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Hydraulic Engineering Construction Teaching Based on Case Method-Taking Wave Climbing as an Example

Shoukai Chen[1,*]

[1]School of Water Conservancy, North China University of Water Resources and Electric Power, Zhengzhou, 450045, China
**Corresponding author*

Abstract: *The course of hydraulic engineering construction teaching is rich in content, wide in scope of research, but short in duration. Teachers often do not have enough time to teach many knowledge points that need to be mastered in practical engineering. For example, the knowledge point of "wave climbing" is seldom reflected in the course, but practical engineering is inevitable. Based on the concept of case method, this paper designed the teaching path, incorporated relevant specifications, and taught the characteristics, sources, calculation processes and formulas of wave climbing in limited class hours, so that students can understand this knowledge point.*

Keywords: *Hydraulic engineering construction*; *Weir crest elevation*; *Wave climbing*; *Case method*

1. Introduction

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. It is the last kilometer to turn the design blueprint into a realistic project and give full play to the benefits of the water conservancy project. The course covers all aspects of construction flow control, earth-rockfill dam engineering, concrete dam engineering, construction organization and management. It has a high level of practicality and comprehensiveness.

Wave climbing is an important part of calculating and determining the elevation of all kinds of hydraulic structures in the course of hydraulic engineering construction [4–6].. However, due to the limited class time and the complexity of wave climbing calculation, this part is usually mentioned in one fell swoop. Moreover, the wave climb value is usually given directly in class or after-school homework. It leads to the ambiguity of the concept of "wave climbing", which is not conducive to students' objective understanding of the origin of determining the elevation of hydraulic structures, and even affects students' practical application of theoretical knowledge after their future work. For this reason, how to enable students to understand the basic concepts, calculation rules and methods of wave climbing in a limited period of time needs to be studied by teachers engaged in hydraulic engineering construction. This paper proposed a teaching method of wave climbing based on case method, and used the opportunity of explaining the knowledge points of weir crest elevation calculation in cofferdam engineering to let students quickly understand the knowledge of wave climbing.

2. Teaching process

The explanation of wave climbing includes the following parts: (1) the derivation of wave climbing: the calculation and determination of cofferdam elevation; (2) the calculation basis and flow of wave climbing; (3) the calculation case of wave climbing.

The specific teaching process is depicted in figure 1, which are as follows: ①Introduce wave climbing while discussing the knowledge point of determining the elevation of cofferdams to help students realize that it is crucial in determining the elevation of various hydraulic structures, including cofferdams; ②Give students two minutes to learn the basis and process of wave climbing calculation; ③Present a real-world engineering scenario, consider the existing circumstances, and inquire as to how to calculate the wave climbing; ④Synchronize the calculation formula with the calculation process,

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that is, explain the formula and share the calculation results, which takes about 10 minutes; ⑤ Summarize the knowledge content of the extension in the last minute.

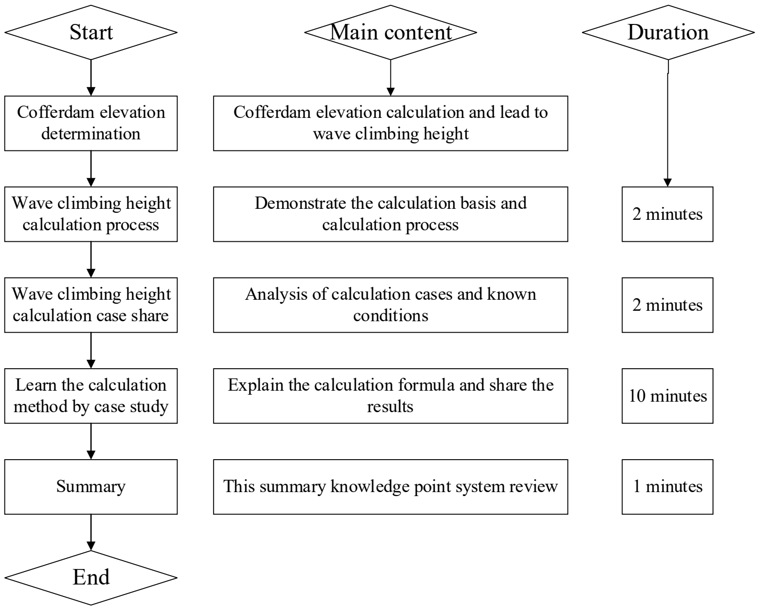

Figure 1 Wave climbing knowledge teaching process

3. Decomposition of teaching process

(1) Lead to the content of "wave climbing"

When explaining the knowledge point of "Weir Top elevation", through the way of "asking questions", teachers lead to the determination of the indexes such as the high value of water level, diversion design flow, wave climbing, and cofferdam grade, and explain these questions and left questions to arouse the curiosity of the students. In the past, the cases and examination questions that students came into contact with were generally given wave climbing values, but in fact, the actual projects need to be determined by themselves. As a result, let students understand that wave climbing is an important part of calculating and determining the elevation of the cofferdam. [7]

(2) Calculation flow of "wave climbing"

According to "Design Code for Construction diversion of Water Conservancy and Hydropower Engineering" (SL623-2013), "Design Code for Roller compacted Earth-rockfill Dam" (SL274-2001) and "Design Code for concrete Gravity Dam" (SL319-2005), the calculation process of wave climbing is combed, as shown in figure 2. It can be seen from figure 2 that the wave climb calculation needs to know certain known conditions, and according to the known conditions, the annual maximum wind speed, zone length, forward wave average climb, wind uvula height, average wave height periodic wavelength and corresponding cumulative frequency climb are calculated respectively, and finally the wave climb value reduced according to direction is obtained. This value is the standard method for obtaining wave climbing value in practical engineering.

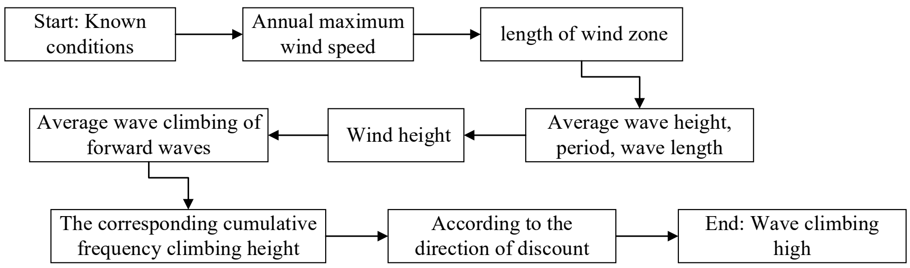

Figure 2 Wave climbing calculation process

(3) Calculation case of "Wave climbing"

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After understanding the basic concept, function and calculation process of wave climbing, students transform an actual engineering case, decompose the initial conditions and boundary conditions, and form a case teaching style, that is, to master important knowledge points through the case process.

Design case: a medium-sized reservoir in Heilongjiang Province, temporary project at V level, 15 meters above the water surface, multi-year average wind speed of 4.07 meters per second, wind direction perpendicular to the cofferdam. The cofferdam is located 12.6 kilometers from the opposing bank, has a water depth of 10 meters in front of it, an average water depth of 7 meters, a side slope of 1:3, and uses dry masonry slope protection for slope protection.

It can be seen from this case that in order to determine the wave climbing, it is necessary to know the level of cofferdam, the average wind speed for many years, the water depth in front of the cofferdam, the slope of cofferdam and the form of slope protection.

(4) A description of the calculation's formula and outcomes

① Annual maximum wind speed: the annual maximum wind speed should be the average wind speed of 10min at the altitude of 10m above the water surface. When only the wind speed at other heights above the water surface can be obtained, the wind speed should be corrected. The calculation formula and results of this example are shown in formula (1).

$$W_{10} = K_Z W_Z \tag{1}$$

Where , W_{10}: Average wind speed for 10 min at a height of 10 m above the water surface; K_Z : Wind speed correction factor, here taken as 1; Z: Height from water surface; W_Z: Average wind speed for 10 min at height Z above the water surface.

② Length of wind zone

The length of wind zone can be determined by three methods:

A. When the water area on both sides of the wind is wide, the distance from the calculated point to the other side can be used

B.When the width B of the local narrowing along the wind direction is less than 12 times the calculated wavelength, 5B can be adopted, but it must not be less than the calculated point to the narrowing point at the same time.

C.When the water area on both sides of the wind is narrow or the shape of the water area is irregular or there are obstacles such as islands, the equivalent wind zone length should be adopted.

This example adopts method A, that is, the distance D=12.6km of the length of the wind zone from the calculated point to the other side.

③Wave height, period, and wavelength averages

The formula of Putian test station [8] should be adopted for the average wave height and average wave period. In this example, the wind speed W=5.86 m/s is determined, along with the average wave height hm=0.22 m, average period Tm=2.08 s, average wavelength Lm=6.73 m, and average period according to average wave height.

④ Wind Yong Height

As indicated in Formula, ascertain the water surface height at the computation position (2). The wind height, e=0.0114m, is determined in this example.

Determine the height of the wind yong surface height in formula (2). The wind height, e=0.0114m, is determined in this example.

$$e = \frac{KW^2 D}{2gH_m} \cos\beta \tag{2}$$

Where, K : The combined coefficient of friction, taken as 3.6×10^{-6} ; β : Calculate the angle between the wind direction and the normal of the dam axis.

⑤ Average climb of forward wave

Determine the average wave climbing of the approaching wave coming from the forward direction on a single slope using the formula in Formula (3). In this instance, the slope coefficient m = 3.0 and

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the forward incoming wave climb height R_m = 0.34m are determined by the shape of the cofferdam slope and berm.

$$R_m = \frac{K_\Delta K_w}{\sqrt{1+m^2}}\sqrt{h_m L_m} \tag{3}$$

Where, R_m : Average wave climbing , m ;m : Slope factor of single slope , taken as 1.5～5.0 ; K_Δ : The roughness permeability coefficient of slope, according to the type of pavement is found from Table 1 ; K_W : The empirical coefficient, found from Table 2.

Table 1 Roughness and permeability coefficient

Type of surface protection	Permeability coefficient
Smooth impervious surface protection (asphalt concrete)	1.00
Concrete or concrete slab	0.90
Turf	0.85-0.90
Masonry	0.75-0.80
Two layers of cast-in blocks (impermeable foundation)	0.60-0.65
Two layers of cast-in blocks (permeable foundation)	0.50-0.55

Table 2 Empirical coefficient

$\frac{W}{\sqrt{gH}}$	≤1	1.5	2	2.5	3	3.5	4	≥5
K_W	1.00	1.02	1.08	1.16	1.22	1.25	1.28	1.30

⑥ Calculate the climb of corresponding cumulative frequency by the average climb of forward wave

The ratio of the average wave height h_m to the water depth H in front of the weir and the related cumulative frequency P (%) can be used to determine the wave climb R_p at various cumulative frequencies. The weir's engineering grade is V, and the associated cumulative frequency is P = 20%; this results in R_p=1.39 m and R_m=0.47 m. The ratio of the average wave height to the water depth in front of the weir is h_m/H=0.02.

(7) Discount according to direction

When the angle between the wave direction line of the incoming wave and the axis of the dam is β, the wave climb is equal to the climb value calculated according to the forward wave multiplied by the reduction coefficient K_β. In this example, the normal angle between the forward wave and the axis of the cofferdam is 0 degrees, and there is no need to reduce, that is, the wave height of the cofferdam: R_p=0.47 m.

4. Conclusion

Wave climbing is an important part of determining the top elevation of cofferdam in the course of hydraulic engineering construction, but the known conditions and calculation process are complicated for students. Taking into account the actual needs of students, this paper proposes to use 10-15 minutes to briefly but systematically explain the calculation of wave climbing for students when teaching the knowledge point of "Weir Top elevation", which is helpful to make up for the lack of students' knowledge in this area. make students have a more comprehensive understanding of the elevation of hydraulic structures.

(1) In class, taking the opportunity of teaching the knowledge points of Weir top elevation, teachers lead to the problems such as wave climbing that affect the calculation accuracy of Weir top elevation, raises the questions, arouses students to think, and puts forward the basis and process of wave climbing calculation.

(2) Under the condition that there is not enough time to systematically explain the calculation method of wave climbing, the actual engineering case and the teaching design are introduced. By calculating each part of wave climbing together with the students, the students can master the calculation rules in a short time and have the preliminary engineering application ability.

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