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Risk from inhomogeneity of DM lime-cement stabilized soil and columns

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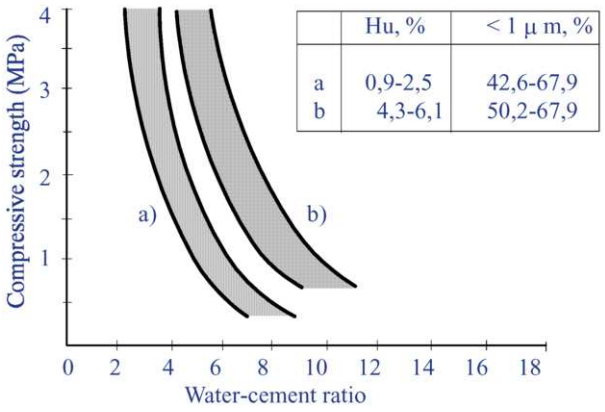
ABSTRACT

Several aspects related to the quality of DM lime-cement stabilisation are highlighted. The preparation of laboratory samples for binder optimisation differs essentially from the mixing procedure in the field (e.g. homogeneity, air content, density, temperature conditions). For obtaining good lab/ in-situ relationship real simulation of the in-situ mixing procedure for the design of optimum binder quality and quantity is necessary, e.g with a small size pilot machinery. The strength properties of stabilised soil is a strongly dependent on w/c (water-cement ratio), thus high cement content results in brittle behaviour which should be reflected in the safety philosophy applied in the design. Scandinavian post glacial clay deposits vary strongly in water content; to achieve uniform w/c ratio asks for real-time adjustment of binder quantity. Pressurized air applied as transport media is entrapped in the soil-binder mixture and reduces strength; pressure is usually increased for greater depth. Binder consumption is measured 30 -40 m behind the mixing tool causing a time shift in QC measurement. Corrections for missing binder quantity may miss the target. Increased energy input during mixing produces better homogeneity at higher cost; the benefits are better predictable strength properties and thus reduced risk for the designer and client. The present high risk level could be reduced by linking on-site determined soil properties to the execution of the DM procedure together with a real-time QC by using sensors placed close to the mixing tool

1 FACTORS OF STRONG INFLUENCE ON QUALITY

Compressive strength of stabilized soil at 28 d was found to depend on water cement ratio (w), fines content (μ) and humus content (h) according to the following equation.

$$28d\ f_c = 0{,}347\,\mu \cdot e^{-0{,}57w} + 0{,}372\,h^2 \cdot e^{-0{,}27w}$$



Taking into account the strong variations of water content with depth in clay deposits the control of binder feeding is a mayor QA task and should preferably be located close to the mixing tool.

Several types of mixing tools are applied for DM column stabilization. Their energy input may vary to a great extent, depending on shape, inclination and number of blades and wings. If the design is based on laboratory samples mixed with dry binder in an open pot according to a non-standardized procedure the determined strength properties may differ essentially from those obtained at samples taken in-situ. Better mixing needs more time and this means higher costs of work performance.

Table 1: Ratio $k = \tau_{insitu}/\tau_{lab}$ showing the wide variation in strength properties as a function of mixing intensity in-situ when compared to values from laboratory samples.

		Unconfined compressive stress		
Mixing tool	levels	< 10 kPa	10...15 kPa	15...25 kPa
	2	0,3	0,4	0,5
	3	0,45	0,7	0,85
	4	0,8	1,0	1,2
	≥ 6	0,9	1,1	1,3

2 DISCUSSION

The high differences in strength properties between laboratory design values and measured in-situ values was asked after. It is therefore of highest priority to built up correlations between standardized laboratory mixing procedures and the work execution depending on mixing tool and mixing intensity (number of blades, of rotations, inclination of wings, lifting speed etc.).

Shear strength determined in laboratory and shear strength determination in the field with penetration testing differ significantly from each other. Penetration tests in hard columns will need extremely high loads and are thus impractical. Penetration methods of which the resistance is measured at the top of the rod are misleading. Friction along rods must be taken into account. Penetration methods of which the resistance forces are measured at the tip of the rods are mostly recommended. To estimate the attainable strength one must reduce the strength obtained from laboratory tests with a factor of 0.3…0.6.