The Study On Scheme of Disease Detection in Highway Tunnel

Jie Song [a], Bin Liu [b], Ming Li [c], Lei Chen [d] and Xinji Xu [e]

Geotechnical and Structural Engineering Research Center, Shandong University, Jinan 250061, China

[a]tom1442@sina.com, [b]liubin0635@163.com, [c]lim_zara@163.com, [d]clei667@163.com, [e]xuxinji1990@163.com

Abstract

The disease within the tunnel is mainly caused through marlstone rock contains gypsum rock hydrophilic expansion, therefore, the first object of engineering treatment is the groundwater, groundwater is the main detection object. In "combining with the inside and outside of holes, electrical method and seismic, geophysical prospecting geological" for the principle, designed the integrated detection scheme of inside and outside holes.

Keywords

Tunnel, disease detection, electrical method, seismic method.

1. General Engineering Situation

Some highway tunnel is double action four lanes discrete highway tunnel. The tunnel of the left line commencement and termination number is ZK33+226～ZK35+700, total length of 2474m, the body of tunnel maximum depth of 221m. The right line commencement and termination number are K33+227～K35+742, total length of 2515m, the maximum depth of 231m. In addition to the import part of tunnel, the left and right line spacing more than 20m. Tunnel construction began in December 2009, and completed in November 2012.

The tunnel import and export are a plane curve, the rest of part is tangential path, the tunnel longitudinal grade is -2.650% and -2.900% respectively.

2. Tunnel Disease Situations

Inner tunnel disease mainly includes lining crack, cable groove damage, the tunnel is out of shape, pavement structural damage and unfavorable geology at the bottom of the tunnel, etc.

2.1 Lining Crack

1) Cracking location

The distributed position of lining crack is most with side wall, hance and vault is less. The left and right hole of the tunnel totally growth 384 cracks, of which 384 located in the side wall position. It occupies 89% of total cracks number, 17 articles located in the hance position, it occupies 4% of total cracks number, 26 article located in arch position, it occupies 7% of total cracks number.[1]

2) Cracking shape

Between the 384 article left and right holes cracks, there are 181 hoop cracks, 47% of the total number of cracks; Longitudinal cracks in 108, 28% of the total number of cracks; Diagonal cracks in 95, 25% of the total number of cracks.

3) Cracking depth

The left and right line of tunnel total select 16 typical cracks, adopt ultrasonic method or core method to detect the cracks depth. From detection: run-through 8 cracks, not run-through 9 cracks, the depth development of no run-through cracks also basic exceed half of second lining depth, and visible surface crack width is tunnel outside surface width, the inner surface narrow.[2-3]

4) Cracking

Tunnel second lining in left and right hole between the side wall and in cable trench location and reserved equipment around the hole has part crack, local split a total of 13, including five left 8 holes and right 5 holes.

2.2 Cable Trench

1) Tunnel left hole: exist tunnel cable trench capsized, cable trench separate from the side wall, lateral wall cracking and breaks position total 30 segments, a total of 918 m, including: the left side 23 section total 379 m, the right side 7 section total 97 m; Tumbling 22 paragraph total 404 m, extraversion section 2 section, a total of 38 m.

2) Tunnel right hole: exist tunnel cable trench capsized, cable trench separate away from the side wall, lateral wall cracking and breaks position total of 10 sections, a total of 309 m, which left 4 section, a total of 66 m; The right side of the period of 96 m; Pour 4 section of 65 m, extraversion section 4, a total of 82 m.

2.3 Tunnel shapes

Tunnel left and right hole has not been testing each section bite into construction clearance, but the measured section contour section has invaded in the tunnel design in outline, sidewall convergence, sidewall and exist outside enlarge, hance convergence, road hump, vault subsidence and so on several main forms of deformation.[4]

2.4 Pavement Structure

1) Pavement Crack: Pavement Crack Total 29. Among them: eight transverse cracks, an oblique fracture 10, Article 11 of longitudinal cracks.

2) The pavement uplift: pavement large-scale uplift position 12, a total of 438 m, the maximum uplift height 22 cm: Among them: 1 fold curvy uplift, a total of 45 m. Uniform rectilinear uplift five, a total of 205 m; Tilt rectilinear uplift 6, a total of 188 m.

3) Pavement exuviate: pavement exuviate 72 segments, total of 1050 m; Among them, 21 segments pavement distribution in the absence of inverted arch area, a total of 448 m; 37 the distributions in the plain concrete pavement inverted arch area, a total of 484 m; 14 distributions in reinforced concrete pavement inverted arch area, a total of 88 m.

2.5 The unhealthy geology at the bottom of the tunnel.

1) The broken unhealthy geological sections of existing at the bottom of the surrounding rock buried depth are shallow, basically pad (not inverted arch section) or inverted arch surrounding rock under the overall is poor, fissure intensive development.

2) Karst developments exist in the road below 8 to 11 m ranges, development type mainly for karst fissure, small local continuous grooves, etc.

3. Disease detection shame

The disease within tunnel is mainly caused through marlstone rock contains gypsum rock hydrophilic expansion, therefore, the first object of engineering treatment is the groundwater, therefore, the engineering geological investigation of tunnel site area of hydrogeology survey's main goal as follow:

(1) Find out tunnel site area groundwater development, supply mode and path and water level situation.

(2) Find out the distribution of groundwater along the tunnel longitudinal axis, the occurrence condition.

(3) Clear the relationship between the groundwater distribution and surrounding rock lithology, determine the scope of the groundwater water power engineering.[5]

Combined with the existing tunnel disease status and surface topography condition, adopting "combining with inside and outside of holes, electrical method and seismic, geophysical prospecting geological" principle, design detection scheme as follows, to meet the three goals of requirements of engineering geological exploration.[6]

(1) Inner hole detection: Adopts ground penetration radar (GPR) (two different antennae: 100MHz、80MHz) to find out the tunnel lining and its cracking of backward 5-8m and water conditions. Adopt shallow high frequency seismic find out behind the lining fissure distribution in within 15 to 30m. Provide details basis for late management scheme design.

(2) Outside hole detection: Adopts big high density electromagnetic method to work on the ground, along the tunnel axis, detecting water and water body occurrence situation of rock around the tunnel. Adopts many turns back to the line power transient electromagnetic method (overlying and underlying) around the tunnel was found water occurrence situation, divide groundwater recharge path to a certain extent. Adopting the controlled source audio-frequency magnetotelluric the tunnel site area of groundwater development situation and the water level to detect, selects supply path. Using low frequency seismic exploration the fracture of overlying rock mass was found, and guide water distribution. Divide the area containing water transmitting range and distribution.

(3) Geological analysis and drilling: Decorate in the designated area of geophysical prospecting drilling for inspection and correction of geophysical prospecting results, combined with the geological analysis of tunnel site area, divided into ground water catchment area, supply mode, the main path and occurrence condition.

4. Conclusion

Investigation analysis the main tunnel disease categories: Lining crack, damaged cable groove, tunnel shape, pavement structure damage and the unhealthy geology at the bottom of the tunnel, etc. On this basis, in "combining with inside and outside of holes, electrical method and seismic, geophysical prospecting geological" for the principle, designed the integrated detection scheme of inside and outside holes.

References

[1] C. Yuan, S.C. Li, S.C. Li, W.T. Li. Study of defects characteristics and repair methods of old tunnel in cold region[J]. Chinese Journal of Rock Mechanics and Engineering, 2011 (S1): 3354-3361.

[2] H.J. Liu, C.C. Xia, H.H. Zhu, X. Luo. Studies on tunnel damage[J]. Chinese Journal of Underground Space and Engineering, 2007, 3(5): 947-953.

[3] X. Luo, C.C. Xia. Current situation and problems of classification of tunnel diseases[J]. Chinese Journal of Underground Space and Engineering, 2006, 2(5): 877-880.

[4] Z.G. Li, Y.J. Zhang. Stability analysis for tunnels with cracked linings and the techniques for repairing the cracked linings[J]. Modern Tunnelling Technology, 2004, 41(1): 26-31.

[5] J.R. Gao, B. Zhang, W. Yuan, W.X. Tu. Study of comprehensive remediation solutions and corresponding equipment for existing railway tunnels[J].Modern Tunnelling Technology, 2013, 50(006): 24-31.

[6] X.A. Yang, H.W.Huang. Tunnel disaster prevention and treatment[M].Shanghai: Tongji University Press, 2003.