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A Light Retrospective

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I have deep geotechnical roots. My grandfather, Wolmar Fellenius, of slip-circle fame, was chairman of the group that published the first book ever with the word "geotechnical" in the title (Swedish State Railways Geotechnical Report, 1922) and my father, Bror Fellenius, headed a government geotechnical design office in Sweden, where many Swedish engineers took their first geotechnical steps.

Like most of us, I received an early soil mechanics experience at the age of about three to five playing with dry and wet sand in the backyard sandbox absorbing Nature's lessons about compaction, angle of repose, liquefaction, etc. Later on, as a twelve year old, weeding beets in a farm — making one cent per weeded metre — I learnt the difference in resistance between clay crust and moist silt soils. My Summer job four years later was to a much too great a part being one of the team of three who manually lifted and dropped the Standard Penetration weight . The pay was somewhat better, a full dollar a day, but the SPT days seemed me endless (could that Summer be the root to my favoring the CPTU over the SPT?) The summer following, I advanced to a position as a surveyor's rod boy for a survey of a series of country roads, which gave me an early insight in importance to adjust to topography, and that the surveyor may walk, but the rod boy runs.

At the age of eighteen, in the Summer of 1954, I worked in the laboratory of Soil Mechanics Limited in London, England, cranking a Casagrande liquid limit apparatus and determining water contents, and also assisting a construction inspector with taking measurements of a lowered water table and chemical consolidation for a reconstruction of Gallions Lock, Port of London. Lasting experience was encountering cockney and living on my own in Chelsea, London. After finishing high school and having completed Swedish army service, in 1956, I had a Summer of working for the Swedish Railroads, in a team manually fixing rail ties and replacing rails. The quintessence of team work, obeying the boss, and carrying one's share of the work assigned to the team were invaluable lessons. Free of high school and Army, I felt ready to go to university, but was uncertain where to go. I tried medical school, the Karolinska Institute, for a while, but felt the studies required too much to

memorize and shifted to philosophy and mathematics at the University of Stockholm, which subjects were far more appealing. So were other opportunities at the university, such as political debates, playing cards, socializing, etc., so passing exams came second. Eventually, it was strongly suggested to me that I try a school where they keep students more in line, and shifted to civil engineering at Royal Institute of Technology, KTH, in Stockholm, which also meant pursuing the family-preferred direction of study.

While enrolled at the KTH, the Summer of 1960 found me at a job in Southwestern Sweden consisting of a research project that involved the driving of 100 m long piles through soft clay—"the Gubbero study". The study was the first application of dynamic measurements in piles ever performed, and it also included measuring long-term deformations due to loading a small group of piles. I contributed rather little to the project, but it kindled my life-long interest in the behavior of piles with regard to construction and response to load. My overall interest in geotechnics was still dormant, though, but I did produce a M.Eng. thesis—best forgotten—having the title "A new settlement theory for clay". On graduation in 1962, I decided to pursue structural engineering and landed a job at the Swedish State Railways learning bridge design, at a pay set to all of \$350/month—the amount was sufficient, although barely, to support a family, even when the about a third went toward paying Swedish tax. It took me a year to realize that designing bridges did not make the earth move, and I changed to geotechnical engineering at Scandiaconsult, a geotechnical consulting engineering firm, where Rune Lundström gave me a solid foundation in engineering and geotechnics, as well as taught me by example how a down-to-earth senior engineer should mentor a fresh-out-from-school junior engineer. Lessons I hold in cherished memory.

After a few years at Scandiaconsult, I decided to try learning less of how things were done and more of why-so and moved to the Swedish Geotechnical Institute, where the Director, Professor Bengt Broms, persuaded me to enroll at the graduate programme at the Royal Institute of Technology, Stockholm. My research interest focused on the settlement of foundations under long-term condition, and I got involved in several long-term field studies of settlement of foundations on sands as well as on clays, as caused by supported load and by regional mining of water and placement of fills. I found that instrumentation always produces values, but not all of these are always meaningful and, subsequently, I invested long hours studying creep and temperature effects on gages used to measure settlement, pore pressures, deformations, and loads with regard to their use for assessing the load response of foundations in compressible soils. On several occasions, Mr. Sölve Severinsson, head of a Swedish construction company and Scanpile Inc., persuaded me to take temporary breaks in the studies to work on pile construction assignments in the UK and Canada, as well as gave me valuable mentoring. In Canada, I got the opportunity to work and share experiences with Francois Tavenas and Mike Bozozuk. My several reports and papers, and a Thesis on the subject of settlement of piled foundations and surrounding soil, earned me a Doctorate with KTH in 1972.

The years at the SGI stand out in memory as very good years, not least because of the immensely fruitful study environment created by Bengt Broms and learning and

working in the company of so many bright colleagues, such as Nils Flodin, Oleg Wager, Lars Hellman, Robert Holtz, and Rainer Massarsch. Bob and Rainer became life long friends.

After completing the academic requirements, I was persuaded by a Canadian friend, J. Clement (Clem) Brodeur, to come to Montreal, Canada, for what was intended to be an interlude of a few years, only, but what turned out to be for keeps. I worked first for a foundation contractor (Western Caissons, these days called Agra Foundations) and then for a consulting engineering firm, Terratech, a Division of SNC Lavalin, where Laval Samson patiently guided me into North American practice of geotechnical engineering. In 1976, I convinced Terratech to purchase a then new innovation, the Pile Driving Analyzer, to become the third consulting engineering firm to acquire the PDA and promote pile dynamics to the construction industry. This opened up not only a new field of endeavor, it gave me the opportunity to meet and learn from new friends, such as George Goble, Frank Rausche, Garland Likins, and Mohamad Hussein. In early 1977, I decided to take on the challenge of going on my own and started Bengt Fellenius Consultants Inc., pursuing pile dynamics and general foundation engineering. In parallel, I tried to introduce to North America soil improvement methods, such as lime cement columns, acceleration of settlement using wick drains, and geotextiles as separation membrane, in collaboration with Burcan Industries Inc. headed by Clem Brodeur. Several very interesting North American soil improvement firsts developed, but the efforts entailed a large amount of travel away from immediate dealings with the daily matters of teenagers at home, and the money was on the low side in respect to a family of five and a mortgaged house. Therefore, when in 1980 the University of Ottawa gave me an offer, I decided to shift goals and pursue an academic career as Professor in Civil Engineering and moved to Ottawa.

During the years at the University of Ottawa, I was learning along with my students and those studying with my colleague and good friend Professor Baris Trak. To mention just a few: Fred Agharazi, Normand Castonguay, Abolfazl Eslami, Amintore Fusco, Jules-Ange Infante, Tommy Lam, Claude Laviolette, Que Soon Lee, Nizamudeen Khan, Hicham Salem, Met Seyhun, and Richard Wan. While at the University, I continued my interest in wick drains, performing laboratory and field studies. I was pleased when in the mid-90s I succeeded in convincing the Ministry of Transportation, Ontario, to perform a large wick drain field trial for a relocated highway (HWY 16) in Ontario, resulting in that the method finally becoming a standard for the Ministry's road work.

In 1980, I opened up a separate commercial venture to offer dynamic testing services (two of my co-workers in the company and former students, Hicham Salem and Fred Agharazi, now operate a company called AATech Scientific pursuing pile dynamics and many other high level geotechnical applications from offices in several locations). Another former student and co-worker, Pierre Goudreault, met my challenge to write software to apply my approach to foundation design, which resulted in UniPile, UniSettle, and UniBear, which software is now marketed by UniSoft Ltd., headed by Pierre, and used in more than 50 countries.

My interest in emphasizing foundation design based on settlement analysis resulted in my developing what I call "the unified pile design", first published in 1984, now included in many international codes and standards. I am a firm believer that settlement and its associated issues, rather than capacity, should be the emphasis of foundation design, be it design of conventional footing foundations or of piles and pile groups. The need for sound basis of the design has led me to develop a special interest in full-scale testing and the principles of basing a design on observed performance of load transfer of the load from the supported structure to the soil—full-scale tests—rather than relying on unsupported theory. I have found much corroboration of my approach in applying the results of full-scale tests performed using the bidirectional-cell test.

I have been active in professional circles, serving as Chairman of the Montreal and Ottawa chapters of the Canadian Geotechnical Society, Chairman of the ASTM Deep Foundations Committee, writing parts of and editing the 1989 Canadian Foundation Engineering Manual, and participating in Code Committees, e.g., the Ontario Highway Bridge Design Code of 1983 and 1992. I was a member of the group of twelve engineers who in 1974 started what became the Deep Foundation Institute.

My work has emphasized geotechnical engineering issues and I have enjoyed writing up the results in papers presenting case histories, design principles, results of thesis work, discussions, etc., including a text book entitled "Basics of Foundation Design", intended to call attention to practical engineering aspects to supplement other more comprehensive texts. I am a strong believer in continuing education and have presented short courses in North America and around the world. I hold that research results and lessons learnt should be freely disseminated and have, therefore, made my publications available for free downloading from my personal web site [www.fellenius.net]. The site now has about 40,000+ visits and about 200,000+ downloads per year. Most of the web-visitors are students, I believe. Indeed, I may not influence my peers that much, but I am surely getting my chance to influence future engineers. A very pleasant consequence of the web site is the large number of e-mails received from colleagues and students around the world, and I really enjoy the discussions and exchange of information that ensue. The exchange gives me an opportunity to respond in kind to the generosity I experienced when, as a young, and not particularly bashful engineer, I wrote questions to reputable geotechnical individuals, such as Lauritz Bjerrum, Ralph Peck, Gregory Tschebotarioff, Geoff Meyerhof, Jorj Osterberg, Gerry Leonards, and others. If these giants in the geotechnical field could take time to respond to me, as they did, I certainly feel I can and should respond to those now writing to me.

I retired from the University of Ottawa in 1998, and later moved to Calgary, Alberta, and in 2009 on to Sidney, Vancouver Island, BC, from where I continue an international consulting engineering practice, which has involved testing and analysis and design of foundations for industrial plants, bridges, and tall tower buildings in North America as well as overseas—East and West.