Research on the Architectural Design Strategies Based on the 2019 Evaluation Standard for Green Building of China

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Abstract. On August 1, 2019, China’s 2019 version of the Evaluation Standard for Green Building GB/T50378 (ESGB2019) was implemented formally. How to develop design strategies based on this standard in order to guide or control green building design is explored in this paper. Firstly, 62 indexes in ESGB2019 which are directly related to architectural design realm are extracted; then the extracted indexes are classified into six categories according to different aspects of building design; finally, possible ways to extract or establish design strategies relating to the two types of extracted indexes are discussed. The result are expected to provide assistants for architects in designing green buildings that would meet the requirements of ESGB2019.

1. Background
On August 1, 2019, China’s 2019 version of the Evaluation Standard for Green Building GB/T50378 (ESGB) 2019 was implemented formally. As an evaluation standard, this is a yardstick for measuring the results of green building (GB) design, but not a tool to guide the GB design process. This may bring some troubles when architects want to design the GB based on it. Firstly, indexes in ESGB2019 are not organized in corresponding to the order of architectural design decisions. Secondly, most indexes in ESGB2019 only describe the required performances of GB, detailed strategies or methods regarding how to achieve those performances are not provided, which brings difficulties and inconvenience to the practicing architect.

In order to guide and control GB design process, architectural design strategies related to the performance required in ESGB2019 are discussed in this paper.

2. Existing researches
In recent years, some researches have been conducted regarding how to apply ESGB in GB design schemes[1]. For example, in 2007, Ding Yifei discussed the possible ways for ESGB to guide the practice of GB design based on ESGB2006[2]. In 2008, Xing Mingquan et al. explored how to design GB based on ESGB2006[3]. In 2014, Liu Kaiying et al. explored the GB design process based on ESGB2006 and summarized the major stages of the design process[4]. In 2015, Shi Gang et al. combined the index requirements of ESGB2014 and discussed the specific design principles and strategies of each stage[5]. In 2015, Xu Jin et al. combined the content and characteristics of each stage of the architectural design to evaluate the design of ESGB2014[6]. In 2019, Hong Shaojun et al. analyzed the necessity and advantages of incorporating green design concepts in the planning stage[7].

In summary, some related researches have been carried out; however, there is still no effective solution for how ESGB can be integrated into GB design process, and no detailed strategy is given for
how GB design can be guided effectively. Moreover, existing studies rarely targeting the newly implemented ESGB2019.

3. Extraction of relevant indexes for GB design
The indexes in ESGB2019 involve 5 different professional areas, they are architecture, structure, water supply and drainage, electrical and HVAC. In order to focus on the architectural realm, 62 indexes that are directly related to the architectural design are first extracted from ESGB2019 (see Table 1).

For example, 5.2.10 “optimize building space and floor layout, and improve natural ventilation effect\(^8\)” is directly related to architectural design so is extracted for further study. 5.2.5 “clear permanent identification of all water supply and drainage pipes, equipment, and facilities\(^8\)” is related to the water supply and drainage design, so is not extracted.

4. Classification of related indexes for GB design

4.1. Aspects of general building design
In order to better integrate the extracted indexes into the GB design process, general GB design process needs to be analyzed first. Xu Jin et al. have divided the aspects of GB design evaluation indexes into 4 categories, which are general building layout, space and form processing, material selection and detailed design\(^6\). On the basis of that, together with consideration of architect's time frame and logic of design, aspects of building design is roughly classified into six categories in this paper, they are: site selection planning, site and exterior space design, interior space design, elevation and form design, detail design and structural selection design.

4.2. Classification and integration of the abstracted indexes
To make is convenient for architects to understand the requirement of each index in ESGB2019 at different design stages, the 62 architectural related indexes in ESGB2019 are classified according to their relevant aspects of design and the general building design process. It is noted that, there are 8 indexes related to two different design aspects at the same time, and there is 1 index that involves three different aspects of design simultaneously (see Table 1).

Furthermore, it is considered necessary to classify the abstracted indexes according to whether they can guide architectural design directly or not. The former ones provide design strategies, while the latter ones only describe the expected performance of building but not explain and design strategies. In this paper, they are named as Type I indexes and Type II indexes respectively. 43 type I indexes and 19 type II indexes have been extracted in the research. (Table 1).
Table 1. Indexes classification and proportion

| Aspects of Design | Types of Indexes | Proportion |
|-------------------|------------------|------------|
| (1) Site selection and plan | (4.1.1) {6.1.2} {6.2.1} {6.2.3} {6.2.4} {8.1.6} {9.2.3} {8.2.6} | 11.11% |
| (2) Site and exterior space design | (4.2.2) {4.2.5} {6.1.1} {6.1.3} {6.1.4} {6.2.2} {6.2.5} {7.2.3} {8.1.3} {8.1.7} {8.2.1} {8.2.2} {8.2.3} {8.2.4} {8.2.5} | 30.56% |
| (3) Interior space design | (4.1.7) {4.2.6} {5.1.2} {6.2.2} {6.2.5} {5.1.4} {5.2.6} {5.2.9} {5.1.4} {5.1.7} {5.2.10} {7.1.1} | 13.89% |
| (4) Elevation and form design | (4.2.2) {7.1.8} {7.1.9} {9.2.2} | 11.11% |
| (5) Detail design | (4.1.5) {4.1.6} {4.2.3} {4.2.4} {4.2.7} {4.2.9} {5.2.2} {5.1.4} {5.1.7} {5.2.6} {7.2.16} {7.2.17} {7.2.18} | 20.83% |
| (6) Structure selection design | (4.1.2) {4.2.8} {9.2.5} {7.1.10} {7.2.15} {7.2.17} {7.2.18} | 12.50% |
| Proportion | 66.67% | 33.33% | 100% |

“{ }” refers to indexes involves two aspects of design.
“{ }” refers to indexes involves three aspects of design.
“{ }” refers to the code of indexes in ESGB2019

5. Extraction / establishment of design strategies based on different categories of indexes

5.1. Extraction of design strategies based on I indexes
Type I indexes are those that can be adopted in the design process directly; therefore, relevant strategies can be extracted based on such indexes directly. For example, index 4.1.1 (the site of building should avoid geologically dangerous areas such as landslides and mudslides; the site should be free of threats from hazardous chemicals and flammable and explosive sources[8]) can be directly extracted as a design strategy in the design stage of “site selection”.

5.2. Establishment of design strategies based on II indexes
Type II indexes emphasize the results of GB design but not clearly explain the ways to achieve those results; therefore, it is necessary to establish design strategies for all such indexes. Following are some of the establishment methods explored in this paper:

5.2.1. Strategy established according to provisions in ESGB2019
In order to implement the indexes correctly, the Standards Compilation Group has formulated the provisions of the standard in the order of chapters, sections and articles, which can provide some specific design strategies. For example, for index 5.2.10 “Optimizing the building space and floor layout to improve the natural ventilation effect[8]”, the corresponding provisions gives some specific strategies, that is “make use of patios, ventilation towers, air guide walls, etc., and improve the hot and humid environment indoor and air quality effectively”, so as to achieve the design effect described by the index itself[8]. The provisions provide reference instructions established based on the indexes themselves,
which are specific to them and have strong reference value.

5.2.2. **Strategy established according to relevant codes in other existing standards**  
The ESGB2019 is a comprehensive evaluation standard for all aspects of GB, comprehensive but not in-depth. In the design process, it is still needed to consult the relevant codes/standards to evaluate such indexes. For index 7.1.1 “the shape, floor plan, spatial scale, and envelope structure of the building shall be designed to meet the national requirements for energy-saving design[8]”. Further evaluation should be conducted with reference to relevant standards such as the Public Buildings Energy Efficiency Design Standard (GB-50189), so as to construct related design strategies. Relevant codes/standards have important guiding significance and reference value and should play their roles in the strategy establishment of related Type II indexes.

5.2.3. **Strategy established according to relevant textbooks**  
It is found that most of the expected design results described by Type II indexes correspond to the the physical environment design of building (Table 2), while textbooks like Architectural Physics[9] exactly analyze various physical environments, and provides a lot of detailed design strategies. For index 7.2.4 “Optimizing the thermal performance of building envelopes[8]”, relevant design strategies can be found in the first chapter of the textbook Architectural Physics, that is, “Adopting raised floor and air layer moisture-proof technology and use porous materials and materials with low heat capacity to decorate the interior surface of the room[9]”. Other Type II indexes can also refer to the relevant chapter of the textbooks to establish corresponding design strategies.

5.2.4. **Strategy established according to relevant existing researches**  
The existing research results in certain fields can be consulted to establish specific building design strategies. For example, for Type II index 8.1.2 “The outdoor thermal environment should meet the requirements of the current national standards[8]”, Liu Shuyu and others used numerical simulation and statistical analysis methods to explore the interaction mechanism between the residential layout and outdoor thermal environment, which provided necessary basis for the generation of design morphology[10]. Existing research involves all aspects of GB design, and has important guiding significance for the specific design process.

5.2.5. **Strategy established according to software simulation and complex calculation**  
For Type II indexes including quantitative requirements, only qualitative analysis is not enough. Quantitative analysis through relevant software simulations and complex calculations are needed to provide specific guidance for the current design. For the II index 8.2.8 “The wind environment inside the site is conducive to outdoor walking, comfortable movement and natural ventilation of the building[8]”, the Computational Fluid Dynamics (CFD) method can be used to calculate the typical wind direction and wind speed in different seasons on the building’s wind environment[8]. This method is accurate but complex, having important reference value for the design process.
Table 2. Aspects of building design and their related physical environments in Type II indexes

| Aspects of building design | Light environment | Thermal environment | Acoustical environment | Wind environment | Energy consumption |
|---------------------------|-------------------|---------------------|------------------------|-----------------|-------------------|
| (1) Site selection        | /                 | /                   | {8.2.6}                | /               | /                 |
| (2) Site and exterior space design | {8.1.1} | {8.1.2} | {8.2.9} | {8.2.6} | {8.2.8} |
| (3) Interior space design | /                 | {5.2.9}             | {5.1.4}                | {5.2.6}         | {5.2.10}          | {7.1.1} |
| (4) Elevation and form design | {5.2.8} | {5.2.11} | / | / | / |
| (5) Detail design         | /                 | {5.1.7}             | {5.1.4}                | {5.2.6}         | /                 |
| (6) Structure selection design | / | {7.2.4} | {5.2.6} | / | / |

In summary, although Type II indexes do not provide specific design strategies directly, they can still be carried out in accordance with the above-mentioned five methods. Further analysis finds that all the 19 Type II indexes have more than one establishment methods. The number and proportion of Type II indexes applicable to different strategy establishment methods are summarized below briefly (Table 3). When establishing strategies, from the point of pertinence, it is recommended to according to the provisions and existing relevant codes/standards first. Then the relevant textbooks and existing related researches can be referred to next. For the Type II indexes that contain quantitative requirements, the software simulation and complex calculations can be carried out then. The specific issues shall be determined based on the specific situation analysis.

Table 3. Number and proportion of Type II indexes applicable to different methods for the establishment of GB design strategies

| Strategy establishment methods                          | Number of Type II indexes | Proportion of Type II indexes |
|---------------------------------------------------------|---------------------------|------------------------------|
| According to the provisions                            | 10                        | 53%                          |
| According to existing codes / standards                 | 15                        | 79%                          |
| According to relevant textbooks                        | 15                        | 79%                          |
| According to existing related research                  | 19                        | 100%                         |
| According to the Software simulation and complex calculations | 15                        | 79%                          |

6. Conclusion
In conclusion, how to establish design strategies based on ESGB2019 has been analyzed and discussed. Firstly, the indexes related to architectural design in ESGB2019 are extracted and integrated into 6 categories according to the general building design process. Then they are classified into Type I and Type II indexes. Finally, for the Type II indexes, five methods for the establishment of design strategies based on ESGB2019 are explored and discussed.

More specific strategy establishment methods and more detailed strategies established based on the 19 Type II indexes, as well as other potential strategy establishment methods, should be further explored in more systematic and in-depth follow-up studies.
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