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Discussion on the Large Deformation Law of Muzhailing Tunnel in Lanhai Expressway

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Abstract: Muzhailing tunnel is a key project of Weiwu section Lanhai Expressway. It is located in the northeastern margin of the Tibetan Plateau. The complex geological enviorments, such as high ground stress, large buried-depth, fault and fold development, soft and fragmented rock, leads to poor self-stabilizing ability. 2# inclined shaft of Muzhailing tunnel is the main object we studied in this paper. During the construction of the tunnel, large deformation, spalling and fall-block occured on the initial support. The accumulated dome sinking vale and peripheral convergence value are large, mainly presented by the vault sinking, wall squeezing, shotcrete spalling, fall-block, and steel arch twisting and so on. In this paper, the law of large deformation of the tunnel is discussed.

Key words: large deformation; monitoring measurement; Muzhailing tunnel; deformation law

Introduction

Due to the complex geological conditions, Gansu highway has been in a low level, and the economic development has been restricted seriously. To this end, the line from Weiyuan to Wudu section in Lanhai Expressway is newly created, and Muzhailing tunnel is the key project. Large deformation has been caused during the construction process of the 2# inclined shaft in the middle of Muzhailing tunnel, which seriously affected the construction [1,2,3].

1. Engineering background

Muzhailing tunnel is located in high altitude areas, not only the buried depth is large, but also engineering geological conditions are extremely complex. The surrounding rock is mainly carbonaceous slate. The rock is soft and fragmented, and joint fissure is developed, crumple is serious. The buried-depth is large, and ground stress is high, so the rock self-stability is poor and it's a special unfavorable geological zone.

2. Deformation data acquisition and analysis

The monitoring and measurement items of the 2# inclined shaft of Muzhailing tunnel mainly include the vault crown

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settlement and the peripheral convergence. The accumulative deformation increases as the depth of the tunnel increases, while the deformation of the portal section is stable. According to the construction schedule and deformation data statistics, there are three deformation stages.

1）K0+000～K0+250

The tunnel face reveals that the lithology of the surrounding rock is mainly carbonaceous slate. It's a thin monoclinic structure, with broken rock mass, partial crumpled development, low strength, poor rock cementation or no rock cementation in some place, and the integrity and stability of the surrounding rock is poor. The buried depth of the tunnel is 67m to 132m, and the support lining type is XVe. The main support parameter: distance between each H175 steel arch which is set in the whole ring is 0.5m; 8 lock anchors, L=3.5m; systematic bolts, L=4.0m, the ring spacing and vertical spacing is 1.0×0.5m; C25 shotcrete thickness is 28cm. According to the statistics, the maximum value of the vault sinking is 178mm, and the maximum deformation rate is 11.1mm/d, the peripheral convergence value is relatively small. There is partial cracking and shotcrete spalling phenomenon on the initial support.

2）K0+250～K0+394

The tunnel face reveals that the lithology of the surrounding rock in section 2 is similar to section 1. But part of the rock mass is torturous, the rock can be disintegrated and softened if it meets water, and the integrity and stability of the surrounding rock is poorer. The buried depth of the tunnel is 132m to 215m, and the support lining type is XVc. The main support parameter: distance between each H175 steel arch which is only set in the upper ring and not set in the invert is 0.8m; 8 lock anchors, L=3.5m; systematic bolts, L=4.0m, the ring spacing and vertical spacing is 1.0×0.8m; C25 shotcrete thickness is 25cm. According to the statistics, the accumulative maximum peripheral convergence value is 402mm, the deformation rate is 51mm/d, while the maximum value of the vault sink is 386mm and the deformation rate is 36mm/d. The deformation and damage on the initial support and steel frame of the tunnel are serious, some steel frame are distorted and destoryed.

3）K0+394～K0+416

The tunnel face reveals that the lithology of the surrounding rock in section 3 is similar to section 1 & section 2. But part of the rock mass was torturous, the rock water collapse easily softened, the surrounding rock integrity and stability is the poorest. The tunnel buried depth is 215m to 226m, and the support lining type is XVc. According to the deformation of the initial support, some support parameters were strengthened during construction from K0+394 to the face of the tunnel on the basis of the original design. ① Reserved deformation was adjusted to 40cm from 20cm which was designed originally; ② H175 steel arch spacing was adjusted to 60cm per ring from 80cm. Add steel frame in the invert of inithial support, then with the arch wall they can be closed into a ring. In the upper bench construction, the lock anchor was added to 4 pipes on each side of the beach, while there is no one in the original design. In the middle and lower bench construction, the lock anchor was added to 4 pipes on each side of the beach, while there are 2 pipes in the original design. The quantity of lock anchor pipes on a ring is totally added to 24 pipes, while there are only 8 pipes in the original design, L=3.5m. ③ Systematic bolts was constructed according to the original design, and the ring spacing and vertical spacing is 1.0m×0.8m; ④ C30 reinforced concrete is used in the secondary support lining construction. The main steel bars ring spacing is adjusted from 25cm to 20cm, and thickness is 50cm. Deformation situation: the accumulated maximum value of dome sinking for Section K0+401 is 153mm, the accumulated maximum value of peripheral convergence is 100mm, and the invert has not yet excavated, and there is still continous deformation.

3. Deformation law of 2# inclined shaft

Through the monitoring data analysis, the main deformation law of the surrouding rock and initial support in 2#

inclined shaft of Muzhailing tunnel are listed below[4,5].

1）K0+000～K0+250

The deformation was large in the prophase, and it turned gradually stable in the later stage(conventional type). Deformation mainly appeared in the dome sinking, while the peripheral convergence was relatively small. The total deformation was not large, which was within the design limit, and it was in a normal controllable range. The accumulative value of dome sinking during the first week excavation was 80% to 90% of the total, while the value from the time when secondary invert constructed to the secondary arch lining was closed into a ring was 10% to 20% of the total.

2）K0+250～K0+394

① The deformation was larger in the prophase, and it turned to ladder growth in the later stage (abnormal type), Section K0+386 was a typical one. ② Deformation was mainly appears in the dome sinking and peripheral convergence, and the later was relatively larger than the former. ③ The total deformation was large, which exceeded the design limit, and some initial support clearance sections had irrupted into the inner contour line.

The large deformation of Section K0+386 occurred during the first week excavation, at the same time, the accumulative peripheral convergence was about 50% of the total convergence value. The second large deformation was 30% to 40% of the total which occurred from the time when lower bench and invert was excavated to the initial support was closed to a ring. The value from the time when the invert constructed to the secondary arch lining was closed into a ring was 10% to 20% of the total.

3）K0+394～K0+416

①The deformation was the largest in the prophase(abnormal type), and the growth type is similar with K0+250～K0+394 section, but the accumulative deformation is relatively small. Section K0+401 was a typical one. ② Deformation was mainly appears in the dome sinking and peripheral convergence, and the later was relatively larger than the former. ③As a result of the support strengthening (especially added the steel frame in the inverted arch), the total deformation reduced relative to K0+250～K0+394 section, and it was within the design limit. Howerver, the inverted arch has not excavated, and the deformation is continues, so further monitoring is needed.

4）Carbonaceous slate deformation law summary

According to the deformation and monitoring data of the 2# inclined shaft in Muzhailing highway tunnel and the study for the deformation situation of Muzhailing railway tunnel in Lanzhou-Chongqing railway during the construction, the deformation characteristics of carbonaceous slate is listed below.

① The carbonaceous slate has expansibility which is more obvious when it meets some water. ② The plastic extrusion deformation is especially obvious at the hance arch steel support link; ③ The deformation is large and does not converge, and the peripheral convergence value is often larger than the dome sinking value. ④ It is sensitive to the construction disturbance, especially to the excavation of every steps and inverted arch or blasting vibration, and large deformation is easily occured after the disturbance. ⑤ Jumping. the deformation is continuous after the lining has been closed to a ring. Sometimes, the deformation continues after stops for a period of time.

Inferred from the fact that Muzhailing highway tunnel is above the Muzhailing railway tunnel and the geological conditions is the same, the deformation characteristics of the two tunnels should have many same places or similarities, and the first four characteristics have been verified in the excavation process of 2# inclined shaft.

In view of the above characteristics, ensuring the safety distance between tunnel face and secondary lining, when the secondary lining is constructing, the surrounding rock may still have a large deformation. This is contrary to the new austrian method which considers that the secondary lining should be constructed after surrounding rock stress

is basically released. There is too much stress on the secondary lining, and it might lead to cracking deformation, clearance interrupted, or even instability and collapse, and so on.

Conclusion

1) The unconventional large deformation characteristics of the carbonaceous slate tunnel construction have been reflected in the 2# inclined shaft of the Muzhailing tunnel. It is suggested to set up the scientific research test section in the 2 # inclined shaft to carry out the test of the stress (stress or strain), and it could provide basic data for the tunnel design changes, safe and rapid construction in the future.

2) Strengthen the support efforts, in accordance with the "strong support, weak release, support while release, rapid construction" construction principle. Rapid construction means rapid excavation, rapid support and rapid closure.

3) Other suggestions

①In strict accordance with the design or design change for construction, follow the "pipe ahead, strict grouting, short excavation, strong support, fast closure, regular measurement and tight lining" principle, careful and safe construction.

②According to the monitoring data and the surrounding rock conditions, adjust the support parameters in time, dynamic design, dynamic construction, to ensure the safety of tunnel construction.

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