Constraint modulus of mixed-grained cohesive soils
Le module oedométrique des sols cohérents à grains mélangés

W.W.RATTAY, Institute for Constructional & Civil Engineering, Academy of Building, GDR
G.GÜNTHER, Institute for Constructional & Civil Engineering, Academy of Building, GDR

SYNOPSIS: As mixed-grained cohesive soils are designated soils contained components of clay, silt, sand and gravel. From view geological it refers especially to boulder clay and boulder marl originated from sediments of pleistozaen. For the estimation of their serviceablness for constructional purposes among others it is necessary to know the stress-strain behaviour. For many building relevant cases this can take place on the basic of the oedometer test. For determination of the stress-strain behaviour of mixed-grained cohesive soils extensive tests have been taked out in a large oedometer. The influence of the density, of the water content and of the fine grain content on the constraint modulus was realized quantitative and qualitative.

1 INTRODUCTION

In the GDR the foundation soil in surface near regions consists largely of mixed-grained cohesive soils. From view geological it refers to boulder clay, boulder marl, silt a.s.o., originated from sediments of the pleistozaen. These are characterized by a long granulometric curve, extended from the clay fraction to the silt fraction. From soil mechanics view these soils are cohesive sands and cohesive gravels. The problem by the utilization of this soils for engineering applications is that the index properities are influenced by the characteristics of cohesive and non-cohesive components. This means that the traditional calculation characteristic factors depend not only on the phase composition, but on the specific characteristics of soils. Previous studies (Leussink 1969 and Malmborg 1983) show, that for it is availlable the fine grain content ($d \leqslant 0{,}063$ mm).

The stress-strain behaviour belongs to the importantest soil constants. For many built practical cases the constraint modulus M_o is used as computation parameter. This is determined by the confined compression test (oedometer test). With the constraint modulus the stress-strain behaviour of the subsoil is realized as a role only approximately. A great number of advantages (single test technique, good reproducibility) justifies however even further his applicability.

In the literature are made demands on the relation between the maximum grain diameter of the soil and the dimensions of the oedometer. For the examined soils oedometers are necessary with an interior diameter of about 300 mm.

The aim of the tests consists in the qualitative and quantitative registration of the most important influence factors on the deformation behaviour. Developing on it the constraint modulus is predestinated.

2 EXPERIMENTS

The mixed-grained cohesive soils applied to the experiments have been prepared by mixture of good graduated gravel and clay. On this basis various distribution curves with given fine grain content were realized. Fig. 1 shows the examined distribution curves and the distribution curves of the original materials.

For the purposes of the experimental programme the placing density, the initial water content and the fine grain content were varied.

As experimental device a specific developed large capacity oedometer (Günther 1983) was used.

The main dimensions are:

- inside diameter 310 mm
- utilizable specimen height 400 mm
- maximal test load 1000 kN/m^2

The obtaining two and two values (σ , s') of the oedometer tests formed the base for the test interpretation. Proceed from the definition of the constraint modulus M_o

$$M_o = \frac{d\sigma}{ds'} \qquad (1)$$

and by acceptance of a semilogarithm connection between σ and the related settlement s'

$$s' = a \cdot \ln\sigma + b \qquad (2)$$

is

$$M_o = \frac{1}{a}\sigma = a'\sigma \qquad (3)$$

The compression index a' was determined for any test.

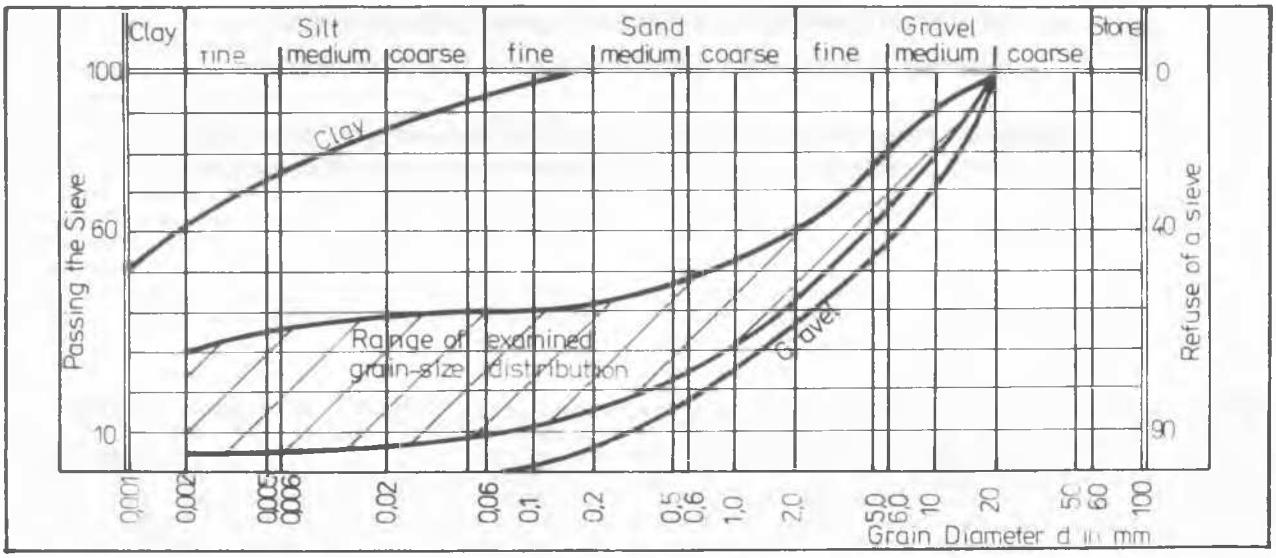

Fig. 1. Grain size distribution curves

3 RESULT

The influence of the initial void ratio, the water content and the fine grain content on the coefficient of consistency was provided qualitative for any mixed grained cohesive soils.

The compression index fundamental decreases by increased initial void ratio for any water content and any soil. The influence of the density decreases with increased void ratio and increased water content and disappears partial total.

The addition of fine grain at cohesionsless soils is able to influence the deformation process positive and negative. This effect is influenced on the phase composition. Proceeding on the water content of the soil we can discern 3 states.

State 1: dry ($w \ll w_{opt}$)

In case of dry state the increase of the fine grain content by a high density effects a reduction of the compression index. By a low density however it occurs a increase of compression index.

State 2: moist ($w \approx w_{opt}$)

It exists the same tendency as in state 1, but in a weaker form. The influence of the fine grain content on the compression index disappears almost.

State 3: wet ($w \gg w_{opt}$)

By a high water content the increase of the fine grain content results in principe a reduction of the compression index.

The transition between the 3 states proceeds continuous. Considering the increase of a mixed-grained cohesive soil the deformation behaviour develops unfavorable, independent of the density and the fine grain content. The above described results are figured in fig. 2.

The direct quantitative fixing of the above described facts is extraordinary complicated and only possible with a high experimental expenditure. The effect of the influence coefficients to the deformation conditions is of a complex nature.

In such cases it is common to realize the connection between the interesting charactering value and the influence factors with the aid of mathematical statistical methods. Therefore are examined several variants of the connection between the compression index, the density and the water content for specific equal granulometric curves with the aid of the correlation and regression analysis. The following common equation shows as a rule the highest correlation coefficient.

$$\ln a' = - A \cdot e_a - B \cdot w + C \qquad (4)$$

The inclusion of the fine grain content as an additional influence factor no led to a correction of the equation (4). In this equation the fine grain content cannot be registered in an explicite form. It is realized especially by the influence of the interaction of density and water content. Therefore it is exacter to consider the influence of the fine grain content on the coefficient of consistency by recording of his influence on the size of the coefficients in equation (4). Fig. 3 shows the result.

The development of the coefficients shows, how the modification of the influence factors affects on the compression index. The coefficient A decreases with increased fine grain content. Thereby is recorded the decreasing influence on the density. Compared to it the coefficient B increases overlinear, by which is characterized the increased influence of the water content. The coefficient C decreases gradually and indicates to the decrease of the compression index by increased fine grain content. By these realized studies was showed the complexe influence of the density, the water content and the fine grain content on the deformation mechanism of the mixed-

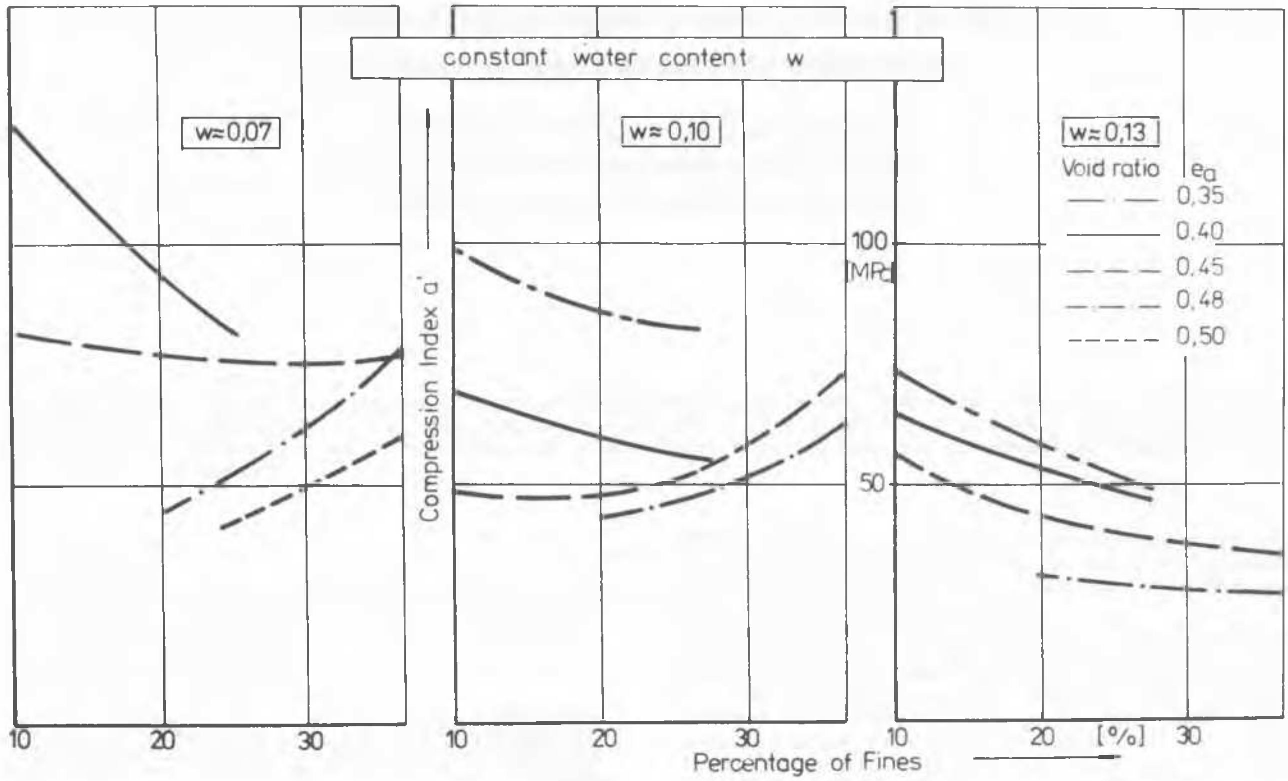

Fig. 2. Connection between the compression index, density, water content and fine grain content

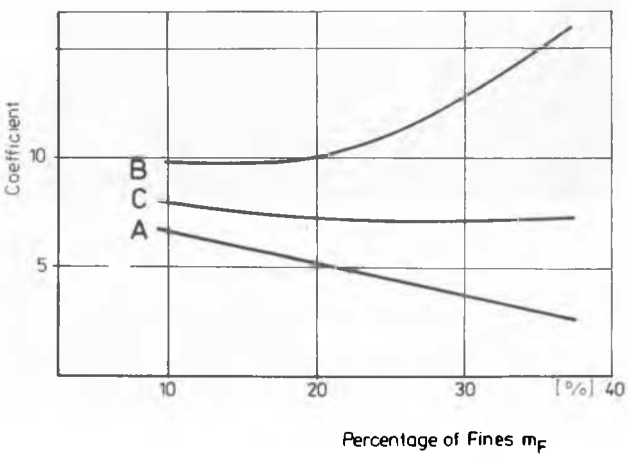

Fig. 3. Influence of the fine grain content on the coefficients

grained cohesive soils. In carrying of this works it is necessary to integrate the results in the valid earthwork standards. By that possibilities were created to better consider the building characteristics of this soils.

4 SUMMARY

With the introduced recherches it was demonstrated that the deformation mechanism of mixed-grained cohesive soils is influenced substantially by the density, the water content and the fine grain content. Thereby it is to consider that this values influence mutually one another and therefore it is necessary to consider these in complex.

On ground of these statistical results it is possible to determine approximately the compression index by knowledge of the particle-size distribution and the phase composition. This way permits to determine the using of a mixed-grained cohesive soil for a construction problem.

For the further improvement of the results it is necessary to include the problems of the durability of a fill and of the essential compaction for the reaching of a gived phase composition.

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