Influence of contact phenomena on structure-subsoil interaction: finite elements method analysis

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Summary.The analysis of deformation of geotechnical structures is formulated by using 3D elasto-viscoplastic relationships incorporating pore pressure. Finite element implementation is then performed for both, contact and structure. Solid isoparametric elements are developed. Contacts elements with zero thickness are also carefully developed, allowing for pore pressure in slip and stick range. The novelty of the contribution consists of using elasto-viscoplastic model incorporating pore pressure for 3D contact. Using implemented spatial elements in the program HYDRO-GEO elasto-viscoplastic analysis of interaction between structure and subsoil was carried out. Earth dam alongside with concrete weir and excursion trough in one of Polish earth dams (Dobczyce) was analyzed. Simulation of deformation of structure and slide of soil on surface of the retaining wall was studied.

Introduction

Phenomenon of contact is very important in variety of engineering problems. In cases where significant differences of material properties of structure and subsoil occur serious problems in theoretical and numerical modeling of interaction between the structure and subsoil exist. In geomechanics very often we meet such problems, e.g. piles, geo-fibers reinforcement of soil, links of weak soil layer, retaining walls, etc. Some group of structure-subsoil interaction problems can be successfully modeled as 2D phenomenon. There are these for which appropriate modeling simplification can be assumed. However there is a group of problems, which requires full 3D modeling e.g. slip on a corner of structure, lack of domination of one of dimension of the structure, etc.

To be able to model the response to loading of spatial object taking into account contact, there is a necessity to use finite element method and introduce special elements called contact elements. The last describe the contact zone between solid elements and allow modeling various effects in this zone.

Aim of investigation

The goal of this study was to examine both from theoretical and numerical point of view the influence of contact phenomena on structure-subsoil interaction. The numerical analysis was carried out by using finite element methods including spatial contact elements with zero thickness. 3D formulation of the interacting structure with subsoil was developed. The program HYDRO-GEO enables to perform numerical calculations of the considered complex contact problem in the 3D case. The paper can be divided into two essential parts.

Discretization

The first part is concerned with discretized 3D description of basic relationships by using the finite element method. To do this 3D solid isoparametric elements were introduced. Pore pressure was taken into account. Spatial contact finite elements were developed and incorporated into the program. These elements cover elasto-viscoplastic contact behavior and take into account pore pressure, slip and stick range.

Numerical part

In this part of the paper the developed discrete model was implemented into the computer program HYDRO-GEO. Then the elasto-viscoplastic interaction between structure and subsoil can be analyzed. A complex system consisting of the earth dam and concrete weir was studied (one of Polish earth dams in Dobczyce). Geometrical model of this system is presented on Figs. 1-2

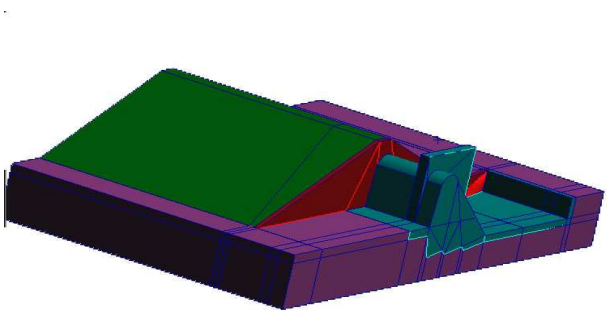

Figure 1 View of the dam from upper water

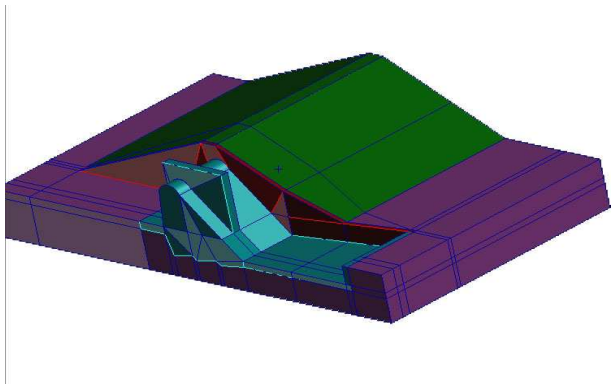

Figure 2 View of the dam from bottom water

On this engineering example the simulation of deformation of the structure and slide of soil on the surface of retaining wall was presented. The obtained results are depicted below on figure from post-processor.

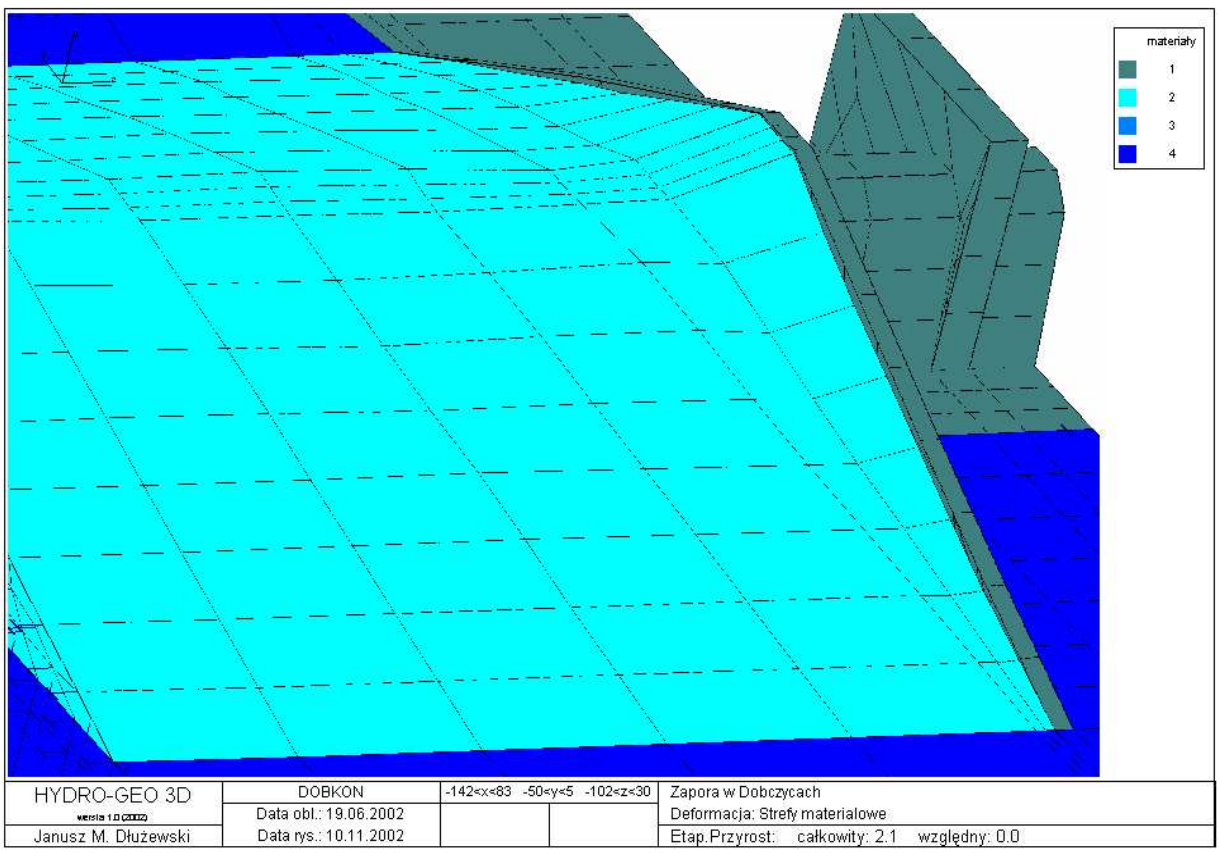

Figure 3 Slide on the surface of contact between the retaining wall and earth dam

Final remarks

Using elasto-viscoplastic model incorporating pore pressure for 3D contact gives new possibilities in comparison to classical elasto-plastic models. Taking into account pore pressure can significantly change the results. A nice feature of this model is that even for nonassociative flow rule we get symmetric stiffness matrix.

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