

Large Storage Tank Structure Design Cases-Based Teaching in Teaching Reform for Major of Oil & Gas Storage and Transportation Engineering

Yanfei Chen* Heng Ni Hong Zhang Fuheng Hou

China University of Petroleum (Beijing), College of Mechanical and Transportation Engineering, Beijing, 102249, China

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ABSTRACT

As one of the compulsory courses of oil and gas storage and transportation engineering, “Strength Design and Safety Management of Storage and Transportation Facilities” is a comprehensive course of both practicality and theory. In order to solve the unbalanced distribution of theoretical and applied content in the teaching process, the teaching team reformed the teaching mode of the structure design of large storage tanks in the course of “Strength Design and Safety Management of Storage and Transportation Facilities” and introduced case-based teaching. On the basis of the original course, practical engineering case analysis such as wind-induced buckling of large storage tank and uneven settlement of tank foundation was added, which increased the proportion of application content. It is a new type of discussion teaching integrating case collection, group discussion and after-class experience exchange. According to the recent three years of teaching practice, students’ interest in this course has increased greatly and teaching quality has improved significantly, which fully verified the feasibility of engineering case-based teaching in teaching reform. The teaching team has gradually improved the teaching process according to the relevant experience and lessons in classroom practice and made a successful attempt in the teaching reform of storage and transportation structure safety courses, which is of positive significance for training application-oriented composite talents with the ability to solve practical problems in the new era.

1. Introduction

In the ever-changing 21st century, the traditional teaching methods no longer meet the needs of current teaching. In the past education mode, the classroom always takes the teacher’s teaching as the center, while the students passively acquire knowledge, that is, the single “transmission -acceptance” teaching method. This kind of traditional teaching method cannot fully arouse students’

learning initiative and enthusiasm, easily make students lose interest in the course and even have the emotion of rejection, which affects the learning efficiency and classroom atmosphere to a certain extent. With the deepening of the reform of the teaching system in universities, it is important for teachers to focus on the improvement of students’ interest in classroom teaching and how to improve the teaching quality^[1].

*Corresponding Author:

Yanfei Chen,

China University of Petroleum (Beijing), College of Mechanical and Transportation Engineering, Beijing, 102249, China;

E-mail: 2562275375@qq.com.

On the basis of traditional teaching mode, case-based teaching introduces some typical engineering cases suitable from actual projects. With engineering design problem as the guide, case-based teaching can fundamentally cultivate students' ability to find problems and solve practical problems. At the same time this can enhance students' interest in the subject and form a virtuous circle^[2]. "Strength Design and Safety Management of Storage and Transportation Facilities" is a new compulsory course for the oil and gas storage and transportation engineering major of China University of Petroleum (Beijing). In this course, the design method of vertical cylindrical steel welded storage tank is introduced in detail. In the previous courses on the tank design, the students' knowledge is often fragmentary. For example, the third chapter of the course "Oil and Gas Storage and Handling System" explains the types and accessories of storage tanks, but it is difficult for students to have an overall and deep impression on the storage tanks only through the tank appearance diagram and accessories given in the courseware; In the course of "Strength of Pipeline and Tank" set up for sophomore, students just mastered the design methods of wall thickness and wind resistant ring, and lack of explanation of relevant design cases, which leads to students' lack of a clear concept for the overall structural design of storage tanks. In view of the above problems, the teaching reform of the course "Strength Design and Safety Management of Storage and Transportation Facilities" has been carried out. In the course, the design of large storage tank, wind-induced buckling, prediction of uneven settlement of tank foundation, seismic analysis and other practical engineering cases closely related to the construction of large oil storage tank were included as auxiliary teaching. The arrangement of specific engineering cases is shown in Figure 1.

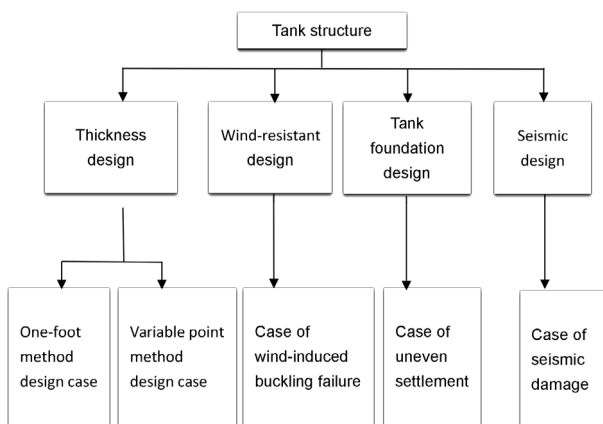


Figure 1. Schematic diagram of engineering case arrangement of large storage tank

Through teaching practice in recent years, the role of case teaching method has been fully reflected. Through a series of links, such as selecting actual cases according to the teaching content, deeply analyzing cases and compiling teaching plans, group communication and discussion, and after-school achievement display and sharing, the students' participation is improved to the greatest extent and the classroom flipping is realized. Moreover, it can make students more fully digest and absorb the content learned in the classroom and cultivate students' ability to solve practical engineering problems with the theory. The effective data of teaching evaluation in recent three years shows that the students who are "very satisfied" with the case teaching mode adopted in this course account for 98%. Compared with 45% of the satisfaction of the traditional teaching mode. Obviously, the case teaching method is more popular with students. From the teaching results, the average failure rate of this course in recent three years is only 2%, which is far lower than other compulsory courses. This fully shows that the new teaching mode with engineering cases can effectively improve the teaching quality and learning effect, stimulate students' interest in tank structure design and mobilize their learning initiative. Interest is always the best teacher. The teaching team of "Strength Design and Safety Management of Storage and Transportation Facilities" takes the opportunity of undergraduate course teaching reform, introduces new teaching mode, and establishes the teaching route from actual engineering cases to complex engineering problems. In recent years, teaching practice has fully verified the feasibility of case-based teaching in structural design of large storage tanks. This teaching method is widely used in oil and gas storage and transportation safety courses or other professional courses. It is of great significance to cultivate innovative talents of new oil and gas storage and Transportation Engineering in the new era^[3-5].

2. Discussion Teaching of Wind Resistant Structure Design Combined with Wind-Induced Buckling Failure Cases of Large Storage Tanks

For a series of storage and transportation structure safety courses including "Safety and Integrity Management of Oil & Gas Storage and Transportation Engineering Facility" and "Strength of Pipeline and Tank", students generally think that there are too many formula theories, and a large number of formula derivation and complex theory make them intimidated. After class examples are often divorced from the simplification of practical engineering,

so students often do not have a deep understanding of relevant content. In order to fundamentally improve the students' interest in learning, the teaching team explored the teaching mode of case discussion in class and advocated autonomous learning, training students' ability to think deeply and solve engineering problems. As a course of storage and transportation structure safety, the "Strength Design and Safety Management of Storage and Transportation Facilities" needs to be reformed urgently. Therefore, the teaching team carried out a case-based teaching reform of large storage tank structure design. This teaching mode focuses on the wind-induced buckling failure cases of storage tanks in eastern coastal areas of China and other countries under strong natural convective weather and carries out a special discussion on the key wind resistant structure design of storage tank. Combined with thin shell theory, the wind-induced buckling mechanism is studied in depth. Students are guided to carry out the design work of wind girders, angle steels and other tank accessories according to the design specifications of large storage tanks in different countries^[6]. The buckling analysis of the tank was carried out by self-learning finite element analysis software^[7]. Then, based on the above-mentioned knowledge, the failure causes are analyzed in depth from the cases of static wind buckling instability. After consulting the relevant data, the group discusses and analyzes how to draw lessons from the cases of instability failure, and puts forward meaningful improvement methods. Through the reform of the case-based teaching mode, the course theory is closely combined with the design, construction and management of large storage tanks. The purpose of this course is to improve the quality of students' study and application.

3. Case-Based Teaching Combined with Safety Assessment of Tank Structure with Uneven Settlement

Traditional classroom teaching focuses more on the role played by teachers, and the lack of communication with students in terms of teaching content and methods as well as the different acceptance ability of students lead to the fact that students' real needs cannot be reflected. In contrast, case teaching will give students more discourse power and autonomy in class, strengthen the communication between teachers and students, and let teachers truly understand the needs and ideas of students. Compared with the original traditional teaching methods, case-based teaching is more challenging for teachers. Teachers need to collect a large number of case materials according to the teaching objectives of the course, carefully read and

analyze, and then select practical engineering cases that are closely related to the theme and are introduced into the classroom teaching content. At the same time, it is also necessary to control the difficulty of the case to match the students' acceptance ability, so as to strengthen the students' innovation and application ability to the greatest extent. At present, compared with developed countries, China's oil strategic reserve is still very insufficient. With the continuous development of industrialization, not only China's energy demand is increasing, but also the oil import volume is increasing and the source is relatively concentrated. A sound petroleum strategic reserve system has been promoted to a strategic position. The continuous development of the national energy reserve marks a new stage of construction of large-scale crude oil depot. At present, oil tanks are developing in the direction of large-scale. Large oil tanks have the advantages of saving materials, reducing investment and occupying less land. Due to high construction and use costs, most of China's major crude oil storage tanks are located in coastal areas, where the soil moisture content is large. Because of the soil is soft and easy to be compressed, the construction of large storage tanks on the soft soil foundation has great risks. The strength of soft soil foundation is low, so the foundation of large storage tanks is easy to settle. The large fillet weld area at the bottom of tanks produces the stress concentration and even damage. When the tank deformation reaches a certain degree, the floating plate movement is blocked, which not only affects the normal operation of the tank, but also easily leads to more serious leakage accidents. The case of uneven settlement can be combined with the relevant contents of tank foundation design, and can also make full use of the theoretical basis of "soil compressibility" in geotechnical mechanics course. How to prevent foundation settlement and foundation design are organically combined to teach students. This part will carry out the following four topics: (1) the relationship between the compressibility of soil and the stability of tank foundation; (2) prediction method of tank foundation settlement; (3) safety evaluation method of storage tank under the condition of foundation settlement; (4) relevant measures to prevent foundation settlement^[8]. Under the background of building large-scale oil storage in soft soil area, students can understand the design and safety evaluation of foundation settlement through the course of "Strength Design and Safety Management of Storage and Transportation Facilities", which is of positive practical significance for carrying out scientific research in related fields in the future.

4. Case-Based Teaching Combined with Tank Design Specification

With various knowledge and complex theory, “Strength Design and Safety Management of Storage and Transportation Facilities” is an important compulsory course for oil and gas storage and transportation engineering specialty. Because it is a new course and teachers lack relevant teaching experience, the teaching process encountered many difficulties at the beginning. Teachers mainly use traditional teaching methods to teach, but neither class attendance nor final scores are satisfactory. An online anonymous questionnaire survey was conducted among undergraduates in grade 15. The results show that nearly 70% of the students think that the course content is too theoretical and the teaching content is too abstract. Other students said they couldn’t keep up with the teacher in class and lost interest in learning. It can be seen from the anonymous questionnaire survey that due to the lack of fresh engineering practical application content, the students’ ability to accept pure theoretical knowledge is generally weak. Because of oil and gas storage and transportation engineering is a major with both theory and practice. In addition to a small number of graduates engaged in storage and transportation frontier theoretical research, most graduates will go to the front line to engage in the design and construction of pipelines, storage tanks and other storage and transportation facilities. However, in the current professional training program, there are few courses related to engineering specifications. The importance of standardized teaching is also ignored in the teaching of storage and transportation structure safety courses. Therefore, the teaching team summed up the experience and decided to introduce the engineering case-based teaching method. On the basis of teaching theory, combined with the relevant storage and transportation facilities design specifications, the proportion of practical engineering application content was increased and the engineering application ability of students was mainly cultivated, so as to lay a good foundation for their future design and construction work. In this course, different engineering codes are combined with the structural design of large storage tanks to explore the relationship between the American Petroleum Institute standard API650 and The Chinese national standard GB50341. For example, for tank wall design under static load, GB50341 design method is one-foot method, while API650 design code of the United States mainly applies variable point method. Variable-design-point method takes into account the interaction between adjacent panels of different thickness, which can make full use of the material potential although

the calculation is complicated. For these two different tank wall design methods, students can be actively guided to think about the mechanism and discuss the advantages and disadvantages of the two methods. Students are organized to investigate the application of the two codes in the design of large storage tanks by using Internet and other resources. The wind-resistant structure can also be taught in combination with the design norms of different countries, and seminars can be organized, so that students can have a deeper understanding of the similarities and differences of wind-resistant design methods in different norms. In the teaching arrangement of “Strength Design and Safety Management of Storage and Transportation Facilities”, we fully consider how to cultivate students’ autonomous learning ability. After understanding students’ learning ability, classroom needs and interests, we should arrange teaching content reasonably and customize teaching links, objectives and method. Create a good classroom atmosphere, really let students into the classroom and harvest^[9].

5. Conclusion

In the course of “Strength Design and Safety Management of Storage and Transportation Facilities”, part of the structural design of large-scale storage tanks is integrated with the actual cases in the current engineering, which can effectively improve the students’ ability to find and solve problems, mobilize the students’ subjective initiative, and effectively improve the quality of teaching. The data survey shows that “enhanced” process teaching has a high degree of classroom activity, and students are no longer passive recipients in the traditional teaching mode, but actual participants. From the simple to the deep, the first reason is that the knowledge structure is more reasonable and completely in line with the basic rules of cognitive things, which is conducive to the formation of students’ overall understanding of large storage tanks; Second, a large number of practical cases embody the original complex and abstract theory. The original mechanically stacked formula is more like telling a story in case teaching. Students can memorize knowledge points more vividly and deeply according to the clues described in the case; Thirdly, by optimizing teaching methods, this teaching method fully arouses students’ enthusiasm, which not only enables students to have a deeper understanding of classroom contents but also exercises students’ innovation and creativity to a certain extent. Although the case study method has achieved certain results in the course teaching, the improvement of teaching quality cannot be measured simply by the improvement of paper results. More samples are needed to observe and analyze the specific

effects of improving students' application ability and engineering literacy. In addition, the application of case-based teaching in the course of "Strength Design and Safety Management of Storage and Transportation Facilities" is only at the initial stage, and there are still some problems in the specific implementation of teaching methods, which still need to be continuously improved in practice. Such as the proportion of case teaching in the teaching content is still low. This is due to the engineering case teaching itself contains certain limitations. Case teaching is generally based on course selection of certain key content and the intention is to help students deepen the understanding of the course focus on knowledge. If only around a case for teaching, the whole course is not covered. Therefore, in the setting of classroom teaching, it is still carried out in the overall framework of the course, and some important chapters are interspersed with references to case teaching to assist the teaching. In this way, the invisible teaching arrangement also reduces the quality of case teaching and fails to achieve the expected effect. However, in general, the large storage tank structure design seminar teaching organically combined with practical engineering cases has positive significance for improving the application of the training mode of compound talents and improving the quality of undergraduate students. Practice has proved that it is feasible to implement case seminar teaching in class. The teaching team has made a preliminary attempt in the course of "Strength Design and Safety Management of Storage and Transportation Facilities" in the content of structural design of large storage tanks, hoping to play a role in attracting others and further promoting the case-based teaching in other courses of storage and transportation structure safety.

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