A HAZAI TALAJOK SZERKEZETÉNEK ÉS TEHERBÍRÁSÁNAK VÁLTOZÁSA MESZES TALAJSTABILIZÁCIÓ HATÁSÁRA

PhD értekezés

SZENDEFY JÁNOS

Budapesti Műszaki és Gazdaságtudományi Egyetem

Tudományos vezető:

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Thesis:

1., The change of the plasticity index:

Based on my laboratory results I determined the plasticity index of the cohesive soil stabilization with lime narrow to a well defined zone, which is between 5-15%. It is independent of the origin plasticity index of the soil.

The change of the Atterberg-limits causes the narrowing of the plasticity index. The liquidity index of the stabilized soils narrows to 35-45% zone and the plasticity index of the stabilized soils narrows to 25-35%.

2., The change of the grain size distribution:

Based on my laboratory results I determined that the soil stabilization with lime changes significantly the gravel size distribution of the soils.

The cation change results falling away the gravel size distribution curves under 0.063 mm grain size diameter.

The grain size distribution changes slightly above 0.063 mm grain size as well. This change is caused by the cemented soil grains via puzzolain-reaction and the carbonation of the $Ca(OH)_2$.

3., The ending of the swelling propensity:

Based on geotechnical laboratory results I determined that the swelling propensity of the soil can be reduced or ended with soil stabilization with lime. It is important that only sufficient lime quantity results effective reducing or ending.

I determined with x-ray diffraction laboratory measurements that the cation change and pH level rising, during the puzzolain-reaction, destroy together the structure of the swelling clay minerals.

4., The increasing of the shear resistance:

Based on laboratory results I determined the increasing of the shear resistance during the soil stabilization with lime.

The friction angle is increasing and it reaches the 40^{o} with usage of optimum lime quantity. I defined a function for the friction angle increasing.

This function is:

$$\phi = -0.589 M^2 + 7.07 M + 18.9$$

Φ	-	friction angle [^{o}],
M	-	added lime quantity [%].

The regression of the function is R^2= 0.77. The function can not use in case of M=0%, and it gives correct results in maximum required lime quantity (M=8%) for soil stabilization with lime.

The friction angle reaches the function defined value after the mixing 7 days. This short time period shows that the cation change causes the increasing of the friction angle.

The cohesion is multiplying during the stabilization, but it can not defined well with a function. The increasing of cohesion can be measured during long time period, which shows that the increasing is caused by the cation changing and the puzzolain-reaction as well.

5., The decreasing of the water content:
I determined with stoichiometric calculation the decreasing of the water content during the soil stabilization with lime. The calculation was verified with laboratory measurements as well.
I made statistical check for the laboratory measurements and based on it I determined a function for the decreasing.

$$w = w_0 - 0.737\,M$$

w	-	expected water content [%],
w_0	-	initial water content [%],
M	-	added lime quantity [%].

Note:
The determined function is valid for 90 minutes after the soil mixing, which is the time period of lime slaking.

6., The increasing of the bearing capacity:
I suggest to change the bearing capacity laboratory measurements to CBR test instead of uniaxial compression test. Because the lime is not a hydraulic binder in case of soil and the uniaxial compression test causes a lot of problems for preparing the sample and during the storage of it.

I determined different factors separately for the bearing capacity of the soil stabilization of lime:

a., Relation between bearing capacity and optimum water content.
The CBR curves and the Proctor curves of the transient and cohesive soils are positioned in different water content. The maximum bearing capacity can be produced on the dry-side of the Proctor curves and the bearing capacity is quite weak at the optimum water content. It results, that to provide a required compacted soil layers with the required bearing capacity is impossible or possible only with more compaction power.
Instead of the soils, the CBR curves and the Proctor curves of the stabilized soils with lime are covered each other, so the water content of the maximum bearing capacity is equal or around the optimum water content. It results the ability to build a layer with well compaction and high bearing capacity.

b., The rotation of bearing capacity iso-lines in triangle diagram:
A point in the triangle diagram of soil phases has got much higher bearing capacity if it is a point of stabilized soil with lime, than if it is a point of soil.
Bearing capacity iso-lines can be determined in the triangle diagram. The normal of the iso-lines of soils are rotated to left side from the vertical, instead of the normal of the iso-lines of stabilized soils with lime, which are rotated to right side. More added lime than optimum results the returning of the normal to the left side.

c., Bearing capacity of soil stabilization, curing time, durability and freezing:
I determined that the cation change results the short time period bearing capacity rising of the soil stabilization with lime. If the soil is moistening, the lime slaking helps a lot to provide bearing capacity rising.
I determined the time period of lime slaking to 90 minutes, after this mixing can be done, which inducts the cation change and puzzolain-reaction.

I determined the time period of cation change to 7 days, after this time only puzzolain-reaction results any bearing capacity rising.
The lime increases the bearing capacity of the soil with magnitude value. The soil stabilization with lime provides excellent sub-grade in any case if the correct volume of lime is added.
I determine the bearing capacity of soil stabilization with lime in min. CBR=85% after the cation change (7 days), if the mixture had optimum water content, optimum lime quantity was added and the compaction rate is min. T_{rp}=95%.
The durability and freezing tests resulted 15-27% bearing capacity decreasing. The value of the decreasing depends on the mixtures parameters, if the different parameters are not separated the average decreasing is 20 %. It results E_2=150 MPa durable bearing capacity value for soil stabilization with lime.

d., The influence of the soil granulation for the bearing capacity during the cation change time period:
Different soil granulation results different bearing capacity on the top of the layers with similar compaction power. The final rate of the difference of the bearing capacity is equal in the case of soils and in the case of soil stabilization with lime as well, but during the cation change period I registered high difference between them. Well granulation results faster bearing capacity increasing in case of soil stabilization, which can be important to design the site quality controlling.
The equal of the final rate shows that the granulation is not effect negatively the final bearing capacity of the soil, but because of the compaction power and the effectiveness the granulation determining is necessary. I suggest to use maximum 2.5 cm of soil part diameter, which is from an American recommendation.

7., The optimum added lime quantity:
Based on my laboratory measurements, the change of the soil structure and the increasing of the bearing capacity, I determined the optimum added lime quantity for different kind of soils. I separated the soils by the plasticity index. The soils which have not plasticity index, but includes min. 10% under 0.02 mm grain size are in the category of I_p<20%.
The optimum added lime quantity means the lime quantity which produces the highest positive change of the soil parameters.

Soil categories	I_p < 20%	I_p = 20%-40%	I_p > 40%
Optimum added lime quantity	2 %	4 %	6 %

8., Equivalence thickness of sub-grades:
I determined the equivalence thickness of soil stabilization with lime for different mechanical stabilizations, gravely sub-grades and crashed stone+geogrid.
To determine the equivalence thickness I calculated with the long time, durable bearing capacity of the soil stabilization (E_2=150 MPa).

The equivalence thickness is 10 cm soil stabilization with lime layer.

M22 mech.stab	M57 mech.stab.	M80 mech.stab.	FZKA 0/22 crached stone mech. stab.	FZKA 0/32 crached stone mech. stab.	FZKA 0/56 crached stone mech. stab.	Silty, sandy gravel	Sandy gravel

13.9 cm	12.2 cm	11.4 cm	10.2 cm	9.0 cm	8.3 cm	24.2 cm	27.3 cm

The equivalence thickness for sub-grades of Lohmeyer:

R3 kavics	R2 kavics.	R1 kavics	B2 zúzottkő
19.4 cm	12.8 cm	10.0 cm	8.8 cm

The equivalence thickness for 0/64 crashed stone + Tensar geogrid is 5 cm.