Water environment protection and monitoring management during bridge construction in water source conservation areas

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Abstract. Pollutants generation links of wading bridge construction and the sources of waste water were summarized. Some effective measures were presented to prevent water from pollution and the surface water environment has been monitored upstream and downstream of Jinfeng Bridge, Hu kengcun Bridge and Niu Wukou Bridge. The monitoring results indicate that most monitoring items meet the II-level environmental quality standards of surface water. This good tendency is mainly due to the implementation of strict water resources protection measures during the construction process, which provide technical support for water environment safety of Qiandao Lake.

1. Introduction

With the constant enlargement of the highway traffic mileage and network scale, highway construction is facing with more and more difficulties, such as complex geological conditions, higher bridge-tunnel ratio and growing construction difficulty. At the same time, the requirements are getting stricter for ecological and environmental protection. Bridge construction technology is complicated and the construction environment is sensitive in water source protection areas [1-2]. If the treatment is slightly improper, it may cause irreversible impact on the surrounding ecological environment. Therefore, it is particularly important to practice the concept of green highway construction and strengthen the research on water conservation and environmental protection of bridge construction in water source protection areas [3-5].

Qianhuang highway begins near WeiPing Town, which lies at the juncture of Zhejiang and Anhui provinces, and the end is connected to the Qiandao Lake branch of Hangxinjing Highway, 51.422 km in length. It is an important part of G4012 Liyang to Ningde national highway, and passage between Zhengjiang and Anhui provinces, Hangzhou and Huangshan City. The main characteristics are: (1) with a high bridge-tunnel ratio of 43 bridges and 27 tunnels, which accounts for 78.8% of the total mileage; (2) with complex topographic and geological conditions, which restricts the transportation and increases the construction difficulty; (3) passing through environmentally sensitive area (Qiandao Lake 5A scenic resort and secondary water source conservation area) and has been listed as a typical demonstration project of green highway construction by the Ministry of Transport of the People’s Republic of China.

Based on the engineering practice of Qianhuang highway, the bridge construction techniques which may cause obvious or potential water pollution were analyzed and some effective measures were presented to prevent water from pollution. Furthermore, the surface water environment has been monitored and analyzed to strengthen the environmental protection management.
2. Analysis of pollution production links of wading bridge construction

The wading bridge construction process mainly divides into the following several parts in sequence: pile foundation construction, pile cap and pier body pouring operation, box beam construction and pavement construction. Bored pile technology [6] was applied in the pile foundation construction. Therefore, temporary bridge [7] should be put up over the river for bridge foundation construction and the transportation of machinery and materials. The steel casing can be transported to the pier position and hammered to design depth. The drill machine is then installed and starts drilling in steel casing until the required depth of the pier foundation, simultaneously discharging mud. The steel cage can be sunk into the hole of the pile foundation. Finally, underwater concrete can be poured.

Next is the pile cap and pier body pouring operation after the bottoming concrete[8]. Double-wall steel cofferdam was applied in the construction of pile cap, the operation process was: install steel boxed cofferdam→drainage→install steel boxed cofferdam floor→pour bottom concrete→assembling reinforcement for pile cap→pour concrete for pile cap.

During bridge cofferdam construction, the pollutants were mainly generated in putting up overwater construction platform, steel cofferdam sink, drilling pile construction, cofferdam drainage, and temporary construction platform. These activities would disturb sediments at the bottom of the riverbed. The disturbance would increase the concentration of suspended substances in local waters around the cofferdam. But fortunately, the effect was transient on water environment due to short time consuming of cofferdam construction.

As drilling was carried out in the steel casing, no exchange would take place with external water. However, lots of waste slags were produced during drilling, which would pollute water environment seriously if there was no proper treatment. In addition, when pouring underwater concrete, certain muds may spill out of the well, which also would affect water environment if there were no proper drainage measures. At the same time, oil leakage or white garbage caused by poor mechanical protection during construction may cause great pollution to the surrounding water environment.

Above all, Figure 1 presents the pollution generation links according to the bridge construction process.

3. Measures of water pollution prevention and control

In order to avoid the leakage of fuel oil of construction machinery and facilitate the removal of oil spill, an oil fence was laid around the pile foundation construction platform to prevent oil layer diffusion pollution of Qiandao Lake water quality (Figure 2).

Large amounts of muds were needed during bored pile construction. Mud circulating system was applied to improve drilling progress and quality. At the same time, mud and slag can be separated efficiently, as was shown in Figure 3. The former can be reused and the latter would be collected together and transported to the designated site. This treatment can not only save mud but also reduce the pollution to the environment.
4. Water quality monitoring in the bridge construction area[9-11]

With upstream and downstream of Jinfeng Bridge, Hukengcun Bridge and Niu Wukou Bridge as the representative monitoring points, Table 1 lists the monitoring results of water quality in different months. It can be seen from the table that most monitoring items meet the II-level environmental quality standards of surface water. Few items exceeded the limits, however, these excesses may be accidental. Therefore, it shows good tendency in the overall water environment quality.

Table 1. The monitoring results of water quality.

| Monitoring items          | Jinfeng Bridge | Hukengcun Bridge | Niu Wukou Bridge | II-level environmental quality standards of surface water |
|--------------------------|----------------|------------------|------------------|--------------------------------------------------------|
| KMnO₄ index (mg/L⁻¹)     | 2.4            | 1.8              | 1.2              | 1.4          | 0.8          | 0.7          | 0.9          | ≤4          |
| NH₃-N (mg/L⁻¹)           | 0.103          | 0.17             | 0.073            | 0.028        | 0.153        | Not detected | 0.033        | 0.151       | 0.087       | <0.1        | ≤0.5        |
| SS (mg/L⁻¹)              | 7              | Not detected     | 5                | 1            | 4            | Not detected | 4            | 6           | Not detected | 19          |
| TP (mg/L⁻¹)              | 0.08           | 0.017            | Not detected     | 0.015        | 0.01         | Not detected | 0.015        | 0.018       | Not detected | 0.048       | 0.014       | ≤0.025       |
| Petroleum (mg/L⁻¹)       | <0.04          | Not detected     | <0.04            | <0.04        | <0.04        | <0.04        | <0.04        | <0.04       | <0.04        | Not detected | Not detected | ≤0.05        |
| pH                       | 9.36           | 8.83             | 8.86             | 8.15         | 8.9          | 8.58         | 8.45         | 8.25        | 8.42         | 8.53         | 8.47         | 6–9          |
| Water Temp (℃)           | 23.8           | 32.6             | 30.9             | 26.2         | 32.5         | 29.9         | 22.2         | 31.9        | 29.3         |                |              |              |
| DO (mg/L⁻¹)              | 9.98           | 8.49             | 5.9              | 8.5          | 7.69         | 8.67         | 5.01         | 8.48        | 8.12         | 4.86         | 8.1          | ≥6           |

5. Conclusion

Taking Qianhuang highway as example and combining with the project characteristics, water environment protection and monitoring management were studied during the wading bridge construction. Pollutants generation links of wading bridge construction and the sources of waste water were summarized and some effective measures were presented and taken in practice. In addition, the surface water environment has been monitored and the satisfactory monitoring results showed that the presented measures protected the water quality of Qiandao Lake practically and effectively, as well as provided technical references for similar highway construction projects.

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