Journal of World Architecture

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Study on the Principle Model and Simplification of Subway Station Itemized Energy Consumption

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Abstract: Owing to the constant modernization and urbanization of China, most cities have subways, and the total power consumption of subway stations has been rising, which contradicts with China's green goals. In this regard, energy consumption indicators for major energy use projects in subway stations should be established, comprehensive evaluation and detailed research on the current situation of subway operation should be conducted, and specific energy-saving measures should be taken from a diversified perspective. It is crucial to systematically sort out the principle of sub-item energy consumption in subway stations, and practice and explore the specific simplification measures of the principle model of sub-item energy consumption, so as to lay a solid foundation for achieving the goal of reducing energy consumption of subway stations.

Keywords: Subway station; Itemized energy consumption; Principle model; Simplified approach

Online publication: February 13, 2023

1. Introduction

Based on the actual operation characteristics of the main energy consumption systems in subway stations, this paper establishes a set of useful and detailed sub-item energy consumption principle models, including air conditioning, lighting, and vertical transportation system. By inputting the station operation and building name into the system, the rationality of the actual energy consumption of each sub-item of the system can be accurately calculated. Considering the large workload of data collection, the important parameters in the energy consumption model are extracted and integrated through sensitivity analysis, so that the model is effectively simplified, which help ensure that the actual engineering needs are fully met. The accuracy of the root mean square error variation coefficient of the corresponding energy consumption model of the simplified ventilation system, air conditioning system and vertical transportation system meets the standard requirements, which means it can not only greatly reduce the difficulty of data collection, but is also versatile. Besides, this model can also quickly and accurately evaluate the actual operation of the subway station and its energy-saving potential.

2. Principle model of subway station itemized energy consumption

2.1. Energy consumption principle model of ventilation and air conditioning system in subway station

The power consumption of ventilation and air conditioning system accounts for a large proportion of the total subway energy consumption. The corresponding energy consumption principle model is mainly composed of system energy efficiency model and cooling load model. The characteristic model of subway station mainly includes ventilation and air conditioning system, energy consumption and cooling load,

system energy efficiency ratio, operation time of ventilation and air conditioning system and other factors.

2.1.1. Cooling load model

As the subway station is usually underground, the solar radiation is negligible, and the soil temperature is relatively stable, which can keep the heat of the outer enclosure structure in a stable state all the time. The station cooling load is slightly affected by the heat storage factor of the maintenance structure, so the cooling load can be directly regarded as the heat gain. Generally, the cooling load of the ventilation and air conditioning system in subway stations mainly involves the following aspects:

(1) Personnel load

Personnel load mainly includes factors as personnel, total heat dissipation, number of people entering the station, number of people leaving the station, passengers' stay time in the hall when entering and exiting the station, and many more.

(2) Mechanical fresh air load

In the natural ventilation season, the metro station is cooled by mechanical fresh air. In the air conditioning season, the parameters of mechanical fresh air need to be considered, mainly including air density, air volume, outdoor and station air specific enthalpy difference and other elements.

(3) Fan temperature rise load.

The main influencing elements are few, that is, the actual operating power of the forced draft fan.

(4) Unorganized infiltration load

It mainly includes the unorganized air seepage volume entering the waiting hall from the entrance and exit of the subway station and entering the platform through the screen door, the specific enthalpy difference between the outdoor air and the platform air of the subway station, the specific enthalpy difference between the subway tunnel and the platform air, and other factors.

(5) Heat insulation of enclosure structure

It mainly includes heat transfer coefficient and heat transfer of safety door, subway tunnel temperature and platform temperature. In the process of calculating the heat transfer of the maintenance structure outside the station hall layer and the platform layer respectively, the platform layer is usually about 15 meters underground. The surrounding soil temperature can be considered constant and a steady-state calculation method can be adopted. The factors that affect the heat gain of the peripheral structure mainly include the area of the side wall and roof of the station hall layer, the burial depth, the monthly average temperature of the ground surface, the air temperature of the station hall, the distance between the concrete roof of the station hall and the ground surface, the heat transfer of the peripheral protective structure of the platform layer, the heat transfer coefficient of the wall surface, the thickness of the concrete, the soil thickness, the concrete thermal conductivity, the soil thermal conductivity, the area of the outer protective structure of the platform layer, soil temperature of constant temperature layer, and many more.

(6) The heat dissipation capacity of equipment in the station

The heat dissipation capacity of equipment in the station mainly includes vertical transportation system equipment, lighting equipment, display screen, ticket vending machine, ticket gate, and other factors. The cooling load generated by lighting equipment in the heat dissipation process is usually calculated according to its power. The heat dissipation capacity of vertical transportation system equipment is usually calculated based on the energy consumption model of vertical transportation system. The cooling load generated by the operation of other equipment is approximately calculated according to the corresponding power.

2.1.2. System energy efficiency model

In the air conditioning season, the energy efficiency of the ventilation and air conditioning system in the subway station mainly includes the efficiency of the heat sink and the air conditioning terminal, the distribution coefficient of cold water and cooling water, and the performance parameters of the chiller. In the natural ventilation season, the energy efficiency of the ventilation and air conditioning system in the subway station can be regarded as the energy efficiency ratio of the air conditioning terminal.

2.2. Energy consumption principle model of subway station lighting system

As natural light cannot be used for the lighting of underground space of subway station, the influence of lighting can be ignored in the process of calculating lighting coefficient, and the operation mode and operation power is stable. The influencing factors mainly include lighting power, lighting area, lighting system, and service time.

As the location of the subway station hall floor is usually 5-10 meters deep underground, there is little temperature fluctuation, which does not significantly affect the formation temperature. Therefore, the monthly average soil temperature can be used to calculate the energy consumption of the basement lighting system. The relevant factors include the area of the side wall and roof of the station hall, the buried depth of the underground, the monthly average surface temperature, the air temperature of the station hall, and the distance between the concrete roof of the station hall and the ground [1].

2.3. Energy consumption principle model of vertical transportation system in subway station

The influencing factors of energy consumption of vertical transportation system in metro stations mainly include vertical transportation system, actual operation power, and operation time of equipment. Generally, the subway vertical transportation system is divided into escalator and vertical elevator. Due to the obvious differences between the two in terms of working mode and energy consumption characteristics, it is necessary to establish models for calculation according to the actual situation [2].

2.3.1. Vertical elevator model

The vertical elevator under normal working condition is mainly divided into use mode and standby mode. In the use mode, the power consumption of a vertical elevator is high but the time of consumption is short. The specific working time is mainly affected by the number of train arrivals and the number of passengers. The relevant influencing factors include the number of times the vertical elevator runs after a single train arrives at the station, the number of train arrivals, the lifting height of the vertical elevator, and the rated running speed of the vertical elevator. In standby mode, the power consumption is low and the time of consumption is long. The specific waiting time is the total working time minus the working time in use mode [3].

2.3.2. Escalator mode

Generally, the escalator is mainly monitored by induction frequency conversion, there are sensors on the escalator that monitors whether there are passengers entering the escalator, and switches the signal mode based on the monitoring results. The working mode of escalator operated by induction frequency conversion control mode mainly includes rated speed no-load mode, low speed control mode and rated speed loaded mode, which are divided into two states: up escalator and down escalator.

As for the up escalator, during peak hours, a crowd passengers get out of the train and then take the escalator to leave the station. When passengers take the escalator, the operation mode of the escalator is mainly at rated speed with load. After the passengers have left the escalator for some time, the running mode of the up escalator becomes low-speed no-load. In this process, the specific running time of the rated

speed loaded mode of the up escalator mainly depends on the number of single underground arrivals and the density of single passenger alighting. The specific running time of rated speed loaded mode mainly depends on the switching time of the mode. The actual operation time of low-speed no-load mode mainly depends on the time interval of subway arrival [4].

For the down escalator, the energy consumption calculation method is highly similar to that of the up escalator, and the specific difference is mainly the number of switching operation modes. The entry status of subway station passengers is relatively scattered. Suppose that when passengers enter the station in batches, the down escalator will transport the next batch of passengers after transporting one batch of passengers. However, when the time interval between escalator operation mode switching is significantly lesser than that between two batches of passengers, after the first batch of passengers are transported, the escalator operation status will automatically switch to low-speed no-load mode, otherwise it will not switch. According to the calculation of the total number of people entering the station in a fixed period and the number of people entering the station continuously, the number of passenger batches transported by the down escalator can be obtained [5].

3. Simplified version of principle model of sub item energy consumption in metro station

3.1. Sensitivity analysis

Through the detailed analysis of the principle model of sub-item energy consumption in metro stations, the energy consumption calculation method of main systems can be determined in combination with the actual operation of metro stations, which can not only effectively evaluate the energy-saving operation status of each system, but also tap its energy-saving potential. However, in the relevant models, the way to input parameters is highly complex, which will lead to an increase in the workload of field research and data collection and cannot be effectively implemented in actual work. Therefore, the actual energy consumption principle of the ventilation system, lighting system and vertical transportation system of the subway station should be determined to simplify the model, so as to ensure that the relevant model can be applied to any subway station on a large scale, and so that the energy-saving operation evaluation and energy-saving goals can be effectively achieved [6].

Sensitivity analysis is mainly carried out by using a quantitative method to deal with the impact of input on the output, accurately identify the influential parameters, and effectively simplify the energy consumption model by defining the input parameters that can be fixed in any value range within a specific distribution area without affecting the final results. The sensitivity analysis is used to process the energy consumption models of the air conditioning and ventilation system, lighting system, and vertical transportation system of the subway station, which sorts out relevant parameters, ensure that only a few parameters are input into the system, and many sensitivity indicators can be obtained, and most of the input parameters will not affect the accuracy of the model output results [7].

3.2. Research on model simplification

In the process of sensitivity treatment of the simplified energy consumption model of the ventilation and air-conditioning system, there are many input parameters, mainly including environmental parameters in the station, passenger flow, equipment parameters, building information, and many more. In all parameters, when a small number of detailed investigation parameters are input for sensitivity test, other parameters adopt the social average value, and the mean square of the simplified model is used as the standard. After reasonably increasing the detailed investigation parameters for sensitivity testing, the investigation parameters adopting social average values will be reduced, and the root mean square value of the simplified model will not change much compared with the standard [8].

For example, there is a large temperature difference between winter and summer in some places. In

the process of sub-item energy consumption test for a 2-floor standard island subway station, the principle model and simplified model are respectively used to simulate the energy consumption of the air conditioning and ventilation system of the subway station. Through the analysis of the final results, it can be seen that the error between the principle model and the simplified model is small, and it is always within the acceptable range of the engineering precision application field. The test results of this method in the energy consumption principle model of the subway lighting system and the vertical traffic energy consumption principle model are highly similar, so it is determined that the simplified model can evaluate and tap the actual operation of the subway station and the energy-saving potential [9].

4. Conclusion

In order to conduct a detailed study on the reasonable energy consumption indicators of subway stations, it is necessary to design a sub-item energy consumption model of subway stations in advance. This model is based on statistical regression and operation principles, which can not only quickly assess the energy consumption of each sub-item of subway stations, but also provide a strong reference for professionals to fully understand the current building energy consumption. Among them, the application feasibility of the principle model is obviously higher than that of the regression model, mainly because the main aspects involved in the principle model are building structure, ventilation, personnel, operation, etc. Through simulating the real situation of the building model, and combined with the detailed analysis of train sets, passenger flow, buildings and other information, the most reasonable energy consumption indicators of the subway station can be summarized. The factors that the actual energy consumption of the subway station exceeds or falls below the indicators are analyzed, so as to provide strong guidance for the realization of normal operation and energy-saving transformation goals.

Disclosure statement

The authors declare no conflict of interest.

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The Practice of Ideological and Political Construction in the "Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" Course

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Abstract: Under the background of the concept of big ideology and politics, through the organic integration of professional courses and "curriculum ideology and politics," students should not only learn professional knowledge and skills, but also cultivate craftsman spirit, spirit of hard work, professional quality, and professional normative awareness. Taking the "Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" course as an example, this course takes the reform of the three teachings as the background. Firstly, the elements of ideological and political education that are relevant to the course are fully excavated. Then, the ideological and political entry point of the professional course of construction engineering technology are explored. In this way, the effective integration of professional course teaching and ideological and political education elements can be achieved, and the students' qualities can be developed, leading to a effective integration of ideological and political collaborative education in the curriculum.

Keywords: High occupation; Major in architectural engineering technology; Rebar leveling; Curriculum ideology and politics; Collaborative education

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1. Introduction

In December 2016, at the national conference on ideological and political work in colleges and universities, China's leaders said: "We must make good use of classroom teaching as the main channel, and ideological and political theory courses should persistently strengthen them through improvement." All other courses should 'guard a section of canal and plant a field of responsibility,' so that all kinds of courses and ideological and political theory courses go in the same direction and form a synergistic effect" [1]. The "Guiding Outline for Ideological and Political Construction of Curriculum in Colleges and Universities" issued by the Ministry of Education in 2020 not only once again emphasizes the importance of curriculum ideological and political construction in the process of talent training of higher vocational students, but also points out the direction for various disciplines in curriculum ideological and political construction. For vocational colleges, 80% of the courses are professional courses, which means 80% of the students' time is spent on the learning of professional knowledge and skills. So, professional courses and teachers play an important role in carrying out "collaborative education."

As a core professional course of engineering in the construction engineering technology major,

"Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" course should focus more on cultivating students' craftsman spirit of excellence and stimulate students' enthusiasm to serve the country through science and technology. As a professional core course, it undertakes the important mission of cultivating students' morals and practical skills. Taking "educating people comes first, starting with moral education" as the basis of "curriculum ideology and politics," the students' craftsmanship, spirit of hard work, professional quality and professional normative awareness can be cultivated through while learning professional knowledge and skills.

2. Teaching practice of the "Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" course

The "Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" course is taught to first-year students majoring in architectural engineering technology in the second semester, with a total of 64 hours (theoretical lessons: 36 hours, practical training: 28 hours).

3. Teaching objectives

Combined with the professional standards of the Ministry of Education, enterprise certification, and the talent training program formulated by Chongqing Energy College, the standards of the "Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" course and the school's professional school-running requirements, the teaching content was designed, and the objectives regarding knowledge, skill, quality, and ideological and political goals were formulated, as shown in **Figure 1**.

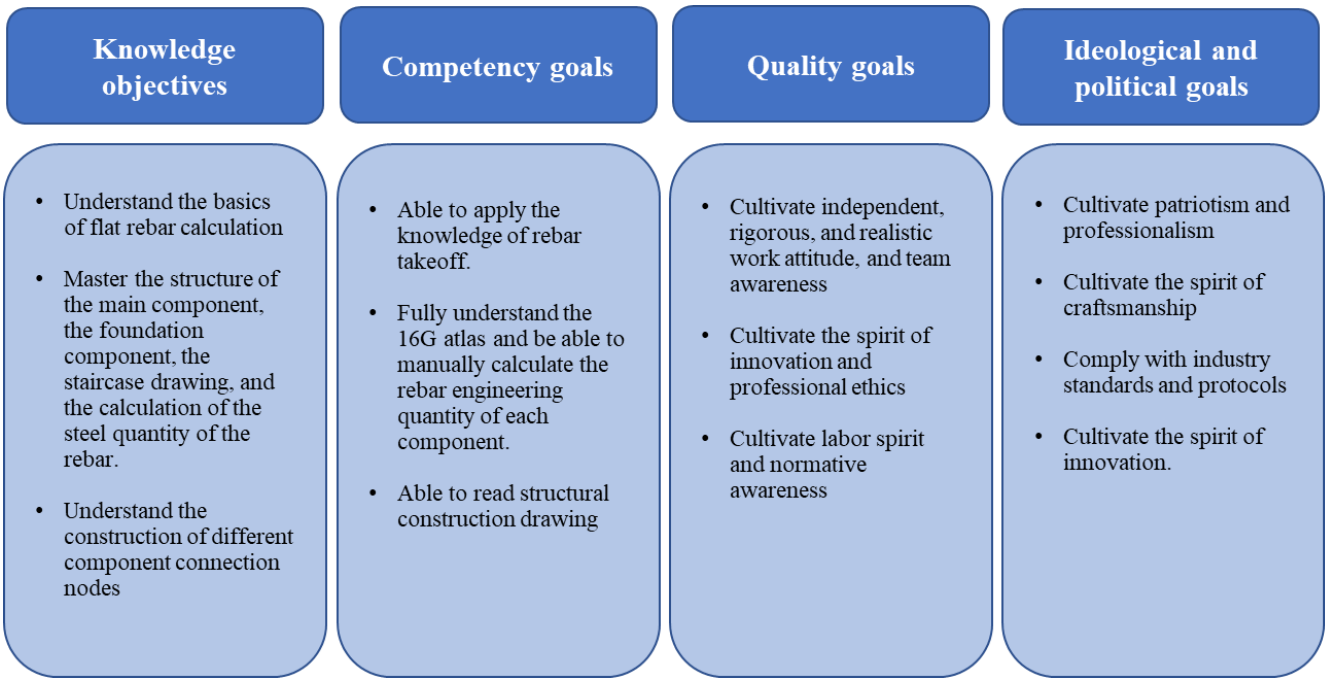

Figure 1. Teaching objectives

4. The concept of ideological and political teaching of the "Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" course

The "Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" course is a professional core skills course and a very practical subject, but improving students' ideological and political literacy plays a very important role in the road of students to grow into excellent builders. Only by deeply excavating the ideological and political education elements contained in this course, taking

professional knowledge and skills as the carrier, achieving the "trinity" of value shaping, ability cultivation, and knowledge transfer, and "seeking perfection and casting ingenuity," highlighting the educational goals of ideological and political education in the curriculum, and ensuring the synergy of ideological and political content between the ideological and political courses and curriculum courses, can the effect of ideological and political collaborative education of the curriculum be achieved.

The teaching method should not be limited to the form of teaching but should adopt various forms such as online and offline blended teaching, project-based case teaching, and task-driven teaching, so that students can fully understand the core of this course.

5. Design of ideological and political teaching process

The main ideas are summarized and sorted out during the teaching of each module, and the entry points of ideological and political elements are explored, so as to achieve an interesting integration of ideological and political elements. In classroom teaching, it is difficult to achieve one-on-one tutoring by teachers for all students, and some students are not very good at actively seeking teacher guidance, afraid of asking questions, afraid of losing face, and so on. In view of this, teachers should encourage students to help each other in the classroom, and tell students that teaching others is the best way to learn and it is the learning method with the highest degree of knowledge retention. When students help each other, their abilities can be improved. In this way, in the classroom, the phenomenon of plagiarism or free riding can basically be eliminated, the learning enthusiasm students facing difficulties can be improved, a good learning atmosphere can be formed in the class, and the students' interpersonal skills can be developed. The design diagram of the ideological and political teaching process is shown in **Figure 2**.

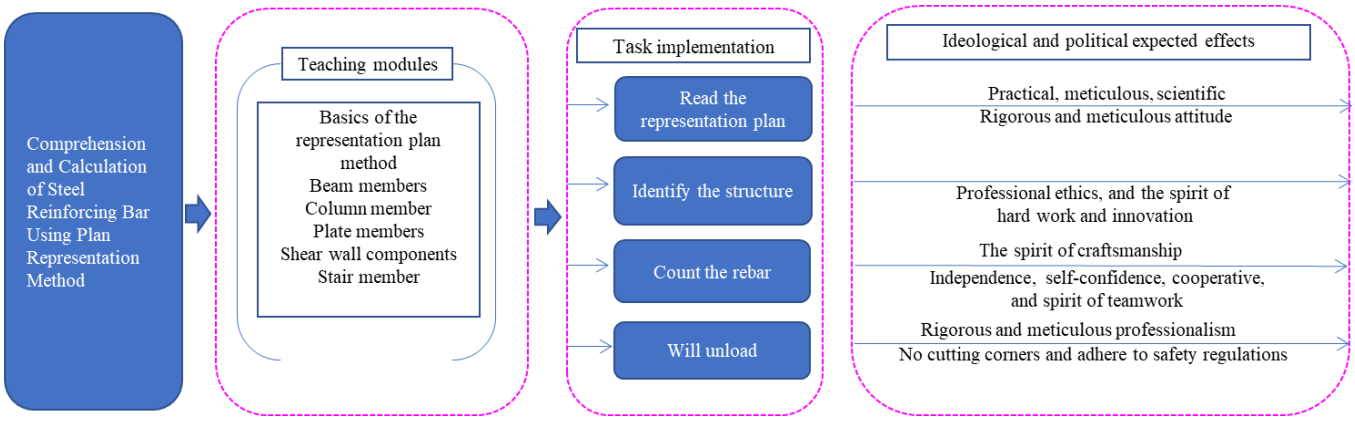

Figure 2. Ideological and political teaching process design

6. Integration and implementation of ideological and political cases of the curriculum

Case analysis is used as the main method of teaching. Before each lesson, students are made to watch major construction projects in "Super Engineering" by China Central Television's (CCTV) that displays cutting-edge technology, so as to understand how these projects change from blueprints to reality, guide students to innovatively use new technologies in future work, improve production efficiency, and implement the development requirements of new processes, so that their professional skills and general skills can be developed. The concept of "invention changes destiny, wisdom creates wealth" needs to be instilled among the students. Through the learning about major construction projects, students understand the rapid development of China's construction technology, personally understand the development of China's economy, technology, and comprehensive national strength in recent years. This helps cultivate students' patriotic feelings and awareness of scientific and technological innovation, promote students to learn professional knowledge and strive to be craftsmen in this big country, and contribute their own strength to

the realization of China's vision of "building a strong country." Students should be made to deeply understand and inherit the essence of ideas and the values of the times in traditional culture, which can be achieved through collaborative education while understanding professional knowledge.

Besides, interviews of outstanding graduates can be played, as well as the great deeds of engineers for students to understand and practice the craftsman spirit of excellence, cultivate students' professional qualities and good habits, and help students in career planning. Through in-class practical training, different role plays, teamwork, and many more, students are taught to follow the rules and look at the big picture. In the teaching of steel cartographic rules, students read and calculate according to the atlas, which is the rules of this course that must be followed. This strengthens the students' awareness of norms, help them understand the concept of rule of law, and improve their awareness of using rule of law to protect their rights.

Moreover, students should be given group tasks to allow group discussions and completing a project as a team. Ideological and political elements related to the content of each section can be randomly introduced. For example, in the teaching module of introducing slab component, the slabs act as the platforms, which can be independent or connected; this can be used as metaphor of different industries of the country, where they are independent but also complementary to each other in completing development goals. In the teaching module of the wall, the wall plays the role of parallel space separation in the building, and the wall will have doors and windows. Just as countries or all walks of life have their own legal constraints and unique rules, China protects itself with "copper walls and iron walls," and at the same time uses the "window" to view the world and create a new world with the "door" of reform and opening up. Through a reasonable division of labor and effective organization, a friendly atmosphere can be created; the spirit of teamwork, enthusiasm and dedication style can be cultivated. When a member of the group encounters difficulties in completing the group which will affect the overall credit of the group, the teacher intervenes in time to guide students to overcome technical difficulties, actively deal with interpersonal relationships, address problems without complaining and shirking responsibility. Through visiting the construction site, observing component modeling and production, steel quantity calculation, and so on, students can cultivate a rigorous working attitude and the spirit of craftsmanship.

Finally, through the comparison of manual and computer takeoff, students are stimulated to innovate and create, and it was mentioned in the 20th National Congress that "there is no end to practice, and there is no end to theoretical innovation [2]." To enable students to constantly innovate and break through while receiving professional knowledge.

7. Pedagogical reflection

7.1. Implementation effect and results

The value objectives of the curriculum are clarified, and the educational effect is improved. The cultivation of patriotism, sense of social responsibility and sense of historical mission in students has a positive educational effect.

In terms of knowledge and ability, emotion and attitude, value and position, classroom teaching and after-class reading are carried out to realize the teaching goal of value shaping, skill development, and knowledge transfer.

7.2. Existing problems

Some students are reluctant to invest more time and energy in class, and there is a large gap in the completion of tasks issued by teachers, and the degree of mastery is uneven, which is not ideal.

7.3. Improvement ideas

Fun tasks can be assigned to students get their attention. At the same time, increase guidance and monitoring before, during and after class.

8. The ideological and political application effect of the "Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" course

In order to investigate the ideological and political effects of the "Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" course, a questionnaire was distributed in the class at the end of the semester. A total of 60 questionnaires were distributed and 58 were recovered, with a recovery rate of 96.7%.

The survey results show that the teaching effect of ideological and political education of the "Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" course is positive. The integration of ideological and political elements into the teaching content of the curriculum has a subtle impact on students' values and outlook on life, so as to achieve the effect of unconsciously instilling an ideology. In this way, students will have a deeper understanding of professional knowledge and its practical application, and their knowledge learning and application ability can be improved, as well as logical judgment and analytical skills; on the other hand, the integration of case teaching and ideology and politics can guide students to think deeply about engineering ethics and values, establish a correct outlook on life, and cultivate good professional ethics.

9. The value of ideological and political construction in the "Comprehension and Calculation of Steel Reinforcing Bar Using Plan Representation Method" course

In short, based on this course, with specific and effective tasks, professionalism is integrated into the learning of "moisturizing things silently," and the organic unity of knowledge imparting and value guidance is completed in the course of teaching. From "ideological and political courses" to "curriculum ideological and political," the core content of ideological and political education is organically decomposed into each teaching of courses, fully embodying the educational function of professional courses， so as to realize the rational return of educational value.

9.1. Promote the spirit of craftsmanship and innovation

The new era of China is called the "infrastructure madness," one after another super projects have been initiated in China, and the problems behind these super projects are also world-class. In the face of these problems, the builders fully develop the spirit of innovation and craftsmanship, and finally overcome them one by one. Among them, the Hong Kong-Zhuhai-Macao Bridge, one of the seven wonders of the modern world, took 15 years from design to completion, with wind resistance of 16 levels, earthquake resistance of 8 levels, and a service life of 120 years, which is a bridge island tunnel traffic cluster project. In the past 15 years, the builders have carried out a series of innovations in terms of design concepts, construction technology, construction organization, management mode, and many more with "embroidery efforts," and various new materials, new processes, new equipment, and new technologies have emerged in the construction of the bridge, which not only fills the gap in many fields in China, but also makes China's cross-sea bridge and tunnel island engineering design and construction management level in the forefront of the world [3].

As future builders, students majoring in architectural engineering technology inherit and carry forward the craftsman spirit and innovative spirit of their predecessors, which is one of the important contents of ideological construction.

9.2. Cultivate the spirit of great love and enhance self-confidence

Through listening to stories of medical workers, builders, laborers, and other walks of life during the Covid-19 pandemic, as well as the "Chinese power" and "Chinese speed" behind Vulcan Mountain Hospital and Leishenshan Hospital, the students' "four self-confidence" can be stimulated their spirit of patriotism can be strengthened, and a sense of national pride and professional mission can be cultivated. Therefore, it guides students to think about how to exert their professional skills and personal strength when the society needs, and how to participate in project construction in the future and how to face the difficult environment and difficulties behind engineering construction of class discussions.

9.3. Safety first

The most important thing in the rebar flat map recognition and takeoff is the safety performance of the component, and the calculation of rebar engineering quantity mainly involves material characteristics. Strengthening students' ideological construction can ensure that students emphasize greatly on safety, keeping in mind the belief of "safety first."

9.4. Cultivate a sense of responsibility and professional ethics

Through understanding the areas prone to accidents and making students discuss the reasons for quality accidents will make students pay attention to the impact of protective layer thickness and other settings on project quality and safety and enhance their sense of responsibility and professional ethics.

9.5. Teamwork spirit

In order to develop teamwork spirit, the class is divided into groups, and a workshop is set up after the class. In the workshop, students are taught how to calculate the length of the rebar needed and the production of the rebar model. Besides, students are made to come up with solutions for the calculation of rebar and construction lashing, and calculate the amount of rebar required to meet the components to reflect the sense of dividend cooperation.

10. Conclusion

In short, based on this professional course, with a concrete and vivid effective task carrier, professional qualities are integrated into the learning of "moisturizing in silence," and the organic unity of knowledge teaching and value guidance is completed in the teaching process, and the core content of ideological and political education is organically decomposed into each teaching of professional courses, so as to realize the rational return of educational value.

Disclosure statement

The author declares no conflict of interest.

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Research on Prefabricated Open Caisson Construction Technology

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Abstract: With the continuous improvement of urban residents' lives, the demand for of urban infrastructure construction increases, requiring more and more advanced engineering technology. We should not only speed up the progress of the project, but also reduce the impact of the construction on the surrounding environment. Our company has had several achievements in this regard, and prefabricated open caisson construction process is one of them. In this paper, the application of prefabricated caisson construction method is analyzed in depth according to the actual situation of the rain sewage reconstruction treatment project of Minghe ecological water system in Dancheng County. Through practice, it is concluded that this construction method greatly improves the construction efficiency, shortens the overall construction process, reduces the construction cost, and effectively improves environmental quality of the construction site, which has good reference value.

Keywords: Prefabricated open caisson; Open caisson construction

Online publication: February 13, 2023

1. Introduction

Prefabricated open caisson is a new form of open caisson, which can fundamentally facilitate the construction, reduce the excavation area and volume of work, and shorten the construction period. At present, the open caisson construction technology is divided into two types: one is vertical section; the second is transverse segmentation. The two methods basically adopt the same technology in the process of splicing assembly, that is, by setting the post-pouring belt to connect each piece. Each section should be reasonably applied pre-stress in the process of splicing, which can significantly enhance the tightness of the connection between the pieces and effectively improve the overall shear performance, in addition to effectively avoiding the problem of water seepage through the wall of the shaft. The construction process of this project is vertical segmentation, and the specific application of the prefabricated open caisson construction method is analyzed in depth as follows.

2. Project overview

The rain sewage reconstruction project of black and smelly water treatment project of Minghe Ecological water system in Dancheng County using prefabricated assembly work well. Its cross-sectional shape is rectangular, there are two parts, using the same structure and size, which can also be used as both jacking well and receiving well. Its specifications are as follows:

$$\text{Length} \times \text{width} \times \text{height} = 7000\text{mm} \times 5500\text{mm} \times 7500\text{mm}$$

Height direction of the well body is divided into three sections, and the connection between each section is made of vertical reinforcement, the height of 1# section is 2500 mm, the height of 2# section is 3000 mm and the height of 3# section is 2000 mm. The well body reinforcement is made of finely rolled steel, and the foot of the edge is treated as an aging section. A 500 mm long post-cast zone was set up and C50 concrete is poured. After the open caisson sinks to the designated position, the distance between the ground and the wellhead should be 2.5 m, the types of soil are mainly silty clay and clay, and the reference values of cohesion and internal friction angle are 20 MPa and 20° respectively.

3. Prefabricated open caisson construction

3.1. Lifting construction

3.1.1. Preparation

(1) Lifting order

The characteristics of the open caisson piece can be divided into two types, namely "[" type and "I" type. Based on the structure of the open caisson, the actual workload, etc., combined with construction safety and procedures, the installation section strictly started from the lower ring, then the middle ring, and finally the upper ring [1].

(2) Personnel, equipment, and materials configuration

The personnel include electricians, installers, surveyors, welders, and signalmen, of which, except for 6 installers, all others were 1 person, totaling 10 persons. The site was equipped with the following equipment: 1 crane for unloading and installation, 1 electric welder for rebar welding, 2 trailers for component transportation, 1 set of gas welding, 2 sets of vibrators for pouring and vibrating. The site was equipped with the following measuring equipment: 2 sets of latitude and longitude meters for verticality detection and control, 1 set of level meter for elevation control, 1 set of 50m steel ruler for axis measurement, 2 sets of steel horizontal ruler for horizontal measurement.

(3) Lifting machinery selection

Because the weight of a single piece reaches 26 T, according to the existing experience, the crane cannot be less than 80 T, thus, the project adopted a 100T car crane, its main parameters are as follows: (i) "[" type components—the rotation radius does not exceed 8m, the lower, middle and upper ring lifting weight is 17 T, 26 T, 22 T, the theoretical lifting weight is 41 T, and the length of its main boom is 17.4 m; (ii) "I" type components—the radius of rotation does not exceed 14m, the lifting weight of lower, middle, and upper rings are 7.5 T, 11 T, and 9.2 T, respectively, the theoretical lifting weight is 17.4 T, and the length of its main boom is 17.4 m.

(4) Measurement control and open caisson observation

Before the construction of the open caisson, the level base points, and control network was laid out. At the same time, the center point of the open caisson and the excavation construction range was determined in accordance to the relevant requirements of the drawings, and cross-line was placed in the surrounding area. If there was an existing building around, real-time observation points for settlement were created and observations were carried out from time to time [2].

(5) Pit excavation

In order to minimize the actual excavation volume and occupy less land, a foundation pit with a depth of 1 m was first excavated by an excavator, and then a water collection pit was set up on the outside of it to allow precipitation.

(6) Mat construction

To avoid uneven settlement from the caisson installation after completion, the method of setting the bedding layer was used to strengthen it, so that the well was properly tilted. After leveling the bottom of the pit by hand, new gravel was laid on the center line of the open caisson, and the thickness was 150

mm, and the machine is used to tamp it after laying. Through calculation, the strength grade of concrete used in the bedding layer was C20, and the thickness was not less than 150 mm. In addition, the control line should be set according to the requirements of the drawings, which is the key to ensure the smooth progress of lifting [3].

3.1.2. Lifting machinery, components into the field

After the car crane comes into the site, its performance is checked comprehensively and must meet the lifting requirements. The ground endurance of the location of the car crane must meet the requirements, and the road can be used as the holding layer and a steel plate of 20 mm thickness is set at the four feet. At the same time, the components are checked in terms of appearance and size, etc. to determine whether the requirements are met.

The components are transported by car, and the transport should be matched with the progress of production and installation, and a reasonable transport plan should be made. When transporting the components, they must be placed smoothly, padded with liner if necessary, and fixed with twine to avoid sliding of the components during transportation, causing collision and falling. In the process of unloading, extra care must be taken to avoid damage and to adopt effective measures to prevent extrusion and collision.

3.2. Installation construction

The crane and the transporter are arranged on site in strict accordance to the drawings, and the lower ring of the open caisson is installed first and is fixed after installation is completed to prevent displacement when other members are installed. The member plate and the arc reinforcement is tied or welded. The welding method is one-sided lap welding, the required lap length is not less than 10 times the diameter of the reinforcement, and the welding seam should be full and keep even, so that the member has good integrity and avoid tilting [4].

After the lower ring is installed, the formwork support and concrete pouring is carried out. The formwork stiffness and all reinforcement knots should be sufficient to avoid problems such as rising of the formwork during the pouring process. C50 concrete is used for pouring, its collapse degree should be between 12–14cm, and the pouring height is 1.5 m. While pouring, we should use vibrating bar to vibrate evenly to avoid over-vibration and omission. After the construction of the lower ring is finished, the same method is used to construct the middle and upper rings.

3.3. Prestressing tensioning

3.3.1. Material preparation

The prestressing steel used in the construction must meet the current standard, and the tensile strength should be able to reach 1040 MPa. The steel used in the construction has a modulus of elasticity of 2.0×10^5 MPa, an elongation of 9%, and a cross-sectional area of 490.9 mm^2. The anchorage and the corresponding supporting equipment should also meet the current standard. The galvanized metal bellows is used as the prestressing orifice, and the grouting construction is carried out by ordinary pressure grouting process, and its inner diameter is strictly controlled by 60 mm. A total of 44 pieces of fine-tied rebar of 2.5 m, 38 pieces of 3 m and 6 pieces of 0.5 m were configured on site; 50 sets of anchorages and 88 connectors were also configured [5].

3.3.2. Tensioning construction

Tensioning was performed by single end tensioning method with a tensioning control stress of $0.65 f_{pyk}$ and an under-anchor tensioning stress of 675 MPa. The force bars were tensioned at 330 kN, and the basic principle of symmetric tensioning was followed. The tensioning procedure was determined as follows:

0→1.03 times the tensioning control stress→1.0 times the tensioning control stress, and then the anchorage was held for 2 min. During the tensioning process, the stress control was given priority and the elongation value control was supplemented, and the deformation occurring in the well wall was fully considered, and the actual tensioning force of the force bars was mastered according to the sensor data. Before tensioning, all instruments and equipment were calibrated, while after tensioning was completed, necessary measurements and calibration were made. If the effective tensioning force did not meet the requirements, it was supplemented.

3.3.3. Borehole grouting

The middle ring of the open caisson is equipped with pressure grout hole, and the pressure grout should be carried out within 48 h after the completion of tensioning, and the pressure grout should become dense. The water-cement ratio of the slurry was 0.35–0.40. The amount of grouting agent can be adjusted according to the situation, while strength, fluidity and water secretion tests were carried out, and the 28 d compressive strength was required to exceed 30MPa.

3.3.4. Seal anchor

If the reinforcement on the sealed anchor end is too long, it is removed and then sealed with M20 cement paste.

3.4. Post-pouring zone construction

3.4.1. Mold support

The height of the mold support was 6 m, and the stiffness of the formwork and all the reinforcement joints should be firm to avoid problems such as mold rise during the pouring process.

3.4.2. Pouring

C50 concrete with a collapse degree of 12-14cm was used for pouring. Pre-excavated holes were opened at 4.5 m between the depth of the well and the bottom surface so that the vibrating bar could be inserted and vibrated. During the pouring, the vibrating rod must be inserted quickly and pulled slowly to ensure the continuity of construction, without interruption in the middle, otherwise the construction quality will be affected [6].

3.5. Open caisson sinking

3.5.1. Preparation

According to the existing geological data combined with the specific situation of the site, the sinking was carried out in an undrained way. In the sinking process, the long-arm hooker takes the soil from the center to both sides, and after forming a depression in the central part of the bottom of the shaft, the soil of the edge foot will be squeezed into it, and then continue to take the soil to ensure that the sinker continues to sink, and the sinking speed was kept within the range of 0.3-0.5m/d. Before sinking, the sinking coefficient was checked and the value 1.25 was used as a standard to ensure that sinking is completed successfully. If this requirement cannot be achieved, the sinking depth should be reduced, and additional loads can also be applied at the top of the well wall [7].

3.5.2. Open caisson sinking

The soil was excavated manually, lifted by electric hoist and loaded by hand truck. The soil taken out from the well shall not be stacked within 2 m of the well to prevent tilting due to the soil pressure becoming large. The soil was excavated continuously from the middle of the caisson to the four sides in layers. The

thickness of each layer was 0.4-0.5m. The soil bank was reserved around the edge foot, and then the cutting was carried out symmetrically and evenly along the shaft wall according to the interval of 2-3m. If the soil is compressed under the action of the edge, the caisson can enter the soil and avoid the formation of tilt. If there is little sinking, the excavation continues from the middle and continues to extend around. In addition, the soil beneath the cutting edge must be cleared in time to ensure that the sinking remains smooth.

When sinking, it is necessary not only to prevent uneven settlement and sudden settlement, but also to avoid deformation of the open caisson. In the process of internal excavation, the thickness of excavation is strictly controlled, and the excavation is carried out continuously from the middle to the surrounding area to ensure the symmetry and uniformity of excavation, while the soil platform is reserved for layer-by-layer cutting according to the actual requirements. After the caisson was sunk below the ground level, other processes were carried out, including reinforcement tying, mold support and pouring. The next round of excavation and subsidence was carried out when the strength of concrete was sufficient. The template was removed before the caisson entered the soil layer, and the soil collection stopped at a position 20 cm away from the designed depth for real-time observation. If the weight of the open caisson alone cannot sink to the specified depth, manual soil collection should be carried out slowly to ensure that the caisson reaches the required depth [8].

3.5.3. Substrate cleaning and sealing

(1) Substrate cleaning

When the open caisson was 0.1m away from the design elevation, the excavation was suspended and the open caisson was sunk to the required elevation by its own weight, and the bottom was sealed after 2-3d of stability was maintained. After the open caisson is sunk to the required elevation, it is necessary to implement a comprehensive cleanup of the substrate and make preparations for sealing the bottom. In the process of bottom cleaning, the height of the bottom surface should be strictly controlled to avoid serious disturbance to the soil at the foot of the edge.

(2) Open caisson sealing

The bottom of the open caisson was newly paved with a pebble layer with a thickness of 150-500 mm, and then concrete was cast in place to form a bedding layer, especially below the foot of the edge, which was filled densely and vibrated evenly to keep the open caisson stable. After the strength reaches the requirement, the reinforcement was tied, and the ends of the reinforcement was stretched into the recess to pour the upper layer of concrete. The contact surface between the new and old concrete was rinsed with clean water and continuously pushed from all around to the central part, and the layer thickness was controlled within 30-50cm, while pounding evenly with a vibrator [9].

In the process of sealing the bottom, the soil surface should be excavated to the design elevation, and if there is standing water in the well, it should be quickly removed. The position of the chisel hair should be washed, and uneven settlement should be avoided during the casting process. Besides, the soft soil layer should be done symmetrically in compartments, and before the concrete strength reaches the requirement, continuous pumping should be carried out, or take other stabilization measures.

3.6. Pipe jacking construction

Based on the guidance from from the relay station between the main top cylinder and the pipeline, the pipe jacking machine is pushed from the working well through the soil layer into the receiving well for hoisting, and the pipeline right behind the road heading machine is set between the two foundation pits, and the foundation pits are connected at the same time. The pipe jacking construction does not require any excavation except for the shaft, which means it occupies less land and does not affect the existing buildings, environment, and traffic. The key to controlling the topping force is to reduce the resistance to topping, and

the most common method is grouting. In addition, grouting can also form a lubricating jacket to reduce the frictional resistance during jacking.

4. Conclusion

Up to now, the open caisson construction of this project has been successfully completed, after inspection, the technical indicators and construction quality meet the requirements of the design and specifications, indicating that the proposed construction methods are reasonable and feasible. Besides, a reasonable application of the aforementioned methods can also shorten the construction period and improve the construction efficiency, indicating that it has good practicality.

Disclosure statement

The author declares no conflict of interest.

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Exploration on Defect Prevention and Maintenance Methods of Highway Tunnel Structure

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Abstract: Highway tunnel traffic safety is an important part of traffic safety. With the aging of tunnels, increase in traffic flow, changes in the operating environment and traffic accidents, the many problems started to occur in tunnels, affecting the operational and structural safety. In this paper, we summarize and analyze the types and causes of defects found in the process of tunnel maintenance at home and abroad, and propose corresponding suggestions for the current maintenance of the main structure of highway tunnels.

Keywords: Highway; Tunnel structure; Safety maintenance

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1. Introduction

In the construction of highway projects, tunnels occupy an important position in road transportation. In recent years, China's highways have been developing rapidly, and their mileage and density are among the highest in the world. Highway traffic is a complex system, with the passage of time, the needs of economic and social development, and the improvement of highway construction standards and technical level as well as the growth of traffic volume, the requirements for highway traffic safety also increases. Highway tunnel structure is generally in the form of single and double holes, and in the domestic highway, the longest The longest road tunnel is more than 20km, and the shortest is about 0.036km. Besides, the design and construction quality of tunnels are also improving. According to the number of lanes, the highway tunnel can be divided into two lanes, three lanes, or four lanes. The traffic speed in the tunnel is stipulated according to the design speed of 80km/h, 100km/h, and 120km/h. In terms of technical standards of highway engineering, the safety of the main structure of highway tunnels is crucial to highway maintenance [1].

2. Overview of tunnel disease and maintenance technology

2.1. Tunnel diseases

According to literature, there are four main forms of maintenance for highway tunnels in China. The first one is the inspection of apparent problems at the tunnel entrance and inside the tunnel; secondly, management of external and internal structural diseases of the tunnel; thirdly, maintenance and replacement of internal tunnel facilities (e.g., electromechanical equipment); and fourthly, routine minor maintenance

of the tunnel structure. From domestic and international research, the common defects in road tunnels are mainly as follows: (1) potholes ; (2) deformation defects such as poor water seepage through the cave wall and sinking of the vault; (3) water seepage from the cave wall (water seepage inside the cave); (4) sinking of the tunnel roof or sinking of the arch shoulder cracking, falling blocks, and many more; (5) settlement breakage and cracks (such as crack expansion, crack misalignment, and so on) occur at the cave entrance or roof; (6) deformation and seal failure of the cave door. (7) cracking (or deformation and breakage and falling off) of the vault; (8) cave roof collapse, arch shoulder collapse or cracking, and so on [2].

2.2. Domestic and international tunnel maintenance technology development

Tunnel maintenance technology started early, with Germany standardizing tunnel maintenance work in the 1970s and Japan starting in the 1990s. In the early days, tunnel maintenance was mainly maintenance-oriented, and the service life of tunnels was improved through various maintenance measures. Germany's highway maintenance program is divided into two phases, the first phase is mainly for regular inspection and repair of vehicles in operation, and the second phase is mainly for daily inspection and maintenance of tunnel structures. In mainland China, before 2000, China did not have a specialized highway tunnel maintenance agency, the only road and bridge management agencies were the ones established by the local government. Since 2000, with the continuous increase of highway length and traffic volume, the highway traffic environment has become increasingly complex. In order to ensure road operation safety, improve management level, and standardize road maintenance and management behaviors, special road maintenance management organizations have been gradually established, and an effective communication mechanism has been formed between highway operating units. In recent years, China has begun to pay attention to the problem of frequent accidents in highways and has strengthened the research on highway defects and management. The early research and development of tunnel maintenance technology has been documented in China and has achieved good results, including the one-year highway tunnel maintenance comprehensive pilot research project (SJTC01) conducted by Professor Shibao Zhang's team at Lishui, Zhejiang, and the cloud-based highway tunnel disaster management and safety monitoring system [3-4].

3. Solution for defects and maintenance measures of highway tunnel main structure

3.1. Analysis of disease causes and treatment methods

3.1.1. Analysis of disease causes

One of the causes of tunnel defects is the poor design of tunnel structure and substandard construction quality; secondly, poor maintenance management may also be an indirect cause of tunnel defects. The generation of tunnel defects is related to environmental factors, such as temperature changes, vehicle overload, and many more. In addition, there are external causes, such as damage to components and structural damage caused by traffic accidents. The current maintenance management model used on China's highways is mostly an after-the-fact maintenance phase, which is a reactive maintenance approach. Only passive maintenance or reinforcement treatment can be carried out after the occurrence of tunnel defects, which is not as good as to implementing preventive maintenance based on the structure of the tunnel and the surrounding environmental conditions (such as ventilation, lighting, temperature, and so on) [5].

3.1.2. Treatment methods

(1) Prevention and strengthening of insufficient lining thickness

During the construction process, the type of surrounding rock and geological conditions should be taken into account to reasonably determine the spacing between the blasthole, reasonably determine the various process conditions of blasting, effectively control the effect of light surface blasting on the excavation surface, and minimize the over-under-digging that occurs in the construction of the tunnel

section; at the same time, a reasonable detection method should be used to ensure sufficient space before the construction of the secondary lining. If insufficient space is found, the initial support must be treated in advance. Tunnels that are in use should be demolished and replaced or reinforced with steel strip to avoid engineering safety accidents caused by non-compliance with design requirements [6-7]. In case of demolition and replacement, when the old lining is removed, the lining that meets the design requirements outside the demolition and replacement area must be protected in order to avoid secondary damage. In the construction of the new lining, the joint part of the old and new construction must be planted with reinforcement and the contact surface should be chiseled to ensure the old and new concrete is properly joined.

(2) Treatment of the cavity behind the lining.
Presence of a cavity behind the tunnel lining poses a great threat to its safety. Therefore, it is necessary to prevent and control the formation cavities behind the tunnel lining. When there is a cavity behind the secondary lining, it is usually drilled and grouted to make it dense. When grouting, the shrinkage rate of concrete should be monitored, and should be regulated by reducing the amount of cement by adding water-reducing agent and extracting liquid, and the shrinkage rate of concrete should be regulated by appropriate amount of expansion. It is also necessary to leave venting holes in the grouting position, and when there is mud flowing out of the venting holes, the grouting should be stopped and plugged immediately to give enough pressure to the cement slurry. If the cavity behind the lining is too large, the treatment effect and construction safety should be fully considered during the treatment, and the corresponding range of lining should be dismantled and rebuilt if necessary [8-9].

(3) Reinforcement of the surrounding rock behind the lining.
During the use of the tunnel, the stability of the tunnel's surrounding rock is affected due to stress changes, the action of groundwater, and so on. Therefore, the stability of the surrounding rock can be achieved by grouting reinforcement; with good rock conditions, the stability of the surrounding rock body can be improved by anchor cable reinforcement support. Conduit is driven into the surrounding rock and slurry is injected to change the adhesion between the surrounding rock, thus forming a support arch on the rock body and ensuring the stability of the rock body. If the rock layer is loose, additional radial anchor reinforcement can be installed at the same time to prevent the displacement of the rock layer and ensure its stability. By grouting the rock layer, a reinforcement ring can be generated in the outer surrounding rock of the tunnel to enhance the stability of the rock layer and improve the stability of the surrounding rock.

(4) Treatment of leaking lining
If leakage is caused by a gap between the liner and the rock, it can be treated by grouting for reinforcement, which not only improves its strength and corrosion resistance, but also enables segmental water repulsion; on the lining surface, leakage due to concrete cracking, especially in single-layer concrete, can be treated by riding joints, diagonal joints grouting, and surface sealing for seepage control.

3.2. Tunnel maintenance recommendations

In recent years, with the rapid development of China's economy and society, the role of highways in the national comprehensive transportation system has become increasingly prominent, and the scale of highway tunnels has become larger and larger. The treatment and treatment of civil structure defects of expressway tunnel is an important task in the daily management of expressway, which is very important to ensure the safe operation of highway tunnel and improve the road traffic capacity. At present, China has built many highway tunnels with many defects, these defects not only bring serious impact on the normal use of the tunnel, but also brings a major risk to the people's lives and property. Therefore, tunnel structure protection should be taken seriously and take effective measures to solve existing issues as soon as possible. At present,

although China's highway tunnel maintenance technology and methods have been greatly enhanced, there are still many problems in maintenance management, such as (1) maintenance construction technology is relatively backward, (2) insufficient maintenance funds, (3) maintenance engineering quality control to be strengthened. Therefore, the maintenance management level of the main structure of the tunnel should be strengthened, and new technologies should be used continuously to improve the quality of maintenance works [10-11]. Combined with the current situation of domestic highway construction and operation maintenance and disease characteristics, the following recommendations are made.

3.2.1. Focus on training high-level technical and management personnel

In the construction of highway bridges and tunnels in China, the most important thing is to strengthen the training of construction personnel. The construction and operation of highway bridges and tunnels fully reflect the role of technical personnel. The publicity and investment in the project need to be increased, relevant technical personnel needs to be actively introduced, and the training of practitioners needs to be improved, so that they have a comprehensive understanding of the work, lay a solid foundation for the maintenance work they carry out, as well as play a role in mentoring and training more professional and technical talents.

3.2.2. Strengthen the coordination of production linkage

To improve the maintenance and management technology of highway tunnels, it is necessary to strengthen the coordination and cooperation among material production, machinery manufacturing, scientific research, and maintenance enterprises to improve the level of tunnel maintenance.

3.2.3. Use new technologies, techniques, and equipment

Highway tunnel operation must not only meet the safety and comfort requirements, but also use more advanced technology. For example, ultrasonic detection technology, automatic monitoring technology, and many more. In the past few years of development, there has been a series of new equipment that are more comprehensive, innovative technology, with high efficiency, high reliability, and other advantages, which can greatly improve the quality of tunnel maintenance. With the rapid development of 5G, BeiDou navigation, and artificial intelligence in recent years, automated inspection and monitoring systems can be developed to conduct regular or irregular inspections of bridges and tunnels at a certain frequency, and collect monitoring data automatically and transmit them to the terminal database for early warning of structural cracks, displacements, water seepage, and other problems, which can then be verified and solved by experts. Compared to conventional methods, the quality and efficiency of maintenance work will be significantly improved, so the promotion of automation and intelligent development of relevant maintenance equipment has a very significant role in enhancing the effectiveness of the management of highway tunnel maintenance.

4. Conclusion

China's highways have been rapidly developing, and the safety and maintenance management level of tunnel main structure is directly related to the overall quality of structural facilities and operational efficiency, which is an important factor to ensure traffic safety. In this paper, we analyze the causes of the main structure of highway tunnels and propose solutions and maintenance management measures for the problems in the daily maintenance of highway tunnels, which can provide some technical references for future research on the safety and maintenance of the main structure of highway tunnels. In the future, it is necessary to increase the investment in the structural safety and maintenance management of highway tunnels to provide a guarantee for safe tunnel operation. The daily maintenance and construction

management of highway tunnels should be strengthened, the emergency rescue plan measures and system of highway tunnels should be improved, and the supervision and inspection efforts should be increased. We should strengthen the technical research work of highway tunnels, to provide a scientific basis for traffic maintenance and management through the introduction of advanced detection means to diagnose and analyze various diseases. Besides, the monitoring of traffic conditions on expressways should be strengthened and promptly deal with problems to ensure highway traffic safety. The protection of road facilities should also be improved to prevent the damage of construction and passage of highway facilities and pollution.

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Improving Classroom Teaching Quality of Architectural CAD Through the Integration of Competition Content

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Abstract: Architectural Computer-Aided Design (CAD) is a highly technical and practical course and is also a course where its knowledge can be directly applied in the working field, which is especially important for higher vocational students majoring in architecture. In order to improve the teaching quality of this course, this paper proposes the integration of competition content into teaching under the based on the original syllabus. Therefore, the content of the "Reading and Drafting of Construction Drawings" competition is integrated into the teaching of this course, so as to realize the balanced development of teaching and competition, enhance students' professional skills and practical ability, and help students adapt to the development of the industry. With that, the goal of personnel training in higher vocational colleges can be achieved.

Keywords: Architectural CAD; Integration of competition and education; Higher vocational education; Curriculum and teaching reform

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1. Introduction

Architectural Computer-Aided Design (CAD) is a highly technical and practical course, and it is also a course and is also a course where its knowledge can be directly applied in the working field. This course involves developing the students' drawing reading skills and computer aided drawing skills, so that they can be proficient in the knowledge of drawing and editing construction drawings, and be competent for a draftsman position. Therefore, it is worth exploring the ways to improve the students grasp' the main content of the course, adapt to the teaching method of the course, and use the professional knowledge to solve practical engineering problems.

Classroom teaching is not only a science, but also an art. The quality of classroom teaching directly affects the quality of personnel training. Students in higher vocational colleges are flexible and active, and their learning motivation largely depends on their intuitive feelings. If teachers can stimulate their interest in learning, they will love the course, thereby improving the teaching and learning effect [1].

2. Problems in the teaching of Architectural CAD

2.1. The teaching of the course is textbook-oriented, which is difficult to stimulate students' interest in learning

Usually, the teaching of basic drawing commands is emphasized in this course and the application of the commands in actual engineering practice is neglected; only software courses of introducing commands is

taught. Teaching has gradually become the teachers reading from the textbook, thinking that teaching the commands in the textbook alone will be sufficient. By using this method, the teacher explains in detail according to the textbook, where the students would understand at that time, but do not know how to apply them in actual construction drawings. This means that they cannot apply what they have learned.

In the traditional teaching method, the teacher explains and demonstrates the operation process on the host computer, and the students simply watch the operation process. During the whole process, the students are in a passive position. After the lessons, most students just imitate what they have seen without being able to think for themselves [2].

2.2. Different levels of foundation among students

Students in higher vocational colleges can be divided into several levels according to their learning status. Some students have a good grasp of the content and can quickly complete the exercises assigned by the teacher. Some students have not fully learned the operation method, but they are embarrassed to ask the teacher, so they discuss with their classmates to complete the exercise. Some students are arrogant but have poor practical skills; they think that they know how operate the commands just by looking at the demonstrations and do not want to practice by themselves, ultimately knowing nothing.

In addition, although many students can master the basic knowledge taught by teachers in class and complete the examples demonstrated by teachers, there are still some students who cannot draw inferences from cases they have learnt into other similar cases and do not know how to work with similar graphics. The reason for this phenomenon is that some students do not fully grasp the operation method of the command, they only understand the results but not the reason behind them and what the teacher is actually teaching; There are also some students who think that it is enough to master the content taught by the teacher in class and do not want to think more by themselves.

2.3. Insufficient teaching equipment

There is also a serious lack of investment in teaching equipment in many schools, resulting in the lack of computer rooms and teaching bases in schools, which cannot guarantee one computer for each student and therefore not meeting the learning needs of students in practical classes [3].

3. Skills' contests are needed in higher vocational colleges

The comprehensive quality of teachers themselves, to a certain extent, determines the quality of students. The teacher's level of professional knowledge and professional skills, and whether the teaching methods are appropriate not only directly affect the effect of education and teaching, but also greatly affect their future development. Therefore, competition items should be introduced into the teaching content, and students should be allowed to participate in various vocational skills competitions inside and outside the school, so as to fully mobilize their learning enthusiasm and initiative. This can not only broaden their horizons, improve their comprehensive quality, cultivate their teamwork spirit, but also improve their competitiveness and increase their employability.

The introduction of competition items into teaching activities and the reform of practical teaching mode can not only enable students to use the knowledge flexibly in the competition, but also test the teaching level and effect of teachers through the competition [4].

The "Reading and Drafting of Construction Drawings" competition in higher vocational colleges is a national large-scale competition, which includes two parts: reading and drawing architectural engineering construction drawing. In the drawing reading section, students are required to answers questions regarding construction drawings and other information. In the drawing part, students are required to use CAD software to draw the specified drawings according to the given data. In order to achieve excellent results in

the competition, students must have solid basic skills, including excellent and meticulous construction drawing reading skills and fast and accurate drawing ability [5]. The mastery of reading and drawing of architectural construction drawings is also the corresponding teaching goal of the Architectural CAD course. Therefore, it is very necessary to integrate competition items into the teaching of Architectural CAD.

4. Integrating competition-related content into classroom teaching

4.1. Adopting multi-level teaching mode

Most of the students in higher vocational colleges have different levels of foundation, which makes great differences in their level of knowledge, learning ability, and interest in learning. For example, some students have been promoted from secondary vocational schools to higher vocational colleges, they have studied CAD related courses before, and have basic CAD drawing skills; while other students from ordinary high schools have not studied this course. If unified teaching objectives, content, progress and examination methods are applied, it will lead to different levels of understanding of the content among students. Therefore, it is important to group of students' based on their learning ability, and different educational measures should be taken accordingly.

(1) Unified teaching and hierarchical practice

Two exercises are given during the lessons, one is compulsory, requiring all students to complete, the other is an extra, where students where students who have faster progress and learning ability can complete. In this way, the order of teaching can be better controlled, and the students of different levels can also learn better with the different exercises given.

(2) Multi-level learning system for the same syllabus

The students are divided into three groups according to their level of learning: A, B, and C. Group A is the upper middle level students, group B is the middle level students, and group C is the students with learning difficulties. After the unified teaching, the teacher let the students in Group A practice by themselves, and to solve problems on their own by referring to books, so as to cultivate their learning methods and abilities. For the students in Group B and Group C, the operation of the system would be explained and demonstrated to then step by step, and then the students will do their own operation exercises. Finally, teachers will focus on individual tutoring for students with learning difficulties in Group C.

(3) Sharing of computers in cases of insufficient facilities

If the computer room of the school is insufficient and there are many people sharing a computer for practice in class, it is best for Group C students to sit together with Group B or Group C students. In this way, the students in Group A can quickly complete the tasks assigned by the teacher in class, and then guide the students in Group B or Group C in doing their tasks. This "twinning" approach can not only strengthen the understanding of the use of drawing commands for students of upper and middle levels, but also make it easier for students of lower levels to accept help from their classmates, so that each student can get effective practice.

4.2. Emphasizing on the innovative application of information technology and teaching methods

With the development of technology, a variety of new media teaching methods have been widely used in the teaching process. Students no longer depend on classroom lessons and textbooks alone to acquire knowledge, but more on digital resources. Students no longer depend on class notes alone for information but also other digital platforms, so teachers are required to make corresponding improvements in teaching resources and teaching methods. For example, teachers can use online teaching tools on the WeChat teaching platform, "Duifenyi."

"Duifenyi" is a free WeChat public account. The WeChat teaching platform of "Duifenyi" can be

operated on both computers and mobile phones. This platform can be used in the following situations: student grouping, grading assignments, posting course resources and online exercises, WeChat messages, taking attendance, giving homework, initiating discussions, distributing questionnaires, and many more. Teachers and students can log in to "Duifenyi" through their computers or mobile phones. After completing the basic operations such as creating semesters, courses and adding classes, teachers can send the generated two-dimensional codes to students, and students can join their classes by scanning the two-dimensional codes. Teachers can post course resources, take attendance, and conduct surveys on the platform, and students can study online, submit their homework, and discuss in groups.

For this course, teachers can post some exercises related to drawing reading or questions about command operation on the platform, so that students can practice repeatedly, which can not only consolidate the students' theoretical knowledge but also strengthen their ability in drawing commands.

In addition, at present, there are many high-quality online information-based teaching resources, such as vocational education professional teaching resource bank and excellent shared courses, NetEase cloud classroom, massive open online course (MOOC), and so on. Teachers should gather the resources in their free time, and select, modify, and innovate them according to teaching needs.

4.3. Promoting learning through competition

For higher vocational colleges, the competition is generally divided into two directions: theoretical knowledge and practical ability. In view of these two directions, corresponding steering groups can be set up to further improve the process, rules, and evaluation of the competitions, so as to make the competitions more institutionalized and systematic. Allow students to gradually get used to competitions rather than making them nervous about it. Although competitions do not need to be held too frequently, it can be held regularly. Students should also be notified about the competitions as early as possible. Teach students to view competitions as normal occasions. In this way, they will gradually focus on learning.

Through the teaching mode of integration of competition and teaching, students' interest in learning Architectural CAD can be stimulated.

A competition-oriented learning environment should be created, priority should be given to students with excellent performance in the learning process of the course to enter the competition training team. An atmosphere, and organically combine skills competition with course learning to achieve the goal of promoting learning through competition.

4.4. Promoting education through competition

The integration of competition into classroom teaching includes integrating relevant skills and knowledge into classroom teaching based on the curriculum standards, adopting a suitable course structure, assessment methods, and many other details, therefore requiring teachers with deep understanding of the subject. Teachers are required to grasp the content of the whole professional curriculum to improve their professional abilities.

5. Change the curriculum assessment and evaluation system

The evaluation system is an important means to evaluate the teaching effect of the course, which plays a guiding role in promoting students' learning and teachers' teaching. Architectural CAD is a practical course, and its traditional assessment methods are formative assessment and final assessment, each of which accounts for a certain proportion of the final score of the course. Among them, the formative assessment is mainly based on the students' performance in class, the completion of homework and drawings, and the final assessment generally comprise of coursework instead of an examination. The disadvantage of this evaluation system is that students usually copy each other's homework and drawings, which cannot reflect

the real learning effect of students, nor can it reflect the learning gap of students. Therefore, the integration of competition items into teaching can include competition training and competition results into the final results of the course. Students who participate in the competition should be encouraged to improve their overall performance appropriately. Students who have achieved good results in the competition and won prizes can be directly exempted from this course; they can also be given comprehensive evaluation good grades according to the award won and their rankings. If the student wins an award in competitions at or above the municipal level, the student can be awarded full score for this course. In this way, students will be encouraged to learn in class, and actively participate in competitions and improve their practical skills.

6. Conclusion

Architectural CAD course as a highly practical course, the effective integration of competition content into classroom lessons promotes the reform of the teaching content and methods of this course, thus improving the comprehensive quality of teachers. Besides, it also helps in developing the students' professional skills and practical ability. Hence, the ultimate goal of personnel training in higher vocational colleges can be achieved.

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Disclosure statement

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Structure Bearing Capacity Testing and Evaluation of Existing Bridges

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Abstract: The bearing capacity testing and evaluation of the existing bridge engineering structure is not only the key to clarify its structural quality and safety performance, but it also can lay a solid foundation for subsequent repairs and maintenance work. To ensure the bearing capacity, durability and reliability of existing bridges, this paper analyzes the importance and methods of testing and evaluation of structural bearing capacity of a bridge. This analysis aims to provide scientific reference for the quality assessment and subsequent repair and maintenance of existing bridge engineering structures.

Keywords: Existing bridge; Bridge structure; Bearing capacity detection; Bearing capacity evaluation

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1. Introduction

With the development of social economy and science and technology, the transportation industry has also made great progress. As an important engineering foundation in modern transportation, the bearing capacity of existing bridge structures is directly related to the application effect and safety of the existing bridge engineering itself. Therefore, suitable technology should be utilized to test and evaluate the structural bearing capacity of bridges, so as to provide a scientific reference for the operation, maintenance, and repair of existing bridges.

2. The importance of testing and evaluating the bearing capacity of existing bridge structures

With urbanization and the advancement of transportation engineering in China, the bearing capacity of existing bridge engineering structures has also been increasingly emphasized. Especially with the continuous increase of traffic load, the load borne by existing bridges is gradually increasing. After a long period of continuous use, the existing bridge structures are prone to some quality problems. If these problems cannot be discovered and dealt with in time, the bearing capacity of the existing bridge structure will reduce overtime, and even cause traffic accidents in severe cases. To prevent these situations from happening, scientific inspection and evaluation of the existing bridge structure need to be carried out using reasonable technical measures. In this way, it is possible to timely and accurately discover the location of insufficient bearing capacity in the existing bridge structure, thereby discovering its structural defects and problems in a timely manner, and formulating effective measures for the repair of structural problems and the improvement of structural bearing capacity [1]. This is very important for the improvement of the structural quality of existing bridge engineering, and the guarantee of bridge transportation effect and safety.

3. Testing method of bearing capacity in existing bridge structures

In the operation and maintenance inspection of existing bridges, static and dynamic inspection are important inspection in the evaluation of structural bearing capacity. Through the reasonable application of these two detection methods, the structural bearing capacity can be determined scientifically, thus ensuring its quality and safety. The following is an analysis of the application of these two detection methods.

(1) Static testing method

The static testing method is one of main methods of testing whether the existing bridge engineering structure is in a good state and suitable for use. The static testing method is also called the static loading method. Its main principle is by simulating the loading of the existing bridge engineering structure under various working conditions using a truck, and by various advanced testing equipment such as total station, crack gauge, deflection gauge, dial indicator, resistance strain gauge, and many more. Besides, the distribution law of the control section and the lateral load of the control section in the bridge structure under various load test conditions, and the possible occurrence of cracks, stress, deformation, and deflection are tested [2]. Based on the data obtained, the relevant parameters of the existing bridge engineering structure can be obtained. Stress calculations are performed according to different loads, and the calculation results are compared with relevant specifications. Then accurate its structural strength, crack resistance and toughness can be calculated accurately to determine its structural bearing capacity.

(2) Dynamic testing method

Dynamic testing is also an important method in structural bearing capacity testing. As far as the current dynamic testing of bridge engineering structures is concerned, the main methods include natural vibration analysis, dynamic response testing, and cable force testing.

Among them, natural vibration testing is generally carried out through random environment excitation method and forced vibration method. The vibration stimulated under excitation through such as ground pulsation and wind load is detected. The main principle of the forced vibration method is to excite the bridge structure through excitation equipment and obtain its natural vibration parameters based on the resonance effect.

In dynamic response testing, loading vehicles are driven through the testing track under various working conditions to generate corresponding excitation, and various dynamic parameters are calculated based on the effect of the load on the bridge structure. These parameters include impact coefficient, dynamic amplification coefficient, dynamic strain coefficient and moving displacement coefficient, and many more [3]. At the same time, the change of its structural state can also be detected through dynamic strain gauges, photoelectric devices, displacement sensors, and many other equipment, and the change in values of parameters can be acquired accurately.

The main principle of cable force detection is to first determine the transverse vibration frequency of the existing bridge cable structure, and then calculate the cable force based using the obtained value. Then, the values are corrected according to the type of bridge structure and the characteristics of its cable, which will then be used to calculate the structural bearing capacity.

4. Evaluation method of bearing capacity of existing bridge structures

There are four main evaluation methods for structural bearing capacity for existing bridges, the first is defect investigation and empirical analysis, the second is comprehensive analysis, the third is analytical calculation, and the fourth is load experiment. The following is an analysis of the application strategies of these evaluation methods.

(1) Problem investigation and empirical analysis

For existing bridge projects, defect investigation and empirical analysis are relatively traditional means of bearing capacity assessment. In this method, the staff have to be clear on various relevant professional specifications and have sufficient professional knowledge and on-site working experience. When inspecting the existing bridge structure, in addition to the basic inspection, it is also necessary to find out the damaged or defective parts of the structure, carry out rigorous inspections on them, and use this as a basis to evaluate the damage or defects. Reasonable assessment should be made including the assessment of the nature of the damage or defect, the severity of the damage or defect, and the impact of the damage or defect. During this process, staff also need to rely on past experience to analyze the main causes of bridge structure damage or defects and evaluate how the existing damage and defects will affect the existing structure [4]. In this way, the structural bearing capacity of the bridge can be scientifically evaluated, and targeted repair and maintenance plans can be formulated.

(2) Comprehensive analysis and evaluation

A comprehensive analysis and evaluation can not only make a reasonable evaluation of the basic conditions of the existing bridge itself, but also scientifically check and calculate the reduction of structural bearing capacity. In a comprehensive analysis, the damage of the structural materials is evaluated by analyzing the results obtained after detecting the cracks between the existing bridge engineering structures. For the calculation of bearing capacity, non-destructive testing technology can be used to test the performance of its structural materials, such as steel corrosion, concrete thickness, chloride ion content, resistivity, carbonation degree, and concrete strength. In this way, scientific judgments can be made on the performance of various structural materials in existing bridges, so as to realize the effective evaluation of the overall structural bearing capacity and provide scientific reference for the subsequent maintenance of existing bridge projects [5].

(3) Analytical calculation evaluation

In the operation and maintenance inspection of existing bridge projects, the analytical calculation evaluation method is also an important method in the evaluation of the structural bearing capacity. In this evaluation, a basic inspection of the bridge structure is first performed, and relevant data obtained from the inspection is used to analyze and calculate its structural performance [6]. This evaluation method involves not only the calculation theory of bridge structures, but also the corresponding bridge experience coefficients. Therefore, the bearing capacity of existing bridge structures can only be calculated and analyzed through theoretical calculation methods or empirical coefficient conversion methods. Because different analysis and calculation methods have different adaptation factors and applicable conditions. Therefore, experts and staff need to make a reasonable choice of specific analysis and calculation methods based on whether the load level coefficient of the existing bridge is known, if the coefficient is known, it can be analyzed and calculated by theoretical calculation method; if the coefficient is unknown it can be analyzed and calculated by empirical coefficient conversion method [7]. In order to ensure the accuracy of the evaluation results, all load measurement parameters and material strength parameters should be subject to real conditions during specific analysis and calculation. In this way, it is possible to make a scientific assessment of the structural bearing capacity of the existing bridge engineering, discover insufficient bearing capacity in time, and is helpful for the repair and maintenance of its corresponding structures [8].

(4) Load test evaluation

Load test evaluation tests and evaluate the actual operating state of the existing bridge engineering structure. Through the reasonable application of this method, the bearing capacity of the bridge structure can be evaluated more intuitively, and the reliability of the evaluation results can be ensured [9]. In this method, structural load capacity is first tested through static and dynamic tests, and the results of the

tests are collected. The data are then analyzed, and the results are compared with the structural performance parameters in the existing bridge project [10]. In this way, the actual performance parameters of each part of the structure can be scientifically determined. Through further analysis and evaluation of these performance parameters, the structural bearing capacity of each part of the existing bridge project can be accurately identified, and a scientific assessment of its structural damage and defects can be made.

5. Conclusion

In conclusion, the structural bearing capacity is the key to ensure its application effect, service life, and safety. Based on this, relevant units, experts, scholars and staff must do a good job of testing and evaluating the bearing capacity of such bridge structures. By carrying out scientific and reasonable testing and evaluation, problems such as structural damage and defects can be found in time, the location of damage and defects can be identified, and the degree of damage and defects can be reasonably evaluated and its impact on the overall bridge structure can be determined. In this way, not only can the bearing capacity of existing bridge engineering structures be determined, but scientific reference can also be provided for the formulation of structural repair plans and the improvement of the quality of follow-up operation and maintenance. This will have far-reaching implications for the protection of the structural bearing capacity of existing bridges, the improvement of the overall performance of existing bridges, and the development of the bridge engineering industry.

Disclosure statement

The authors declare no conflict of interest.

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Reference citations in the text should be numbered consecutively in superscript square brackets. Some examples:

1. Negotiation research spans many disciplines [3, 4].
2. This result was later contradicted by Becker and Seligman [5].
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Journal

Journal article (print) with one to three authors

[1] Yao Y., Xia B. Application of Phase Frequency Feature Group Delay Algorithm in Database Differential Access. Computer Simulation, 2014, 31(12): 238-241.

Journal article (print) with more than three authors

[2] Gamelin F.X., Baquet G., Berthoin S., et al. Effect of high intensity intermittent training on heart rate variability in prepubescent children. European Journal of Applied Physiology, 2009, 105: 731–738.

Journal article (online) with one to three authors

[3] Jackson D., Firtko A., Edenborough M. Personal resilience as a strategy for surviving and thriving in the face of workplace adversity: a literature review. Journal of Advanced Nursing, 2009, 60(1): 1–9,

Journal article (online) with more than three authors

[4] Hargreave M., Jensen A., Nielsen T.S.S., et al. Maternal use of fertility drugs and risk of cancer in children—A nationwide population-based cohort study in Denmark. International Journal of Cancer, 2015, 136(8): 1931–1939.

Book

Book with one to three authors

[5] Schneider Z., Whitehead D., Elliott D. Nursing and midwifery research: methods and appraisal for evidence-based practice. 3rd edn. 2009, Elsevier Australia, Marrickville, NSW.

Book with more than three authors

[6] Davis M., Charles L., Curry M.J., et al. Challenging spatial norms. 2013, Routledge, London.

Chapter or Article in Book

[7] Knowles M.S. Independent study. In Using learning contracts. 1986, Jossey-Bass, San Francisco, 89–96.

Others

Proceedings of meetings and symposiums, conference papers

[8] Chang S.S., Liaw L. and Ruppenhofer J. (eds). Proceedings of the twenty-fifth annual meeting of the Berkeley Linguistics Society, February 12–15, 1999: general session and parasession on loan word phenomena. 2000, Berkeley Linguistics Society, Berkeley.

Conference proceedings (from electronic database)

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Thesis/Dissertation

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No author

[16] Guide to agricultural meteorological practices. 2nd edn, Secretariat of the World Meteorological Organization, 2010, Geneva.

Note: When referencing an entry from a dictionary or an encyclopedia with no author there is no requirement to include the source in the reference list. In these cases, only cite the title and year of the source in-text. For an authored dictionary/encyclopedia, treat the source as an authored book.

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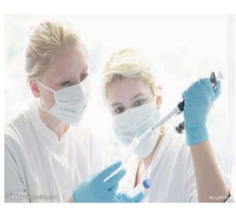
In-service Doctors



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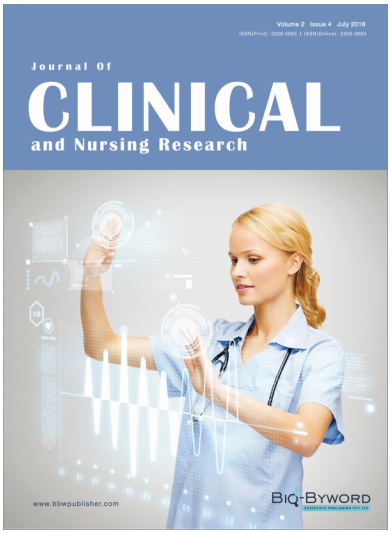

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