Applied SBTOOL to the Research on Performance Evaluation of Green Buildings in Southern Taiwan - A Case Study of the Residential Building Designed for Pingtung County Self-Government Ordinance for Green Buildings

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Abstract. The global climate change and the lack of environmental resources, the issue of sustainable development have been emphasized by global. In response to the development of a sustainable environment, in recent years, ‘green buildings’ have sprung up in large numbers, and the aspect of architectural technology are constantly making breakthroughs and innovations. Whether it is a library, a school building, or even a residential office building, it emphasizes to make a step towards ‘green’. The Pingtung County Government has established the Pingtung County Self-Government Ordinance for Green Buildings in 2016 to regulate the new constructions’ designs in a certain scale must according to thermal insulation, energy conservation, health, and sustainability. This study is to explore the applicability of SBTOOL to green buildings in southern Taiwan, accordingly choosing new-built residential cases in Pingtung County. Pingtung County is located in the south of the Tropic of Cancer. The local climate is hot and enough sunshine, there are many typhoons and rainstorms in summer. The residential planning is according to the ‘Self-Government Ordinance for Green Buildings’ of the Pingtung County Government. Both cases are designed by different construction companies and are the traditional southern Taiwan street house style. The planning concept also considers the current aging of the population in Taiwan and barrier-free environment design. After the evaluation, the scores obtained are between Acceptable Practice and Good Practice, only the barrier-free environment and universal design cannot clearly include in the assessment. On the whole, it is applicable to evaluate the ‘Green Building Residential Case in Pingtung’ by SBTOOL. This study hopes to make the residential cases whose designs are conforming to the Pingtung County Self-Government Ordinance for Green Buildings can provide a reference for the architectural design of the similar climatic environment and geographical features in the global, through the evaluations and analyses of SBTOOL.

1. Research Motivation and Objectives

In response to the development of a sustainable environment, in recent years, ‘green wave’ creates a trend. In addition to publicizing environmental protection and recycling, energy conservation and carbon reduction; green buildings or sustainable buildings have sprung up in large numbers and the aspect of architectural technology are constantly making breakthroughs and innovations. Whether is a library, a school building, or even a residential office building, it emphasizes to make a step towards ‘green’ or ‘sustainability’. Accordingly, a complete sustainable building assessment system can provide
comprehensive information on building quantification, reflecting different life cycle stages have effects on the environment, society, and economy. And provide warnings of building assessment perspective to assist in identify and solve problems. For example, do the assessment in the preliminary planning and design phase of the building, can not only guides the building to the expected goal but also provides early warning and feedback corrections to reduce the negative impact of defective design, and reduce the cost of future construction and operation management. [1] (CHANG KF, 2007).

Pingtung’s environment and climate are good, and its congenital conditions are excellent. Designing residences as green buildings not only combines the regional environmental conditions but also enables the government, the construction company, and residents to achieve a trilateral win. This study applied SBTOOL for preliminary analysis and selected Building Project A and Building Project B to advanced operations, analyzed the scores of the evaluation data, and further explored the differences between green buildings in Pingtung and international sustainable buildings.

2. Pingtung County Self-Government Ordinance for Green Buildings
In order to create a healthy quality of life and achieve the goal of energy conservation, carbon reduction, and mitigation; the Pingtung County Government announced on January 1, 2016, the implementation of the ‘Pingtung County Self-Government Ordinance for Green Buildings’, new-built public, factory or buildings used for the public have to comply with the specifications for green buildings. New-built public-owned buildings with a cost of construction more than NT$30 million, new-built constructions above 16 floors, new-built factories of over 1,000 square meters, and new-built buildings used for the public of over 200 square meters, etc., the roof of the buildings is forcibly laid with thermal insulation facilities, and solar power generation facilities or green facilities, as well as full-scale application of water-saving toilets. To the basic structure of specifications for Green Buildings in Pingtung County, the guidelines of smart site plans include ‘Green Energy on Every Roof’ and aerobic permeable pavement, vertical planting, universal design, effective external shading, application of healthy green building materials, and effective ventilation. Among them, the universal design concept makes each space improve availability, and allow to be used by different groups of people such as men and women, old and young, elderlies, and people with disabilities. Effective external shading's design depends on cornices or shading devices or balconies; and can reduce the energy consumption of environmental air conditioning, improve the indoor light environment, and reduce artificial lighting in the daytime.

3. SBTOOL
This study applies SBTOOL2012 version [2], which consists of three modules (Module A, Module B, and Module C). In the operating procedure, first of all, the professional designer inputs the basic information of the building to Module A, and the regional developer or the third-party decides the weights and the benchmarks of the assessment issues or assessment categories, according to the location and environmental basic conditions of the assessment project. In the part of Module B, the weights and the benchmarks established by the professional design team (architect or designer) according to Module A, that clearly illustrated the 'design data of buildings' section, and fills the basic data, such as, in the floor area of the relevant buildings, the materials and areas of each part applied, cost of construction, equipment system, energy management for operation; in the 'energy consumption in buildings' section, the structural materials used in buildings are calculated for estimating greenhouse gas emissions and embodied. Then in Module C, performing the calculation of system evaluation to complete the 'relative score', 'absolute project result', and 'target score' of different buildings.

4. Research Case Analysis
This study selected new residential cases in Pingtung City, Pingtung County. Pingtung City has a population of about 190,000 people and is the county center of Pingtung County. Also, Pingtung has the title of 'Sun City' due to the blazing sun in southern Taiwan and has the longest duration of sunshine in Taiwan, and there are many typhoons and rainstorms in the summer. The two residential cases selected in this study are designed according to the 'Self-Government Ordinance for Green Buildings' of the
Pingtung County Government. They are respectively designed by different construction companies and are the traditional southern Taiwan street house style, the following is a description of the case data:

“Building Project A” plans to build 77 single-detached houses, which sites are located in the Pingtung cultural Golden Triangle of Pingtung Performing Arts Center, National Pingtung University, and Pingtung Tobacco Factory Cultural and Creative Miniature Park. The case plans six-meter-wide community roads, designing sidewalks and large areas of plant greening in the community, and coordinates with the Pingtung County Government to promote the Pingtung City green buildings, planning deep balconies of the houses, integrating green and sustainable designs like solar photovoltaics, low-carbon and energy conservation, air purification, and regional climate, etc., to create the first green energy community in Pingtung City.

“Building Project B” plans 40 households with 3 floors and a half of single-detached houses. The site is located across from the National Taxation Bureau of Pingtung and adopted front yard parking mode. The building project plans 4 to 5 rooms, and the aquaponics system is imported into the balconies to bring ecological vitality for the buildings, green the buildings, and make the building cooler. Aquaponics, which know-why is to establish a cycle of fish, vegetables, and microorganisms in a soilless environment. Fish provide nutrients to the plants through excrement, the plants absorb nutrients to achieve water quality filtration, and the microorganisms decompose the fish excrement to provide nutrients for the plants. Achieve aquaponics under the soilless water circulation environment, combined aquaculture and soilless cultivation these two major techniques, is a new type of compound cultivation system. With this technology, it is possible to achieve the goal of ‘fish-farming without changing the water and no more worries about water quality, planting without fertilizing and the vegetables grow normally’, accomplish synergistic symbiosis between fish and vegetables, and a sustainable and circular low-carbon production mode with zero-emission in the future.

5. Analysis of Research Results

5.1. Building Project A

- In Group. A Site Selection, Project Planning, and Development scored 1.2 points, Group. B Energy and Resource Consumption scored 0.6 points, Group. C Environmental Loadings scored 2.2 points, Group. D Indoor Environmental Quality scored 3.8 points, Group. E Service Quality scored 2.9 points, Group. F Social, Cultural and Perceptual Aspects scored 2.3 points, Group. G Cost and Economy scored 1.6 points, the total score is 1.83 points, and the final performance result is D+
- “Site Selection, Project Planning, and Development”, the geographic location of Building Project A is good. It is close to the Sha-Shé Creek, Pingtung Performing Arts Center, and Pingtung Station. The traffic extends in all directions, the school district is complete, and the site presents the concept of community. There are private roads in the community, providing sidewalks and driveways.
- “Energy and Resource Consumption”, Building Project A set up fence protection outside the Taiwan Power Company electricity distribution field next to the community entrance and beautified the surrounding areas green plants, that is to maintain public safety and achieve the effect of plant greening.
- “Environmental Loadings”, Building Project A has louvers in the house to allow building users to open windows to prevent volatile organic compounds such as ozone or formaldehyde, cannot remove from the house. The design of the deep balconies, setting up plants on the balconies, can reduce the urban heat island effect, and also, adding 12 pieces of photovoltaic panels on the roofs, can receive bonuses from the Taiwan Power Company. Especially, there is a design of water collecting sumps above the roll-up doors on the first floor of the houses, so that the rainwater can intensively flow into the drain pipes without having water standing in the houses.
“Indoor Environmental Quality”, each household has large balconies in Building Project A. The rooms and bathrooms are also equipped with windows or exhaust fans which can effectively enhance air circulation. The eaves above the garages are designed hollow to have enough lighting.

“Service Quality”, the access control system is applied in the houses to greatly enhance the security of the building users.

5.2. Building Project B

- In Group. A Site Selection, Project Planning, and Development scored 1.3 points, Group. B Energy and Resource Consumption scored 1.5 points, Group. C Environmental Loadings scored 1.9 points, Group. D Indoor Environmental Quality scored 3.8 points, Group. E Service Quality scored 2.9 points, Group. F Social, Cultural and Perceptual Aspects scored 2.3 points, Group. G Cost and Economy scored 1.2 points, the total score is 1.94 points, and the final performance result is D+.

- “Site Selection, Project Planning, and Development”, Building Project B is located near to a junior high school, close to the Finance and Taxation Bureau of Pingtung County and Pingtung Park. There are P-Bike stations nearby that can rent public bicycles, but far away from the bus stops and the train station. Among them, the difference from Building Project A is that the Building Project B has 'Aquaponics' recycling system, which can take part of the solid waste (the excrement of farmed fish) in the building or community as the nutrient source of planting, that effectively make use of the solid waste which is harmful to the environment, and reduce the environmental loadings.

- “Energy and Resource Consumption”, because Building Project B has the aquaponics system, it is no need to change water during the breeding process. Instead, planting vegetables with fish excrements can provide vegetable nutrients. After the vegetables purified the water, the water can be drawn back to the fish ponds for reuse, which can avoid the deterioration of water quality, and form the concept of mutualism that fish are beneficial to vegetables and vegetables are beneficial to fish. This can effectively reuse water resources and is helpful to the environment and ecology.

- “Environmental Loadings”, Building Project B has louvers in the house to allow building users to open windows to prevent volatile organic compounds such as ozone or formaldehyde, cannot remove from the house. The design of the deep balconies allow to set up plants on the balconies, that can reduce the urban heat island effect, and also, adding photovoltaic panels on the roofs, can receive bonuses from the Taiwan Power Company.

- “Indoor Environmental Quality”, Building Project B that each floor has large balconies, and the rooms and bathrooms will also be equipped with windows, which can effectively improve the air circulation. The design of the egg-crate shading devices on the exterior walls of the house not only preserves the privacy of the houses, but also shows the vibrancy of the building facade. On the second and fourth floors of the house, there is a design of skylight that allows sunlight to shine into the house; it can achieve the effects of bright-room and energy-saving without turning on the lights during the day.

- “Service Quality”, in Building Project B, there are street lights on both sides of the road that greatly improve the security of building users.

References
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[2] iiSBE. SBTool. Available from: http://www.iisbe.org/iisbe.

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