The Position of Geotechnical Engineering and Risk Management in Dutch Higher Education

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Abstract. As part of the Dutch national research program GeoImpuls an inventory has been made of the state of the education at Dutch institutes of higher education and post-graduate education in so far as this education concerns geotechnical engineering and geotechnical risk management. Significant differences have been found in the amount of time allotted and detailed technical knowledge taught at different levels and different institutes. Given the limited technical background and limited knowledge of GeoRM for most civil engineering graduates, a split is perceived between the actual and necessary skill set of starting engineers. The impact of this split is discussed in light of international standards for professional engineers.

Keywords. Geotechnical education, geo-risk management

1. Introduction

The goal of GeoImpuls, a Dutch national research initiative, is to halve the amount of geotechnical failures occurring in the building sector between 2009 and 2015. As part of this initiative, a number of working groups have looked at various aspects of geotechnical risk management (GeoRM), to what extent GeoRM is already introduced in daily engineering practice and what improvements can be made (Van Staveren, 2012). One of these working groups focused on the role of higher education. The Authors are all members of this working group.

At the start we identified two possible problems: the sector asserts that the number of graduates with a geotechnical background entering the job market is too low and the sector is increasingly vocal about a perceived split between the knowledge and competencies of recent graduates on the one hand and the demands of increasingly complex projects on the other hand. We set out to substantiate these claims, to make an inventory of the state of geotechnical higher education at graduate and post-graduate level, and to make recommendations to reduce the competencies split. To that end we compare the level of Dutch higher geotechnical education in the light of (proposed) standards for professional geotechnical engineers from neighboring countries.

2. Inventory of Geotechnical Educational Programmes

The inventory of existing geotechnical educational programmes has been made initially in 2011 based on available programme descriptions and study guides for either the academic year 2010-2011 or 2011-2012. In 2013 an update of the inventory has been made based on program descriptions from that year, although this did not lead to significant changes. As only two institutes in the Netherlands have been identified offering any geotechnical education at MSc level, the inventory has been extended to include two Flemish (Belgian) universities with a civil engineering or geotechnical education programme.

A division has been made in polytech programmes, leading to a BSc degree, university programmes, leading to a MSc degree, and (commercial) post-graduate courses. As a result, civil engineering and earth sciences programmes from the following institutes have been reviewed: polytech) Avans Hogeschool, Haagse
Hogeschool, Hanzehogeschool Groningen, Hogeschool Amsterdam, Hogeschool Rotterdam, Hogeschool Utrecht, Hogeschool Zeeland, Windesheim Zwolle, Hogeschool Inholland, NHL Hogeschool Leeuwarden, Saxion Hogeschool; university) TU Delft, TU Twente, Universiteit van Gent, Universiteit van Leuven; post-graduate) Reed Business CGF-1 and CGF-2 courses, PAO post-academic courses, Deltares academy.

For each of these programmes, a detailed inventory has been made of the time allocated to courses dealing with geomechanics, geotechnical and foundation engineering, underground construction or geo-risk management, see WG12 (2014) for full details. When only part of a course is dedicated to one of these topics, only a proportional number of hours or EC (1EC = approx. 28 hours of study load) has been counted. The remaining time has been inventoried in a number of broad categories: mathematics, fundamental physics & mechanics, general civil engineering, general skills & communication, project based education, thesis work and free electives. Where clearly defined geotechnical specialization programmes exist, the inventory includes both a minimal and maximal option. For example, TU Delft offers a Geo-Engineering specialization in the civil engineering MSc programme, see Ngan-Tillard et al. (2012) for details. Students that take this programme follow around 90 EC of geo-engineering related courses in BSc and MSc combined, whereas students that take a different MSc specialization may follow only 10EC of geo-engineering specific courses, mainly during their BSc programme.

Secondly, for each of the programmes and specializations the average number of graduates over the 2002-2011 period has been counted (the Belgian university programs have been excluded from this count). This shows that on average yearly around 720 students enter the Dutch market with a civil engineering or applied earth sciences degree, see Figures 1 and 2, based on the assumption that all MSc graduates have first finished a BSc degree. This number can be split in circa 410 BSc and 310 MSc students per year. An estimated breakdown of the study load per student will be presented below.

Next to university and polytechs, the three post-graduate institutes offer a number of courses. The Reed Business courses attract the largest group of students, as these teach basic geotechnical design methods and are targeted at BSc graduates who enter a geo-engineering profession and MSc graduates who completed a non geo-engineering specialization. The 4 EC basic course attracts some 50 students each year, the 4 EC follow up course between 50 and 100. The other post-graduate courses are more focused on specific topics and mostly targeted at experienced engineers. The various courses combined attract on average 274 participants, for an equivalent study load of 3 EC.

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3. Geo-engineering Specific Content of the Educational Programmes

In order to get an estimate of the course load that each student receives in each programme, the amount of geo-engineering related courses and mathematics, fundamental physics and mechanics courses that a student can maximally select in each BSc programme has been plotted in Figure 3. The remainder of the study load is taken by general civil engineering topics, general skill and project based education. As this is the maximum that a student can select, it is clear that
Most BSc students have received little training on geotechnical engineering. Moreover, not all students will elect to take all geo-engineering related courses. A further breakdown of the geo-engineering specific content is given in Figures 4 and 5. For the polytech programmes, the courses in the first and second year are obligatory and we assume that all students have followed these courses. The remaining courses (up to maximal load) are electives and our estimate is that 10% of all students take these courses. For the university programmes a division has been made in a minimal course load for all students; a maximal load that students that select a geo-engineering specific programme can follow; and the thesis work. We further assume that MSc graduates with a specific geo-engineering thesis topic took the maximum course load, and all others took the minimum. Using these assumptions, the total geo-engineering study load that each student followed is assessed and plotted in Figure 6.

Three out of four students have followed between 3 and 10 EC of geo-engineering specific courses during their entire education, equivalent to 80 to 280 hours of total study load. Only 18 students (2.5% of the graduates) have spent more than 20 EC (560 hours), of which the 12 students that followed the TU Delft Geo-Engineering specialization stand out with around 90 EC.

4. Geo-engineering Specific Content of the Educational Programmes

These numbers make it clear that most graduates have had little geo-engineering specific content in their study and the limited amount of postgraduate courses taken does not significantly change this. Atkinson (2012) recognizes the same issue in the UK and identifies 7 skill groups that geotechnical engineers should have prior to specialization: basic skill (writing & mathematics), material behavior and properties, site investigation & characterization, groundwater mechanics, slope and wall stability, foundation design, (road) embankment construction. He notes that in most cases students

![Figure 3. Maximal percentage of mathematics, physics & mechanics and geo-engineering related courses in the various BSc programmes.](image)

![Figure 4. Number EC of minimal and maximal geo-engineering related study load for the polytech BSc programmes.](image)

![Figure 5. Number EC of minimal and maximal geo-engineering related study load for the university BSc and MSc (BSc+MSc combined) programmes.](image)

![Figure 6. Number of graduates with their geo-engineering related study load (based on BSc program for BSc graduates, on BSc+MSc for MSc graduates).](image)
have been instructed in the basic skills, material behavior and properties, the basics of groundwater mechanics and got an introduction to site investigation. The remainder of the skill should be obtained through post-graduate courses or experience in the first 5 years of their career and prior to further specialization.

Atkinson (2012) does not specify an exact study load for these subjects, something that the Arbeitskreises AK 2.11 der Fachsektion Erd- und Grundbau der Deutschen Gesellschaft für Geotechnik e.V. (AK 2.11, 2013) does. They recommend a minimum curriculum of 100 EC, split in 30 EC mathematics and physics, 30 EC civil engineering, geology and general geotechnics and 40 EC specialized geo-engineering. Depending on the level of education, project complexity and impact, they require 2 to 7 years of subsequent experience.

From the Figures above and the split over the various specific topics, shown in Figure 7, it is clear that most Dutch graduates do only get an introduction to a sub-set of the required skills listed by Atkinson (2012) and do not even get near the 60 EC in fundamentals and basic geo-engineering courses required by AK 2.11 (2013).

5. Conclusions

This inventory of Dutch higher education identifies a generally low study load on geo-engineering specific topics, even for students that selected all possible geo-engineering courses in their study. Only the TU Delft geo-engineering MSc is an exception and would meet the requirements as set by AK 211 (2012). The limited amount of post-graduate education actually taken on an average yearly basis seems inadequate to increase the formal education for most students to this requirement within the first 5 years. Although work experience will increase the competency of young engineers, there is currently no system to impartially record this.

It is the view of the Authors that the possibility of a lack of geotechnical education in and/or the lack of basic knowledge of GeoRM should explicitly be taken into account when assessing possible risks in (large) geotechnical projects. A clear system of identifying the educational level and experience of (geotechnical) engineers would be beneficial when assessing such risks.

References

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