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ENGINEERING GEOLOGY AND GEOTECHNICS IN CIVIL ENGINEERING

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Abstract: Optimization and reliability of civil engineering and mining generates the need for more and more specified data about the ground-water environment and forecasts of possible changes. This article presents the meaning, scope (boundaries) and the competence of engineering geology and geotechnics in historical, formal and practical (real) terms. Three groups of views are presented concerning the relation between engineering geology and geotechnics, their place and relationship against the background of other disciplines. It has been noted that ranking of criteria and competencies of engineering geology and geotechnics still remains unresolved.

1. HISTORICAL ASPECT

The concept of *engineering geology* has been known since the nineteenth century, and the term *geotechnics* (*geotechnique*, *geotechnical engineering*) appeared only in the twentieth century. The first to introduce the term engineering geology was the Englishman William Smith (1769–1839). He was regarded as the "father of engineering geology" [1], [3], [4], [6], [9].

Information about the relationship between civil engineering and geology can be gathered from many historical sources. White [15] shows that geological knowledge was appreciated and used by such masters as Marcus Vitruvius Polio (1st century BC), Leonardo da Vinci (the turn of the 15th and 16th centuries) and William Smith (the turn of the 18th and 19th centuries) [17]. Zekkos et al. [18] indicate that already in the works of Homer (8th century BC) appeared the names of geological and geotechnical engineering works. However, the year 1880 is considered as the beginning of modern engineering geology. This year, in England, there appeared the very first printed manual "Engineering Geology", by William Henry Penning [10].

Engineering geology was separated from geology as an independent field, inspired by "explosion" in the construction industry in the nineteenth century: railways, steel mills, mines, factories, roads, bridges, tunnels, dams, power lines, etc. Construction engineers at least since the eighteenth century felt the need for a theoretical description of the cooperation of foundation and ground. There is a big merit in this field due to: Coulomb (1773), Rankine (1857), Boussinesq (1855), Pauker (1856), Mohr (1882), Kurdiumov (1889), Prandtl (1920), and many others [16].

However, Terzaghi is considered to be the creator of modern soil mechanics. In 1925, in the book "Erdbaumechanik auf bodenphysikalischer Grundlagen" [14] he showed that external ground reaction forces can be identified by number. For the theory to be successfully applied in practice it is necessary to introduce appropriate theoretical models and simplifications, depending on the characteristics of soil. This way of analyzing the interaction between the ground and the foundation immediately aroused great interest and inspired the development of new fields of engineering knowledge – *soil mechanics*.

During Terzaghi's lifetime, about 30 000 scientific publications appeared, including at least 1000 monographs and soil mechanics textbooks [8]. In parallel with the development of theories, a lot of energy was used in technology of research focused on soil in the laboratory and in the field. Owing to the new research technology, especially the laboratory one, there is the possibility of determining and measuring certain properties of soils. This field of knowledge is called *soil behavior* [12], [13], [16], [17]. The soil behavior was closely related to the *soil mechanics*, and later it became a part of it. In this way, both soil behavior and soil mechanics have become components of engineering geology.

The more geological-engineering work had been performed, the greater was the need to exchange ideas and experiences. In the United States, in 1888 "Engineering Geology Division" was established at the Geological Society of America [7]. In 1964, during the 22 International Geological Congress in New Delhi the International Association of Engineering Geology (IAEG) was set up. First International Congress IAEG was held in Paris in 1970 [7].

Table 1

Important events in the early development of the fields of engineering geology and geotechnics

Important events in history	
Engineering geology	Geotechnics
1888 – Engineering Geology Division was established at the Geological Society of America in the United States	**Until 1936** – Geotechnics was organized by several national committees (Sweden, France)
1964 – International Association of Engineering Geology (IAEG) was set up during the 22nd International Geological Congress in New Delhi	**1936** – First International Conference on Soil Mechanics and Foundation Engineering (ICSMFE) in Harvard
1970 – First International Congress IAEG in Paris	**1953** – International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) had become firmly established during the third ICSMFE in Switzerland

At the beginning of the twentieth century there were also opinions that engineering geology is not an independent field, but it is an element of the design work. It had been

decided that in order to "consolidate forces" and improve the design of foundations, excavations, embankments and earthen structures, the works including geology, soil mechanics and designing would be treated together and called *geotechnics*. Firstly, geotechnics went to the Nordic countries (Sweden, Norway) and the United Kingdom and Germany [6], then to the United States (geotechnics, geotechnical engineering).

Geotechnics was organized in several national committees (Sweden, France). It was incorporated in the international organization in 1953 during The Third International Conference on Soil Mechanics and Foundation Engineering (ICSMFE) in Switzerland.

Important events of the early development of the fields of engineering geology and geotechnics are given in table 1.

2. RELATION BETWEEN ENGINEERING GEOLOGY AND GEOTECHNICS

Currently, in the language of civil engineering there are two concepts: *engineering geology* and *geotechnics*. In practice, these are often used as alternatives. Engineering geology and geotechnics, as history shows, have the pedigree and the same goal. However, their position in the structure of science, especially in civil engineering is not clearly defined. The field is called the engineering geology or geotechnics depending on the transfer of context and "center of gravity" in the direction of geology or in the direction of technical applications. Depending on the views, geotechnics is considered to be the part of engineering geology [17], or vice versa engineering geology as part of geotechnics [11]. To date, the boundaries between the engineering geology and the geotechnics have not been clearly defined. Therefore, in many situations there is the question of competence between engineering geologists and geotechnical engineers. In addition to the dispute shall be included in "authority" of bureaucracy.

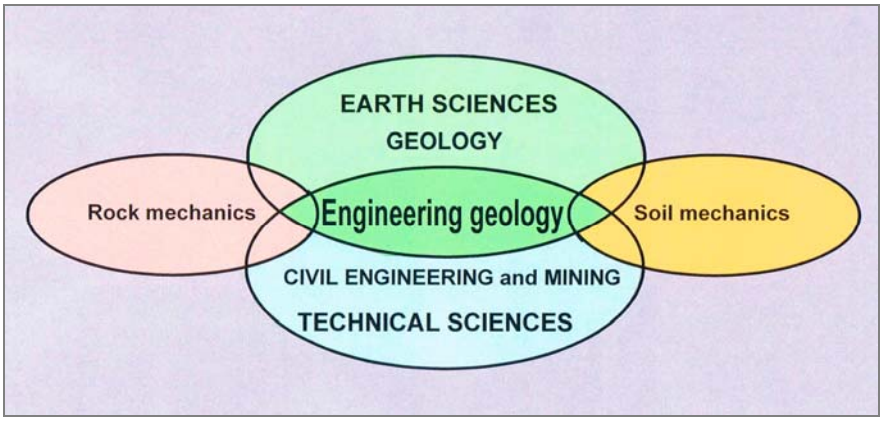

Fig. 1. Engineering geology against the background of other disciplines viewed according to materials of the 7th IAEG Congress [7]

From the historical development, the essence of ***engineering geology*** (in the original meaning) lies in describing the geological environment in terms of needs of civil engineering and ***geotechnics*** – using data of the geological environment in the civil engineering.

Figures 1, 2 and 3 illustrate different approaches to engineering geology and geotechnics, and their place among the related sciences.

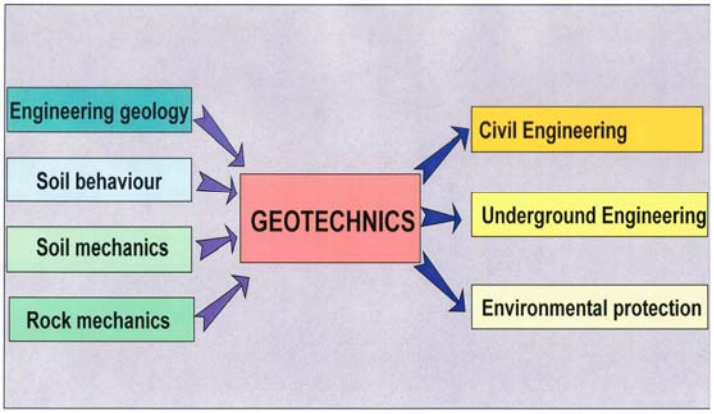

Fig. 2. The relation between geotechnics, engineering geology and construction [5]

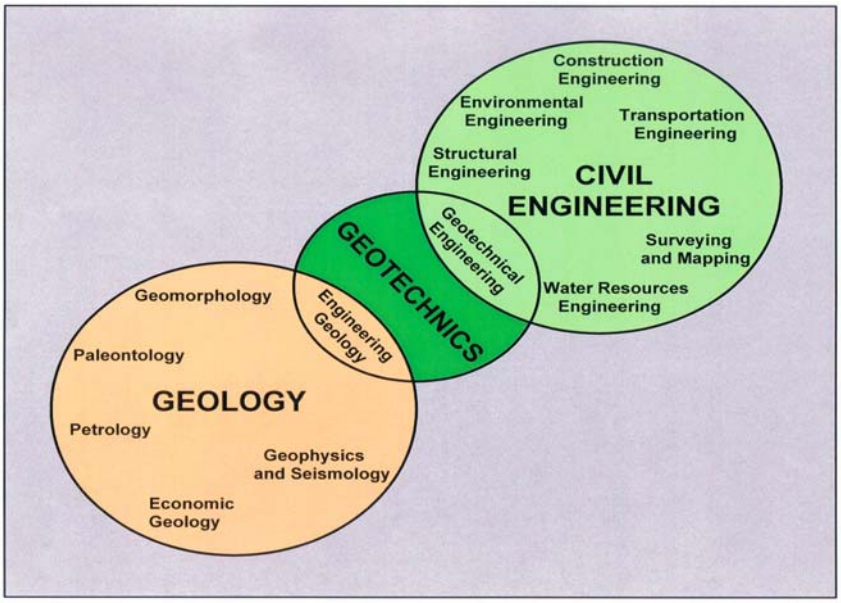

Fig. 3. Geotechnics, geology and civil engineering viewed against the background of other disciplines [2]

Presented above the three general groups of views (figures 1, 2, 3) seem to be clear. However, the ranking of criteria and competencies of engineering geology and geotechnics still remains unresolved.

3. CURRENT SITUATION AND OUTLOOK

As recently observed, the polarization of opinions on the competence in the assessment of geological/geotechnical environment for the purposes of civil engineering, does not serve well for the basic aim of optimizing the design process as well as minimizing the negative impact on the environment.

In Poland, for example, the construction law passes the setting of the geological-engineering/geotechnical conditions for foundation of buildings into the hands of geotechnical engineers. Previously, these cases fell within the competence of engineering geologists. This method refers to the early twentieth century geotechnics. The difference is that at that time engineering geologists and their geology were included in geotechnics. Currently, engineering geology became part of geotechnics but engineering geologists have been left outside for possible use in geotechnics. According to the current law, engineering geologist has the right to recognize engineering-geological environment for regional planning, environmental protection, and in the cases where during the phase of project preparation, it is known that geological conditions are complicated.

The new Polish and European legislation (EUROCODE 7) on the geotechnical design says nothing about the relationship between the scale of projects and competences. It is not known, for example, how to divide the competences during use of the neural network in identification of the characteristics of the geological-engineering environment or in the case of engineering on a global scale. Meanwhile, underground mining already reaching a depth of almost 4 000 m (South Africa), it is planned to execute opencast mines to a depth of 800 m below the surface of the site (mountain Blagodar to the Ural Mountains in Russia). Geological drilling holes reach a depth of over 9 km and it is planned to reach 15 km. Only in Russia from 1917 to 1971 there were established more than 1000 new cities. On a world scale, man moves each year 10 000 km^3 of land masses, as Sergeev said, referring to the data of Riabčikov [12], [13], [19]. The man regularly becomes one of the major exogenous forces shaping the surface of the earth's crust.

4. SUMMARY

Current discussions about the competence and strategy of engineering geology and geotechnics usually end with the argument of the need to be included in the requirements of the European Union, European directives and Eurocodes, etc. In many cases,

the law was drafted so that it can serve for a temporary boom or for the needs of one professional corporation.

The effect of such a policy can be easily foreseen: in the near future, we await further work on the modernization of law in the field of geotechnics and engineering geology.

In this situation, the authors see the need for a comprehensive discussion in international forum about the place and role of engineering geology and geotechnics in civil engineering and mining.

Conclusions from such a discussion will provide the basis for preparing the new law so that it would not disturb the development of engineering geology and geotechnics, and at the same time, for serving civil engineering in a universal sense.

REFERENCES

[1] BALASUDARAM M.S., RAO G.S.M., *History and development of engineering geology*, India Records, GSI, 1972, 104(2), 1–22.
[2] CODUTO D.P., *Geotechnical Engineering*, Prentice-Hall, New Jersey, 1999.
[3] CULSHAW M., REEVES H., WILLIAMS R., ROSE T., REEVES G., CHARMAN J., GRIFFITH S., *Engineering Geology through the centuries*, EGGS AGM&Evening Meeting, 17th June 2008, Burlington House, London, 2008.
[4] GLAZER Z., MALINOWSKI J., *Geologia i geotechnika dla inżynierów budownictwa*, Wydawnictwo Naukowe PWN, Warszawa, 1991.
[5] FORSTER A., REEVERS H.J., *William Smith and development of engineering geology in England*, Quarterly Journ. of Eng. Geol. and Hydrogeol., Vol. 41, No. 2, 2008, 165–170.
[6] HOLTZ R.D., KOVACS W.D., *Introduction à la geotechnique*, Edit. École Polytech. de Montréal, 1992.
[7] KACZYŃSKI R., *Engineering-geological education*, [in:] R. Radaszewski (ed.), *Geologos, Współczesne problemy geologii inżynierskiej w Polsce (Recent problems of engineering geology in Poland)*, Uniwer. im. A. Mickiewicza, Inst. Geol., No. 11, 2007, 71–84.
[8] KISIEL I., LYSIK B., *Zarys reologii gruntów. Działanie obciążenia statycznego na grunt*, Wyd. Arkady, Warszawa, 1966.
[9] KRISHNASWAMY V.S., *History and development of engineering geology and geotechnology in India*, Proc. Intern. Assoc. Eng. Geol., Vol. VIII, 1982, 361–369.
[10] PENNING W.H., *Engineering Geology. Reprint William Henry Penning*, Kessinger Publ. Ed., paperback, 1880.
[11] REUTER F., KLENGEL K.J., PAŠEK J., *Ingenieurgeologie*, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig, 1977.
[12] SERGEEV E.M., *Inzenernaia geologiia*, Izd. Mosk. Univ. Moskva, 1978.
[13] SERGEEV E.M. at al., *Gruntoviedenee*, Izd. Mosk. Univ. Moskva, 1971.
[14] TERZAGHI K., *Erdbaumechanik auf bodenphysikalischer Grundlagen*. F. Deuticke, Leipzig–Wien, 1925.
[15] WHITE G.W., *Essays on History of Geology*, Reprint of essays originally publ. 1951–1976, "Engineering geology in construction of National Road – 1825", Reprint from the "Engineering Geologist: (Eng. Geology Div. of the Geol. Sc. of Amer.), Vol. 1, No. 3, Oct. 1966, 11–14.
[16] WIŁUN Z., *Mechanika gruntów i gruntoznawstwo drogowe*, Wyd. Kom. i Łącz., Warszawa, 1962.

[17] WIŁUN Z., *Zarys geotechniki*, Wyd. Komun. i Łącz., Warszawa, 1987.
[18] ZEKKOS D., ATHANASOPOULOS G., ATHANASOPOULOS A., MANOUSAKIS J., *Element of Engineering Geology and Geotechnical Engineering in the Homeric poems*, Intern. Symp. "Science and Technology in Homeric Epics", [in:] *Ancient Olympia*, Greece, 27–30 Aug., 2006.
[19] ZOLOTARIOV G.S., *Inzenernaia geodinamika*, Izd. Mosk. Univ., Moskva, 1983.