Time Capsule Project:
Finnish Geotechnical Society (SGY)

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Pre – 1930s

Before 1930, Finnish Geotechnical Practice closely followed those of the neighbouring countries, Sweden and Norway, and to a lesser extent, Soviet Union. In the 1920s, new innovations shaped the geotechnical engineering in Finland. For example, the Swedish weight sounding test (Figure 1) found its way to Finland and it still used widely to this date. The Swedish weight sounding test is used to identify soil layers (soft soil versus stiff frictional soil) and for rough assessment of strength and deformation properties via the sounding resistance.

Figure 1 Swedish weight sounding test in the year 1960, photo by Olavi Karasjoki (link to archive page)

One significant event in the 1920s was the funding of a separate geotechnical unit under the national railway agency as a response to the slope failures and other issues facing the railway structures in Finland. This geotechnical unit invested in extensive ground investigations and development of geotechnical calculation methods, which pushed the field of geotechnical engineering in Finland onwards.

The decade of the 1930s

The construction sector in Finland was quiet in the 1930s due to the economic depression. During the last half of the decade the amount of infrastructure construction projects increased, and the first engineering consultancy company, which specialised in geotechnics, was funded by Per Alenius (Tammirinne 2011). In the beginning, the company focused on harbor structures.

In 1938, the first vertical drainage (with sand drains) test structure was constructed on clayey gyttja soil in the city of Helsinki (Tammirinne 2011). Later, vertical drainage test embankments were constructed from time to time, but the method never became common in Finland. However, the method is attracting interest once again as less carbon-intensive ground improvement and foundation methods are under consideration in most larger construction projects.

The decade of the 1940s

One major milestone in the history of geotechnical engineering in Finland occurred in 1948 as the professorship of foundation engineering and soil mechanics was established in the Helsinki University of Technology (Tammirinne 2011). Geologist Thord Benner was granted this professorship, but unfortunately he died shortly after. The professorship was later, after several years, granted to K. V. Helenelund who received his PhD in 1951.

The decade of the 1950s

The Finnish Geotechnical Society (SGY) was funded in the meeting held on January 21st 1951. Professor K.V. Helenelund invited the participants to the meeting. The conclusion of the meeting was that a society needs to be funded, and the participants agreed on a definition for geotechnical engineering: “Geotechnics is an engineering field which investigates the suitability of subsoil and rock for the purposes of building foundation, embankment material, dams, and the related soil and rock properties their artificial enhancement.”

The rules of the SGY were established and they are still in place (https://sgy.fi/in-english/):

The aim of SGY is to act as a non-profit link of professionals working in the field of geotechnical engineering in Finland and to promote and implement the research of the field, and to contribute to the education. To fulfil these aims SGY organizes events and enhances the guidance and publications of the field. The society has co-operation with other organizations of the field.

The decade of the 1960s

The construction works for the underground shopping centre “Asematunneli” and its interconnecting tunnels to Helsinki Central railway station started in 1965 (City of Helsinki 2020). The extend of the construction project was greater than ever seen in Finland, and one of the main challenges was a 15-meter-deep waterproofed excavation (Figure 2). Asematunneli was completed in 1967, and the construction of various underground spaces in Helsinki has not ceased yet.

Figure 2 Excavation for Asematunneli in 1967, photo by Grünberg Constantin ([link to archive photo])

On November 3rd in 1965 a great slope failure occurred at **Kimola floating log canal** in southern Finland (Kankare 1969). In only about five seconds 90,000 m^3 of clay slid into the canal. The length along the canal was 240 m and the width of failure was 80 m (see Figure 3). At the time of failure, the canal had been in its final depth for nine months. The slope failure was preceded by a heavy rainfall. The great failure launched an investigation that concluded that the conventional $\varphi = 0$ method is unreliable if used to calculate the long-term stability of slopes in fat slightly overconsolidated clays. On contrary, the simplified c- φ analysis, based on measured pore pressures, was proven to be quite reliable for the Kimola canal case (Kankare 1969).

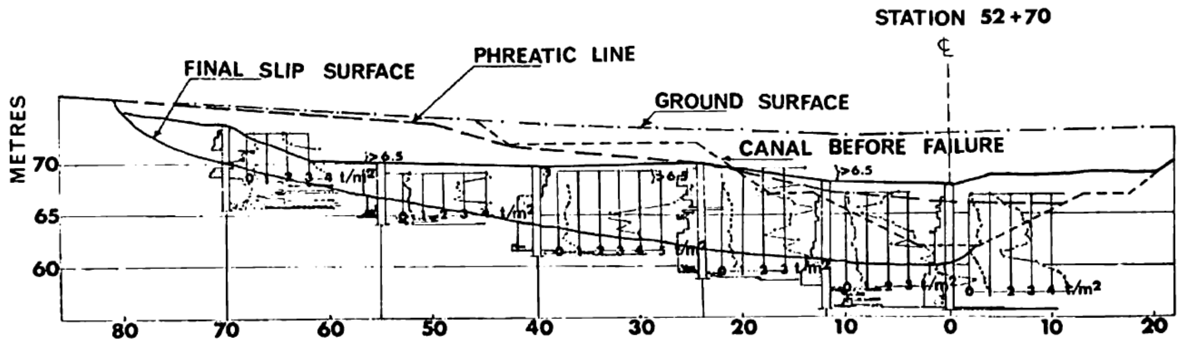

Figure 3 Cross-section from the failure area after the slide at Kimola canal (Kankare 1969).

Another significant canal construction project in the 1960s was the Saimaa canal, that was finished in August 1968 (Tammirinne 2011). The extent of ground investigations for the Saimaa canal was significant, and most geotechnical engineers that were involved in the project describe it as one of the most significant learning experience. The slope design was thoroughly optimized, and therefore local failures were common, although luckily there were no human casualties (Tammirinne 2011). The connection between theory and practice was stronger than usual, as the design office was located right next to the construction site.

The decade of the 1970s

In the beginning of 1970s, new projects were numerous and the work by geotechnical engineers was characterized by new building and infrastructures rather than renovation/repair projects.

A rare tunneling technique, ground-freezing, was used in the construction of Helsinki metro line near the Helsinki Railway square (starting in 1974) in order to pass the clayey fault zone at Kuuvi district (City of Helsinki 2020). Besides Finnish engineers, specialists from London, Leningrad and Gothenburg participated in this unique project (Tammirinne 2011).

The construction of Päijänne tunnel was started in 1973 (Tammirinne 2011): This 120 kilometers long rock tunnel was excavated for the purpose of transporting drinking water from the lake Päijänne to the Helsinki capital region. The cross-section of the tunnel is on average 16 square meters. The most unique sections of the tunnel are 30-120 meters below the ground surface. The tunnel was finalized in the year 1982 and it has been renovated since then. It still provides around one million residents with drinking water. The Päijänne water tunnel is the second longest tunnel in the world (https://en.wikipedia.org/wiki/List_of_longest_tunnels).

In the 1970s, the development of the Finnish sounding method, static dynamic penetration test, started in the geotechnical unit of City of Helsinki (Tammirinne 2011). This sounding method combines the cone penetration test (CPT) and dynamic probing. The CPT is used for soft soils such as clays and silts, and the test is switched to dynamic probing to penetrate frictional soils such as sands, gravels and glacial till. The extension rods are rotated during the static dynamic penetration test in order to decrease rod friction and to maintain straightness. This sounding method is widely used nowadays due to its versatility. The method is used to identify soils layers and to define the suitable depth for end-bearing piles.

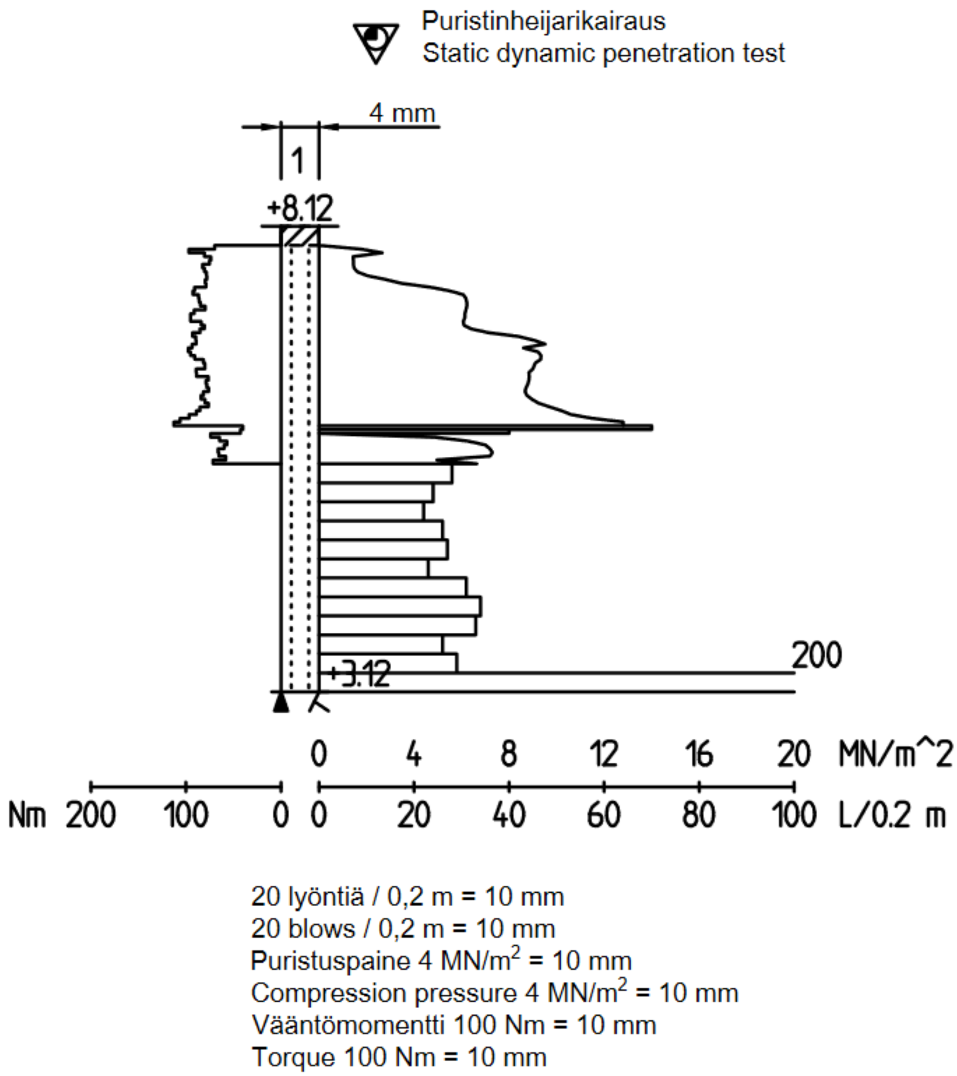

Figure 4 How the measurements of static dynamic penetration test are illustrated (SGY 2021).

The decade of the 1980s

The 1980s was a decade of progress and breakthrough for the deep mixing (i.e. deep stabilization) ground improvement technique in Finland. The development of deep stabilization started in the 1960s in Scandinavia (in Sweden especially) and in Japan. The first test site in Finland with lime columns (column stabilization) was completed in 1974 (Tammirinne 2011), and since then the method has been further developed for the Finnish soft soil conditions. In the 1980s, the dry mixing technique and binder recipes were studied and improved, and as a result, the method used in Finland was more efficient and versatile than in other countries were the column stabilization method had been used (Tammirinne 2011).

In the 1980s, an idea was born about the mass stabilization method with cement-based binder (see Figure 5). This Finnish ground improvement method was further developed in the 1990s. Unlike column stabilization, the mass stabilization could be used for e.g. peat soils and to treat excavated soils (e.g., *Forsman et al.* 2015). The Finnish mass stabilization equipment has been since then exported to Mexico, among other countries.

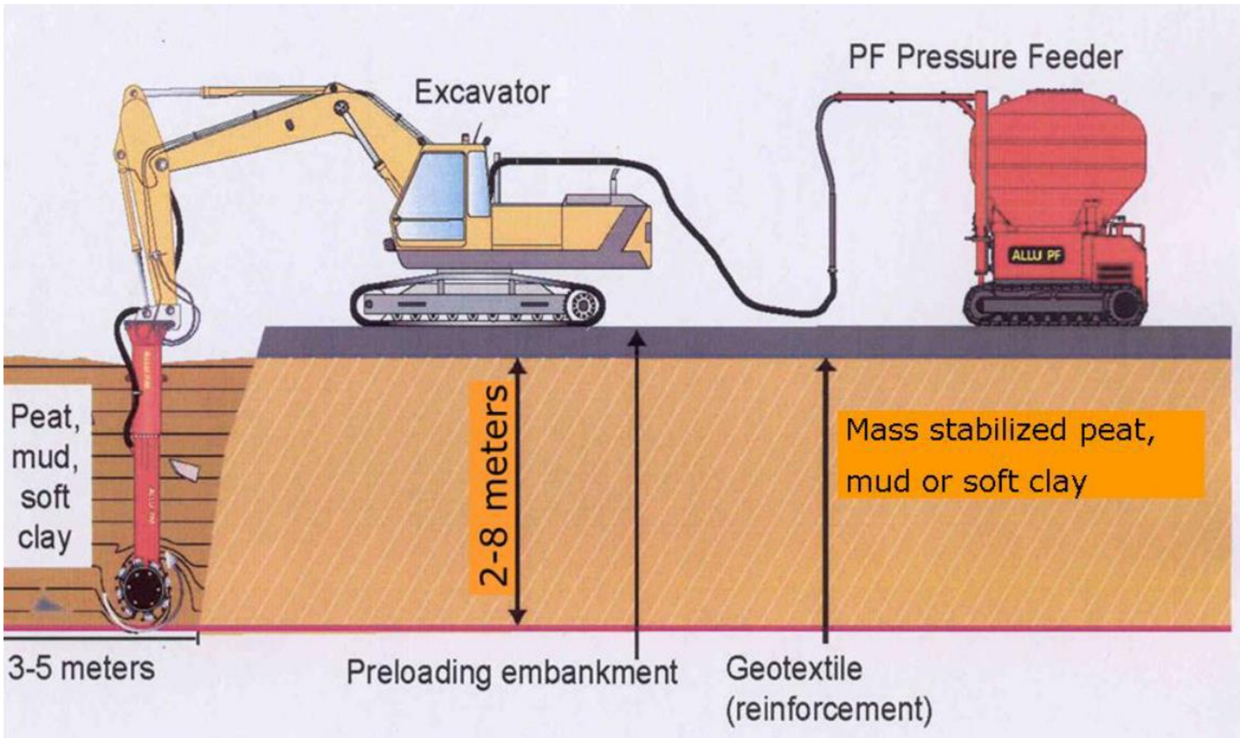

Figure 5 The principle of mass stabilization ground improvement method. Current equipment can reach a depth of 7..8 meters (Forsman et al. 2015).

The decade of the 1990s

In 1991, the first issue of "Geofoor" magazine was published by the SGY. Geofoor is still being published today, although the contents have somewhat evolved. Nowadays the focus is in describing case studies and current megatrends, while the first issues contained rather academic articles. All the Geofoor issues are available to read at https://sgy.fi/toiminta/geofoor-lehti/. Figure 6 shows the cover of the first issue and the 50th issue published in 2020.

GEOFOOR

No. 1/6.8.1991

Toimittanut: Markku Tammirinne

Geotekniikan keskustelu- ja tiedotusfoorumi

SGY:n 40-vuotisjuhlaseminaarissa Jouko Törnqvist kaipasi ja myös lupaili geotekniikan alan keskustelufoorumin avaamista SGY:n jäsenkunnalle ja muillekin geotekniikasta kiinnostuneille henkilöille ja tahoille. Alkuaan Joukon esittämä ajatus "tiedotuslehtisen" aikaansaamisesta on peräisin VTT:n geotekniikan (nykyisin tie-, geo- ja liikennetekniikan) laboratorion sisällä käydyistä tutkimus- ja kehitystoiminnasta tiedottamista koskeneista keskusteluista. Em. keskusteluissa mukana olleena lupauduin käynnistämään tälläisen toiminnan. Ja tässä se ensimmäinen "numero" tulee ja samalla avataan maailman ensimmäinen GEOFOOR Suomessa.

Kutsuttakoon tätä (ensimmästäkin) painotuotetta lehdeksi, vaikka se ei vielä eikä ilmeisesti tulevaisuudessakaan täytä kaikkia lehden tunnusmerkkejä. Lehteä kehitetään sen mukaan, minkä vastaanoton se saa lukija- ja avustajakunnalta. GEOFOOR kehittyy tai lakastuu sitä käyttävien aktiivisuuden mukaisesti.

GEOFOOR tarjoaa jokaiselle jotakin

GEOFOOR on avoin kaikille ja kaikenlaisille kirjoituksille ja mielipiteille, kunhan ne vain liittyvät (edes löyhästi) geotekniikkaan. Jokainen numero tulee varmaankin olemaan sisällöltään erilainen. Sisältö tulee riippumaan hyvin suuresti siitä, mitä aineistoa toimittajalle lähetetään. GEOFOOR ei ole minkään tahon virallinen äänenkannattaja. Ei edes SGY:n, vaikka se jaetaankin (käytännöllisistä syistä) SGY:n jäsenkirjeiden mukana. Mielipidekirjoituksissa kaivataan jonkinmoista poleemisuutta, jotta mielipiteenvaihtoa todella saataisiin aikaan. Lehti-nimestään huolimatta siinä ei yleensä julkaista teknis-tieteellisiä artikkeleita. Niille on olemassa julkaisufoorumeita varsinaisissa aikauslehdissä. GEOFOOR'ista ei ole tarkoitus muodostaa myöskään edes piilomainosfoorumia.

Miten GEOFOOR toimii

Toistaiseksi GEOFOOR:iin tarkoitetut kirjoitukset tulee toimittaa SGY:n sihteerille (osoitetiedot toisaalla lehdessä). Kirjoitusten tulee olla lyhyehköjä ja ne toivotaan valmiiksi koneella kirjoitettuina tai levykkeellä ASCII-muodossa, jolloin ne on mahdollista tulostaa lehden edellyttämään asuun toimituksessa. Toimitus ottaa mielellään vastaan myös vihjeitä ja ehdotuksia lehdessä käsiteltäviksi asioiksi. Näitä aiheita pyritään toteuttamaan kulloinkin käytettävissä olevien resurssien mukaisesti.

GEOFOOR ilmestyy epäsäännöllisesti, vaikkakin tiettyyn säännöllisyyteen pyritään. Tavoitteena on 3-5 numeron vuosittainen ilmestymistiheys.

Lehdessä voisi olla esim. seuraavan tapaisia pysyvähköjä palstanimikkeitä:
- luettua/saksittua (kirjat/raportit/artikkelit),
- tapahtumia (olleita/tulevia),
- mielipiteitä (kysymyksiä/kannanottoja/vastauksia),
- tätä tutkitaan (isoja tai pieniä hankkeita/tuloksia, havaintoja)
- uutuuksia (laitteet/menetelmät).

Jos sinulla on mielessä jotain, jonka haluaisit myös muiden tietoon tai sinua askarruttaa joku muitakin mahdollisesti kiinnostava asia, niin ota yhteys GEOFOOR'iin.

Figure 6 First issue of Geofoor from 1991 (on the left) and the 50th issue published in 2020.

During the 1990s, the economic depression heavily shapes the construction sector and field of geotechnical engineering in Finland. Many geotechnical engineers are forced to move into other sectors as the field is suffering from lay-offs and unemployment. Consequently, the number of civil engineer graduates reduced by over 50 % during the 1990s (gray columns in Figure 7), which contributed to the lack of geotechnical engineers faced by the sector today.

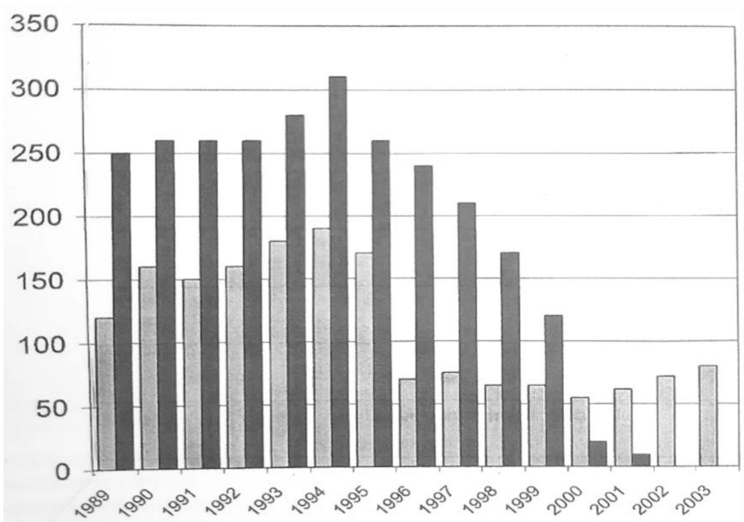

Figure 7 Civil engineer graduates (gray columns) and technician graduates (black columns) in Finland (figure by R. Rasmus /TAMK, published in Tammirinne 2011).

The decade of the 2000s

The construction sector has recovered and the job aspects for geotechnical engineers have become better. The decade of 2000s is marked with urbanization and the increasing need to construct on soft soil sites, as all the stiff subsoil or rock sites have already been used in city areas. New residential areas are constructed at soft clay/gyttja sites that used to be fields and to peat-rich natural areas. Due to challenging subsoil conditions, geotechnical design and foundation engineering has a significant impact on the construction costs.

Soil stabilization (deep mixing) is increasingly used as a soil improvement method to avoid excessive settlements of roads, streets and yard areas, for example. Compared to the amount of column stabilization and mass stabilization in Finland during the year 2000, the amounts approximately doubled by 2010 (Figure 8). Deep mixing with lime-cement has become the routine ground improvement method in both building and infrastructure sectors, although the high carbon footprint of lime-cement forces the field to consider alternative binder materials (e.g., ashes and other industrial side streams).

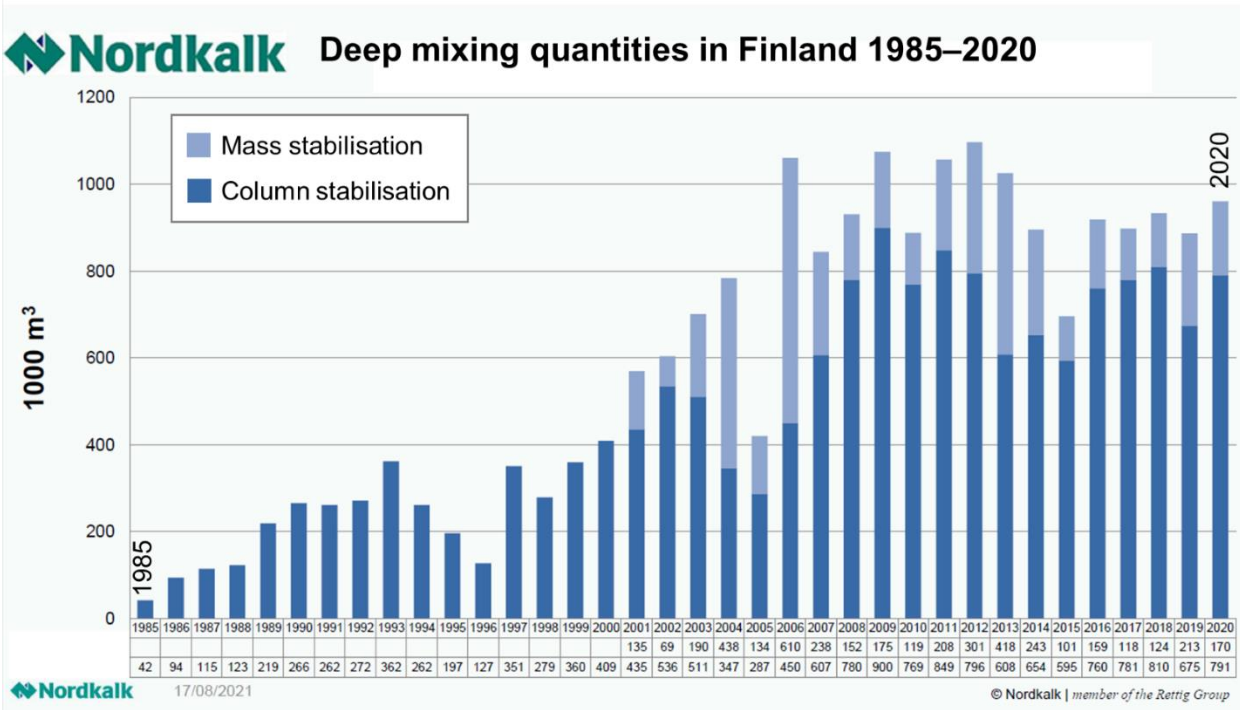

Figure 8 The amount of deep mixing in Finland (modified after Kuusipuro 2021).

As the soft clays continue to pose challenges, the academic research in Finland is increasingly focusing on constitutive modelling. Anisotropic soil models such as S-CLAY1 (Figure 9) ja S-CLAY1S (see e.g. Koskinen 2014) are being developed at the Helsinki University of Technology (now Aalto University). The research is supported by comprehensive experimental research (laboratory tests on soft Finnish clays) conducted at the soil laboratory since the 1980s.

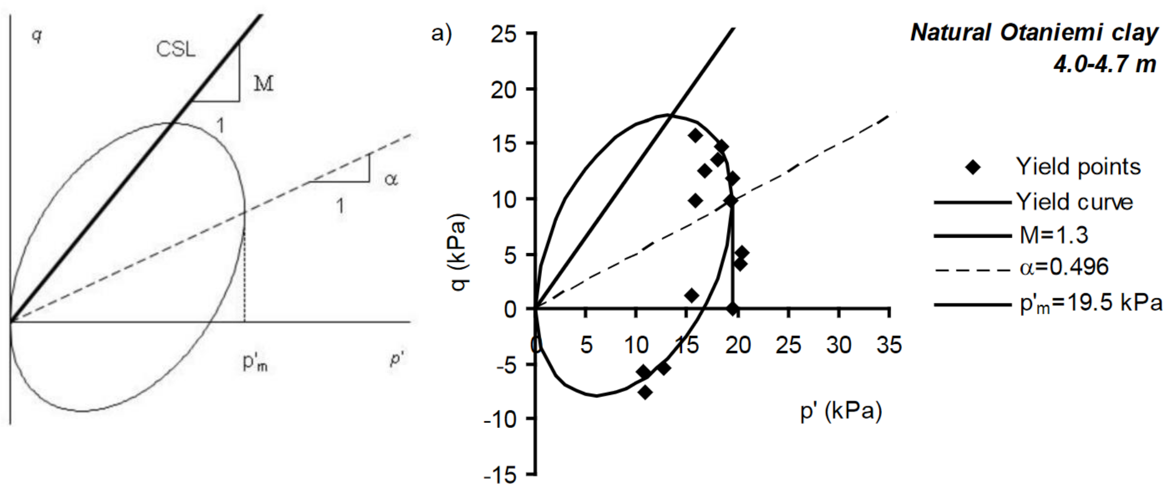

Figure 9 Yield surface in the S-CLAY1 model (left) and observed yield points for Finnish soft clay (right) (Koskinen 2014).

The stability of some existing railway embankments on soft soils is raising concern and being investigated at the Tampere University of Technology (now Tampere University). In 2009, a full-scale failure test was performed for a railway embankment on soft and sensitive Perniö clay by Tampere University of Technology and Finnish Transport Agency (see e.g. Lehtonen *et al.* 2015). The subsoil was loaded until failure by means of containers filled with sand, on railway tracks (Figure 10). The experiment was extensively instrumented, and the monitoring data has been shared open access (http://urn.fi/urn:nbn:fi:csc-kata20150507094517328502). The moment of failure was also filmed, and the video has been shared via YouTube (see https://www.youtube.com/watch?v=oS77DPw_SYQ)

Figure 10 Full-scale failure test at Perniö, Salo. Containers were filled with sand (Lehtonen 2011).

The decade of the 2010s

In 2011, the Finnish Geotechnical Society (SGY) published the book "Ojakoinnista geotekniikan osaajiksi" (Tammirinne 2011) to celebrate the 60 years anniversary of SGY (Figure 11). This book describes not only the history of the society but the developments of geotechnical engineering in Finland since the beginning of 1900s. Further, the book shortly covers the role of geotechnical engineering in the early human history, starting from time of the pyramids in Egypt. This 395-page publication showcases the major events and innovations and introduces the main contributors and active members of the field of geotechnics in Finland. As such, this book naturally forms the main contents of the SGY's time capsule.

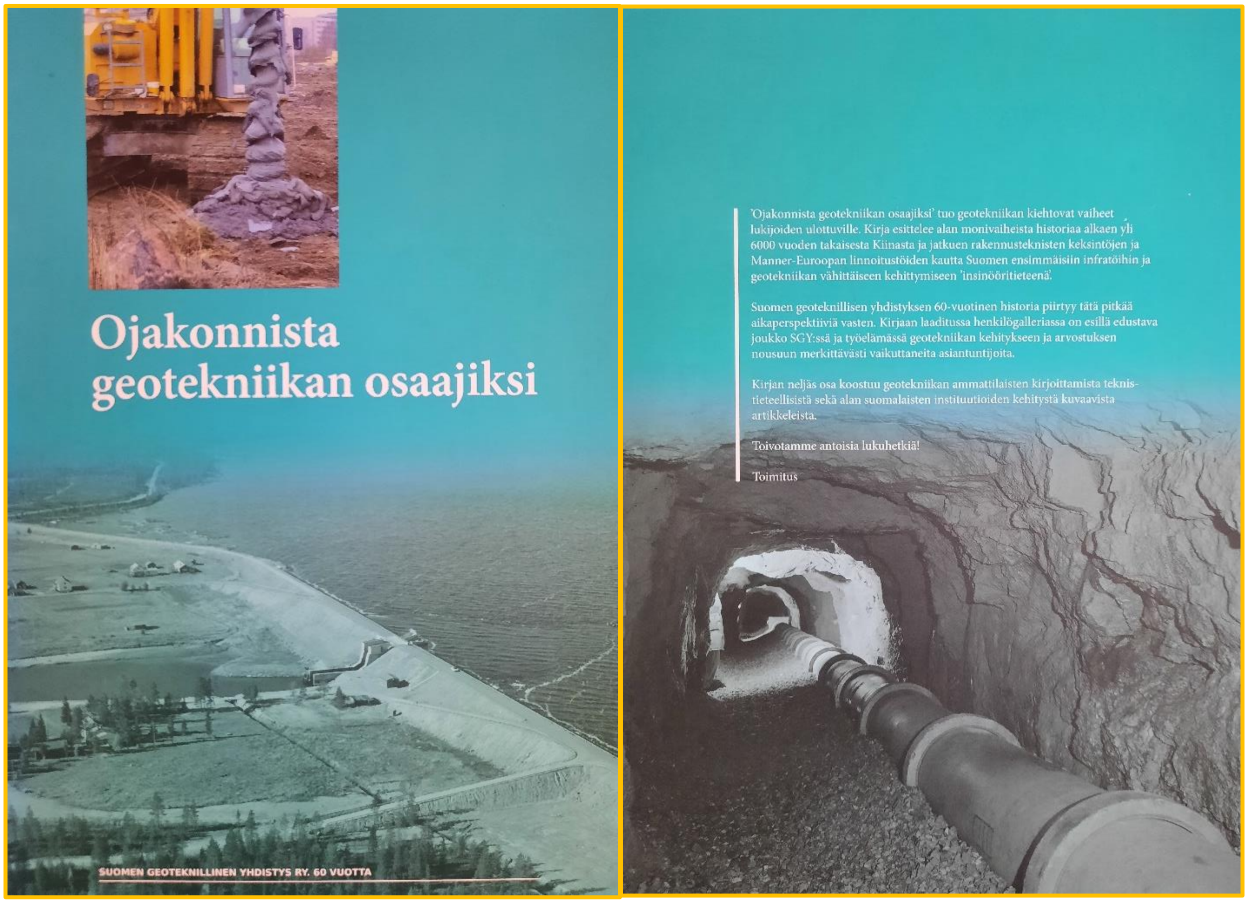

Figure 11 History of Finnish Geotechnical Society and geotechnics in Finland was showcased in the "Ojakoinnista geotekniikan osaajiksi" -book (Tammirinne 2011).

The Kimola canal, where the major slope failure occurred in 1965, was renovated and then opened for traffic in August 2020. The renovation works started in summer 2018. The canal was widened to allow larger cruise ships, and the geotechnical design was aided by Aalto University's research group to ensure thoughtful stability analyses supported by a comprehensive laboratory testing programme and in-situ pore pressure measurements. The log crane was demolished and a 12-meter-high lock, among the largest in Finland, was built. A 70 meters long rock tunnel in the canal was preserved but modified to serve ship traffic. After opening to traffic, the Kimola canal attracted more visitors during the remaining summer season than estimated for a whole season.

The decade of the 2020s

In the 2020s, the lack of geotechnical engineers marks the field more than ever. More geotechnical engineers are retiring than new graduates are entering the job market. Hence, there is a constant lack of resources in the field of geotechnical design that affects the consultancy companies. As a response, new committee is established in SGY: the School Committee aims to increase the visibility of the field and to attract new students to study geotechnical engineering. The committee offers grants to those geotechnical engineers who visit upper secondary schools to tell young students about the field aiming to increase student intakes at the degree programmes that include geotechnical engineering. At the same time, Communications Committee of SGY creates a brochure (print and online) that that is distributed to all upper secondary schools in Finland, to increase the visibility of the field and to attract more students.

The number of SGY members has been accordingly decreasing, and the society is investigating ways to attract more members. Currently there are approximately 500 individual members and almost 50 corporate members.

Soft soils continue to pose challenges in Finland. Slope failure and landslides (Figure 12) are fortunately rare, but poor subsoil conditions increase the construction costs especially in growing city areas. There is a growing need to find solutions that are both economical and sustainable, and the lack of geotechnical engineers makes this task even more difficult.

Figure 12 Landslide in soft clay at Paimio in 2021 (photo: Turun Sanomat).

The future

Extrapolating current megatrends, it is likely that more and more construction will be made in difficult geotechnical conditions and urban environment. As the cities are becoming denser, construction needs to be executed at unfavorable subsoil conditions that require extensive soil improvement and/or substantial pile foundations. On the other hand, foundations like concrete or steel piles would mean considerable amounts of embodied carbon, and hence alternative foundation methods need to be developed.

The increasing pressure to reduce carbon footprint and the net zero carbon objectives will affect the whole life cycle of structures from planning to usage. The usage of virgin materials and materials with large carbon emissions will have to decrease, while the utilization of recycled and waste-based materials will increase. These objectives will affect the composition of foundations (low-carbon concrete piles and shallow foundation, low-carbon steel piles) and the soil improvement methods. For example, the deep mixing method that is commonly used in Finland, will be modified to include more low carbon and alternative binders to replace conventional binders such as lime-cement. Further, there will be an increasing pressure to design foundations that are reusable, rather than just suitable for recycling.

The use of numerical methods will steadily increase due to a need for more accurate modelling and designs. Similarly, as the computing becomes more efficient, the usage of simulation-based reliability analysis can become more commonplace. Due to the increasing need for smaller economical and environmental costs, the geotechnical designs need to become more optimized than ever, as the conventional conservatism-based design approaches are no longer sustainable. This optimization process will demand for more accurate modelling and risk-informed decision making. As the software and AI development will aid the geotechnical designer in ground investigation data processing and modelling, more resources will be available for the designer to find the most optimal geotechnical design for the problem at hand, while considering the whole life cycle of the structure.

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