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Original Paper

Research on Practical Teaching Reform of Applied University Courses: A Case Study of "Concrete Structure Design"

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Abstract

By analyzing the current situation and deficiencies of the teaching of concrete structure design courses, summarizing teaching experience, and combining with the characteristics of our university's "applied" talent training, this study explores the teaching reform of concrete structure design courses for the 2021 level civil engineering majors. The exploration primarily focuses on optimizing teaching content, improving teaching methods, strengthening practical components, and diversifying assessment methods. Practice has shown that this approach has a demonstrative effect on undergraduate teaching in civil engineering at our university.

Keywords

Concrete Structure Design, Applied, Teaching Reform, Practice and Innovation, BIM Technology

1. Introduction

The cultivation of applied talents primarily focuses on developing practical abilities and aims to cultivate engineering professionals with innovative capabilities. Applied innovation talents should reflect the harmonious development of students' knowledge structure and engineering capabilities. They should possess strong hands-on practical skills typical of engineering students, solid theoretical foundations and analytical abilities characteristic of science students, as well as a certain level of innovation capabilities within the field of civil engineering. Additionally, in 2016, the Ministry of Education first proposed the construction of "new engineering disciplines", successively forming guiding opinions such as the "Fudan Consensus", "Tianjin University Action", "Beijing Guidelines", "UESTC Plan", and the "New Engineering F Plan". In April 2019, the Ministry of Education held the

"Six Excellences and One Top" Plan 2.0 Launch Conference, comprehensively promoting the construction of new engineering disciplines, strengthening the cultivation of urgently needed strategic talents, and enhancing the ability of universities to serve economic and social development.

As one of the important foundational courses in the field of civil engineering, concrete structure design requires students to comprehensively apply the basic theories of structural mechanics, fundamental knowledge, and methods of structural design learned in their studies. They are expected to demonstrate innovative thinking, propose novel and reasonable structural solutions that encompass both fundamental theory and practical engineering applications.

2. Problems in Course Teaching

2.1 Disconnection between Theory and Practice

Traditional concrete structure course designs often overly emphasize the impartation of theoretical knowledge while neglecting the cultivation of practical skills. Students learn theoretical knowledge in the classroom but lack opportunities to apply it to actual engineering projects, resulting in a significant disconnection between theory and practice. For example, in recent years, the construction of new single-story industrial buildings has mostly adopted light portal frame structures, while the use of concrete frame structures for factory buildings has become relatively rare. However, the curriculum for single-story industrial building structures in the teaching outline comprises 12 hours, accounting for 25% of the total course hours (48 hours). Although the "Concrete Structure Design" course extensively covers theoretical explanations of factory composition, internal force analysis, and structural measures, corresponding practical components are addressed in the course design corresponding to "Steel Structure Design." However, the main content of the course design includes the design of steel roof structures, concrete roofs, concrete crane beams, concrete columns, and other components, without providing students with effective practical experience.

2.2 Outdated Course Content

The rapid development of concrete structure technology sees the emergence of new design theories, materials, and construction methods. However, some course designs lag in updating their teaching content, failing to timely incorporate the latest industry standards and cutting-edge technologies. This results in a gap between students' knowledge and skills and industry demands. If teaching content fails to keep up with these innovations, students may lose competitiveness in the job market as they lack the latest skills and knowledge. For instance, in recent years, high-performance concrete, prestressing technology, BIM technology, among others, have seen widespread application in engineering. However, many textbooks still adhere to traditional concrete structure design concepts and methods, failing to timely reflect the development and application of these new technologies. If teaching content does not cover these new areas, students may struggle to adapt to these changes in their future careers. Moreover, the textbooks used in the curriculum, such as the one edited by Liang Xingwen and published by Science Press in 2006 (1st edition), contain a significant portion of content that does not comply with the requirements of the revised "Code for Design of Concrete Structures" GB50010-2010, which was updated in 2015. This discrepancy leads to errors in teaching difficulty and timeliness.

2.3 Insufficient Faculty Resources

Some schools lack teachers with rich engineering practice experience and teaching experience, resulting in uneven teaching quality in course designs. At the same time, limited opportunities for teacher training and development make it difficult to keep pace with industry developments, impacting teaching quality.

2.4 Outdated Course Evaluation System

Many courses still primarily rely on exam scores for evaluation, overlooking the assessment of students' practical and innovative abilities. This singular evaluation method not only fails to comprehensively reflect students' overall qualities but also easily leads to students overly prioritizing scores at the expense of practical skill development. Therefore, there is a need to establish a more comprehensive and scientific evaluation system that incorporates various factors such as students' practical abilities, innovative capabilities, teamwork spirit, etc. This will better facilitate students' comprehensive development.

3. Curriculum Reform Exploration

The fundamental principle of engineering education accreditation is centered around students and outcome-oriented, aiming for continuous improvement in education quality. Therefore, in response to the characteristics of the course and the existing issues, the author proposes the following corrective measures and viewpoints in terms of teaching mode, course design content, and enhancement of evaluation system:

3.1 Reform of Teaching Methods

In teaching, classroom lectures are supplemented with various teaching methods such as model teaching, on-site teaching, laboratory teaching, and a combination of online and offline teaching. Depending on the arrangement of course content, teaching can employ methods such as "flipped classroom" and "case-based teaching." Through multi-stage interactive teaching, a classroom teaching environment is created where teachers take the lead and students participate deeply, achieving teaching effectiveness centered around "learning and students" with the goal of "teaching and learning."

Furthermore, to enhance teaching effectiveness, we can introduce simulation software such as PKPM, YJK for structural design, and Revit for simulation, allowing students to engage in concrete structure design in a virtual environment. This teaching method not only helps students better understand theoretical knowledge but also enables them to acquire more skills through practice. According to relevant research data, using simulation software for teaching significantly enhances students' practical and innovative abilities.

3.2 Integration of Multiple Related Course Designs in Civil Engineering

At the current stage, the content of course design is based on given parameter data to design a reinforced concrete ribbed slab. Due to the limited variability of the design parameters, it is difficult to have each student work on a unique project, and similar issues exist in the design of other related courses. Therefore, it is possible to integrate and arrange the designs of multiple related courses. For example, in the same semester, courses such as "Seismic Design of Building Structures," "Foundation Engineering," and "Plane Surveying" can be integrated to provide multidimensional parameter data, allowing each student to work on a unique project. This integrated approach covers the entire design process from architecture to structure to foundation, achieving a holistic course design. This strengthens students' knowledge systems, fosters their innovation and engineering awareness, and truly achieves the purpose of design practice.

Additionally, as the concrete structure course design is a continuation of the concrete course, conducting the course design after the course teaching often coincides with the end-of-term examination period, leading to tight deadlines for students and potential forgetting of previously learned knowledge. Therefore, it is advisable to release the course design content simultaneously with other related courses, and maintain communication among relevant course instructors to adjust the course content and design sequence to the same pace. This allows students to complete the course design while the course is being taught, ensuring efficiency and leaving a lasting impression.

3.3 Improvement and Enhancement of the Evaluation System

(1) Enhancing the Evaluation System for Course Design

In the guidance process of course design, inconsistent responsibilities and teaching levels among guiding teachers often lead to inconsistent design requirements, making it difficult for student grades to reflect their true level, and ensuring the quality of course design is challenging. To ensure comprehensive and objective evaluation, systematic and comprehensive regulations should be established from topic determination, scheme arrangement, guidance process, mutual inspection of stages, format of calculation instructions, standards of construction drawings, forms of defense, to assessment of grades. This will achieve quality control throughout the entire process of course design.

(2) Adjustment of Course Assessment Methods

Compared to theory-focused mechanics courses, the ultimate goal of design courses is to enable students to apply what they have learned. Thus, the focus of student learning should shift from rote memorization for exams to understanding and practical application. Therefore, allocating 70% of the course assessment to course design and 30% to regular attendance can enhance students' emphasis on applying knowledge.

(3) Increasing Teacher-Student Communication

Course instructors can understand students' mastery of professional knowledge in the course through classroom teaching, discussions, online quizzes, and homework. They can also calculate the course objective evaluation value based on final exam scores and regular assessment grades, identify the reasons for low evaluation values, and propose improvement measures in a timely manner. Additionally, leveraging information technology-assisted teaching tools such as "Yuketang" for comprehensive online and offline communication with students can be beneficial. The classroom data analysis results provided by such tools can also serve as a basis for adjusting course content and improving teaching methods.

4. Implementation of Teaching Reform

Starting from the practical course of concrete structure design, a survey and research analysis were conducted on its current status. The focus was on comprehensive course design, the integration of comprehensive practice, and the connection of professional knowledge that can be applied in engineering practice. This included setting up situations, practical content, and assisting other practical aspects, all of which underwent corresponding reforms and research.

4.1 Course Design

In previous courses, the design topics were not closely integrated with practical engineering, and the construction drawing was drawn using traditional methods only. Additionally, the content of reinforcing concrete one-way slab ribbed floor design and the training of non-seismic and seismic design abilities of reinforced concrete frame structures were not comprehensive.

Therefore, during execution, the course design content and requirements were correspondingly aligned with practical engineering. The non-seismic design and seismic design of reinforced concrete frames were merged into one course design, which was incorporated into the "Seismic Design of Building Structures" course. In the "Concrete Structure Design" course, single-story industrial plant design was added, along with the design of two-way slab ribbed floors and staircase components. This expanded the practical content, increasing the integration with practical engineering. It enabled students to master the entire process design of reinforced concrete frame structures and single-story industrial plants, gain a deeper understanding of concrete experimental specimen design, and develop comprehensive abilities for graduation projects.

4.2 Application of BIM Technology

In the previous courses, only conceptual content was explained without introducing BIM technology, indicating a lack of comprehensive integration with contemporary practices. Therefore, during execution, BIM was incorporated into course teaching. Two-dimensional graphics were converted into three-dimensional models, such as the cast-in-place ribbed floor slab shown in Figure 1. This was achieved by fully utilizing software functions like rotation, zooming, and slicing, allowing students to gain a more intuitive understanding of beam-slab structures.

For existing models, students can also design virtual tours to provide an immersive understanding of beam-slab structures. Through the 3D model, students not only recognize that cast-in-place ribbed floor slabs consist of slabs, secondary beams, and main beams, but also gain insight into the connections between various components. This facilitates their comprehension of simplified diagrams and load calculations for slabs, secondary beams, and main beams. Taking the slab component as an example, establishing a reinforcement diagram in the BIM model dynamically showcases aspects such as internal reinforcing bars, distributed bars within the slab, edge bars along walls, and negative bars at beam supports (Xiao, Zhang, & He, 2020).

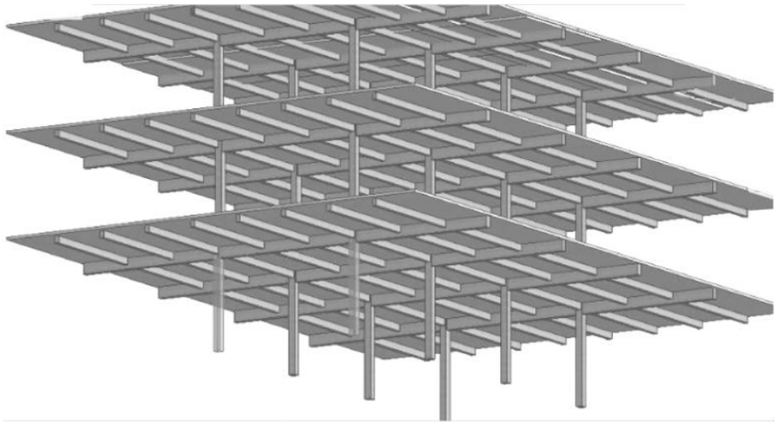

Figure 1. Cast-in-Place Ribbed Floor Slab

Consequently, this use of BIM reinforcement diagrams enables students to more intuitively understand the entire reinforcement layout of the slab structure, grasp the arrangement of structural reinforcement more effectively, and better relate to practical engineering applications.

4.3 The assessment mechanism

The assessment mechanism has shifted from the original 40% for regular attendance and 60% for exam scores to the current setup of 30% for regular attendance and 70% for course design scores. With practical engineering requirements as the starting point, the assessment now includes course design evaluations incorporating practical engineering tasks and assessments of practical engineering abilities. The primary focus is on enhancing students' comprehensive practical abilities in the field, thereby avoiding extreme reliance on theoretical knowledge alone. This approach encourages students to flexibly and systematically master both theoretical knowledge and practical skills, aligning with the goal of talent cultivation in the new era.

5. Practical Teaching Achievements

The practical teaching reforms have yielded the following achievements: (1) Students have shown a significant increase in interest in the course, transitioning from passive learning to active engagement, resulting in a more dynamic classroom atmosphere. (2) Through the preparation of component calculation documents, students have gained a deeper understanding of knowledge points. They have learned to consult standards and related materials, enabling them to flexibly grasp professional knowledge and lay a solid foundation for future learning and work. (3) Learning to use Revit simulation software has enabled students to master the transformation from two-dimensional to three-dimensional visualization, enhancing their spatial imagination skills. This lays the groundwork for independent learning and boosts their confidence in learning. (4) By modifying the assessment mechanism, students have demonstrated a notable improvement in their academic performance.

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