

# **RETHINKING THE ROLE OF ENGINEERING EDUCATION: FROM THE PERSPECTIVE OF SUSTAINABLE CONSTRUCTION**

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**Abstract:** Sustainable construction is an urgent task rather than fashion concept of the construction industry. The implementation of sustainable construction needs a large amount of knowledgeable and skilled professionals. Therefore, the educational system should solve the upcoming problems on how to provide high quality and enough human resources of sustainable construction to the industry. In this paper, based on a backward thinking, the author first identifies what professionals the market needs in terms of promoting sustainable construction. Afterwards, the author analyzes the educational mechanism as well as the career path of the students whose major are related to construction industry in mainland China. Finally, the author has put forward some suggestions on how to improve the education and certification system in order to meet the requirement of sustainable construction.

**Keywords:** Sustainable Construction; Professional Education; Registered Engineers

## **1. Introduction**

In the last twenty years, the development of the construction industry in Mainland China has contributed tremendously to the boom of national economy. However, the negative side of construction has also been concerned by the government and general public because of resource consumption and environmental impact. Therefore, sustainable construction is a critical task rather than a fashion topic for us at present. The implementation of sustainable construction needs not only methodologies, tools and techniques but also the professionals who are knowledgeable and skilled in this field. To some degree, human resource is an important determinant for promoting sustainable construction, which forces us to pay more attention to our education. The concept of sustainability and sustainable development as a theme for general education in civil engineering was developed and illustrated by Willilam E.Kelly (2008) with examples from Catholic University of America. While Yuhong Wang (2009) discussed the process of planning a sustainability related course in the graduate CEM program of the CE department at Lawrence Tech University which can be referred by the educator in course planning and teaching. In this paper, the author will not concentrate on detail course development but try to answer the following two questions from a broader perspective of sustainable construction: (1) What are the main tasks of the professionals in promoting sustainable construction? (2) How to connect the current professional education and certification system with sustainable construction? In addition, the author will give some suggestions on how to ensure engineering education to meet the demand of sustainable construction.

## **2. The tasks of different professionals in promoting sustainable construction**

### **2.1 Designer**

The designers usually use the tools or techniques as well as useful database of sustainable

construction to direct their design behavior. For example, they need to conduct some simulation and calculate the energy consumption of a building, or make comparison between different design alternative and try to find the most optimized solution of the problem.

The designers in the construction industry can be classified into different types such as the architect, the structure engineer, the mechanical & electric engineer and etc. Among these different types of designers, the architects are usually the “Dragon Head” of promoting sustainable construction of a project. That is, the architectural design determines, to some degree, the alternative of structure, mechanical and electrical design. Therefore, it is very important for the architect to master the knowledge of sustainable construction not only of architectural design but also of the structure or mechanical & electrical design. In addition, another important task for the architect to promote sustainable construction is to direct, or sometime persuade the owner to accept new methodologies and techniques of sustainable construction. Furthermore, the architect should explain their sustainable design alternative to the contractor. He or she should also be familiar with the sustainable knowledge on construction sites.

## **2.2 Contractor**

The contractor’s task seems to be very easy in terms of implementing the design alternative of the architect. However, the sustainable management on the construction site has a series of systematic work to do in order to realize sustainable construction. For example, the contractor needs to think about how to save energy and material during the construction phase, how to illuminate noise, how to prevent solid waste, water, and air pollution, how to protect the worker’s health as well as how to use recycled materials to the largest extent etc. In addition, the contractor also needs to learn new construction techniques on sustainable construction.

## **2.3 Project management consulter**

The work scope of project consulter to promote sustainable construction is quite broad which covers the life-cycle of a project, from feasibility study, planning and design, construction to close out stage. The project management consulter, to some extent, acts as the adviser of the owner. Therefore, the task of the project management consulter should direct the owner to accept the concept of sustainable construction in the very early stage of a project. To a further step, they should help the owner clarify their requirement of sustainable construction in a tendering document as well as select the sustainable design and construction alternatives. They should also help the owner to supervise the designer and contractor to ensure their works are based on the principles of sustainable construction.

In general, the designer, the contractor and the project management consulter play an important role to promote sustainable construction of a project. Therefore, to build a sound education and certification system for these professional is quite crucial.

## **3. Professional certification and registration system in Mainland China**

The system of registered engineers (RE) in Mainland China starts from 1990s. With more than ten years of development, several education and certification branches of this system have been established which separately cover different partners of a construction project including the project management consulting engineer, the architect and the constructor.

At the same time, the quantity of professionals in the construction industry has increased nearly five times from 1980 to 2007 according to the statistic data issued by the National Bureau of Statistics (2009), which is shown in figure1. Therefore, how to manage the huge amount of professionals is an important task of the government. The system of RE is one of the crucial measures taken by the government in order to regulate the managerial mechanism of these professionals. The RE in Mainland China can be classified into project management consulting (Jian Li) engineer, the cost engineer, the constructor, the architects as well as the structure engineer etc.

The qualification of RE follows a regulate procedure. In order to be certified as a certain kind of RE, the professionals should firstly be pre-qualified according to their education background as well as the working experience. Secondly, they should pass the certification exam which tests the knowledge and skills of their daily work. After passing the exam, the professional needs to register in a company and all his or her professional information will be transferred to the management system of RE of the government. This registration is called initial registration. The validation of the initial registration lasts for a certain amount of period. Afterwards, the professionals should apply for a continuous registration and be assessed once again. The qualification of continuous registration is based on the working achievement of these professionals and their attendance of the continuous professional education after initial registration. In addition, if a professional changes his or her job from one company to another, he or she should follow a procedure of changing registration.

Furthermore, the qualification of the companies is correlated to the system of RE in the construction industry. For example, a consulting company of project management is classified into different ranks. In a company of the highest rank, the quantities of RE should be no less than 25 persons. By means of such measure, the management of RE has been paid much attention to not only by the professionals but also by the construction companies.

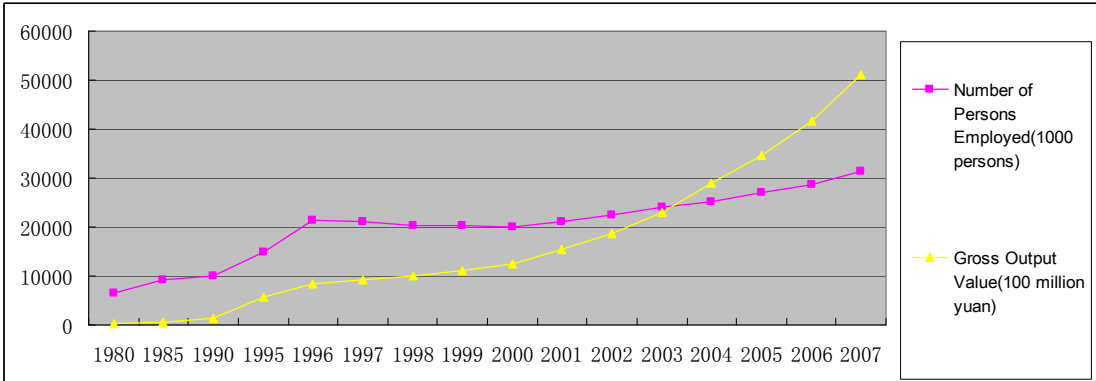


Figure1 Numbers of person employed in the construction industry

Shown in figure2, the system of RE starts from the project management consulting engineer in 1993. Afterwards, the systems of registered architect, cost engineer and constructor were established step by step.

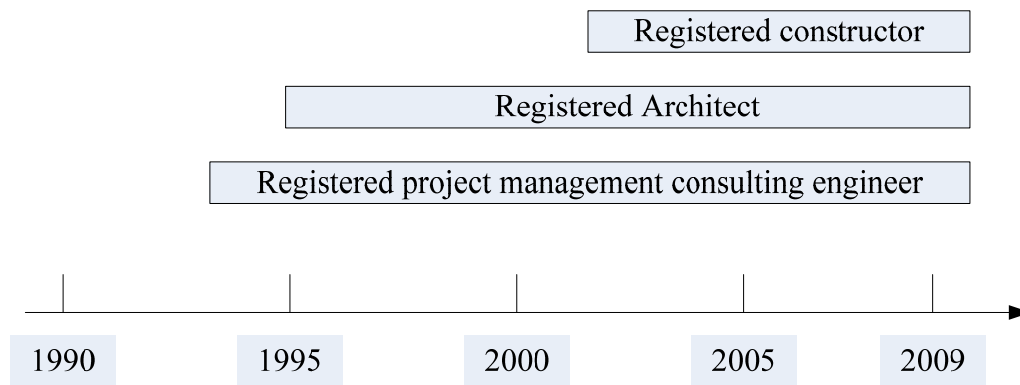


Figure2: The history of the system of registered engineers

The system of RE in Mainland China has nearly covered each partners of a construction project. A consulting company of project management should include a certain amount of registered project management consulting engineers, cost engineers, structure engineers, and registered architects etc. At the same time, a design company should include a certain amount of registered architects as well as registered structure engineers. A construction companies should include a certain amount of registered constructors and registered cost engineers as required. Some specialized consulting companies, such as the cost consulting companies, should include a certain mount of cost engineers.

In this paper, the author will just present three main registered professionals which are crucial to promote sustainable construction. The managerial mechanisms of them are shown as follows:

### 3.1 Registered architect

The system of registered architect starts from 1995. According to the Ministry of Housing and Urban-Rural Development of the People’s Republic of China (2002), the registered architect is classified into two ranks, which are separately nominated as architect and associate architect. The pre-qualification requirement of registered architect includes:

- Ten years of working experience of architectural design after graduation from two years of undergraduate study major in architectural design or nine years of working experience of architectural design after graduation from three years of undergraduate study major in architectural design or
- Seven years of working experience of architectural design after graduation from four years of undergraduate study major in engineering or five years of working experience of architectural design after graduation from five years of undergraduate study major in engineering or
- Three years of working experience of architectural design after being awarded the bachelor degree of architects or
- Two years of working experience of architectural design after being awarded the master degree of architects

Professionals whose major is related to architectural design such as urban planning can also be certified as registered architects. However, they need more years of working experience for pre-qualification. After passing the pre-qualification process, the professionals should take the certification exam which includes the subjects such as basic knowledge of pre-design and site

design, architectural design, building structure, building physics and facilities, building materials, building economics, construction issue and etc. They should also complete the architectural alternative design, technical design and site design of a project case. Professionals who pass the certification exam may register as an architect in a design consulting company. The certification process of associate architect is nearly as same as architects with a lower standard of qualification.

### **3.2 Registered constructor**

The registered constructor can be also called the registered construction builder. The system of registered constructor starts from 2003. According to the Ministry of Housing and Urban-Rural Development of the People's Republic of China (2007), the registered constructor is classified into two ranks, which are separately nominated as constructor and associate constructor. The pre-qualification requirement of registered constructors includes:

- Six years of working experience in which as least four years is related to construction management after graduation from three years of related undergraduate study or
- Four years of working experience in which as least three years is related to construction management after graduation from four years of related undergraduate study or
- Three years of working experience in which as least two years is related to construction management after graduation from postgraduate study or being awarded a related double bachelor degree or
- Two years of working experience in which at least one year is related to construction management after being awarded a related master degree or
- One year of working experience related to construction management after being awarded a doctor degree

After passing the pre-qualification, the professionals should take the certification exam which includes four subjects including construction economics, construction law and related knowledge, construction project management as well as professional practice in construction management. The professional who passes the exam may register as a constructor and work as a project manager in a construction company. The certification process of associate constructors is roughly as same as the constructors with a lower standard of qualification.

### **3.3 Registered project management consulting engineer**

The system of registered project management consulting engineer starts from 1993. According to the Ministry of Housing and Urban-Rural Development of the People's Republic of China (2008), the pre-qualification requirement includes:

- Three years of working experience related to project management after graduation from three years of undergraduate study and being awarded the junior professional titles ( Zhong Ji Zhi Cheng) related to engineering or economics or
- Being awarded senior professional titles ( Gao Ji Zhi Cheng) related to engineering or economics or
- Three years of working experience related to project management after graduation from a secondary technical school (Zhong Zhuan) before 1970 and being awarded the junior professional titles related to engineering or economics.

After passing the pre-qualification, the professionals should take the certification exam which includes four subjects: basic theory and related laws and regulations of project management,

contract management of construction project, quality, time and cost control of construction project as well as case analysis of project management. After passing the exam, the professional may register as a consulting engineer of project management in a consulting company.

### 3.4 Career path of these professionals

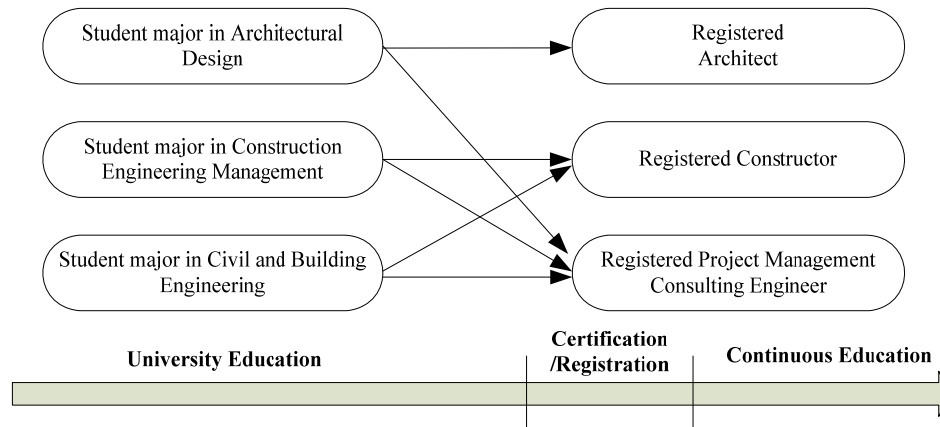


Figure3 Comparison of the career paths of registered engineers

Different academic education provides varied career paths for the students to different types of registered professionals. Shown in figure3, the students major in architectural design may follow the career path to become registered architects or registered project management consulting engineers. The students major in construction engineering management may follow the career path to become registered project management consulting engineers or registered constructors. Meanwhile, the student major in civil and building engineering may follow the career path to become registered constructors or consulting engineers.

## 4. Link education and certification system to sustainable construction

### 4.1 Education

#### 4.1.1 University education & Professional education

The education of sustainable construction should be aligned with the career path of the professionals. That is, the university should put the course and content related to sustainable construction in their teaching plan and curriculum. The course of sustainable construction can be either independent or integrated with other courses. For example, for the student major in CEM we could add some new courses which concentrate on the tools, methodologies and techniques about environmental protection, energy saving, as well as human health. Another alternative is to integrate the main content into current courses. For instance, when we teach risk management we could add the content of environmental risk which may be affected by the construction process. Or when we teach student project planning, we could teach student about how to plan the project in a sustainable way. After graduation, the professionals may take some training and education and follow the path of being certified as an engineer. Therefore, in the professional education of registered professionals we should also add the content of sustainable construction.

#### **4.1.2 General education & Special education**

General education and special education are both necessary for the professionals to improve their understanding, knowledge and skills of sustainable construction. General education may provide general concept, fundamental principles as well as common tools to the professionals. For example, we can teach the general assessment tools such as BREEAM, LEED and SBTool to all construction professionals. In addition, we may also teach the fundamental principle about sustainable development, Low carbon construction, as well as the professional ethics to the professionals. The special education is related to the major and career path of the professionals. For example, architects should take courses of sustainable architectural design, while constructors may take courses about sustainable construction technologies as well as sustainable management of construction site. It should be noted that the special education of any professionals should not be isolated from other fields. For example, architects should learn some knowledge such as sustainable structure, mechanical & electrical design as well as sustainable construction technologies.

#### **4.1.3 Technical education & Managerial education**

The promotion of sustainable construction, to some degree, is a managerial issue rather than a technical one. For example, in the Shanghai World Expo 2010 the organizer wants the large program to demonstrate a splendid and sustainable way of urban planning and development. The most important task of the organizer is to direct all the participants to build their pavilion in a sustainable manner. This is a managerial issue for the organizer. In addition, in some project, the architects or project management consultants should integrate different parties to promote sustainable construction. These works need communication and coordination which also belongs to management. Therefore, besides the technical education, managerial education is also very important for the professionals.

#### **4.2 Certification and Accreditation**

Another way to promote sustainable construction is to integrate the content of sustainable construction into the certification system of the professionals. For example, we may add the content of sustainable construction in the exam of certification. In addition, for the university education, the government should add the content of sustainable construction in program accreditation.

#### **5. Conclusion**

The promotion of sustainable construction needs the arduous efforts of all the professionals. The education and certification system of RE plays an important role to facilitate the implementation of sustainable construction. The education on sustainable construction should have both technical and managerial content which covers a professional's career path. In addition, general education and special education are both necessary. Moreover, the certification and accreditation system should also be linked to the education of sustainable construction. In this paper, the author just gives a preliminary analysis on how to improve the system of education to promote sustainable construction. Detail investigation and research on providing more reasonable and effective education to the professionals need be further conducted.

## 6. Acknowledgement

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