

PERMAFROST CHANGES AND ENVIRONMENTAL PROBLEMS ALONG THE QINGHAI-XIZANG HIGHWAY

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ABSTRACT: The Environment of permafrost region along Qinghai-Xizang highway has been interfered and damaged seriously during the last years by mankind economic activities. Permafrost under the roadbed has been degenerated obviously. Talik range has been extended gradually and original natural environment around it has been damaged. The mileages of highway crossing the permafrost region today are shortened 18km than that of the 70's. In this paper, according to ice content, class of permafrost, relief and landforms etc., permafrost region along the highway and comprehensive evaluation zonation have been made. And specific measures for protecting the permafrost environment has been put forward.

KEY WORDS: environmental changes of permafrost region, environmental evaluation, permafrost protection

Qinghai-Xizang Highway is a main highway joined Tibet to the interior and there is 550km crossing permafrost region from Germu to Lhasa. Along with laying petroleum pipelines, expanding residential area and constructing large buildings, ecotypic environment has greatly changed along the highway, thus leading to permafrost changes.

I. PERMAFROST ENVIRONMENTAL PROBLEMS

The meaning of "permafrost environment" extends with traffic and economic daveloping in permafrost region. It means not only the simple nature environment^[1], but also the disturbed and damaged natural environment by mankind. Permafrost layer is the main part of permafrost environment. Its existence and change are closely related to and interacted on all permafrost

environments. Because of this reason, permafrost environment changes includes permafrost changes and natural environment changes in permafrost region.

1. Permafrost Changes

Under roadbed with asphalt pavement along the Qinghai-Xizang Highway, because especial solar radiation, heat equilibrium and heat absorption of dark asphalt pavement, heat absorption is much more than exothermic in a year under the most of roadbed of permafrost region. Permafrost under roadbed has degenerated in varying degree, so the roadbed has subsided, the pavement was damaged. For natural vegetation was damaged by mankind, permafrost table and the ground temperature has changed. The permafrost changes are shown as following:

1.1 *The length of highway crossing the permafrost region is gradually shorten*

In the 1970's, investigation along the highway showed that the northern boundary of island permafrost was at K2877+600 of Xidatan and the southern boundary of continuous permafrost was at K3424, north of Anduo. Exploratory data for 1990 demonstrated that the southern and northern boundary of permafrost has been changing indeed. Especially the southern boundary of continuous permafrost has moved northwards 16km, at K3408, at present, the length of the highway crossing permafrost region has been shorten about 18km.

1.2 *Talik expands gradually*

In the high temperature permafrost region nearby talik, permafrost layer is thin with high temperature. It is clear that permafrost was degenerated under the roadbed, for example, frozen ground with rich ice was found under the highway in the west side of Yamer River (K3104+600 to K3111+266) in the early 1980's and at present the most sections has become talik. The permafrost with rich ice content under the roadbed from the south of Tuotuo River to Kaixinlin (K3154+150 to K3159+550) in the early 1980's has also disappeared. Apparent degeneration of permafrost also occurred in the basins landform. Permafrost layer with several meter thickness under roadbed has been thawed completely.

1.3 *Artificial permafrost table under roadbed falls every year*

According to 380 roadbed centre holes, about 65% of roadbed section in

permafrost region are unlinked frozen ground in vertical. It lies high plain and basins and valleys where mean annual air temperature ranges from -4.0 to -6.0°C . The thawing depth under the roadbed is in excess of the freezing depth each year. Surplus heat in roadbed has accumulated and the artificial permafrost table goes dawn year by year, which caused the permafrost to become discoincided in vertical. Depths of the artificial permafrost table is in range of 4.5m to 7.0m generally along Qinghai-Xizang Highway; the most depth of artificial permafrost table is respectively 10.1m in Xitatan, 9.1m in high plain of the Chumer River, 7.3m in the Tuotuo River Basin, 5.3m in the Tongtian River Basin. As a result, the thaw core was formed between the seasonal frozen layer and the artificial permafrost table, its thickness is from 0.5m to 2.0m , the most thickness is 6.6m , thawed passageway under the roadbed have been formed about several tens kilometers. The majority of the thaw cores have held water in whole year, the artificial permafrost table has been fell further by the water, at last this leads to strong non-uniform settlement of the roadbed and damage of pavement. The length of the serious damaged section is 32% of the length of the highway in permafrost region.

1. 4 *Change of permafrost under buildings*

After building asphalt pavement and petroleum pipeline, the large buildings and residential area presented along the highway. Because of economic activities develops rapidly in recently years, permafrost environment around residential area is ruined seriously. After vegetation was damaged, natural permafrost table fell (Table 1) and ground temperature risen (Table 2), the thaw tray was formed under building with heat, the confining thaw circle has formed round the pipeline.

Table 1 Comparison between the nature permafrost table and artificial permafrost table along the highway

Sites	Permafrost table (m)	
	Natural sites	Damaged sites
Xidatian	3. 45	5. 8
Wudaoliang	1. 8—2. 5	2. 8—3. 6
Fenghuoshan permafrost station	1. 4—1. 7	2. 2—2. 8
Tuotuo River transport station	Permafrost in 1970's	There is not permafrost in a well at depth of 8m. after building in 1990's

**Table 2 Comparison of the ground temperature nearby Fenghuoshan
permafrost station (°C) (observed in June 6—24, 1984)**

The observe Holes location	Depth (m)												
	1	2	3	4	5	6	8	10	12	14	15	16	20
The observe hole of natural sites	-1.2	-2.5	-3.0	-3.2	-3.2	-3.0	-2.8	-2.5	-2.4	-2.4	-2.3	2.3	-2.2
The observe hole 5m from the builds		-0.2		-1.4		-1.7	-1.6	-1.4	-1.6	-1.6	-1.6	-1.6	-1.5

2. Changes of Natural Environment

Permafrost layer is of high sensitive to climatic, hydrologic, ground surface conditions and so on. Permafrost existence and development have been restricted by geography, geomorphology, hydrology, pedology, biosphere, etc.

Once the vegetation in permafrost region was damaged, the resumption is very slow, for example, a sector of Fenghuo Mountain was damaged by mankind in the 1960's, and now, vegetation don't recover. Some regions even become irreversible ecotype condition, such as, Xidatian, high plain of the Chumer River. Because vegetation was damaged, the moisture or thermal in the surface ground and permafrost disturbution has been changed. This accelerates permafrost table to fall. As permafrost table become deeper and even completely disappear, thus leads to ground water level dropping, the moisture in the ground surface decreasing, ground temperature rising, the ground surface further drying, so it promotes further desertification. Ecotype environment in the region has been damaged finally by the bad cycles and become irreversible.

After vegetation was damaged, the ground ice melted, resulting in ground settlement, building damage and thermokarst landform, thawing landslips, thaw depressions and lakes. Permafrost has changed surface runoff characteristics and water drainage system in the cold region, and formed tiny spot likes, wide and shallow valleys and marshes. As thaw lakes in the high plain of the Chumer River have formed by ground ice thawing. Permafrost layer controls ground water's formation and distribution. Ground water and permafrost layer acts and restricts each other. There are many taliks along the highway so regional hydrogeologic conditions become more complex. Because human action changed ground water condition, there are much pingos and spring icings.

In the thaw core of lower roadbed, the ground water is of larger pressure. During spring the pingos with a pressure water on the fragility sections of the

highway pavement has formed, some pingos suddenly bursted and spurted water into the air, for example, a pingo with water bursted in the north slope of Tao'erjiu Mountain, at K3390 on June 27, 1990, with a 6m-diameter deep pit. This seriously imperilled traffic safety.

II. ANALYSIS ON THE PERMAFROST REGION ENVIRONMENT

In order to ensure the Qinghai-Xizang Highway has a good run, exploit reasonably natural resources, and understand correctly and master the law of the changes of permafrost environment, it is necessary to evaluate permafrost environment along the highway comprehensively. Comprehensive evaluation means the law of regional distribution about permafrost environment, ground surface stability and landscape change, all these are a comprehensive reflection of permafrost change. The process from formation to melting of ice in permafrost is a main factor that leads to the changes of permafrost environment. So the evaluation of ground surface stability depend on permafrost type that is determined by ice content and lithologic characters. The intensity and character in the change process, and subsidence after the ground melted and rate of the thermokarst process.

The distribution difference of permafrost types and ground ice were closely related to topography and landform. It is reasonable to evaluate permafrost environment according to large geomorphologic unit, ground surface stability and landscape change (Table 3).

The evaluation method reflects summarily feature of regional permafrost environment. The "ground surface stability" in Table 3 only reflects that a certain stability occupies relative superiority in the region. It means that there is still a few amount steadiness section in the stability area; and a few unsteadiness in the steadiness area. For example, in the northern slope in Fenghou Mountain, there developed most ground ice. Most section of the highway is the extreme steadiness and steadiness area, but the area that bedrock was buried shallowly and with low ice content is steadiness. Therefore it must be careful to choose building sites.

III. ENVIRONMENTAL PROTECTION OF PERMAFROST

Permafrost environment is a very fragile ecosystem. Permafrost layer is very sensitive to change of outside conditions. During the last decades, plateau climate trends warm and economic activities has reflected. This frailty even seriously threatened stability of the highway or other buildings. It is important for economic

Table 3 Permafrost environment comprehensive analysis along the highway

Regions	Mileage of beginning and end	Ground surface landscape	Annual mean air temperature (°C)	Feature of permafrost			Proportion of each types frozen ground (%)	Degree of ground surface stability	Tensity and feature in the change process
				Distribution types	Ground temperature (°C)	Thickness (m)			
Xidatan	K2878—2891	Ground surface arid, vegetation rare, moving dunes	-2.0—4.0	Island permafrost	+0.2—0.5	<20	F:15 D:18 Sh:15 S:52	Steadiness	Feeble, middle, desertification trend
				continuous permafrost	-2.8—4.0	80—120	H:22 B:31 F:38 D:9	Unsteadiness or less steadiness	Intense, the irreversible process are a few
Mountains regions	Kunlun mountains	Vegetation rare, rock wastes, stone streams and solifluction on the slopes, surface water and ground water developed, ground ice in the valley	-5.2—7.0	Mainly continuous permafrost, a few talik	-2.0—4.0	80—120	H:14.3 B:262 F:23.4 D:4.1 Sh:29.0 R:3.0	Unsteadiness or extreme unsteadiness	
	Tanggula Range			Continuous permafrost	-1.0—3.0	30—100	H:40.3 B:27.9 F:11.3 D:13.4 Sh:7.1	xtreme unsteadiness or unsteadiness	Intese the many process are irreversible
Low mountains and hill regions	Hoh Xil Range	Vegetation developed, swamp, slope wash, many types of permafrost phenomenon	-5.5—7.0				Continuous permafrost		
	Fenghuo Mountains			H:37.0 B:13.4 F:15.4 D:24.3 R:9.9	Unsteadiness or extreme unsteadiness	Intense the some process are irreversible			
	Kaixin Range	Continuous permafrost, local talik	0.0—1.0	0—50			H:13.8 B:8.6 F:19.0 D:34.5 R:24.1		
	Taoerjin Mountains				Continuous permafrost, piece talik	-1.0—2.0	30—70		

(Continued Table 3)

High plains velleyes or basins	Qumar River high plain	K2923— 2987	Island permafrost in the marsh muck, solifluction on the slope, denes in the talik	-4.5— 5.0	Piece perma- frost, local talik	0.0— 1.0	0—40	H:39.9 B:23.0 F:13.4 D:10.4 Sh:12.2 R:1.1 H:14.0 B:46.4 F:6.3 D:24.3 Sh:7.2 R:1.8	Unsteadiness or less steadiness	Port intense, the some process are unreversible
	Beilu River basin	K3038— 3050							Less steadiness or steadiness	Middle or feeble, desertifi- cation trend
	Tuotuo River basin	K3140— 3160		-4.2— 4.5	Piece perma- frost, piece local talik	0.0— 0.5	0—30	H:4.6 B:19.7 F:14.9 D:6.6 Sh:20.0 R:34.2 H9.3 B:15.4 F:5.1 D:11.6 Sh:20.0 R:38.6	Steadiness or less steadiness	Feeble or middle, a few psrocess are unreversible
	Tongtian River basin	K3177— 3215							Steadiness	Feeble desertification trend
	Buqu River basin	K3215— 3310		-4.2— 6.0	Piece talik, island perma- frost	0.0— 1.0	0—50	B:12.6 F:3.8 D:2.2 Sh:17.2 R:64.2	Steadiness or less steadiness	Feeble or middle a few process are unreversible
Liangdao River to Nierong highland		K3408— 3500	Patch permafrost in the marsh muck, a few moving denes	-2.0— 4.0	Patch perma- frost	0.5— 0.2	<20	Perma- frost: 10—20 s:80—90	Extreme unsteadiness or unsteadiness	Intense, permafrost degenerating, desertification trend

construction to protect permafrost environment, the both should be treated equally. Before any building is constructed, engineers must pay much attention to protecting permafrost environment and avoiding permafrost ecotype environment being bad again. In renovating engineering of the highway, the following problems must be considered.

(1) Implementing the principle of comprehensively administrating and protecting permafrost. According to the environmental evaluation, it must take all advantageous measures to protect permafrost environment.

(2) Ground surface vegetation should not be damaged, and should be kept in original state as well. It would be best to take the ways of centrally getting soil and fast carrying by large machiner.

(3) Building drainage system should not affect permafrost environment along the highway. On both sides of the highway and near buildings it is not allowed to put and store indiscriminately productive and domestic sewage.

(4) Rebuilding must have a feasible plan and rational distribution in residential area. Don't wantonly occupy land and grazing land. Don't wantonly pile up rubbish.

(5) Strengthening monitoring the trend changes of cryopedology phenomenon, especially comprehensive cryopedolgy observation, at the same time, carrying out the studies of cryopedology forecast, combing with substance project.

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