Factors effecting the saturation of triaxial samples

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Abstract

This article presents investigations into influences on the saturation behavior of coarse-grained soil samples in the triaxial test. The aim of the investigation was to find out whether there are other relevant influencing factors that enable an optimization and acceleration of the saturation process, apart from the known method of flowing CO_2 through the samples. The influencing factors analyzed herein were the method of sample preparation, the person executing the test, the infiltration rate and the residual O_2 content in the supplied pore fluid. A significant influence could be demonstrated for the residual O_2 content in the pore fluid. It was also found that other influencing factors, which were not investigated in this study, affect the saturation behavior to a similar extent.

Method

In order to be able to investigate influences on saturation behavior, a matrix experiment was created and carried out using the Taguchi method [1]. This method has been well tested and allows conclusions to be drawn about the strength and direction of the effect of the analyzed influencing factors with a comparatively small test volume. Herein the results of an ANOVA is presented. ANOVA is used to compare the variance of different factors against the means. Slightly gravelly sand was analyzed, which were restored to a porosity of n=0.375 by different methods of sample preparation with a initial water content of 1%. The samples were then flowed through at a constant infiltration rate with a cell pressure of 30 kPa until the volume of water introduced had reached twice the pore volume. This was followed by saturation in stages [2] up to a maximum saturation pressure of 800 kPa. The B-value achieved was determined for each stage.

Following the procedure described, the subsequent factors were analyzed

1. the sample preparation methods, Moist Tamping, Air Pluviation and Impact Fork Compaction
2. Three different executing persons
3. the infiltration rates 0.500ml/min, 0.225ml/min and 0.050ml/min [3]
4. the use of non-degassed water and water with an O_2 content of less than 15% as pore fluid

The tests were analyzed for the saturation pressure at which the limit B-value was reached.

Results

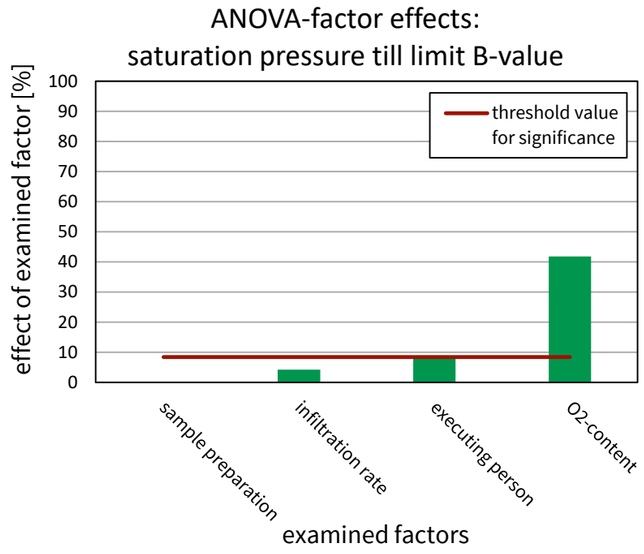

Figure 1: Influence of the examined factors on the achievement of the normative limit B-value of 95%

As can be clearly seen in Figure 1, the effect of the O_2 content in the pore fluid exceeds the threshold value for significance at a confidence level of 99.9% and thus has a demonstrable influence on the saturation behavior of coarse-grained triaxial samples.

In the tests carried out, the samples with low residual O_2 content were saturated with 150 kPa less backpressure. This can be seen in Figure 2 by comparing the mean values of the test series with low and high O_2 content. By using degassed water, the saturation pressure can be demonstrably reduced by 150 kPa for the material analyzed.

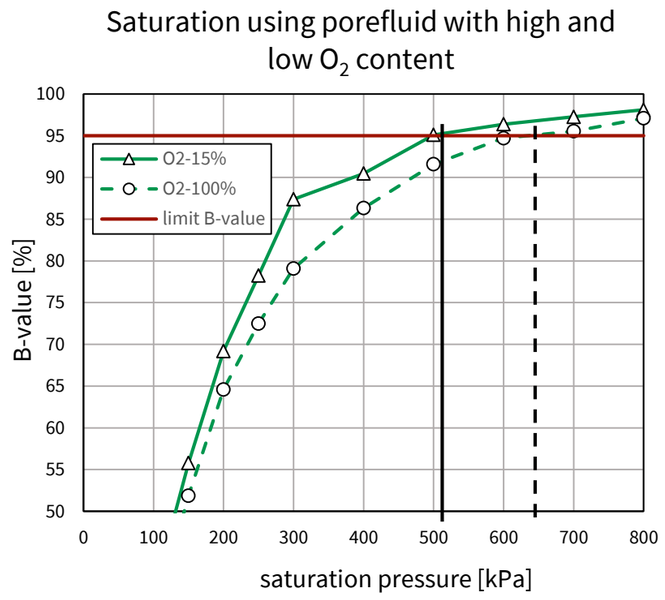

Figure 2: Average saturation curve with low and high O_2 content in the pore fluid

For the other analyzed influencing factors, some influences were detected during the course of saturation. For the infiltration rate and sample preparation method these effects were only detectable directly after infiltration or in the first pressure stages but ultimately showed no relevance for reaching the limit B-value. The effect of the testing person showed changes in the direction during the saturation process. In addition, a comparatively high proportion of non investigated factors was found.

Summary

It was found that the O_2 content in the pore fluid has an significant influence on the saturation behavior of coarse-grained soils. Factors such as the infiltration rate and the sample preparation method showed influences at the beginning of saturation, but were not relevant for reaching the limit B-value of 95 %. The proportion of non investigated factors was relatively high, which suggests either the existence of other relevant but uninvestigated influencing factors or a high scatter in the determination of the B-values aside the herein presented results.

[1] Klein, B.(2021): Versuchsplanung - Design of Experiments, De Gruyter Oldenbourg Studium, De Gruyter Oldenbourg, Berlin.
[2] K. H. Head, R.J. Epps (2014): Manual of Soil Laboratory Testing. Volume 3: Effective Stress Tests. 3rd Edition
[3] Kutter, Bruce L. (2013): Effects of capillary number, Bond number, and gas solubility on water saturation of sand specimens. In: *Can. Geotech. J.* 50 (2), S. 133–144

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