Application of ventiduct embankment in Qinghai-Tibet railway construction

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1. Introduction

The Qinghai-Tibet railway, known as the No.1 project of "Great West Development" and the test run will begin on July 1 2006, is built on the permafrost plateau as the highest altitude and longest track in the world. The total length between Geermu and Lhasa is 1142 km, of which about 960 km are located in the region with altitude above 4000 m, and about 550 km traversing the continuous permafrost region. To guarantee the stability of the 550 km permafrost embankment and its deformation under control, a series of measures are employed in the design stage and construction stage. Ventiduct embankment is one of the measures firstly employed in the railway construction of Qinghai-Tibet permafrost region.

To evaluate the effectiveness and feasibility of the particular embankment structure in Qinghai-Tibet permafrost railway, several full-scale test embankments were constructed at some representative field site. In this paper, the ventiduct embankment (DK 1026 + 290) constructed at Qingshuihe experimental section is presented with partial field observation results. The effectiveness of ventiduct embankment structure has been verified and the particular permafrost embankment structure hereafter has been adopted in Qinghai-Tibet permafrost railway construction.

2. Mechanism of ventiduct embankment

Ventiduct embankment, that is to say, the ventiduct is installed horizontally at the middle or bottom of the embankment, and work together with the backfill materials as a composite ventilating embankment. On the one hand, the heat conductivity of air in the ventiduct is lower than that of backfill, the ventiduct play the function of thermal insulating layer and reduce the heat quantity conducting into the subgrade. On the other hand, the air flow inside the ventiduct radiate the embankment heat by convection mode; in winter, the flowing of the cold air inside the ventiduct lower the bedding temperature effectively, increase its cold storage and protect the permafrost stratum. Thus, the heat stability of the embankment is increased.

3. Test program

The sketch of the test embankment (DK 1026 + 290) is shown in Fig. 1 (Jiang, 2002). The PVC ventiducts (inside diameter of 0.4 m) are installed above the ground 0.3 m with spacing of 0.6 m. The instruments are installed for observing the ground temperature, settlement and so on. 5 boreholes for measuring the ground temperature were set at: middle of embankment (1 borehole), embankment shoulder (2 boreholes), toe of slope (2 boreholes). The measured temperature is utilized for determine the thaw depth and study the variation of permafrost table. The settlement plates are installed at four depths (surface of gravel layer, natural ground surface, middle of the active layer and top of the permafrost table). The construction of the test embankment was completed on December 2001, the tracking work passed the test embankment on May 2003. The observation duration is 3 years (from December 2001 to December 2004).

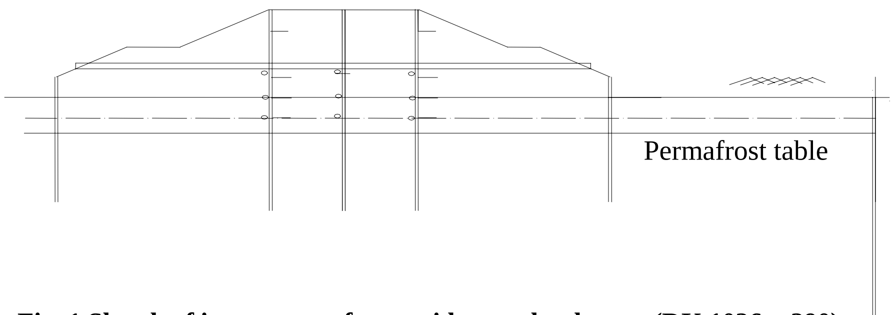

Fig. 1 Sketch of instruments for ventiduct embankment (DK 1026 + 290)

Keywords: Qinghai-Tibet railway, ventiduct embankment, permafrost table, settlement

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4. Results and discussions

4.1 Variation of the depth of permafrost table

The variation of the depth of permafrost table for cross-section DK1026 + 290 are listed in Table 1.The depth of the frozen table are measured from the natural ground surface, the negative sign for the depth of artificial permafrost table means that the permafrost table has been uplifted above the natural ground surface. Compared with the datum for a embankment without ventiduct it is clearly indicated that the ventiduct can effectively uplift the permafrost table and protect the permafrost stratum.

Table 1 Variation of depth of permafrost table for the ventiduct embankment

Mileage of cross-section	Position for measuring temperature	Depth of natural permafrost table (m)	Depth of artificial permafrost table (m)	Height of backfilled embankment
DK 1026 + 290	Left shoulder	2.40	- 0.5	5.40
	middle	1.42	- 0.06	4.81
	Right shoulder	2.80	- 0.04	4.26
A embankment without ventiduct	Left shoulder	1.44	1.21	4.89
	middle	1.44	0.95	4.55
	Right shoulder	1.44	1.52	3.83

4.2 Layered settlement variation with time

The layered settlement vs. time relationship left side and right side of embankment are shown in Fig. 2. Due to the installed ventiduct in the embankment, the settlement of embankment surface was retarded efficiently when ground surface happened to large settlemen.The total surface settlement for left side (light side) and right side (shade side) of the embankment are 22.8 cm and 14.1 cm, respectively. The difference of settlement between the lift side and right side of embankment is mainly due to Orientation effect of the embankment slope.

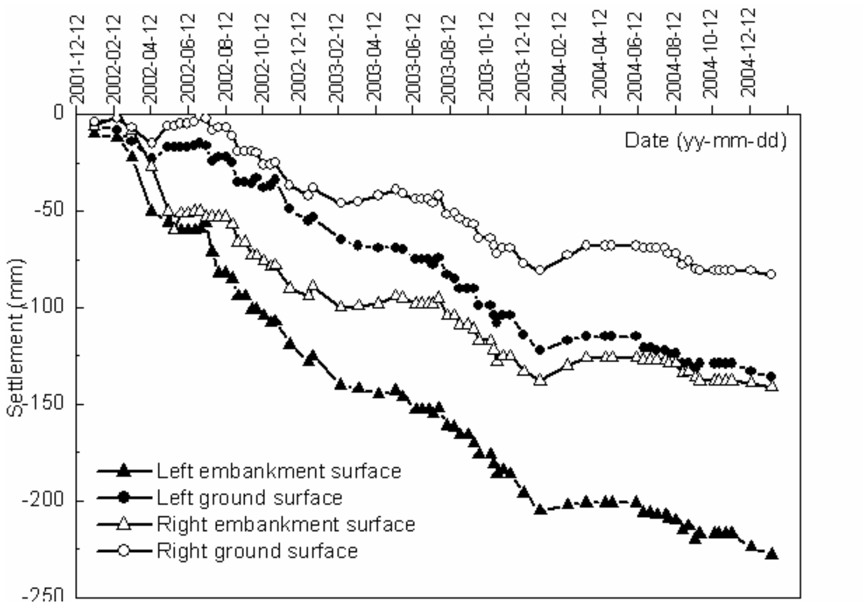

Figure 2 The observed settlement for ventiduct embankment (DK 1026 + 290)

5. Concluding remarks

Based on the observation for test embankment (DK1026 + 290), the conclusions can be summarized as:

1) The ventiduct embankment can uplift the depth of permafrost table effectively. 2) For the permafrost embankment with backfill height of 4-5 m on Qinghai-Tibet railway, the main settlements are originated from the embankment body and the underlying permafrost stratum. The settlement of the underlying permafrost stratum accounts about 60% of the total settlement. 3) The settlement of the light side of the embankment are larger that that of the shade side of embankment, the effect of the asymmetric temperatures on the settlement are externalized in the test section embankments. 4) The mechanism and effect of ventiduct embankment should be investigated further more, for example, the effect of ventiduct diameter, the effect of the embedded depth.

Reference:

[1] Fu-Qiang Jiang (2002). “Embankment structure of railway on Qianghai-Tibet permafrost plateau”, *Chinese railway*, 2002 (4), pp. 57-59.