Original Article

A Sustainable Design Method of Daesun Flour Mill Renovation - Focused on Relationship between Structure, Environment, and Materials

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Abstract

As Korea's manufacturing industry declined and Seoul's urban expansion accelerated, factories that controlled major industries were developed in various forms. In the Yeongdeungpo area, most industrial facilities were redeveloped into large-scale commercial facilities. However, among these, the Daesun flour mill is the only industrial heritage facility that has preserved its historical and cultural value while conserving its shape. This study focuses on the Daesun flour mill, recently registered as Seoul excellent building asset No. 2. Consequently, it was found that the design was implemented responsively to the changed usage of the space. Accordingly, different usage methods were proposed. It was found that differentiated design methods are being proposed, oriented toward structural stability, environmental improvement, and a relationship of dialog with common materials. It has value as a sustainable design methodology. It is not a space where the memories of the past have been lost, but it can become a space that aims for a new future by further amplifying the power of the space created by the past and the charm of the present. From this perspective, the significance of this study is revealed.

Keywords: Industrial Heritage, Urban Regeneration, Structural Stability, Environmental Improvements, Dialog with Materials.

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INTRODUCTION

Background and Purpose of Research

Seoul has gradually expanded in modern times. Until the 1960s, development was concentrated to the north of the Han River, and the population and economy developed and concentrated to the north of the Han River. However, in the 1970s, as Seoul gradually expanded along with the change of government, the development of Gangnam, the area south of the Han River, accelerated. Accordingly, factories, vehicle depots, and detention centers located in the suburbs of Seoul were moved to its expanding suburbs through development south of the Han River. Currently, those places have been transformed into public spaces or residential, commercial, and business spaces. As Korea's manufacturing industry declined and Seoul expanded, factories in Yeongdeungpo closed while other factories moved. Consequently, a large-scale factory site in Yeongdeungpo was left, and these spaces were newly developed, taking on the appearance of present-day Yeongdeungpo. Until now, the Yeongdeungpo factory area had been developed in various forms. However, this large-scale development not only created a separation from the surrounding small buildings but also nullified its original function; thus, it did not play a role of encouraging industrial development as intended at the time of planning. Among these, the site of the Daesun flour mill served as a factory with historical and cultural value. Most of the industrial facilities in Yeongdeungpo (Bangnim Textile, Gyeongseong Textile, etc.) were converted into commercial facilities, but the Daesun flour mill Brewery remained in its original form [1]. Like this, modern cities are focusing on revitalizing their cultural heritage both in architecture and other fields. Renovating urban industrial heritage buildings is an important part of this process, one that cities have long been engaging in as urbanization continues to increase. This has become even more pressing as in recent years, urban problems have threatened people's quality of life and changed the nature of community, thereby increasing the need for sustainable urban development. In this context, sustainability includes not just development-related practices, but also an increase in well-being and social bonds, community building, social support, and urban infrastructure renewal [2].

Recently, Daesun flour mill was registered as Seoul excellent building asset No. 2. Firstly, from the perspective of historical value, it contains the use and appearance show the change of the times in Korea. Secondly, from the landscape value, it comprises buildings gathered within a certain range retain

their own beauty in addition to the aesthetic value of individual buildings. Thirdly, from the viewpoints of the artistic value, it represents the architectural features of the building, such as architectural beauty and architectural technology. Finally, in the way of socio-cultural value, it can include those that reflect the characteristics of the region and help to understand the region, which can increase the economic effect of the region through conservation and utilization.[3]

Based on this background, the Daesun flour mill was designed to create architecture that can last for a long time as a piece of industrial heritage that has adapted various methods of increasing density while preserving the value left behind. This is in line with the goal of urban sustainability, and when analyzed from a macroscopic perspective, it is possible to find an effective, sustainable regeneration approach in the growing urban context. The ultimate purpose is to propose a sustainable design methodology through this.

Methodology and Research Scope

There are several viewpoints dealing with contemporary trends in urban design. Some are focusing on philosophical aspects. Others are emphasizing on the scientific contribution of the authors. Frequently, those are mixed together. Based on this, the methods how to make a critical approach can be classified. Followings are representative methodologies. In an international context, the theories and ideals dominating today's urban design discourse have been examined and defined in various ways, resulting in differing categorizations and definitions such as "territories of urban design," "images of perfection," "urban design force fields," "integrated paradigms in urbanism," "urbanist cultures and approaches to city-making," "new directions in planning theory," "models of good design," and "typologies of urban design." [4] Among these methodologies, this study follows the "new directions in planning theory method". The theoretical content is the value of sustainability, and the new direction is to find the value of heritage. This regeneration has value as a critical approach.

Regarding the research scope, especially Yeongdeungpo where urban expansion has been accelerating was selected. Because the Seoul Metropolitan Government confirmed the areas around Bangnim Spinning, Gyeongbang, and Yeongil Market, including Yeongdeungpo Factory, as special planning zones to ensure large-scale development, and most industrial facilities were redeveloped into large-scale commercial facilities.

The Daesun flour mill is the only industrial heritage facility that has preserved its historical and cultural value over time, preserving its shape. This study focuses on the recent renovation of the Daesun flour mill. Among the mill's 23 buildings, the design of eight buildings selected for remodeling was chosen as the scope of the study.

Sustainable Approach Through Regeneration

History of Regeneration

Historically, renovation and recycling are not unfamiliar concepts. The renovation of buildings built early in the Italian Renaissance period was the first building recycled in Europe [6]. The meaning of recycling in these times, In the case of socio-culturally advanced Europe, the original uses of underused spaces ranged from old castles and monasteries as the product of monarchy and religious architecture to railway stations, power plants, factories, warehouses, and coal mines as the remains of modern industrial facilities. These buildings, which became ineffective due to the transition of industry as changing times, were reborn into spaces with various types and uses, such as museums, art galleries, parks, theaters, galleries, shops, performance halls, and cafes through recycling. This was the meaning of recycling in these times. World-class architects are also jumping onto the recycling of underused spaces. This is because there are other projects with different charms than new construction, and new aesthetic results are possible. Recycling into cultural spaces through renovation is a trend that is spreading widely. In Korea, as urban regeneration projects increase, the number of existing industrial buildings repurposed and reused is on the rise in the 21st century. This is due to a positive response from residents to maintain the temporal value of the place while preserving the historical memory of the building. From this perspective, it can be said that the preservation of industrial heritage leads to a discussion on the necessity and possibility of recycling. Many facilities are thus classified as redevelopment targets or faced with demolition, and the inevitable situations need to be thoroughly reconsidered. In the case of Korea, this problem is even bigger. Many industrial facilities have been moved from the city center due to changes in the industrial structure; however, they are relatively difficult to maintain by repair and recycling and are often demolished. Of course, not all facilities must be preserved, but it can be said that preservation and maintenance depend on how the standards for preservation are viewed and how much weight is placed on the efficiency of recycling [5].

Value of Regeneration and Intervention

The concept of industrial heritage has been widely used since the formation of The International Committee on the Conservation of Industrial Heritage (TICCIH) in 1983, and has been used as an official term. The committee defines industrial heritage as a relic of industrial culture of historical, technical, social, architectural, or scientific value. Industrial heritage specifically encompasses factories, warehouses, mines, the land where the production process remains, power plants, transportation facilities, and all related infrastructure facilities. Thus, the term industrial heritage refers to all buildings and facilities related to production in the industrial era, and they recognize industrial heritage as a cultural asset to society. In this study, the concept of "industrial heritage" is defined as a generic term for industrial facilities that have

contributed to industrialization and its supporting infrastructure, such as canals, railroads, and ports. The concept of "heritage" encompasses facilities with high preservation value and those with utility value. Regardless of their historical and architectural value, if industrial heritage—meaningful and convertible to a pleasant public space—is symbolic as a facility that acquires a place characteristic of a specific area or if the facility is recycled and utilized, these also fall within the research scope [7].

The value of regenerating industrial heritage is significant for the following reasons. If old buildings can be recycled without tearing them down, they can be possibly economically and architecturally valuable. Industrial heritage has a potential as a strategy for urban regeneration. As it encompasses a relatively large site, it has the advantage of securing sufficient public and green spaces in the dense downtown if converted into public facilities and parks. Efforts are being made to lay the foundation for regional regeneration by recognizing and reusing the value of modern industrial heritage in recent trends.

The discussion on industrial heritage reuse is becoming more active for three reasons. The first reason is the multilayer spectrum of industrial heritage. Industrial heritage mostly shares its context with the local industry representing the region and has a deep connection with the production structure and lifestyle of local residents. In addition, industrial heritage has the characteristic of being a medium of local culture, representing the coexistence of modern memory and life. These attributes of industrial heritage are in line with the trend of the times that demands the fusion of local cultures today. The second reason is the flexible usability of industrial heritage. Industrial facilities are mostly reinforced concrete structures without internal columns, masonry, or wooden structures; therefore, they have the possibility of various transformations based on creative ideas. The rough artificial beauty of industrial facilities and sophisticated modern design can be combined to create a form that can express various textures. The third reason lies in the potential economic value of industrial facility regeneration. As industrial facilities offer new possibilities, they present a cultural and economic opportunity to convert facilities that have been deteriorated and neglected into opportunity assets at once [8].

As elements fundamental to surface depth -aside from their structural purpose- pillars and walls also bring about a spatial order. As structural elements are designed according to the requirements, in terms of sizes and positions in order to best support the space, they are also calibrated to match the spatial character. The finalized sizes and gaps between the pillars and beams generate a spatial rhythm and instill a certain sense of musical order.

A surface has depth, minute details are usually produced on vertical surfaces, as movements, suspensions and flow are formed and controlled by these perpendicular surfaces-i.e., walls. As the depth of a surface increases, it eventually turns into an in-between space. By regarding this space created at the boundary as surface medium, the inside world communicates with the outside world communicates with the outside world [9]. Accordingly, the regenerated space according to the surrounding boundary faces a different world.

The Daesun Flour Mill as a Sustainable Design toward Urban Sustainability

At a 2002 academic conference in Bangalore, India, Alastair Fuad-Luke introduced the concept of slow design in his presentation. He argued that the thoughtful and responsible designers of the 21st century will design sustainable products and services. These products have been described as serving human needs without degrading and depleting resources, compromising the potential and diversity of ecosystems, or limiting the possibilities for present and future generations. Regarding environmental issues, Fuad-Luke maintains that new expressions such as green design, design for the environment, design for assembly and disassembly, eco-efficiency, eco-design, eco-redesign, sustainable product design, and sustainable product systems have appeared over the past decade. These concepts allow designers to recognize the environmental, social, and moral impact and urge them to have a holistic view and think of a product within the entire system [10].

William McDonough, the author of Cradle to Cradle, emphasized that the cause of problems in modern industrial society stems from inadequate design and that everything must be redesigned in an environmentally friendly manner. He also noted that sustainable design is an ideal point that exists in balancing the environment, economy, and fairness [11].

Stuart Walker, the author of Sustainable by Design, explained that the issue of sustainability is an increasing trend and that sustainable design is an approach that applies sustainable development ideology and principles emphasized in the second half of the century. He also suggested that sustainable design is more nature-oriented than traditional design [12].

Pursuing urban reuse, rather than adding new value, ultimately ensures urban sustainability. To this end, various international scholars have examined and defined several terms in urban design. The three dominant ideals are new urbanism, post-urbanism, and sustainable urbanism, although other categories, such as everyday urbanism, ecological urbanism, and landscape urbanism, are also common. All these approaches share a concern with shaping and composing public spaces and creating livable and healthy places that include variation, interest, familiarity, interaction, and contrast [12].

To supplement the existing definitions of the city as an entity, some environmental researchers have adopted the term "urban ecosystem" to identify the qualities of urban areas (Douglas 1981; Millennium Ecosystem Assessment 2005; Sterns and Montag 1974) [9]. Through this lens, urban sustainable development can be understood in terms of economic, environmental, and social factors. Indeed, in 2002,

the World Summit on Sustainable Development (WSSD) adopted the Johannesburg Declaration, stating that sustainable development involved the balanced development of the environment, society, and the economy. According to this model and the Sustainable Communities Plan, sustainable communities are places where people want to live and work, now and in the future. They meet the diverse needs of existing and future residents, are sensitive to the environment, and contribute to a high quality of life. They are safe and inclusive, adequately planned, built, and run, and offer equality of opportunity and good services for all [13].

In the environmental terms, the sustainable development focuses on protecting the integrity of ecological systems. It is realized through efforts to improve the quality of life, to preserve ecological diversity, and to reproduce resources while minimizing waste [13]. It considers the long-term impact of urban development on the environment and efficiently utilizes existing natural resources. In addition, the environmental sustainability recognizes the value of the ecosystem as the sole source of air, water, and soil. It includes the restoration and maintenance of the natural environment through the utilization of natural resources and reuse resources, such as greening and water circulation systems [3].

Sustainable social development seeks to enrich the human dimension by harmonizing social relations and cultural pluralism. It views the culture as the glue binding together all other concerns and underlying political and economic behavior. In addition, the culture can build the values that drive collective actions toward a globally sustainable future. Social sustainability deals with maintaining humans' quality of life and harmony through socio-cultural diversity and maintaining a harmonious relationship between developmental and value norms. It relates to local culture, identity, accessibility, stability, and equity, ultimately aiming to revitalize local communities [13]. Further, it makes efforts to promote community through residents' voluntary participation in the urban development process and in the ability to adapt to changing the community needs and desires [3].

Finally, sustainable economic development aims to improve the human welfare through the increased consumption and production of goods and services. Economic sustainability is focused on citizen welfare and the supply, consumption, and production of goods. This starts with the recognition that environmental resources are limited and must be preserved to meet the needs of present and future generations. It balances the economic benefits with potential future costs. On the quantitative side, the economic sustainability prioritizes efficient growth, development, and productivity [12]. In terms of quality, it coordinates the utilization of resources and direction of technological development. As the local economies continue to develop steadily, many governments are instituting specific economically sustainable initiatives, such as energy conservation, new material development, material recycling, and construction methods, which consider logistical costs and energy-saving transportation systems [3].

All three of these perspectives toward urban sustainability can be seen in the Daesun flour mill renovation. First, from the perspective of environmental sustainability, the flour mill's primary feature is improving its environmental maintenance. Most architectural actions were processed to minimize the effects on the surroundings, efficiently utilizing the existing structure and material to preserve the original form of the space. The designers made obvious efforts to conserve the environmental ecosystems as well. In terms of social sustainability, the revitalized Daesun flour mill was developed explicitly to foster identity regeneration and citizen participation.

The Yeongdeungpo District was the central industrial complex built in the suburbs of Seoul during industrialization and has continued to function as such until recently. However, as the local population density increased due to the mass influx of population, existing industrial facilities and sites were incorporated into the city center as urban space expanded, and the existing factory complexes reached the point of becoming disgusting facilities. Afterward, from the perspective of the urban regeneration, the trend of recycling industrial facilities and underused land into art and cultural complexes continued, but it had the side effect of creating another community far from the existing local identity. Located in between, the Daesun flour mill held the key to solving the problem as there is no free space for residents to rest because there are no open or green spaces around them. As a space that can mediate the conflict that changes in the surrounding context create, the Daesun flour mill area will be regenerated into a park to provide scarce green space. By operating as a social platform, it lays the foundation for representing the local identity. Finally, this space plays a role in community revitalization, partaking in the city's functions through an independent cooperative economic system.

ARCHITECTURALIZATION METHOD OF THE DASEUN FLOUR MILL RENOVATION

Among the 23 buildings that make up the site of the Daesun flour mill, the space was grouped based on the value of the space, and eight buildings were selected for regeneration. The purpose of most facilities is to be developed as a complex cultural space. The site condition is as follows. On the side of Yeongsin-ro, near the entrance to the Dasun flour mill factory, relatively tall buildings of about 30 meters are located [1]. On the other two sides of the triangular site, there were wooden and masonry structures along with a flour factory, rising six stories high. The silos were placed on the side of the main road. The area marked in blue on Figure 1. is the current renovation area, and the tall buildings, including the silos and flour mill in gray, are part of the second phase project [3].

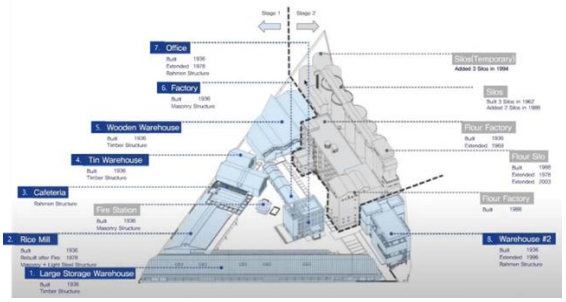


Figure 1. Eight buildings under the 1st phase process of renovation [3]

Large Storage Warehouse

The large storage warehouse located at the entrance was the largest building on the site. Built in 1936, it was a single-story timber structure with a width of 14.5 m and a length of 100m. The roof was in the form of a gable of timber structure, and the lower part, the ceiling beam, was about 4.2 m high, reaching a height of one floor, and the high part, the ridge part, was 7.7 m, which corresponded to the height of the second floor. Judging that the biggest attraction was the lack of columns, the architect decided to keep the column-free space and the wooden structure truss and that made this possible. Thus, it was planned that there would be an element of structural reinforcement from the outside, insulation would be added, and the environmental improvement aspect would take place between the existing and new buildings. [3]

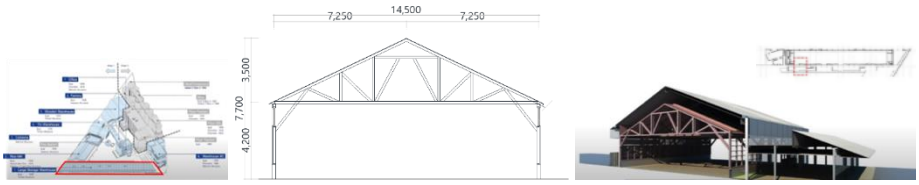


Figure 2. Large Storage Warehouse: Current status(middle) and Regeneration plan(right) [3]

Rice Mill

The rice mill was the largest building in the site with a trapezoidal plane with a length of about 54m and a width of about 22m. The roof was a form of protruding clerestory on the gable roof of the steel structure, showing the possibility of using it for various spaces. It is composed of masonry and light steel structure. Owing to the large volume, the strategy was to actively increase the density and utilize the space. In addition, a middle floor was planned for installation. The improvement of the environment would be implemented through this middle-level area, which was also the starting point for structural reinforcement and contained all pipes and drafts necessary for the facilities within the slab itself. [3]

Figure 3. Rice Mill: Current status (middle) and Regeneration plan (right) [3]

Cafeteria

The cafeteria had a length of about 21.1m and a width of about 9,1m in the shape of an L and included a courtyard inside. It consisted of a space with a gable roof, and the lower part, the ceiling beam, was about 2.7 m high, reaching the ceiling height of the residential space, and the high part, the ridge part, was 4.6 m. sense of human scale space. In this case, the space between, which formed a courtyard like space, was the most attractive characteristic. This created a space that retains the feeling of being outside, although it is indoors. One direction of the roof terrace opened the relationship with the square; in another, the connections with the square would be implemented, and the other direction offers a view from the roofline.[3]

Figure 4. Cafeteria: Current status (middle) and Regeneration plan (right) [3]

Tin Warehouse

The tin warehouse was a large space with a length of about 30m and a width of about 22m. It was built in 1936 and was used as a warehouse for a timber structure. This space also consisted of a space with a gable roof, and the lower part, the ceiling beam, was about 5.0m high, which corresponded to the height of the first floor, and the high part, the ridge part, was 7.5m, a large space with a high sense of space reaching two floors. It had a magnificent sense of scale. In the case of the tin warehouse, there were numerous ways to utilize the space. Inside, there is a space where the middle floor was hung with wood, and it is divided overall according to its purpose, using partitioning panels or concrete masonry. By dividing the mass to make a passage, an attempt was made to reveal the cross section of continuously overlapping traces of time [3].

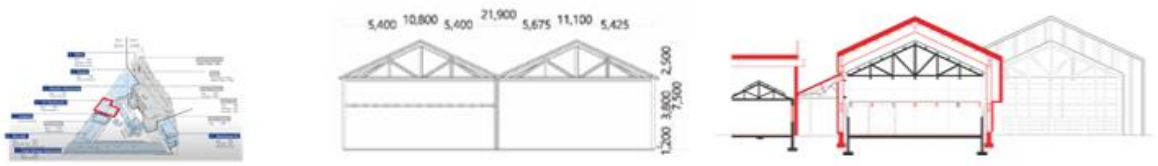


Figure 5. Tin Warehouse: Current status (middle) and Regeneration plan (right) [3]

Wooden Warehouse

The wooden warehouse was located in the innermost part of the site adjacent to the flour mill and silo. It was built in 1936 with a masonry structure. The overall scale is a large-scale space with a width of 43.5m and a length of 36m, but the width of 43.5m is divided into 14.5mx3ea and has a gable roof of the same shape. The lower part of the gable, the ceiling beam, is about 4.5m, which is equivalent to the height of one floor, and the high part, the ridge, is 7.6m, which is a warehouse with a continuous spatial effect with a high sense of space reaching up to two floors. It was a space with many columns. There were three types of columns, wooden, steel, and H-beams, traced as being used for a fashion show to install lighting. The architect decided that the process of adding pillars was so attractive that he wanted to keep the space made up of column forests alive. Accordingly, the existing asbestos roof was removed, and a new roof was covered by adding H-beam columns that could sufficiently secure the new roof. [3]

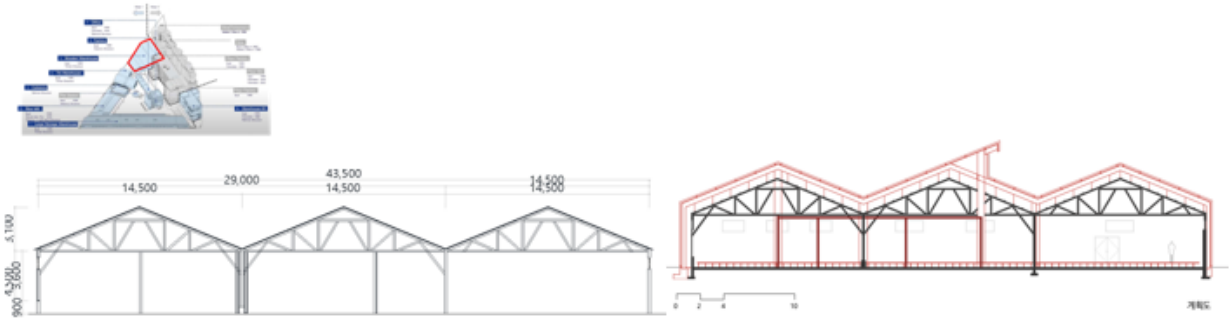


Figure 6. Wooden Warehouse: Current status(Left) and Regeneration plan(Right) [3]

Masonry Factory

The masonry factory faced the triangular main plaza at the front and the backyard was adjacent to the backyard with a flour factory in between, so it was located in the center of the site facing open spaces on both sides. It was built in 1936 and was a masonry structure. The scale was about 7.2m wide and 48.2m long and had a linear shape with two buildings in the middle. The roof was in the form of a gable and has a mass with high side windows, and the lower part of the gable, up to the ceiling beam, was about 4.0m high, which was equivalent to the height of one story. It was a factory with a sequential spatial form. The building facing the front square and backyard square was characterized by the red brick masonry walls and tiles on both sides. When observed closely, many traces of the processes of extending the structure existed. Thus, the architect focused on making these traces a little more prominent. In the interior, the long space divided by various layers helped one feel the traces of time when passing through each space. With the materials from various eras stacked on the outside as well, users are expected to be able to infer such traces and logical processes over time when completed. [14]

Figure 7. Masonry Factory: Current status (Left) and Regeneration plan (Right) [3]

Office

The office was located at the heart of the site, first built in 1936 and then ex-tended in 1978. It was a building of a rahmen structure with a width of 13m and a length of about 13.1m with 1st basement and 2 stories above the ground. Temporarily used as an office, the building was rebuilt in the 1970s and is the only structure on the site that includes a basement floor. An emergency shelter was located in the basement, reflecting the historical context in which it was built. The building was used to manage the facilities on the site, and a two-story extension was planned from its current situation. The façade facing the square would be equipped with a media façade to increase the utility of the plaza and would be a device to support activities in the square. [3]

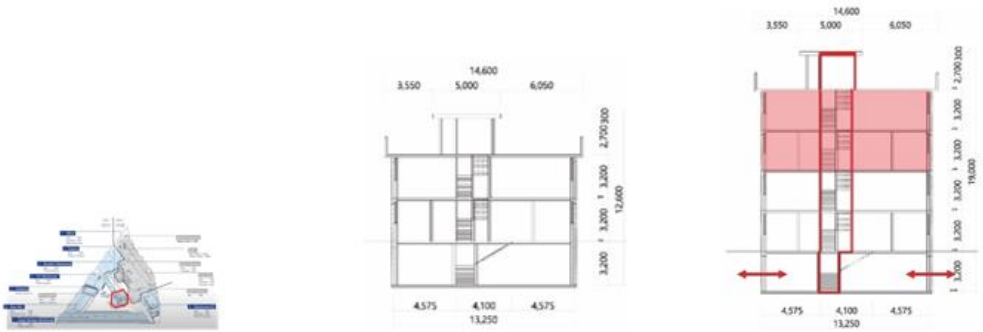


Figure 8. Office: Current status(middle) and Regeneration plan(right) [3]

Warehouse #2

The warehouse #2 was completed in 1936 and extended in 1996. It is a ramen structure, and the first reinforced concrete ramen school in Korea is now used as the Jongno-gu Office, which is two years older than that. It has sufficient value as a building asset. The scale is about 60m wide and 27m long in the shape of an L. It is a concrete rahmen structure with the upper part extended using sandwich panels. The third floor has already been demolished and a three-story steel-framed extension would be extended on top of the current two-story building. This building was completed in 1936. The architect wanted to emphasize that the value as a building asset is sufficient. The newly added building would be placed so that it extruded compared to the form of the existing structure and surrounding buildings. Consequently, the façade facing the square could be utilized to the maximum, and the one facing the public road appeared to embody the vertical rhythm of the silos. [3]

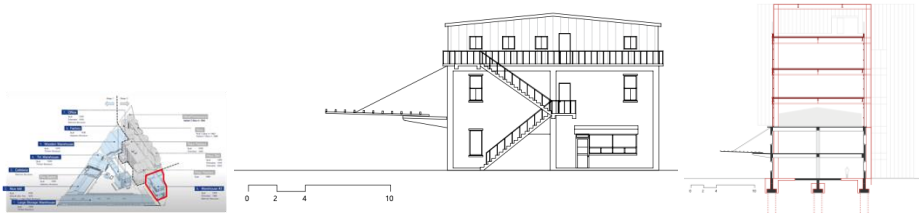


Figure 9. Warehouse #2: Current status(middle) and Regeneration plan(right) [3]

Sustainable Design Method: Considering the Relationship between Structure, Environment, and Materials

Securing Structural Stability

Each of the eight building groups has a slightly different value as a building asset. In some cases, because of the structural stability, structural stability must be secured, or because of the scale, the design approaches were different.

First, the most interesting and diverse methods of securing structural stability through the deformation of horizontal members such as roofs or slabs were presented. In the large storage warehouse(3.1), the space was the most attractive because it was a non-human space. By utilizing these spatial characteristics, the large storage warehouse preserves the non-human space as it is and maximizes the functionality while amplifying the huge sense of space. A new external skin was fitted to the existing roof as an element for structural reinforcement. Conversely, the rice mill is the building with the largest volume; therefore, structural enhancement was secured by dividing the space and creating a middle level. If In the large storage warehouse(3.1) is structural reinforcement through expansion, the rice mill(3.2) is the structural reinforcement through division. A similar method to the expansion of the large storage warehouse(3.1) is applied to the tin warehouse(3.4). Here, a reinforced structure was proposed by using recycled wooden frames in combination with steel structures for the middle level.

In the cafeteria (3.3), a corresponding structural reinforcement was proposed to create a new function by converting exterior space into interior space by taking unused outdoor space and giving it a usable indoor function through the addition of a roof. The wooden warehouse (3.5) structure was reinforced by replacing the old roof.

The next method is to increase structural stability by reinforcing or increasing the number of columns, which are vertical members. This is the clearest and most classic method. However, but it creates a different atmosphere depending on the space; therefore, the effect was more than expected. The wooden warehouse (3.5) added supplementary H-beam columns to propose a space with the opposite charm to that of 1 without columns, and the aesthetics of the contrast were reproduced. Thus, the reinforcement of the structure through columns appeared as an integration of space and structural reinforcement via the addition of supporting columns in the masonry factory (3.6).

Finally, the method of increasing structural stability through the extension of its mass was implemented through the two-story extension, along with underground level usage and extensions, in the office (3.7) and a three-story extension of the steel structure in warehouse #2 (3.8).

Environmental Improvements

Environmental improvement is closely related to the structural reinforcement presented above, and unique methods have been proposed that suggest the possibility of facility improvement within the structure. First, in the large storage warehouse (3.1), the architects tried to improve the usability and flexibility of large spaces by reinforcing insulation in the secured space with a new external skin added for structural reinforcement. Environmental improvements were also made between the existing and renovated buildings. In the rice mill (3.2), the equipment elements could be hidden in the free space under the lower part of the slab, which was structurally added. By adding a high side window to the roof, the only steel member, and introducing a skylight, an attempt was made to improve the environment through natural ventilation and lighting. Thus, the proposal of a passive system through space renovation appears more active.

As an improvement to the environment through the reversal of internal and external spaces, a roof was added to the cafeteria(3.3)'s external space to improve the usability of the space. In the tin warehouse (3.4), an active attempt was made to improve the environment by allowing air circulation (passive system) through a new hallway created by dividing masses.

The masonry factory (3.6) sought the environmental harmony through vernacular materials. The architect chose the method of creating harmony with the surrounding environment by emphasizing this as the most honest way and overlapping vernacular materials such as bricks built over the years.

Finally, to propose a relationship with the surrounding environment, the office (3.7) installed a media façade to the extended mass to interact with the surrounding environment, including the inner plaza. The warehouse #2(3.8) tried to improve the environment in a broader sense by demonstrating a way to respond to the urban context and surrounding environment by expanding it to the urban perspectives.

Dialog with Materials

The attraction of all eight buildings was diverse, and the source of that the charm comes from materials mirroring different times. Deriving attractions in a contemporary manner does not mean that the architect must reproduce the old appearance as it is but that it contains the technology and values of the contemporary context. This is represented as the dialog with materials.

Both the large storage warehouse(3.1) and rice mill(3.2) are buildings that belong to large spaces within the complex. In the large storage warehouse(3.1), the material beauty of the original roof truss in the existing wooden structure will be shared not only in the present but also in the future. It is a considerably delicate design method where the external skin is proposed to preserve the wooden structure. However, the rice mill(3.2) is the only space built with steel trusses that were restored with a steel structure after the existing wooden structure was burned down in a fire. The architect had no reason to transform this steel structure. Nevertheless, the slab

was added for space utilization, allowing visitors to experience the modern beauty of the material provided by the steel frame truss up close. In addition, the shadows of the dazzling steel truss created by the light passing through the high side window is expected to have a decorative effect that breathes life into a large space that exceeds the human scale.

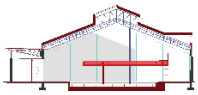
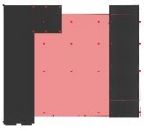
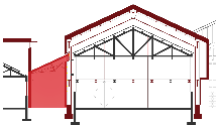
The cafeteria(3.3) is a space where you can appreciate the remnants themselves. The transition to the inner space of the yard, which was the outside, made it possible to experience a new space where you can appreciate the masonry materials, which retain the traces of time, from the inside as well. It will be a place that transcends time and space.

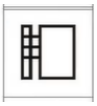
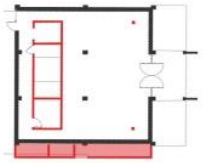
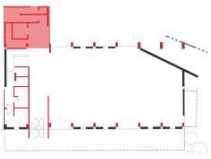
In the tin warehouse(3.4), as there are numerous elements of space utilization, the architects proposed a hallway between them while dividing the mass. Through the hallway, people can feel the overlapping trusses and experience the traces of time given by the materials. If the tin warehouse(3.4) had overlapping steel trusses, the wooden warehouse could engage in dialog with the past in the column forest constructed from the different eras through the overlapping of columns made at the different times.

However, it is the masonry factory(3.6) that seeks the environmental harmony through the vernacular materials. The architect chose the method of creating harmony with the surrounding environment by emphasizing this as the most honest way and overlapping vernacular materials such as bricks built over the years.

The office (3.7) will be a vertical two-story extension by preserving the history of the reinforced concrete rahmen structure, which has the longest history in Korea. As the concrete of the past and the extended area meet, the new and old coexist as an architectural asset, and the value of the material is felt. In warehouse #2(3.8), the third floor is demolished from the existing third floor, lowered to the second floor, and the third floor is extended to the fifth floor, which is a gesture considering the height and shape of the surrounding silos. It is assumed that the selection of the materials for these two buildings was proposed so that the renovated buildings as a whole play a public role outside the square and the roadside from the urban perspective.

Table 1. Sustainable design method considering the relationship between structure, environment and materials (Sources: Daesun Flour Mill Yeongdeungpo Factory[3] and authors).

		Structural Stability	Environmental Improvements	Dialogue with Materials	
1.Large Storage Warehouse		Fitted with a new external skin as a structural reinforcement element	Reinforcing the insulation in the added roof skin to improve usability & flexibility	Sympathy with original wooden structure roof trusses	
2.Rice Mill		Adding a middle level allowing structural enhancement	Equipment elements hidden under added slab. Natural ventilation & light adding high side windows & skylights	Modern beauty of steel trusses & vitality of the space & their vibrant shadows	
3.Cafeteria		Converting unused outdoor space and giving it a usable indoor function	Adding roof to external space to improve usability of space	Transitional space appreciating masonry materials retaining traces time from inside	
4.Tin Warehouse		Using recycled wooden frames in combination with steel structures for middle level	Allowing air circulation (passive system) through a new hallway created by dividing masses	Overlapping trusses with through the hallway	

 5.Wooden Warehouse		Replacing old roof and addition of supplementary H-beam columns	Harmony with surrounding environment with overlapping vernacular materials as bricks built	Dialogue with the past in the column forest constructed from different times	
 6.Masonry Factory	Square  Backyard square	Integration of space and structural reinforcement adding supporting columns	Overlapping vernacular materials such as bricks built over the years	Sympathize with the traces of extensions in the enclosed square & backyard square	
 **7.Office**		2 story extension along with underground level usage &extensions	Installing a media facade to the extended mass interacting with the surrounding environment with inner plaza	Preservation of reinforced concrete rahmen structure with the oldest history in Korea	
 8.Warehouse #2		3 story extenstion of steel structure. The extruded mass renews the road side facade	Response to the urban context and surrounding environment	Harmony with silos and urban context	

CONCLUSIONS

This study began with the exploration of sustainable design methodology. As an example, we focused on the Daesun flour mill located in Yeongdeungpo, Seoul, which has cultural value and a long history of over 80 years.

As discussed in the theoretical review, sustainable design should be based on economic, social, and cultural sustainability, and how to leave the remnants of the past is important. However, it should also be accompanied by considerations on various methods to increase the density by economic utility. It should serve as a cultural building point that can represent the social identity of the region.

Based on these contemporry demands, industrial heritage that has lost its use value is the most effective object. For the Daesun flour mill, an architectural solution was proposed that responds to the changed purpose in a more sustainable manner while preserving the values left behind. This design was not a concept orientation but a method that was thoroughly utilized and responsive to new usability. This strategy is differentiated from other regeneration designs thus far, and the summary is as follows.

First, to become a sustainable design, it is necessary to focus on changing usability—the role of a space that can accommodate change. This must be applied differently for each building. The Daesun flour mill is mostly composed of warehouses, which are non-human spaces. Therefore, spaces with high floor heights on a single story were characteristic. This space was sometimes used as a larger space by taking advantage of its size. When internal elements form various layers, a method of dividing the space into small-scale functions was proposed. In this case, contrary to the former extra-large structure, various large, medium, and small spaces interact and are flexible; therefore, various widths and heights can be secured. It is also possible to design a space that is converted into an interior environment. In this case, it becomes an unexpected space where the exterior façade is contrastingly experienced from the interior space. Clearly, the most difficult task was to consider the publicity of the new operation for a group of buildings that had no prior consideration for publicity and social community because it was previously a non-human space such as a warehouse. Here, to revitalize the community toward the plaza and secure the publicity of the city through the elevation and extension of the building's mass, it was proposed to secure usability and the elevation of the protruding mass to harmonize with the surroundings. It can also be evaluated as a valuable and interesting sustainable design approach in that it is a new attempt without relocating existing buildings.

Next, in proposing an architectural method that responds to the changes in the desired behavior, the focus should be placed on the relationship between the structural stability, the

environmental improvement, and the materials.

First, among the eight buildings, all of which have different appeals, in some cases, a different approach must be taken either because of structural stability, or because structural stability must be ensured, or because of their scale. The remaining task is to let them express their various charms and bring them back to life to show them in the contemporary times. In other words, the current interpretation of structural stability should take precedence in constructing a design concept. This is not a matter of structure but one of space that contains sustainable life, which is why the sustainable construction of such space is guaranteed.

Second, rather than the concept of reproducing the past as it is, the architect needs to create a space that can last for 100 years or more as current technology and the environmental issues evolve, and the environmental sustainability is implemented through the software. This is not a problem of applying new technology but an issue that needs to be considered deeply to find the possibility of new environmental improvements in existing areas.

In conclusion, a meaningful relationship can be created when structure, environment, and materials are considered rather than individually. Hence, it is not a space where the memories of the past have been lost but one that aims for a new future by further amplifying the power created by the past and the charm of the present. In the future research, such a meaningful and sustainable design methodology should be traced from the various perspectives.

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