

Reform and Practice in the Course Construction of “Cement and Cement Concrete”

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Abstract: *The graduate course “Cement and Cement Concrete” at the University of Science and Technology Liaoning is built in quality by optimizing its teaching content; systematic deepening of teaching reform emphasizes teaching models, resource development, assessment methods and curriculum ideological and political education. Closed loop evaluation during teaching implementation constantly tests and provides feedback on teaching effectiveness which serves as a dynamic foundation for improvement of high-quality course construction. Its reform practice and construction path provide reference and lesson for teaching reform of other similar courses.*

Keywords: *“Cement and Cement Concrete”; course construction; reform and practice; graduate education*

1. Introduction

The cement industry is transforming towards an intelligent model through digital technology (artificial intelligence and big data), limited textbook teaching because of the lagging knowledge update of the traditional course “Cement and Cement Concrete”, there is an urgent need for teaching reform^[1-2]. Empowerment of the teaching of the graduate course “Cement and Cement Concrete” with new-era technologies improve the efficiency of teaching and students' practical ability, cultivate innovative talent with responsibility^[4-6]. In 2025, The University of Science and Technology Liaoning promote the “1+3+2” education system reform aims to build a high-level curriculum system matching the university's discipline positioning and development goal; When revising the 2025 version of the professional master's training program, the School of Civil Engineering still designate “Cement and Cement Concrete” as a core course in the engineering materials direction, optimize the syllabus based on the OBE concept, emphasis on student-centered approach, laying the foundation for high-quality course construction. We will fully implement the high-quality course construction of this course in 2026, optimize the teaching content, emphasize “teaching models—resource development—assessment and evaluation,” deepen the teaching reform, practice the trinity of “textbooks—teaching—teachers”, organic integration of curriculum ideological and political education, closed-loop evaluation in teaching implementation, evaluate teaching effectiveness and systematically advance high-quality course construction. Construction ideas are summarized as follows:

2. Optimizing Teaching Content to Effectively Support Teaching Objectives

Course “Cement and Cement Concrete” The course consists of 32 class hours. The teaching goal includes: Knowledge level: Requires graduate students to systematically master the core fundamental theories of cement, deeply understand the composition - structure - performance relationship of cement concrete, be familiar with the cutting edge advances for special cements and functional concretes, and master the industry standards, engineering specifications and sustainable development trends; Ability level: On basis of knowledge, cultivates the theoretical analysis and experimental design abilities of graduate students, strengthens their skills to solve practical engineering problems, improves their proficiency in retrieving literature and tracking frontier, enhance their academic expression and teamwork competencies; Value level: On basis of knowledge and abilities, this course guides graduate students to develop a consciousness of autonomous learning and lifelong learning, practicing the concept of sustainable development, enhance confidence in the path and cultural confidence, cultivate critical thinking and internalize patriotic sentiments and sense of responsibility.

According to the teaching objectives of this course, we optimized the teaching contents: In terms of knowledge, the course team supplemented by explaining and extensively discussing new types of concrete and integrated industry standards and engineering specifications for cement and cement concrete into teaching; in terms of abilities, the course team supplemented teaching cases, actively introducing frontier knowledge into class, focusing on transforming and applying research achievements in teaching; in terms of values, the course team adopted a subtle and unobtrusive education strategy, deeply embedded ideological and political elements in the teaching of professional knowledge points and case discussions without being too preachy, organically integrating the scientific spirit, engineering ethics, and green low-carbon concepts so as to guide students to imperceptibly establish their dedication to family and country, cultural confidence, and sense of responsibility in their professional growth, which achieve an organic unity between value guidance and knowledge transmission.

3. Focusing on "Teaching Models—Resource Development—Assessment and Evaluation" to Deepen Teaching Reform

3.1 Teaching Models

We have implemented different teaching methods in our course team for teaching model reform: Case-based teaching model, Blended teaching model, Problem-oriented teaching model, Seminar and flipped classroom teaching model, Project-based learning teaching model etc.

Case-based teaching model: In class teachers teach knowledge points of graduate students gradually deep with "case introduction - problem raising - design analysis - knowledge point explanation". For example, in teaching about concrete durability, we choose two teaching cases like Beijing Xizhimen Overpass and Beijing Sanyuan Bridge; for teaching about high-performance concrete, we choose two teaching cases like Beijing Daxing International Airport and Shanghai Tower. We introduce teaching from the teaching cases which can make graduate students understand complex problems deeper.

Blended teaching model: Teachers design course using Chaoxing Platform, enriching online teaching resources; teachers combine online resources with offline class instruction in a way of "online self-study (raising questions), classroom learning (solving problems) and extracurricular extension (extending questions)", stimulating the interest for autonomous learning among graduate students. Teachers could monitor online learning effectiveness by students anytime via the Chaoxing Platform.

Problem-oriented teaching model: Guide graduate students to actively explore with problems and achieve the purpose of understanding knowledge points by teachers. For example, in teaching on hardened concrete structures, we will take out a pack of A4 paper to ask such questions as why an entire pack of paper can withstand compression while one sheet of paper is easy to tear? It makes us think about the interfacial characteristics of hardened concrete structures.

Seminar and flipped classroom teaching model: How "Students searching the literature-preparing courseware-giving presentations-teachers commenting" realize a change of knowledge from "acceptance" to "creation". Organizing students for seminar and flipped class on frontier topics like "special concrete".

Project based learning teaching model: Theoretical teaching with actual scientific research project including multidisciplinary knowledge (materials, structures, environment) etc; e.g., the research on replacement materials and strengthening methods for hidden cap beams and the experimental study on the application of ultra-lean iron ore in high-strength concrete that is undertaken by the author are used as teaching projects for concrete admixtures and aggregate performance.

3.2 Resource Development

Based on Chaoxing MOOC, we establish online course, introduce abundant teaching resources and share resource information. Total online resource task points is 152. Based on the total class hours and course objectives, to show a clear chapter structure, except for Chapter 1, there have two subsections of each chapter which can facilitate graduate students' in-depth online learning. We develop multiple aspects such as multimedia courseware, mind maps, joint university-enterprise course construction, textbook selection, teaching videos, teaching cases, engineering standards, journal resources, knowledge expansion and discussion. We will introduce their construction methods one by one below.

Multimedia courseware: All course PPTs have lots of texts and pictures, all courseware has been uploaded on each chapter which fully covers the multimedia courseware. **Mind maps:** Design a mind map according to the content of each chapter that can be used by graduate students to organize their logic and improve their memory. **Joint university-enterprise course construction:** Invite enterprises like Ansteel Green Resource Technology Co., Ltd. and other enterprises to give reports and exchange ideas at our university in order to achieve the construction and improvement of the online resource repository for course teaching. **Textbooks:** We choose “Concrete Materials Science (Second Edition)” edited by Gou Mifeng, Luo Shuqiong, and Guan Xuemao as the textbook for graduate teaching based on the teaching contents and course objectives. More than 10 textbooks were chosen as auxiliary teaching textbooks such as “Cement and Cement Concrete (Second Edition)” edited by Shen Aiqin and Guo Yinchuan, “Ordinary Portland Cement Technology” edited by Cao Wencong and Yang Shusen, “Newly Compiled Handbook of Concrete Technology” edited by Li Jiye, Liu Jingqiang, and Zhang Mingzhan, “Fundamentals of Concrete Admixture Application” edited by Jiang Yaqing, “Concrete Fracture Mechanics” authored by Xu Shilang, “Green Low-Carbon Concrete” edited by Jiang Jinyang. They are combined with online learning for each chapter and uploaded to the Chaoxing Platform as electronic textbook PDFs.

Teaching videos: Our course team introduced the videos, micro-lectures and animations, uploading teaching videos (cement production, one-time feeding, two-time feeding), building and improving online video resource repository.

Teaching cases: We chose our own research projects that we were in charge of, supervising graduate theses, innovating and entrepreneurship supervision as teaching cases; we also took the academic report contents of experts both inside and outside the university as teaching cases; we also took typical doctoral dissertations, master's theses and journal papers which are closely related with the teaching content of every chapter of this course (we downloaded them from CNKI including foreign language literature like English and Japanese) as teaching cases and integrated it into each teaching chapter respectively.

Engineering standards: Course team uploads relevant engineering technical standards on learning platform. Such as in the section "2.2 Aggregates" upload standards like “JTG/T 3650-2020 Technical Specifications for Construction of Highway Bridges and Culverts”, “JTG/T F30-2014 Technical Specifications for Construction of Highway Cement Concrete Pavements”, “JTG F40-2004 Technical Specifications for Construction of Highway Asphalt Pavements”, “GB/T 14685-2022 Pebble and Crushed Stone for Construction”, “GB/T 14684-2022 Sand for Construction”, “GB/T 25177-2010 Recycled Coarse Aggregate for Concrete” and “GB/T 25176-2010 Recycled Fine Aggregate for Concrete and Mortar”. So that during online learning, graduate students can compare the technical parameters of aggregates by different standards (In the section "8.2 Design and Measures for Concrete Durability", the course team uploads standards such as “GB/T 50082-2024 Standard for Test Methods of Long-Term Performance and Durability of Ordinary Concrete”, “GB/T 50476-2019 Standard for Design of Concrete Structure Durability”, “DL/T 5241-2010 Technical Specifications for Durability of Hydraulic Concrete”, “JTG/T 3310-2019 Specifications for Design of Concrete Structure Durability of Highway Engineering”, and “TB 10005-2010 Code for Durability Design of Railway Concrete Structures”. So that during online learning, graduate students can comparatively learn about concrete durability from different standards).

Journal resources: We also developed journal resources on the Chaoxing Platform. For instance, in the section "1.1 Definition and Classification of Concrete", we have linked Chinese Library Classification (CLC) numbers so that graduate students can master the classification of cement, concrete, and concrete products by CLC numbers and be familiar with their respective CLC numbers; In the section "1.3 Teaching Materials for This Course" we upload PDF documents like “Summary of the Graded Catalog of High-Quality Scientific and Technological Journals (Fifth Edition)”, “Ranking of Chinese Academic Journals” and “Overview of Chinese Core Journals (2023 Edition)”, add online links to some important domestic and international journals in the field of "civil engineering materials", making graduate students familiar with important domestic and international journals related to cement and cement concrete, guiding students to start from the perspective of journal resources, reading journal literature and mastering the latest research hotspots in cement and cement concrete.

Knowledge Expansion and Discussion: Set knowledge expansion content for the teaching resources of each chapter in "14.1 Knowledge Expansion". To stimulate the thinking of graduate students, expand their academic horizon and stimulate their interest in autonomous exploration such as the Three Gorges Project, new dry-process cement production technology, the Hong Kong-Zhuhai-Macao Bridge, Shanghai Tower, the Wuhan Yangtze River Bridge, the central substance hypothesis of concrete,

Longtan Hydropower Station, fiber reinforcement spacing theory, the expansion mechanism of alkali-carbonate reaction, molecular tailoring theory and graft copolymerization technology, special mortar, the fracture process zone (FRZ), the St. Francis Concrete Gravity Dam, etc., in the "Discussion" section on Chaoxing Platform, the course team has set up a small discussion area; post questions at any time according to the course progress, organize students to discuss. In "14.2 Knowledge Discussion", the course team has set up a large discussion area, organize students to prepare courseware in groups according to the discussion topics, conduct centralized discussions. The major discussion topics will be set as follows in the teaching in 2026: the latest research hotspots in cement and cement concrete, a new type of admixture, new feeding and mixing technology, a new type of durability loading device, smart concrete, polar engineering materials and extraterrestrial engineering materials. We have established discussion areas for communication, discussion and problem solving between teachers and students, really involving graduate students into teaching activities.

3.3 Assessment Methods

The original single end-of-course assessment was changed into: regular performance (30%) and end-of-course assessment (70%). Regular performance assess from the perspective of classroom performance, study notes, online resource learning, classroom discussion, etc.; End-of-course assessment evaluate from the perspectives of knowledge assessment, ability assessment, ideological and political assessment, etc. Assessment question designs for 2026 are shown in Table 1.

Table 1 End-of-Course Assessment Questions for 2026

Question No.	Test Question Content	Question Type	Assessment Perspective	Score
Test Question 1	Test Question 1: Browse some important domestic and international journals about cement and cement concrete, integrate literature reports in the past three years, elaborate on the latest research hotspots of cement and cement concrete, present your view from a point of energy conservation and emission reduction and sustainable development.	Essay Question	Knowledge, Ideological and Political Education	20points
Test Question 2	Test Question 2: Students are required to discuss new technologies for chemical admixtures for concrete, independently design a new type of chemical admixture, and discuss its mechanism and feasibility.	Essay Question	Knowledge	20points
Test Question 3	Test Question 3: Students are required to discuss new technologies for the feeding and mixing process of cement concrete and express their own opinions and ideas.	Essay Question	Knowledge	20points
Test Question 4	Test Question 4: Designing a durability loading device for concrete considering the synergistic effect between two factors or multiple factors. Requirements: Students must draw with pencil and ruler when introducing details (composition, innovativeness, scope of application, etc) about their loading device.	Design Question	Ability, Ideological and Political Education	20points
Test Question 5	Test Question 5: The students have been tasked with doing a concrete mix proportion design based on the materials used for constructing a shear wall in a certain project, as well as the design requirements.	Design Question	Ability	20points

Reformulate all test questions without fixed answers (in 2026 assessment questions), which can be discussed, designed and imagined by graduate students. For Test Question 1, both knowledge and ideological and political education account for 10 points respectively; The ideological and political

education is mainly evaluated from the perspective of energy conservation and emission reduction and sustainable development. For Test Question 4, both knowledge and ideological and political education account for 10 points respectively; The ideological and political education is mainly evaluated from the perspective of truth-seeking and innovation. Knowledge assessment takes up a total score of 50 points in the test questions, while ability assessment takes up a total score of 30 points and ideological and political education assessment accounts for a total score of 20 points.

4. Integration of Curriculum Ideological and Political Education through the Trinity of “Textbooks—Teaching—Teachers”

4.1 Mining Ideological and Political Elements from Textbooks

We carefully study the teaching textbook and auxiliary teaching textbooks, really integrating knowledge transmission with virtue through education. For example, according to the auxiliary teaching textbook “Concrete: A Cultural History” (by Adrian Forty), we explain "Concrete is not a sustainable building material", "Concrete is environmentally sustainable, and its green certification performance exceeds that of steel and wood". According to the auxiliary teaching textbook “Problems and Research in Modern Concrete Science” (by Yang Wenke), we explain "admixtures—every medicine is somewhat toxic," so for the negative effect of admixtures, the use and development of admixtures will take an correct and scientific path.

4.2 Subtle Integration of Ideological and Political Teaching

We analyzed each stage of our course “Cement and Cement Concrete.” Deeply studied ideological and political education elements with literature retrieval and internet platforms from different aspects such as historical stories, famous quotations, scientific stories, and current hot topics. According to this, we build up a curriculum ideology and political case library. We choose some teaching contents for example: "Development History of Concrete", "Properties of Fresh Concrete", "Durability of Concrete" and "Mix Proportion Design of Concrete." Explain course content from perspectives of "innovation," "learning by doing and doing by learning, mutual help and solidarity," "straightening one's attire and looking in the mirror," and "the concept of green development," respectively.

4.3 Enhancing Teachers' Ideological and Political Literacy

Based upon the teacher ethics education, professional study, thematic seminars as important indicators, strengthening training and guidance in aspect of course teaching concepts: Through different exchanges (such as training on curriculum ideological and political teaching ability for college teachers) our course team helps teachers promptly understand new development trend of curriculum ideological and political education; Establishing an internal-external training system encouraged teachers integrating advanced concepts into professional teaching, greatly improved their overall capability to carry out curriculum ideological and political construction.

5. Conclusion

Today, after our course team finish a high quality course construction of “Cement and Cement Concrete” based on the Chaoxing Platform, the graduate students' learning initiative and learning effectiveness greatly increased during the teaching practice in 2026. We will focus on industry frontiers and academic development, update course contents timely, improve teaching handouts, guarantee the advanced nature and adaptability of this course, and gradually push forward the construction experience so that the teaching reform methods can give some useful references for similar institutions.

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