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The Terzaghi, Peck and Casagrande Historical Libraries: a resource for the geotechnical profession

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ABSTRACT

NGI is the custodian of three historical libraries, the Terzaghi Library, the Peck Library and the Casagrande library. The collection of manuscripts, photographs, original technical drawings, artistic drawings, anecdotes, university courses, correspondence and project reports by four pioneers of our profession is unique, from a geotechnical and a bibliographical point of view. The geo-libraries are today the largest collection of original manuscripts that documents the birth of a science. This paper takes the reader on a tour of the libraries. In 1957, Terzaghi's early material in a dusty pile in Vienna was shown accidentally to Laurits Bjerrum. Through the years, the historical libraries have become a large physical and digital repository forever available to our profession. In addition to the invaluable technical content, the collections give insight into Terzaghi, Peck and the Casagrande brothers' personality and creativity, work methods, developments and accomplishments, relations with people and sense of organisation. One can find, for example Terzaghi's "Notes on Construction (1912-13)" which cover almost the entire field of civil engineering and led to the invention of soil mechanics. The libraries contain also treasures of inspiring quotes that many of us have not heard before or forgotten. A short perusing in the documents reveals that Karl Terzaghi was a brilliant, fearless and enthusiastic man, an independent thinker; Ralph Peck was a conscientious, diplomatic, down-to-earth and caring gentleman, and first of all a man of judgment; Arthur Casagrande a gifted teacher and consultant with bold, "no-nonsense" ideas and Leo Casagrande a pioneering educator and consultant, a man of substance with amiable personality.

RÉSUMÉ

NGI dispose de trois bibliothèques historiques, la bibliothèque Terzaghi, la bibliothèque Peck et la bibliothèque Casagrande. Ces collections de manuscrits, photographies, dessins techniques et artistiques, anecdotes, cours universitaires, correspondance et rapports de projets par quatre pionniers de notre profession sont uniques, d'un point de vue géotechnique et bibliographique. Les géo-bibliothèques sont aujourd'hui la plus grande collection de manuscrits originaux qui documente la naissance d'une science. Cet article raconte l'histoire des bibliothèques. À l'origine (1967), Laurits Bjerrum voulait rassembler les vieux documents de Terzaghi abandonnés à Vienne. Aujourd'hui, les bibliothèques sont à la fois un précieux référentiel sur l'histoire de notre profession. En plus de leur contenu technique, les collections donnent un aperçu de la personnalité et de la créativité de Terzaghi, Peck et Arthur et Leo Casagrande, leurs méthodes de travail, leur développement et réalisations et leurs relations interpersonnelles. On peut y trouver, e.g., les "Notes on Construction (1912-13)" de Terzaghi qui couvrent presque tout le domaine du génie civil et ont conduit à l'invention de la mécanique des sols. Les bibliothèques contiennent également des trésors de citations inspirantes que beaucoup d'entre nous n'ont pas entendues auparavant. Un court séjour dans les bibliothèques révèle que Karl Terzaghi était un homme brillant, intrépide et enthousiaste et un esprit indépendant, Ralph Peck, un gentleman consciencieux, diplomatique, terre-à-terre et attentionné, et avant tout un homme de bon jugement; Arthur Casagrande un enseignant et consultant doué avec des idées audacieuses; et Leo Casagrande un pionnier, un homme de substance avec une aimable personnalité.

1 INTRODUCTION

NGI has the privilege of hosting three historical libraries in its headquarters in Oslo, Norway: the Terzaghi Library, the Peck Library and the Casagrande Library. Karl Terzaghi is deservedly known as the father of modern soil mechanics and geotechnical engineering. Ralph B. Peck,

one of Karl Terzaghi's closest colleagues and professor at the University of Illinois, Urbana, was recognised as a "Man of Judgment", a superb educator and an expert consultant. The Casagrande Library honors Arthur and Leo Casagrande, colleagues of Karl Terzaghi and mentors for Ralph Peck. Arthur was a gifted teacher and a highly respected expert consulting engineer, Leo was a

pioneering educator and innovative consultant, and he was the first to promote electro-osmosis in the US. The four pioneers, while academics, were extremely prolific consultants and worked on projects all over the world.

2 DO WE NEED HISTORICAL LIBRARIES?

In our days of home office, digital meetings and cloud storage, is there a need for or benefit from historical libraries? The authors reply with an enthusiastic yes! The three Historical Libraries assemble the lifework of four of our pioneers. NGI sees it as a privilege to be the custodian of the legacy of Terzaghi, Peck and the Casagrande brothers and wishes to preserve their works for future generations. Past US Geo-Institute President Gregory (2017) asked: "*Are We Losing the History of Our Geotechnical Pioneers?*". By pioneers, he meant prominent engineers and geoscientists who had direct links to Terzaghi as either associate or colleague or protégé or mentee in class or practice. These pioneers expanded the young field of soil mechanics. Among those who no longer are with us come to mind Ralph B. Peck, Laurits Bjerrum, Alec Skempton, Alan W. Bishop, Arthur and Leo Casagrande, Jean Kérisel, Harry Seed, Gerry Leonards, Robert V. Whitman, T. William Lambe, Robert F. Legget, Victor Milligan, Victor de Mello, Nabor Carrillo, Alfred R. Jumikis, Gregory P. Tschebotarioff and Donald W. Taylor, among others. The 1960-1980s saw tremendous growth in the principles and practice of soil mechanics.

Because fewer and fewer of our pioneers are still with us, young engineers do not have the opportunity to meet them and hear about the development of our science. However, the stories are truly fascinating and need to be told. To fill in the gap, the profession can (1) include geotechnical history in undergraduate or graduate courses; (2) consult Historical Libraries (e.g., Imperial College has a "Skempton Collection" and Harvard has a "Casagrande Collection"), or (3) read biographies of our pioneers, e.g. Terzaghi (Goodman, 1999); Skempton (Niechcial, 2002); Bjerrum (Flaate et al., 2003); Peck (DiBiagio and Flaate, 2000; Dunicliff and Peck-Young, 2006). However, there are still too few such biographies.

3 A TOUR OF THE HISTORICAL LIBRARIES

3.1 The "Norwegian connection"

The Historical Libraries at NGI are a story of friendship and mutual respect among pioneers. They are also an expression of trust in NGI to preserve the documents for future generations. In 1957, Laurits Bjerrum was shown an unsorted pile of Terzaghi works. This material formed the initial Terzaghi Library. The three libraries are now a large repository of documents forever available to the profession. In addition to their invaluable technical content, the collections provide insight into our pioneers' personality, creativity, work habits and achievements.

There was always a "Norwegian Connection" with the MIT-Harvard academia. The close mutual friendship and respect among five pioneers, Karl Terzaghi, Ralph B. Peck, Arthur and Leo Casagrande and Laurits Bjerrum, NGI's first director, started it all (Figs 1 to 4).



Figure 1. Bjerrum, Terzaghi and Arthur Casagrande at NGI in 1957 (field testing equipment in the back)



Figure 2. Karl Terzaghi, Leo Casagrande and Arthur Casagrande, 1955 (left to right)

Bjerrum's relationship with Terzaghi was remarkable. When Bjerrum became Head of NGI in 1951, one of Bjerrum's first acts was to discuss with Terzaghi what the approach of NGI should be. Characteristically, Bjerrum had definite ideas of his own, but his and Terzaghi's matched very well. Bjerrum came to visit and lecture at MIT and Harvard on several occasions. He stayed with the Terzaghis and quickly became one of the family. Ralph Peck said in his tribute to Laurits Bjerrum upon his death in 1973: "*Bjerrum is the one who came closest to appreciating Terzaghi's ideas and ideals as to the way soil mechanics should be developed and practiced.*" All of Terzaghi's fundamental studies came out of practical problems. NGI's strategy has been based on this principle for 70 years.

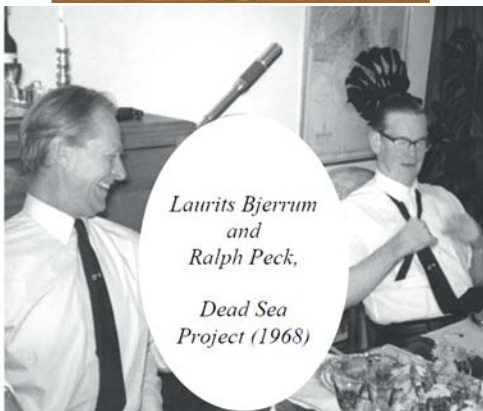


Figure 3. Bjerrum and Peck in Stonehenge (1953): 1968: young, dedicated and facetious and fun-loving!

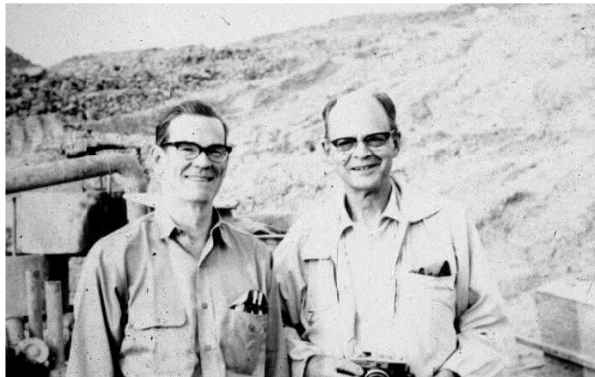


Figure 4. Peck and A. Casagrande at Lower Notch Dam, Montréal River, Lake Témiscamingue, Canada (1968)

3.2 The physical libraries

Each of the libraries are meeting or project rooms where engineers and scientists work. Figure 5 shows a plan view of the libraries in NGI's main building in Oslo, and Figure 6 a glimpse of part of one wall in the Peck Library.

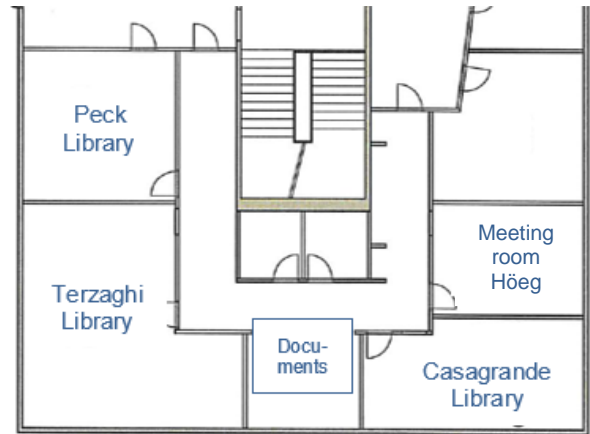


Figure 5. Historical Libraries in NGI's building in Oslo (north points upward, horizontal dimension 28 m)

3.3 The virtual libraries

The historical Libraries can be reached on www.ngi.no. The user can search in each library with keywords, author or year, and ask for pdf-copies. If the document is not already digitized, NGI will digitize it. Table 1 exemplifies some of the documents under the letter W for each library. Including a list of all documents for the three libraries in the format of Table 1 would take 28 more pages!



Figure 6. partial view of one wall in Peck Library (2020)

3.4 The Terzaghi Library

The Terzaghi Library is the result of fortunate circumstances and Laurits Bjerrum's vision. Ralph Peck recalled that Bjerrum was fascinated not only by the way Terzaghi's mind operated but also by how Terzaghi reacted to his contemporaries. Terzaghi had lost his early records, having left Austria in a hurry. When Bjerrum visited Professor Ö. Fröhlich, Terzaghi's successor in Vienna, he saw, by the merest of chance, a large pile of

dusty debris which he realized were Terzaghi's early papers. Bjerrum asked Terzaghi permission to catalogue the documents. Bjerrum already saw in these documents

the nucleus of a library on the history of the developments of soil mechanics (1973 lecture by Ralph B. Peck).

Table 1. Topics in database for each historical library, selected documents and projects starting with W (partial list)

Terzaghi Library		Peck Library		Casagrande Library	
Document/Project	Year	Document/Project	Year	Document/Project	Year
Walton Reservoir	1939	W & LE Bridge	1949	Walter Bouldin Dam	1966
Waneta Power Plant	1951	W. R. Grace, Memphis	1952	Warehouse, Virginia ABC Board	1952
Wellpoint method for excavation foundation pits	1927	Wabash River Power Plant	1952	Warehouse, Newburyport, MA	1954
Whatshan Power Station	1953	Waimea Reservoir	1955	Water Main Settlements Hartford, CT	1972
Wiener Reichsbrücke	1934	Waiomao Slide (until 1993)	1959	Water Pollution Control Plant, Washington D.C.	1951
Wilson Tunnel	1955	Walter Bouldin Dam (until '88)	1967	Weadock Power Plant	1967
Windsor Brine Field	1949	Walter George & Inglis Dams	1972	Welland Canal, Ontario, Approach Fill	1970
Windsor Generating Sta.	1948	Washington Street Tunnel	1946	Wellston Coal Conveyor	1950
Winnetka Crib Wall Failure	1941	West Duffin Outfall Sewer	1975	WES, Effect Long-Time Loading	1963
Wolga-Don-Kanal	1955	West Liberia Mining Co.	1949	WES, Peat Blasting	1951
Woodfibre, B.C.- landslide	1955	West Side Interceptor	1971	WES Triaxial Research 1950-51	1980
Wyandotte Chemicals Corp.	1947	Western Electric Co., Denver	1948	West Arthur Place	1965
		White Cross Hospital	1958	West Branch Dam	1962
		Willow Gloen Siphon Collapse	1973	Wilson Tunnel / Kalihi Tunnel	1953
(Year is year of project start)		Wilson Tunnel	1954	Wyoming Sta, Coal storage, found'ons	1977
		World Trade Center	1967		

Bjerrum sent the catalogues to Terzaghi. Terzaghi saw the historical and technical value of the documents and the advantage of bringing them together with those he had accumulated at Harvard and MIT. Terzaghi asked Bjerrum to save the papers for later and start a library. In January 1960, Laurits Bjerrum wrote to Karl Terzaghi:

"There is another reason for wishing that both of you will come to Oslo this year. The "Terzaghi Library" is now a matter of fact and here in my office I face a wall which contains 12 metres run of the material which we received from Vienna and which is now meticulously arranged, bound, put in boxes and placed on the bookshelves. I have already made use of a good deal of the information and we are indeed proud of having this material here and I would like to show it to you. I guess you have already forgotten how productive you must have been in the early days and how many pages you have written during the period up to 1936. I am especially proud of your 'Notes on Construction (1912-13)' which cover almost the entire field of civil engineering and which leads to the invention of soil mechanics in a very clear and impressive way."

The years 1960-63 were a period of ill health for Karl Terzaghi. He passed away in 1963, never seeing his library. In his will, Terzaghi bequeathed his technical works to NGI. The Terzaghi Library was inaugurated in 1967, with Ruth Terzaghi, children and grandchildren present. As recently as 1992, NGI received 10 m³ of documents for the library from Ruth Terzaghi's estate.

3.4.1 The Terzaghi Collection

After working as a consultant and serving in the Austrian Air Force during World War I, Karl Terzaghi accepted in 1916 a position at the Imperial School of Engineers,

Istanbul, and later became professor at Robert College in Istanbul. Much research had been done on foundations, earth pressure, and stability of slopes. Terzaghi set out to organize the results and provide unifying concepts. The results were published in his most noted work, *Erdbaumechanik* (1925) or *Introduction to Soil Mechanics*. In 1925, Terzaghi went to MIT where he worked unceasingly for the acceptance of his ideas, serving also as consulting engineer for many construction projects. In 1929, he accepted the newly created chair of soil mechanics at the Vienna Technical University. He returned to the US in 1938 and became professor of civil engineering at Harvard University in 1946, where he stayed until his retirement in 1956.

Terzaghi kept careful notes of his experiments and thoughts of his early years and maintained an enormous correspondence with everybody who had some interest in soil mechanics throughout the world. Professor Dick Goodman, himself an extremely proficient researcher and writer, spent five years to read and translate 82 volumes of diaries, peruse 15,000 letters and study numerous essays, publications and reports to produce his unique 340-page biography, *Karl Terzaghi: The Engineer as Artist*.

The Terzaghi Library at NGI includes:

- Vienna material (until 1940s)
- Harvard material (until 1963)
- Ruth Terzaghi's estate
- Consulting reports, publications, manuscripts
- Notes
- Diaries and agendas, autobiographical material
- Correspondence organised by countries
- Photographs, drawings. Artistic sketches
- Medals, tokens of appreciations, honorary PhD

The collection offers insight into Terzaghi's personality, work methods, and life. The documents point out to a brilliant, fearless and enthusiastic personality who dominated the soil mechanics and foundation world for decades. Terzaghi was diligent and followed through his responsibilities to completion. He had high standards of intellectual honesty, he was an outstanding observer but was suspicious of intuitive approaches.

Terzaghi's work habits were exemplary. He was objective, rational, an independent thinker capable of long days and continuous hard work. Yet, Terzaghi relished friendship and gave much of himself to those he enjoyed being with or learning from. He could be demanding of friends. He loved geology, reading and travelling. Terzaghi's motto might have been "Persevere or perish", as he quoted in a letter to Wittenbauer in January 1918.

Karl Terzaghi's "Notes on Construction (1912-13)" include 52 small booklets in German or English that cover almost the entire field of civil engineering. Terzaghi's thoughts on topics such as geology, geography, grouting, tunnel construction, hydropower, irrigation, blasting, settlement gave birth to the field of soil mechanics. The booklets include several engineering projects, including colourful locations such as Belle Fourche (South Dakota), Columbia and Snake Rivers (British Columbia and Washington State) and Strawberry Valley (California).

The Terzaghi Library is also unique from a bibliographical point of view. The library is the largest collection in the world of original manuscripts documenting the birth of a scientific speciality (Husby, 1995).

3.5 The Peck Library

While Karl Terzaghi was a close friend of NGI's first director Laurits Bjerrum, Professor Ralph Peck was friend and colleague of all three NGI's first three directors, Laurits Bjerrum, Kaare Høeg and Suzanne Lacasse. The latter two worked in the US until the 80s and became close to Ralph through their interest in soil behavior and foundation design. Ralph Peck had also written a touching tribute of Laurits Bjerrum on the occasion of Laurits' untimely death in 1973. In the mid-90s, Ralph Peck was looking for a home for his works and projects. Universities were contacted, but these did not seem to have the infrastructure to support a large dedicated collection.

New set of fortunate coincidences: In 1997, Ralph B. Peck and the first author were at the same hotel and placed next to each other in the line waiting for breakfast (Ralph was 85 years old, with some vision challenges by then). This led to daily breakfasts (elsewhere) and metro rides, and renewed acquaintance with NGI, new projects, and nearly daily fax exchanges Oslo-Albuquerque. One evening in Albuquerque (NM), while discussing soil mechanics, its future and the legacy of the profession's pioneers, the first author simply suggested that NGI would be the ideal place for Ralph's lifework, just beside the Terzaghi Library. Ralph and his family agreed. Ralph was adamant that the library should not become a shrine. The three Historical Libraries have therefore become lively meeting places for NGI personnel and NGI clients.

The Peck library was inaugurated in 2000 in the presence of Ralph Peck and his children Nancy and Jim

(Fig. 7). It was especially rewarding for NGI to have the honoree present and active for the celebration.



Figure 7. Ralph Peck at the inauguration of the Peck Library (2000) and working in the Terzaghi Library (1997)

3.5.1 The Peck Collection

Ralph Peck had extraordinary mentors: Arthur and Leo Casagrande, Karl Terzaghi, Al Cummings, Ray Knapp and Ralph Burke. Before Ralph started his long career at the University of Illinois, he worked as a consultant with the Casagrande brothers. The Peck Library at NGI includes:

- Consulting reports, publications, manuscripts
- Diaries and agendas, autobiographical material
- Field workbooks, notes, photographs
- Lectures
- Voluminous correspondence organized by person
- Personal scrapbook (kept by Ralph's mother)
- Medals, appreciations, honorary PhD's (Fig. 8)
- Medal of Science awarded by President Ford (Fig. 9)

The collection offers insight into Peck's personality, work methods, his consulting projects around the world

and his relationship with colleagues and clients. Ralph Peck worked on over 1,000 consulting projects.

Ralph had a unique way with words. He described Karl Terzaghi as follows: *"Karl was totally dedicated to his work. He was a very intense person, and he couldn't quite understand why other people didn't work as hard as he did. [...] Most people regarded him as very stern. But I do not think that is right. He was really a very kindly person. He didn't mind if you made a mistake, but you had better only make a mistake once."*

The Peck Library also tells the story of the struggles, tribulation and challenges in the writing of the Terzaghi and Peck 1987 book: long evenings, interminable discussions, disheartening cuts, blind alleys, and phases of exasperation and renewed energy.

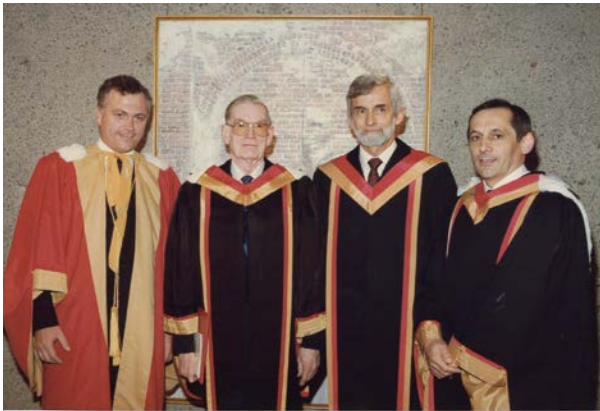


Figure 8. Peck's PhD h.c. at Université Laval (1987) (M. Gervais, R.B. Peck, P. LaRoche, F. Tavenas)



Figure 9. US Medal awarded to R.B. Peck (1974)

3.6 The Casagrande Library

After Arthur and Leo Casagrande passed away, Dirk Casagrande (Leo's son, also a geotechnical engineer) offered Arthur's archives to the US Army Waterways Experiment station (WES), following Arthur's wishes. Many project files had already been provided to WES for archival purposes. Dirk organized the voluminous collection. Many files did not concern work at WES projects. WES gradually questioned the feasibility of storing the entire collection. By the time the cataloging was completed (2011), WES decided that they did not have room for the collection.

Dirk Casagrande then offered the collection to NGI, which was pleased to accept. But Arthur's daughters subsequently decided that the collection should reside at Harvard University. Harvard had earlier declined Arthur's archives, but now decided to accept it. Dirk regretfully informed NGI. NGI was still interested in obtaining the leftover files from Arthur combined with Leo's archives to establish the Casagrande Library (Fig. 10). Fate again, it turned out that Leo's files had duplicates of Arthur's files because the two brothers worked as a team on most of their projects. Many files are still in Arlington, a suburb of Boston, awaiting NGI to "bring the documents home". WES has also graciously offered to transfer its collection to the Casagrande Library at NGI.



Figure 10. Leo and Arthur Casagrande (Austria 1930s; USA 1969)

Quoting Dirk Casagrande in his opening address at the Casagrande Library inauguration: *"Both Arthur and Leo thought very highly of Laurits Bjerrum, as of course did Terzaghi and Peck. It seemed fitting that the archives of Ralph, Arthur and Leo, all eminent disciples of Terzaghi, would be accumulated under the same roof with Terzaghi's archives"*. The Casagrande Library was inaugurated in 2017, in the presence of Leo's sons Dirk and Ralf and daughter Imogen. WES was part of the inauguration program, with Maureen K. Corcoran, and in spirit Bill Marcuson.

3.6.1 The Casagrande Collection

At the opening of the Casagrande Library, Dirk Casagrande (2017) told the dramatic story of the Casagrande brothers. The Casagrande family stems from an aristocratic Italian family from Milano in the 15th century (Fig. 11a). Arthur and Leo's father was taken prisoner by the Russians in 1915, escaped, was recaptured and was finally allowed to return to his family in 1922, 4 years after the war ended. He had suffered greatly, and died shortly thereafter, at the age of 46. Arthur and Leo faced ignorance and poverty. But due to an intellectual and

determined mother, they went to school. Arthur graduated as civil engineer, specialty hydraulics, emigrated to the US in 1926 and worked for the U.S. Bureau of Public Roads and MIT as an assistant to Karl Terzaghi. Arthur became a U.S. citizen in 1931 and joined Harvard University in 1932. Arthur quickly became a leader in the field. Arthur conceived and organized the 1st ISSMFE¹ Conference at Harvard in 1936. In 1938, Arthur was the one who convinced Harvard University to hire Karl Terzaghi.



Figure 11. (a) Coat of arms of the Casagrande lineage and (b) The Casagrande brothers with enigmatic smiles.

Leo earned a Civil Engineering degree, specialty structural engineering, in Vienna in 1928. At Arthur's urging, he came to the US in 1930 to work at MIT. After two years, he returned to Vienna² to complete a PhD under Terzaghi (1933). Seeing how busy Arthur was with his career and realizing that Arthur would not find time for a Doctor's degree after joining the faculty at Harvard, Leo assembled several of Arthur's notable papers and publications into a thesis and submitted it to the Technical University Vienna. The university accepted this work and bestowed on Arthur a Doctor of Technical Sciences degree, also in 1933.

While at MIT, Leo carried out laboratory tests to investigate the effect of sending electric current through saturated fine-grained soils. He discovered that electro-osmosis dewatering was much quicker and more effective for strength increase than gravity drainage for these soils.

Leo and his family lived in Berlin under very severe conditions until 1944: e.g. dishes rattling in cupboards during bombings, waking up in the morning to find an unexploded firebomb that had come through the roof and landed in Leo's bed. During the war and post-war years, Arthur sent care packages from the US. Leo lost a lot of weight, and his teeth became so loose that it was difficult for him to eat solid foods. Leo and his family left for the German Baltic coast in 1944 with little more than their clothes on their backs. Almost all of his professional documents were lost.

After World War II ended, Arthur increased his efforts to also get Leo and his family to the US. Upon arrival in the US in 1950, Leo established a soil mechanics laboratory in the basement of his house and worked as a

consultant with Arthur. He became a lecturer and then professor at Harvard in 1955.

The Casagrande Library at NGI includes:

- Consulting reports, technical notes and correspondence, for 260 consulting projects
- R&D activities, in particular on development of electro-osmosis for soil stabilization
- Photographs, correspondence, drawings,
- Harvard University courses
- Lectures
- Initial documents on Atterberg limits, A-line, USCS classification system and seepage under dams
- Publications, manuscripts and notes.
- Humorous interpretations of soil mechanics by the students at Harvard.

Arthur was well organized and seemed a tireless worker, despite health problems. He was very particular about having things just right, he was a compulsive perfectionist. Dirk Casagrande stated *"It was somewhat frustrating to work with him for preparation of reports, because any draft [...] needed to be essentially rewritten a number of times before it was finally considered acceptable. This attention to detail was one of the many qualities that made him such an excellent engineer."*

Arthur was in demand for major earth and rockfill dams and liquefaction, Leo for foundation design and electro-osmosis. Leo had started writing a book in Berlin. The manuscript was one of the documents that were lost.

Among the many interesting and challenging projects that Arthur and Leo worked on together was the Leaning Tower of Pisa. They had been engaged by an Italian firm to find a solution for arresting the progressive lean. Arthur and Leo proposed in 1974 the application of tension center theory, which had been developed by the eminent Nabor Carrillo to explain the ground subsidence in California that resulted from crude oil extraction. For stabilizing the tower, Arthur and Leo proposed the drilling of boreholes with enlarged bases to gradually remove clay from the up-lean (north) side of the tower foundation, and thus develop controlled settlement on that side. Their group did not win the project. However, 21 years later, freezing of the foundation soils was attempted under the guidance of Professors John Burland and Michele Jamiolkowski with the intent of stabilizing the tower until a tensile restraint system could be installed. But the freezing caused an increase in lean of the tower. In 1999, controlled foundation soil removal from the up-lean side was started, with an immediate beneficial effect. The procedure was slowly continued for 2 years, resulting in stabilization and reduction in tilt by 40 cm at the top.

Electro-kinetics was introduced to the US by Leo in the 1950s to move fluids through rocks and soils under a unidirectional electrical current flow. He had used the technology in Europe for soil stabilization

Arthur nominated Terzaghi for the Medal of Science:

"In addition to those figures in the engineering world whose names are connected with some remarkable structure, there is a small group of great engineers, often scarcely known to the layman, who have profoundly influenced the mode of thought of their contemporaries,

¹ International Conference on Soil Mechanics and Foundation Engineering

² Terzaghi left for Vienna in 1929, taking Leo with him as PhD student.

and consequently have initiated new eras in civil engineering practice. Professor Terzaghi is one such man, and his stature is comparable to that of Navier in the early 19th century and Euler in the 18th century."

Arthur made a substantial impact on the practice of earth and rockfill dams and the development of foundation engineering that may be without parallel in the field of engineering. He dedicated his life to "finding a better way" and "trying something else", bringing engineering breakthroughs (paraphrased from citation by WES at the Arthur Casagrande Building dedication, 1981).

4 INSIGHT IN OUR PIONEERS

All four pioneers considered themselves as "Soil Mechanics and Foundation" engineers (before the profession became known as Geotechnical Engineering). Karl Terzaghi had a healthy respect for his disciple Arthur, as did Arthur for Leo, yet praise was a rare commodity in those days, except for Ralph Peck who was the diplomat of the group.

Our pioneers taught us a working method: critical observations, understanding fundamentals, evaluating soil behavior and, not the least, using engineering judgement. Terzaghi also said: *"To acquire competence in the field of earthwork engineering, one must live with the soil. One must love it and observe its performance not only in the laboratory but also in the field, to become familiar with those of its manifold properties that are not disclosed by boring records."* As a younger man, Terzaghi wanted to formulate a rational analytical or empirical methodology, properly embracing geological constraints, for designing works founded on soils. In his 40s, having achieved his first target, he pursued the practice of engineering passionately to test and temper the emerging methods with reality. Terzaghi expressed his personal beliefs about the practice of engineering (after Goodman, 1999):

- Take on only what your competence allows you to handle.
- Unravel a site's geological history and use it to develop the site investigations.
- Look at imperfections in sampling and testing and variability in morphology, properties and layers.
- Assume the worst configuration of properties and boundary conditions consistent with the investigations.
- Request measurements to be made on the site, with sufficient lead time to establish behaviour before, during and after construction.
- Follow through on every angle and every sub-task.
- Do not oversimplify site model, properties or response.
- Provide definite and explicit recommendations in a way that is immediately useful to the client. Explain the difference between success and failure, safety and catastrophe.
- Take responsibility as an engineer, even beyond the specifics of one's own specific assignment, and remain aware of your ethical responsibility.
- Learn continuously from experience and publish meaningful experiences for the "betterment" of the profession.
- When criticizing previous work, be courteous and explain the nature of the disagreement yet be firm.

4.1 More than engineers

The late Professor Robert V. Whitman, MIT, said: *"Karl Terzaghi was an excellent lecturer. [...] he was alternately charming and hard on you. He was infamous for chewing out the poor graduate student who projected his slide upside down, even though quite possibly Terzaghi himself was the one who put it upside down"*.

"Arthur was similar to Terzaghi as a person, in that he was a bit crusty as well as socially delightful. Arthur built up the soil mechanics program in the graduate school at Harvard to a preeminent position in the US. He was an excellent experimentalist and developed the concept of critical void ratio in sands. Arthur was known for his precise lectures. He made major contributions to our understanding of soil behavior and the development of laboratory testing equipment and procedures."

Robert Whitman also wrote that Arthur was *"kind to his students who came to him with personal problems, and often contributed funding from his own pocket. His students felt his personal interest, his genuine concern for their future, and the graciousness of his personality"*.

Whitman also said: *"Ralph Peck was picked by Terzaghi to be his man on the site for the Chicago subway excavations. Peck was an absolutely charming person, but firm as an engineer"*. Richard Goodman said about Ralph Peck in the dedication of his Terzaghi biography: *"To Ralph Peck, A courageous, strong, and honest human being whose teaching, writing and speaking and practice of civil engineering continue to light the way"*.

Leo was known at Harvard as the "Gentle Professor", in recognition of his aimable personality. He was soft-spoken, imposing in stature because of his tall body and elongated features and enigmatic smiling face (Fig. 11b). He was the right complement for Arthur and Karl Terzaghi.

Ralph Peck wrote: *"Leo Casagrande was a person of great warmth and personal charm. A solid, experienced civil engineer who combined high technical ability with good judgement and, in proper balance, scientific rigor with an awareness of the needs of practical engineering and construction. [...] His students found him to be a superb teacher, at once scientific and practical, who required thoughtful solutions encompassing the broad as well as the specialized picture!"*

"Always responding without delay but considering carefully all factors before reaching a conclusion, the Casagrande brothers were rarely wrong. At a time when it was fashionable to be applied scientists in university circles, they were proud of being engineers" (from Praise to the Casagrande brothers at Harvard University).

The libraries also contain treasures of inspiring quotations or lessons learned that many of us have not heard before or forgotten. Table 2 lists a few of these from the Terzaghi and Peck Libraries. (The Casagrande quotations are under development.)

Karl Terzaghi coined the expression that geotechnical engineering is a science and an art. Many geologists and geotechnical engineers are also artists, demonstrating that geotechnics is a science appealing to both scientific and artistic minds. Figure 12 illustrates the works of three such scientists and artists.

Table 2. Quotes and lessons learned from our pioneers (The Terzaghi and Peck Libraries, NGI, Oslo)

Terzaghi	Peck
<i>"Our theories will be superseded by better ones, but the results of conscientious observations in the field will remain as a permanent asset of inestimable value to the profession."</i>	<i>"An instrument too often overlooked in our technical world is a human eye connected to the brain of an intelligent human being."</i>
<i>"Theory and calculation are not substitute for judgement, but are the basis for sounder judgments."</i>	<i>"Theory and calculation are not substitute for judgement, but are the basis for sounder judgments."</i>
Recipe for success: 1) Enjoy what you do. 2) For every project, go to the site and see for yourself.	Recipe for success: 1) Enjoy what you do. 2) Never tire of asking why the soil / structure behaves as it does. 3) Write with more discrimination
<i>«Happiness? I have learned the meaning of the word in this year. Continuous creative activity. Clarification of confused material [case studies, geotechnical profiles] and sympathetic, guiding influence on earnestly striving young men (!)». Karl Terzaghi, 40-yr old, Istanbul, 31 Dec. 1923 (diary where he annually summarized the year's events).</i>	<i>"Everybody agrees that an engineer should have good judgment. I'm not sure how to define what judgment is, [but it should include]:</i> – <i>An ability to select and solve the right problem.</i> – <i>An ability to establish reasonable performance criteria for the design.</i> – <i>A sense of proportion or sense of fitness (i.e. Does the result seem about right?)."</i>
<i>"The worst habit you can possibly acquire is to become uncritical towards your own concepts and at the same time sceptical towards those of others. Once you arrive at that state, you are in the grip of senility, regardless of your age."</i>	The one-page summary: <i>"If you can't reduce a difficult engineering problem to one 8-1/2 X 11-inch sheet of paper, you will probably never understand it".</i>
<i>Nature has no contract with mathematics. she has even less of an obligation to laboratory tests and results.</i>	<i>"If something is discovered that does not agree with the hypothesis, rejoice! You can then really learn something new, you are on your way to an understanding of the problem.</i>
<i>When Yves Lacroix asked Terzaghi how much time he ought to spend on writing his report, he got the following advice: "Spend on it as much time as necessary to inform the reader with as few words as practicable about all the significant findings and about the essential features of the construction operations which have been performed".</i>	<i>"The most fruitful research grows out of practical problems."</i>
	<i>"Engineering is indeed a noble sport, and the legacy of good engineers is a better physical world for those who follow them".</i>
	<i>"I don't do jobs that I can't visit".</i>
	<i>"I am not against computers by any means, but I am against using them blindly"</i>
	<i>No theory can be considered satisfactory until it has been adequately checked by actual observations".</i>
	<i>"Theory and calculation are not substitute for judgment, but are the basis for sounder judgment"</i>

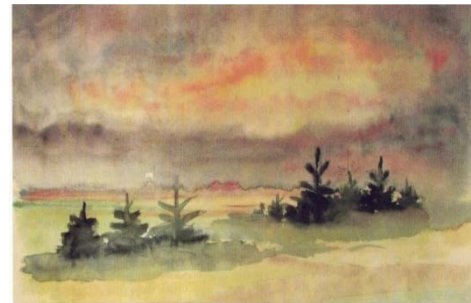


Figure 12. Drawing by Karl Terzaghi of Bay Lodge Cottage (1924); Watercolor by Laurits Bjerrum (Jutland, west coast of Denmark, 1938); Sketches by Arthur Casagrande (unknown year)

4.2 Enjoying a good laugh

Our pioneers also could be facetious:

Karl Terzaghi and his quick mind never missed a chance for a witty response (reported by Cameron E. Mirza while a graduate student at University of Illinois, 1965-67):

Karl Terzaghi was an expert witness in the late 1950's. The opposing lawyer quoted lines from Karl Terzaghi's 1943 book "Theoretical Soil Mechanics". The opposing lawyer asked Terzaghi if the quote was not what he had written in his 1943 book. Terzaghi said "Yes". The lawyer then pursued, triumphantly: "The testimony you just gave contradicts what you wrote, does it not Dr. Terzaghi?". Those in the courtroom who knew Karl Terzaghi were hushed into disbelief. Terzaghi calmly replied: "Sir, do you think I am such a vegetable that I have not learned anything new since then?"

Ralph B. Peck simply said: "*If it is not chocolate, it is not dessert!*".

Arthur Casagrande in turn said in a lecture attended by the first author (1972): "*I would not rely on a test [the SPT test] which results depend on whether the driller had a fight with his wife the night before or spaghetti for lunch!*"

One graduate student, a bachelor who worked 6.5 days a week, was asked by Arthur why he did not work on Saturday afternoons. The student replied that the ½ day was necessary to complete his errands within that narrow window. Casagrande suggested that he marry to have someone look after those things, and that the student would never amount to much because, obviously, he had not organized his life carefully enough.

4.3 Canadian flavour

Ralph Peck worked on more than 77 projects in Canada, the Casagrande brothers on 40 projects, including the Saint Lawrence River Crossing (Boucherville) and the Manicouagan Dams (Gervais 2020). Karl Terzaghi was also heavily involved in several Canadian projects, mainly in BC and the well-known Terzaghi Dam.

Ralph Peck did confide that the projects he enjoyed most were the ones in Canada where the problems were challenging, the state of practice good and the engineers competent and friendly. Figure 13 gives an example of one such project, the James Bay project.

Ralph Peck received a special award from the Canadian Geotechnical Society (CGS) (Fig. 14). Ralph cherished the soapstone sculpture, which is now with his daughter Nancy Peck Young. In his reply after receiving the special CGS award, Ralph said:

"Thank you for this very moving experience, and the chance to relive so many memorable moments in your vast country:

- *for climbing over and under the fallen timbers of the future left abutment of Bennett Dam,*
- *for the excitement of finally encountering and draining the water that threatened the stability of Downey Slide,*
- *for the magnificent display of Northern lights on a clear night at Churchill falls,*

- *for standing on the bottom of the buried gorge of Lower Notch (Fig. 15), where excavation and replacement changed a potentially modest embankment to one of the highest in Canada,*
- *for the greatest of all projects in my career, the ultimate can-do engineering and logistic feats of James Bay,*
- *for the hours of camaraderie in bunk houses across the continent over half a century,*
and for the pride I take in the accomplishments of my colleagues and friends here in the land of my birth."



Figure 13. La Grande Project (left to right, top to bottom: G. Gauthier, P. Mora, J. Perreault, J. Levay (photo), D. Madill, D.D. Campbell, W.F. Swiger, R.B. Peck, G. Larocque)



Figure 14. Ralph peck with CGS Special Award "Chanutchka, the dancing bear" (2002)

5 SUMMARY AND PERSPECTIVE

The three Historical Libraries are a source of inspiration for NGI-employees, clients and visitors. NGI sees its role as the custodian of the Terzaghi, Peck and Casagrande's documents on behalf of the geotechnical engineering and

geoscientist profession. NGI wishes to preserve the works of the four pioneers for posterity (and hopefully someday set up a Bjerrum Library). The libraries are a place (virtual or physical) where one can get to the roots of the thinking at the time of the development of geotechnical engineering science. The collections at NGI provide insight into four of the giants of our profession.

The documents reveal that:

- Karl Terzaghi was brilliant, fearless, enthusiastic;
- Ralph Peck was diplomatic and caring, a man of judgment;
- Arthur Casagrande was a gifted teacher and "no-nonsense" consultant, with bold ideas;
- Leo Casagrande was a pioneering educator and innovative consultant, with an amiable personality.



Figure 15. Lower Notch Dam, northeastern Ontario, where Casagrande, Terzaghi, Peck were consultants

Each was concerned with the future of geotechnical engineering. And they were visionaries. For example: At the time of his honorific doctorate at Université Laval, Ralph Peck, already in 1987, gave the lecture "Nature and

the Civil Engineer", including the need to accommodate nature and find nature-based solutions!

Even before that, another pioneer, Alec Skempton, said on the BBC, already in 1950: "*It is one thing to be an outstanding engineer or scientist, but to combine that with an understanding of the human values and to practice both together, is a combination everyone should aspire to*" (quote from the Peck Library).

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