CONSTRUCTION METHOD FOR RAPID RECOVERY OF EXISTING TUNNEL LINING

TECHNICAL FIELD

The present invention belongs to the technical field of tunnel construction, and in particular relates to a construction method for rapid recovery of existing tunnel lining.

BACKGROUND

At present, the operating mileage of domestic highway and railway tunnels continues to increase. During the construction or operation of some tunnels, due to geology, construction quality, repeated load of operating vehicles and other reasons, geological disasters such as serious cracking of lining, inward extrusion and ballast bed uplift are found in many tunnels, which do not meet the requirements of tunnel safe operation; or in the construction stage, due to high ground stress or the construction action of active faults, the completed part inverted arch cannot continue to bear or affect its use, so it is necessary to dismantle and replace the diseased section in full ring.

In view of the above-mentioned emergency rescue project of special geological disasters of tunnels, to realize the expansion and resumption of operation of single tunnel and single track in a short time, it is necessary to carry out simultaneous construction of multiple working surfaces. Faced with numerous lining restoration construction procedures, there are some problems, such as mutual interference of various procedures, extreme difficulty in logistics organization in tunnel, and difficulty in construction organization and management.

SUMMARY

An object of the present invention is to provide a construction method for rapid recovery of existing tunnel lining, aiming at the technical problems of difficult material transportation and slow construction progress in tunnels with multiple working faces in the prior art.

To achieve the above object, the present invention adopts the following technical solutions.

A construction method for rapid recovery of existing tunnel lining includes the steps of:

step 1, dividing a main hole operation section, and performing tunnel inverted arches construction;

the partition including four sections: a secondary lining region, a first trestle region, a second trestle region and an expanded excavation region in sequence along a length direction of the main hole operation section, with an interval between adjacent sections of 20-50 m; and

simultaneously performing the tunnel inverted arches construction in the first trestle region and the second trestle region;

step 2, paving and hanging a tunnel full-section waterproof board on the main hole operation section;

step 3, performing lining steel bar construction after the waterproof board is paved and hanged; constructing a positioning steel bar, mounting circumferential steel bars and longitudinal distribution steel bars according to the positioning steel bar, and finally mounting a connecting bar between two layers of steel bars;

step 4, performing the construction of a longitudinal circumferential waterstop, including the overlapping of the longitudinal circumferential waterstop;

step 5, lining pouring and maintenance; adopting a hydraulic steel formwork integral lining trolley by the lining, adopting a large arc steel formwork lining bench by the secondary lining, and forming an arch wall by one-step molding; and

step 6, repeating steps 1-5 to complete the recovery of all tunnel linings.

In the technical solution of the present invention, to realize the rapid recovery of the existing tunnel, by adopting a tunnel inverted arch double trestle opposite logistics method, the simultaneous construction of a secondary lining region, a double inverted arch trestle region and an expanded excavation region is realized, which improves the logistics efficiency of various construction regions and solves the technical problems of material transportation in multi-working faces of the tunnel. Combined with a tunnel full-section waterproof board paving structure and a lining cushion layer paving structure, the construction speed of the waterproof board and a cushion layer is effectively improved; and combined with the layer-by-layer concrete pouring via chute in segmented windows construction method, the concrete of the secondary lining arch wall can be quickly fed window by window. The mechanical layer-by-layer concrete pouring in segmented windows improves the concrete pouring speed of the secondary lining of the tunnel. In the later stage, it is maintained by moving a fog cannon and a moisturizing film to ensure the overall quality of the secondary lining concrete construction.

In a preferred solution of the present invention, in step 1, a front end of the main hole operation section is arranged with a first transverse channel, and a rear end of the main hole operation section is arranged with a second transverse channel; and the logistics transportation of the first trestle region is performed through the first transverse channel, and the logistics

transportation of the second trestle region is performed through the second transverse channel. The first transverse channel and the second transverse channel communicate through a horizontal guide parallel to the main hole.

The first transverse channel is close to the secondary lining construction region, and the second transverse channel is close to the expanded excavation region.

Preferably, inverted arch construction procedures of the first trestle region and the second trestle region are performed synchronously, logistics directions are opposite, and a logistics transportation direction in the inverted arch construction process of the expanded excavation region is the same as that of the first trestle region.

Preferably, the inverted arch spacing corresponding to the first trestle region and the second trestle region is 20-24 m.

In a preferred solution of the present invention, in step 1, the tunnel inverted arch construction specifically includes:

the inverted arch preliminary bracing and the pouring are performed in the first trestle region and the second trestle region.

In a preferred solution of the present invention, in step 2, the paving and hanging of the waterproof board includes the steps that:

a, anchoring steel bars are mounted on side walls on two sides of the tunnel with an anchoring depth of 40 cm;

b, a clamp point is set every 60 cm along a longitudinal length of the waterproof board, a clamp length of the waterproof board is 3 m, and a total of 4 clamp points are set; and the waterproof boards are paved from one side to the other;

c, similarly, a waterproof board and a clamp are used on the other side to clamp an end of the other waterproof board; and

d, after the waterproof board and the clamp are adjusted in place, the waterproof board is ultrasonically welded by a hanging ladder.

In a preferred solution of the present invention, after the mounting of the waterproof board is completed, the inverted arch formwork is mounted, and the inverted arch concrete is poured and cured. After the inverted arch construction is completed, the trestles are dismantled.

Preferably, in step 4, construction procedures of the overlapping of the longitudinal circumferential waterstop include the steps of:

S1, cutting off the rubber of an overlapping convex part of a steel-edged rubber waterstop;

S2, leaning a steel plate waterstop and the steel-edged rubber waterstop together, anchored with at least two rivets on two sides; and

S3, tightly bonding, after the rivets are anchored, a gap between the steel-edged rubber waterstop and the steel plate waterstop with an adhesive material.

Preferably, in step 5, lining pouring construction procedures include: chiseling a concrete surface, constructing a cushion layer, and finally performing segmented lining pouring by windows.

Preferably, before the construction of the cushion layer, a midline of a bottom edge line of the cushion layer, a midline of a hoop hose and a midline of a drainage board strip are marked on a preliminary bracing surface, the bottom edge line of the cushion layer paved is a rail top elevation, the hoop hose and the circumferential drainage board strip are staggered, the cushion layer is paved between adjacent hoop hoses, and a plurality of dovetail clips are arranged between two adjacent cushion layers in the longitudinal circumferential direction.

Preferably, the cushion layer is made of polyethylene.

Preferably, the lining pouring adopts layer-by-layer concrete pouring via chute in segmented windows, the lining pouring uses a lining trolley, and the lining trolley is arranged with a graded diversion device, the graded diversion device including multi-stage diversion components from top to bottom, each multi-stage diversion component including a main hopper, a main flow tank, three-way diverter grooves, diverter string cylinders and window drainage channels.

Preferably, the secondary lining pouring is bottom-up layered symmetrical pouring with layered vibration, and a low-frequency vibrator and a high-frequency vibrator are combined in the concrete tamping process.

In summary, since the above technical solutions are adopted, the advantages of the present invention are that:

1. In the technical solution of the present invention, by proposing a tunnel inverted arch double trestle opposite logistics mode and an inverted arch double channel construction method, synchronous construction of four regions of a secondary lining region, a double inverted arch trestle region and an expanded excavation region is realized, the logistics efficiency of each construction section is greatly improved, and the material transportation problem in multi-working face tunnels of small section and short section tunnels is overcome.

2. Based on multi-section synchronous construction, the technical solution of the present invention also combines the construction of the tunnel full-section waterproof board paving and hanging structure, the lining cushion layer paving and hanging construction effectively improves the waterproof effect of an overlapping position of the waterproof board, and combines the secondary lining trolley with the graded diversion device in the secondary lining pouring process to realize the window-by-window rapid feeding of the tunnel full-section and improve the rapid recovery of the secondary lining. After the pouring of the secondary lining is completed, the maintenance methods of high and low frequency vibration, moving fog cannon and moisturizing film are further combined to ensure the final construction quality of the secondary lining.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a construction flow chart of the present invention;

FIG. 2 is a schematic diagram of a partition of a main hole operation section of the present invention;

FIG. 3 is a logistics transportation route map during tunnel inverted arch construction of the present invention;

FIG. 4 is a schematic diagram of a waterproof board paving and hanging structure of the present invention;

FIG. 5 is a schematic diagram of a hanging structure of the present invention;

FIG. 6 is a schematic diagram of a clamp structure of the waterproof board paving and hanging structure of the present invention;

FIG. 7 is a schematic diagram of the overlapping of a longitudinal circumferential waterstop of the present invention;

FIG. 8 is a schematic structural diagram of a cushion layer of the present invention;

FIG. 9 is a schematic structural diagram of a dovetail clip of the present invention; and

FIG. 10 is a schematic diagram of a graded diversion device of the present invention.

Reference numerals and denotations thereof: 1-first transverse channel; 2-second transverse channel; 3-secondary lining region; 4-first trestle region; 5-second trestle region; 6-expanded excavation region; 7-steel pipe; 8-clamp; 9-waterproof board; 10-adjustment bolt; 11-anchor bolt; 12-steel plate waterstop; 13-steel-edged rubber waterstop; 14-longitudinal construction joint; 15-drainage board strip; 16-hoop hose; 17-cushion layer; 18-dovetail clip; 19-main hopper; 20-main flow tank; 21-three-way diverter groove; 22-diverter string cylinder; and 23-window

drainage channel.

DETAILED DESCRIPTION

To make the object, technical solution, and advantages of the present invention more clearly understood, the present invention will be described in further detail below with reference to the accompanying drawings and embodiments. It is to be understood that the specific embodiments described herein are merely for illustration of the present invention and are not intended to limit the present invention.

Embodiment 1

The embodiment is explained in combination with specific cases, and the construction method of this embodiment is successfully applied to the emergency rescue project of special geological disasters in a tunnel in a certain mountain.

Project overview

An entrance of a certain tunnel of Wari Railway was located in Puxian County, and an exit was located at a junction of Yaodu District and Hongdong County of Linfen City. It was designed as a double-hole single-track tunnel, with a total length of 23468.5 m on an upstream line and a total length of 23441 m on a downstream line. After the tunnel was put into operation, geological disasters such as serious lining cracking, inward extrusion and ballast bed uplift had been found many times in the tunnel. After monitoring and observation, the diseases continued to develop and the sections continue to increase. After demonstration by the expert meeting, it was clear that a tunnel disaster was mainly caused by special geological disaster factors such as complex geological structure, groundwater change, and gypsum-salt rock. It was necessary to dismantle and replace the diseased section in the whole ring, and dynamically adjust special sections and measures according to monitoring situations in the construction process.

A construction method for rapid recovery of existing tunnel lining is provided, and an overall construction process is understood in combination with FIG. 1. Before construction, the preliminary bracing section is inspected and rechecked. The center line, level, section size and clearance size of the tunnel all meet the design requirements to ensure that the lining does not invade a tunnel building boundary.

The following steps were specifically included:

In step 1, a main hole operation section was divided and tunnel inverted arches construction was performed. The main hole operation section was located between two transverse channels,

and the partition included four sections: a secondary lining region 3, a first trestle region 4, a second trestle region 5 and an expanded excavation region 6 in sequence along a length direction of the main hole operation section. A first transverse channel 1 was arranged on one side close to the secondary lining region 3, and a second transverse channel 2 was arranged on one side close to the expanded excavation region 6, as shown in FIG. 2, which was a schematic diagram of the partition of the main hole operation section, and the first transverse channel 1 and the second transverse channel 2 were communicated through a parallel pilot tunnel parallel to the main hole.

Adjacent sections were spaced between 20-50 m; and the inverted arch bracing was 14 m (bracing 3 m/cycle), the pouring is 12 m, and the spacing between the two inverted arches is 24 m.

In the embodiment, the parallel pilot tunnel was used as a main transportation channel, a transverse channel was added to connect the parallel pilot tunnel and an expansion line, a parallel auxiliary guide pit was preferentially constructed through the main hole, and the main hole was constructed through the parallel auxiliary guide pit after completion. A cluster-type short-distance working face rapid construction operation was adopted in which more short construction operation sections were set, the operation section was constructed in two directions, the construction operation surface was increased, and the construction progress was accelerated.

FIG. 3 shows a logistics transportation route map in the tunnel inverted arch construction process. In the tunnel inverted arch construction process, the first trestle region 4 and the second trestle region 5 were performed synchronously, and the logistics transportation directions were opposite, in which a logistics organization direction of the expanded excavation region 6 was the same as that of the first trestle region 4. Concrete and a steel frame were transported from the first transverse channel 1 to each construction operation section.

The inverted arch steel bar setting and ballast discharging of the first trestle region 4 were performed after passing through the secondary lining region 3 and then passing through the first transverse channel 1.

The inverted arch steel bar setting and ballast discharging of the second trestle region 5 were performed through the second transverse channel 2 after passing through the expanded excavation region 6.

The ballast discharged from the expanded excavation region 6 sequentially passed through the second trestle region 5, the first trestle region 4 and the second lining construction region,

and was transported through the first transverse channel 1. Drilling and blasting and leveling the site in advance before slag excavation of inverted arch expansion, regardless of the time-consuming drilling and blasting of inverted arch, the drilling and blasting of inverted arch and expansion drilling and blasting were performed simultaneously. The specific logistics transportation route diagram is shown in FIG. 3.

The rapid demolition of the existing tunnel lining concrete was performed in the expanded excavation region 6.

In this embodiment, the preliminary bracing of the tunnel adopted anti-seepage and sulfate-resistant shotcrete and wet shotcrete.

In the process of logistics organization of inverted arch double trestle bridges, attention is paid to:

a, the expansion and excavation of ballast of the second lining must start after the inverted arch trestle is returned to its position;

b, during the expansion and excavation of ballast for the inverted arch, the expanded excavation region 6 cannot perform ballast discharging and anchor spraying operations;

c, the excavator is parked in a short transverse channel region; and

d, materials such as steel frame, steel mesh, anchor rod and locking foot anchor pipe of the expanding and excavating working surface arrive near a working region before the inverted arch is ballasted out.

In step 2, the paving and hanging of a tunnel full-section waterproof board 9 was performed on the main tunnel operation section; and specifically, the paving and hanging of the waterproof board 9 is shown in FIG. 4. The paving and hanging process of the waterproof board 9 is as follows:

(1) Φ22 anchoring steel bars are mounted on side walls, anchoring 40 cm. The specific hanging structure is shown in FIG. 5.

(2) Clamp 8 points are set every 60 cm along the waterproof board 9. A length of the clamp 8 of the waterproof board 9 is 3 m, and a total of 4 clamp points are set. The waterproof boards are paved from one side to the other. The forms of the waterproof board 9 and the clamp 8 are shown in FIG. 6.

(3) Similarly, a waterproof board 9 clamp 8 is used on the other side to clamp an end of the other waterproof board 9.

(4) After the waterproof board 9 and the clamp 8 are adjusted in place, the waterproof board 9 is ultrasonically welded by a hanging ladder.

In step 3, after the waterproof board 9 was paved and hanged, lining steel bar construction was performed.

After the waterproof board 9 was paved, the steel bars were binding, and the steel bars used in this project were centrally processed and formed in a processing plant, and then transported to the site for use. A positioning steel bar was constructed, circumferential steel bars and longitudinal distribution steel bars were mounted according to the positioning steel bar, and a connecting bar was finally mounted between two layers of steel bars.

After the paving of the waterproof board 9 was completed, the inverted arch formwork was mounted, and the inverted arch concrete was poured and cured. After the inverted arch construction was completed, the trestles were dismantled.

In step 4, the construction of a longitudinal circumferential waterstop was performed.

Because a rubber part of the steel-edged rubber waterstop 13 has a bulge, one side of a groove of the steel plate waterstop 12 faces a preliminary bracing surface. When a longitudinal construction joint 14 is overlapped, the steel plate waterstop 12 and a circumferential steel-edged rubber waterstop 13 cannot be closely attached, and there is a large gap in the middle, which is a weak link of waterproofing. It is necessary to strengthen the overlapping construction of the circumferential longitudinal waterstop. Specific settings are shown in FIG. 7, and an overlapping construction sequence is as follows:

(1) the rubber of an overlapping convex part of a steel-edged rubber waterstop 13 was cut off;

(2) a steel plate waterstop 12 and the steel-edged rubber waterstop 13 were leaned together, anchored with three rivets on two sides; and

(3) after the rivets were anchored, a gap between the steel-edged rubber waterstop 13 and the steel plate waterstop 12 was tightly bonded with an adhesive material.

In step 5, secondary lining pouring and maintenance; a hydraulic steel formwork integral lining trolley was adopted by the lining, a large arc steel formwork lining bench was adopted by the secondary lining, and an arch wall was formed by one-step molding.

Before the construction of the cushion layer 17, a midline of a bottom edge line of the cushion layer 17, a midline of a hoop hose 16 and a midline of a drainage board strip 15 are

marked on a preliminary bracing surface, the bottom edge line of the cushion layer 17 paved is a rail top elevation, the hoop hose 16 and the circumferential drainage board strip 15 are staggered, the cushion layer is paved between adjacent hoop hoses 16, and a plurality of dovetail clips are arranged between two adjacent cushion layers 17 in the longitudinal circumferential direction.

The following steps are specifically included:

1. Concrete surface chiseling: a specific construction process of: pouring concrete → spraying retarder (slurry lifting is completed) → chiseling (high-pressure water gun washing) → interface cleaning (water accumulation and waste residue removal).

Concrete pouring shall be performed according to a concrete construction technology. A retarder is sprayed, an interface between a secondary lining end and an inverted arch end is treated, and the retarder is sprayed on an end template before closing the die. The retarder is sprayed on a top surface of a small side wall immediately after the concrete lifting is completed (retarder spraying is completed within 20 minutes). Washing: after the initial setting or pouring of concrete for 6-8 hours, a high-pressure water gun is used to wash the concrete interface at high pressure. The interface is cleaned and the accumulated water and waste residue on a construction interface are removed.

2. Construction of polyethylene cushion layer 17 (5 cm thick);

A material of the cushion layer is a polyethylene foam board, a thickness is designed to be 50 mm, side walls and arch sections are set; and the polyethylene cushion layer is processed in blocks, a processing size is 1.5 m*1.5 m, and a thickness is 50 mm. Dovetail clips are adopted for fixing. As shown in FIGS. 8-9;

(1) Alignment: red paint is used to spray out a bottom edge line of the cushion layer 17 and center lines of the hoop hose 16 and the drainage board strip 15 on a preliminary bracing surface. A bottom edge line paved in the cushion layer is a rail top elevation, the hoop hose 16 and the circumferential drainage board strip 15 are arranged in staggered ways, and a center line spacing is 1.6 m.

(2) A bottom dovetail clip is mounted: a material size of the cushion layer is 0.75 m*1.5 m, and a spacing between dovetail clips is 81 cm*78 cm (a longitudinal direction of a ring).

A cushion layer is paved between the adjacent hoop hoses 16 at a clear distance of 3 m. A size of the buffer cushion layer 17 is 0.75 m in high × (1.5 +1.5) m wide, 39-40 cm are reserved at two ends, and the spacing of dovetail clips 18 is 77cm, with four dovetail clamps at the top

and bottom.

(3) A polyethylene buffer layer is adopted. From bottom to top, a dovetail clip and a buffer layer are mounted in turn.

(4) The bottom two layers of the cushion layer are paved by ladders before the inverted arch waterproof board 9 is paved, and an upper part is constructed by a bench after the inverted arch and the inverted arch filling and pouring are completed.

3. Segmented lining pouring by windows: the lining pouring adopts layer-by-layer concrete pouring via chute in segmented windows, the lining pouring uses a lining trolley, and the lining trolley is arranged with a graded diversion device, the graded diversion device including multi-stage diversion components from top to bottom, each multi-stage diversion component including a main hopper, a main flow tank, three-way diverter grooves, diverter string cylinders and window drainage channels.

Lining pouring adopts chute window by window layered pouring:

The lining pouring adopts layer-by-layer concrete pouring via chute in segmented windows, the lining pouring uses a lining trolley, and the lining trolley is arranged with a graded diversion device, the graded diversion device including multi-stage diversion components from top to bottom, each multi-stage diversion component including a main hopper 19, a main flow tank 20, three-way diverter grooves 21, diverter string cylinders 22 and window drainage channels 23.

Through the combination of hopper, main chute, "three-way" diverter chute, diverter string cylinder and window chute, valves are set at all levels of insert plates to make concrete flow to all working windows, to realize the window-by-window feeding of concrete for the second lining arch wall. Two main diverter buckets are set at the center line of the top platform of a 12 m trolley, and two primary diverter grooves are set on the left and right sides of each main diverter funnel. The primary and secondary diversion grooves are composed of an arc-shaped chute and a primary funnel. Eight diversion chutes are arranged on left and right sides of the primary funnel to lead to the corresponding working windows of primary and secondary platforms. A tertiary diverter groove is composed of a string cylinder, a secondary funnel and an arc chute. The string cylinder connects the primary funnel and the secondary funnel. Four diverter chutes are arranged on the left and right sides of the secondary funnel to the corresponding working window of the tertiary platform.

Specifically, the setting method of lining window pouring is as follows:

When a concrete mixer truck is transported to the site, it is pumped into the main hopper of the top platform by a concrete transfer pump. The concrete shall be poured horizontally in layers and symmetrically, the speed of pouring concrete and the pouring height on one side shall be controlled, and the difference of pouring height on two sides shall not exceed 0.5 m. A vertical distance from a nozzle of a delivery hose to a pouring surface shall not exceed 2 m, and the height before and after the trolley shall not exceed 1 m to prevent concrete segregation. Concrete is poured continuously, and a time interval between pouring two adjacent layers is controlled within 2 h.

4. High and low frequency attached vibrator vibration;

A vibration time of the traditional attached vibrator is not easy to control, which is easy to cause over-vibration and external defects such as "sand turning". The traditional plug-in vibrator is based on the large spacing between concrete windows of a lining trolley, which can't be fully covered by the vibrator, and it is easy to cause vibration leakage. The side wall is prone to quality defects such as honeycomb pits and steel leakage, and the vault is prone to void, so the strength of concrete is difficult to meet the design requirements.

To overcome the above defects, in this embodiment, a vibrating rod and a high and low frequency attached vibrator are used for concrete tamping, and a trolley is equipped with 8 low frequency vibrators (arranged on a side formwork and 8 high frequency vibrators (arranged on a top formwork), totaling 16 sets.

(1) In the actual pouring process, a concrete slump is controlled at 180 mm, symmetrical pouring is adopted, and layered vibration is adopted.

(2) The windows on the first, second and third floors are poured by chute. When the concrete is poured to a position about 1 m higher than a vibrator, the vibrator of this floor is started for 10 seconds at the same time, and the attached vibrators of the second and third floors and a vault are vibrated for 10 seconds at the same time. After 12 hours of demoulding, the surface flatness and smoothness of a whole concrete bin are good, and the strength at 28 days is greater than a design value.

5. Secondary lining maintenance

After demoulding, a movable fog gun is used to spray and cure the lining concrete, and a fog gun device can be fixed on a sprinkler to realize spray maintenance of concrete in each section of the tunnel or dust removal in the tunnel. During the maintenance period, the concrete

surface should be kept continuously wet, and a temperature of maintenance water should be basically the same as an ambient temperature. When the temperature is lower than 5℃, water should not be sprinkled for maintenance.

Moisturizing film maintenance concrete maintenance: for example, when a concrete temperature is high before formwork removal, the water not lower than 20°C is used to spray a formwork to cool down. After formwork removal, a moisturizing film should be hung to cure a concrete surface.

A second-lined trolley is used to pave and hang the moisturizing film. The maintenance is performed in sections from top to bottom to prevent leakage of the moisturizing film. All exposed surfaces of concrete cured with plastic sheets should be tightly covered.

The foregoing is merely a preferred embodiment of the present invention, and is not intended to limit the present invention, and any modifications, equivalents and improvements made within the spirit and principles of the present invention should be included within the scope of protection of the present invention.