

Memorial to Arthur Casagrande

1902-1981

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After a long illness, Professor Arthur Casagrande passed away on September 6, 1981.

Since 1963 when the "father" of modern soil mechanics, Karl Terzaghi, passed away, Arthur Casagrande was generally considered the chairman of soil mechanics. He earned this standing by more than 50 years of hard work and a single-minded devotion to the development of soil mechanics as a science. He was a brilliant man who had a great amount of common sense and a thorough grasp of the theoretical relationships governing the properties of soils and groundwater flow. When combined with his vast experience as an engineering consultant, these attributes resulted in an almost uncanny ability to solve problems in applied soil mechanics.

Although Casagrande was not a geologist, his work in soil mechanics and foundation engineering required a good working knowledge of geology. Because of the many experienced geologists all over the world, he considered it not necessary to become an expert in the field of geology. On many projects in which he was involved as consultant, particularly for dam projects, he often recommended that a geologist be engaged to study the conditions. During his more than 50 years as educator, researcher, and engineering consultant, he had the opportunity to work with and become friends with many geologists. Through this association, he was nominated and accepted for membership in the Geological Society of America in 1958.

Arthur Casagrande was born in Haidenschaft, Old Austria, in 1902. He decided at an early age that he wanted to become an engineer. In 1919 he enrolled in the Technical University in Vienna, Austria, to study civil engineering. After receiving his civil engineering degree in 1924, he continued at the university for two more years as an assistant in hydraulics.

In 1926 Casagrande emigrated to the United States and accepted a job with Carnegie Steel in New Jersey detailing steel structures. He soon contacted the Massachusetts Institute of Technology (MIT) in an effort to obtain work in hydraulics. During an interview at MIT, he had the good fortune to meet Professor Karl Terzaghi who was impressed by Casagrande and offered him a position as his assistant during the summer of 1926. At that time Terzaghi was struggling to transform the empirical art of foundation engineering into a predictable science. Casagrande accepted Terzaghi's offer and thus got in on the "ground floor" of soil mechanics.

At the end of 1926, Casagrande took a position with the Bureau of Public Roads and was assigned to Professor Terzaghi at MIT, with whom the bureau had a research grant. During the next three years, Casagrande was involved in research directed toward improving apparatus and techniques for testing soil. In particular, he developed the liquid limit device, the hydrometer test to determine soil particle sizes, the consolidation

apparatus, and the horizontal capillarity test. In addition, he carried out field investigations on frost action and developed criteria for the frost susceptibility of soils that have been adopted by highway designers in many parts of the world.

In 1929 when Terzaghi accepted a professorship at the Technical University in Vienna, he engaged Casagrande to establish a soil mechanics laboratory for him. With leave of absence from the Bureau of Public Roads, Casagrande first visited several centers of soil mechanics research in Germany and Sweden. During this period he conceived the need for triaxial and direct shear strength testing equipment.

When Casagrande returned to MIT in 1930, he designed and built his first triaxial test apparatus and his first direct shear machine. During the next two years, he concentrated on establishing the strength and consolidation characteristics of soils, and in particular of undisturbed clays. This led to the discovery that excess porewater stresses develop during shearing. In addition, he developed a procedure for identifying the pre-consolidation pressure of clays and of evaluating consolidation time curves by means of semi-logarithmic plots. Casagrande proceeded to summarize the results of his research in the form of a thesis, and thus earned his Doctor of Science degree from the Technical University in Vienna in 1933.

In 1936 Casagrande's name spread worldwide when he conceived and organized the First International Conference on Soil Mechanics and Foundation Engineering, which was held at Harvard University. Terzaghi served as president of that conference, although he had initially told Casagrande that soil mechanics was not yet ready for an international conference. The conference was a big success.

In 1940 Harvard promoted Casagrande to tenure position as associate professor. The same year, he married Erna Maas. They have two daughters: Vivien born in 1942 and Sandra born in 1945. Vivien is currently an associate professor at Vanderbilt University, and Sandra is a medical doctor specializing in neuropsychiatry.

From 1940 to 1942, Casagrande trained more than 400 army officers on the soil mechanics aspects of airfield construction. During this period, he also developed a soil classification system, which was later adopted by the Corps of Engineers and by the Bureau of Reclamation as the Unified Classification System.

In 1946 Casagrande became Gordon McKay Professor of Soil Mechanics and Foundation Engineering at Harvard. That same year he started research on the resistance of soils to dynamic stresses, as part of a Corps of Engineers' study to determine the feasibility of replacing the Panama Canal by a sea-level canal. In this connection, he was also requested to advise on maintaining the stability of the existing canal slopes, which are partially located in a weak clay shale formation that has very low residual shear strength.

Until his retirement from Harvard in 1973, Casagrande was a very active and innovative teacher. He also initiated and supervised extensive research in soil mechanics. He was devoted to his students and strove not only to provide them with a thorough understanding of soil mechanics theory but also to apply the theory to the solution of practical problems. He stressed the point that soil is not a man-made material like steel or concrete and therefore does not lend itself to accurate predictions of its behavior. He often illustrated his point by drawing on his own extensive experiences as a consultant. After they left Harvard, most of Casagrande's students became highly respected engineers, and many also accepted positions at universities. Frequently, Casagrande had the opportunity to work with one or the other of his former students in connection with his consulting activities, and he always treated them as equals, respecting their opinions, although not always agreeing with them.

In 1970 Casagrande joined with his brother, Leo, and his nephew, Dirk, to form a geotechnical consulting group under the name of Casagrande Consultants. He retained

an office at Harvard University where he continued to work until shortly before his death. In addition to his strenuous consulting activities, which took him to all parts of the world, he spent considerable time writing papers and preparing lectures to be presented at various conferences and functions. Casagrande was very conscientious about the accuracy and clarity of everything he wrote, and he was never totally satisfied with the end product, even after many revisions. Despite this meticulous nature, he managed to write or co-author more than 100 professional papers and articles during his career.

Casagrande considered earth and rockfill dam engineering to be the most interesting and challenging area of applied soil mechanics. He introduced many new design and instrumentation concepts and thus earned the reputation of being one of the world's foremost dam experts. His advice was sought for the design and construction of most of the major earth and rockfill dams constructed in the past 40 years, including the recently completed, record-breaking Tarbela Dam in Pakistan and the huge Itaipu hydroelectric project, which is still under construction in Brazil.

Casagrande's background in hydraulics proved to be very useful in analyzing problems of groundwater seepage. He made extensive use of flow nets for analyzing seepage through, under, and around dams. This led to the development of more effective seepage control principles, which he incorporated into his designs.

Casagrande was occasionally called upon to investigate the reason for distress or failure of a structure. He usually accepted these assignments with reluctance because it meant that he would probably have to criticize a fellow engineer. But he generally accepted because it was an opportunity for the profession to learn from an oversight or a mistake. One such assignment was the investigation of the Teton Dam failure.

Casagrande considered it his duty and a privilege to guide research programs in soil mechanics and foundation engineering whenever this was requested of him. For many years he was a member of an advisory board that guided the soil mechanics research undertaken by the Corps of Engineers. He also served on numerous committees, including the GSA Committee on Dams and Reservoirs.

Arthur Casagrande was an active member of many professional societies. He was a member of the National Academy of Engineering, Fellow of the American Academy of Arts and Sciences, Fellow of the Geological Society of America, Honorary Member of the American and Boston Societies of Civil Engineering, Honorary Member of the Mexican Soil Mechanics Society, the Venezuelan Soil Mechanics Society, the Japanese Soil Mechanics Society, and of the National Academy of Exact, Physical and Natural Sciences of Argentina. He was also a member of the International Society for Soil Mechanics and Foundation Engineering, the U.S. Committee on Large Dams, the American Society for Engineering Education, the Society of Harvard Engineers and Scientists, and of Sigma Xi. In addition, he was president of the Boston Society of Civil Engineers and of the International Society for Soil Mechanics and Foundation Engineering.

SELECTED BIBLIOGRAPHY OF ARTHUR CASAGRANDE

- 1932 The structure of clay and its importance in foundation engineering: *Journal of the Boston Society of Civil Engineers*, v. 19, no. 4, p. 447-451. Reprinted in *Contributions to Soil Mechanics, 1925-1940*, Boston Society of Civil Engineers, p. 72-113.
- 1935 Ice pressure determinations in clay soils: *Engineering News Record*, v. 115, no. 4, p. 127.
- 1936 Characteristics of cohesionless soils affecting the stability of slopes and earth fills: *Journal of the Boston Society of Civil Engineers*, v. 23, no. 1, p. 13-32.

- Reprinted in Contributions to Soil Mechanics, 1925–1940, Boston Society of Civil Engineers, p. 257–276.
- Determination of the pre-consolidation load and its practical significance, *in* Proceedings of the First International Conference on Soil Mechanics and Foundation Engineering, Volume III: Harvard University, p. 60–64.
- 1937 Seepage through dams: Journal of the New England Water Works Association, v. 51, no. 2, p. 131–172. Reprinted in Contributions to Soil Mechanics, 1925–1940, Boston Society of Civil Engineers, p. 295–336.
- 1938 The shearing resistance of soils and its relation to the stability of earth dams, *in* Proceedings of the Soils and Foundation Conference of the U.S. Engineer Department, Boston: p. A1–A20.
- 1942 (with Fadum, R. E.) Application of soil mechanics in designing building foundations: Proceedings of the American Society of Civil Engineers, p. 1487–1530. Reprinted in Transactions of the American Society of Civil Engineers, 1944, v. 109, p. 383–490.
- 1944 (with Carrillo, N.) Shear failure of anisotropic materials: Journal of the Boston Society of Civil Engineers, v. 31, no. 2, p. 74–87.
- 1947 Classification and identification of soils: Proceedings of the American Society of Civil Engineers, v. 73, no. 6, p. 783–810. Reprinted in Transactions of the American Society of Civil Engineers, 1948, v. 113, p. 901–991.
- 1948 (with Sannon, W. L.) Strength of soils under dynamic loads: Proceedings of the American Society of Civil Engineers, v. 74, no. 4, p. 591–608. Reprinted in Transactions of the American Society of Civil Engineers, 1949, v. 114, p. 755–772.
- 1949 Notes on swelling characteristics of clay-shales: Harvard University, 16 p. (unpublished).
- 1950 Notes on the design of earth dams: Journal of the Boston Society of Civil Engineers, v. 37, no. 4, p. 405–429.
- 1951 (with Wilson, S. D.) Effect of rate of loading on the strength of clays and shales at constant water content: *Géotechnique*, v. 2, p. 251–263.
- 1953 Theories and hypotheses of general character—soil properties, classification, engineering geology, *in* Proceedings of the Third International Conference on Soil Mechanics and Foundation Engineering, Volume II: Zurich, Switzerland, Imprimerie Berichthaus, p. 307–312.
- 1959 (with Rivard, P. J.) Strength of highly plastic clays: Norwegian Geotechnical Institute, Publication no. 31, p. 4–22.
- 1961 Control of seepage through foundations and abutments of dams: *Géotechnique*, v. II, no. 3, p. 161–181.
- 1965 Role of the calculated risk in earthwork and foundation engineering: Proceedings of the American Society of Civil Engineers, v. 91, no SM4, p. 1–40. Abstract in Transactions of the American Society of Civil Engineers, 1968, v. 133, p. 530–532.
- 1972 (with Wilson, S. D., and Schwantes, E. D., Jr.) The Baldwin Hills reservoir failure in retrospect, *in* Proceedings of the Specialty Conference on Performance of Earth and Earth-Supported Structures: American Society of Civil Engineers, v. 1, pt. 1, p. 551–588.
- 1975 Liquefaction and cyclic deformation of sands, a critical review, *in* Proceedings of the Fifth Panamerican Conference on Soil Mechanics and Foundation Engineering: Buenos Aires, Sociedad Argentina de Mecanica de Suelos e Ingenieria de Fundaciones, Volume V, p. 80–109.