Finite Element Software Analysis of Engineering Structure Test and Teaching Reform of Integration of Production and Teaching

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Abstract. The reform of information teaching in civil engineering specialty is an inevitable result under the background of information age. The course of architectural structure is a very important course of civil engineering, and civil engineering is a very practical major. Most of the civil structure test work needs to be completed with the help of computer software analysis, the industry to civil engineering students software application ability requirements are increasingly high. How to carry out the finite element software analysis teaching of structural test has become the key to cultivate applied civil engineering professionals. It not only enables students to master the basic theory of building structure test, but also cultivates students' ability of test design operation and SAP2000 software to establish finite element model. In the teaching, sap2000 software was used to analyze the finite element model of concrete frame and string beam structure. In order to better complete the finite element software information teaching of this course, reform the teaching method, adopt the combination of online and offline teaching, and better apply the teaching method of the integration of production and teaching, put forward some targeted solutions.

Keywords: Teaching reform · Finite element software · Integration of production and education

1 Introduction

The integration of industry and education is the deep cooperation between industry and education. The integration of industry and education more closely combines industry practice with teaching and learning. The school has become a center of talent cultivation and a practical place of production for scientific research and cultivation. In his report to the 19th National Congress in 2017, the General Secretary put forward the idea of deepening the integration of industry and education. It is also mentioned in the Implementation Plan of the National Vocational Education Reform that enterprises should actively support the vocational education of Chinese students and focus on cultivating high-level, high-tech, skilled and high-quality talents. Therefore, vocational education in China is not only facing the old problems of continuing to strengthen industry-education

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integration and school-enterprise cooperation, but also facing the new task of how to promote the training of applied talents. We are very urgently aware of the importance of the integration of industry and education, and we have put forward a plan to promote the integration of industry and education.

2 The Necessity of Promoting the Integration of Industry and Education in Civil Engineering Structural Test

2.1 It is Conducive to Promoting the Healthy Development of Vocational Education

Vocational education is an important approach to cultivating high-skilled talents, and the development of our country more from a large number of skilled talents in high technology, high technology talented person is the pioneer of scientific and technological achievements into real life, science and technology thought idea into reality, cannot leave the efforts of high-tech talent, innovation of science and technology experts is extremely valuable spiritual and social wealth, Highly skilled people also play an irreplaceable role. They turn ideas into reality and have strong creativity. Both of them are the talents that our country needs in the journey of building a great modern socialist country. Therefore, colleges and universities set up a strong practical major on the knowledge of students, quality also put forward higher requirements. The training idea of "integration of production and education" is in line with this way of training high-skilled talents, and colleges and universities should vigorously support and promote it.

2.2 It is Helpful to Stimulate Students' Creativity and Innovation, and Create Conditions for Students to Combine Theory with Practice

Colleges and universities establish and develop majors related to production practice, and carry out teaching methods into learning. This teaching system provides students with good practice conditions and rare opportunities for exercise. In the courses of study related practice, students in the teacher's leadership, under the guidance of professional, apply the professional knowledge of the teacher has taught into practice, so that the students have a more profound understanding of basic specialized knowledge, and more enhanced skillfully use this professional knowledge to solve the problems in the actual situation in this major. Moreover, the combination of production and education will stimulate the potential creativity of students, and encourage students to make continuous progress and innovation in practice, which is more conducive to their future development. Such innovative thinking, innovative ability and innovative talent cultivation exactly meet the development of the school, the industry and the country [1].

3 The Current Situation of Our SCHOOl's Civil Engineering Structure Experiment to Promote the Combination of Production and Education of Online and Offline Mixed Information Teaching Reform

3.1 The School Promotes the Integration of Industry and Education

Changchun Institute of Technology at present belongs to the people's government of Jilin province, the architectural college of Changchun, Changchun industrial college, Changchun college of hydraulic and electric engineering, three national excellent college merge and become, is a key technology is given priority to, and the fusion tube, arts, the sciences, arts disciplines province-owned universities. Since several junior colleges are national excellent junior colleges with 50 years of running experience, Changchun Institute of Technology, on the basis of integrating the advantages of these schools and combining with its own characteristics, presents a diversified development trend of these disciplines.

Application-oriented undergraduate education has played a very positive role in promoting China's economic and social development. It has also cultivated a lot of highly skilled talents for our country, and played a positive role in meeting the needs of high-level application-oriented talents and promoting China's higher education to the Chinese people. Therefore, the school attaches great importance to students' practical courses, and constantly strengthens the implementation of student-centered integration of production and education.

Since mergers create, gradually establishing basic computer learning training center in the university, and engineering skills training base, advanced high-tech technology training center, the power system simulation training bases, civil engineering construction Training Center, modern business simulation training practice base and management engineering internship training base and so on 10 campus practice training center, In addition, there are 131 off-campus practice training bases for students' practical training, 84 of which are in normal operation, providing students with learning convenience. There are also 4 practical training demonstration centers of Jilin Province level, which provide practical places for students' study and life.

3.2 Mixed Online and Offline Teaching

Information-based teaching can not only improve teachers' application level of information technology, update teaching concepts, change teaching methods and improve teaching effects, but also encourage students to use information technology to learn independently, enhance the ability to analyze and solve problems by using information technology, and improve students' comprehensive literacy. Information-based teaching can also break the barriers between school and society, realize complementary advantages, learn from each other, strengthen the adaptability of students.

The training of applied talents also needs to strengthen the training of professional core competence, so the training curriculum system is very demanding. For civil engineering majors, courses in building structures include analysis and testing of building

structures, so this course requires high practical ability, and it is particularly important for vocational ability training. Therefore, how to make students learn this course well is very important. For this course, the blended teaching method of MOOC online and BOPPPS offline is adopted. Finally, students can master the relevant knowledge of systematic structural design, have the ability to solve architectural structural design problems, determine the layout scheme of various structures according to the needs, and conduct structural analysis. The teaching method is for students to watch MOOC videos in advance to preview what they have learned, make notes and upload them for the teacher to check. Discuss in groups, find cases related to what you have learned, and summarize them. Finally, the results of this class are tested by in-class tests. Through these teaching methods in class, we have cultivated the good learning habits of teamwork and self-disciplined learning among students. Students establish a good thinking mode of finding problems actively. A very important part of this course is the experiment of building structure. This course has strong practical ability. After years of teaching experience, the course teaching process has been a complete set of teaching process [5].

For example, an important experiment in this course is to test the compressive strength of concrete with the rebound instrument method. When teaching students about this experiment, teachers will clearly tell students about the basic knowledge of the experiment. Students divide the test area according to the relevant principles. When students measure, make the axis of the rebound instrument always perpendicular to the component plane. Students bounce back 16 times for each test area. Test the depth of concrete carbonation layer after students rebound. The test Angle is corrected first, and then the test surface is corrected. According to the measured depth of carbonation layer and the corrected rebound value, the strength values of each test area can be obtained from the table. The average strength value of concrete of structure or component can be calculated from the strength value obtained from the table in each test area [6].

As shown in Table 1 Rebound data. The first three values in the table are the minimum values, and the last three values are the maximum values. In the process of data processing, three minimum values and three maximum values are removed from the 16 rebound values, and the remaining 10 average values are taken.

The rebound instrument method mainly uses the mutual relationship between the strength of concrete and the surface hardness to indirectly test the strength of concrete by the method of testing the surface hardness of concrete. Figure 1 shows the test of rebound Angle regulator. The teacher will tell the students how to use the rebound instrument is very important, in the use of the spring rod has been extended against the concrete test area, light pressure cap tail, then measured the rebound value of this area. Teachers often tell students that these are basic experimental operations, and this test method is often used in engineering practice. Therefore, students must master such basic experimental skills, which is more conducive to the students to integrate into the enterprise practice as soon as possible. Our school also constantly encourages innovative experiments. Our teachers lead students to form research groups to carry out research projects, so as to open up our students' innovative thinking and promote the development of the whole civil engineering industry. After finishing the experiment, the teacher will tell the students that it is also very important to fill in the experiment report, which records the experimental data of the experiment done by the students. However, in the traditional teaching mode

Table 1. Rebound data

Serial number	Rebound record				
1	39	47	45	39	38
2	40	50	49	40	40
3	43	52	50	45	44
4	45	54	52	46	46
5	58	56	54	48	49
6	58	56	56	56	50
7	58	56	58	58	52
8	58	58	58	58	52
9	58	59	58	59	56
10	59	59	58	59	56
11	60	60	58	60	58
12	60	60	58	60	58
13	60	60	58	61	59
14	60	60	58	61	60
15	60	60	60	62	60
16	60	62	60	62	60
Mean value	59.3	59.4	58.4	60	57.1
Strength of presumption (Mpa)	55.1	55.2	53.4	56.4	51

Note: Table source: The data comes from the architectural structure course example of Civil engineering major of Changchun Institute of Technology

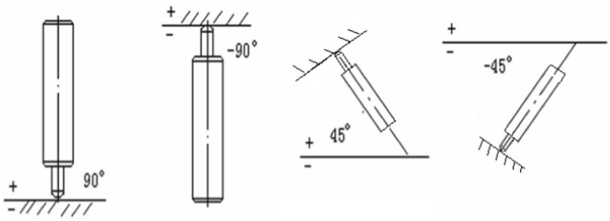

Fig. 1. The regulation of the Angle of rebound instrument test. Note: Picture source: The picture is from the teaching plan of Civil Engineering major Architectural structure course of Changchun Institute of Technology.

of our school, our students are learning mechanically, filling in and writing exactly what the teacher says, which also loses the original purpose of doing experiments. If we want to make progress and development, we need to break the traditional inherent mode, according to each group's own experimental procedures and methods to write experimental reports, to truly reflect the results of their own experiments.

3.3 sap2000 Software Finite Element Model Analysis

Due to the limitations of test scale, test site, equipment capacity and test funds, the vast majority of structural test objects are using structural models. As computers become more powerful, finite element analysis, which used to be done with servers, can now be done with cheaper personal computers and even portable laptops [9]. As an important auxiliary means of engineering, finite element analysis has become an easy tool for engineering and technical personnel and even students. At present, the graduation design of civil engineering major in China is centered on information, innovation, engineering application and other directions, and these are inseparable from the application of civil engineering computer software. With the deepening of finite element concept in universities and design institutes, both students, teachers and designers will inevitably come into contact with or use finite element software in daily life. The most basic concept of finite element method is to solve the problem of seismic performance by dividing the object of analysis into finite modules, as shown in Fig. 2, components in the finite element model are divided into grids, then these small blocks are analyzed and the results are combined to find a solution for the entire building structure.

Students use sap2000 software to conduct pushover analysis and time history analysis of the structure. Through the analysis of concrete frame structure, Fig. 3 shows the structural model of SAP2000 concrete frame. Pushover method and time history analysis make designers understand the response of structure under earthquake to a certain extent, and find the weak link in the structure.

SAP2000 software has an integrated user interface. Model establishment, analysis, design and result display are carried out under a unified interface. It is suitable for students who are new to finite element software and can establish good spatial imagination and structural analysis ability with the help of this software [10]. When the SAP2000 software is used to model the seismic load analysis of the concrete frame, the results of modal analysis and response spectrum analysis can be quickly obtained by using the linear static analysis method, and the shear force and bending moment of the section of each member of the frame can be calculated, and the SAP2000 software can be used to determine whether the section of the member meets the bearing capacity requirements. Figure 4 shows the bending moment diagram of the column. At the same time, the SAP2000

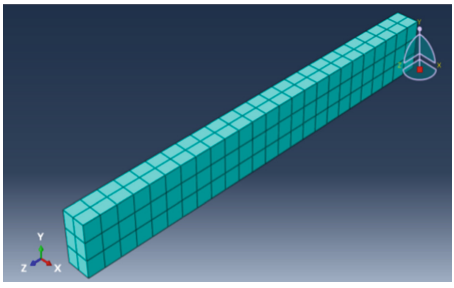

Fig. 2. Mesh of components in finite element model. Note: Picture source: The picture is from the structural engineering students Structural software course assignment report of Changchun Institute of Technology.

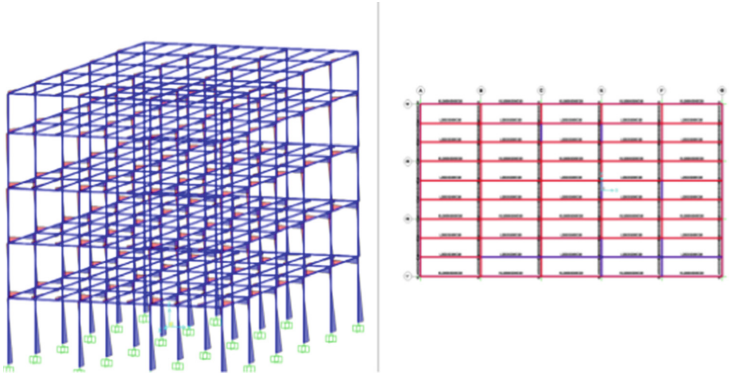

Fig. 3. Sap2000 software concrete frame structure analysis. Note: Picture source: The picture is from the structural engineering students Structural software course assignment report of Changchun Institute of Technology.

software can check the design of the structural member according to the Chinese code, and get the member that does not meet the requirements of the code [7].

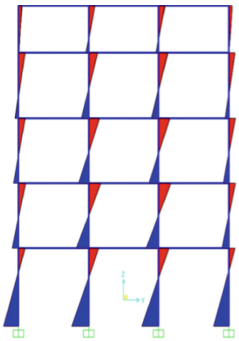

Fig. 4. Bending moment diagram of column. Note: Picture source: The picture is from the structural engineering students Structural software course assignment report of Changchun Institute of Technology.

Table 2. Internal force data of a position of frame under different working conditions

Working condition	Qy	Qx
Position (Relative to both ends)	Node179 (0m)–158(2.4m)	Node98 (0m)–122(8m)
Maximum shear value V2	77KN(at2.4m)	33.673KN(at8m)
Maximum bending moment M3	−277.5245KN.m(at2.4m)	134.8484KN.m(at2.4m)
Maximum deflection value	−0.000162m(at1.44m)	0.001467m(at1.5m)

Note: Table source: The data comes from the structural software course assignment report of structural engineering students in Changchun Institute of Technology

In the SAP2000 software, drawings can be drawn by CAD and imported into the SAP2000 software for the modeling and analysis of steel structures. Moreover, the modeling of SAP2000 software can observe the deformation and load of structures from a 3D perspective. The three-dimensional image view effect enhances students' understanding of course knowledge. Figure 5 shows the CAD model imported for modeling analysis.

A middle school comprehensive experimental building project five floors on the ground, 19 m high, the main functions of the building for laboratory, classroom, lecture hall; There is a basement under the ground, and the main building functions are parking garage, equipment room and air defense basement. String beam structure is located in the multifunctional lecture hall area on the fourth floor of the laboratory building. CAD drawing model, and then the upper string, lower string, strut, purline in turn into SAP2000 software. PE cable with software defined material Q345 and 1670. Define the cross section as the strut H300x300x12x20 lower string H400x300x12x30 purline H500x200x10x12 upper string H500x400x14x35. After defining the material and section, select the object group, and specify the upper chord, lower chord, strut frame section and material in turn. Define the cable section and draw the cable with the default Settings. Because the situation of the support is not easy to judge, it is first analyzed according to the assumption that both ends are fixed and one end is sliding. The main internal function of the girder is prestress, and the external load is dead load, live load and temperature load. Dead load: In order to more clearly reflect the influence of load application sequence on the calculation of string beam structure, dead load is divided into two parts: structural dead weight and external permanent load. Temperature load: According to the local meteorological data, the closing temperature of the steel structure of the awning is 15 ± 5 °C, and the temperature difference is mainly 35 °C. Considering the above meteorological data, the closing temperature is assumed to be 20 °C, and the temperature difference when considering use is ± 30 °C. Two temperature loads of ± 30 °C are defined. Prestress: The effect of prestress in SAP2000 can be considered in terms of temperature load. Using the linear expansion coefficient of the material, the prestress applied to the cable can be simulated by cooling the wire cable unit. Figure 6 shows the finite element analysis of the model. Table 2 shows the internal force data of a certain position under different working conditions.

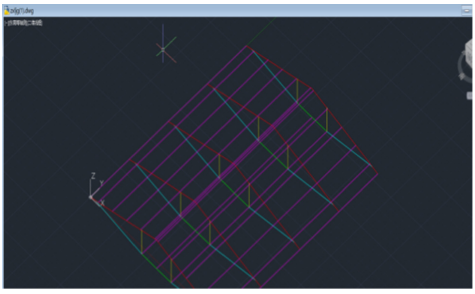

Fig. 5. CAD model of string beam structure. Note: Picture source: The picture is from the structural engineering students Structural software course assignment report of Changchun Institute of Technology.

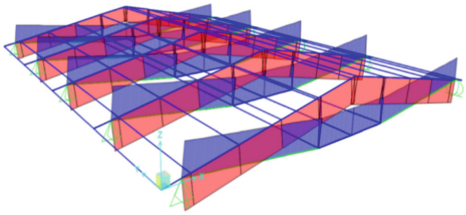

Fig. 6. Finite element model analysis of string beam structure. Note: Picture source: The picture is from the structural engineering students Structural software course assignment report of Changchun Institute of Technology.

3.4 Introduce Structural Design Competition for College Students to Improve Their Interest in Learning

The National College Students Structural Design Competition is a discipline competition with the highest recognition in civil engineering majors [8]. The competition aims to improve students' hands-on ability, cultivate their innovation ability and team consciousness, and enable students to "learn by doing" and "learn by doing". For students majoring in civil engineering, by participating in structural design competition, they can exercise their computer drawing and modeling ability, improve their ability to analyze and solve problems, and also exercise their practical ability, which will be helpful for future employment.

Since August 1, 2021, the teaching reform and practice of civil engineering structure experiment course of "Excellence Plan Class" in our school has been put into practice, and won the special prize in the 2019 Jilin University Students Structure Design Competition, and won the first prize in the research and application of complete set technology of prefabricated concrete structure in 2020.

Through the cooperation between schools and enterprises, the course content is connected with vocational practice, which is an important way to cultivate talents for application-oriented undergraduates. Through cooperation with enterprises, our school is more conducive to the development of students, the school and even the whole industry.

4 In View of the Civil Engineering Structural Test of Our School, the Corresponding Measures to Further Promote the Integration of Production and Education

4.1 Improve and Optimize the Teaching System

Through the combination of theory and practice to establish a scientific and reasonable modular curriculum system, and after the completion of phased learning skills assessment, to ensure that students master the operation, to better integrate into the development of the enterprise. Reform and practice should also be carried out in practice courses to better support the orientation of civil engineering "excellence Plan class" professional personnel training [2].

4.2 Improve the Professional Construction of Laboratory Personnel

No matter what industry or field, professionalism is always the most critical weapon to win. Laboratory related personnel must strengthen learning, requirements to achieve enough professional. At present, relying on the course of "Civil Engineering Structural Test" of "Excellence Program Class", and through the development of series of experiments, the laboratory construction is further promoted, and the professional ability and management level of laboratory teachers are improved [4].

4.3 The School Strengthens the Communication with the Enterprise

The main problem of the insufficient integration of production and education is that the connection between the school and the enterprise is not close enough. Because the two subjects are in different environments and do different work, there are great differences between the cultures, and the work practice is not comprehensive enough in the minds of students. Therefore, it is necessary to strengthen the communication and cooperation between the school and the enterprise. Schools can invite enterprises to preach on campus, or put the research projects of the research group into the practice work of enterprises [3].

5 Conclusions

Under the background of integration of industry and education, through school-enterprise cooperation, teaching content and work content are connected, and teaching process and production process are connected. Since the reform of curriculum teaching, the students' learning enthusiasm has been greatly improved, the learning effect has been significantly enhanced, and the unqualified students have been gradually reduced. In the follow-up study of relevant courses, students have shown a relatively solid theoretical knowledge and basic skills. The reform and innovation of architectural structure curriculum reform in the application of civil engineering teaching is the historical mission given to teachers in the information age. It is the requirement of new engineering teaching reform and information-based teaching to reform the teaching content of experimental application of building structure and to innovate its teaching mode and evaluation system. With the actual architectural structure test as the carrier, the teaching content of architectural structure test and its software is constantly enriched through the combination of online and offline teaching, and the teaching mode and teaching effect of the integration of production and teaching are constantly completed.

Acknowledgments. Jilin Province higher education teaching reform research topic. Teaching reform and practice of civil engineering structure experiment course in "Excellent Planning Class", Research on stable bearing capacity of concrete filled steel tube parabolic hingeless arch in plane. Project number: JJKH20180992KJ, 2021cit002.

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