F2. Material non-linearities

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In geotechnics, it is very rare to be able to study a structure exclusively using linear behavior assumptions (except for certain dynamic analyses). It may be useful to first perform a linear calculation, to check that the geometry and boundary conditions are correct and get a preliminary idea of the deformation that the loading may cause. Nevertheless, the results should be put in perspective as they can be completely wrong in some cases: for an excavation in front of a cast wall for example, the kinematics calculated with linear behavior are clearly different from the one observed.

1. **Constitutive laws**

Even when limited to cases that are perfectly saturated or perfectly dry, the behavior of soils is complex. In practice, elastoplastic models are most often used, which give a force-displacement relationship that is non-linear but independent of time. The effects of creep and viscosity can be considered for particular applications when required - and if the corresponding parameters can be obtained experimentally - but the use of such models remains limited.

Among the elastoplastic models, perfectly plastic linear elastic models are still most often used (see the survey cited by Gilleron, 2016). The use of non-linear elastic models associated with one or more plastic collapsible mechanisms is gradually becoming widespread, particularly under the influence of software developers: in some cases, they give results that are much more representative of reality (for example, for excavation in front of a molded wall), but the influence of each parameter of the models is not necessarily well controlled. Generally, the choice of a constitutive model for soils must consider the objectives set for the calculation, the type of structure (and the type of stress to which the soil will be subjected), the level of precision of the available reconnaissance and laboratory tests.

2. **Initial state**

For non-linear models, the stiffness of the material depends on the initial state of the stresses in the studied soil mass (and possibly other parameters, such as strain-hardening or damage). Therefore, the determination of the initial stresses has a decisive influence on the results. Unfortunately, the initial stresses are generally evaluated in a very simple way: they are either assimilated to a "geostatic" stress field (for a solid with a horizontal surface), or obtained by applying gravity to the whole mesh from a state of zero stress. These processes are relatively poor compared to the complexity of the rheological models used for soils. However, they remain unavoidable in practice, for lack of a better way of estimating initial stresses in the soil.

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