The Temperature Field Analysis of Rubble Subgrade in Permafrost

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ABSTRACT

Based on the test results and analysis, rubble foundation was adopted in the permafrost at the Qinghai-tibet railway, when the subgrade was done, it is obvious to see the exchange of heat energy with air, the temperature in the subgrade would reduce quickly which will lead to thawing depth was lower than the natural thawing top-limit, thus permafrost was limited the damage by rubble foundation.

KEYWORDS： permafrost; rubble subgrade; temperature field; thawing top-limit.

INTRODUCTION

Golmud-Lhasa Section of Qinghai-Tibet Railway crossed 550km permafrost region, the highest elevation of the railway was 5072m in the Dangla Mountains, the length of the railway was 965km above an elevation of 4000m[1].

The permafrost swamp was distributed over a considerable extent in Anduo section of Qinghai-Tibet Railway, the frost heave of soil greatly changed, the strength of the soil delined and stored a great quantity moisture content when it thawed, The soil was formed swamp. The railway foundation existed crosswise slope which the thawed ice in the frozen soil would flow along , the stability of the foundation was destroyed when the water declined the strength of potential slip surface, due to building an embankment , the stability of the foundation was variation with the upper limit changed of permafrost. According to a quantity of real data, the trend of temperature and influencing factors and handling measures would be discussed from the upper limit of frozen soil in the subgrade of railway which had adopted the measures of geogrid and piece of rocks.

THE TEMPERATURE TOP-LIMIT AND DISTRIBUTION TYPES

The deepest zero degree top-limit was the balance result of heat from froze soil and sun radiation, along with the factor of soil heigh, packing material, permafrost condition, climate character and so on, there are different type of toplimit, see Figure 1, A contains a core of permafrost, but remain some melting soil layers, B only contains a core, C shows top-limit ascends to subgrade, D displays top-limit don't change, E illustrates the top-limit declines[2].

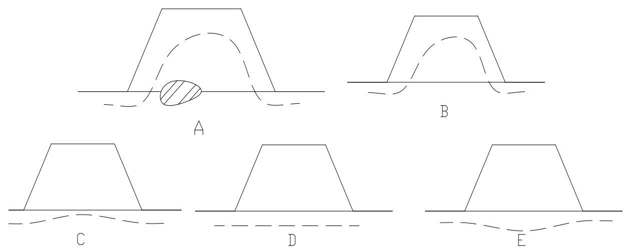


Figure 1: the top-limit in the subgrade

TEST SECTION FIELD CONDITION

Test section field character

The mileage range of test section from DK1449+500~DK1450+000, total length 500m, mean annual temperatures -2.9℃, The unidentified seasons, subzero is long, the end of September to May of the following year is freeze-up, minimum temperature occurred in January, the highest temperature is in July. DK1449+680 has completed geothermal drilling work in 2003 and the pipe under the protection.

Foundation treatment and Temperature measuring hole arrangement

The hole of DK1449+680 is shown in Figure 2.

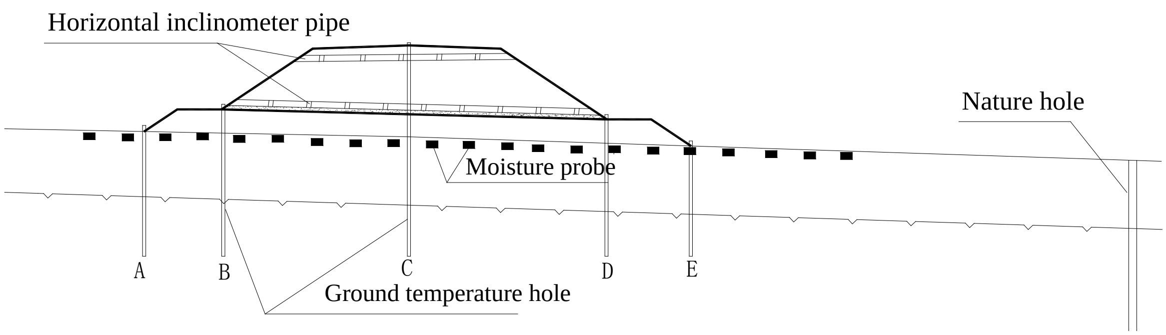


Figure 2: the Piece of rocks transect and the laid thermometer hole

There were five holes in the DK1449+680(see fig3), C was arranged in the middle of the railroad, the depth of C was 10 meter, contained 20 temperature measuring points. B and D were arranged in the shoulder, the depth was 8 meter, contained 16 temperature measuring points respectively. A and E were arranged in the lowest part of loading berm, the depth was 6 meter, contained 12 temperature measuring points respectively. B was embedded in the subgrade surface 50cm, other temperature measurement tube should reveal the filling surface (or ground) 50cm.

FOUNDATION TREATMENT MEASURES OF RAILWAY BASE TEMPERATURE DISTRIBUTION CHARACTERISTICS AND VARIATION TENDENCY

Filled rubble foundation treatment measures of ground temperature analysis

There is a certain difference between the measured natural top-limit and design of toplimit, so, in the analysis about the ground temperature, we will use the measured natural toplimit, natural temperatures as shown in Figure 3.

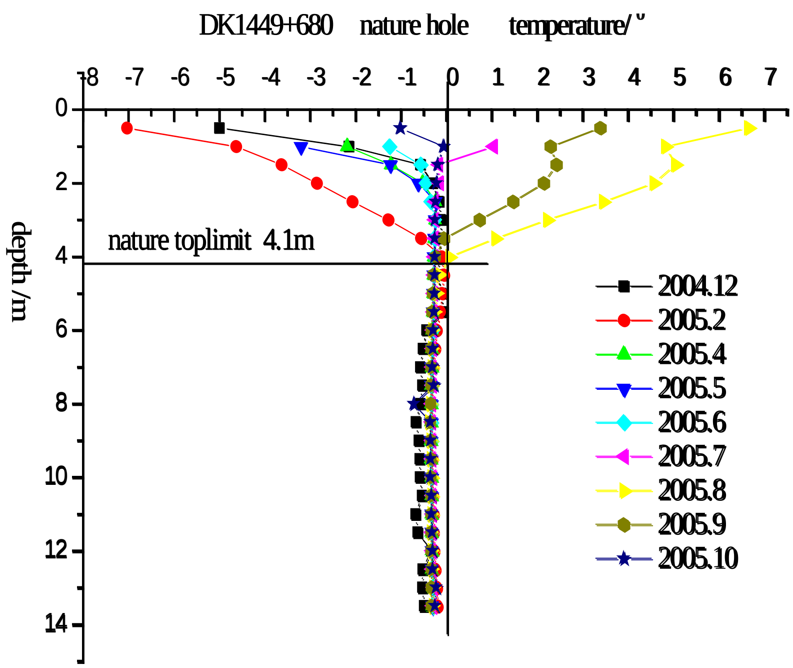
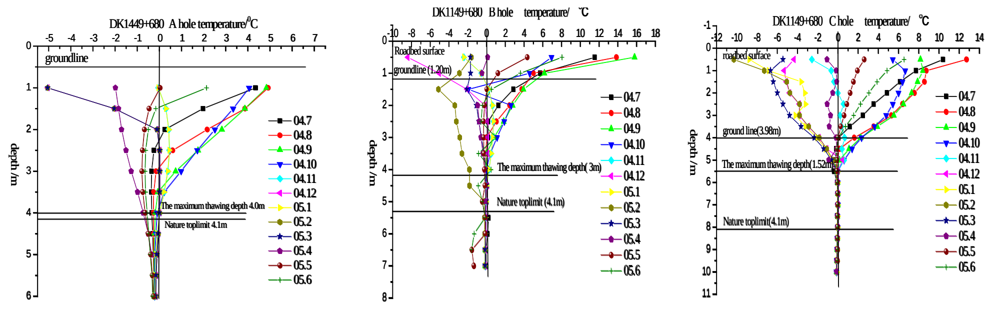
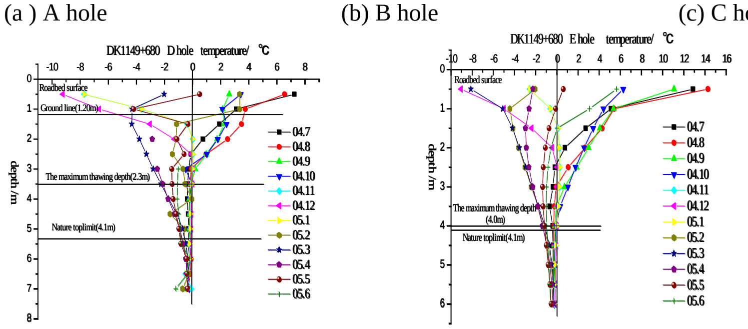


Figure 3: DK1149+680 natural temperature test

2004 July to 2005 June test results were as shown in Figure 4.



(a) A hole (b) B hole (c) C hole



(d) D hole (e) E hole

Figure 4: DK1449+680 each test hole temperature data graph

The test results have shown that:

(1) In this five the temperature measuring hole in the two test cycle, ground temperature was consistent with seasonal temperature variation trend, the upper limit of permafrost changed, its variation belonged to C type, which was the advantageous situation for subgrade.

(2) From 2004.7 to 2005.6, in the left loading berm slope hole (A hole) melting depth was 4.0m, it was improved by 0.1m than natural permafrost toplimit, the right loading berm slope hole (E hole) melting depth of 4.0m was improved by 0.1m, the left shoulder hole (B hole) melting depth of 3m was improved 1.1m, the right shoulder hole (D hole) melting depth of 2.3m was improved 1.8m ; in the subgrade center hole (C hole) melting depth of 1.52m was improved 2.58m. Below the maximum thawing depth, the soil temperature changed a little, refer to table 1.

Table 1: 680 thawing depth

680 Test section	A	B	C	D	E	Natural toplimit
2004.7~2005.6 The maximum thawing depth	4.0m	3.0m	1.52m	2.3m	4.0m	4.1m
Difference	-0.1m	-1.1m	-2.58m	-1.8m	-0.1m	

(3) From Figure 4 we can see, below the surface, the heat exchange effect of rubble foundation was obvious, after subgrade filling the temperature accumulating effect was not obvious, and dissipated quickly, each test hole melting depth of subgrade body portion was less than the measured natural limit (4.1m), improved artificial permafrost, filled stone played the role of ventilation, permafrost was protected, under the subgrade soil did not produce large amounts of melt[3][4], after backfill, subgrade thermal equilibrium state resume soon, the top-limit has increased differently. By this measure, the dissipated heat was faster, cold easily.

Ground temperature distribution characteristics and change trend

(1) Near surface, annual temperature and annual amplitude were bigger, the thickness of permafrost active layer, the summer melt depth was deeper, in a cycle of freezing and thawing, rubble foundation can dissipate heat effectively caused by the construction disturbance, so in the geothermal field the permafrost table didn't reduce.

(2) In the main part of the subgrade the thaw depth was lower than sunny slope, sunny slope was deeper than shady slope, as a result of the difference of solar radiation intensity and time, sunny slope melted earlier than shady slope, but freezing time was later than the shady slope, so sunny slope foundation was more susceptible to thermal disturbance of roadbed filling[5].

(3) Based on measured data and data fitting, can get the maximum thawing depth varies with the season (see Fig. 5).

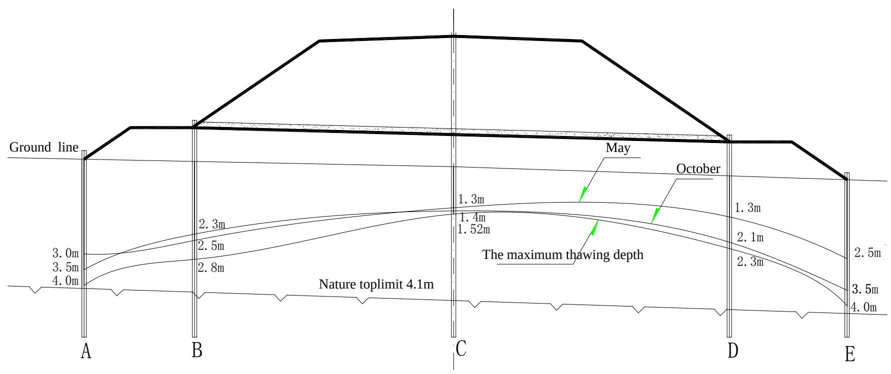


Figure 5: DK1449+680 maximum thawing depth of seasonal distribution

From Figure 5 we can see, different test hole section the location of zero temperature is changed, caused by the construction and the boundary conditions changed and heat balance broke. The maximum thawing depth appears in October, because the largest heat storage in this time. Even so, the maximum thawing depth of each temperature measuring hole is lower than the measured natural top-limit (4.1m), this form is helpful for frozen soil and the stability of roadbed, conclude that this measure can be quickly dissipated heat, cooling capacity get promotion, protection of permafrost.

CONCLUSION AND SUGGESTIONS

Conclusion

By analyzing the measured data, get the following conclusions:

(1) Different subgrade cross section, geothermal depth changes consistent with seasonal temperature variation trend.

(2) For rubble foundation treatment measures, due to the heat exchange effect is obvious, subgrade after construction accumulates little quantity of heat and disappear quickly. Thawing depth is lower than the measured natural top-limit[6], Thus throwing rubble can protect frozen soil, At the same time also has a certain role in storage cooling capacity.

Treatment measures and suggestions

Combined with the geological conditions of the Qinghai-Tibet Plateau permafrost wetland foundation treatment measures mainly use rubble, at the same time in the roadbed with geocell or geogrid reinforced structure, the measures have positive significance for improving the strength of weak foundation, ensuring the stability of the foundation, reducing the compressibility of soft foundation and the settlement and differential settlement of the foundation, especially not direct ly destroying permafrost wetland vegetation. But there are some problems about the geogrid or geocell and permeable soil construction measures, such as quantity of heat caused by construction disturbance cannot be timely released, on the stability of roadbed is unfavorable, frost heaving and thaw settlement cannot be solved well, so if the stone source is relatively rich, convenient, rubble foundation treatment measures should be used as first.

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