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# OCR and POP parameters in Plaxis-based numerical analysis of loaded over consolidated soils

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**Abstract**

The paper discusses deformation of over consolidated soils in Hardening Soil Model in terms of their initial stress state. When carrying out numerical analysis in Plaxis, it has been stated that Hardening Soil Model "remembers" the history of previous loadings. In forming the initial stress state of over consolidated soils with the pre-overburden pressure POP, there occurs the more reliable description of the soil deformation process than with the over consolidation ratio OCR. These findings are valid for odometer conditions and for real geotechnical calculations.



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## 1. Introduction

Software systems with a wide range of soil models such as Plaxis, Abaqus, ZSOIL, ANSYS, etc. are a popular and more accessible tool for conducting geotechnical calculations. In here, according to the European Geotechnical Community [1], the users of the software systems have some difficulties when dealing with them, the main ones are: selection of the most adequate soil model; indication of the soil model parameters; initialization; analysis of the

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calculation results obtained.

To overcome each difficulty it is required to study and analyze them carefully, as their total solution can improve trouble-free long life and economic justifiability of designing and erecting buildings and structures.

In many works devoted to problem-solving in carrying out numerical analysis of geotechnical problems, there exists a common approach [2, 3, 4]. This approach stems from the fact that if pre-consolidated soils occur in the ground bed simulated with a numerical problem, then the overconsolidation ratio OCR is used to describe the initial stress state and the performance of the soils under the loads. However, Plaxis allows the pre-overburden pressure – POP to be used for these purposes. The task of identifying specific use of OCR and POP during the numerical analysis has not been solved.

The paper investigates the differences in developing the initial stress state of overconsolidated soils when using OCR and POP parameters. Hardening Soil Model being a part of Plaxis software system is used as a soil model; it has gained popularity in geotechnical calculations due to its adequacy [5-8].

The paper aims at identifying the differences when using the overconsolidation ratio OCR and pre-overburden pressure POP involved in developing the initial stress state of overconsolidated soils and their deformation under loading.

## 2. Initial Stress State

The initial stress state of the ground bed depends not only on the vertical and horizontal stresses of soil dead weight, but the pre-consolidation pressure $\sigma'_p$ [9] - maximum vertical pressure that the soil had in the past; it could be created by a glacier or sedimentary rocks that are not available any more or by a technological process [10, 11].

The soil suffers from the vertical pressure of its own weight $\sigma'_{yy}$; this pressure is called natural or domestic pressure.

If the pre-consolidation pressure $\sigma'_p$ is greater than the domestic pressure $\sigma'_{yy}$, the soil is overconsolidated, and the horizontal stresses $\sigma'_{xx}$ exceed the vertical ones $\sigma'_{yy}$ in the initial stress state. If the pre-consolidation pressure is missing, the soil is normally consolidated and the vertical stresses exceed the horizontal ones.

To determine the pre-consolidation pressure $\sigma'_p$ data processing operations of oedometer tests are carried out. A number of methods for determining the pressure $\sigma'_p$ has been created, but the method of Casagrande is preferable [12]. One can use the direct method, when the characteristic fracture on the oedometer curve $\varepsilon = f(\sigma)$ indicates the pre-consolidation pressure $\sigma'_p$.

Plaxis allows calculation of the initial stress state to be carried out automatically using the coefficient of earth pressure $K_o = \sigma'_{xx} / \sigma'_{yy}$. By default it is believed that the simulated soil is normally consolidated, so the coefficient of earth pressure in normal consolidation $K_o^{NC}$ is used; it depends on the angle of internal friction and is automatically evaluated by the formula after Jaky [13, 14]: $K_o^{NC} = 1-\sin\varphi$.

If the soil is overconsolidated, adjustment of the coefficient of earth pressure $K_o$ is required specifying the value of the overconsolidation ratio OCR and pre-overburden pressure POP.

OCR is evaluated by the formula: $OCR = \sigma'_p / \sigma'_{yy}$. If $OCR \leq 1$, the soil is considered to be normally consolidated, when $OCR > 1$ - it is overconsolidated.

POP is evaluated by the formula: $POP = |\sigma'_p - \sigma'_{yy}|$ and is not used in the classification of soils (Fig. 1).