Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2015, 7(3):640-645

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Research on teaching of green building design

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ABSTRACT

With construction and development of the ecological cities and green buildings, the building education should actively integrate related contents to the old teaching system. The building performance simulation technology can provide technology support for design of green buildings. This paper lists features and application of performance simulation software of different buildings, introduces teaching process on the preparation phase, middle phase and achievement phase in the graduation design courses of green buildings, applies digital technologies on different phases, summarizes problems and experiences in teaching, and proposes the recommendation for establishing green building teaching system.

Key words: Performance simulation; Architecture; Software application; Teaching methods.

INTRODUCTION

The green building design has become one of the important research subjects in the contemporary building fields. The historical social responsibilities should be assumed, the relation between buildings, environments and natures should be thought carefully, and sustainable development of the environment and social should be regarded as the core of building education in building education. Now many universities with architecture specialty have known importance of the green building education in China and are actively implementing the teaching reform and exploration of the green buildings. For example, Tsinghua University has early implemented teaching in design and theory of the biological building for undergraduates and postgraduates [1], [3]. Tongji University regards "biological city environment and green and energy-saving building" as one of four key subjects. Southeast China University establishes the teaching research team for green building design, explores vertical integration of the green design teaching for the undergraduates, and realizes hierarchical and systematic teaching of the green design. Tianjin University organizes the college students to participate in the international "solar decathlon competition"[2]. Xi'an University of Building and Technology attempts the education and teaching reform in "biological building design" field. The South China University of Technology explores teaching of the green building design in the subtropical regions.

The researchers have continuously established the "Green building design based on digital technology" course series in the graduation design teaching for undergraduates in architecture specialty, continuously summarize experiences, gradually perfect the teaching methods, and form the teaching characteristics of assisting the green building design by applying building performance simulation technology[4]. The following part briefly introduces the application of the building performance simulation technology in green building design, reviews teaching process of the graduation design course series of green building, and finally gives some recommendations for green building education.

APPLICATION OF BUILDING PERFORMANCE SIMULATION TECHNOLOGY IN GREEN BUILDING DESIGN

From 60s in 20th century, the scholars in different countries started to study simulation technologies of the building environment. After evolution for multiple years, a great advance is achieved and different software emerges. Some frequent building performance simulation software and their main functions are shown in Table 1.

The building performance simulation software can provide data support for designers on different design phases and drive scientific and reasonable design. The building is designed on different phases. Design includes different contents on different phases. With deepening of design, different specialties will participate in design and the corresponding building performance simulation should be performed on different phases. First, the design purpose of different building design phases should be identified, then the corresponding simulation process of the design process should be identified, and finally two processes will collaborate with each other.

Table 1.Frequent building performance simulation software and main functions

Type of software	Name of software	Main functions
Thermal engineering software	Doe-2	Energy consumption analysis for different time and life cycle cost (LCC) analysis of HVAC system
	Energyplus	Solar utilization scheme design, building thermal performance research and multi-area air flow analysis
	Dest	Annual in-building temperature computing for different times, air conditioner unit load computing, AHU device load and efficiency computing, hydraulic computing of wind and water pipeline, and type selection computing of refrigeration station equipment
Ventilation software	Airpak	Air flow, air quality, heat conduction, pollution and comfort of simulation ventilation system
	Flovent	Building flow analysis, indoor and outdoor air flow field, smoke and dust, temperature field and concentration field analysis
optical software	Radiance	utilization efficiency research of artificial light and natural light, quantitative psychological values and physical value, and rendering function
	Agi32	point-to-point luminance of indoor and outdoor actual surface or virtual computing surface and real-time rendering of scenarios with
	DIALUX	Luminance computing and simulation with former as the main means
	Lightscape	Scenario rendering of indoor design, product design and light design
Acoustical software	EASE	sound amplification system engineering design simulation under certain building sound and electric sound condition
	Raynoise	Noise prediction and control, environment and building acoustics and design of virtual reality system
	ODEON	Simulation analysis of indoor acoustic sound quality parameter and prediction and evaluation of industrial and environmental
	Cadna/A	Prediction, evaluation, engineering design and research of multiple noise sources and city noise planning
Comprehensive software	Ecotect	Comprehensive technical performance analysis on design phases such as solar radiation, thermal engineering, optics,
	IES(VE)	Comprehensive analysis of building energy consumption, pipeline, circuit, lighting, sunshine, fluid ventilation, cost evaluation and scheme comparison

TEACHING PRACTICE OF GREEN BUILDING DESIGN

The researchers have continuously established green building design subject series by using the digital technology means in the graduation design teaching for undergraduates[5]. The subjects for recent five years include “Green old treatment building” (in 2008), “Green office building” (in 2009), “Green kindergarten” (in 2010), “Green international school” (in 2011) and “Green community center” (2012). These subjects are from the enterprise-sponsored projects and domestic green building design competition. When the subjects are selected, we will select the familiar weather environment of students and qualified survey sites, grasp proper building area in the task proposal, avoid complex functions, and enable students to dedicate more vigor into environmental analysis, multi-scheme comparison and technology deepening.

Teaching is divided into three phases, which are briefly described as follows:

1.Design Preparation Phase
Besides routine field survey and analysis of students under leadership, the case analysis, software learning and subject teaching are set for the green building design subject on this phase.

2.Case Analysis
To enable students to intuitively recognize green building as quickly as possible, we require each student to select one green building instance at home and abroad and conduct detailed parsing and research at this step, deeply analyze the selected building in local weather, ecological strategy and technical means, summarize the results to the demonstrative document, schedule dedicated teaching time for exchange on the class, and enable students to receive more knowledge in a short period.

3.Software Learning
Before the design starts, the students should be trained on software centrally. We use Ecotect software in this design teaching and introduce software such as light collection analysis software Radiance, ventilation analysis software Airpak and noise analysis software CadnalA1 and encourage students to learn software independently and apply it in the assisted design.

4.Subject Teaching
The green building does not form a complete teaching system in undergraduate teaching. Most students have no deep and systematic understanding on the green building. The teachers have performed lectures on this subject several times.

The course I introduces the green building. First the background and basic concept on the green building are stated to enable students to have preliminary recognition on the green building and know mutual relation between natural environment and building, principle and application method of natural recycling resource technologies, and work steps of green building design.

The course II states the green building technology. After students establish preliminary green building concept, the frequent design means and practical technologies of green building is explained and summarized by combining actual case, so the students will not be “put in a quandary”.

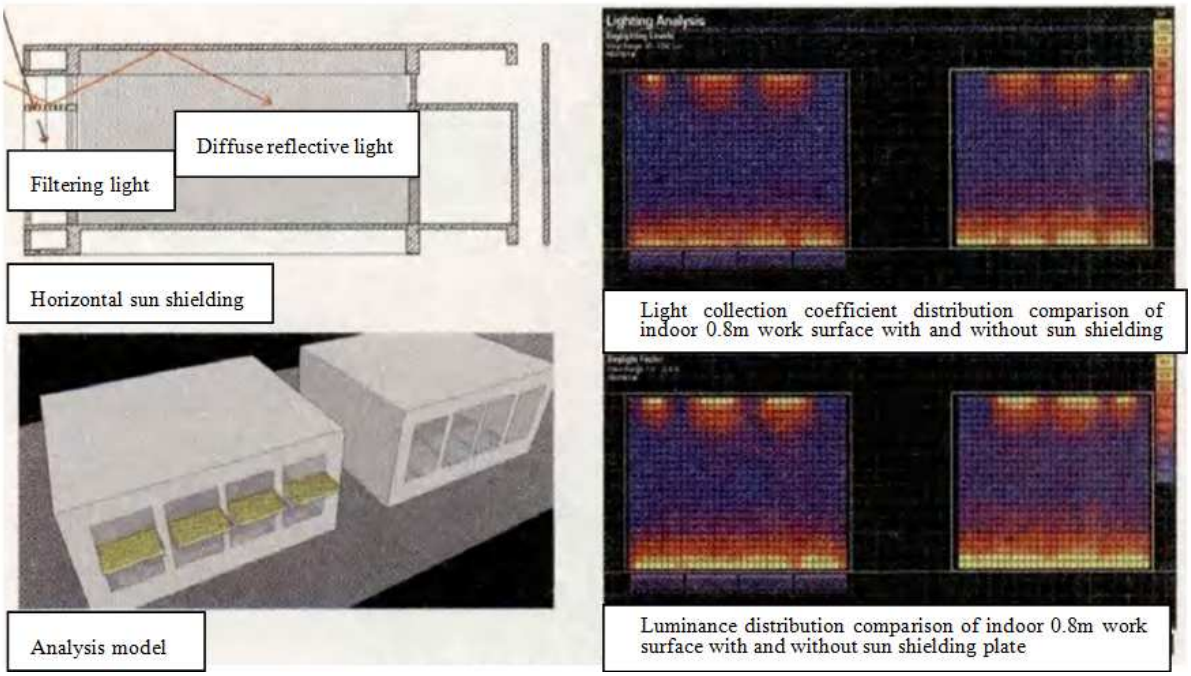
The course III explains related standards and evaluation system of green building, including China “Green building evaluation standard” and America LEED evaluation system, so students have comprehensive understanding on the green building.

The course IV reviews and summarizes building physical knowledge, leads students to review important knowledge points of the building physics course, enables students to understand data obtained in software analysis, and gradually and deeply guides and analyzes students.

5.Middle Phase of Design
It is emphasized to guide design from the view of green building on the start phase of the design, focus on reasonable design and reasoning process, motivate balanced applications of different technology strategies to most extent, and maximize ecological efficiency of the design scheme.

Weather Tool is used to analyze the weather conditions of the building on the early design phase to get the foundational data such as temperature, humidity, wind strength and direction and proper orientation of the project site. Students can design a draft and establish a preliminary software model for analysis by analyzing weather, combining the actual site conditions, and considering the building functions. The researchers recommend students to consider different layout modes on the early scheme phase, establish models to intuitively compare sunlight, light collection and temperature data in the software, and deepen understanding on the influences of the scheme layout reasonability and surrounding environment on the building in comparison.

After a preliminary design idea is obtained in the scheme conception, one can establish a simple model, analyze and compare the scheme in sunlight and ventilation, find the best layout and combination mode via multi-scheme comparison, and deeply design it. Shown in the Figure 1, one can analyze the wind environment of possible planned layout modes in the design and get the best layout mode. After the building layout is identified, one can further deepen the space and technology details inside the building and analyze room layout, sun shielding mode, window opening mode and size, if the additional sun room is applied, and if the indoor ventilation well is added. The building performance simulation technology can provide effective data support for above analysis. Shown in the Figure 2, the window sun shielding design is studied via simulation.



The teachers in building structure and building equipment will be invited to participate in teaching and provide professional technology support for students on this phase. Teachers from different specialties will be invited to participate in middle-phase drawing evaluation for graduation design, communicate with students for the scheme in a face-to-face manner, propose comments and recommendations for work of students on the next phase, and guide students to adjust and deepen the design scheme of the students from different professional view. The students should evaluate the scheme by self-according to the related evaluation standards of the green building to find problems and change and perfect the design scheme.

The design is gradually improved via work on previous two phases. To form the final scheme, the tendency for over-emphasizing technology should be avoided. The scheme is not only composed of technologies. The building function, building and environment coordination and building culture property should be considered.

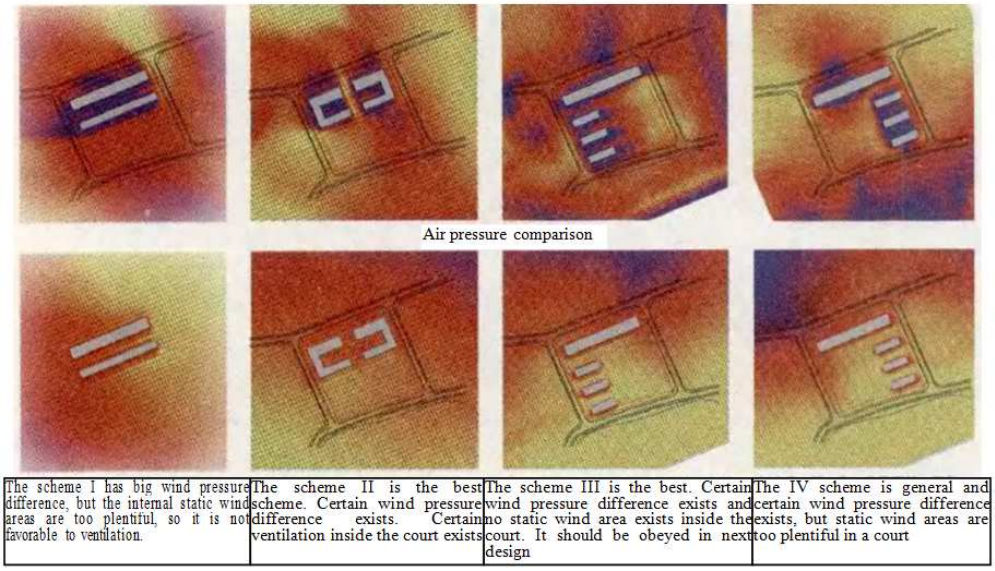


Fig.1 Research on ventilation of different planning layouts

Fig.2 Research on window sun shielding design simulation

6. Design Achievement Phase

For the achievement phase in the final month, The researchers request students to not only embody one final design

scheme in the achievement of the formal drawing, but also describe gradual analysis and deepening process via the charts. The lighting, light collection, ventilation analysis and noise analysis drawings should be directly applied in the formal drawing on the design phase and the design strategy and technical means used in the design should be described in different subjects.

Students can completely know the concept of the green building, preliminarily grasp how to design green buildings, and skillfully apply the assisted design software by learning the design course of the green building.

CONCLUSION

With the teaching practice in recent years, the following problems should be summarized:
(1)To construct a complete green building teaching system, it is necessary to further optimize the course setup, adjust the teaching mode and integrate knowledge on related specialties.
(2) Students should strengthen learning of digital technologies on the undergraduate phase. Besides grasping of traditional software such as AutoCAD and SketchUp, the students should be guided to learn the analysis software such as Ecotect on the senior grades in undergraduate education, apply them in design courses, and improve them in actual operation and exchange.
(3) It is very important to combine the design idea with actual operations in teaching of green building design, so students can have more opportunities to know the materials and equipment, even participate in construction. The teaching mode combined with practice can train the design capability, social cognition, adaption and influence capability of students.
(4) The green building involves knowledge on multiple subjects besides the building, so the experts in different fields should participate in teaching of the green building.

Acknowledgements
To construct a perfect green building teaching system, the idea of the green building design should be implemented through the whole teaching process for undergraduates and related theory courses should be gradually integrated into existing framework of the building education, so students can erect correct and sustainable resource and environment idea, have complete knowledge on green building and city environment for sustainable development, grasp design method of green building, and know related technology and evaluation indexes via learning on the undergraduate education phase.

Before a complete green building teaching system is established, the following information on green building should be added to the old teaching framework for different grades in the undergraduate education:

When the Building Introduction course is taught for the grade 1 students, the green building should be introduced, for example, elements in nature ecologies such as sun, air, wind, rainfall and plants, energy consumption of building environment, heat preservation and isolation and recycling materials of maintenance structure, and building full-life cycle, so the students can preliminarily grasp the city and building knowledge on sustainable development and erect correct building environment idea.

From the grade 2, the keys on green building should be integrated into the design course and construction course. The teaching for grade 2 students should focus on teaching and application passive technologies, for example, building shape, natural ventilation, natural light collection, sun shielding, rainfall, surface water collection and terrain utilization.

From the grade 3, the keys on green building should be integrated into the design course, building physics and building equipment. The teaching for grade 3 students should focus on combination of passive space design and active technology applications, for example, air-conditioner ventilation technology, water processing and circulation technology and solar building integration.

From the grade 4, based on establishment of the green building concept and qualitative cognition, the computer simulation and quantitative computing and environmental evaluation method should be introduced into the teaching, which will be attempted in city design and high-level building design subject.

A comprehensive and deep design subject including whole environment and building technology should be completed in the second semester of the grade 5 for graduation, which can summarize and completely embody design and teaching achievement of the green building for grade 5 students.

The above part gives acknowledgements on the green building education. Current teaching practice is the

preliminary exploration on teaching of green building teaching. Students should know the theory and technologies of the green building in graduation design and grasp operation skills of related building performance simulation software. We should continue implementing more practices and research, strengthen exchange and cooperation with the colleges at home and abroad, assimilate advanced experiences, and gradually construct a perfect green building teaching system in practices.

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