ON THE ISSUE OF USING COLD ASPHALT-CONCRETE MIX IN CONDITIONS OF MONGOLIA

D. GERELNYAM, Ph.D.

Department of Road
(Government Implementing Agency)

e-mail: gerelnjam@mail.ru

Abstract

This paper discusses some of the research results on storing and using cold asphalt-concrete for road constructions without compressing it in the natural and climatic conditions of Mongolia.

Keywords**:** cold asphalt-concrete, compression

Introduction

Mongolia has a vast territory, yet its population is small and sparse. Infrastructure here is poorly developed and number of vehicles moving per day or traffic rate is low.

Moreover, because the country contains such diverse natural and climatic zones as Gobi, desert, steppe, high mountains and forest steppe, it is considered to be effective to base road constructions in Mongolia on the experiences of countries with diverse ecological and climatic regimes.

One of the examples of it is the use of cold asphalt-concrete for road constructions in Mongolia conditions.

Natural conditions

It is clear that stability values of road pavement are influenced mainly by natural and climatic factors. Mongolia is located in the north part of Central Asia and isolated from mild oceanic climate by high mountains, the highest altitude above sea level is 4347 m, the lowest - 560 m, and average elevation is 1580 m above sea level. There is about 80-90 degree seasonal fluctuation as winter temperature reaches -45°Ñ-50°Ñ and summer temperature is about +35°Ñ+40°Ñ. This kind of continental climate is a major factor to exert an influence on road maintenance.

The northern part of the Mongolian territory is a continuation of Siberian landscape and the southern part covers a region that contains Central Asian Gobi desert or semi-desert zones; the western and northern parts are mountainous; the southern and eastern parts are usually plateaus and southern parts include Gobi and desert zones. These types of diverse landscapes contribute to the sharp-changing continental climate of Mongolia. It is characteristic that winter is cold with little snow, whereas summer is short, but hot.

Some of the many physico-geographic phenomena that occur in Mongolia are: winter atmospheric pressure front with the highest value passes through here and it is also the southernmost point of permafrost distribution on the world (47^{o} of latitude of the Northern Hemisphere). Moreover, it contains Gobi and desert zones at 50.5° of latitude, which is the northernmost point for such natural zones. Thus, Mongolia is located right on the transition zones from Siberian forest to the Gobi desert.

This kind of difficult natural conditions may not only mean that it is difficult for road constructions, but may even be advantageous in that it is possible to learn and use experiences of different countries with different climatic situations. We have to be aware that the Mongolian people are expecting a lot from us as we declared and started the “Millennium road” project, which was what people really looked forward to seeing the results.

We also have to carefully judge among experiences of countries where different technologies were successfully introduced to build roads that suit well to their peculiar regions such as African deserts, Siberian taiga and Kyrgyz’s high mountains.

On the cold asphalt-concrete mix

It is very important that select a correct model and suitable technology to build high quality roads in different regions by taking into account potential environmental and climatic risks.

From the mid 1990s, scientific institutions for roads in Mongolia, road workers, and researchers started studying the cold asphalt-concrete mix. The main reason it attracted our attention was not only its advantages, but also the fact it was broadly used in many countries that are located at the same or close latitudes as our country. From these countries, some of the highly developed countries such as the USA, Great Britain, France, Germany, Switzerland, Finland, Spain, Belgium, Japan, Russian Federation, Poland, and Yugoslavia use the cold asphalt-concrete mix for road constructions.

Development of the cold asphalt-concrete mix

In the end of 19th century, a German engineer Damman discovered a new material, for which degoti (äåãîòü) of coal could be used as binder and called it a "cold asphalt-concrete" when he applied for a patent. After Switzerland bought this patent, it has been used at a worldwide scale and each country has developed their own technology that suit well to their environmental and ecological conditions when introducing this material for road constructions. For example, in Switzerland, bitumen was diluted with gasoline or kerosene and that liquid bitumen in turn was used to prepare the cold asphalt-concrete; whereas, in Canada, it was considered that it was more suitable to prepare the cold asphalt-concrete with bitumen emulsion which was their introduced version of the technology to the country.

The first part of the 20th century marked the most active period for the utilization of the cold asphalt-concrete. For example, the first asphalt-concrete road was built in Russia (former Soviet Union) in 1928 and the first cold asphalt-concrete-producing factory was built in Moscow in 1932.

In 1934, a researcher P.I. Peregud wrote in his book "The cold asphalt-concrete" that the mix depends upon the following factors:

- particle composition of mineral components;
- climatic conditions;
- storage time;
- and storage conditions.

At that time, Russian researchers and scientists determined that precipitation (remnant) of bitumen and waste products from some factories could be used as binding materials for the cold asphalt-concrete mix.

Thus, not only the cold asphalt-concrete mix has been improved with time and its quality has always been increased, but also it became one of the most popular materials for road constructions in developed countries.

For example, judging from the international standards or regulations that were developed by an extensive studies with the AASHTO program, based on the researches conducted by scientists from Finland and other countries, the mixes we call “Myagkiy asphalt” and ‘’Neftegraviy” are actually cold asphalt-concrete.

Advantages of the cold asphalt-concrete

What are the advantages of the cold asphalt-concrete?

1. Amount of bitumen required for the mix is small and liquid bitumen or bitumen emulsion can be used.
2. Less electric power is required compared to a hot asphalt-concrete mix.
3. It is possible to prepare and store it ahead of time to use during the road construction seasons.
4. Technology to use it for road construction is relatively easy, thus it is possible to use the most common implements.
5. Crevice ratio is small on the road built with the cold asphalt-concrete mix.
6. Pavement made with the cold asphalt-concrete mix doesn’t easily differ from the one constructed with hot asphalt-concrete mix.
7. The main advantage acknowledged at an international level for the cold asphalt-concrete mix is that it is considered as an ecologically-sound product.
8. It also prolongs the time of road constructions.

Judging from the above, we consider that it is possible to use the cold asphalt-concrete in the Mongolian conditions.

One thing about the cold-asphalt-concrete mix that has not been understood completely up to date is to determine a time period for which the cold asphalt-concrete mix can be stored without being compressed. Compression is a loss of the friable nature of the mix during storage and we started understanding secrets of storing it without loosing its quality.

Our research aimed at the quality change due to environmental and other factors during the storage of the mix by boxing it in the open field along the road that is being built. Mainly, the goal was to predict or make a prognosis of the change in compression of the material because the compression starts with the same time as a temperature of the mix decreases.

Here we discuss some of the results of our research. But one has to remember that every country has adopted this technology by adjusting it to their specific environmental conditions.

Because compression of the cold asphalt-concrete mix happens over a long time, the mix should be prepared and stored ahead of time, so the stability of the road can be reached within a short time after paving. Therefore, preparing and storing the mix well ahead of time is considered to be efficient.

If the time to milk cows at a dairy farm is delayed by 30 minutes once, weekly product of the farm varies and there will undoubtedly be a loss in the amount of milk produced. Similarly, storing the cold asphalt-concrete too long and loss of technological regimes will contribute to the compression or hardening of the mix to turn it into an industrial waste. Therefore, the most important thing to take into our account is right storage condition for the mix without compacting it.

There are some factors, which have the main impact on the compression of the mix. They include:

- characteristics of the primary bitumen;
- amount of the bitumen in the mix;
- temperature at the starting time of the mix storage;
- temperature of the storage environment;
- and the height of boxed mix.

The height is important when the mix is boxed and piled up with a certain angle.

To determine the compression, we used to get samples from the mix to prepare a matrix and measured with specific instruments. This of course is not possible to predict how long the mix can be stored. However, our program has an advantage in that it makes it possible to estimate the storage time by programming environmental, climatic factors, as well as the condition of cold asphalt-concrete mix.

For example, the temperature change and the storage time in the central region of the country is different from Bayan-Olgii aimag, and of course it is also different in Zuunbayan. These all can be estimated by our program and if the number of days to store the mix for that region is fixed, bitumen characteristics and the temperature at the starting time of storage can be varied to achieve at the aimed storage duration.

We determined compression of the mix during our industrial experiment. As a result, our program has been tested and confirmed.

In the experiment, the cold asphalt-concrete was prepared with three different bitumen binders and stored at 5 different temperatures for 150 days. We tried, as a rule, to create the worst possible conditions in our experiment.

And this clearly indicates the possible storing time for the mix.

Based on the values given in the table, the general equation to determine the compression rate per unit of time is given.

Compression rate per unit of time:

$$b = \frac{dP_{sl}}{d\tau}$$

Change of compression due to temperature and time:

$$P_{sl}(T) = P_{sl}(0) + b(T,\tau)dt$$

where

$P_{sl}(0)$	- compression value at the time of boxing the mix;
$b(T,\tau)$	- compression rate as a function of temperature and time;
$T(\tau)$	- temperature of the mix that changes over time.

We also formulated a function that determines the initial Đ(0).

Initial compression value at the time of boxing:

$$P_{sl}(0) = 6 + 0.15(T_0 - 10)$$

Finally, the formula to determine the compression value was written as a sum.

The general formula to determine the compression value written as a sum:

$$P_{sl}(\tau) = 6 + 0.15(T - 10) + \sum_{i=1}^{N} b_i(T)\delta\tau$$

As a result of the research we suggest that it is possible to estimate the number of days for which the asphalt-concrete mix should be stored by programming such climatic conditions of the region as changes in physical heat and in temperature without determining the compression by the method of sampling.

Conclusion

It is possible to determine the storage time of the cold asphalt-concrete mix without compressing it by modeling the relationship between all the environmental factors of the region that exert an influence on road constructions.

About the author: D. Gerelnyam – graduated from the Institute of Road Engineering in Kharikov, Ukraine in 1993 with a Master's degree. Between 1993 and 1997, she worked as a lecturer in road engineering at the Technical University of Mongolia. In 1997-2001, she studied at the University of Road Engineering in Moscow, Russia and graduated with a Ph.D degree. Now she works at a Mongolian Road Institute as a specialist in research and study and standard. She is a member of the International Association for Road Education and a senior member of Mongolian Road Society. Her main interest of research is in pavement technology.