Research on Design and Cost of Temporary Roads in Mechanized Construction of Transmission Line

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Abstract. The full process mechanized construction of overhead transmission lines has been rapidly promoted in recent years. For construction equipment to arrive the site, temporary road should be constucted first. As the prerequisite for mechanized construction of transmission lines, the construction of temporary road has significant impact on engineering construction. At present, there is no systematic method for the construction of temporary roads. This study focuses on the design of temporary roads in construction. Based on the collected main parameters of mechanized construction machinery, the principles and technical requirements for temporary road construction have been determined. Temporary road construction schemes in typical scenarios of plains and mountainous areas are specified. Based on 2018 electricity quota pricing standards, the construction cost of temporary road is estimated, and highlighting cost-saving measures during construction are considered. This research achievement can serve as a reference for the design and pricing of subsequent power grid projects, thereby facilitating the optimization of design schemes and investment control of transmission line engineering.

Keywords: transmission line; temporary road construction; mechanized construction; construction cost

1 Introduction

In recent years, in order to solve the problem of high labor intensity, slow construction progress, and the risk of safety accidents in transmission line engineering, it is clear that mechanized construction needs to be vigorously promoted[1]. Due to the complex terrain such as mud, hills and mountains, the transmission line engineering is complicated and diverse, and the popularization of mechanized construction is also greatly hindered by the complicated terrain, geology and traffic conditions along the line[2]. The arrival of mechanical equipment used in mechanized construction at the construction site often requires the construction of temporary road. As one of the important links to carry out mechanized construction, the rationality of temporary road scheme determines the feasibility and cost of mechanized construction to a certain extent[3]. In recent years, with the comprehensive promotion of mechanized construction of transmission lines, researchers have studied the approach scheme of mechanical equipment, and summarized many design experiences and methods.

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Mawdesley et al.[4] indicated that well-planned roads at the construction site can improve transportation efficiency and reduce transportation time.Thomas et al.[5] pointed out that reasonable road layout can improve construction safety and reduce the occurrence of accidents.Wang[6] pointed out that the main constraint of mechanized construction of transmission lines in the bog area is the road. In river network area, there are three main road construction methods: traditional temporary road (fill, expand, flatten, compact), laying steel plate, laying ultra-high molecular material paving plate, among which laying paving plate method is superior in comprehensive aspects, and it is recommended to use in temporary road construction in river network area.Chen[7] studied the temporary road construction scheme of mechanized construction on paddy field terrain, and used paving gravel and steel plate to build temporary roads for at the construction site.

The relevant research has certain guiding significance for transmission line mechanization, but there are still many unsolved problems at this stage. On the one hand, the design, size and other parameters of temporary roads used in the existing project vary a lot. On the other hand, when estimating the cost in the early stage, there is a lack of referable cost level, which leads to overspending or a large surplus of the road cost.This study focuses on the design of temporary road in construction of transmission line, and calculates the corresponding costs, so as to provide references for the design and investment estimation of transmission lines in the early stage, and thus improve the accuracy of project construction investment management.

2 Main considerations of temporary road design

There are three main influencing factors of temporary road scheme, which are terrain geology, traffic conditions and construction equipment used [8].

2.1 Terrain and geology

Terrain and geology have a significant impact on the temporary road, which is mainly reflected in three aspects: First, terrain and geology affect the selection of foundation. Different foundation types need to be configured with different construction equipment, which further affects the width and bearing capacity of the temporary road. Second, the bearing capacity of different soil soils is different, which affects the bearing capacity of the temporary road. Some sections with poor geological conditions need to take measures to strengthen the road. Third, some special terrain such as rivers, beaches, etc., special measures, building temporary trestle for example, need to taken to construct the approach.

2.2 Traffic conditions

The construction of roads depends largely on the existing traffic conditions. When the existing road conditions are good, the mechanical passage can directly use the existing road;For some towers with poor road conditions but good terrain conditions, the original roads can be widened and reinforced; When there is no existing road, temporary roads or temporary trestles can be built.

2.3 Construction equipment used

The construction temporary road should meet the requirements of construction equipment . The basic requirements for the temporary road can be summarized by collecting relevant parameters such as width, weight, climbing ability and minimum turning radius of common equipment in mechanized construction. The main parameters of each equipment are shown in Table 1.

Table 1. Performance parameters of common mechanized construction equipment.

Classification	Name	Model	Width(m)	Weight (no load)	Max ramp angle(°)
Excavation	Rotary drilling rig	KR110D	2.6	32	25
		KR150D	2.6	38	25
		KR125ES	3	32	25
	Micro pile drilling rig	WZFT300B	2	17	25
	Anchor drilling rig	MDS-30	/	/	/
	Caterpillar excavator	SY235H	3	23.0	35
Lifting	Truck crane	STC250S	2.5	32.4	25
		STC500E	2.65	42.5	25
		STC800T6	2.8	47.6	25
Transportation	Concrete tank truck	HYS-5000	2.5	25	20
	Tracked truck	SJ-Y05	1.6	2.4	35
	Light truck	WQK-34	1.9	2.4	15

3 Typical design of temporary road

3.1 Technical requirements

3.1.1 Bearing capacity requirements

Temporary roads need to have sufficient bearing capacity to maintain the smoothness and stability of the road surface during construction, avoid problems such as potholes and subsidence on the road surface, so as to ensure the safety and efficiency of vehicle driving. The bearing capacity requirements of the approach road mainly depend on heavy construction equipment. If heavy machinery such as rotary drilling rig needs to enter the road, the bearing capacity of the subgrade is required to be greater than 80kPa. When there are soft soil such as silt and cultivated soil on the surface of the plain area, the characteristic value of the bearing capacity of the foundation is about 40-50kPa, which needs to be strengthened. After the original pavement is cleaned, filled and compacted, 0.1m gravel is laid and compacted to meet the bearing capacity requirements. When the road pass through the cultivated land, in order to reduce the disturbance of the surface of the vehicle, 10mm steel plates can be laid.

3.1.2 Width and slope requirements

The width and slope of the approach road should be the vehicle width and climbing ability of the entered machinery as the boundary. According to Table 1, the width of the construction machinery of the transmission line is generally no more than 3m. In order to ensure driving safety, the width of the approach road should be no less than 3.5m, and the boundary shall be limited by colored flag ropes on both sides of the road. Considering the climbing ability of the construction equipment (Table 1), the road slope should be controlled within 25°, and the road surface with large slope should be opened if necessary.

3.1.3 Drainage requirements

The slope of the construction road in the mountainous area is steep. In order to prevent water and soil erosion caused by rain erosion, temporary drainage ditches should be excavated in the inner side of the construction road for the sections with obvious drainage and erosion phenomenon. The drainage ditches can be 0.3m×0.3m and the ditches should be compacted.

3.2 Design principles

According to the characteristics of the temporary road of the overhead transmission line, the design principles of temporary road construction are summarized as follows :

(1)The relevant requirements of laws and regulations, regulations and local policies for environmental and water protection should be implemented, and temporary road construction should be carried out after comprehensive comparison and selection according to local conditions.

(2) Maximize the use of existing roads for transportation, minimize the occupation of arable land, reduce the destruction of vegetation, and reduce soil erosion.

(3) The road should meet the requirements of construction vehicles, comprehensively consider the equipment needs of mechanized construction. The road width shall be not less than 3.5m and the temporary road and existing road junctions shall be appropriately widened to meet the turning and turning requirements of vehicles.

(4) Shorten the route as much as possible and take a straight line, while considering transportation safety and economic rationality, less open trunk lines, more open branch lines. If some routes need to use curves, the road width at the turn should be appropriately widened.

(5) The road slope is generally controlled within 25°, and the tower with a topographic slope of more than 35 degrees is not recommended for mechanized construction.

(6) After the completion of the project, attention should be paid to the restoration of land and vegetation to meet the relevant requirements of soil and water conservation and environmental protection.

3.3 Typical design of temporary road in common engineering conditions

According to the topography and characteristics of transmission line construction, the typical scene of engineering construction can be concluded as plain area and mountain area. The schemes under various working conditions are discussed.

For plain areas, existing roads can be prioritized, and some rural roads that do not meet the needs of construction machinery need to be reinforced to avoid cement roads being crushed. The section with good geological conditions, the section with good geological conditions, the vehicle can pass after clearing and compacting. If the geological condition is poor, the pavement is reinforced by laying pond slag and gravel, and the thickness after rolling is about 10cm; Or lay more than 10mm steel plate, through this method can reduce the ground pressure, reduce the settlement of the road surface, and reduce the settlement difference. When rivers and other obstacles need to be passed, single-span temporary Bridges need to be erected, and assembled steel trestles are often used.The typical scenes of construction and temporary road schemes are as follows:

(1)The existing cement road can be used. Extra care is needed to avoid damage the cement road surface.If heavy equipment such as concrete tankers, cranes or rotary drilling RIGS pass by, wooden planks should be placed on the cement road for reinforcement, and old tires can also be palced when crawler equipment walks. When placing the board, the laying width should cover the wheel or track width, not less than 1.5m (Figure 1 (a)); When placing the tires, two tires are needed per meter (Figure 1 (b)).

(a)Laying boards (b)Laying tires

Figure 1. Reinforcement of cement road.

(2)The existing farm track or gravel road can be used.The existing road shoulud be 3.5m at least ,when the road is not wide enough, widening, flattening and compaction are needed.

(3)When the bearing capacity of road is poor, there are two ways of reinforcement as shown in Figure 2.

Reinfocement plan A: Fill 0.1m thick gravel after the original road bed is shaped and compacted.

Reinfocement plan B: Lay steel plates after the original ground is leveled and tamped. The steel plate is generally laid vertically,and laid side by side. The front and back of the steel plate should be fitted as far as possible to reduce the gap and ensure the integrity and stability of the road surface.


(a)Paving gravels


(b)Laying steel plates

Figure 2. Temporary road for weak soil.

For mountainous areas, the original cultivar road and gravel road should be used as much as possible, and generally use the obstacle clearing, road bed shaping, widening, etc. It should rely on topographic geology to reduce the amount of soil and rock, avoid the formation of high slopes, and try to avoid the impact on forest areas and high value crop areas.The bearing capacity of the earth in the mountainous area is usually high, and the construction vehicle can pass after the excavation of the earth and rock, the trimming of the slope, and the leveling and compacting of the ground(Figure 3).

Figure 3. Temporary road in mountainous areas.

4 Cost estimating of temporary Roads construction

4.1 Cost estimating methology

According to the temporary road scheme proposed above, the cost of each scheme is estimated based on the current 2018 electricity quota pricing standard.The usage and cost of manpower, materials, and machinery are taken from the road construction quota in the “Budget Quota for Power Construction Engineering Volume 4: Overhead Transmission Line Engineering (2018 Edition)”.The unit price of gravel includes material and transportation costs. The steel plate is considered to be leased for 15 days, and the rental cost is 11 yuan per ton per day.Taking into account the mean slope, the excavation volume is approximately 3m3/m.

4.2 Construction cost estimating

According to current 2018 electricity quota pricing standard, the cost of each scheme is estimated. The breakdown of the cost is provided and the contributions of each component are also showed in the following table.

(1)Widening, flattening, and compacting the surface , with a width of 3.5m. The estimated cost is 80010 yuan/km as shown in Table 2.

Table 2. Construction cost of road leveling

Number	Work	unit	work amount	comprehensive unit price(yuan)	Total cost(yuan/km)	Proportion
1	Flattening and compacting the surface	m^2	3500	13.45	47075	59%
2	Clean-up and recovery	m^2	3500	9.41	32935	41%
Total					80010	100%

(2)Temporary road with gravel with a width of 3.5m. The estimated cost is 169876 yuan/km as shown in Table 3.

Table 3. Construction cost of temporary road with gravel

Number	Work	unit	work amount	comprehensive unit price(yuan)	Total cost(yuan/km)	Proportion
1	Flattening and compacting the surface	m^2	3500	13.45	47075	28%
2	Pave 10mm gravel	m^2	3500	7.29	25515	15%
3	Clean-up and recovery	m^2	3500	14.51	50785	30%
4	Gravel	m^3	350	132.86	46501	27%
Total					169876	100%

(3)Temporary road with steel plates with a width of 3.5m. The estimated cost is 90503 yuan/km as shown in Table 4.

Table 4. Construction cost of temporary road with steel plate

Number	Work	unit	work amount	comprehensive unit price(yuan)	Total cost(yuan/km)	Proportion
1	Installation, dismantling, and entry and exit of steel plates	t	274.75	150	41213	46%
2	Steel plate leasing	t* day	4121.25	11.96	49290	54%
Total					90503	100%

(4)Temporary road in mountainous areas with a width of 3.5m. The estimated cost is 132750 yuan/km as shown in Table 5.

Table 5. Construction cost of temporary road in mountainous area

Number	Work	unit	work amount	comprehensive unit price(yuan)	Total cost(yuan/km)	Proportion
1	earthwork excavation	m3	3000	17.58	52740	40%
2	Flattening and compacting the surface	m2	3500	13.45	47075	35%
3	Clean-up and recovery	m2	3500	9.41	32935	25%
Total					132750	100%

4.3 Disscussion

In areas with good geological conditions, the main factor affecting the cost of temporary road construction is the road width. In actual construction, in sections with good geological conditions or near highway towers, tracked machinery can directly pass instead of the construction of temporary roads and improve economic efficiency. For newly built roads, the width of the temporary road needs to be limited by colorful flag as shown in Figure 4.

Figure 4. Temporary road boundary restriction

Road sections with abundant surface water and soft soil can be reinforced with steel plates or gravel. During construction, it is necessary to comprehensively consider the gravel transportation distance, steel plate usage, and environmental protection requirements at the construction site, and choose a plan that is more economical and convenient for construction .

When constructing temporary roads in mountainous areas, the cost of earthwork excavation accounts for 40%. During construction, efforts should be made to utilize existing tractor roads, sand and gravel roads, reasonably select the route of temporary road, and reduce the amount of earthwork excavation.

5 Conclusion

In this paper, the temporary road of transmission line construction is studied, and the temporary road schemes under common engineering conditions are summarized.The corresponding construction costs are estimated base on current 2018 electricity quota pricing standard. The conclusions are as follows:

(1) The temporary road should be comprehensively considered in combination with terrain and geology, traffic conditions and construction equipment.

(2) The design principles and technical requirements of temporary road construction schemes under common engineering environments are proposed, which can provide reference for the mechanized construction of transmission line.

(3) Cost saving measures should be considered during the construction phrase.For plain area, the width of the temporary road needs to be strictly limited. The reinfocement method should be consider based on environmental and technical facors.For mountainous area, the route of temporary road should be reasonably selected to reduce the amount of earthwork excavation.

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