11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

NUMERICAL MULTISCALE MODELLING OF HYDROPHOBIZED SAND USING MINIMAL KINEMATIC BOUNDARY CONDITIONS PROCEDURE OF HOMOGENISATION

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Key Words: *Multiscale Modelling, Hydrophobized Sand, Minimal Kinematic Boundary Conditions Method.*

Hydrophobization is defined as a process of modification of properties of material aimed to increase resistance against the penetration of water. Usually it affects surfaces of concrete, masonry, plaster or other building materials by means of emulsions based on silanes and siloxanes. In the paper we present a numerical model of sands that are hydrophobized in the whole volume by alkoxysilane emulsions, using a novel technology of hydrophobization, recently developed [3], [2]. We theoretically predict effectiveness of the hydrophobization process and properties of te hydrophobized sand.
The legitimacy of applications of hydrophobized sands in geotechnics will be confirmed best if it would be proved, that the hydrophobization process doesn't have negative influence on theirs mechanical strength properties and compactibility. Experiments shows that the value of filtration coefficient depends on the level of hydraulic head of the water in the domain occupied by the sand. Namely, the value of the velocity of the filtraiting water rises after a specific treshold, different for each granular composition. This treshold is called a perforation pressure pp and is related to the percolation prcess in the medium under sufficiently high hydraulic head.
In the numerical analysis, the hydrophobized sand is treated as a three-phase medium, in which the behaviour of water in pores is governed by negative wetting angle at the iterface water - solid (as illustrated in Figure 1).

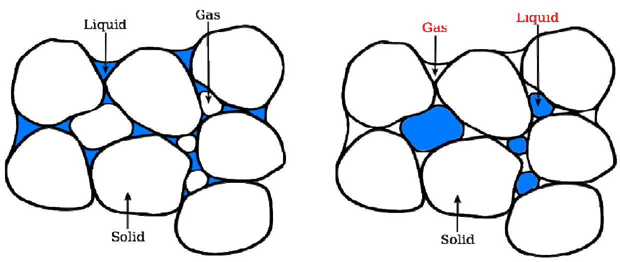

Figure 1. Representative elementary volume (REV) for usual and hydrophobized sand

Such a material shows unusual behaviour, for example – the presence of water does not causes any increase of cohesion. Because of the obvious scale separation between structural levels, a suitable homogenisation procedure must be applied to discover the properties (permeability, cohesion, angle of internal friction) of an equivalent material at the macro scale. In this paper we apply the minimal kinematic boundary conditions (MKBC) procedure of homogenisation (see [1]). This procedure is rarely used jet. It is adapted to the two scale modelling scheme in the paper. This approach is basing on the analysis of representative elementary volume (REV) in which, by means of Lagrange multipliers, mean strains and flux are imposed. These Lagrange multipliers are treated as mean, unknown stress and gradiennt of hydraulic head. The boundary condition for micro-scale are limited here to the necessery set that eliminates rigid motions. The resulting algorithm is simple and numerically efficient. We discuss the advantages and disadvantages of MKBC methods. Since any special hypothesis concerning the microstructure is required, the method is sutable for disordered media like soils We highlight that the local and global problems are naturally coupled “in both directions” (this is not a case for traditional formulation basing on asymptotic homogenization). This coupling is crucial for mechanics of large deformation, soft soils, soils consolidation and others problems, in which material properties evolve during the loading process.

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