Discrete-element modelling of the mechanical behaviour of non-woven geotextiles subject to puncture loading

Discipline: modelling in geomechanics

Research thematic: geosynthetics

Description of the hosting institute

The PhD student will associate to the HBAN research unit in Irstea Antony of which one of its research topics focuses on the behaviour on short term (resistance) and long term (durability) of geosynthetics in geotechnical structures. The HBAN research unit is equipped with technical means to characterize the physicals properties of geosynthetics and study their hydraulic and mechanical behaviour.

The PhD student will have strong links with the ETNA research unit in Irstea Grenoble which develop engineering tools for preventing natural hazard in mountainous areas and with the OHAX research unit in Irstea Aix-en-Provence which develop global approaches for geotechnical structures auscultation and diagnosis tools for their safety assessment.

Description of the thesis subject

The geomembrane lining systems are complex systems that associate granular layers and geosynthetics. These systems enable to combine both drainage and barrier functions. Geomembrane lining systems are key component of some hydraulic structures (e.g. high-altitude dams) or some structures for environmental protection (e.g. landfill). Indeed, the sealing system durability is necessary for the integrity of the structure because any breakage in the sealing could induce significant consequences for public health, safety and goods.

In lining systems, sealing is ensured by a geomembrane that can be made with various polymeric compositions. Drainage function that can be required below and above geomembrane is generally ensured by a granular layer. In most cases, a vertical stress acts on the whole lining system. For instance, this stress or pressure is due the overlying water column weight in the case of high-altitude dams or due to the overlying waste column weight in the case of landfills. This stress induces puncturing actions that can induce localized failures in the sealing system. A geotextile can be used to protect geomembrane against puncturing actions. This geotextile is in most cases a non-woven needle-punched product that can have various physical parameters: nature, diameter and length of fibers, thickness and mass per unit area of the layer, etc. Moreover, depending of the manufacturer, various needle-punching techniques and physic-chemical treatment provide various mechanical characteristics to the products (elastic compression and bending modulus for example).

To ensure the durability of the structures that include lining system, the design of geotextile is a major issue. This thesis study aims to investigate by numerical modelling the needle-punched geotextile mechanical behaviour subject to puncturing actions, which is the core of the matter. A challenge is to explicitly take into account the geotextile microstructure and its evolution. Numerical modelling will be implemented by the discrete elements method (DEM). An experimental work is planned to set boundaries for new numerical models. This thesis will enable to define and justify the design rules of geomembrane lining systems that are essential organ for structures safety.

Framework of the thesis

Contract period: 36 months from 2015 November to 2018 end of October.

Workplace: Irstea Grenoble in the first part of the thesis (18 months) for the good learning of Yade software and Irstea Antony in the second part of the thesis.

Doctoral school: IMEP2, N°510 (Grenoble)

Expected profile and requirements for the position:

Master of research or graduate in geotechnical engineering – civil engineering - materials science. The candidate is expected to have strong knowledge in mechanical behaviour of geomaterials. A training course in numerical modelling in a research laboratory will be profitable.

Expected skills: motivation for research work, faculty for working independently and in a team, capability to formulate concepts, curiosity, constructive criticism, patience, perseverance and scientific rigour.

Good level in English.

Keywords: geomembrane, geotextile, discrete elements modelling, Yade software.

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