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Reform and Practice of the Teaching System of Combining Virtual and Real Teaching in the Experimental Course of "Asphalt and Asphalt Mixture"

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Abstract. Experimental teaching is an important carrier for cultivating innovative spirit and practical ability. By using the combination of virtual and real methods, the breadth and depth of experimental teaching content are expanded, the time and space of experimental teaching are extended, and the quality and level of experimental teaching are improved. This article introduces the overall framework of the virtual reality combination teaching system for the "Asphalt and Asphalt Mixture" experimental course. Through teaching reform, the effectiveness of experimental teaching has been effectively improved, students' basic experimental skills and techniques have been better trained, and students' further understanding and consolidation of basic theoretical knowledge have been deepened. Finally, taking the "Three Major Indicators of Asphalt" experiment as an example, the architecture and teaching methods of the virtual reality combination experimental teaching system were elaborated in detail, as well as the role of cultivating students' experimental skills and independent innovation ability.

Keywords. Asphalt experiment; Combination of virtual and reality; Teaching reform and practice.

1. Introduction

With the implementation of major strategies such as "Made in China 2025", "the Belt and Road" and "Internet plus", the new economy represented by new technologies, new formats, new models and new industries is booming, which puts forward higher requirements for engineering science and technology talents and urgently needs reform and innovation in higher engineering education [1, 2]. The "Emerging Engineering Education" is a reform aimed at higher engineering education. Practical teaching of engineering majors is a crucial teaching link in cultivating applied talents in higher engineering education, and the Road and Bridge and River Crossing Engineering majors are engineering majors with strong practicality. In the context of the construction of Emerging Engineering Education disciplines, only through practical teaching and strengthening the cultivation of students' engineering abilities can we achieve the

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cultivation of high-quality composite engineering and technical talents who can solve practical engineering problems [3]. Therefore, it is particularly necessary to promote the reform of practical teaching by combining the theoretical and practical teaching of road and bridge and river crossing engineering majors.

At present, in the reform of practical teaching in undergraduate colleges, reforms have been mainly carried out in the construction of engineering training bases, strengthening cooperation with enterprises, academia, and research, as well as improving the team of practical teachers, and good reform results have been achieved [4][5]. However, for asphalt and asphalt mixture courses, due to their long teaching cycle and lack of practical links, it is difficult for students to deeply learn relevant theoretical knowledge, and they lack the practical operation ability of experiments, making it difficult to connect with engineering practice [6]. Through classroom teaching alone, students have difficulty understanding the design and performance of asphalt and asphalt mixtures, and do not have the ability to solve practical engineering problems. The "Asphalt and Asphalt Mixture" experiment is an important foundational course in the field of road and bridge engineering. This course plays an important role in students' systematic understanding and mastery of theoretical knowledge [7].

Experimental teaching is an important carrier for cultivating innovative spirit and practical ability. By using the combination of virtual and real methods, the breadth and depth of experimental teaching content are expanded, the time and space of experimental teaching are extended, and the quality and level of experimental teaching are improved [8]. The experiment of "asphalt and asphalt mixture" is a traditional experimental teaching project in the course of road construction materials. However, due to the long time and strong comprehensiveness, it is usually demonstrated by teachers during undergraduate teaching, and students watch or watch video animations to complete it. Students have fewer opportunities to hands-on operation [9]. This passive learning method is difficult to stimulate students' interest. In this context, conducting research and practice on the virtual reality combined teaching system for asphalt and asphalt mixture experiments not only improves experimental efficiency and saves teaching costs, but also deeply changes teaching concepts and methods, which is of great significance for cultivating students' professional practical and innovative abilities.

2. Introduction to the Experimental Course of "Asphalt and Asphalt Mixtures"

The "Asphalt and Asphalt Mixture" experiment is a fundamental course in studying the performance technology of asphalt pavement materials [10]. Through courses and experimental teaching, students can understand the technical performance and testing methods of asphalt pavement materials, explore the relationship between the internal composition and technical performance of materials, and master the technical performance and improvement methods of materials.

Basic requirements for experimental teaching of "asphalt and asphalt mixture":

1) Understand the structure, function, operating procedures, and metrological calibration methods of the main experimental instruments;

2) Understand the testing methods for the technical performance of commonly used asphalt pavement materials and master the testing methods;

3) Master the design methods of asphalt mixtures;

4) Master the processing methods of experimental data.

3. The Experimental Teaching Model of Combining Virtual and Real

3.1 Objectives

The objectives to be achieved in this study are as follows. Firstly, in conjunction with the transformation and upgrading of majors in the context of Emerging Engineering Education, we aim to enhance professional vitality and cultivate high-quality road engineering talents. Secondly, Enrich teaching resources: Through the combination of virtual and real, stimulate students' interest in learning and improve their understanding of professional knowledge.

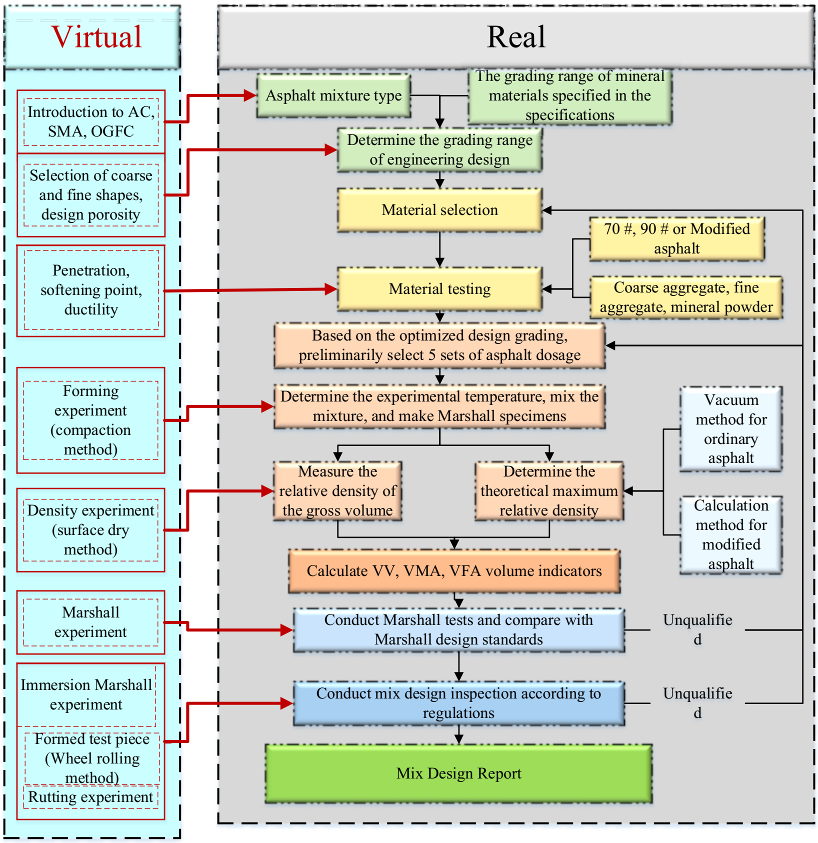

Figure 1. Research content on the combination of virtual and real

3.2 Research Contents

This study adheres to the principle of "combining virtual and real, and complementing each other", and takes the design of dense asphalt concrete mix proportion as the main line [11], as shown in Figure 1. Starting from several major modules such as virtual simulation overall design, material selection and testing, specimen forming and testing, interaction and assessment design.

4. Experimental Cases of "Three Major Indicators of Asphalt"

4.1. Penetration Experiment

4.1.1 Purpose and Scope of Application

Suitable for measuring the penetration of road petroleum asphalt, polymer modified asphalt, and liquid petroleum asphalt distillation or emulsified asphalt evaporation residue, measured in 0.1mm. The standard experimental conditions are temperature 25 ℃, load 100g, and penetration time 5s.

The penetration index PI is used to describe the temperature sensitivity of asphalt. It is recommended to measure the penetration at three or more temperature conditions such as 15℃, 25℃, and 30℃, and calculate it according to the specified method. If the penetration at 30℃ is too large, 5℃ can be used instead. The equivalent softening point T_{800} is equivalent to the temperature at which the penetration of asphalt is 800℃, used to evaluate the high-temperature stability of asphalt. The equivalent brittleness point $T_{1.2}$ is the temperature equivalent to a penetration of 1.2 for asphalt, used to evaluate the low-temperature cracking resistance of asphalt.

4.1.2 Experimental Methods

1) Preparation

- Prepare the sample, adjust the constant temperature water tank to the required experimental temperature
- Inject the sample into the test mold, with a height exceeding 10mm of the needle penetration value, and cover the test mold
- Cool in air for 1.5 to 3 hours, then keep it warm for 1.5 to 3 hours in a water tank at a test temperature of ±0.1℃, adjust the penetrometer to be level

2) Procedure

- Place the test mold on the instrument tripod, with a water depth of no less than 10mm above the surface of the sample
- Slowly lower the connecting rod, coarse bar → fine adjustment, just make contact and return to zero
- Press the release button, the timing and standard needle drop start simultaneously, and automatically stop at 5 seconds. The schematic diagram of the penetration experiment is shown in Figure 2.
- Read the displacement value of the display window, accurate to 0.1mm
- At least three parallel tests shall be conducted on the same sample, and the distance between each measuring point and the edge of the container shall not be less than 10mm. The temperature should be accurately controlled during each test, and the standard needle should be replaced or wiped clean during each test
- For samples with a needle penetration greater than 200, use at least three standard needles. After each test, leave the needles in the sample until the test is completed and removed

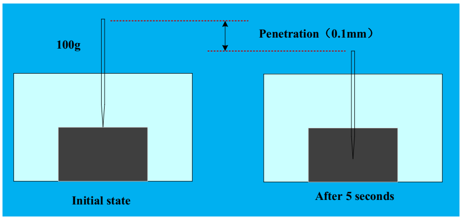

Figure 2. Schematic diagram of penetration experiment

4.2. Softening Point Experiment

4.2.1 Purpose and Scope of Application

Suitable for measuring the softening point of road petroleum asphalt and polymer modified asphalt, as well as the softening point of liquid petroleum asphalt, coal tar asphalt distillation residue, or emulsified asphalt evaporation residue.

The softening point is an indicator reflecting the thermal stability of asphalt materials and a measure of asphalt viscosity.

4.2.2 Experimental Methods

1) Preparation

- Place the sample ring on the base plate coated with isolation agent, inject asphalt into the sample ring, and fill it slightly higher than the inside of the ring surface; Slightly raised for easy scraping of the mold
- Cool at room temperature for 30 minutes and scrape flat with a hot scraper, as shown in Figure 3

2) Procedure

- Place the sample together with the base plate in a water tank at 5±0.5℃ for 15 minutes, while placing the bracket, steel ball, and positioning ring in the same water tank
- Inject distilled water that has been boiled and cooled to 5℃ into the beaker, with the water surface slightly lower than the depth mark on the vertical pole
- Place the sample ring in the circular hole in the middle of the bracket and cover it with a positioning ring; Put the whole support into the beaker, adjust the water level to the mark, and keep the water temperature at 5±0.5℃
- Insert the thermometer through the center hole of the upper plate, so that the temperature measuring head is flush with the bottom of the sample ring
- Place the steel ball in the middle of the positioning ring, activate the electromagnetic stirrer, and start heating
- The sample gradually drops when heated, and the instrument automatically obtains the temperature value when in contact with the floor. The schematic diagram of the softening point experiment is shown in Figure 4

Figure 3. Scrape the softening point sample

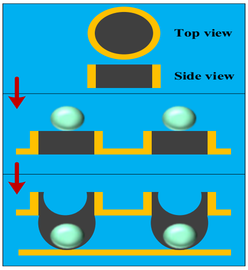

Figure 4. Schematic diagram of softening point experiment

4.3. Ductility Experiment

4.3.1 Purpose and Scope of Application

Suitable for measuring the ductility of materials such as road petroleum asphalt, polymer modified asphalt, liquid petroleum asphalt distillation residue, and emulsified asphalt evaporation residue.

The test temperature and tensile rate for asphalt ductility can be used according to requirements. The commonly used test temperature is 25℃, 15℃, 10℃ or 5℃, and the tensile rate is 5±0.25cm/min. When using 1±0.5cm/min for low temperature, it should be noted in the report.

4.3.2 Experimental Methods

1) Preparation

- Mix glycerol and talcum powder in a ratio of 2:1 by mass and apply a evenly mixed isolation agent to the inner surface of the base plate and copper mold, and then assemble it
- The asphalt sample is injected back and forth from one end of the mold to the other end, slightly higher than the mold
- After cooling the specimen at room temperature for 1.5 hours, use a hot scraper to scrape it flat and place it in a constant temperature water bath at the specified temperature for 1.5 hours, as shown in Figure 5

2) Procedure

- After curing, remove the test piece from the bottom plate, place its two ends on the metal columns at the sliding plate and groove ends, and remove the side mold. The water surface should be no less than 25mm from the surface of the test piece
- Start the ductility tester and observe the extension of the sample carefully
- When the specimen is pulled apart, read the reading on the display screen in cm, as shown in Figure 6

Figure 5. Scrape the ductility sample

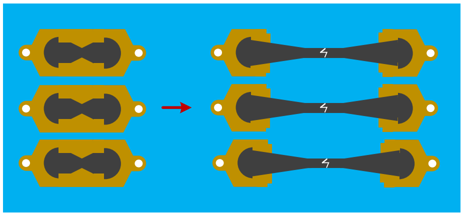

Figure 6. Schematic diagram of ductility experiment

4.4 Case Analysis

According to the basic architecture of the experimental teaching system that combines virtual and real elements, different methods of combining virtual and real elements are designed for each experimental project according to the experimental teaching content, teaching methods, and equipment. Take the experimental project of "Three Major Indicators of Asphalt" as an example to elaborate in detail.

The "Three Major Indicators of Asphalt" experiment is a key experimental project for evaluating asphalt materials, involving the grading, high and low temperature performance of asphalt materials [12][13]. In the experiment, students can learn to use instruments and equipment correctly, master various testing methods, understand relevant engineering concepts, and obtain experimental skill training based on the experimental principles.

The first level requirement of the experiment is to measure the basic properties of asphalt materials provided by the laboratory. The second level requirement is to improve the experimental plan or method in order to minimize the error of the experimental data as much as possible. The third level requirement: if encountering abnormal test data, it is necessary to analyze whether the data is incorrect or within a reasonable range through the material synthesis mechanism, and study how to obtain the required performance of the material by adjusting the formula reasonably.

The teaching implementation process mainly includes three parts: first, pre-experiment preview, through the provided materials and virtual simulation experiments. The second is to conduct on-site experimental testing, where students select appropriate instrument settings in the laboratory based on pre class preparation to correctly complete material performance testing. Finally, it is necessary to complete the experimental summary and write an experimental report, which also includes discussions on the thinking questions proposed by the professor to further stimulate students' thinking.

5. Improvement of Teaching Methods

1) Reasonably arrange teaching content

Regarding the existing teaching materials on asphalt and asphalt mixtures, reduce the amount of theory appropriately and focus on practice. Update and supplement some content during teaching. For example, in response to the rapid changes in norms and standards, when understanding new norms and provisions, consult information to update knowledge. On this basis, the content of each chapter in the original textbook is screened, and the new norms and standards are integrated into the teaching, explaining the purpose and implementation methods of the modifications to students [14].

2) Adopting multimedia teaching

In the case of limited teaching hours, teaching more content within the specified time will inevitably result in teachers being overwhelmed, students not having time to think, and difficult to accept. The use of multimedia and a combination of virtual and real teaching methods can solve this problem. For example, collecting a large amount of materials such as photos, videos, and design drawings. [15].

3) Combining engineering case teaching to guide students to actively learn

In the teaching process, change the teacher centered cramming teaching method and replace it with a heuristic, and self-learning discussion based active teaching method model of "student-centered, with ability development as the goal", thus turning students into active and active knowledge explorers. For example, in the news, it was reported that a large area of asphalt pavement had been damaged several months after being paved. During the teaching process, relevant news reports and on-site pictures were first displayed to students, and then combined with the teaching content, students were guided to discuss the cause of the accident. Finally, the teacher came to the conclusion. [15].

4) Excellent students participating in scientific research projects

Not only graduate students, but also outstanding undergraduate students can enhance their understanding of asphalt and asphalt mixture majors by participating in scientific research. Integrating research projects into undergraduate teaching and involving some interested outstanding students is of great benefit in enhancing the understanding of asphalt and asphalt mixture professional knowledge and understanding the forefront of the discipline.

5) Change the course assessment method

Traditionally, asphalt and asphalt mixture courses are mostly assessed through closed book exams. The drawbacks of this assessment method are obvious. Students will adopt a rote memorization approach and ask the teacher about the scope of the exam. By using course papers or experimental reports for assessment, students will have enough time to think and search for information, allowing them to fully understand the knowledge points.

6. Conclusion

1) The paper aims to reform teaching methods and models, and embrace the multiple strategic opportunities and challenges of professional development with a holistic approach of "Emerging Engineering Education", providing strong talent protection and intellectual support for the upgrading of the transportation industry and social development.

2) The combination of virtual and real can effectively solve the problems of high cost and energy consumption, long time consumption, and difficulty in conducting traditional experiments. In the process of combining virtual and real, the guidance of educational theory was taken into account.

3) This study is a practical application of the "Emerging Engineering Education" reform in the field of road engineering, which can enhance professional competitiveness and enhance students' employment practical abilities. At the same time, it has certain reference significance for the talent cultivation mode and practical teaching reform of other engineering majors.

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