

# Research on the Teaching Reform of the Course of Principles of Concrete Structure Design in the Background of Engineering Education Professional Certification

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**Abstract.** The implementation of engineering education professional certification has pointed out the way for our country to cope with the new round of scientific and technological revolution, and further laid the foundation for the training of professional practical talents, which has important guiding significance. The principle course of concrete structure design is one of the important basic courses for civil engineering majors, but there are some defects in the actual teaching process, such as good teaching content, single form, less combination of new technology and less practical knowledge. Based on the concept and requirements of engineering education professional certification, this paper horizontally compares the teaching methods of concrete structure design principles courses in colleges and universities in China and Singapore. And further summarize the experience, put forward the teaching reform measures to improve the teaching quality of the course, in order to provide reference for the curriculum reform of domestic colleges and universities.

**Keywords:** Civil Engineering; Engineering Education Professional Certification; Principles of Concrete Structure Design; Singapore.

## 1. Introduction

In recent years, with the development of China's economy and technology, the traditional engineering industry is facing the impact of a new round of scientific and technological revolution and technological change, and the employment situation of college students is very grim. In order to further improve the professional quality of engineering graduates and meet the needs of social enterprises, the Ministry of Education vigorously promotes the teaching reform of engineering majors in colleges and universities. In 2016, China became the 18th formal member of the Washington Agreement, indicating that China's engineering certification education reform is gradually in line with international standards [1]. The engineering education professional certification refers to the specialized certification implemented by professional certification institutions for engineering professional education offered by higher education institutions, which has the characteristics of international equivalence, student center, output orientation, continuous improvement and so on. The aim is to provide preparatory education quality assurance for relevant engineering and technical talents to enter the industry [2]. It turns the focus of teachers' teaching to the needs of students, focuses on examining the rationality and timeliness of talent training objectives, and sets up an improvement mechanism according to the acceptance of students. Based on the requirements of engineering certification, many domestic scholars have put forward teaching reform plans for civil engineering courses such as material mechanics [3], soil mechanics [4] and steel structure [5]. In the process of teaching, students' subjective initiative and practicality have been brought into full play, and good teaching results have been achieved.

The principle of concrete structure design is one of the main courses of civil engineering in our country, and it is also a professional basic course with strong practicality and involving norms. It is based on three major mechanical theories, and the teaching contents include the basic properties of reinforced concrete materials, the design methods and structural requirements of all kinds of basic members, the checking calculation of deformation and crack width, and the calculation and analysis of prestressed concrete members [6]. Thus, students can master the design and reinforcement

methods of basic components such as tension, compression, shear and torsion, strengthen students' engineering practice ability, and lay the foundation for the study of follow-up professional courses and graduation design. Through continuous attempt and research, domestic researchers have also tried to apply various modern educational methods to this course, such as CDIO teaching mode [7], flipped classroom [8], introducing solid models and engineering cases [9], etc. All of which are aimed at improving the teaching quality of the course of concrete structure design principles, improving students' innovative and practical ability, and making the major meet the requirements of engineering certification.

But on the whole, the domestic higher engineering course teaching model draws lessons from the former Soviet Union model, which has some limitations. Singapore covers an area of 680 square kilometers, but its economic, cultural and educational development has reached the level of developed countries [10]. The construction industry has made a great contribution to the development of Singapore's economy and construction. The vigorous development of the construction industry is closely related to its forward-looking talent strategy and the internationalization strategy of civil engineering higher education [11]. Coupled with the large number of Chinese in Singapore, it has a very important reference value for the higher education of civil engineering in China. The author has had the honor to teach the course of the principle of concrete structure in domestic and Singapore universities (Nanyang technological University), and has some opinions on the teaching mode and teaching content in Singapore. Based on the relevant background of professional certification of engineering education in China, this paper puts forward the existing problems in the teaching of principles of concrete structure design in China, compares and discusses the similarities and differences between China and New Zealand. And summarize the experience, optimize the teaching of domestic concrete structure design principles, in order to provide guidance for the course to meet the requirements of professional certification of engineering education.

## **2. Problems in the Course of Principles of Concrete Structure Design in China**

The course of principles of concrete structure design is a course with equal emphasis on theoretical knowledge and practical knowledge. Sun H X[12] summarized the characteristics of the principle course of concrete structure design as "four more than two strong", that is, many concepts, many principles, many experimental phenomena, many calculation formulas, strong theory and strong practicality. Therefore, there are often many problems in the teaching of concrete structure design principles in China, which restrict the cultivation of students' engineering practical ability, and it is difficult to meet the requirements of professional certification of engineering education.

### **2.1 The Teaching Content is Relatively Single, and the Combination of New Technology is Less**

The design principles of concrete structures in China are usually taught in the first year of junior year, accounting for 2.5 credits, mainly in the form of theoretical knowledge. In Singapore, the course is divided into 24-hour lectures and 12-hour theoretical lectures, and the number of class hours is generally higher than that in China. In the lecture class, the school will invite different experts and scholars to explain the design concept, beam strength design requirements and maintenance plans and other engineering knowledge.

The main contents of domestic courses are to learn the mechanical properties of reinforced concrete materials and the basic methods of structural design according to the teaching order, the calculation of section bearing capacity under different actions, the checking calculation of deformation and crack width of concrete members and the calculation of prestressed members. And the main content of the Singapore course, according to the teaching order, the mechanical properties of reinforced concrete materials, structural analysis (including load analysis), critical interface calculation of beams in various states, steel bar binding and construction methods, reinforced concrete maintenance and so on. The gap in the first few parts of the teaching content is relatively small. In the follow-up content, China pays more attention to the investigation of students'

computing ability, while Singapore pays more attention to the integrity of the knowledge system. Technical operations such as steel bar binding and configuration are often taught in civil engineering construction courses in China [13]. However, from a horizontal point of view, the teaching content of the principle of concrete structure design in China is relatively simple and less combined with new technology.

Taking structural calculation and analysis as an example, only relatively simple calculation methods of frame structures are taught in China, which are mostly based on the relevant knowledge of the three mechanics and do not involve more extracurricular expansion. On the other hand, the course of concrete structure design in Singapore gives three methods for the calculation of frame structures, which are in the following order: the calculation of bending moment and shear coefficient, the method of moment distribution and the method of calculation integral, etc. The three have different engineering application conditions, and the calculation of bending moment and shear coefficient is limited to continuous beams with the same span and the same member size. The law of moment distribution can be used in any type of loading mode and frame structure, and the calculation result is more accurate than the former. Computer analysis is the most efficient and accurate method, which is suitable for large and complex frame structures. In the classroom, we also give examples to calculate the three calculation methods to further deepen the impression of the students. At the same time, in the chapter of concrete maintenance, the course on the principle of concrete structure design in Singapore introduces in detail the surface characteristics of steel bar, the calculation method of Anchorage length of steel bar and the mechanism of transferring steel bar force. a relatively complete concrete reinforcement system is constructed. However, this part is not explained in the domestic teaching, which is difficult to meet the relevant requirements of engineering education professional certification.

## **2.2 The Form of Teaching is Relatively Single, and the Students' Interest in Learning is Low**

Some of the knowledge in the course of the principle of concrete structure design comes from engineering practice, such as the selection of some coefficients, which is difficult for students to master. In addition, some students are not solid in the study of the pre-curriculum, resulting in a weak grasp of basic concepts, which is easy to make students feel boring, and then have a fear of difficulties [14]. Furthermore, it further affects the students' engineering practice ability, and it is difficult to meet the requirements of engineering certification.

The traditional course model of concrete structure design principle in our country is that teachers use blackboard or PPT to explain specific examples, and assign classroom assignments, the final examination, students accept passively, the overall process is relatively simple. Scholars at home and abroad have also found that the explanation of basic concepts, calculation methods and calculation steps in the teaching content, as well as the simulation of some complex graphics, can be demonstrated by multimedia courseware to deepen students' understanding [15].

In Singapore classroom, teachers adopt more abundant teaching models, such as video, electronic model, laboratory experiment and so on. In addition, the course content is optimized by analogy during the teaching period, and students are encouraged to discuss and report. Chapter 5 of the Singapore Concrete Structure Design Principles course specifically explains the concept of stirrups and the concept of concrete trusses. in which teachers compare stirrups to the pedals of a saddle for students to understand. At the same time, it is assumed that the cracked reinforced concrete beam is a parallel truss structure composed of oblique brace and transverse tension bar, and does not have tensile capacity. On this basis, students can better understand the curriculum knowledge, and accord with the student-centered teaching concept under the certification of engineering education.

## **2.3 Little Practical Knowledge is Involved, and Students do not Exercise Enough**

The professional certification of engineering education emphasizes the demand-oriented of enterprises, focusing on the cultivation of students' engineering practice and innovation ability [16]. This also requires that the talent training of civil engineering specialty should be changed from

"knowledge type" to "practice type". Although the course of concrete structure design principle mainly describes the design method of reinforced concrete members, there are both theoretical derivation and experimental research, and special attention should be paid to the training of practical ability.

The design principle of concrete structure in our country attaches importance to the explanation of basic concepts, mostly focusing on simple design methods, and the cultivation of students' engineering practice ability is weak, so it is difficult to meet the requirements of professional certification of engineering education. In recent years, through continuous improvement, domestic colleges and universities actively integrate knowledge such as "concrete structure design method" and "Building structure load Code" in the teaching process [17], which makes students come into contact with professional codes in advance to a certain extent. In the teaching of the principle of concrete structure design in Singapore, the teacher led the students to interpret the specification earlier, demonstrated it by using the model, and integrated it well into the course test. Taking the design principle of concrete structure in Singapore as an example, the calculation idea of this question is not complicated, but the students are investigated from many angles combined with the calculation of ultimate load reinforcement and the consulting of design chart.

Fig.1 shows that A column section is reinforced with certain number of H32 bars symmetrically about YY axis as shown in Fig.1 (the number of bars shown in Fig.1 is for illustration purposes only). An ultimate load  $N = 2250\text{kN}$  is applied along the Z-Z axis.  $f_{ck} = 32\text{N/mm}^2$  and  $f_{yk} = 500\text{N/mm}^2$ . The bending moment concerned is about the major axis Y-Y. (a) Assuming the ultimate moment that can be supported by the column section is  $304\text{kN}\cdot\text{m}$ , use the design chart (see appendix) to find out the total number of H32 bars ( $A_s$ ) required. (b) Assuming the total number of H32 bars ( $A_s$ ) is six, determine the ultimate moment that can be supported by the column section by section analysis.

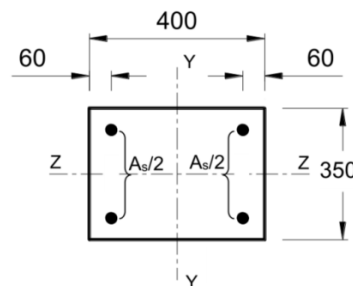


Fig.1 Example drawings of the final exam of Singapore's concrete structure design principles

### 3. Reform Measures for the Course of Principles of Concrete Structure Design

There are some problems in the course of the principle of concrete structure design in our country, such as single teaching content and form, little combination of practical knowledge and so on, which affect the enthusiasm of students to study, and it is difficult to meet the requirements of professional certification of engineering education. Based on the above analysis and combined with many years of teaching experience, the author puts forward the corresponding teaching reform measures for this course.

#### 3.1 Enrich the Classroom Teaching Model

The theory classroom teaching is the main body of the concrete structure design principle course, and adopting a richer classroom teaching mode can improve the teaching quality. On the basis of the traditional teaching model, teachers should further deepen students' understanding of basic concepts. Analogy to the teaching model in Singapore, using analogy and other ways to help students understand.

At the same time, we continue to increase the teaching methods, explain the content with concrete structure engineering cases and models, and organize content sharing meetings for students who are interested in this part of the content. this requires teachers not to introduce the basic theory

and practical knowledge of specific components or structures in isolation. The author also organizes the students of Grade 2017 of Zhejiang University Ningbo Institute of Technology to share and report on the corresponding knowledge points of the concrete structure design course before each class, and guide the students to take the initiative to collect materials after class. The above measures not only enhance students' ability of innovation and exploration, but also make students better exposed to new technologies and new technologies, which is also in line with the teaching philosophy of Singapore.

### **3.2 Strengthen the Implementation of Practical Links**

Practical teaching is an important part of the teaching of civil engineering, and it is the key way and means to improve the innovative ability, practical ability and professional quality of professionals. For the course of the principle of concrete structure design, Nanyang University of Technology combines the course content with laboratory experiments. For example, the Chapter 2 of the course introduces the creep of concrete under long-term load. It shows the time-deformation curve as well as the strain gauges and test pictures.

The Zhejiang University Ningbo Institute of Technology, where the author works, has a series of complete concrete experimental equipment processes, teaching models and experimental sites. There are a variety of teaching models, including simply supported beam, T-beam, rectangular beam and so on, which can play a good role in teaching students. The laboratory experiments and experimental models are introduced into the teaching activities of the theory classroom to simulate the conditions of the construction site and effectively meet the requirements of professional certification of engineering education. At the same time, professional teachers should introduce scientific research and innovation activities into classroom teaching, guide students interested in concrete scientific research to carry out college students' scientific research activities, realize students' combination of production and learning", and achieve the goal of training practical talents. The outline of the National medium-and long-term Education Reform and Development Plan (2010-2020) clearly points out that it is necessary to improve the quality of personnel training, support students' participation in scientific research, and strengthen practical teaching.

### **3.3 The Improvement of the Examination Method of the Course**

The examination method of the course is a particularly key link in the whole teaching process, and its reform also needs to proceed from the reality to meet the requirements of engineering education professional certification. In the course assessment of Zhejiang University Ningbo Institute of Technology, the team of professional teachers will set up a database of examination questions according to the contents of the course. One set of AB papers will be selected in the final examination, and the rest will be used as make-up examination papers. At the same time, the proportion of the final examination of the principle of concrete structure design course is further reduced, and we continue to pay more attention to the usual grades and classroom performance.

In the later stage of the examination, our school will gradually introduce the examination method of "semi-open book" to the course of the principle of concrete structure design, the closed book method will be adopted for the basic concept knowledge, and the open book form will be used for the calculation questions that need to find the standard. This practice is also in line with the national registered engineer examination.

## **4. Conclusion**

The course of principles of concrete structure design is an important professional basic course, and its curriculum reform is not only the need of curriculum construction, but also the demand of students' training under the background of professional certification of engineering education. Reasonable reference to the teaching experience of the course of concrete structure design principles of Nanyang technological University in Singapore can play a positive role in the curriculum construction in China. By means of enriching classroom teaching mode, strengthening

practice links and contents, and improving students' assessment mechanism, we continue to combine the teaching of the principle of concrete structure design with the professional certification of engineering education. So as to cultivate a group of civil engineering talents with high practical and innovative ability.

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