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Research Article

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Practice of Optimizing and Adjusting the Single Width of Railed Transport Inclined Shaft in Dabashan Tunnel

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Abstract

This thesis studies the optimization of the right width of the ventilation inclined shaft of Dabashan Tunnel, according to the results of the tunnel site investigation, combined with the mountainous terrain to adjust the location of the inclined shaft opening, and the intersection location with the main line, optimize the original design of the inclined shaft of 670m, longitudinal slope -33%, to an inclined shaft of 1,582m, combined longitudinal slope -9.6%, to achieve the purpose of the change from the tracked to the rail-free transportation system, this paper analyzes the technical advantages and disadvantages of the before and after optimization. This paper analyzes the technical advantages and disadvantages before and after optimization, and discusses the impact of this change on the construction of this project.

Keywords: Railed Transport, Trackless Transport, Inclined Shaft Optimization

1. Introduction

With the continuous advancement of engineering technology, the method of expanding the construction working surface by increasing the number of sloped shafts has been widely adopted to realize the purpose of "long tunnels, short tunnels", which makes the design and construction of extra-long tunnels more efficient and feasible.

The longitudinal slope of the inclined shaft is an important part of the design of the inclined shaft. The increase of the longitudinal slope is not conducive to the mechanical transportation and the drainage of the inclined shaft against the slope, and it increases the risk of evacuation of the personnel in case of a sudden burst of water in the water-rich inclined shaft. If the longitudinal slope is small, the length of the inclined shaft will increase. For mountain tunnels, due to the mountainous terrain undulation and space limitations, there may be no good engineering conditions, which is not conducive to the use of natural differential pressure to assist tunnel ventilation, increasing the ventilation cost, so the longitudinal slope of the inclined shaft becomes a key element that directly affects the inclined shaft transportation mode and construction equipment. However, the longitudinal slope of the inclined shaft is not simply determined by the transportation mode in the process of inclined shaft optimization, and unfavorable geological areas should be avoided as much as possible when choosing the location of the inclined shaft and the longitudinal slope.

In this paper, we will focus on the optimization of the right ventilation shaft of Dabashan Tunnel from tracked to trackless transportation. We will discuss the optimization process and analyze the advantages of trackless transportation in the construction phase and the positive impacts on construction efficiency and safety. Through the study, we aim to provide reference for the optimization of the construction of extra-long tunnels through inclined shafts, in order to achieve the goal of more efficient and safer tunnel construction.

2. Project Overview

Dabashan long tunnel for the A Lan Expressway control project, located in Ankang City, Shaanxi Province, Langao County, Taohe Town, crossing the Shaanxi-Chongqing border, built by Shaanxi, Chongqing Province, and Chongqing Chengkai high-speed docking. The tunnel left line is 13.593km long, the right line is 13.561km long, of which the left line in Shaanxi is 8.217km long, and the right line is 8.195km long, which is divided into 3 construction sections, 2 in Shaanxi and 1 in Chongqing. The tunnel adopts two-way four-lane highway standard, design speed 80km/h, building limit 10.25×5m, the overall longitudinal slope of the main tunnel is herringbone slope, the maximum depth of about 1112m, the contract duration of 2005 days (66 months).

2.1 Original Design of the Dabashan Tunnel

The construction scope of this project: ① left line start and end pile number is ZK85+600～ZK89+574.219, the total length is 3974.219m; right line starts and end pile number is YK85+600～YK89+554.354, the total length is 3954.354m; ② No.1 ventilation inclined shaft (also construction inclined shaft, tracked transportation, the right width of 670m/-30%, the right width of 620m/-33%). 33%).

2.2 Project Highlights

• Construction Organization for Rail Transport

Rail transport for the site requirements, equipment investment requirements, organizational difficulties, low construction efficiency, high overall costs, high security risks, seeking a breakthrough is the key to determine the success or failure of the entire project.

• High Schedule Pressure

The contract duration of the project is 66 months (construction is scheduled to start in October 2020 and is expected to be completed in 2026). In order to realize the task of opening to traffic during the "14th Five-Year Plan" period, the internal control target of the project is to complete the whole project in the middle of 2025, combining with the long key lines of the tunnel, high construction safety risks and other engineering characteristics, the construction progress is under greater pressure.

3. Inclined Shaft Optimization

3.1 Analysis of the Duration of the Original Design Program

The length of the right railed inclined shaft is shorter, so the right railed inclined shaft into the main hole construction for the calculation of the construction period: the plan is to start the right railed inclined shaft into the hole construction on October 1, 2020, in accordance with IV 90m/month, V 30m/month progress indicators, the right railed inclined shaft construction length of 620m, according to the calculation of Table 1, the right railed inclined shaft construction period is planned to be 11.2 months (2020 October 1 ~ 2021 September 4), construction duct section 169.28m is expected to take 1.7 months, the intersection picking construction, construction site layout in the hole is expected to take 1 month. (October 1, 2020 ~ September 4, 2021), the construction of duct section 169.28m, is expected to take 1.7 months, the intersection of picking the top of the construction, the hole construction site layout is expected to take 1 month, is expected to November 26, 2021, with the hole construction conditions.

serial number	milepost number (of a vehicle)	Perimeter rock grade	Length (m)	ergonomics (m/month)	Duration (months)	time allocated for a project starting node	time allocated for a project terminating node	Cumulative duration (months)	note
1	K0+000-K0+080	V	80	30	2.67	2020/10/1	2020/12/21	2.67	
2	K0+080-K0+220	IV	140	90	1.56	2020/12/21	2021/2/20	4.22	Spring 2022 impacts 2 weeks
3	K0+220-K0+290	V	70	30	2.33	2021/2/20	2021/5/2	6.56	
4	K0+290-K0+620	IV	330	90	3.67	2021/5/2	2021/9/4	11.14	
5	add up the total		620						

Table 1: Calculation of Construction Period for the Right Inclined Shaft of Dabashan Tunnel

According to the plan on November 27, 2021 into the main hole left line for construction, through the research in recent years using rail transportation with the same type of tunnel construction efficiency, predict the main hole of the Dabashan Tunnel using rail transportation complete sets of equipment for construction, predicted efficiency: V perimeter rock (all fault zones) 30m / month, IV perimeter rock 80m / month, III perimeter rock 110m / month, according to Table 2 calculations, the sloping shafts and the main hole excavation, According to Table 2, the construction period of 62.0 months (i.e. December 1, 2025, excavation to the Shaanxi-Chongqing border), taking into account the second lining lagging behind the palm surface and road surface, decoration and other engineering construction period of 4 months, while the Dabashan Tunnel through a number of fault fault fracture zones, water-rich section, the construction process is faced with a variety of uncontrollable factors such as water influx, the contract duration of 66 months, there is the risk of breach of contract.

serial number	milepost number (of a vehicle)	Perimeter rock grade	Length (m)	ergonomics (m/month)	Duration (months)	time allocated for a project starting node	time allocated for a project terminating node	Cumulative duration (months)	note
1	Right tracked inclined shaft	-	2020/10/1			2021/11/26	2021/11/26	14	Inclined shaft construction on
2	zk85+890-zk86+024	IV	134	80	1.68	2021/11/27	2022/1/16	15.71	Main hole construction on
3	ZK86+024-ZK86+084	V	60	30	2	2022/1/16	2022/4/1	17.71	Spring 2022 impacts 2 weeks
4	zk86+084-zk86+224	IV	140	80	1.75	2022/4/1	2022/5/24	19.46	
5	zk86+224-zk86+624	III	400	110	3.64	2022/5/24	2022/9/12	23.09	
6	zk86+624-zk86+684	IV	60	80	0.75	2022/9/12	2022/10/5	23.84	
7	ZK86+684-ZK86+744	V	60	30	2	2022/10/5	2022/12/5	25.84	
8	zk86+744-zk86+804	IV	60	80	0.75	2022/12/5	2022/12/27	26.59	
9	zk86+804-zk87+314	III	510	110	4.64	2022/12/27	2023/5/31	31.23	Spring 2023 impacts 2 weeks
10	zk87+314-zk87+374	IV	60	80	0.75	2023/5/31	2023/6/23	31.98	
11	zk87+374-zk87+434	V	60	30	2	2023/6/23	2023/8/23	33.98	
12	zk87+434-zk87+494	IV	60	80	0.75	2023/8/23	2023/9/15	34.73	
13	zk87+494-zk87+944	III	450	110	4.09	2023/9/15	2024/1/17	38.82	
14	zk87+944-zk88+144	IV	200	80	2.5	2024/1/17	2024/4/2	41.32	Chinese New Year 2024 impacts 2 weeks
15 16	zk88+144-zk88+224 zk88+224-zk89+574	V IV	80 1350	30 80	2.67 16.88	2024/4/2 2024/7/6	2024/7/6 2025/12/1	43.99 62	Shannon border, between Shaanxi and Chongqing
17	add up the total		3684						

Table 2: Calculation Table for the Duration of the Left Line Penetration of the Dabashan Tunnel

3.2 Comparison of Optimized Solutions for Inclined Shafts

Compared with tracked transportation, trackless transportation has the remarkable features of high efficiency, low cost and good safety. Through the background investigation of the two-stage survey and design of the project and the field survey of the tunnel site area, taking into account the factors of total construction period control, operation ventilation and cost investment, it is proposed to adopt the optimization of the right width of the inclined shaft into a trackless transportation inclined shaft, which can improve the construction efficiency of the main cavern, and help the project to complete the construction tasks in accordance with the contract.

Optimization of Inclined Shaft Line Simulation Trial Calculation

According to the actual topography of the site and the design

elevation of the main tunnel, a trial calculation is proposed, and the length of the inclined shaft is calculated according to the straight-line distance from the entrance of the inclined shaft to the intersection of the main tunnel.

serial number	Inclined shaft opening elevation (m)	Length of inclined shaft (m)	Intersection Stakeout	Intersection elevation (m)	Reverse construction length (m)	Positive construction length (m)	Combined slope
1	1270	1650	ZK86+000	1134.15	400	3574	8.23%
2	1300	1400	ZK86+300	1139.7	700	3274	11.45%
3	1320	1300	ZK86+330	1140.26	730	3244	13.82%
4	1340	1400	ZK86+780	1148.58	1180	2794	13.67%

Table 3: Comparison of Options for Adding Trackless Inclined Shafts in Dabashan Tunnel

According to the results of the trial calculation, taking into account the geological conditions, length of the inclined shaft, the comprehensive slope rate and other factors, combined with the site terrain conditions, the selected elevation of about 1300m to arrange the construction of the inclined shaft opening with convenient conditions, the site can be used as a gently reinforcing steel processing site, concrete mixing station site.

serial number	Inclined shaft opening elevation (m)	Length of inclined shaft (m)	Intersection Stakeout (m)	Intersection elevation (m)	Reverse construction length (m)	Positive construction length (m)	Length of critical lines (m)	Combined slope
Option 1	1300	1266	ZK86+100	1136.00	500	3474	4740	12.95%
Option 2	1300	1400	ZK86+300	1139.70	700	3274	4674	11.45%
Option 3	1300	1660	ZK86+600	1145.25	1000	2974	4634	9.32%
Option 4	1300	1844	ZK86+800	1148.95	1200	2774	4618	8.19%

Table 4: Comparison Table of Trial Calculations for Trackless Inclined Shaft Scheme in Dabashan Tunnel

According to the comparison table can be seen scheme 1, 2, 3, 4 key line length is not much difference, but scheme 2, 3, 4 compared to scheme 1 need to construct more 122m, 260m, 444m, scheme 1 sloped shaft integrated longitudinal slope of 12.95%, close to the limit of trackless transportation equipment climbing slope, is not conducive to the construction of safety, recommended the second set of programs, that is, selecting the intersection of ZK86 +300, reverse construction 700m, forward (big pile number Chongqing direction, that is, the key line) construction 3274m.

3.3 Optimization of Inclined Shaft Design Parameters

According to the selected scheme 2, after communicating with the design unit, since the angle of intersection between the inclined shaft and the main hole in scheme 2 is 33°, the angle is too small, which is not conducive to the picking of the roof and the transportation of materials.

After optimization, the level curve of K1+385-K1+582 section is optimized from straight line to round curve, after optimization, the inclined shaft and the main cavern are at 82°, and the length of the inclined shaft becomes 1,582m, and the comprehensive longitudinal slope is -9.6%. Buffer platform is set every 360m, length 40m, longitudinal slope -3%. Crossing location: ZK86+380, after entering the main cave, construction of 3194m in the direction of big pile number (Chongqing) and 780m in the direction of small pile number (Shaanxi). through the nearby 7# vehicular cross-hole to the right cave K86+430, construction of 3124m in the direction of big pile number (Chongqing) and 830m in the direction of small pile number (Shaanxi).

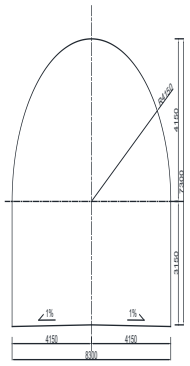

Figure 1: Dimensions of the Section of the Trackless Inclined Shafts

In order to fully understand the geology and water-rich surrounding rocks at the optimized location of the inclined shaft, EM3D technology was used to explore the optimized inclined shaft tunnel site area, and to macroscopically understand the overall surrounding rock conditions and water-rich areas in the tunnel site area. According to the report of the EM3D physical exploration results, the optimized inclined shaft traverses two small fault fault fracture zones (with a combined length of about 80 meters) and two water-rich segments, which were verified through drilling holes in accordance with the results of the physical exploration combined with the topography of the tunnel site area. Based on the physical exploration results and the topography of the tunnel site, the project carried out drilling verification of the water-rich sections and fault fracture zones. According to the results of physical exploration and drilling, combined with the geological longitudinal section (mapping version), the lining parameter section design was carried out, and the optimized dimension of the trackless inclined shaft was adopted as the dimension of the construction inclined shaft designed in the neighboring 19th bidding section.

3.4 Duration Analysis of Optimized Trackless Inclined Shafts

The construction length of the trackless inclined shaft is 1582m, and the construction efficiency of the inclined shaft is calculated to be 15.8 months (October 1, 2020 to January 21, 2022) according to the optimized construction period of the inclined shaft, which is calculated to be 120m/month for Class IV surrounding rock and 80m/month for Class V surrounding rock. After picking the top of the construction, open up the working face, is expected to enter the main hole left hole construction date: February 20, 2022, in accordance with the trackless construction parameters: V perimeter rock (all fault zone) 30m / month, IV perimeter rock 100m / month, III perimeter rock 180m / month of the monthly construction index, the specific construction sequence and calculation of the construction period are as follows:

3.4 Analysis of the Construction Period of the Left Hole

It is planned to start the construction of left hole on December 20, 2021 Construction of 1000m toward Chongqing end (big pile number) to ZK87+380 (construction of 8# vehicle cross-hole is completed, and this cross-hole can be used for the construction of right and left hole interchanges in the future), construction date from February 20, 2022 to November 4, 2022 At this time, the construction of palm surface was increased to the Shaanxi end (small pile number), and the construction was carried out to the starting point of the section, and the construction date was from November 5, 2022 to August 26, 2023. After that, the construction of 620m right width ventilation inclined shaft was reversed from the cave, and the construction date was from August 27, 2023 to April 27, 2024.

At the same time, the left hole to the Chongqing end of the non-stop construction, from ZK87+380 to the left hole end ZK89+574, the construction period from November 5, 2022 to December 27, 2024 to the Shaanxi-Chongqing border, the cumulative construction period of 50.3 months.

3.5 Analysis of Construction Period of the Right Hole

Construct the right hole through 7# vehicle cross-hole, and the intersection position with the main hole is K86+430, and construct 870m to K87+300 (8# vehicle cross-hole construction is completed) toward the Chongqing end (big pile number), and the construction date is from March 20, 2022 to October 28, 2022. At this time, the construction of palm surface toward Shaanxi end (small pile number) is increased, and the construction is carried out until the beginning of the section, and the construction date is from October 29, 2022 to December 31, 2023. After that, the construction of 670m right width ventilation inclined shaft is reversed from the cave, and the construction date is from January 1, 2024 to July 31, 2024.

At the same time the right hole to the Chongqing end of the non-stop construction, from K87 +300 to the right hole end K89 +554, construction period from October 29, 2022 to December 27, 2024 to the Shaanxi-Chongqing border, the cumulative construction period of 50.6 months.

serial number	milepost number (of a vehicle)	Perimeter rock grade	Length (m)	ergonomics (m/month)	Duration (months)	time allocated for a project starting node	time allocated for a project terminating node	Cumulative duration (months)	note
1	zk86+380-zk86+624	III	244	180	1.36	2022/2/20	2022/4/2	1.36	Entering the main cavern construction
2	zk86+624-zk86+684	IV	60	100	0.6	2022/4/2	2022/4/20	1.96	
3	ZK86+684-ZK86+744	V	60	30	2.47	2022/4/20	2022/7/4	4.43	
4	zk86+744-zk86+804	IV	60	100	0.6	2022/7/4	2022/7/22	5.03	
5	zk86+804-zk87+314	III	510	180	2.83	2022/7/22	2022/10/16	7.86	

6	zk87+314-zk87+374	IV	60	100	0.6	2022/10/16	2022/11/4	8.46	
7	zk87+374-zk87+434	V	60	30	2	2022/11/4	2023/1/3	10.46	
8	zk87+434-zk87+494	IV	60	100	0.6	2023/1/3	2023/1/22	11.06	
9	zk87+494-zk87+944	III	450	180	2.5	2023/1/22	2023/4/22	13.56	Spring 2023 impacts 2 weeks
10	zk87+944-zk88+144	IV	200	100	2	2023/4/22	2023/6/21	15.56	
11	zk88+144-zk88+224	V	80	30	3.14	2023/6/21	2023/9/25	18.7	
12	zk88+224-zk89+574	IV	1350	100	13.97	2023/9/25	2024/12/7	33.59	Chinese New Year 2024
13	add up the total		3194						impacts 2 weeks

Table 5: Calculation of the duration of the left line of the Dabashan Tunnel, ZK86+380, toward the large pile number penetration

serial number	milepost number (of a vehicle)	Perimeter rock grade	Length (m)	ergonomics (m/month)	Duration (months)	time allocated for a project starting node	time allocated for a project terminating node	Cumulative duration (months)	note
1	zk86+380-zk86+229	III	151	180	0.84	2022/11/5	2022/11/30	0.84	
2	ZK86+229-ZK86+089	IV	140	100	1.4	2022/11/30	2023/1/12	2.24	
3	zk86+089-zk86+019	V	70	30	2.33	2023/1/12	2023/4/6	4.57	Spring 2023 impacts 2 weeks
4	zk86+019-zk85+600	IV	419	100	4.66	2023/4/6	2023/8/26	9.69	
5	add up the total		780						

Table 6: Calculation table for the duration of penetration of the left line of Dabashan Tunnel ZK86+380 Toward the Small Pile Number

serial number	milepost number (of a vehicle)	Perimeter rock grade	Length (m)	ergonomics (m/month)	Duration (months)	time allocated for a project starting node	time allocated for a project terminating node	Cumulative duration (months)	note
1	K86+430-K86+609	III	179	180	0.99	2022/3/20	2022/4/19	0.99	Inclined shaft into the main tunnel construction
2	K86+609-K86+669	IV	60	100	0.6	2022/4/19	2022/5/7	1.59	

3	K86+669-K86+739	V	70	30	2.33	2022/5/7	2022/7/17	3.93	
4	K86+739-K86+799	IV	60	100	0.6	2022/7/17	2022/8/4	4.53	
5	K86+799-K87+299	III	500	180	2.78	2022/8/4	2022/10/28	7.31	
6	K87+299-K87+359	IV	60	100	0.6	2022/10/28	2022/11/15	7.91	
7	K87+359-K87+429	V	70	30	2.33	2022/11/15	2023/1/25	10.24	
8	K87+429-K87+489	IV	60	100	0.6	2023/1/25	2023/2/12	10.84	
9	K87+489-K87+929	III	440	180	2.44	2023/2/12	2023/5/11	13.28	Spring 2023 impacts 2 weeks
10	K87+929-K88+129	IV	200	100	2.47	2023/5/11	2023/7/25	15.75	
11	K88+129-K88+219	V	90	30	3	2023/7/25	2023/10/25	18.75	
12	K88+219-K89+554	IV	1335	100	13.35	2023/10/25	2024/12/17	32.1	Chinese New
13	add up the total		3124						Year 2024 impacts 2 weeks

Table 7: Dabashan Tunnel right line K86+430 to the Big Pile Number Through the Duration of the Calculation Table

serial number	milepost number (of a vehicle)	Perimeter rock grade	Length (m)	ergonomics (m/month)	Duration (months)	time allocated for a project starting node	time allocated for a project terminating node	Cumulative duration (months)	note
1	K86+430-K86+219	III	211	180	1.17	2022/10/29	2022/12/3	1.17	Inclined shaft into the main tunnel construction
2	K86+219-K86+079	IV	140	100	1.4	2022/12/3	2023/1/15	2.57	
3	K86+079-K86+009	V	70	30	2.33	2023/1/15	2023/8/15	4.91	Spring 2023 impacts 2 weeks
4	K86+009-K85+600	IV	409	100	4.56	2023/8/15	2023/12/31	14.1	
5	add up the total		830						

Table 8: Calculation Table of the Duration of the Right Line of Dabashan Tunnel K86+430 Toward the Penetration of Small Pile Number

Comparative Analysis of Solutions Before and After Optimization of Inclined Shafts Rail transport is inefficient, with long process cycle time and high cost; high requirements on site and equipment, complex system, and difficult organization and maintenance.

Trackless transport efficiency, speed, simple procedures, construction organization is relatively simple; not high requirements for the site, the cave trestle, lining cart and other equipment adaptability, material transport does not require a second inverted; less special equipment, will not cause a lot of idle machinery and equipment; construction management and operators are more familiar with the trackless transport method

and equipment, the construction is more secure.

• Progress

According to the above original design of the railed inclined shaft construction program, the duration of the penetration of 62.0 months; the use of trackless inclined shaft construction program, the duration of the penetration of 50.6 months, the penetration of the duration of savings: 62-50.6 = 11.4 months.

• Security

Tracked transportation construction, winches, mine cars, rails, wire rope and a series of equipment, high safety risk, high maintenance costs, personnel commute by mine car, high safety risk. Trackless transportation equipment is commonly used equipment, low maintenance costs, low safety risk. Slag and concrete, section steel frame, rebar and other materials transportation cross-influence is small.

Adopting trackless construction inclined shaft, in the process of disposing of 6-13 large gushing water in Dabashan Tunnel, the construction of pumping station and the arrangement of supporting facilities of pumps were completed quickly, which reduced the difficulty of emergency rescue and disposal in the process of construction.

• Costs

Comparative analysis of costs in terms of excavation, machinery and equipment inputs, and management costs due to the duration of the work, based on the research study.

• Annotation

The unit price for railed transportation is the reference unit price for the railed inclined shafts in tunnels of other projects of the Company, and the unit price for trackless transportation is the unit price for subcontracting under the post-bid budget under the condition of trackless transportation in our project;

The list unit price of excavation in the table is the owner's contract unit price minus the remaining construction cost after the cost of explosives, and the list unit price of concrete construction is the owner's list contract unit price minus the cost of the corresponding materials and the remaining construction cost after the cost of concrete mixing;

The cost of rail transportation car budget: winch operators, signallers 24 hours a day, three-shift system, labor costs for 300,000 / month, electricity costs for 100,000 / month, maintenance costs for 100,000 / month, An Lan 20 standard rail construction period of 66 months, excluding the preliminary and final construction time, according to the winch system using 55 months of time to calculate the total cost is as follows: (30 + 10 + 10)* 55 = 27.5 million yuan; double-hole winch system and supporting winch house need a total of 10 million yuan, track laying and installation and wire rope total cost of 13 million yuan, so the total cost of winch system of An Lan 20 standard is budgeted at 50.5 million yuan;

The construction period under trackless transportation is expected to be reduced by 11 months compared with railed transportation, and the management fee of the project department can be reduced by 7.88 million yuan through calculation.

In summary, the addition of the trackless transportation inclined shaft option would reverse the loss by $117 million.

serial number	Main breakdown	quantities (m^3)	List unit price ($)	Subcontract unit price for rail transportation ($)	Budgeted unit price for trackless transportation ($)	Total inventory vs. rail transportation ($ million)	Total inventory vs. trackless transportation ($ million)	Total tracked vs. total budget for trackless transportation ($ million)
1	Slant shaft excavation	206552	300.65	280	100	426.53	4144.47	3717.94
2	Main hole excavation	785408	128.38	150	75	-1698.05	4192.51	5890.56
3	Shotcrete for inclined shafts	14816	569.57	380	350	280.87	325.31	44.45
4	Main hole shotcrete	43613	176.67	300	300	-537.88	-537.88	0.00
5	Inclined shaft second lining construction	18769	187.8	300	200	-210.59	-22.90	187.69
6	Main hole second lining construction	95270	249.28	200	165	469.49	802.94	333.45

7	Full cost of winch system					-5050	-700	4350.00
8	Cost of additional inclined shafts				3636		-3636	-3636.00
9	Project department overheads			6023	5235		788	788.00
10	add up the total					-6319.63	5356.45	11676.08

Table 9: Comparison of construction costs between trackless and tracked construction of Dabashan Tunnel

4. Conclusion

After the study, the right width of the ventilation inclined shaft of Dabashan Tunnel is optimized from a railed transport system to a trackless transport system, and the analysis of the technical advantages and disadvantages before and after the optimization shows that in the construction of Dabashan Tunnel of the project, the use of the optimized trackless transport inclined shaft has significant technological advantages, improves the efficiency of the construction, and helps the project to shorten the construction period in a scientific and reasonable way, and saves the cost of the construction and the management expenses [1-6]. Through the research of this project, it provides a reference case for the selection of the route and construction method for the construction of long tunnels into the main line through the inclined shaft, and also provides a new reference scheme for the realization of "long tunnel, short tunnel" for the extra-long tunnels.

References

1. Chang, L. (2009). Optimization technology of railed transport system for long inclined shaft with large slope. *Journal of Tunnel Construction. 29*(5): 574-578.
2. Gang, L., Shaokang, P., Panpan, Y. (2019). Design and optimization of railed transport system for steep-slope double inclined shaft in Tiantai Mountain Tunnel. *Tunnel Construction (in Chinese and English). 39*(12): 2050-2057.
3. Jun, C., Sipeng. S. (2007). Optimization of construction and transportation scheme for 7~# inclined shaft work area of Taihangshan Tunnel. *Tunnel Construction, 2007*, (S1): 52-54.
4. Shengxiang, L. (2003). Optimized design and construction of inclined shaft in Pengshui Tunnel. *Railway Standard Design*. (5): 40-42.
5. Wenhai, Z. (2004). Ventilation design for construction of multiple working faces in No.3 inclined shaft of Usheling long tunnel. *Railway Construction Technology.* (S1): 11-14, 6.
6. Zhongxiao, D., Biao, G., Wanping, P. (2006). Thoughts on the construction of inclined shaft of Ushering special long tunnel. *Journal of Railway Engineering*. (2): 59-63.