Ronald F. Scott
1929 – 2005

Ronald Fraser Scott, the Dotty and Dick Hayman Professor of Engineering, Emeritus, died on August 16, 2005. He was 76. An internationally acclaimed expert in soil mechanics and foundation engineering—or geotechnical engineering as it is now known—his research interests included the basic properties of soils and how they deform, the dynamics of landslides, the behavior of soil in earthquakes, the physical chemistry and mechanics of ocean-bottom soil, the physics of the freezing and thawing processes in soils, and the properties of the moon's surface.

Scott was born in London and grew up in Perth, Scotland. After gaining a bachelor's degree in civil engineering from Glasgow University in 1951 and an ScD in civil engineering (soil mechanics) from MIT in 1955, he worked with the U.S. Army Corps of Engineers on the construction of pavements on permafrost in Greenland, and with consulting engineers Racey, McCallum and Associates in Toronto, before joining Caltech as an assistant professor of civil engineering in 1958. Rising through the ranks, he became the Hayman Professor in 1987, and retired in 1998.

On February 11, a memorial gathering in Scott's honor was hosted by Norman Brooks (PhD '54), Irvine Professor of Environmental and Civil Engineering, Emeritus. Caltech provost and professor of civil engineering and applied mechanics Paul Jennings, (MS '60, PhD '63, who took one of Scott's soil mechanics classes as a graduate student), told the gathering that Scott had taken on a challenging field. "As engineering materials, soils are simply not nice," he said. "They are complicated two-phase media, composed of a porous collection of particles and a fluid in the pores, typically water. As such, soils are kind of noneverything—nonlinear, nonelastic, nonhomogeneous, nonisotropic and therefore from the viewpoint of solid mechanics, noneasy." But, he said, Scott was a Caltech type of engineer—half engineer, half scientist—who developed engineering tools and approaches based on a rigorous understanding of the fundamental mechanics involved.

"This real-world messiness of soils translates to the classroom," Jennings added. "Around the country, soil mechanics courses are often not popular because the material resists the elegant mathematical simplifications that take one so far in other materials, like metals. Ron's courses were different; they were well-appreciated and popular because he met the challenges of soil complexity head-on in his unique and interesting way."

Many boys dream of being a backhoe operator when they grow up, but Scott achieved the ultimate: He was the first person to dig on the moon. The instrument he designed and operated, shown here on Surveyor 3 shortly before its 1967 launch, had a telescopic arm with a box-like scoop at the end. Scott's results gave the green light for Apollo 11.

When he began teaching, there were no textbooks that suited Scott's rigorous scientific approach based on the mathematical principles of solid and fluid mechanics, so he wrote several of his own, including *Principles of Soil Mechanics* (1963) and *Foundation Analysis* (1981).

"His understanding of the theoretical issues was profound," said James Knowles, the Kenan, Jr., Professor and Professor of Applied Mechanics, Emeritus, "but his work was always motivated by real-world problems and needs, and he accumulated much practical experience by consulting on such problems as landslides and soil liquefaction." Living as he did in a region highly prone to landslides and earthquakes, Scott's expertise was called upon many times by consulting firms and government agencies. He was an advisor dur-

ing the investigations that followed the Baldwin Hills Dam failure in Los Angeles in 1963 and the Bluebird Canyon landslide in Laguna Beach in 1978, and worked with Fred Raichlen, professor of civil and mechanical engineering, emeritus, to design the foundations of submarine wastewater outfalls to withstand earthquakes and high waves.

Scott pioneered the use of centrifuges in soil dynamics, recognizing that the mechanical properties of soils depend on the pressures to which they're subjected. The soil at the bottom of a large earthen dam, for example, is under an enormous amount of pressure from the weight of the soil above and around it. Laboratory-sized scale models, using much less soil, can't reproduce this. Scott's solution was to spin the model in a large centrifuge to achieve forces 50 to 100 times the acceleration due to gravity. His centrifuge also incorporated a computer-controlled shaking table that could model the intense motion of soil during an earthquake. "This technology has been copied and refined at other labs around the world, but Ron was the originator," said John Hall, professor of civil engineering and dean of students.

In the 1960s, Scott's expertise made him the ideal person to evaluate whether the surface of the moon would be safe to walk on. At the time, many people thought it was covered in a deep layer of fine dust, like talc, that wouldn't support the weight of a human. As a principal investigator for Surveyors 3 and 7, two unmanned craft preparing the way for the Apollo 11 manned landing, he designed an instrument to examine the structure and load-bearing strength of the lunar soil.

Scott's box-shaped, claw-mouthed scoop, or "soil mechanics surface sampler," as NASA called it, was attached to a telescopic arm and could be moved around and lifted up and down by radio signals from Earth. The scoop could dig trenches, scrape up soil, and even lift large clods and drop them to break up the lumps. And by filling the scoop with soil and compressing it, Scott and JPL engineer Floyd Roberson could estimate its bearing strength.

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Surveyor 3 landed on the moon in 1967, and "for the next two weeks," Scott later wrote in the February 1970 issue of *E&S*, "Floyd and I happily and sleeplessly played with the lunar surface soil on the inside surface of a 650-foot-diameter crater." The moon's surface, they concluded, was like damp sand, and safe to walk on.

When the time came for the manned landing, Scott waited anxiously on July 20, 1969, as Neil Armstrong climbed down the ladder of the lunar module *Eagle*. Everyone remembers Armstrong's first words, "That's one small step for man, one giant leap for mankind," but not many remember what he said next: "I sink in about an eighth of an inch. I've left a print on the surface." Those were the words Scott wanted to hear.

There's a postcript to this story. In November 1969, Apollo 12's module landed close to Surveyor 3, and Charles Conrad and Alan Bean walked over to take a look at it. Conrad cut off the scoop and brought it back to Earth in two Teflon bags. Scott was present when the bags were opened. "If I had known I would see it again," Scott told *E&S*, "I would have left the scoop completely packed with lunar soil."

The two Viking spacecraft that landed on Mars in 1976 also needed soil scoops, and again, Scott worked on those. As mentioned in *E&S*, No. 4, 2005, some of the soil collected by the scoops was used in a life-detection experiment designed by another Caltech faculty member, Norman Horowitz, who died shortly before Scott.

Former students and colleagues at the memorial gathering mentioned Scott's high standards. "He did not tolerate sloppy or inaccurate research or engineering," said Raichlen, "and he had little patience with others who fell into that category." A "fiercely independent thinker," Scott "valued academic integrity above all else," said John Ting, MS '76, professor and dean of engineering at the University of Massachusetts at Lowell. "It wasn't about the size of the research group, or the amount of funding—it was about the purity of the academic pursuit, and asking and then answering the key questions in the most elegant (and often the least expensive) way." Two of Scott's former graduate students, Hon-Yim Ko (MS '63, PhD '66), Murphy Professor of Engineering at the University of Colorado at Boulder, and Thiam-Soon Tan (MS '82, PhD '86), associate professor of civil engineering at the National University of Singapore, also paid tribute to their mentor and friend. Many of the speakers remarked on Scott's wit, his wry sense of humor, and his infectious laugh.

Scott cultivated a love of literature and was an omnivorous reader, said his son, Grant, a professor of English at Muhlenberg College in Pennsylvania. And in a fitting tribute to his soil-engineer father, he said "My father loved words—especially puns—where there was slippage in the slope of language, perhaps a kind of liquefaction where two letters supporting a dam of meaning gave way or there was a semantic friction or failure. He liked to see words collapse into other words, and watch as a seismic shift altered the landscape of a sentence."

Scott was elected to the National Academy of Engineering in 1974. His awards included the American Society of Civil Engineers' Walter L. Huber Civil Engineering Research Prize in 1969, the Norman Medal in 1972, and the Thomas A. Middlebrooks Award in 1982. He was also selected to be the ASCE's Terzaghi lecturer in 1983, and the British Geotechnical Society's Rankine lecturer in 1987. Considered to be the two highest honors in Scott's field, they are rarely awarded to a single person.

He is survived by Pamela, his wife of over 46 years, sons Grant, Craig, and Rod, and seven grandchildren. □