Evaluation of Designs for Reuse of Japanese Style Houses in Taiwan

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Abstract
During the Japanese Colonial Period, the Japanese built many Japanese style houses in Taiwan. The residents of these Japanese style houses changed after World War II, but they were still used as residential houses. Starting in the 1990s, many of these houses have been dismantled because of obsolescence. This has also brought opportunities for conservation and reuse. However, there have been many diverse ideas for the redesign of Japanese style houses. It has been difficult to reach any consensus on the reuse of these houses. This study has proposed obtaining criteria weights by use of the Analysis Hierarchy Process, and has employed fuzzy set theory and TOPSIS to evaluate the performance of reuse design in actual cases. The results have indicated that using this method can integrate opinions from diverse personnel, so that the decision-making process on reuse design may be made smoother, and become comprehensive.

Keywords: AHP; TOPSIS; Japanese style house; reuse design; Taiwan

1. Introduction
During the Japanese Colonial Period (1895-1945), many Japanese came to Taiwan, the military and policemen first, then government officials, businessmen and their employees. As known from statistics, there were more than 380,000 Japanese and over 100,000 Japanese households living in Taiwan during that period (Ref.1.). Soon after their arrival, the Japanese authority in Taiwan – the Governor-General's Office, began to build official residences for military servicemen, policemen and officials, so that they could work and live in Taiwan. In the mean time, Japanese companies, some of which became state-owned, including mines, sugar refineries, breweries, and salt fields, also built residences for their Japanese staff (Ref.2.). Furthermore, the Japanese government planned to arrange for some farmers to immigrate to Taiwan, so, Japanese immigrant villages were built (Ref.3.). Therefore, throughout the 50 years of period, the Japanese built many houses in Taiwan.

These newly built Japanese houses were designed by Japanese architects, inheriting the styles, materials and construction methods familiar to the Japanese. After the Japanese left Taiwan, these houses were taken over by the new government, and allocated to public servants and state enterprise employees. Hence, most Japanese style houses were used for several more decades (Ref.4.). In the 1990s, since these Japanese style houses were mostly made of wood, they had become dilapidated after decades of use, and due to rapid economic development and soaring land prices, these Japanese style houses began to be dismantled.

On the other hand, architectural historians and environmental groups noted that, though these buildings were not as splendid as other public buildings built during the Japanese Colonial Period, they were past residences of many people. The lush vegetation in the gardens of these houses was also important providing green lands in urban areas (Ref.5.). Therefore, the conservation campaign to preserve Japanese style houses, not only focused on the value of the buildings, but also their significance to residents' life and the urban environment. Care was taken to begin preserving and reusing Japanese style houses across Taiwan, some of which were even designated as relics or historical buildings due to cultural significance. Nowadays, more than one hundred Japanese style houses have been designated or registered as cultural assets, among which 21 were groups of houses (Ref.6.). There are still many other cases of voluntary conservation and reuse.

Since later users of Japanese style houses after World War II came from Mainland China, without knowledge of Japanese culture, they had different views of dwellings from the Japanese. Thus, many Japanese houses were used and altered in different ways. In the past, there has been research on such various use methods due to different cultures (Ref.4,7.).

These houses that have been used and modified, in various ways, have begun to be preserved and to play
new roles. In reuse design, designers have, seemingly, more freedom to show creativity because of material service life and partially changed perceptions of the use of buildings; but the priorities of residents' memory-keeping, social significances, and even architectural value are different from new construction designs or other historical buildings' reuse designs.

Past studies have indicated that, successful reuse design can maintain original architectural value, retain common memory, reduce building waste, and even promote community concern for the environment (Ref.8,9.). Since Japanese style houses across Taiwan have witnessed users of various culture backgrounds, and are facing the demands of a new era, many people, e.g. house owners, architects, and urban planners have very diverse ideas of how to reuse these houses. As a result, it is difficult for designers to make final decisions on reuse design. At present, among hundreds of preserved Japanese style houses, more than 80% are still waiting for a final reuse decision. Therefore, this study has aimed to provide concrete methods to facilitate the decision-making on reuse design for these Japanese style houses.

As most critiques on reuse design decisions are subjective opinions that are not quantified, they are difficult to analyze and present as data. This study aimed to use sophisticated methods for qualitative decision-making, such as the Analysis Hierarchy Process (AHP), fuzzy set theory to solve uncertain opinions, and TOPSIS to rank priorities, in order to evaluate the reuse design in actual cases. The results are expected to help project managers and designers to make decisions on reuse design for Japanese style houses through the integrated method. Also, it is expected to obtain and provide more information during analysis, whether concerning the application of methodology, the effects of various cultures on perceptions of building use, and possibilities for later reuse as well.

2. Methodology of Evaluation

The evaluation procedure used in this study consists of several steps. First, we identify the criteria and sub-criteria considered in evaluation of reuse design for Japanese style houses in Taiwan. After constructing the evaluation criteria hierarchy, we calculate the criteria weights by applying the Analytic Hierarchy Process (AHP) method. The measurement of performance corresponding to each criterion is conducted using fuzzy set theory. Experts were asked to evaluate selected reuse cases with respect to each criterion by using a linguistic variable. The possible values for this variable could be any of the following: "very good", "good", "fair", "poor", "very poor". Each linguistic term can be characterized by a triangular fuzzy number representing its approximate value range between 0 and 1. These numbers can be further assigned as lower value, modal value and upper value, denoted as \((l,m,u)\), where \(0 \leq l \leq m \leq u \leq 1\), \(m\) is the most likely value of the linguistic term, and \(l, u\) are lower and upper bounds, respectively, to reflect the fuzziness of the term.

A fuzzy number is a convex fuzzy set, characterized by a given interval of real numbers, each with a grade of membership between 0 and 1. In this study, triangular fuzzy number will be used in our model. The membership function is defined as:

\[
u_A(x) = \begin{cases} 
\frac{(x-l)}{(m-l)} & l \leq x \leq m \\
\frac{(x-u)}{(m-u)} & m \leq x \leq u \\
0 & \text{otherwise}
\end{cases}
\]  

(1)

In order to form the decision matrix, assume that we have \(p\) decision makers as responsible for evaluating \(m\) alternatives with respect to \(n\) criteria. Consider \(p\) triangular numbers

\[D^{(k)}_{ij} = (l^{(k)}_{ij}, m^{(k)}_{ij}, u^{(k)}_{ij})\]

where \(k=1,2,...,p, i=1,2,...,n, j=1,2,...,m\).

Using addition of triangular numbers and division by a real number gives the triangular average \(D_{ij}^{(k)}\).
When the aggregation defined by a triangular average number is expressed by a crisp value which represents best the corresponding average, this operation is called defuzzification. In this study the defuzzified value of a fuzzy number can be obtained from the formula:

\[
X_y = \frac{l_y + 2m_y + u_y}{4}
\]  

(3)

2.3 The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

Hwang and Yoon introduced the TOPSIS method based on the idea that the best alternative should be the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution in 1981 (Ref.12.). The reason for choosing TOPSIS as the ranking technique instead of using a full AHP method in the study is that it avoids an unreasonably large number of pairwise comparisons.

The TOPSIS solution method consists of the following steps:

Step 1: Normalize the decision matrix: The normalization of the decision matrix is done using the following transformation, each \( r_{ij} \) is calculated as

\[
n_y = x_y / \sqrt{\sum_{j=1}^{n} x_j^2} \quad i = 1,2,\ldots,m, \quad j = 1,2,\ldots,n.
\]  

(4)

Step 2: The columns of the normalized decision matrix by the associated weights are multiplied. The normalized weighted decision matrix is displayed as follows:

\[
v_{ij} = w_j n_y \quad i = 1,2,\ldots,m, \quad j = 1,2,\ldots,n.
\]  

where \( w_j \) represents the weight of the \( j \)-th criterion.

Step 3: Determining the positive and negative ideal solutions: The positive and negative ideal value sets are determined, respectively, as follows:

\[
A^+ = \{\max_{j \in J} (v_{ij}) | i = 1,2,\ldots,m\}
\]

(6)

\[
A^- = \{\min_{j \in J} (v_{ij}) | i = 1,2,\ldots,m\}
\]

(7)

where \( A^+ \) is the set of benefit criteria and \( A^- \) is the set of cost criteria.

Step 4: Measuring the distance from positive and negative ideal solutions: Two Euclidean distances for each alternative are calculated as follows:

\[
S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - A^+)^2}, \quad i = 1,2,\ldots,m
\]  

(8)

\[
S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - A^-)^2}, \quad i = 1,2,\ldots,m
\]  

(9)

where \( S^+ \) and \( S^- \) represents the distance of alternative Ai from the positive and negative ideal solutions, respectively.

Step 5: Calculating the relative closeness to the ideal solution: The relative closeness to the ideal solution is defined as follows:

\[
C_i = \frac{S_i^-}{S_i^- + S_i^+}, \quad i = 1,2,\ldots,m
\]  

(10)

where \( R_i \) represents the relative closeness.

Step 6: Ranking the performance of the reuse designs: Reuse designs can be ranked based on \( R_i \) in which the highest score is the best case.

3. Criteria for Evaluating Reuse Design

At present, Japanese style houses in Taiwan are preserved as single houses or groups of houses. Most single houses are preserved for their special significance or colonial history, while groups of houses are preserved due to historical context and/or significance to the surrounding environment, including industrial or urban development history. Both cases are expected to be preserved dynamically, rather than statically, with reuse design applicable to sustainable development.

In terms of reuse design, past studies have proposed related factors, such as ecological and cultural sustainability, environmental effect, economic efficiency, historicity of the building, cultural and artistic value, technological value, and social significance (Ref.8,9,13,14,15,16.).

The Japanese style houses in Taiwan were built before World War II and provided for Japanese to live in Taiwan. In opposition to Taiwanese houses, which emphasized rites, defense and fire control, and resulted in closed compounds made of bricks, stones and earth, the Japanese style houses are wood structures with open verandas. The reason is that Japanese architects coming to Taiwan continued residential styles and material structures familiar to Japanese.

At the same time, as scientific research, they studied house buildings applicable to natural conditions in Taiwan. According to articles published in the Taiwan Architectural Journal (Ref.17.), Japanese scholars considered that some features of Japanese houses, such as removing shoes before entering an elevated indoor space, tatamis on the floor for people to sleep on, flexible use of space by sliding door partitioning, Japanese style wood structures, and verandas open to gardens, should be continued to adapt to the hot and humid climate in Taiwan. More attention had to be paid to building orientation, ample garden area, depth of veranda, floor elevation height, and indoor space flexibility, in order to improve heat stroke prevention and ventilation (Ref.18.).

In addition, most of these Japanese style houses were official residences and company houses, and differed in size for position and rank, as in Japan. The interior
design also reflects the ranks of the residents, such as shelving recesses (chigaidana), studying places (shoin), picture recesses (tokonoma), and transoms (ranma). Some high-ranked official residences had Western style reception rooms or reading rooms.

Based on past studies on reuse design and case study reports, this study considered the conservation value and current reuse demand for Japanese style houses in Taiwan, and generalized the following aspects to establish the criteria:

- **Cultural aspect:** When the house is famous as the former residence of an eminent person, then the house being preserved can reflect the memorial significance. If preserved as a relic of the official residence in the Japanese Colonial Period, it should reflect the various grades of interior, and the characteristics and living style of Japanese living space, including unique space layout, and special spaces, such as closets and studying place, picture recesses, and transoms. Some luxury Japanese style houses incorporated Western style rooms, which also can be seen as characteristics of the houses. From the Japanese Colonial Period until the present, many Japanese style houses have been used by different persons, so there are lasting effects from alterations in various periods. In some cases, these are historical values to be maintained in reuse design as well. Hence, from the cultural perspective, historical value, artistic value, architectural value and distinctive identity, are the sub-criteria for evaluation.

- **Functional aspect:** The former Japanese style houses have flexible function rooms and open spaces, thus are often regarded as appropriate for public use. However, when converted from residence to public use, room scale, sound transmission, and number of occupants should be considered in design. From a functional viewpoint, amenities, spatial adaptability and route rationality can be deemed sub-criteria.

- **Environmental aspect:** The reuse of Japanese style houses is not only aimed at preserving the buildings, but it is also expected that the existence and reuse of the houses can preserve part of the urban context and historical foundation of the neighborhood, and can play a positive role in the surrounding environment, such as improving the urban scene and local characteristics, as well as the natural environment. In particular, as discussed by Japanese architects during the colonial period, it was specially required that gardens should be large to help adjust to the hot and humid climate in Taiwan. The large old trees and the rich variety of plants in gardens of Japanese houses have become important urban or local natural resources. Therefore, the role of reuse design from an environmental viewpoint can be evaluated in terms of urban context, scenic improvement and physical condition.

- **Conceptual aspect:** For most Japanese houses now, reuse design differs from pure conservation, as functions change, and private space transforms to public space, and as utilization of new materials and new technology which have solved many problems which were difficult in the past. In reuse design, since this generation of users grew up with different cultural backgrounds, how to solve problems with creativity, how to promote the harmonious coexistence of diversified cultures, and the prospects for sustainability, should be evaluated.

- **Economic aspect:** To achieve the goal of sustainable operation, economics is an important part. The expenditure for initial rehabilitation, budgets for annual operation and maintenance, and definition of profit gained from reuse should be evaluated.

- **Technological aspect:** New functions require new materials and methods, and there are many new technologies and equipment that were unavailable in the past, which can solve architectural problems from the past, such as seismic retrofits, fire prevention and improving the comfort of the interior environment. However, simply using new equipment and material to solve problems in old buildings may create new problems. For instance, excessive reinforcement will result in strengths far higher than the original wood structure stiffeners, leading to damage of original wood structures during earthquakes; or an air conditioning system may circumvent the original ventilation, resulting in higher humidity or dewing in hidden locations, and termite nuisance. Therefore, techniques must be carefully assessed for benefits and probable negative effects when used with original structure systems, the air-conditioning equipment and disaster prevention facility as well.

- **Social aspect:** As most Japanese style houses were transformed to state properties after the war, and official residences were reclaimed, most of the land and buildings become public property. As wooden houses were gradually demolished, the common Japanese style houses and gardens became only childhood memories for many people. In recent years, conservation of Japanese style houses has been launched by local residents, and approved by governments only after discussions and public hearings, so that the Japanese houses can be kept and reused in various ways. Therefore, reuse of the Japanese style houses is not only an architectural issue, but also a social issue. Extending community empowerment, and maximizing citizen welfare and promoting potential beneficial effects for the surroundings, are sub-criteria from a social viewpoint.

4. **Empirical Study**

From representative reuse cases of Japanese style houses with various functions, we selected 8 projects as the objects for empirical study. Their reuse functions are coffee house, tea house, community workshop, dance studio, restaurant, cultural space, and museum.

The Museum of Yilan Government History is the former official residence of the Yilan Colonial Prefectural Chief, was completed in 1906, and acted
as the Yilan County Magistrate's residence after the war. In the 1990s, this area, around the Prefectural Residence, as a part of the urban redevelopment zone, was to be demolished. Since the camphor tree in the garden had grown so large that to link hands around the tree needed at least two people, the Magistrate found it regrettable to log this old tree, hence, the decision on preserving the tree extended to preserving the building. The Magistrate thought that it was the residence for many former magistrates of Yilan, and many important decisions were made here. Also, the history of Taiwan ruled by Japanese should be known to younger generations. Therefore, this residential house was reused as the Museum of Yilan Government History in 1997, and registered as a historical building in 2001. (Fig.1.2.)

The Musashibo Japanese Restaurant is situated next to the Museum of Yilan Government History. It was the residence of former Yilan Prefecture officials and Chief Secretaries after the war. After the Magistrate's residence reassignment was completed and recognized, this building was also adopted as a conservation project to maintain an image of an official residences district, and was transformed into a restaurant after completion of refurbishment in 2003. To enhance the convenience of new functions, great changes were made in both indoor space and structure, and only part of the original building façade remained. Like the previous case, it was registered as a historical building in 2001. (Fig.3.)

The Keelung Cultural Association office was the former house of Japanese timber merchants built in 1931, and the house of the Taiwan Naval Commander after the war. The military had planned to demolish it, but after the last resident moved out in 1997, it was kept due to efforts by local citizens. It was registered as a historical building in 2002, and is now the Keelung Cultural Association.

Wisteria Tea House was first built in 1921 as the house of Asaka, the Standing Councilor of the Maritime Association during the Japanese Colonial Period, and became the residence of Chou De-wei, the Director-General of the Keelung Customs Administration, after the war. As it is near National Taiwan University, and Mr. Chou was a scholar who had studied abroad in Germany and hosted many scholars, it was the venue of gathering for many famous liberal scholars.

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1. Entrance hall
2. Theme exhibition
3. Conservation exhibition
4. Featured exhibition
5. Exit hall
6. Briefing room
7. Ticket counter
in Taiwan at that time. Later, it was inherited by his youngest son Chou Yu, who kept his father's style and maintained it as a congregation venue for scholars and recluses. In 1981, it was officially recognized as Wisteria Tea House, so that more people could visit freely. In 1997, due to its influence on the development of local democratic ideology, it was designated as a historical relic of Taipei City (Ref.19.). Following Chou Yu's preference and sense of the house, he kept features of the Japanese wooden house, and made some changes to partially expand the structure into a two-storey building, and added traditional Chinese furniture and decorations.

Canvas café was formerly a duplex dormitory built in the 1930s, and was the house of immigrants from Mainland China after the war. It was rented to an artist couple in 1995 as a coffee house and exhibition space. The original building structure and façade is preserved, but the Japanese style sliding doors have been moved, tables and chairs added, and paintings hung. It now subtly shows a Western atmosphere. (Fig.4.)

The training ground affiliated with the Yoga Association is a former Japanese dormitory built in the 1920s, and was home for immigrants from Mainland China after the war. It was bought by the President of the Yoga Association and used as a Yoga training room. The main change in the reuse design was to move the entrance to the veranda, which faces the original backyard and change the larger backyard into a parking lot.

Tsai Jui-Yueh Dance Institution, built in the 1920s, was formerly a four family residence for middle and lower rank Japanese policemen. Since Ms. Tsai Jui-Yueh, the celebrated Taiwanese dancer, purchased it in 1953, it has been used as a dance studio, and renovated four times in response to rising space needs. The neighboring house was also bought and cleared to form classroom and living space. In 1999, it was designated as a historical relic of Taipei City for the significant contributions made by Tsai to Taiwan's dance history (Ref.20.). However, half of it was destroyed by fire

![Fig.5. Tsai Jui-Yueh Dance Institution (Photo by the Author)](image)

![Fig.6. Interior of the Mayor's Salon (Photo by the Author)](image)

| Table 1. Weights of the Sub-criteria |
|-------------------------------------|
| Goal                               |
| Criteria                           |
| Sub-criteria                       |
| Rank                               |
| Evaluation for reuse design of     |
| Japanese style houses              |
| 0.217                              |
| Cultural                           |
| Historical value                  |
| 0.0716                             |
| 4                                  |
| Artistic value                    |
| 0.0380                             |
| 12                                 |
| Architectural value               |
| 0.0625                             |
| 6                                  |
| Identity                           |
| 0.0449                             |
| 10                                 |
| Functional                        |
| Amenity                            |
| 0.0284                             |
| 17                                 |
| 0.135                             |
| Spatial Adaptability              |
| 0.0743                             |
| 3                                  |
| Route rationality                 |
| 0.0324                             |
| 15                                 |
| Environmental                     |
| Urban context                     |
| 0.0269                             |
| 18                                 |
| 0.112                             |
| Scenic improvement                |
| 0.0616                             |
| 7                                  |
| Physical condition                |
| 0.0235                             |
| 19                                 |
| Conceptual                        |
| Creativity                        |
| 0.0632                             |
| 5                                  |
| 0.243                             |
| Sustainability and reversibility  |
| 0.0795                             |
| 2                                  |
| Harmonious coexistence            |
| 0.1004                             |
| 1                                  |
| Economical                        |
| Cost for rehabilitation           |
| 0.0456                             |
| 9                                  |
| 0.103                             |
| Cost for maintenance              |
| 0.0174                             |
| 21                                 |
| Benefit from reuse                |
| 0.0399                             |
| 11                                 |
| Technological                     |
| Structural system                 |
| 0.0503                             |
| 8                                  |
| 0.101                             |
| Air-conditioning equipment        |
| 0.0136                             |
| 22                                 |
| Disaster prevention facility      |
| 0.0371                             |
| 13                                 |
| Social                            |
| Citizen welfare                   |
| 0.0291                             |
| 16                                 |
| 0.089                             |
| Community empowerment             |
| 0.0368                             |
| 14                                 |
| Potential beneficial effect for the surrounding |
| 0.0231                             |
| 20                                 |
soon after that. After reuse design and completion of construction in 2003, it has multiple functions, including a dance studio, a coffee house, and an art and culture exhibition space. For events and performances, the dance studio can be extended to outdoor open space. (Fig.5.)

The Mayor's Salon, built in 1940, was formerly the residence of the Taipei Mayor both in the Japanese Colonial Period and after the war. The city opened it as a coffee house in 1996, and it now has been renovated to serve as a restaurant, an art work exhibition space, store, a cultural classroom and a conference room. The reuse design kept the original layout and structure, but there were great changes in the interior. (Fig.6.)

The 7 criteria consist of 22 sub-criteria as elaborated in the previous section shown in Table 1. First, the experts, including architects, conservation scholars and reuse managers, were asked to assign corresponding numerical values based on the relative importance of the criteria with respect to the overall goal of evaluating the reuse design of Japanese style houses in Taiwan. The verbal judgments from *equally important to extremely more important* were then rated with a scale range of 1-9. After doing all pairwise comparisons among the criteria, the pairwise comparison matrix was constructed. Similarly, the pairwise comparison procedure was then applied to sub-criteria. Computations were done by computer software. Table 1. also shows the relative weights for each criterion and sub-criterion, which were obtained by applying AHP.

The weights for each of the aspects are: cultural (0.217), functional (0.135), environmental (0.112), conceptual (0.243), economical (0.103), technological (0.101) and social (0.089). The weights describe in general which concepts of the reuse design were of more concern.

Ranked by the weights, the top six evaluation sub-criteria are: harmonious coexistence (0.1004), sustainable development (0.0795), spatial adaptability (0.0743), historical value (0.0716), creativity (0.0632), and architectural value (0.0625). Apparently, except for conserving the value of the houses, experts are most concerned with how well the design can adapt to new uses and future uses.

Then, the experts were asked to evaluate the 8 reuse cases with respect to each sub-criterion by using linguistic variables "very good", "good", "fair", "poor", or "very poor" and further assign numbers as lower or "very poor" and further assign numbers as lower

| Criteria | Museum of Yilan Government History | Musashibo Japanese Restaurant | Keelung Cultural Association | Wisteria Tea House | Canvas Cafe | Tsai Jui-Yueh Dance institution | Mayor's salon | Yoga Association |
|----------|----------------------------------|-------------------------------|-----------------------------|------------------|-------------|-------------------------------|---------------|------------------|
| Historical value | 0.911* | 0.482* | 0.813 | 0.893 | 0.652 | 0.755 | 0.732 | 0.629 |
| Artistic value | 0.841* | 0.427* | 0.813 | 0.709 | 0.795 | 0.600 | 0.650 | 0.789 |
| Architectural value | 0.870 | 0.366* | 0.893b | 0.709 | 0.738 | 0.486 | 0.514 | 0.686 |
| Identity | 0.939* | 0.396* | 0.795 | 0.823 | 0.766 | 0.657 | 0.600 | 0.484 |
| Amenity | 0.755 | 0.864* | 0.598 | 0.766 | 0.818 | 0.846 | 0.455* | 0.541 |
| Spatial Adaptability | 0.789 | 0.452* | 0.761 | 0.629 | 0.709 | 0.680 | 0.514 | 0.870* |
| Route rationality | 0.936* | 0.714 | 0.893 | 0.514 | 0.823 | 0.813 | 0.336* | 0.600 |
| Urban context | 0.686 | 0.680 | 0.629 | 0.795 | 0.714 | 0.864* | 0.709 | 0.457* |
| Scenic improvement | 0.657 | 0.795 | 0.336* | 0.680 | 0.629 | 0.888* | 0.732 | 0.366 |
| Physical condition | 0.911* | 0.800 | 0.686 | 0.623 | 0.563* | 0.709 | 0.738 | 0.571 |
| Creativity | 0.571 | 0.795 | 0.248* | 0.761 | 0.841 | 0.864* | 0.511 | 0.595 |
| Sustainable development | 0.916* | 0.307* | 0.813 | 0.513 | 0.684 | 0.679 | 0.427 | 0.709 |
| Harmonious coexistence | 0.738 | 0.188* | 0.595 | 0.771 | 0.846* | 0.823 | 0.338 | 0.795 |
| Cost for rehabilitation | 0.338* | 0.686* | 0.539 | 0.600 | 0.629 | 0.427 | 0.498 | 0.543 |
| Cost for maintenance | 0.600 | 0.364* | 0.732 | 0.598 | 0.652 | 0.571 | 0.543 | 0.846* |
| Benefit from reuse | 0.543 | 0.893* | 0.364* | 0.818 | 0.795 | 0.784 | 0.813 | 0.484 |
| Structural system | 0.888 | 0.916* | 0.484 | 0.795 | 0.571 | 0.709 | 0.543 | 0.482* |
| Air-conditioning equipment | 0.795 | 0.870* | 0.368* | 0.714 | 0.543 | 0.777 | 0.686 | 0.570 |
| Disaster prevention facility | 0.870* | 0.859 | 0.455 | 0.657 | 0.455 | 0.864 | 0.709 | 0.396* |
| Citizen welfare | 0.888* | 0.218* | 0.766 | 0.711 | 0.600 | 0.813 | 0.823 | 0.571 |
| Community empowerment | 0.784 | 0.446* | 0.916* | 0.813 | 0.629 | 0.893 | 0.818 | 0.454 |
| Potential beneficial effect for the surrounding | 0.709 | 0.736 | 0.218* | 0.721 | 0.595 | 0.963* | 0.709 | 0.454 |

a b is the best performance out of the 8 cases and w is the worst performance out of the 8 cases

Table 3. Final Ranking of Reuse Design Cases

| Reuse Design Cases | Rank | Similarity to Ideal Solution |
|--------------------|------|------------------------------|
| Museum of Yilan Government History | 1 | 0.752 |
| Tsai Jui-Yueh Dance institution | 2 | 0.703 |
| Canvas Cafe | 3 | 0.678 |
| Wisteria Tea House | 4 | 0.666 |
| Yoga Association | 5 | 0.554 |
| Keelung cultural association | 6 | 0.536 |
| Mayor's salon | 7 | 0.389 |
| Musashibo Japanese Restaurant | 8 | 0.375 |
criterion evaluated by respondents was measured as a fuzzy number with triangular membership function. We use Eq. (3) to defuzzify the fuzzy numbers, which are as shown in Table 2.

Finally, by using TOPSIS, we aggregate the weight of evaluation criteria and the matrix of performance to evaluate the selected cases. The evaluation results can be seen in Table 3.

5. Discussion and Conclusion

Reuse design of Japanese style houses in Taiwan is a controversial issue. They have different significances to people of different periods, even people of one period view then differently. They were also used and altered by people of different cultural backgrounds, therefore, before reuse design, the various viewpoints should be considered, and many complex problems must be faced.

This study demonstrated that the AHP approach is a useful tool to help support a decision in reuse design. It integrates the opinions and evaluations of experts and revises the complex decision-making system into a simple element hierarchy system. According to the evaluation, experts regarded conceptual aspect as the most important one, in which, harmony of old and new is most considered, followed by sustainable development; the second place was the criterion of cultural aspect, in which historical value was of most concern; in functional aspect, space adaptability is of most concern. As seen, Japanese style house reuse is not simply conservation. More attention should be paid to contemporary use and future development.

On the other hand, this study employed fuzzy set theory to generalize subjective ideas. Among evaluations of actual cases, experts who participated in questionnaire surveys stated that it was easier to answer the questionnaires after using this method, and agreed on that of considering probability in a linguistic sense could better obtain fair and correct results than traditional statistical methods. TOPSIS is an adequate tool for selecting the best case.

In this evaluation, due to the high score of cultural aspect and functional aspect, the Museum of Yilan Government History was regarded as the best reuse design case. As to the Tsai Jui-Yueh Dance Institution, though great changes were made due to fire, the reuse design was comprehensive in all aspects, which was regarded as a good case. Similarly, the Western style Canvas Café was recognized as showing creativity and harmonious coexistence between old and new, and was regarded as a successful case as well.

Therefore, seemingly conflicting criteria reflecting the opinions of the different experts, can be integrated, after weighting and produce useful evaluations of design criteria. So, reuse design for buildings need not, now, be endless arguing. Problems often criticized in the past, such as inability to show creativity, or ignoring architectural values in reuse designs, can also get direct answers after such an evaluation process.

This study not only presented the reuse characteristics of Japanese style houses in Taiwan, but in terms of methodology, the reuse design evaluation and decision-making method proposed in this study will help to identify the criteria that are applicable to reuse of various building types, value ideologies or users, depending on the criteria weights obtained from their own questionnaire surveys. Meanwhile, not only the actual reuse cases mentioned in this study, but also reuse design alternatives can employ this method to evaluate optimum designs.

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