Design and construction of precast reinforced concrete drain pipe in water conservancy project

Tang xiaoling, Li bin
School of Civil Engineering, Guizhou University, Guiyang 550025, China

Abstract: At the bottom of slag dump site in water Conservancy projects, large diameter reinforced concrete drainage pipes are often used for drainage. Due to the large depth of burial, if the prefabricated reinforced concrete drainage pipe is damaged during construction or use, it will have a great negative impact on the safety of the project and it will be very difficult to repair. There is no relevant basis in the water Conservancy code and there are safety risks. Taking actual engineering as an example, the calculation results according to the design specifications and finite element analysis are compared and analyzed. the limitations of designing according to the water supply and drainage codes are explained. Some engineering solutions for the reinforcement design of prefabricated reinforced concrete drainage pipes with large buried depth are given out. These results can provide reference for hydraulic engineering designers.

1. Introduction
The abandoned slag field of water Conservancy project in Guizhou Province is usually located in the mountainous area. Such abandoned slag field needs to consider drainage. However, due to its large displacement, it is often necessary to bury large diameter prefabricated reinforced concrete drainage pipes at the bottom of the abandoned slag field. Through the literature investigation, it is found that prefabricated reinforced concrete drainage pipes have different design specifications in municipal engineering, transportation engineering, and railway engineering, but there is no corresponding specification in water Conservancy projects. In general, the slag disposal site of water Conservancy projects has a large amount of slag disposal and the prefabricated reinforced concrete drainage pipe is buried deep. If the prefabricated reinforced concrete drainage pipe is damaged during construction or use, it will have a great negative impact on the safety of the project and it will not be easy to repair.

By using Midas gen software, this paper analyzes the construction of precast reinforced concrete drainage pipes and water Conservancy projects in the dregs field of Juntun reservoir hub area in Jiangkou County, Guizhou Province. These results can provide reference for other similar projects.

2. Project Profile
The slag field is located in Hekou Village, southwest of Nuxi Town, Juntun County, Jiangkou County, Guizhou Province. The topography of the slag field is Chonggou, with a total storage capacity of 245,000 square meters. It covers an area of 2.24 hm², and the III prefabricated reinforced concrete drainage pipe has a diameter of 1.8 meters. The maximum burial depth is 28 meters.

The foundation is C15 concrete foundation. The foundation has a capacity of 180 Pa. The basic and prefabricated reinforced concrete drainage pipes are shown in Fig.1.

During the construction process, when the slag was dumped to 12 meters, it was found that the top of the pipe was cracked at point A.
3. Design review

According to the design code of pipeline structure of water supply and drainage engineering (GB50332-2002), the design code of buried precast concrete circular pipe structure (CECS14:32002) is reviewed. When the buried depth reaches 15 meters, the class III precast reinforced concrete drainage pipe, with a diameter of 1.8 meters tube, reaching the maximum bearing capacity [33.02 kN•m/m], the calculation table of each load value and internal force effect coefficient is shown in Table 1.

| Load type and number             | Characteristic value of a load (kN/m) | Each internal force system number |
|----------------------------------|--------------------------------------|----------------------------------|
|                                  |                                      | Kma     | Kmb     | Kmc     | Kna     | Knb     | Knc     |
| 1. Tube weight                   | 20.22                                | 0.211   | 0.079   | -0.090  | 0.109   | -0.079  | 0.250   |
| 2. The tube filled with water    | 17.67                                | 0.000   | 0.044   | -0.048  | 0.000   | 0.000   | -0.069  |
| 3. Tubing pressure               | 0.00                                 | 0.000   | 0.000   | 0.000   | 1.000   | 1.000   | 1.000   |
| 4. Pipe roof covering            | 680.40                               | 0.000   | 0.060   | -0.060  | 0.000   | 0.000   | 0.500   |
| 5. Lumen soil heavy              | 6.26                                 | 0.000   | 0.049   | -0.083  | 0.000   | 0.000   | 0.500   |
| 6. Pipe roof pressure             | 0.00                                 | 0.000   | 0.060   | -0.060  | 0.000   | 0.000   | 0.500   |
| 7. Pipe jacking (live)           | 46.80                                | 0.000   | 0.060   | -0.060  | 0.000   | 0.000   | 0.500   |
| 8. Lateral earth pressure        | 171.72                               | 0.000   | -0.040  | 0.040   | 0.000   | 0.000   | 0.000   |
| 9. Lateral water pressure        | 0.00                                 | 0.000   | -0.040  | 0.040   | 0.000   | 0.000   | 0.000   |
| 10. Side car (live)              | 15.60                                | 0.000   | -0.040  | 0.040   | 0.000   | 0.000   | 0.000   |
| 11. Concentrated test            | 0.00                                 | 0.318   | 0.318   | -0.182  | 0.000   | 0.000   | 0.500   |

Maximum internal force result: bending moment standard combined control value $M_k=32.959\,\text{kN} \cdot \text{m}/\text{m}$, corresponding $N_k=370.564\,\text{kN}/\text{m}$. Internal force combination: $-1.0$ tube self-weight +1.0 tube full water +1.0 external soil load + $\psi_q$ ground live load, internal force position C point. The foundation calculation meets the requirements (the rest of the calculations are omitted).

It can be seen from the design review that the tube has not reached the maximum depth. In theory, point B should not be cracked, but it is also found that the maximum buried depth of the tube will exceed the design requirements after completion.

4. Finite Element Software Calculation Analysis

The buried prefabricated reinforced concrete drainage pipe has complex forces and many influencing factors: foundation and foundation form, construction technology and construction sequence. According to the site construction situation, the author uses Midas gen software to establish three models, which are the normative calculation model A (Fig.2); Construction site simulation model B
(Fig.3), considering the support effect of 18 centimeters compacted backfill; Construction site simulation model C (Fig.4) considers the support of 36 centimeters compacted backfill.

The boundary 1 in the canonical calculation model A (Fig.2) is a fixed support with a load of 680.4 kN/m$^2$; the boundary 1 in the construction site simulation model B (Fig.3) is a fixed support, and the boundary 2 is the elastic support of the Y-direction node, $SD_y=100$ Pa, the load is 680.4 kN/m$^2$; the boundary 1 in the construction site simulation model C (Fig.4) is the fixed support, and the boundary 2 is the elastic support of the Y-direction node, $SD_y=100$ Pa, and the load is 680.4 kN/m$^2$.

The bending moment calculation results are shown in Fig.5, Fig.6, and Fig.7, respectively.

The calculation results of section stress are shown in Fig.8, Fig.9, and Fig.10, respectively.

The calculation comparison shows that:

1. The maximum value of the bending moment changes according to the effect of the backfill of the pipe side (depth, compactness) on the lateral support of the pipe, and sometimes even exceeds the maximum value calculated by the specification.

2. The maximum tensile stress of the section appears at the top of the pipe at point A, which proves that in the actual project, the first crack of the pipe is the pipe top A.

3. When the maximum allowable tensile stress of the section is reached at the point A of the pipe top, the bending moment value calculated according to the specification does not reach the maximum bending moment value, which also explains why the pipeline does not reach the maximum buried depth when the pipeline is cracked.

4. As the base foundation support increases, the section stress of the pipe is significantly reduced. It can be seen that if the buried depth of the pipeline is too large, the pipeline bearing capacity can be improved by increasing the height of the cladding tube.
5. Conclusion
In the water conservancy project waste slag yard, the prefabricated reinforced concrete drainage pipe has a great influence on the construction process due to the large burial depth. In the water supply and drainage engineering pipeline structure design specification (GB50332-2002) and the water supply and drainage project buried precast concrete, it is recommended to consider the design and construction of the circular pipe structure design (CECS 14:32002):

(1) Construction should be backfilled in accordance with the strict requirements of the Atlas during construction;
(2) In the design, it should be noted that the finite element software check design is adopted according to the actual construction conditions;
(3) When the buried depth of the pipeline is large, the pipeline bearing capacity can be increased by increasing the height of the piping.

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