

Breaking New Ground - Women in Geotechnical Engineering

Anna Lankford Burwash

Introduction

Geotechnical engineering presents very practical challenges. Something needs to be designed or a problem needs to be solved. Safety and affordability are major considerations. High levels of ambiguity are usually a given. Communication skills are very important. The number of women who have chosen to take up these challenges has increased over the last 50 years. However, women still represent a small percentage of the total number of people in geotechnical engineering. Women continue to be in the position of breaking new ground. At first, breaking new ground often meant doing geotechnical work that had never been done by women before. In current geotechnical practice, breaking new ground can be more accurately described as the solution of new problems or pursuit of new activities on behalf of the profession.

This article briefly describes early involvement of women in geotechnical engineering. It identifies from the writer's perspective some of the events and trends in the 1950s and 1960s that helped encourage her to consider the pursuit of post-secondary study and a career in either science or engineering, and may have influenced the choices of other young women at that time. Finally, the article describes some of the activities and contributions of several contemporary women in geotechnical engineering.

Early Involvement of Women

The writer feels quite confident in asserting that women have been involved in geotechnical engineering as long as men have. Many of these women had no formal training in engineering. They provided support and assistance to geotechnical activities in which their husbands were engaged in. For example, Mrs. M. Skempton designed the layout and cover for *Gèotechnique*. The

first issue of the journal was published in 1948.

A very notable example of a woman who had Ph.D. level training in geology was Ruth Doggett Terzaghi who worked closely with her husband, Karl Terzaghi. She was described as his "highly competent associate" who even taught some of his classes. (Casagrande 1964)

Mrs. Ellen Louise Mertz, a Danish geologist, was an effective intermediary and networker. In 1950, the position of Head of the Norwegian Geotechnical Institute (NGI) was advertised in the Scandinavian countries. Dr. Laurits Bjerrum was employed by the Swiss Federal Institute of Technology at the time and was likely unaware of this challenging employment opportunity. Mrs. Mertz knew Bjerrum and she knew Olav Folkestad who chaired the selection committee. She told Folkestad that she knew someone who would be a very good candidate for the position. Bjerrum was hired and he had a very distinguished career at NGI until his death in 1973. (Norwegian Geotechnical Institute Staff 1973)

Events and Trends in the 1950s and 1960s

The launch of Sputnik in 1957 increased public awareness of the importance of science and engineering to society. At the time, the writer was a young child who was enrolled in an elementary school in a rural community on the Eastern Shore of Maryland in the United States. Up until this time, teachers in the school had little academic preparation in science and therefore had been hesitant to initiate strong science-based course work in the classroom. This situation quickly changed. The science content increased quickly.

In 1959, the President's Scientific Advisory Committee issued a statement on Education for the Age of Science.

The statement stressed the importance of developing the talents of all students to their fullest potential. (Wilson 1992) In the local school, principals asked their teachers to encourage their "good students" to actively consider a career in engineering or science. Without that type of encouragement, very few would have even considered the proposition. Teachers enrolled in science courses in the evenings and participated in special summer programs. Classroom discussions about the activities of the International Geophysical Year (1957-1958) provided additional interest in subterranean investigations. By the time the writer was in senior high school, her small-town school was able to offer a modern physics course that had been developed for secondary schools in cooperation with leading universities including Massachusetts Institute of Technology. These types of developments helped level the playing field so those rural students could compete successfully for admission to engineering and science degree programs at major universities.

Other profound changes came to the writer's small town in the late 1950s and early 1960s as a result of increased national emphasis on research and development in space. In 1958, the creation of the National Aeronautics and Space Administration (NASA) marked the beginning of a civilian space program in the United States. An aeronautical launch facility on nearby Wallops Island in Virginia was the site of studies to support the human space program. As the facility's staff grew in numbers, there was an influx of technicians, engineers and scientists who worked in the NASA Space Program. Their children enrolled in the local schools and university. Students from other parts of the country came to participate in cooperative work terms. In short, high technol-

ogy arrived on the doorstep of a community that had been largely engaged in agriculture and food processing. It was clear to local students that with the right blend of education and experience, a person could have a challenging career in engineering or science.

In the 1960s, engineering curricula in universities began to stress scientific fundamentals (Grayson 1996). Although the undergraduate degree curriculum varied from university to university, it was often possible for a person who was interested in pursuing a technical career to delay making a decision between engineering or science until the second or third year of study. From the point of view of a woman who had an interest in engineering, this approach represented an opportunity to try engineering without a significant delay in graduation if she decided that science or another field was more to her liking.

In 1964, the Civil Rights Act (Title VII) came into effect that prohibited discrimination against women in all aspects of employment in the United States. This legislation was very timely.

Contemporary Women in Geotechnical Engineering

Because this article is part of a special issue of *Geotechnical News* that commemorates the 50th anniversary of conferences in Canada on geotechnical engineering, it is important to point out that none of the contemporary women mentioned in this article attended the first conference in Ottawa in 1947. Many had not been born yet. The writer who is probably the oldest woman mentioned in this section of the article was definitely alive at the time but her travel budget for the 1947/1948 period was already committed to a trip to Mexico. (fig. 1).

It is very difficult to get beyond anecdotal information when trying to determine the approximate numbers of women involved in geotechnical engineering in any given year. Most studies on women in engineering do not subdivide the aggregate data to this extent. Not all professional women in the geotechnical field are engineers, so even if statistics based upon numbers of women geotechnical engineers were

available, the statistics would not provide any information on the women with geology, geophysics or environmental science backgrounds. Until the 1970s in the United States, much less than 1% of the total number of practicing engineers in all engineering disciplines were women.



Fig. 1 The author in Mexico City in January 1948. Left to right: Doris Kelley Lankford (the author's mother), the author, Howard James Lankford (the author's father), Mrs. Tinker and Mr. Tinker (fellow tourists).

In Canada it was not until 1978 that the Canadian Council of Professional Engineers (CCPE) started measuring the impact of women on the supply of engineers. Initial statistics focused on the number of women enrolled in undergraduate and graduate programs in Canadian universities. At that time, women represented about 5% of undergraduate students in engineering and 4.6% of engineering graduate students. In 1982, *Engineering Manpower News* reported that of a total 110,000 professional engineers in Canada, less than 1,400 were women. (Canadian Engineering Manpower Council 1978, 1982)

According to Matyas (1992), in 1989, women earned 53% of all bachelor's degrees received in the United States. They received 15% of the bachelor's degrees in engineering awarded that year. In 1988, 4% of the engineers in the United States were women. In contrast, 30% of U.S. scientists were women.

The Canadian Council of Professional Engineers reported in 1992 that

women in Canada still comprised less than 10% of undergraduate students in engineering and that less than 2% of Canadian engineers were women.

Although the number of women in geotechnical engineering is still small, their individual contributions to the field are substantial. In order to illustrate

this point, the writer contacted a small sample of women and asked them to provide information about their geotechnical work and other professional activities for this article.

Women Who Received Their First University Degree Before 1971

Dr. Suzanne Lacasse

Dr. Suzanne Lacasse is the Managing Director of the Norwegian Geotechnical Institute (NGI) in Oslo, Norway. NGI has a subsidiary office in Malaysia. She has held this position since 1991 and has been an employee of NGI since 1980. She has worked in consulting research and university teaching and in the process of doing so has worked in Canada, the United States, The Netherlands, France, England and Italy. She speaks seven languages. From 1976 to 1978, she was Head of the Soil Mechanics Laboratory at Massachusetts Institute of Technology and a recipient of the MIT Effective Teaching Award in Civil

Engineering. Dr. Lacasse is Canadian. Her areas of expertise include laboratory and in-situ testing, field observations, soil behaviour, foundation analysis, numerical analysis, probabilistic analysis, knowledge-based systems, computer programming and university teaching. Some of the national and internationally significant projects she has undertaken are: the Hibernia project in Canada; projects related to safety of tailings dams in the United States; and projects involving offshore structures in the North Sea.

She has been an Associate Editor of the *Canadian Geotechnical Journal* and is currently on the Editorial Board of the *ASTM Geotechnical Testing Journal*. She is a member of the Board of Directors of the Norwegian Geological Survey and of the Research Council of Norway Engineering and Sciences.

Dr. Priscilla Provost Nelson

Dr. Priscilla Provost Nelson is Program Director and Senior Engineering Coordinator for Engineering at the National Science Foundation in Arlington, Virginia. She started in her current position in August of 1996. Prior to taking on this position, she was a Professor of Civil Engineering at the University of Texas at Austin. She holds Adjunct Professor status at the University while the last two of her remaining students are finishing their Ph.D. studies.

Dr. Nelson is a geologist and engineer. Her primary areas of expertise are rock mechanics, tunnelling and excavation technology and equipment. She received The Basic Research Award of the U.S. National Committee for Rock Mechanics NAS/NAE in 1993. In the same year, she was elected to the Board of Directors of the U.S. University Council on Geotechnical Engineering Research. She is a member of technical committees of the Geotechnical Division of the American Society of Civil Engineers (ASCE) and was appointed to the Division's Executive Committee in 1995. She was appointed to the inaugural Board of the Geo-Institute of ASCE in 1996. She was President of the American Rock Mechanics Association from 1995 to 1996. In 1995, she was elected

to The Moles, an association for the heavy construction industry. Dr. Nelson was keynote speaker and Chair of the 2nd North American Rock Mechanics Symposium held in Montreal, Quebec in June of 1996.

Some of the projects of national and international significance that Dr. Nelson has worked on included the Superconducting Super Collider, Low Level Radioactive Waste Disposal in Texas, the Trans-Alaska pipeline and major tunnel projects: The Channel Tunnel; TARP in Chicago; and the Loma Larga tunnel in Monterrey, Mexico.

Heather J. Cross

Heather J. Cross is a hydrogeology consultant whose home base is Dartmouth, Nova Scotia. She has attained Certified Ground Water Professional status with the National Ground Water Association in the United States. She is a member of the Well Construction Advisory Board that provides advice to the Nova Scotia Ministry of the Environment. In addition to her consulting activities she is an Adjunct Professor at the Technical University of Nova Scotia where she currently teaches a graduate course in Groundwater Chemical Quality.

She has also taught hydrogeology courses as a Special Lecturer at Dalhousie University. From 1974 to 1980 she was employed as a hydrogeologist with the Nova Scotia Department of the Environment. As a consultant she has undertaken studies on the environmental effects of uranium mining, milling and waste management, detailed contaminant studies, peer reviews of environmental consulting reports, groundwater evaluation and water supply assessment.

Mona Bechai

Mona Bechai is a Manager, Civil Field Services at Ontario Hydro in Toronto, Ontario. She is currently responsible for civil maintenance, instrumentation, inspection and monitoring of Ontario Hydro hydroelectric dams. This work involves consideration of needs for 247 dams having an average age of more than 50 years. She has worked on developing options for deep disposal of low

to intermediate level nuclear wastes and was involved in the design and construction of the first reinforced earth wall to be built under water, that is, without dewatering.

She has served as a Regional Director of the Engineering Geology Division of the Canadian Geotechnical Society and is currently a member of the Executive of the Southern Ontario Section of the Society.

Anna Lankford Burwash

Anna Lankford Burwash is an American-born Canadian citizen. Her primary areas of geotechnical interest are in muskeg and engineering in northern environments. Her professional career has included work as an engineering consultant, management consultant, university researcher and as a civil servant in three Ontario ministries. She currently holds a senior policy position in the Ministry of Health.

She was a Regional Director (Atlantic Provinces) of the Canadian Geotechnical Society from 1973 to 1976. She has served on the Associate Committee on Geotechnical Research of the National Research Council of Canada and on the Editorial Board of the *Canadian Geotechnical Journal*. From 1980 through 1987 she was a member of ASTM D18.18 Subcommittee on Peats and Other Organic Soils and served a two-year term as Chair. She has been very active in the Technical Council on Cold Regions Engineering of the American Society of Civil Engineers. She was appointed to the Council's Executive Committee in 1988 and was its Chair in 1991/92. She continues to be a member of three of the Council's administrative committees: Awards, Publications and Education.

Women Who Received Their First University Degree from 1971 to 1980

Dr. Deborah J. Goodings

Dr. Deborah J. Goodings is a faculty member in the Department of Civil Engineering at the University of Maryland in College Park, Maryland. She is currently on a sabbatical leave at Cambridge University in England. She

teaches undergraduate and graduate students and conducts research concerning landslides, sinkholes, reinforced soil, cratering, grouting, geo-environmental problems and cold regions geotechnique. Before becoming a university professor, Dr. Goodings worked on the Tarbela Dam in Pakistan for two years. Before that she was a field engineer for the Ontario Ministry of Natural Resources where she was involved in field mapping and stability assessment of slopes (Champlain Sea Clay) on the South Nation River.

Dr. Goodings' Ph.D thesis work at Cambridge University on centrifugal modeling of slope failures was acknowledged by Dr. A.N. Schofield in the Twentieth Rankine Lecture presented in 1980. (Schofield 1980)

Dr. Sandra L. Houston

Dr. Sandra L. Houston is Professor and Interim Chair of the Department of Civil and Environmental Engineering at Arizona State University. Her major subject areas of interest in geotechnical engineering include arid-land soils, unsaturated soils, collapsible soils, problem soils, cemented soils, saturated and unsaturated groundwater flow and high-temperature behaviour of soils. Dr. Houston is very active in the Geotechnical Division of the American Society of Civil Engineers as a member of the editorial board of the *ASCE Journal of Geotechnical Engineering*, Chair of the Unsaturated Soils Subcommittee and a Control Group member of the Soil Properties Committee. She is Secretary of the Unsaturated Soils Committee of the International Society of Soil Mechanics and Foundation Engineering and Secretary of the Board of Directors of the United States University Council for Geotechnical Engineering Research.

Sue E. Evison

Sue E. Evison is a senior geotechnical engineering consultant with AGRA Earth and Environmental Limited in Calgary, Alberta. Her primary areas of geotechnical expertise are in numerical modelling, slope stability, tunneling and trenchless technology. In her work on the McKnight Boulevard sewer reha-

bilitation, a world precedent was set for materials handling in a trenchless cured-in-place relining technique. She has been involved in complex numerical analyses in hydrogeological, geotechnical and structural engineering applications. Examples include: seepage studies for analysis of flow through a proposed 800-metre-long semicircular rockfill cofferdam and underlying highly fractured bedrock into a proposed open pit excavation at a uranium mine; detailed finite element simulation of soil-pipe interaction for a high-pressure gas pipeline in soft Bangkok clay in Thailand; and detailed two-dimensional finite element simulation of soil-structure interaction for a seabed-founded structure in the Beaufort Sea.

She is a Director (Southern Alberta) of the Canadian Geotechnical Society. She has been very active in the Association of Professional Engineers, Geologists and Geophysicists (APEGGA) since 1987. She was recently elected as a member of the APEGGA Council.

Anne S. Poschmann

Anne Poschmann is a principal in Golder Associates in Mississauga, Ontario. She is responsible for technical and administrative control of geotechnical engineering projects with specific emphasis on major transportation networks and municipal services.

The technical scope of her activities has included feasibility studies, geotechnical investigations, foundation design, and testing and monitoring during construction. The range of transportation and municipal service projects has included expansions of the Toronto Transit Commission subway system; contraction, relocation or rehabilitation of major bridges in Ontario usually in urban areas; roadworks design; and sewers. She is often involved in very complex projects involving use of deep foundations or tunnelling.

Anne was a Director and Treasurer of Consulting Engineers of Ontario from 1991 to 1994. She has been very active in the Southern Ontario Section of the Canadian Geotechnical Society and has been a member of the National Engineering Week-Ontario Steering Committee from 1993 to the present.

Women Who Received Their First University Degree from 1981 Onwards

Dr. Mary Roth

Dr. Mary Roth is an Assistant Professor at Lafayette College in Easton, Pennsylvania. Lafayette College does not offer graduate study so all of her students are undergraduates. Dr. Roth received her own undergraduate degree at Lafayette.

She is very active in committees of the Geotechnical Division of the American Society of Civil Engineers. She is presently a Control Group member of the Earth Retaining Structures and the Geotechnical Safety and Reliability Committees.

From 1994 through 1996 she was a member of the Geotechnical Specialty Conference organizing Committee and co-editor of the proceedings of the Specialty Conference held in Madison, Wisconsin in August of 1996.

Susan W. Hollingshead

Susan W. Hollingshead is employed as a Geotechnical Engineer/Quality Coordinator by Klohn-Crippen Consultants Ltd. in Richmond, British Columbia. She is a Registered Professional Engineer in Alberta, the Northwest Territories, Ontario, and the Yukon Territory.

She is a Registered Professional Engineer and a Registered Geoscientist in British Columbia. She is currently involved in developing a formalized quality management system for the company.

Her geotechnical experience includes: design of shallow and deep foundations for residential, commercial, and industrial structures; design review of soil-structure interaction problems involving pipelines founded in soft ground; preparation of technical specifications for excavation, fills, piles and vibro-replacement; liquefaction assessments; construction management; soil investigations; field instrumentation and testing. She was Chair of the Vancouver Geotechnical Society in 1993/94.

Jodi Everard

Jodi Everard is a Project Engineer in the Geotechnical Division of AGRA Earth and Environmental Ltd. in Burnaby, British Columbia. She has been involved in various aspects of geotechnical and environmental engineering since 1992. Her areas of specialization include: the use and interpretation of in-situ testing tools for both geotechnical and geo-environmental applications; site assessment; soil mechanics and foundation engineering; and dynamic and earthquake engineering. At AGRA, she has been involved in a range of projects including design of foundations for commercial and industrial structures; slope stabilization; design of waste dumps, tailings dams and heap leach facilities; seismic design of foundation systems and bridges; dynamic analysis of machine foundations, excavation and shoring design; and design and construction monitoring of landfill and leachate collection facilities.

Prior to her studies in civil engineering and geotechnical engineering, she received a bachelor's degree in mathematics. She is fluent in English and French and conversant in Spanish. She has worked on projects across Canada and in the United States, Australia, Russia, Finland, Estonia and South America. In 1995/96, she was Chair of the Vancouver Geotechnical Society.

The women whose work is described briefly in this article, represent a small sample of women in geotechnical engineering. They and their growing number of female colleagues around the world continue to bring their imagination, vision and commitment to geotechnical engineering.

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ANNA LANKFORD BURWASH was born in Maryland. She graduated in civil engineering from Carnegie Mellon University, Pittsburgh in 1968 and with a professional development degree in engineering from the University of Wisconsin-Extension in 1981. In 1993, she received a certificate in gerontology from Ryerson Polytechnic University.

Anna moved to Canada in 1968 and became a Canadian citizen in 1974. She has been employed in engineering consulting in New Brunswick and Alberta. Her initial experience in applied research studies in muskeg and permafrost was gained at

the Muskeg Research Institute of the University of New Brunswick. Her geotechnical consulting experience was obtained as an employee of Geocon Ltd. in Fredericton, New Brunswick and Hardy Associates Ltd. in Calgary, Alberta.

In 1980 Burwash established a consulting firm in Calgary that provided management consulting services including assistance in recruiting geotechnical personnel. In 1987 she became a technology consultant in the Ontario Ministry of Industry, Trade and Technology. In 1988 she became a manager of the Ministry of Community and Social Services. Since 1990 she has been a project manager in the Long-Term Care Policy Branch, Ministry of Health.

Ms. Burwash has had extensive involvement in technical societies and committees, including the Canadian Geotechnical Society, *Canadian Geotechnical Journal*, National Research Council Associate Committee on Geotechnical Research, Engineering Institute of Canada, American Society for Testing Materials, and chair of the Executive Committee of the Technical Council on Cold Regions Engineering of the ASCE.