Considering the condition of climate and soil in road and bridge construction work

/in the example of the road from Erdene soum to Undurkhaan/

A. Anand, Ph.D., Vice Prof. (Soil Engineering Co., Ltd.)

Preface

The prediction of the change of the world climate is becoming true today. Before, the climate change resulted from only the natural factors, but today, human activity has started influencing this change.

It is more clearly seen in our country during the last years that the earth and the human activity have been changing the climate. The temperature of the permafrost in Mongolia that is situated in the southern frontier of the permafrost of the world has changed and it is having the trend to thaw and thus, it is increasing the phenomenon of soil bulging /piling up/. The soil bulging is being studied since 1970's for the use of building and facilities and reached the certain results and the development of manuals, recommendations, norms and rules and their introduction to the industry has reflected to reach the results. And the event to research the influence of the soil bulging to the road and bridge construction work and to work out the engineering measurements to fight against this influence is required due to the practical necessities.

In this paper, I wrote the situation of the research of geological and geo-morphological conditions of the 250 kilometers of strip of land situated in the area between Erdene soum of Tuv aimag and Undurkhaan soum of Khentii aimag, its brief history and the result of the experiment of the soil and materials executed in the lab.

During the study, we have widely used the methodologies of International Standards such as ASTM and AASHTO in the experiment of the soil and materials for the construction of strip of road and bridges.

When we made an Experiment of Dynamic Penetration /EDP/ in every 10. Meter by drilling down to 11.0-20.0 meters deep in Dutluur mountain pass, Togos, Kherlen, Tsenkher, Jargaltkhaan and Murun rivers that are situated along the strip of the road, N size is greater than 50 or is in very strong and high density classification. This has determined that the soil being surveyed can become a reliable fundament for the bridge facility.

As looking at the result of the analyses and lab experiment made for the soil and materials, however the CBR that shows the strength of the soil and materials to be used in the fundament of the dam can meet the requirement in most cases, some indications were obtained to mix appropriate additional components in lower part of some dams and fundaments.

The event that the composition of parts smaller than 0.075 mm in the soil along the strip of road is greater than 10 % shows that it can result to the soil bulging during the freezing. Therefore, it is required to research the soil bulging and road materials in detail from the different aspects according to the special plan.

Climate

The average temperature in the world tends to become warmer 0.4-1.1^{o}C in 2025, 0.8-2.6^{o}C in 2050 and 1.4-5.8^{o}C in 2100 than the temperature in 1990. This is the change that has never happened since the glaciation period. The number of hot days will increase and the cold days will decrease. This is not so good thing. Due to the climate change, the climate in Mongolia tends to become dry and furthermore, the nature would more desertify and precipitation will increase however the number of cold days have decreased.

During the winter and spring, there will be sudden strong snowy storm and 20-30 sm. of snowy cover will exist on the traffic road. Then the traffic movement will completely be stopped. (This phenomenon happened on the traffic road between Ulaanbaatar - Sukhbaatar on May 2001.) There is no guarantee for that such phenomenon will not happen in the horizontal direction's millenium road.

It is revealed that the average temperature per year in Mongolia is becoming 1.56^{o}C warmer, of it, 1.61^{o}C warmer in winter and 0.3^{o}C colder in summer by the survey of L.Natsagdorj, D.Dagvadorj and N.Namkhajamts [8]. Since 1940, the number of days colder than –25^{o}C has decreased by 10-15 days and the number of the days warmer than 30^{o}C has increased by 2-6 days. The yearly precipitation was mainly decreased in May by 17 percent. However, there was a lot of precipitation in May 2002. This is one of examples that are showing that there is a great change in climate.

The average temperature per year in Mongolia during the first 25 years of this century is prognosticated to be 1.8-2.8^{o}C warmer, of it, 1.4-3.6^{o}C warmer in winter and 1.0-3.0^{o}C colder in summer and the warming will be increased by 1-2 times furthermore.

The climate indications of major urban area located along with the 250 kilometers of strip of land from Erdene soum to Undurkhaan obtained at the result of our survey made last year are shown in Table 1.1.

Table 1.1. Main indications of climate

No.	Climate indications	Undurkhaan	Murun	Jargaltkhaan	Tsenkhermandal	Bayandelger	Erdene
1	Average temperature per year (^{o}C)	-0.8	0.2	-1.3	-1.8	-1.1	-2.5
2	Absolute high temperature (^{o}C)	38.9	38.9	38.9	38.9	35.0	35.0
3	Absolute low temperature (^{o}C)	-46.3	-46.3	-46.3	-46.3	-40.2	-40.2
4	Average temperature per day (^{o}C)	12.8	12.8	12.8	12.8	8.3	8.3

5	Calculated temperature in outside (^{o}C)	A day	-34.7	-30.4	-30.0	-30.4	-28.4	-29.9
		3 days	-35.4	-31.0	-31.0	-31.0	-29.5	-31.7
		5 days	-37.2	-31.7	-32.1	-31.7	-30.5	-33.6
6	Average absolute temperature in July (^{o}C)		32.9	32.9	32.9	32.9	28.8	28.8
7	Average temperature in January (^{o}C)		-37.2	-37.2	-37.2	-37.2	-32.5	-32.5
8	Precipitation, by year (mm)		255.7	255.7	255.7	255.7	282.5	248.8
9	Snow weight gPa (kg/m^2)		0.50 (50)	0.50 (50)	0.50 (50)	0.50 (50)	0.35 (35)	0.35 (35)
10	Wind pressure put into normative (kg/m^2)		0.27 (27)	0.27 (27)	0.27 (27)	0.27 (27)	0.35 (35)	0.35 (35)
11	Average speed of the wind per year (m/sec)		3.6	3.6	3.6	3.6	2.6	2.6
12	Average temperature on the surface of the soil per year (^{o}C)		1.7	1.7	1.7	1.7	1.4	1.4

As looking at the Table 1.1, however the average temperature per year is 0.2^{o}C-2.5^{o}C and the wind and snow pressures/weights are the same from Jargaltkhaan to Undurkhaan soums, it have increased between Jargaltkhaan and Erdene soums and having a difference of 20 kg/m^2 as for the snow and 8 kg/m^2 as for the wind. However the general trend is like that, the many natural and climatic phenomenon that happen with certain intervals, especially, snow storm, serum flood and flood resulting from the increase of the water of rivers due to the rainfall influences the traffic movement negatively. Therefore it is correct to study such natural and climatic phenomenon in the direction of the millenium road.

As for the geo-morphology, the surveyed strip of the road includes mountains with different heights that are formed by stretching from the Khentii mountain range to the southern west part and their river basins and ravines. The western part the strip of the road is mountainous and cut by the ravines and the eastern part of the strip of the road has an open steppe surface.

The area along with the strip of the road can be classified into 3 categories by its relief character: 1/ Relief of erosion and accumulation, 2/ Relief of carried items-accumulation and 3/ Relief of carried items-wash ups.

Relief of erosion and accumulation includes the mountainous region that is pushed up to the absolute height of 1500-1900 meters and deeply cut by the ravines and dominated by the tectonic development. In this classification of the relief, the physical and geological phenomenon and events are clearly distinguished. Also, the middle part of the strip of the road includes relief with ridges with low height, small hills, knolls and rises with height of 1100-1300 meters.

Relief of carried items - accumulation covers the hills with low height pushed up to the absolute height of 1000-1150 meters, even steppe and hollows between the mountains. The steppe of Chandganii dominates in the most part of the relief. Also, the temporary stream, dry pebbles arisen due to the human actions and some ponds existed resulting from the strong surface erosion occur in this relief.

Relief of carried items- erosion includes mainly the river basin and open steppe in which the accumulation of the alluvium and proluvium is dominated and spread out. There is a Togosiin hollow, river basins of Kherlen, Tsenkher, Murun and Khujkhaan situated at the 1000-1050 meters of absolute height.

Surveyed situation. The research work for the precious stones was organized in the mountain Bayan-Ulaan and watershed of rivers Kherlen and Tsenkher and their hollows between 1892-1983 at first time. The geological stretch map was designed in 1913-1914 by consolidating the results of the research and trip organized since that time. In 1924-1925, Russian researcher Kutlenskii made a detailed survey in the river basins of Kherlen, Tsenkher and Murun rivers, determined the Batiolite, a deep zone of Granodiorite and revealed the development of the young accumulation of the Perm and Jury at the certain

level. During this process, he had been researched the tin deposit in the Tugalagtai ridge and made wide range of mapping that includes mineral waters and springs.

In 1938-1960, he made a research and survey for the mineral resources in Khentii aimag and prepared the maps with scales of 1:1000000, 1:500000, 1:200000 and 1:50000. Moreover, V.A.Grunichev and N.A.Marinov have made a soil survey along with the road built in the direction of Ulaanbaatar-Undurkhaan-Choibalsan and prepared reports. During the last years in 1970-1980, researchers made a research and survey for the mineral resources in the river basins of Kherlen, Tsenkher and Murun rivers and prepared the maps with scales of 1:500000, and 1:200000. Although the survey for the ground road and geology was organized along with the strip of the road, the survey didn't meet the modern requirements. As for the highway, there haven't been made any surveys.

As for the geological formation, areas to be covered by the survey are included in the geo-synclinal system of frowning in Western Mongolia. The rocks and stones can be classified into 3 categories generally by their age, origin and types. 1/ complex of accumulation and stones originated from the deepness and aged from Perm and Jury, 2/ complex of lower and medium Paleosoy with variable origins and 3/ complex of accumulation of 4^{th} Neogeny. While the complex of Perm and Jury such as granites and Granodiorite originated from the deepness dominates in the mountainous zone in the western part, the schist, sandy stones, gneiss, allevrolite, argillium and congremerate are dominating in the medium part of the Poleosoy's complex and accumulated stones with the origin of alluvium-proluvium, deluvium-prolluvium and elluvium-deluvium that are the complex of the fluffy accumulation of 4^{th} Neogeny are spread out over the whole area. Mainly the sandy pebbles with sandy and muddy stuff are dominated in the composition of alluvium-prolluvium accumulation and exist in I and II hillock of the river basins and shallow parts of the rivers. The accumulation of delluvium-prolluvium is situated in hollows between the mountains and their slopes in the form of gravel and sandy stones with muddy stuffing. The accumulation of elluvium-delluvium are spread out mainly over the tops, hills and slopes of

the mountains and usually consists of sand and gravel and with sandy and muddy stuffing and are strongly affected by the decaying process.

As for the earthquake zone, the mountainous region of Khentii is included in the inactive earthquake zone comparing to the other areas of Mongolia and Russian researchers have determined that the magnetic indication in the Erdenekhaan mountain situated far from the strip of the road is M=5.8. There is a scarce information about the earthquake.

As for the hydrogeology, rivers, streams and springs originated from the Khentii mountain range merge with the Kherlen River and flows into the Pacific Ocean. When drilling down to the 20.0 meters on the hillock of the shallow part of Kherlen, Murun and Tsenkher rivers, the ground water was stabilized at the depth of 0.35-1.0 meters. The ground water has the hydraulic connection with the water of its close river. And when drilling down close to the dry pebbles in Khujkhaan, Jargaltkhaan and Togos rivers, the ground water was stabilized at the depth of 6.6-8.8 meters.

Soil condition

There is the permafrost in the 15 percent of the territory of our country. There are soils that bulges when it is frozen, especially the land around the river basin of Darkhan and Selenge that slides down when it is wet, a soil that swells when the water and humidity is increased and huge sized crumbs and rocky soils exist in about 30 percent of the territory. But, no permafrost and soil that swells were not revealed along with the 250 kilometers of the trace of the road surveyed by us. But there was a fluffy soil in a small area that can slide down. There are soils in the most area that bulges when it is frozen and slides down when it is thawed. The process of becoming marshy tends to be intensified in the western hillock of the shallow part of the river Kherlen.

The fluffy soil such as dusty sands and fine sands carried by the wind /eolovium/ is observed in the northern side of Murun soum. The degradation process that can be arisen

due to the surface erosion and slopes and the condition of the land that is cut by the hills and ravines can influence the traffic road breaks and damages.

The muddy part is dominating in more than the 10 percent of the strip of the road being surveyed. There are a very few places that can not reach the 10 percent. This shows the condition for the bulging and sliding down. Especially, the soil of the marshy areas of which the ground water is close to the surface is very weak and fluffy and thus, the bulging can be arisen. The seasonal freezing fluctuates between 2.5-3.8 meters.

There are a lot of mixtures of gravel and sand with the big granules in the strip of the road and thus, it is completely possible to use them in making a dam and fundament for the road in case of preventing from the freezing. But is required to use them in other layers by creating an appropriate composition. The percentage of the CBR after soaking for 4 days in the bedrock should be more than 7 % in the 93 percent of the road. As looking at the result of the experiment, this indication meets the requirement in most cases. Although some of the soils do not meet the requirement for the materials of the lower layer of the dam and fundament, there will be no difficulty in taking engineering measurements to meet this requirement. It is required to create the appropriate composition of the materials to be used in the upper layer of the fundament and/or strengthen by the cement.

The drilling with 20.0 meters of depth and the experiment of the dynamic penetration were made in every 1.0 meter for the bridge to be built in the rivers Kherlen, Tsenkher, Murun and Togos along with the strip of the road. Finally, I will mention some of the results of the experiments, observation and surveys made in some of the areas because the bulging and the sliding down are mainly results to the difficulty in the road and bridge construction work.

There are some of experimental and research works that haven’t been executed before 1990 in Mongolia have started. Our organization introduced the Standard Penetration Test at every 1.0 meters to the engineering geological survey by making a drilling with the depth of

20.0 meters in the area of the bridge in the rivers of Orkhon and Burgaltai in 1994-1994. During the process of this event, we have made the observation in the marshy area of the cost of the river Orkhon in order to make measurements of soil temperature, bulging and sliding downs. The soil temperature and measured boreholes are shown in the Scheme 1.

We have measured and determined the soil temperature every month by installing the electric resistance's thermo-resistor with the type MMT-4 in the borehole with the depth of 10.0 meters. 10-11 thermo-resistors were installed at 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 7.5 and 9.0 meters in each borehole.

The depth of the freezing and thawing of the ground in Orkhon and Burgaltai rivers are shown in the Scheme 2. The depth of the freezing was 2.3-2.5 meters resulting from the higher ground water. The bulging of the soil was determined by making the measurements of geodesy by using the marks of the depth that was approved as a new discovery. The bulging does not exceed 9.0 sm.

The survey held in 1970-1980 was approved that the bulging does not happen in the whole depth. The layer that can result to the bulging is $0.8H^H$ in muddy soil and $0.6H^H$ in huge sized crumbs. /H^H – normative depth of the soil freezing/ We have worked out a formula for determining the normative depth in Mongolia and the results obtained from this formula is shown in BNbD 2.02.01-94 and BNbD 1.01.-93.

The bulging is 8-20 sm. and the bulging power is 0.7-1.2 kg/sm2 in areas that result to arise a medium and a big bulging. This was revealed at the result of the experiment executed by A.Anand [1,2,3] and D.Dashjamts [6,7]. The event that Z.Binderya [4] and B.Batkhuyag [5] have surveyed the methods of using the sand pad in the soil that bulges and the evaluation of the bulging of muddy soils and worked out the practical methods and recommendations has a high importance. The result of the survey conducted in our country was very similar to the result of the survey conducted in Ural's region by V.B.Shvets [10] and the survey conducted in Chita region by B.B.Yolgin and I.I.Jeleznyak [9]. Also, the

similarity of the classification and theoretical-practical basis obtained at the result of the survey of the soil bulging in the direction of road, bridge and building construction shows that the principles stated in the norms and rules that are being developed at the result of the survey and experiment of the national scientists and international scientists such as I.A.Zolotarya, N.A.Punova, V.M.Sidenko [11], I.I.Leonovich and N.P.Vierko [12] are the same.

Conclusion

1. It can be assumed that the survey of the soil in the area for the bridges' facility along with the strip of the road is sufficient for creating the bridge projects.
2. The survey of the soil and materials in the area of the strip of the road is completely sufficient for developing the technical and economic basis.
3. It is required to survey the soil and materials in detail when developing the draft project for the strip of the road. Especially, it is required to conduct an experiment and survey that can completely meet the requirement for the materials for the lower layer of the dam fundament.

Scheme 1. Borehole drilled near to the bridges in Orkhon and Burgaltai rivers to measure the soil temperature.

1 – measuring tool, 2 – plastic tube for the temperature 3 – thermal sensor 4 – sandy stuffing that contained gravel 5 – dry sands

Scheme 2. Situation of freezing and thawing of water and soil

1 – Bridge in Orkhon 2 – Bridge in Burgaltai

Months								
X	XI	XII	I	II	III	IV	V	VI