Research on surrounding rock phase change effect to the initial supporting in cold region tunnels

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Abstract: In order to study the influence of surrounding rock temperature phase change to the initial supporting force, temperature sensors, pressure box, steel force meter were used to monitor the tunnel environment temperature, surrounding rock temperature, pressure between surrounding rock and shotcrete layer, steel stress etc. The results show that the average environment temperature remain about 9 ˚C, surrounding rock temperature increased with the exposure time, the melting depth is 1m when exposure time is 7d; the change of pressure between spray layer and supporting was small; constructing insulation layer in time can protect the surrounding rock and improve initial supporting force obviously, the research results can provide basis for tunnel construction in cold region.

Introduction

Since the end of the 20th century, a lot of cold region tunnels have been built. The problem of construction safety in cold region tunnels is very important, so the effect of phase change in construction process on the stability of surrounding rock should be studied further. Tunnel construction would destroy the original temperature field of surrounding rock, the construction of blasting, construction machinery and so on would produce a lot of heat, which caused tunnel environment temperature higher than the temperature of surrounding rock, the surrounding rock would melt, which results in the decrease of bearing capacity, after the tunnel breakthrough, the temperature would reduce and the surrounding rock would freeze again, which would produce a huge frost heave force to the primary support. So the disturbance of construction temperature field to surrounding rock, and the corresponding conditions spray layer and the force situation of steel arch shelf, and keep the surrounding rock stability is the key problem of cold regions tunnel construction. In this paper, the tunnel environment temperature in the construction of tunnel, the surrounding rock temperature, the initial supporting force were measured by the temperature sensor, the pressure boxes and reinforcement stress meter. The timing of constructing the original support was determined, which can provide references for construction of cold region tunnels.

Testing program

Test sections and points

There were two test sections planed at tunnel entrance (figure 1), The test sections were following the tunnel construction section, temperature measuring points were in 4m depth of surrounding rock, YH5101 type of temperature sensor was adopted, primary support stress

monitoring point was set along the tunnel, YH0720 earth pressure boxes were embedded between surrounding rock and shotcrete layer, monitoring the contact pressure between them, at the beginning of earth pressure box layout as shown in figure 3 (b); YH0428 reinforced steel stress was used to monitor the steel arch stress distribution, the arrangement was shown in fig.1.

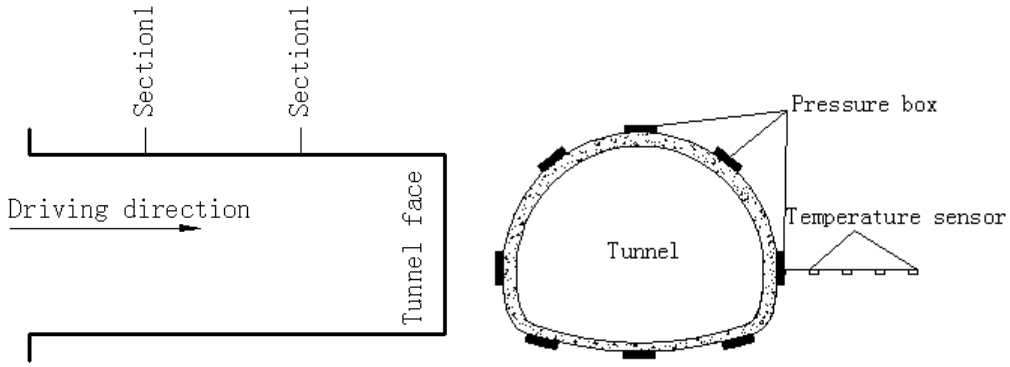


Fig.1 Test layout

Test project and equipment

Main test projects include construction environment temperature field, the radial temperature field of surrounding rock, the contact pressure between surrounding rock and shotcrete layer and the steel stress. In order to get reliable test data, adopted YH5101 type of temperature sensor, YH0720 type soil pressure box, YH0428 type steel meter, as well as YH8005 automated collection system, all sensors were connected to the automatic acquisition system host, unified timing acquisition data, export data regularly. Test equipments were shown in fig. 2.

（a）YH5101temperature sensors （b）YH0720pressure boxes

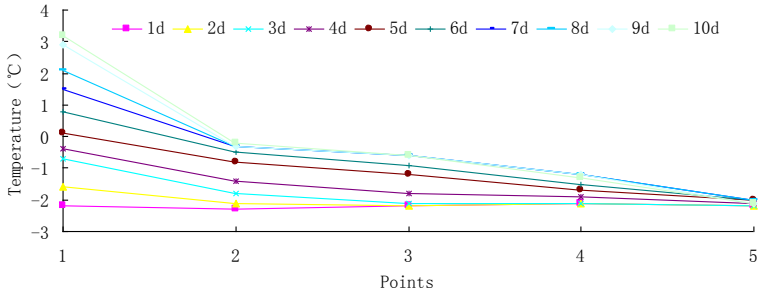
Fig.2 The testing sensors

Test results analysis

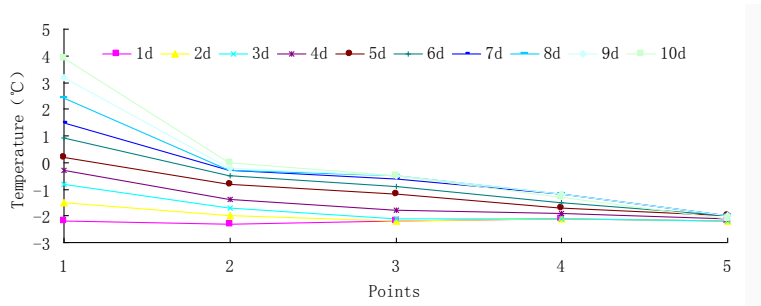
Surrounding rock temperature

The temperature results of the radial surrounding rock are shown in fig.3. It could be seen that the radial temperature of surrounding rock affected by tunnel environment temperature, the surrounding temperature increased with the growth of the exposure time, the influence of measuring point one was most obvious and temperature rise rate was the fastest, this is because the measuring point 1 is located in the most inside, the farther the depths of the surrounding rock, the smaller the influence; the temperature rise rate was slow with thermal insulation layer, the heat preservation effect was obvious, setting insulation layers could delay the melting of the frozen zone of the surrounding rock effectively. The temperature of point five was almost invariant, the effect at 4m

depth of surrounding rock was not obvious, the temperature of surrounding rock was influenced by environmental temperature range up to 3 m under the condition of thermal insulation layer.



a.section1

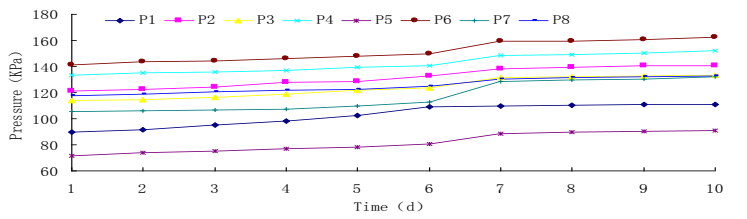


b.section2

Fig.3 Radial temperature of surrounding rock

The surrounding rock pressure

The contact pressure between surrounding rock and shotcrete layer was shown in fig.4, it could be seen that the variation of surrounding rock pressure was not obvious, it grow slowly at 1 ~ 6 d, but has a relatively large increase at 6 ~ 7 d, this is because the surrounding rock was melt with the time increase; the pressure of surrounding rock was biggest at point 4 and 6, which appeared in the arch foot, more attention should be paid when sprayed concrete arch foot, the secondary lining at arch foot should be strengthened accordingly. Overall surrounding rock pressure amplitude was small, it is because the secondary lining had not applied, the deformation of primary lining changed with the surrounding rock, which reflected the characteristics of the flexible support.



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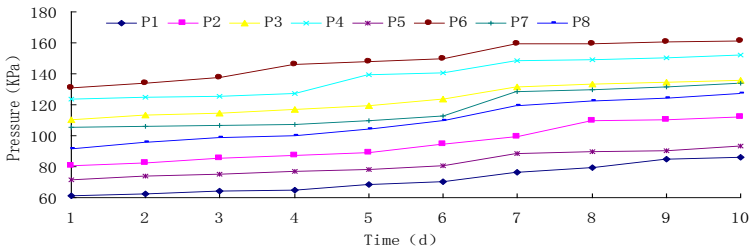

b.section2

Fig. 4 Surrounding rock pressure

Conclusions

(1) The surrounding rock temperature increased gradually with the exposure time of the initial supporting, the contact pressure started to increase at 7d, the overall trend was not obvious.

(2) The thermal insulation layer can effectively slow the melting of the surrounding rock under the condition of construction factors, the spray layer and steel arch stress was improved significantly.

(3)The frozen depth was 1m without thermal insulation layer, it would be reduce conducting thermal insulation layer, which not only improve the supporting force but also reduce the frost heave force.

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