A brief comparison of existing regional green building design standards in China

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Abstract. A large country with a variety of regional natural, cultural and economic conditions, China has established a number of green building design (GBD) standards both at national and regional (provincial and municipal) levels. Some researches have been conducted to review and compare such standards. The main aim was to provide valuable references for the establishment of new regionally specific GBD standards in different regions of the country. This paper introduces the preliminary results of the researches. The distribution, frameworks and content of the existing regional GBD standards are introduced and compared in relating to the regionally specific climate, resource, economic and cultural conditions. Conclusions are provided and further researches are recommended.

1. Introduction

To regulate and guide green building development, China established a national green building design (GBD) standard in 2010[1]. Since then, ten regional GBD standards have been developed in five provinces/autonomous regions (Guangxi[2], Zhejiang[3], Jiangsu[4], Shaanxi[5,6] and Qinghai[7]) and five cities (Beijing[8], Tianjin[9], Shanghai[10,11], Wuhan[12] and Chongqing[13]) of the country, which distribute in four of the five climate zones for building thermal design in China (Table 1). Comparisons of such standards were conducted in some funded projects, the results of which are briefly introduced in this paper.

Table 1. Climate zones of the existing regional GBD standards in China

| Names of the Regions | Provinces/ Autonomous Regions | Cities | Severely Cold | Cold | Cold in Summer & Hot in Winter | Hot in Summer & Warm in Winter | Temperate |
|----------------------|-------------------------------|--------|---------------|------|-----------------|-----------------|-----------|
| 1 Guangxi            | ⌈                             | ⌈      |               |      |                 |                 |           |
| 2 Zhejiang           | ⌈                             | ⌈      |               |      |                 |                 |           |
| 3 Jiangsu            | ⌈                             | ⌈      |               |      |                 |                 |           |
| 4 Shaanxi            | ⌈                             | ⌈      | ⌈            | ⌈    |                 |                 |           |
| 5 Qinghai            | ⌈                             | ⌈      | ⌈            | ⌈    |                 |                 |           |
| 6 Beijing            | ⌈                             |        | ⌈            |      |                 |                 |           |
| 7 Tianjin            | ⌈                             |        |               |      |                 |                 |           |
| 8 Shanghai           | ⌈                             |        |               |      |                 |                 |           |
2. Comparison of the general frameworks

2.1. Extension of professional areas
The general frameworks of the existing regional GBD standards all consist of 5-7 chapters, each involves one of the building professional areas (e.g. planning, architecture, structure, water, heating & cooling, electric). Comparing to the national standard, all the regional ones have extended their frameworks into more professional areas (e.g. landscape design, interior design, etc).

2.2. Emphasis of process management
Comparing to the national standard, the existing regional ones put more emphasis on the process management. For example, most of the regional standards add a special chapter named “green building scheme”, which requires for an overall planning of GBD project to be prepared at the beginning stage of a building design project.

2.3. Relating to green building assessment standards
Some regional GBD standards (e.g. Beijing and Chongqing standards) are directly related to green building assessment (GBA) standards. Some lists all the main indicators of a GBA standard in their appendix, others establish a set of items that are closely related to the key GBA criteria.

2.4. Attention to special technologies
Some regional standards (e.g. Beijing, Wuhan, Zhejiang and Shaanxi standards) set specific requirements for some special technologies, e.g. technologies used in the curtain wall system, rainwater reclaim system, solar heating and photovoltaic system, heat pump system, etc.

2.5. Provision of assistant information
Most regional standards provide assistant information for GB design. For example, Beijing, Tianjin, Jiangsu, Chongqing, Shaanxi, Qinghai and Zhejiang standards all provide lists of commonly used local materials and or plants, meteorological parameters for design and boundary conditions for software simulations, etc.

2.6. Establishment of inner zoning
Large provinces with obviously different environmental conditions mostly established inner zoning in their regional standards. For example, Guangxi, Jiangsu, Shaanxi and Qinghai standards have established 2,3,3 or 5 zones respectively.

3. Comparison of the content

3.1. Frequency count of four symbolic words
“Climate”, “resource”, “economy” and “culture” were selected as four symbolic words related to the regionally specific conditions. Frequency count of these words in the existing regional GBD standards show the following: a) “resource” accounts for the highest frequency of appearance, followed by “economic”, “climate” and “culture”; b) “climate” and “resource” appear more in the less developed inland regions, while “economy” and “culture” appear more in the more developed coastal regions.

3.2. Description of regional conditions

3.2.1. Climate conditions. While all the existing regional standards use professional terms in the meteorology area, some standards (e.g. Chongqing standard) also uses some popular sayings, such as “mountainous city”, “fog town” and “stove place”, for the description of regional climate conditions.
3.2.2. **Resource conditions.** A large variety of resource are mentioned in the existing regional GBD standards. They not only involve some widely acknowledged ones, such as renewable energy, water, land, materials, wildlife, wastes; but also some not normally recognized ones, such as existing buildings, infrastructure, space and information, etc. The descriptions of resource conditions in different regional standards vary largely and are hardly comparable. For example: “XX is a water shortage city”[2]; “the average annual natural lighting resource in XX is less than other places in north China”[12]; “thick and soft soil is distributed in its east coastal areas”[3]; “XX belongs to a solar energy sub-abundant area”[8]; “XX possesses special mountainous environmental resources”[13]; “its solar energy resource is rich in the north and poor in the south”[4]; “there are collapsed loess areas in XX” [5-7]; “the precipitation in XX is unbalanced in space/time”[7], etc.

3.2.3. **Economic and cultural conditions.** There is a lack of description of regional economic and cultural conditions in all of the existing regional GBD standards.

3.3. **Design requirements relating to regional conditions**

3.3.1. **Design requirements relating to regional climate conditions.** In the existing regional GBD standards, design requirements relating to regional climate conditions normally involve the following aspects: site plan, outdoor environment, sunlight accessibility, solar thermal utilization, natural ventilation, local vegetation, permeability of site surface, water system, rainwater utilization, water for landscape, water for irrigation, wetland, etc. Some standards also provide more specific design requirements/suggestions that are closely related to the special regional climate conditions. For example, standard in the mountainous areas calls for attention to the relationship between hillside buildings and their surrounding micro-climate[13]; standards in the hot and rainy regions emphasizes waterproof and shading design of the exterior walls, etc[2].

3.3.2. **Design requirements relating to regional resource conditions.** Some regional GBD standards provide requirements that are closely related to their specific regional resource conditions. For example, Guangxi standard “encourages the use of reclaimed water in its inland areas” and suggests “application of seawater for toilet flush in the water shortage island/coastal areas”. For regions where underground water is a precious resource (e.g.Zhejiang province), their standards require “not to apply heat pump systems that uses underground water as a resource”. In the mountainous regions (e.g.Chongqing city), their standards suggest “utilization of the mountainous environment and consideration of the terrace space, etc”. Some standards provide specific information relating to solar energy resource. For example, Tianjin standard advises that “10°southwest is the best orientation for building solar energy utilization in the Tianjin area.”

3.3.3. **Design requirements relating to regional economic and cultural conditions.** There are few requirement relating to regional economic and cultural conditions in the existing GBD standards. The economic related requirements only involve “technical and economic analysis of buildings”; the culture related requirements mainly refer to “cultural buildings” as a necessary component of public facilities.

4. **Conclusions and further research**

Overall speaking, while all the existing regional GBD standard share similar structure as that in the national one, their frameworks and content have been enriched and customized mainly in the following aspects:

- **The frameworks are enriched.** New chapters are added and more professional areas (e.g. landscape design, interior design) are involved; articles regarding process management, lists of assessment indicators and assistant information regarding new/special GB technologies are also supplemented.
• *Inner zoning are established.* For regions that cover a large area and possess very different natural, economic and cultural conditions, inner zoning has been established and more specific requirements are provided for each of the inner zones.

• *Description of regionally specific climate conditions and suggestions for the climate adaptive design are provided.* Both meteorology terms and popular sayings are used for the description of regionally specific climate conditions. Specific suggestions for the climate adaptive design are also provided in some of the regional standards.

• *Description of regionally specific resource conditions and suggestions for the resource adaptive design are provided.* A large variety of regional resources are mentioned and some resource specific design suggestions are also provided.

Further researches are recommended to explore the detailed effects and influences of the above GBD standards in the real GBD projects in China.

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