio as shown in the above figure.

The sample was segregated based on seven age groups: 8.67% of the respondents were below 18 years, 10.67% aged between 18-25 years, 14.67% between 26-30 years, 40.67% between 31-40 years, 16.67% between 41-50 years, 8.67% between 51-60 years and above 60 years. The sample included large number of responses from participants aged between 31-40 years.

In this questionnaire, the two age groups 18-25 and 26-30 are analyzed separately. The reason is that the respondents are all Chinese, according to the age of education, 18 to 25 years old is the time to receive university education.

The age of 26-30 is the time when you first entered the society. It is predicted that these two age groups will have different results from other age groups, so the 20 generations are divided into 18-25 and 26-30.

## 4. DATA ANALYSIS

**(1) Data Coding**

Using Microsoft Excel, the collected data was filtered to exclude elements that were relatively undesirable. Each data set was coded based on the category (structural and decorative elements) and subcategories (for example, building shapes were coded as A1-Cube, A2-Cylinder, A3-Triangle). Following data compilation, statistical analysis of the questionnaire data was performed using SPSS. Respondents were asked to evaluate the buildings using a 5-point Likert scale. Based on the responses obtained from the survey, an overall score was calculated for each element.

In the preliminary analysis, it was found that most of the renovated buildings had an exposed material facade. Hence, building material was a base predictor of building color. For example, if the building featured an exposed concrete facade, the color of the building was gray or if the facade was made of exposed brick facade, the color of the building was red/brick red. In order to avoid erroneous results these categories were excluded in such cases.

This research uses One-Way ANOVA by summing the scores obtained from the questionnaire survey of each individual respondent of each element category in accordance with the methodological approach adopted in similar studies (Yoon, 2021; Lee, 2014).

## (2) Analysis of Questionnaire Survey Data

### 1.Initial findings

Figure 1 shows the user preferences of different elements for different age groups and gender. The age group above 60 years was excluded, as no sample was available in this group.

The following set of results were obtained for different age groups and gender:

1) Decorative elements (such as buildings materials) with sub-categories that included the use of multiple items were given highest scores by all the participants.
2) A comparative analysis of preferences for different age groups showed that the age group between 41-50 years evaluated the elements with relevantly low scores when compared to the other groups. When asked about the reason for their evaluation, the participants rated the elements based on the uniqueness of the external elements. In contrast, the other age groups rated the elements with relatively high scores based on the decorative and exterior appearance.

### 2.ANOVA Hypothesis

One-way or single factor ANOVA was used for comparative analysis of elements in each case. The overall score obtained from the questionnaire was used as the dependent variable. P-values were used for determining the level of significance of the facade elements used for renovation. The respondents were asked to evaluate the nine elements selected from the preliminary analysis on a 5-point Likert scale.

For measuring the variability within the group:

1) $P < 0.05$ (Reject Null Hypothesis) – The element in the category has "statistically significant impact"

2) $P > 0.05$ (Fail to reject Null Hypothesis) – The element in the category has "No statically significant impact"

Table 5. ANOVA Results

| Architectural elements | | F | P(Sig.) |
|---|---|---|---|
| Building shape | Basic form | 1.692 | 0.184 |
| Exterior wall | External material | 4.356 | 0.000* |
| Roof | Roof form | 5.467 | 0.004* |
| | Roof material | 7.26 | 0.000* |
| Entrance | Entrance and internal connection | 2.107 | 0.097 |
| | proportion on the facade | 7.697 | 0.000* |
| | Border around the entrance | 10.483 | 0.001* |
| | Entrance canopy | 0.362 | 0.547 |
| | Entrance location | 23.202 | 0.000* |
| Door | Opening types | 0.478 | 0.489 |
| | Door material | 2.803 | 0.038* |
| | Door height | 0.457 | 0.633 |
| Window | Window form | 4.421 | 0.000* |
| | Opening types | 4.124 | 0.000* |
| | Window ratio | 2.389 | 0.092 |

Following the data collection, each element was analyzed to measure the extent of variability within the groups. To check the consistency of the questionnaire results, a test of reliability was performed, and the resulting Cronbach's Alpha was 0.996 ($\alpha \geq 0.9$).

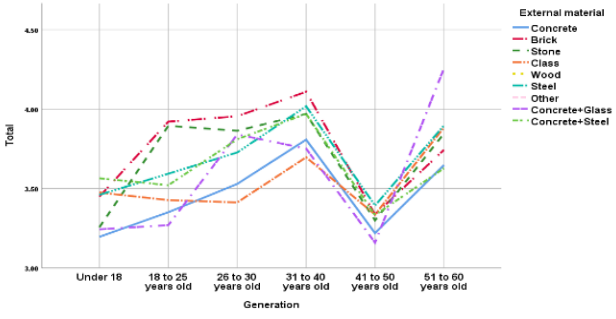
### 3. ANOVA results and Analysis for different age groups and gender

The analysis was divided into three sections:1) ANOVA was performed on the entire sample to analyze the overall user preference of elements; 2) The sample was segregated based on age groups and gender to analyze the impact of sample characteristics on the elements; 3) ANOVA results were compared with the results from the preliminary analysis.

The results of the analysis show that among all the elements selected for the study only nine elements namely exterior material, facade proportion, border around the entrance, entrance location, roof form, roof material, door material, type of window, window (opening and closing) was statistically significant ($P<0.05$) and have greater impact on the overall results. Overall Findings: Based on the evaluation scores given by the respondents, 9 out of 15 elements show significant impact on the users' preference (As shown in Table 5). Entrance and Internal Connection, Entrance Canopy, Opening types of doors, door height and building shape showed no statistical significance. This indicates that the users scored these categories with lower scores when compared to the other elements.

Table 6. External Material Preference by Generation

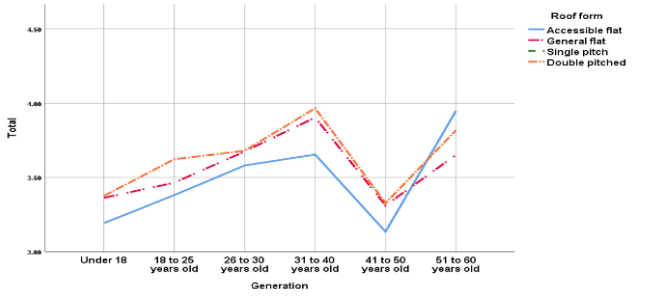
| Elements | Usage | ~18 | 18~25 | 26~30 | 31~40 | 41~50 | 51~60 | total |
|---|---|---|---|---|---|---|---|---|
| External material | Brick | 3.38 | 4.00 | 3.98 | 4.04 | 3.46 | 3.73 | 3.85 |
| | Steel | 3.56 | 3.59 | 3.68 | 3.94 | 3.38 | 4.08 | 3.75 |
| | Concrete + Steel | 3.85 | 3.44 | 3.91 | 3.93 | 3.48 | 3.62 | 3.77 |




Findings related to the materials demonstrate that the overall responses from various age groups have shown high preference for 'brick' and stone'. Among the combination elements, the users highly prefer the use of 'concrete +iron' in the facade indicating that this combination mainly used in modern buildings is more easily acceptable. The results of this category indicate that the responses obtained from all the participants were similar irrespective of age and gender. As shown in Table 6.

Table 7. Roof form preference by generation

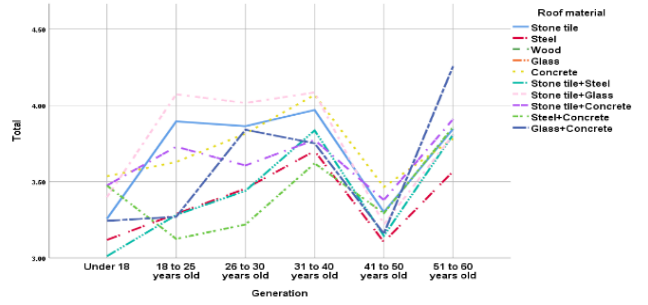
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Roof form** | **Double pitched** | 3.39 | 3.64 | 3.68 | 3.95 | 3.17 | 3.65 | 3.67 |
| | **General flat** | 3.31 | 3.51 | 3.76 | 3.9 | 3.22 | 3.47 | 3.63 |
| | **Accessible flat** | 3.26 | 3.38 | 3.7 | 3.68 | 2.97 | 4.03 | 3.53 |




As seen in Table 7, apart from respondents in the 51-60 age group, others have expressed similar opinion on the roof form and selected the 'Double-Pitched Roof'. Although traditional and used very often, this roof form has been the most popular typology adopted around the world based on its aesthetic and climatic relevance.

Table 8. Roof Material Preference by Generation

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Roof material | Stone tile+ Glass | 3.38 | 3.56 | 3.77 | 3.89 | 3.28 | 3.69 | 3.75 |
| | Concrete | 3.47 | 3.63 | 3.85 | 4.04 | 3.38 | 3.68 | 3.78 |
| | Stone tile | 3.23 | 3.81 | 3.95 | 4.00 | 3.12 | 3.85 | 3.75 |




Perceptions of roofing materials varied across groups, as shown in Table 8. The respondents aged between 18 to 40 years prefer concrete and stone as there has been a resurgence in popularity of these materials that are often associated with modernist architecture. In this study, the selected industrial buildings date back to the industrialization period of Korea, when large industrial spaces were constructed using a stone and concrete as these materials are extremely rigid and uniformly hard. The below 18 age group are inclined more towards the material combinations.

Table 9. Proportion on the Facade Preference by Generation

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Proportion on the facade | Big | 3.42 | 3.72 | 3.93 | 4.2 | 3.6 | 3.54 | 3.88 |
| | Middle | 3.35 | 3.61 | 3.61 | 3.93 | 3.59 | 3.92 | 3.74 |
| | Small | 3.3 | 3.42 | 3.59 | 3.84 | 3.31 | 3.94 | 3.63 |

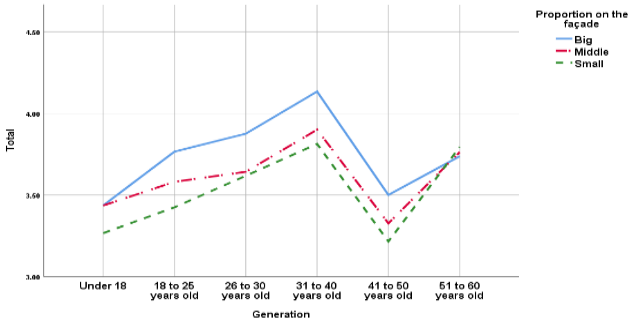



Table 10. Border the Entrance Preference by Generation

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Border the entrance | Opaque | 3.53 | 3.48 | 3.84 | 4.00 | 3.51 | 3.94 | 3.79 |
| | Transparent | 3.26 | 3.52 | 3.57 | 3.88 | 3.39 | 3.86 | 3.66 |

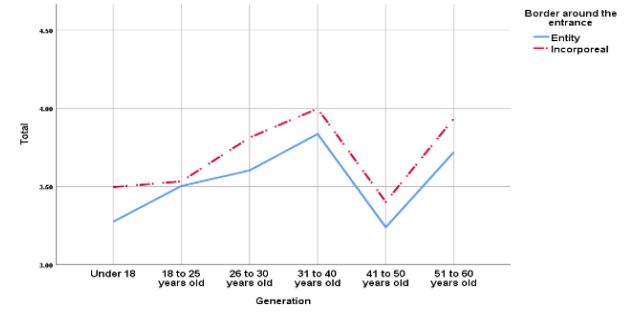
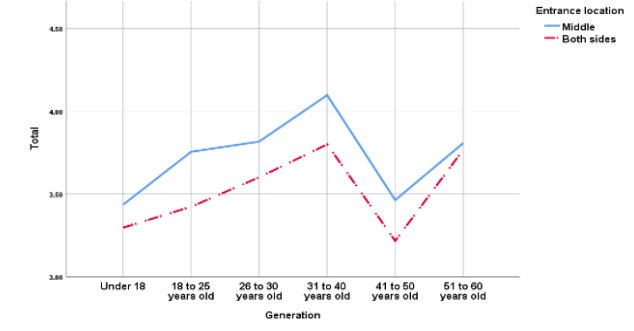



Table 11. Entrance Location Preference by Generation

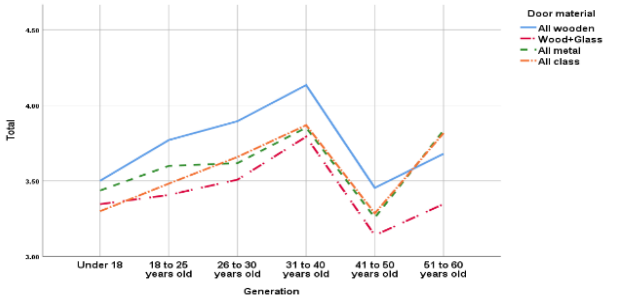
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Entrance location | Middle | 3.41 | 3.67 | 3.86 | 4.12 | 3.62 | 3.77 | 3.86 |
| | Both sides | 3.3 | 3.45 | 3.56 | 3.83 | 3.35 | 3.92 | 3.63 |




The responses regarding 'Proportion of Facade', 'Boundary around the entrance' and 'Entrance Location' illustrate the same trend as seen in the Tables 9-11. Most of the respondents prefer a large, middle entrance as it creates a grand manner appearance and immediately attracts the visitors towards the building.

Table 12. Door Material Preference by Generation

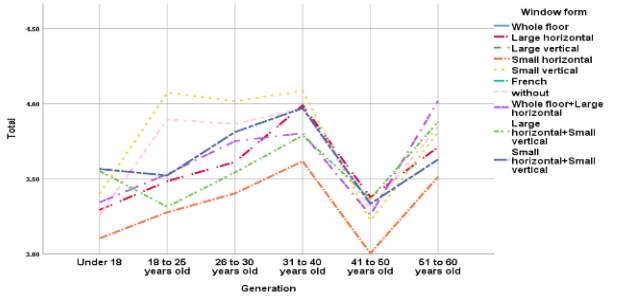
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Door material | All wooden | 3.77 | 3.88 | 3.73 | 4.1 | 3.28 | 4.15 | 3.86 |
| | All Glass | 3.3 | 3.43 | 3.58 | 3.88 | 3.23 | 3.76 | 3.62 |
| | All metal | 3.65 | 3.56 | 3.5 | 3.85 | 3.2 | 3.88 | 3.65 |




Doors made with wood were highly regarded as most of the entrance doors in Asia are designed with a natural, earthy feel and are often made of wood. With the rising popularity of traditional architecture, renovated buildings have been replaced with timber frame doors in recent years. The combination of different materials for the doors has been undesirable among all age groups. The survey results are summarized in Table 12.

Table 13. Window Form Preference by Generation

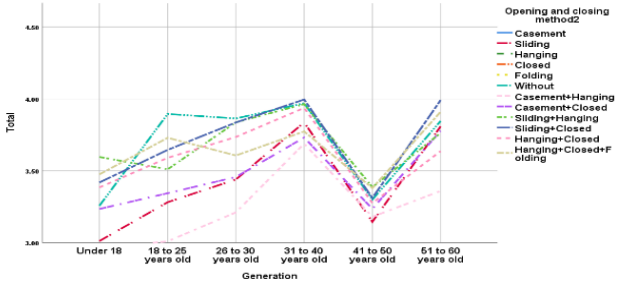
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Window form | Small vertical | 3.19 | 3.31 | 3.43 | 3.62 | 2.96 | 3.38 | 3.39 |
| | S.horizontal + S.vertical | 3.38 | 3.5 | 3.86 | 4.03 | 3.24 | 3.46 | 3.71 |
| | L.horizontal | 3.38 | 3.69 | 3.68 | 3.92 | 3.08 | 3.92 | 3.67 |




Small horizontal and vertical windows have been selected as the most acceptable opening as it is easy to operate and includes a large view of the surrounding context. As shown in Table 13.

Table 14. Opening Types Preference by Generation

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Open close method | Sliding+ Closed | 3.45 | 3.56 | 3.67 | 4.04 | 3.25 | 4.00 | 3.75 |
| | Sliding+ Hanging | 3.58 | 3.38 | 3.86 | 3.99 | 3.36 | 3.62 | 3.73 |
| | Without | 3.54 | 3.69 | 3.55 | 3.75 | 3.32 | 3.69 | 3.62 |

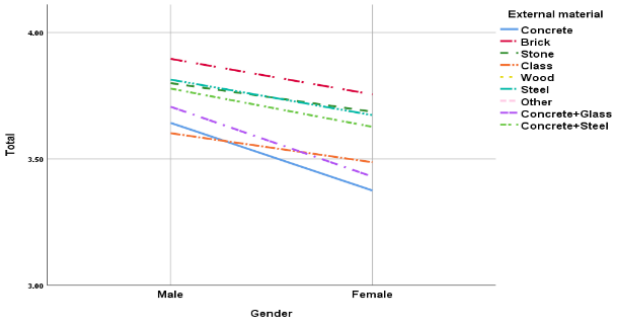



In Table 14, analysis based on Age Groups: Common findings for all age groups show that the cases in which sub-categories included the use of multiple items were given highest scores. For instance, in some of the cases the facade was redesigned using multiple materials or was painted with different color combinations. These cases were scored higher and were preferred over the others by all the age groups.

The evaluation scores of participants below 18 years and aged between 41-50 years were relevantly lower than the other age groups as mentioned earlier. The other three age groups evaluation showed higher scores indicating their preference for modern facade elements, which were used for renovation in these cases. The overall results portray that the participants below 18 years disfavored the exterior design of renovated buildings while the other age groups appreciated the remodeling of old buildings by redesigning the facade and improving the external appearance.

Table 15. External Material Preference by Gender

| Elements | Usage | Male | Female | total |
|---|---|---|---|---|
| External material | Brick | 3.89 | 3.77 | 3.85 |
| | Steel | 3.82 | 3.66 | 3.77 |
| | Concrete + Steel | 3.78 | 3.69 | 3.75 |




All the external materials listed have been assigned higher scores by male respondents (as shown in Table 15). A significant change in the scores is observed for the usage of 'glass' for the

exterior as it absorbs more heat, causes glare, and must be handled with care.

Table 16. External Material Preference by Gender

| | | | | |
|---|---|---|---|---|
| Roof form | Double pitched roof | 3.89 | 3.77 | 3.85 |
| | General flat roof | 3.82 | 3.66 | 3.77 |
| | Accessible flat roof | 3.78 | 3.69 | 3.75 |

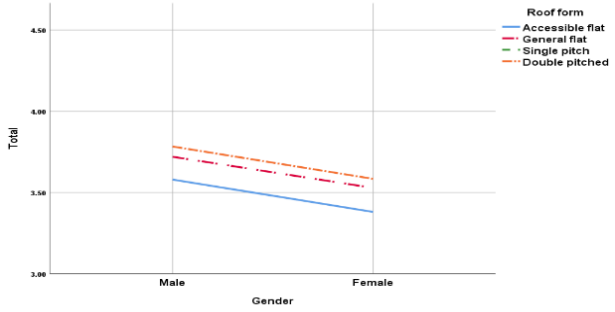
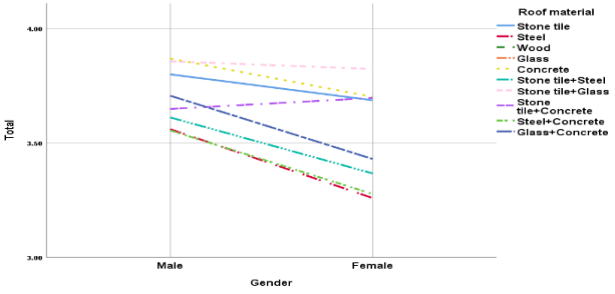



Table 17. Roof Material Preference by Gender

| | | | | |
|---|---|---|---|---|
| Roof material | Concrete | 3.86 | 3.62 | 3.78 |
| | Stone tile +Glass | 3.67 | 3.68 | 3.67 |
| | Stone tile | 3.8 | 3.64 | 3.75 |




As seen in Table 17, the stone tile and concrete combination was found to be the most preferrable roof material for the female respondents while most of the other categories have been favored by the male respondents.

Table 18. Proportion on the Facade Preference by Gender

| | | | | |
|---|---|---|---|---|
| Proportion on the facade | Big(30%~50%) | 3.93 | 3.79 | 3.88 |
| | Middle(20%~30%) | 3.83 | 3.57 | 3.74 |
| | Small(10%~20%) | 3.73 | 3.44 | 3.63 |

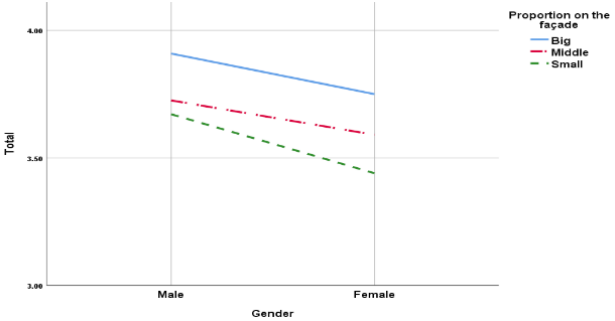



Table 19. Border the Entrance Preference by Gender

| | | | | |
|---|---|---|---|---|
| Border around the entrance | Entity | 3.89 | 3.61 | 3.79 |
| | Incorporeal | 3.74 | 3.49 | 3.66 |

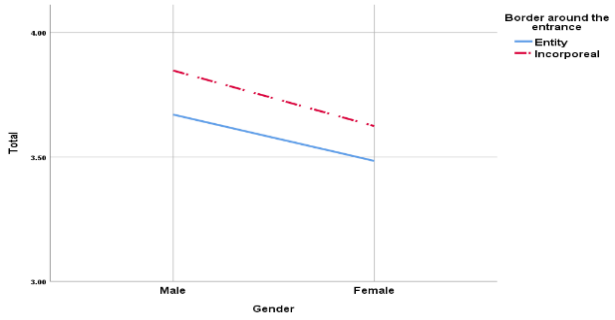



Table 20. Entrance Location Preference by Gender

| | | | | |
|---|---|---|---|---|
| Entrance location | Middle of building | 3.93 | 3.73 | 3.86 |
| | Both sides | 3.73 | 3.44 | 3.63 |

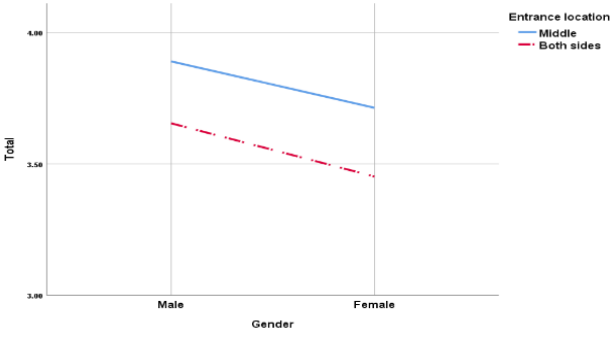
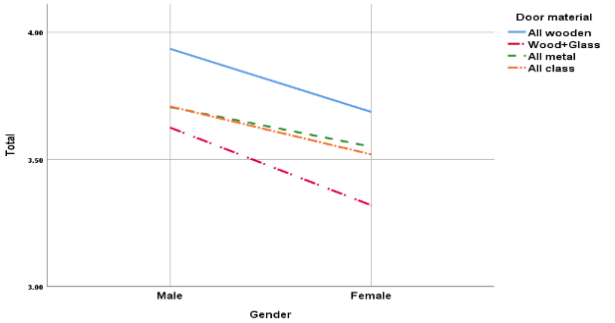



Table 21. Door Material Preference by Gender

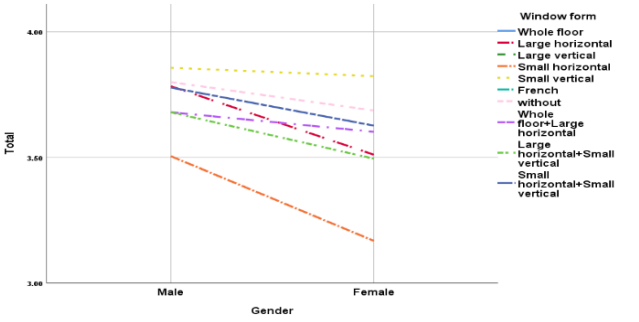
| | | | | |
|---|---|---|---|---|
| Door material | All wooden | 3.95 | 3.68 | 3.86 |
| | All Glass | 3.68 | 3.5 | 3.62 |
| | All metal | 3.69 | 3.56 | 3.65 |




In contrast to the results obtained from the analysis of responses in different age groups, the opinion of male participants has been more favorable than female participants. As shown in Table 16, Table 18-21.

Table 22. Window Form Preference by Gender

| | | | | |
|---|---|---|---|---|
| Window form | Small vertical window | 3.53 | 3.13 | 3.39 |
| | S. horizontal+ | 3.76 | 3.62 | 3.71 |
| | S. vertical | 3.70 | 3.62 | 3.67 |




In the view of responses regarding window form, the 'small vertical window' scored the highest among both the gender groups. The results from Table 22 show that the overall score for 'small horizontal windows' given by both the genders is low and is inconsistent with the scores obtained from the analysis of the age groups. These results, therefore, indicate that the preferences of male and female respondents within each age group have been diverse and more oriented toward individual opinion.

Table 23. Opening Types Preference by Gender

| | | | | |
|---|---|---|---|---|
| Open close method | Sliding +Closed | 3.80 | 3.65 | 3.75 |
| | Sliding +Hanging | 3.77 | 3.67 | 3.73 |
| | Without | 3.55 | 3.76 | 3.62 |

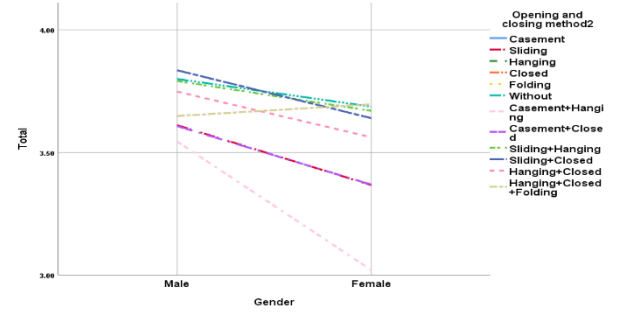



Table 23 shows that the 'Opening types' preferred by male respondents is contrary to the female group and is inconsistent with the results obtained from the analysis of different age groups. The high levels of variation in the results are due to the distinct opinion among all the age groups. The respondents within the age group of 31-40 years have expressed a greater acceptance rate towards the methods mentioned in the survey. In the case of gender groups, respondents have given high scores for hanging and sliding typologies as these are the most used 'open-close methods' in Korea.

Analysis based on Gender: The evaluation results based on gender showed that female participants' scores were relatively lower than the male participants and the average mean score.

Table 24. Judgment of Element Statistical Difference

| | Sum of Squares | df | F | P(Sig.) |
|---|---|---|---|---|
| total*External material | 29.600 | 6 | 4.356 | 0.000* |
| total*Roof form | 12.445 | 2 | 5.467 | 0.004* |
| total*Roof material | 56.963 | 7 | 7.26 | 0.000* |
| total*Proportion on the facade | 17.486 | 2 | 7.697 | 0.000* |
| total*Border around entrance | 11.929 | 1 | 10.483 | 0.001* |
| total*Entrance location | 26.253 | 1 | 23.202 | 0.000* |
| total*Door material | 8.563 | 3 | 2.503 | 0.058 |
| total*Window form | 30.035 | 6 | 4.421 | 0.000* |
| total*Opening types | 32.667 | 7 | 4.124 | 0.000* |

*Have statistically significant

This indicates that the female participants had critical views regarding the exterior appearance and the material usage in few cases. But the overall results show a similar trend in both groups for considerable number of elements.

**(3) Comparative Analysis of Preliminary Findings and ANOVA Results**

Contrary to expectations, the facade elements used for renovation of the fifteen industrial heritage sites selected for this study were unpopular and did not include new building materials. This explains that the site was renovated on basis of historic preservation/conservation principles and adaptive reuse design methods. The findings of this study show that the user preferences appear to be contrasting in comparison. The following findings explain the contrasting results obtained from the comparative analysis of Initial Study and User Preferences:

Table 25. Comparison of Frequency of Use and Preference of External Facade Elements

| | Elements | Order | Case usage | | Questionnaire Preference | |
|---|---|---|---|---|---|---|
| Exterior Wall | External material | 1 | Concrete | 11 | Brick | 3.85 |
| | | 2 | Steel | 3 | Steel | 3.77 |
| | | 3 | Brick | 2 | Stone | 3.76 |
| Roof | Roof form | 1 | Double pitched roof | 6 | Double pitched roof | 3.72 |
| | | 2 | General flat roof | 6 | General flat roof | 3.66 |
| | | 3 | Accessible flat roof | 3 | Accessible flat roof | 3.51 |
| | Roof material | 1 | Concrete | 9 | Stone tile + Glass | 3.85 |
| | | 2 | Steel | 6 | Concrete | 3.81 |
| | | 3 | Stone tile | 4 | Stone tile | 3.76 |
| Entrance | Proportion on the facade | 1 | Small | 9 | Big | 3.86 |
| | | 2 | Middle | 4 | Middle | 3.68 |
| | | 3 | Big | 2 | Small | 3.59 |
| | Border around the entrance | 1 | Entity | 11 | Entity | 3.77 |
| | | 2 | Incorporeal | 4 | Incorporeal | 3.61 |
| | Entrance location | 1 | Both sides of the building | 11 | Middle of building | 3.83 |
| | | 2 | Middle of building | 4 | Both sides of the building | 3.59 |
| Window | Window form | 1 | L. Horizontal window | 10 | Without | 3..76 |
| | | 2 | Small vertical window | 4 | Small horizontal + Small vertical | 3.73 |
| | | 3 | Whole floor | 3 | L. Horizontal window | 3.69 |
| | Opening types | 1 | Closed | 10 | Sliding + Closed | 3.77 |
| | | 2 | Hanging Window | 7 | Without | 3.76 |
| | | 3 | Sliding Window | 6 | Sliding + Hanging | 3.75 |

Entrance: The size of the entrances was scored the lowest due to their small size. Most of the factory buildings were designed with small entrances for workers and a large single entrance for transportation.

Exterior material: Concrete and stone were widely used materials for exterior renovation. On contrary, the participants rated concrete with a very low score and brick, which was the least used material with a higher score.

Roof form: The results in this category showed identical results in both the analyses.

Roof materials: Steel (metal roofing) was the most used roofing material in most of the buildings. In comparison to the results from the survey, the participants preferred all the other sub-categories including stone tiles, wood, glass and concrete to steel.

Proportion of openings in the facade: Based on proportional analysis of facade opening, most of the cases had smaller openings which covered 10-20% of the facade. The survey results portrayed that the users preferred medium (20-30%) or large (30-50%) size openings.

Entrance location: Both the sub-categories, middle opening entrance and corner door openings were preferred by the users and highly used in the renovation process.

Similar trend was seen in other sub-categories in both the initial analysis and the survey results.

In conclusion, few of the existing facade elements retained during the renovation might be unappealing to the survey respondents. To preserve the structure and conserve the historical significance of the industrial fabric, the continuity of a few exterior elements is essential as these physical aspects portray the historical significance of the building during the industrialization period. For instance, in most renovation projects, the continuity of fixed elements such as the size of windows and doors is essential to preserve the former style of openings in the building. As most of these retained elements are outdated and are not visually appealing in the modern era, the users often disapprove even though the original style is chronologically important for narrating the history of the industrial landscape. These contradictions are clearly visible in the data collected through the questionnaire survey as the preference scores of some of the elements fluctuate due to the varied opinion on the preservation of historic elements in the building.

## 5. DISCUSSION AND CONCLUSION

Economic progress and urban expansion have led to an increase in the number of abandoned factory buildings during recent decades. Shan (2006) emphasizes on the use of old factory buildings for protecting our environment and promote sustainable development. The renovation of old buildings can also help in tackling urban problems at a local scale by increasing economic vitality of the industrial sites and provide employment opportunities to the local residents. Therefore, it is important to consider adaptive reuse and preservation methods to conserve the old abandoned industrial sites that have a greater historical significance in our cities. This study attempts to highlight the importance of renovated factory buildings in old industrial sites through detailed analysis of fifteen cases in Korea.

Previous studies have focused on structural elements and building morphology (Lee, 2006; Oh, 2008). Few studies have highlighted the importance of decorative elements, phenotypic elements and form-based facade design methods. With reference to prior studies, the present research study analyzes various structural and decorative elements and their usage in renovation of old factory buildings in Korea. The findings in the preliminary analysis show an architectural perspective of visualizing the facade elements. Results from the initial analysis were used for preparing a visual survey questionnaire to understand the users' view. The study also examines the user preferences of facade elements used for the renovation of old factory buildings based on different age groups and gender. The findings from initial analysis from an architectural perspective were compared to the results obtained from the user preferences. Taken together, these findings suggest that the users' preferences were contrasting in comparison to the exterior facade elements used in most of the cases.

The overall findings of the present study suggest the importance of integrating users' preferences for selecting different facade renovation elements to increase the usability, occupancy, and economic efficiency of renovated industrial heritage sites. The study results include three main findings obtained from the analysis of data collected from a representative sample of all age groups and gender through a visual questionnaire survey that can help in attracting more visitors to renovated historical sites in the future.

First, the preference scores obtained from female respondents are lower than the male respondents, which explains that the female respondents were very keen and have expressed a strong opinion on each of the facade element categories selected for the study. Secondly, although there is a variation in the scoring pattern of male and female respondents, the overall evaluation results show a similar trend among most of the categories for both groups. Irrespective of their gender, few of the elements selected for the study were given equal scores by all the respondents. Lastly, among the ten categories of elements selected for the study, scores related to material and color showed high variation among both the gender groups, a large proportion of the female respondents perceived color and material as the most important exterior elements that can create a unique image of the building.

Therefore, the preferences of different age and gender groups obtained from this study demonstrates users' visual perception that help in improving the utilization rate and economic efficiency of renovated industrial buildings. In the future, based on the user group priority, designers can integrate the users' perception of about different elements and use the data while planning the renovation. This study portrays a possibility of visual preferences among different respondents that can

help architects and urban professionals to consider the user preferences as a priority in the decision-making process.

The initial findings of this research illustrate the frequency of use of different facade elements in renovated industrial buildings followed by a questionnaire survey on the users' perception. Even though most of the buildings selected in the study are harmonious with the surrounding context and have a uniqueness of their own, the respondents were easily affected by the physical appearance of the physical setting. This study is limited to the results obtained from a visual questionnaire survey conducted for a representative sample of users by showing photographs of the buildings. Due to the lack of understanding regarding scale and sensory experience of the physical context, few of the respondents expressed difficulty in scoring the elements. In future investigations, the use of Virtual Reality (VR) based techniques can help the respondents to clearly visualize the buildings and express a stronger opinion towards the architectural elements used in the building renovation. Further, other socio-economic indicators such as employment type, education level, and preliminary knowledge of the selected sites can help in understanding the impacts of these indicators on the responses recorded during the survey. Since most of the images used in the survey were obtained from internet-based sources, the clarity of elements and the detailed texture on the facade were unclear. However, more research regarding the different aspects of renovation of historic buildings including the interior spaces, access and movement, area programming, and other architectural components is needed.

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## ENDNOTES

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