The issues of frost on the design of embankments

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ABSTRACT

In the context of extreme climatic conditions of Mongolia, an appropriated and economically justificable road projecting by using adequately the road embankment and by considering the soil quality, local geological, hydrological and hydro-geological factors, and also the traffic characteristics, will bring economic benefits in order to improve the road use quality and extend the road whole-life. One of the forms to increase the road construction efficiency is by projecting the road embankment taking into consideration all the factors that could influence the embankment construction aiming to allow the circulation of the normative speed automobiles in the carriage and pavement way.

Vocabulary: road-base soil, excavation/digging, soil carrying capacity ratio, excavation/digging slope quotient, wind and pluvial weathering, cold pile, normal pavement pile size content, embankment and excavation/digging work layer, soil pile grading and classification

Introduction

The road construction, that extends to the sites/places with different climatic conditions, is continuously suffering the influence of climatic and road stream factors, and a very expensive construction both at the construction and the use phases. On the other hand, the road construction must answer the main requirement in order to guarantee the economically available automobile traffic computable speed all year around. The road walk section/side-walk use influence the supply of computable speed. However, the road walk section workable condition, its deformation and, consequently, the damage rhythm depend on the embankment workability as the base of construction. Thus, it is very important to project adequately the embankment construction taking into consideration the working condition in order to guarantee a good stability.

Naturally in case of Mongolia, the road embankment suffer deformation due mainly to the natural and climatic factors, especially the acid reaction caused by an excessive moisture in low temperature condition.

1. Specifities of the annual hydro and thermal regimen principles in the context of climatic conditions of Mongolia

Mongolia is situated in the Central Asian region with average altitude above the sea level of 1200-1600 m characterized by an extreme cold climate. Usually, starting on October until the end of January, the soil freeze and remain frozen until May and June, and starts thawing in mid-May and mid-June. Image 1 shows the land and road embankment that remains frozen fro 7-8 months, a situation very common for our country. At the end of February and beginning of March, the pavement layer creates piles causing its deformation dut to the fact that the freezing continues for a long period reaching the 3-4 m depth. This freezing creates in April, considered as the beginning of the thawing, the moisture accumulation/concentration in the embankment crone layer.

The research on road use demonstrates that road embankment loose greatly its compaction in sections with different levels thus creating many cold piles as shown on Photos 1 - 3. This situation is explained by the low traffic density (especially, of trucks) and by the fact that during the dry period of May and June the embankment cannot recuperate its lost compaction.

But, by the other, it also can be explained by the mixture of the clay soil and increased dust content.

In case of our country, in May and June the crone layer is getting dried by the spring wind even when at the given depth the frozen layer still remains.

2. Embankment projecting by thermal regimen

Our country has a low atmospheric precipitation, but creates a high moisture accumulation/concentration in sub-ground soil according to the law of thermo-diffusion. The embankment compaction thins out depending on the moisture value accumulating in the embankment or the pressure value formed in its defile lattice. Thus, it is important to define the structure while projecting, before the embankment construction in place presenting any kind of moisture, aiming the prolongation of the road construction whole-life period and the decrease of the use-related expenses/cost.

"Road Projecting 32,01,00" had divided the land/soil in 3 types, by moisture condition, as described by BNbD in Image 2. The Tables 1 and 2 show the land/soil classification and the indication of its work layer altitude according to the BNbD requirement.

The 3-types land/soil is the most dangerous site due to the surplus moisture accumulation/concentration in the embankment and work layer in that place/site. Naturally, in case of road and climatic zones IV and V, the moisture 3-types land/soil is rare so the use of clay and sand soil is advantageous. However, other road and climatic zones refer to the Khangai region of our country, so the moisture 3-types land/soil places/sites are usually situated along the carriage way/road. So, in the embankment projecting for these sites/places, the use of the good sieve and low size pile grave and sand soils is proper, in order to accumulate less moisture in its work layers**.**

In this case, during the elaboration process of the gravel and sand soil selection technical requirements is necessary to follow the actual requirement concerning to the elevation value of the sub-ground water level, mentioned in the Table 2, but, on the other hand, it is more appropriated to avoid the use of the clay soil and the construction of the connected work layer to the road embankment, to be constructed with the high developed layer, especially the asphalt and concrete layer.

It is visible on the example of the road construction cold tolerance test:

Basic data:

Z_l=20 cm, layer thickness made of stable material

Z = 300 cm, freezing depth

L_{ob}=2 cm, normal pavement layer pile size

α_0= 250 - 350, climatic quotient

B = 5, indicator of the embankment soil specific structure

Idea:

By the cold resistance test calculation it was obtained the distance between the soil water level and the pavement layer of H = 566 cm. Considering this calculation it is clear that the embankment has constructed with the clay and sand soils. In the case of the moisture 3-types land/soil, if the sub-ground water level is 1-2 m in depth, the embankment height must be of 3 m. The calculation effectuated by myself, is not in accordance with the standard content fixed by he BNbD in "Road Projecting".

According to the above exposed, it is necessary to establish a pile limit of 2-4 cm for the use of the sand and clay soils in road pavement layer. In the case of countries with more pleasant climatic conditions or more smooth winter climate, this exigency is fixed in 1 cm increasing the requirement formulated to the soil to be used in embankment, and also the use of the clay soil corresponds to this requirement. However, in our country the pavement layer pile size is definitely big, the fact confirmed by the use of 10-20 years old roads, due to the physical conditions.

It stands to reason that one of the forms of the decrease of the road construction cost is the broad use of the local become cooler material and, consequently, the decrease of the transit distance, but for the given road construction cost caused by the utilization of the clay soil in embankments following the standards, the use durability become shorter so why the maintenance cost is high and probably economically not available. So for the high moisture original source soil it is advantageous the construction of embankment by using the standard and low size pile soils despite of the increase of the road construction cost.

The Table 3 describes the soil cold piles classification according in conformity with the "Road Smooth Pavement Projecting VSN 46-83" followed actually in Russia, former USSR, in places where the natural and climatic conditions are similar to our country. So in the 3-types soil embankment projecting the use of the I group soil that avoids the creation of piles when used in embankment work layer, is proper.

CONCLUSIONS

1. In the context of the cold climatic conditions of Mongolia, the use of soils that avoid the formation of piles in the embankment work layer, is the main factor of the decrease of the road total cost and improvement of the productivity.

2. It is necessary to select and execute maintenance attending to the fact that the use of clay soils in the work layer, aiming the decrease of the road construction cost, allows the acceleration of embankment compaction thin out, in the conditions like of our country.

3. In future, it is necessary to conduct research on the embankment construction techniques attending to the natural and climatic conditions of Mongolia and taking into consideration the actual position defended at the international level, to normalize the pavement layer pile size.

4. In my understanding, it is necessary to revise the standards presented in the Table 24 of the "Road Projecting" BNbD 2-01-00.

5. During the road design phase, it is more appropriated the definition of the embankment moisture value, because, nowadays, we need on this requirement.

6. It is necessary to place the technical requirements in the layer in depth of 70%.

As the confirmation of the idea explained in this paper, I can refer the fact that in Mongolia it is possible to find some places where the soil material does not present piles. Generally, in the earthwork sites, the adequate placement of the extracted soil in embankment respecting the hydro-thermal regimen, is considered a condition of the road construction characterized by a high quality and a longer durability.

REFERENCES

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Image 1

Annual Embankment hydro-thermal regimen regularity

Image 2

Local Moisture Classification and Calculation Diagramme

1st type soil

Layer water evasion provision
Sub-ground water level is lower than the active depth

2nd type soil

Layer water evasion non-provision
Sub-ground water level is lower than the active depth

3d type soil

Layer water evasion non-provision
Sub-ground water level is above the active depth

Image 3

Embankment moisture source

Image 4

Embankment moisture stability transition

Table 1

Clay soils types

Type	Difference	Sand content, masse in %	Plasticity value
Sandy	Big and light	> 50	1-7
	Light	> 50	1-7
	Dusty	50-20	1-7
	Heavy and dusty	< 20	1-7
Clayey	Light	> 40	7-12
	Light and dusty	< 40	7-12
	Heavy	> 40	12-27
	Heavy and dusty	< 40	12-17
Clay	Sandy	> 40	17-27
	Dusty	< 40	17-27
	Thick	Without standard	> 27

Table 2

The smallest value of the pavement layer elevation to the sub-ground water level

Working soil	Inferior value of the pavement layer elevation Road and climatic zones			
	II	III	IV	V
Small size sand, light sandy	1.1. ---- < 40 0.9	0.9 ---- 0.7	0.75 ----- 0.55	0.5 ---- 0.3
Dusty sand, dusty sandy	1.5 ----	1.2. -----	1.1 -----	0.8 -----

	1.2	1.0	0.8	0.5
Light and heavy sandy, clay	2.2. ---- 1.6.	1.8 ----- 1.4	1.5 ----- 1.1	1.1 ----- 0.8
Heavy and dusty sandy, light and dusty clayey, Heavy and dusty clayey	2.4. ---- 1.8	2.1 ----- 1.5	1.8 ----- 1.3	1.2 ----- 0.8

Table 3

Soil pile grading classification

Soil pile grade	Soil characteristics	Soil moisture type	Relative pile value (%) at the freezing depth 1,5m	Soil pile grade group
No piles	Big and mid-size, grain less than 0.05mm and content less than 2% sand	2-3	Less than 1	I
	Big and mid-grain and the less 0.05mm grain content less than 15% gravel sand, Small grain and less 0.05mm grain content less than 2% sand	1	Less than 1	I
Form less piles	Big and mid-size, grain less than 0.05mm and content less than 15% gravel sand Small grain and less 0.05mm grain content less than 2% sand	2-3	1-2	II
	Small grain and less 0.05mm grain content less than 15% sand	1	1-2	II
	Small grain and less 0.05mm grain content less than 15% sand Light big sandy	2-3	2-4	III

	Dusty sand Dusty sandy Light and heavy, and heavy dusty clayey Clay	1	2-4	III
Form piles	Light sandy Light and heavy dusty clayey clay	2-3	4-7	IV
	Dusty heavy sandy Dusty light clayey	1	4-7	IV
Form many piles	Dusty sand Dusty sandy Dusty heavy clayey	2-3	7-10	V
Form an excessive number of piles	Dusty heavy sandy Dusty light clayey	2-3	More than 10-15	VI

Embankment to be elevated

1 – embankment work layer

2 – embankment lateral slope

3 – embankment body

4 – embankment soil-base /land/