On Optimization and Adjustment of Road Line of Duozegou Bridge, the B Bid Section Road Project in the Upper Reaches of Ya-lung River

Xiaolin Wang[1] and Wei Yin[2*]

[1]School of Civil and Environmental Engineering, City College of Southwest University of Science and Technology, Mianyang, Sichuan, 621000, China
[2]China Railway 20 Bureau Group Third Engineering Co., Ltd, Chongqing, 400000, China

Abstract: Based on the external reconstruction project of B bid section road project in the upper reaches of Ya-lung River, this paper takes the total consideration of whole construction period control, construction risk, construction difficulty and investment saving of the Duozegou Bridge, and puts forward some optimization suggestions. From the aspects of the feasibility of the optimization, economic comparison and selection, this paper makes a deep discussion on the section of this road line, and obtains obvious results, which has won the great praise of the owner company. Meanwhile, this paper summarizes the experience for similar projects in the future, and provides reference for other similar projects at the same time.

1 Preface

In the road construction, the line optimization and adjustment are always the things that the construction companies wants to do but not able to. The construction companies will not generally consider the optimization and adjustment of road line under the influence of construction risk, investment cost, feasibility and other factors. However, taking Duozegou lines as examples, this paper puts forward some suggestions for the optimization of road line, and illustrates the reasons, feasibility and economic comparison and selection of the project.

2 Introduction

The length of road line from Yulaxigou to Yazhugou section, the external reconstruction road in upper reaches of Ya-lung River hydropower station is 13.156 km. The standard of road design is grade four, the speed is 20 km/h, and the width of roadbed and roadway is 7.0 m and 6.5 m, respectively. Among them, there are two tunnels with a length of 1996 m and seven bridges with a length of 716 m. Duozegou Bridge with 279 m is one of them, while other line bases total 10.444 km.

The whole length of external reconstruction road divided into two bid sections, that is, A and B bid section. The section from Yulaxigou to Yazhugou is B bid section, with the range between K99+500.00 and K104+700.00 and the length at 5.2 KM. The main controlling projects in this section are Duozegou Bridge and Yazhugou Tunnel etc.

Duozegou Bridge is located at the mouth of the ditch and across Duozegou, with total length at 279 m. The pile number of the starting and ending mileage is K99+647-K99+926. The bridge is a continuous rigid frame bridge of 68+120+68 m and a simple-supported beam bridge with 1×13 m.

3 Reason for Optimization

The project started in early March 2015, and organized and implemented according to the plan.

Duozegou Bridge is a full-line control project. In order to promote the construction of the bridge, the construction sidewalk is to be excavation first in Duozegou, according to the actual situation. The construction sidewalk has paved to the main pier on both sides of the ditch at present. Pile foundations of the main pier are ready for excavation. However, there exit many potential safety hazard during the preparation of manual pile digging.

Firstly, the diameter and pile length of 2# and 3# main pier of Duozegou Bridge was 2.8m and 45m, respectively. According to the design drawing requirements and the actual situation on the site, the pile foundation construction adopts manual digging. After investigation of the construction site, the construction platform's slope of pile foundation on both sides is steep and the rock layer is broken, which is easy to collapse or slip. The excavation of pile foundation by explosions, the vibration wave produced by blasting is easy to cause the loosening of the mountain and induce the geological hazard of the slope. In the construction process of pile excavation, if the slope is in danger situation, the landslide will bury the working platform, and the people

*Corresponding author's e-mail: [2]Yinwei8609@163.com

in the hole are difficult to escape, including operators at the mouth of the hole, who also have no safe place to escape. Therefore, the safety risk is very high.

Secondly, The Duozegou Bridge traverses near the mouth of Duozegou, which shows in a "v" shape. The width of the ditch center is 10 × 15 m, and the gradient of both sides of the slope is large. The water flow in the ditch is large amid rainy season, so it is easy to lead to seepage and water accumulation in the hole during the construction of pile foundation. In addition, broken rock layer of hole wall, developed crack, and hole invaded by rain for a long time, so it is easy to collapse, and the safety risk of digging operators is high.

Thirdly, The Duozegou Bridge is close to the mouth of the Duozegou and near the Ya-lung River Canyon, with strong seasonal wind, and even stronger instantaneous wind. The height of the main pier is 65 m and 68 m, respectively, and the height of tower crane is 85 m. During the construction of pier body binding reinforcement, it is difficult for the operators to stand at a high place under the influence of strong wind, and it is very easy to fall or even fall, with great risk. At the same time, when the pier template has installed amid strong wind, a large-scale swing, rotation and loss control of may happen due to its large size, and the template may be hit operators. In addition, during the construction of continuous beam cantilever grouting, the tower crane has easily affected by strong wind when the large template or object hoisted, operators working at high and equipment are subject to great safety risks when tower crane loses control of hoisting objects.

Fourthly, Due to the topographic reasons of construction site, workface of 2# and 3# plinth of Duozegou Bridge was narrow and small. In order to put hole-digging devices on and meet the construction requirements, the existed platform needs to be dig vertically downwards for 15 m, resulting in a height of side slope at 70m. The side slope is extremely steep, with high safety risk of construction.

Fifthly, no supporting measures have designed for the side slope of 1#, 2# and 3# pile of Duozegou Bridge. However, during the actual construction, due to the influence of the geological conditions of the terrain, the collapse may occur. Considering the safety of construction and later operation, it is necessary to support or reinforce the side slope, such as hanging net spray anchor and a deep-hole anchor rope, with the supporting areas total 3000 m^2. This is bound to boost project investment, increase the difficulty of construction and extend the construction period.

4 Proposed Project of Line Adjustment and Optimization

According to the above situation, it recommended to optimize the adjustment of the Duogou Bridge line, in order to reduce construction difficulties and safety risks and to save project investments. The specific projects are as follows:

First, it proposed to translate the Duozegou Bridge to the right of the line (upstream of Duozegou) by 320 m. After line adjustment, the total length of the bridge reduced from 279 m to about 100 m, and the height of piers reduced from 68 m and 65 m to about 40 m to 50 m. After the optimization, bridge structure became simple. The construction difficulties and the safety risks greatly reduced, due to relatively flat terrain on both sides of bridge location.

Secondly, open line sub-grade shall be in form of a half-filled and half-cut, in order to reduce the excavation of the mountain and combine with on-site terrain. According to the preliminary measurement, the excavation volume of the sub-grade increased by about 89000 m^3, and the filling volume increased by 2700 m^3. The retaining wall arranged on the Duozegou side of the open line sub-grade, with the wall height at 3 m to 16 m and the length at about 420 m. The C20 stone concrete amount increased by about 9000 m^3, and the M10 mortar rubble is about 2300 m^3. In order to facilitate drainage, open line sub-grade will pass through many gullies after line adjustment. Therefore, it is necessary to add more slab culverts with the size of 2.0 m×2.0 m and a total length of about 33 m.

Thirdly, for the line slope of the line after the adjustment of the line, in order to ensure the safety of construction and operation, it is recommended to set the anchor frame girders on the roadbed slopes of K99+715～K99+835, K100+029～K100+115, and the support area is about 5900m^2, the rest of the slope is provided with hanging net spray anchor protection, and the protection area is about 12600m^2. For the road sections where there may occurs rock-fall risks, passive protective fences needs to be set up, with the height at 4 m, the length at about 300 m, and the area at 1200 m^2.

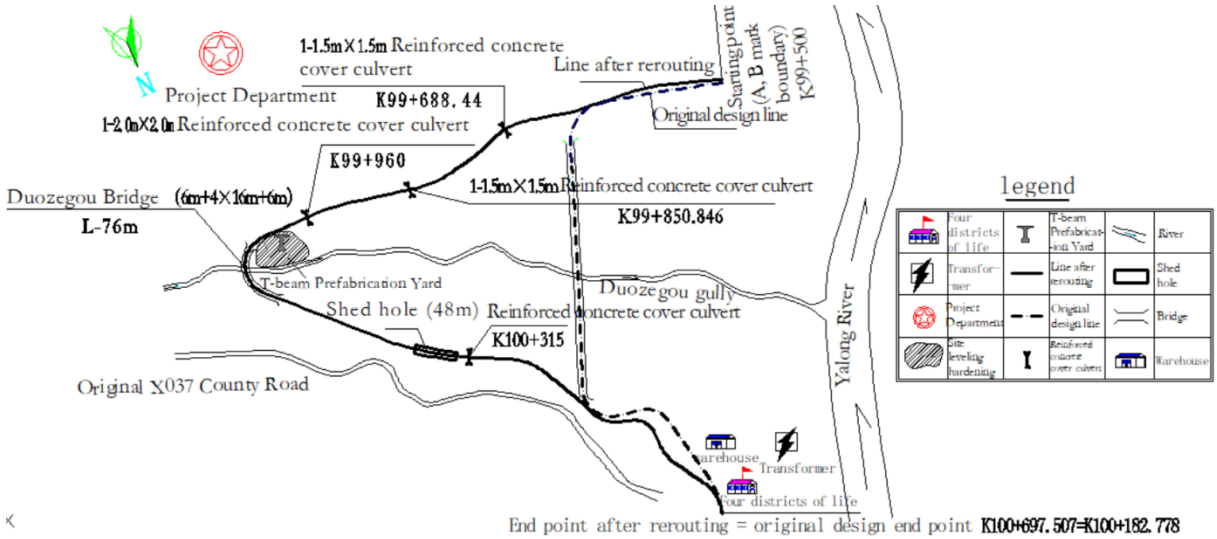

Figure 1. General plan layout of Adjustment of Road Line of Duozegou Bridge

Figure 1 illustrates:

(1) The pile number of the starting and ending mileage is K99+500-k100+697.507.

(2) Arrange large temporary facilities in combination with engineering characteristics and actual site conditions.

(3) Main operation areas, such as office area, living area, oil depot, supply warehouse and machine parking area shall be equipped with sufficient number of fire extinguishers, fire-resisting sand, fireproof spades and other fire equipments and emergency rescue materials, machines and tools.

(4) The site layout of this section after adjustment follows the principle of "saving land as much as possible, reducing the waste of social and public resources, paying attention to environmental protection and conducive to construction" on the premise of meeting the construction requirements.

(5) This diagram is a schematic one, only showing the approximate position and correlation.

(6) The length of adjusted road line is 1,697 m, among which there are one bridge, four culverts and one shed.

(7) The project department is located in the work committee of Xia'zhan district, Yulasicountry, with relatively convenient transportation and external contact. It is easy to communicate with the local department.

5 Economic Comparison and Selection Analysis

Table 1. Quantity for adjusted construction

Serial number	Project name	Sub-project name	Quantity
1	Earthwork	Excavation Fill	89000 m³ 2700 m³
2	Retaining wall	C20 Concrete C20 Schist concrete M10 Mortar rubble	130 m³ 9000 m³ 2300 m³
3	Side-slope support	Hanging net spray anchor Anchor cable frame beam	12600 ㎡ 5900 ㎡
4	Culvert	K99+960 K99+852 K100+140	Cover culvert 33 m （2.0m×2.0m）
5	Bridge		3×30 m Cast-in-place box beam
6	Protection	Passive stone network	1200 ㎡

Table 2. Cost comparison

Line adjustment proposal				Original design
Project name	Unit	Quantity	Total price (yuan)	Duozegou Bridge
Dig earth volume	m³	17800	234248	
Dig the stone quantity	m³	71200	2782496	

Soil filling quantity		m^3	1160	14024.4	
Stone filling quantity		m^3	1540	28828.8	
Retaining Wall	C20 Concrete	m^3	139	117379.9	
	C20 Schist concrete	m^3	9000	5469030	
	M10 Mortar rubble	m^3	2300	923151	
Hanging net spray anchor		㎡	12600	3024000	
Anchor cable frame beam		㎡	5900	12390000	
Passive stone network		㎡	1200	909180	
Culvert		m	33	518943.8	
Bridge			1	8209893	
Total (yuan):		34621174.9			44587211

Illustrates:

(1) The referential price of the bridge after adjustment is 1.8 times as much as that of the Ledinggou Bridge (the structure is a cast-in-place box girder with 72 m high).

(2) If the construction of Duozegou Bridge follows the original design, a large number of slope supports need to be added, leading to the increase of costs to 3 million yuan.

(3) The grid beam of anchor cable frame converted into ㎡ according to the internal group price.

(4) The unit price of other items is calculated by the contract, of which the hanging net and shotcrete-bolt is calculated by m^2 according to the unit price of the detailed item.

6 Site photos and schematic diagram of optimization

Figure 2. Schematic diagram of side slope of 2# plinth of Duozegou Bridge

Figure 3. Schematic diagram of side slope of 3# plinth of Duozegou Bridge

Figure 4. Schematic diagram of line adjustment and optimization

7 Conclusion

Although line optimization and adjustment is not common in road engineering construction at present, it takes a variety of influential factors into account, based on different conditions in practical application, especially in the control project of the whole line construction. Line optimization and adjustment reduce the project costs, shorten the construction period and obtain obvious results, which summarizes the experience of similar projects, and provides references for other similar projects at the same time.

References

1 Hu, C.Y. (2016) Research of Cross Optimization Principles and Typical Schemes of First Class Highway Routes in Plateau Mountainous Areas. Highway Traffic Science and Technology, 1: 273-277.

2 Wang, X.H. (2013) Route Optimization and Adjustment of Local Labels Based on Genetic Hierarchical Comprehensive Evaluation Model. Highway Traffic Science and Technology, 4: 40-51.

3 Hu, Q.W. (2019) Comparison and selection of highway route optimization schemes in Mountainous Areas. Jiangxi Building Materials, 3: 135-137.

4 China Communications First Highway Survey and Design Institute Co., Ltd. (2017) Design Specification for Highway Alignment. China Communications Press, Beijing.

5 Xu, J. L. (2018) Road survey and design. China Communications Press, Beijing.