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Teaching practice of artificially lowering groundwater level in the course of hydraulic engineering construction

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Abstract: *The course of hydraulic engineering construction involves many contents, wide scope and short class hours, and teachers often do not have enough time to teach many knowledge points that need to be mastered in practical projects, among which the knowledge point of "artificially lowering groundwater level" has this characteristic.Based on tube-well method and well-point method, this paper designs the teaching path based on the concept of case teaching method, and makes use of effect drawings, engineering drawings, PPT animation, FLASH animation and engineering cases in limited class hours to make students understand the basic principles, technical characteristics, scope of application, design and calculation of these two0 methods. Finally, the students can initially master the calculation of the displacement of foundation pit, the number and layout of pipe wells in artificially lowering groundwater level, and have the preliminary ability of engineering practice.*

Keywords: *Hydraulic engineering construction; Artificially lowering groundwater level; Tube-well method; Well-point method; Case teaching method*

Hydraulic engineering construction is a professional core course for students majoring in water conservancy [1-3]. It is a professional course that closely combines theory with practice and the last kilometer to turn the design blueprint into a realistic project and give full play to the benefits of the hydraulic engineering. On the basis of summarizing the advanced experience of water conservancy and hydropower construction at home and abroad, this course starts with construction procedure, construction technology, construction organization and management, cooperates with three major controls, two major management, one coordination, does a good job of on-site construction management and study how to effectively teach a subject of water conservancy and hydropower engineering. The course "Hydraulic Engineering Construction" covers all aspects of construction flow control, earth-rockfill dam engineering, concrete dam engineering, construction organization and management, and its practicality and comprehensiveness are strong.

In the chapter of water flow control in the hydraulic engineering construction course, the section of foundation pit drainage needs to talk about the knowledge of manually lowering the groundwater level. Limited by the total class hours, there is often not enough time for this part of the content to be taught, and students often have little knowledge of the knowledge [4-5]. However, in terms of talent demand, the calculation of "artificially lowering the groundwater level" is a special concern in practical engineering and the pre-foundation of construction organization and mastering this calculation method is very important for students [6]. Therefore, how to enable students to master and use theoretical methods to solve and analyze the process of artificially lowering groundwater level in a limited period of time needs to be studied by teachers engaged in the hydraulic engineering construction course. This paper puts forward a teaching method of artificial lowering of groundwater level based on case teaching method, which aims to complete the teaching of two common concepts and types of artificial lowering of groundwater level, pipe well method and well point method, especially the fast calculation method, and maintain students' learning effect and preliminary practical ability within 45 minutes.

1. Teaching content and path

The explanation of artificial lowering of groundwater level includes the following parts: (1) the deficiency of open arrangement method; (2) the characteristics and scope of application of pipe well method and well point method; (3) the calculation of artificial lowering of groundwater level.

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The specific teaching process is shown in figure 1, which are as follows: (1) reviewing the contents of the previous section in 5 minutes, using the ways of asking questions about important knowledge points, students' answers and teachers' supplementary answers to strengthen students' memory of the knowledge points in the previous section; (2) using 5 minutes to analyze the shortcomings of the open drainage method in the previous section, which leads to the fact that the open arrangement method cannot guarantee that the groundwater level can be lowered manually when the foundation pit is dry; (3) it takes about 15 minutes to teach the relevant knowledge points of pipe-well method and well-point method by a variety of display methods, such as effect drawings, engineering drawings, PPT animation and FLASH animation; (4) the actual foundation pit dewatering case of the project is designed, and the calculation method and calculation process are synchronously explained how to calculate and determine the well-point method to artificially lower the groundwater level, which takes about 15 minutes; (5) review the main contents of this section in the last 5 minutes and talk about the knowledge that needs to be extended after class.

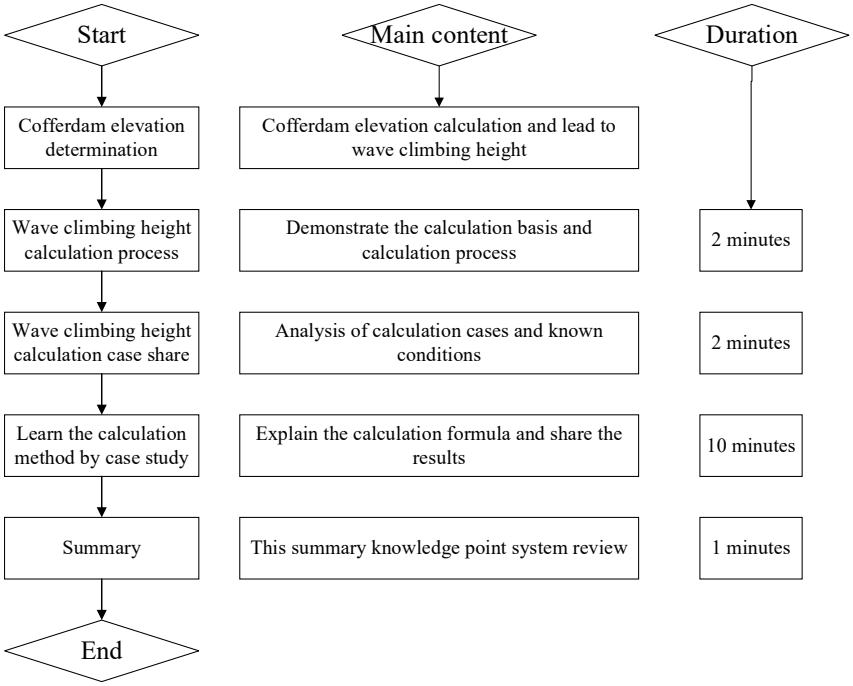

Figure 1: Teaching path of artificially lowering groundwater level

2. Decomposition of teaching process

(1) Review of the previous section (5 minutes).

The key points of the initial drainage construction organization include the falling speed of water level, drainage time, pump selection and capacity, pump layout and drainage methods, as well as the composition and layout of regular drainage. (about 2 minutes).

Please answer the drainage speed and time of the foundation pit of the earth-rock cofferdam, students are required to master this basic requirement (about 1 minute). That is, the falling speed of the water level should be adapted to the characteristics of the foundation and the material of the cofferdam, and it is generally controlled at 0.5~1.5 m/d, in which the 0.5~0.8 m/d at the beginning of the drainage of the earth-rockfill cofferdam can reach 1.0 m~1.5 m/d when the earth-rock cofferdam is nearly drained, and the drainage time is generally 5~7 days for large-scale foundation pits and no more than 3 ~5 days for medium-sized foundation pits.

Please ask another student to answer the layout characteristics of the regular drainage system. Here, we will examine whether students understand the differences and reasons for the drainage system layout in the excavation process of the foundation pit and the construction of the main project. This will enhance students' understanding of the different construction sequences of the foundation pit (about 1 minute)，and provide a brief summary of the answers to students' questions. That is, the arrangement of the drainage system in the process of foundation pit excavation is based on the principle that it does not

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hinder the excavation and transportation work, the dry ditch is arranged in the middle of the foundation pit, the catchment well is arranged on the outside of the outline line of the building, and the bottom of the collecting well should be lower than the bottom of the trench; when the main building is built, the drainage system is arranged around the foundation pit and located on the outside of the outline of the building, so as not to affect the construction of the main project.

(2) Lecture on "artificial lowering of groundwater level" (20 minutes).

First of all, it explains the shortcomings of the arrangement method, and introduces the concept and type of artificially lowering the groundwater level. Here is the transition of regular drainage in the previous section to let students understand the reasons for the introduction of the construction technology of "artificially lowering the groundwater level" (about 5 minutes).

① The deficiency of clear arrangement method. The open arrangement method is generally suitable for clayey soil layers with small precipitation depth and coarse-grained soil layer or small water seepage. When the precipitation depth is large, it is necessary to reduce the elevation of drainage ditch and catchment well for many times, change the position of pump station, affect the construction, and it is easy to produce accidents such as landslide and pit bottom uplift.

② In the process of foundation pit excavation, when the foundation is lower than the groundwater level, the groundwater will continue to infiltrate into the pit because the aquifer of the soil is cut off. During the rainy period, the surface water will continue to flow into the pit. If no dewatering measures are taken, the water flowing into the foundation pit can be discharged in time or the groundwater level will be lowered, which will not only worsen the construction conditions, but also cause slope collapse and decrease the bearing capacity of the foundation after the foundation soil is softened by water. In addition, when there is a confined aquifer under the foundation pit, if the water is not reduced, the foundation may be destroyed. Therefore, in order to ensure the engineering quality and construction safety, measures must be taken to control the groundwater level before or in the process of foundation pit excavation to keep the foundation soil dry during excavation and foundation construction.

③Manually lowering the groundwater level: before the foundation pit excavation, a well pipe is drilled around the foundation pit, and after the groundwater seeps into the well pipe, it is immediately removed, so that the groundwater level is lowered below the bottom of the excavation foundation pit.

④ Explain the principle, function and construction method of artificially lowering groundwater level, and compare the difference between tube well method and well point method. This part focuses on the teaching content of this section, which is interspersed with pictures, texts, videos, practical cases, etc., in which videos and practical cases are linked by multimedia links (about 15 minutes).

Principle of tube well method [7]: a series of pipe wells are arranged around the foundation pit, the suction pipe of the pump is put into the pipe well, and the groundwater flows into the well under the action of gravity and is pumped away by the pump. The method is suitable for coarse and medium sandy soil with permeability coefficient of 10~150 m/d. When the groundwater level is required to be greatly reduced, pipe wells can be used to lower the groundwater level by layers, or centrifugal deep well pumps can be used in pumping equipment, and the dewatering depth can reach more than 20 m.

The principle of the well point method [8]: different from the pipe well method, the well point method combines the well pipe with the suction pipe of the pump, that is, the well pipe of the well point system is the suction pipe of the pump, which is not only simplified in structure, but also convenient for construction, including light well point and deep well point. For example, a light well point is a drainage system composed of well pipes, water collection pipes, ordinary centrifugal pumps, vacuum pumps and water collection tanks. The method is suitable for soil layers with permeability coefficient ≥ 0.1 m/d. The light well point can lower the groundwater level by 4~5 m, and when it exceeds this range, the well point can be arranged in layers.

The functions of artificially lowering the groundwater level generally include:①preventing the groundwater from pouring into the pit; ②preventing the collapse of the slope caused by the seepage of groundwater;③eliminating the pressure caused by the difference of the groundwater level in the soil layer at the bottom of the pit, that is, preventing the piping at the bottom of the pit; ④reducing the lateral load on sheet piles after precipitation; ⑤eliminating the seepage of groundwater and preventing the phenomenon of quicksand; ⑥ after lowering the groundwater level, it can also consolidate the soil and increase the bearing capacity of the foundation soil.

The intake equipment that artificially lowers the groundwater level is called a filter tube. The filter

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pipe is usually made of seamless steel pipe with a length of 1.0~1.5 m and a diameter of 38 mm or 51 mm, and the pipe wall is drilled with a filter hole with a diameter of 12~19 mm. The bread outside the skeleton tube is filtered with 2 layers of raw silk cloth or plastic cloth with different pore sizes. In order to make the running water flow smoothly, the plastic pipe or trapezoidal lead wire is separated between the skeleton pipe and the filter screen, and the plastic pipe is wound into a spiral along the skeleton. The outside of the filter screen is wound with a thick iron wire protection net, and the lower end of the filter pipe is a cast iron plug. The upper end of the filter pipe is connected with the well point pipe.

(3) Calculation example of "artificially lowering groundwater level" (15 minutes).

After figuring out the basic concept of artificially lowering the groundwater level, the students provide an actual foundation pit case, decompose the initial and boundary conditions, display it in the form of picture and text, and form a case teaching style. That is, to master important knowledge points through the case process.

In order to determine the layout of the well point method, the data that should be mastered should include: (1) hydrogeological data: groundwater aquifer thickness, pressure or non-pressure and groundwater change soil quality, soil permeability coefficient, location of impervious layer. (2) Engineering properties: such as the shape, size and depth of foundation pit (foundation groove). (3) Equipment conditions: such as well pipe length, water pump.

Design case: in the fine sand foundation with permeability coefficient K=30 m/d, the opening size of the excavated foundation pit is a × b = 13.6 m × 18.6 m. The surface elevation is 105.2 m and the groundwater level is 105.0 m. The elevation of the bottom of the foundation pit is 101.5 m, and the elevation of the roof of the impervious layer is 97.9 m. Use light well points to lower the groundwater level. The pipe of well pipe is d = φ38 mm, the length of filter pipe is 1.2 m, the distance from well point to the edge of foundation pit is 2.0 m, and the number of well points and average spacing are calculated.

Based on the basic conditions, this paper puts forward "how to determine the number and layout of pipe wells in order to ensure the dry construction of foundation pit?" The question, guide the students to think. Then, in the process of explanation, we introduce the calculation program that the students need to master, the corresponding calculation formula and parameters [9-10], and constantly cause the students to think about it and calculate the case together in the process of explanation. The specific explanation process is as follows:

Set the groundwater level to 0.5m below the bottom of the foundation pit (specification requirements!), then:

● Reduction of groundwater level S=105-101.5+0.5=4.0m

● Distance from groundwater level to the top of impervious layer H=105-97.9=7.1m

●The distance between the well point and the edge of foundation pit :c=1m，

then the area surrounded by the well point: F=(a+2c)(b+2c)=(13.6+2)(18.6+2)=321.36m^2

●Area leading radius of foundation pit: $r=\sqrt{\frac{321.36}{\pi}}=10.11m$

●Influence radius of groundwater decline: $R=1.95S\sqrt{HK}=1.95\times4\sqrt{7.1\times30}=114\text{m}$

● Water depth above the top of impervious layer in foundation pit: h=H-S=7.1-4=3.1m

●→Total pumping capacity: $Q=1.36\frac{K(H^2-\text{h}^2)}{\lg R-\lg \text{r}}=\frac{30(7.1^2-3.1^2)}{\lg114-\lg10.11}=1582\text{m}^3/\text{d}$

●Allowable flow rate: $V_\varphi=65\sqrt[3]{K}=65\sqrt[3]{30}=201.97\text{m/d}$

●Single well drainage capacity: $\text{q}_{\max}=\pi\text{dl}V_\varphi=\pi\times0.038\times1.2\times201.97=28.9\text{m}^3/\text{d}$

●Number of wells required: $\text{n}=\text{k}\frac{Q}{\text{q}_{\max}}=1.25\times\frac{1582}{28.9}=68\approx69$

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●Spacing of wells: $d = \frac{P}{n} = \frac{2(a+b+4c)}{n} = \frac{2(13.6+18.6+2\times1)}{69} = 1.05(m)$

This case is that the actual project inevitably needs to solve the problem of foundation pit drainage, but many project builders do not know how to calculate the displacement of foundation pit and the layout of dewatering wells, so that the layout of pipe wells often depends on experience and is not reasonable. Students' mastery of this knowledge is helpful to improve students' competitiveness in employment. This case can be used for reference in the follow-up curriculum design, graduation design and future work.

3. Conclusion

The drainage of foundation pit is an important work in the construction of water conservancy project, in which the difficulty lies in the method of manually lowering the groundwater level, especially the scientific and reasonable determination of the location, size and number of pipe wells and the selection of pumps, which directly affect the safety and cost of foundation pit construction. However, because of the many contents and short class hours of hydraulic engineering construction course, there is not enough time to explain it systematically. This paper puts forward a teaching system of artificially lowering groundwater level based on case teaching method, which can enable students to master both basic theory and practical needs in a limited time.

(1) In class, the working principle and arrangement of tube well method and well point method for artificially lowering groundwater level are explained by effect drawings, engineering drawings, PPT animation, FLASH animation and other display methods, so as to make students more intuitively understand the consistency between the content and the actual project, and strengthen students' understanding and memory of important knowledge points.

(2) Under the condition that there is not enough time to systematically explain the calculation method of artificially lowering groundwater level, the actual engineering case is introduced and the teaching design is introduced to calculate the displacement of foundation pit and the layout of dewatering wells together with students. Let students master the design and calculation rules in a relatively short time, so that they have the preliminary ability of engineering application.

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