CEMENT STABILIZED BASE AND ITS UTILIZATION ON LOW TRAFFIC VOLUME ROADS IN THE SHARP CONTINENTAL CLIMATIC CONDITIONS

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Summery

Here we have formulated the results of laboratory and field tests of the possibility of cement stabilization of the soil and its utilization on low traffic volume roads in the conditions of the Mongolian nature and climate.

Key words: Cement stabilized soil. The low volume traffic. The sharp continental conditions. Freezing-thawing. Wetting-drying. Surface worn-out and durability. The qualities of the stabilized soil. The utilization of the stabilized soil.

The objectives and content

The Mongolian Technical University (MTU) and the Japanese Ashikaga Institute of Technology of Japan (JAIT) jointly conducted indoor tests and field studies of the soil stabilization since 1997 at the order of the Mongolia Traffic Road Board.

The objective of the research was to survey the possibility of utilizing the cement stabilized soil on the low traffic roads in the natural and climatic conditions of Mongolia.

The Mongolian nature and climate differ from those of other countries by the sharp continental nature. In particular, there are frequent temperature and drying-wetting fluctuations not only around four seasons but also for a day. Such being the case the underground water level fluctuates a lot. There are peculiar phenonmena in Mongolia as in the majority of places there has been widespread frost bitten foundation soil for many years. In the areas with no frost the foundation soil is deeply frozen in the season and heaves out, swell or cupped. Such unstable soil is spread in many places.

The items of studies include the following work:

A. In laboratory conditions:
- Complete analysis of the cement stabilization materials; in particular to determine the most dry density and adequate dampness;
- Study the strength of cement stabilized soil (CSS) respective of the cement content, water-cement ratio and other conditions;
- Investigate the quality of CSS durability in freezing thawing;
- Study the quality of CSS durability in wetting drying;
- Investigate the damage and durability of the outer layer of the surface;

B. In a number of cycles of four seasons of the year on the experimental road:
- observation of the change (of damage) of the road surface

- measurement of the unevenness of road surfaces;
- the pavement depression;
- The changes of water-heat levels of the base were meaured.

Here we are looking at some results of research not published before and at the same time have formulated the final results of the studies.

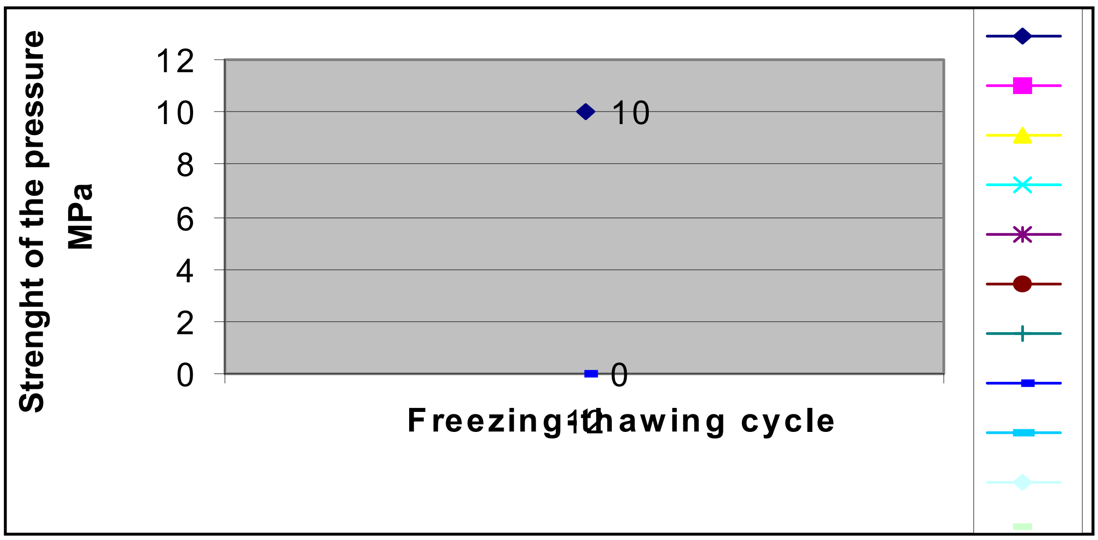
THE QUALITIES OF THE CSS AND THE FACTORS AFFECTING THEM

By cement stabilization calsium silicate the main element (constituting 70…75%) In the cement soaks in the water whereby highly adhesive substance such as calcium water silicate aqueous and calcium aqueous ferment increasing the strength and durability, CSS differs from ordinary concrete or cement dough in the cement content and also in that it accelerates or deaccelerates hydrothesis and hydrolysis processes and other chemical reaction in the fluctuation of the fibre of hard part of the soil, that takes place in a very wide range. The main factors that affect this happening are the composition of soil fibre; the chemical and mineral contents; the soil ionization, moisture volume. Water cement ratio, the origin of soil, the amount of organic ingredient in the soil structure, the results of its decay; temperature, moisture regime and other conditions of stabilization and exploitation period.

CSS Freezing—Thawing

The freezing-thawing experiment was done in the repetition of 14 cycles first by freezing by freezing for 24 hours then thawing in –20”C on the modern equipment of crating the environment of low temperature and moisture. During the experiment we have been observing the loss of CSS test weight and the changes of dry density.

It was observed at all tests that as the number of freezing-thawing grew there was a tendency of increasing weight losses. This is explained by the fact that at the repetition of freezing-thawing cycles the unevenness of the tested surface changed and what's more the small bumps and lumps peeled off. After the certain number of freezing-thawing cycles, as to all the tests, the dry density reduced compared to what was earlier. This is an important result of evaluating the error of the experiment. We have shown in Table 1 the results of the repeated investigations of the dependence of the average compression durability of CSS on the number of freezing-thawing cycles, by probing various cement contents.



● cement content 4%

◆ cement content 6%

☐ cement content 8%

▲ cement content 10%

Figure 1 **The Dependence of CSS Durability on the Number of Freezing-thawing Cycles**

The figure shows that the dependence of average compression durability of CSS on the number of freezing-thawing cycles is expressed by

R=a n + a n + a n + a

Here R is CSS compression durability; a n – the number of freezing-thawing cycles; a , a , a , a - the soil types and coefficients ofcement content dependence. As to the sample taken from Nogoon Dov of Central *aimag* (sample #1) you can see from Figure 1 how the contents of these coefficients depend on the cement contents.

Figure-1

Components of cement %				
	-a1	A2	A3	A4
4	0.001	0.0261	0.1961	3.0900
6	0.002	0.0336	0.0171	4.0033
8	0.005	01041	0.4055	5.0667
10	0.0026	0.0673	0.3203	6.1633

The results of the tests show that the CSS compression durability had a tendency of decreasing as to any cement contents in the first freezing-thawing cycles but gradually grew from the 3^{rd}-4^{th} cycles. Then it agaian falls down from the 11-12^{th} cycles depending on the cement contents. Therefore the tests show that CSS does not loose its durability up to the 11-14^{th} cycles of freezing-thawing in up to –20° C.

The Moisture and Dryness of CSS

We made the tests in drying-wetting cycle by leaving a CSS sample with different compositions in the drying oven at 60° C for 24 hours and afterwards leaving it in the water with the temperature of 21° C for 24 hours. We have shown in Figure 2 the results of the moisture and dryness durability tests made on the samples with 4, 6, 8% cement contents (sample #2).

Drying-wetting cycle

● cement content 4%

◆ cement content 6%

□ cement content 8%

Figure 2 Dependence of CSS Durability on the Number of Drying-wetting Cycles

The linkage of CSS compression durability to the number of drying-wetting has different laws depending on the cement contents. Forinstance when the cement content is 4% the linkage is of square parabola form.

$$R_{(4\%)}= -c_1m^3+c_2m+c^3$$

When the cement content is above 4% the linkage is expressed by numerous members of the 3rd order:

$$R_{(>4\%)}=-c_4m^3+c_6m^2+c_7m+c_8$$

Here m is the number of drying-wetting; c_1 ……. c_8 - the coefficients dependent on soil types and cement contents.

Themore is thenumber of drying-wetting cycles the better is the CSS durability. The boundary of this growth is different depending on the cement volume. In the case when the cement volume is above 4% the durability growth stops after the 11-12th cycles and furthermore starts to fall. The relative high moisture- dryness durability of CSS shows that it can successfully be utilized in the sharp continental climate.

The damage endurance of the surface layer

The issue of the damage and endurance of thesurface course is ofmore significance for the low cost road studies.

In studying the surface course damage we used the new experimental equipment invented at the Japanese Nippon Hodo Corporation and we have shown its scheme in Figure 3. We heated the Japanese emulsified bitumen and the bitumen takes from Mongolia and sprayed the solution on the CSS specimen. After that we compared its damage to the untreated specimen.

The rubber pipe put on the device was so much durable as to give in to very little deflection under vertical strains and grating force. We measured and investigated the raveling depth and the weight loss of the specimen caused by repeated damaging effects. We have reached a number of conclusions as a result of the experiment. The considerable reduction of the total weight loss caused by the damage depth or damages will occur only when the vertical strains are 3-5 kgc/cm 2. Therefore the effect of the surface treatment will better serve for the low traffic volume roads.

For the same reason in the less traffic volume conditions the cement stabilized, untreated surface layer willhave certain capability to oppose the wheel damage.

Since the CSS is capableof penetrating deep intothe surface the most suitable material for the treatment of such surface is emulsified bitumen. In the case when hit bitument is used for treating cement stabilized surface it must have some time to dry our after the production. As to the traffic intensive roads the grating force of wheels is high. That's why it is necessary to treat the surface with the deep penetration method.

Other laboratory tests and field research

The results of other laboratory tests and the field researchhave been detailed in the previous works [1], 12], [13].So here we have deliberated the main results.

Conclusion, the major outcome

1. **The results of the indoor tests of CSS durability show:**

- The fact that the CSS durability remained at a sufficient level after repeated freezing-thawing and drying-wetting indicates that it is possible to use such a soil for the high way base course in the region with sharp moisture-dryness and freezing-wetting conditions.
- When the comparative durability of soil stabilized during the drying-wetting tests and the weight loss are taken in comparison with the freezing-thawing tests then it reveals a common link irrespective of environmental changes.
- If the degrees of frailty of wetting-drying and freezing-thawing tests are compared it is quite clear that the feezing-thawing is more harmful than moisture-dryness for CSS durability.
- The mathematical form of the CSS durability changes during the freezing-thawing and moisture-dryness period are expressed by (1), (2), (3) and multiple numbers
- Although the way of CSS surface treatment affects the road ……..capability of receiving the wheel grating force the positive affect of the surface treatment will be more apparent on the low traffic volume road.
- In the low traffic volume conditions the untreated surface course solidified with cemenet will have certain capability of resisting the wheel grating. But the more suitable material for surface treatment in the given test conditions is emulsified bitumen. If the hot bitumen spray is used for the surface treatment the stabilized base layer must have dried for the definite post production time.

1. **The research made on the experimental road shows:**

- In the Mongolian conditions the indices of road …..durability and defaults fluctuate to a very broad range depending on the cement contents, the thickness of stabilized layer, the composition of paving materials, the base, sub base and the regime of water-heat of the embankment.
- The content of cement weight in the stabilized soil composition in the Mongolian sharp continental climate has to be 4% and above.
- The quality indices of road durability will depend much on the structure of stabilized base. The thickness of the stabilized layer has a role to play in affecting it. Besides, out

of the tested options the double thickness of stabilized layer with other cement contents was more productive.

- It is observed that the water and heat regime of the embankment and original ground specifically influence the indices of the road durability and stability. The freezing-thawing exert overwhelming affect on the stiffness of the stabilized base. The stabilized base sharply reduces the ground heaving.
- It is quite possible to improve the road longevity and stability, by effectively linking the right composition of cement and soil mixture, road pavement and the base construction and linking it with the water and heat regime of base ground and embankment.
- Because of the high fluctuation possibility of original ground and embankment in four seasons of the year it is necessary to test the soil and cement mixture in repeated frying and wetting cycle.

Finally, we conclude that it is fully possible to use cement stabilization of soil in the base on the low traffic volume roads of Mongolia which has a sharp continental climate.

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